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DELIVERY ORDER NO. 0023
ENVIRONMENTAL SERVICES
PROGRAM SUPPORT
CONTRACT DACA31-00-D-0011

RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

WORK PLAN
ADDENDUM NO. 14
RCRA Facility Investigation at Solid Waste Management Unit 40/71

FINAL DOCUMENT

September 2002

PREPARED BY:

URS

5540 Falmouth Street, Suite 201
Richmond, Virginia 23230
(804) 965-9000 main
(804) 965-9764 fax

COMMONWEALTH *of* VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY

W. Tayloe Murphy, Jr.
Secretary of Natural Resources

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

Robert G. Burnley
Director
(804) 698-4000
1-800-592-5482

5 November 2002

Mr. James McKenna
Radford Army Ammunition Plant
SIORF-SE-EQ
P.O. Box 2
Radford, VA 24141-0099

RE: Addendum's 13 & 14 September 2002

Dear Mr. McKenna:

This office has reviewed the referenced draft document and concurs with Addendum's 13 & 14. No revisions to the document are required. Please provide this office a copy of the final document when it is completed.

If you have any questions, please call me at 804.698.4308.

Sincerely,

Mark S. Leeper
RPM

cc: Norman L. Auldridge - WCRO, DEQ
Beth Lohman - WCRO, DEQ
Durwood Willis - DEQ
Robert Thompson, Region III, U.S.EPA, 3HS13

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

Date: October 10, 2002

In reply
Refer to 3HS13

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

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

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

Re: Radford Army Ammunition Plant
SWMUs 40 & 71
Work Plan Addendum 14
Document submittal and review

Dear Mr. McKenna and Ms. Jake:

The U.S. Environmental Protection Agency (EPA) has reviewed the Army's September, 2002 *Work Plan Addendum 14* for the investigation of SWMUs 40 and 71, located at the Radford Army Ammunition Plant (RFAAP). Based upon our review, *Work Plan Addendum 14* is approved. In accordance with Part II. (E)(5) of RFAAP's Corrective Action Permit, *Work Plan Addendum 14* is now considered final.

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

Sincerely,

Robert Thomson

Robert Thomson, PE
Federal Facilities Branch

cc: Russell Fish, EPA
Leslie Romanchik, VDEQ-RCRA
Sharon Wilcox, VDEQ-CERCLA
Mark Leeper, VDEQ-CERCLA

ATK
ALLIANT TECHSYSTEMS

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

September 11, 2002

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

Subject: Work Plan Addendum 13 RCRA Facility Investigation at Solid Waste Management Unit 54, September 2002
Work Plan Addendum 14 RCRA Facility Investigation at Solid Waste Management Unit 40/71, September 2002
Radford Army Ammunition Plant
EPA ID# VA1 210020730

Dear Mr. Thomson:

Enclosed is a certified copy of "Work Plan Addendum 13 RCRA Facility Investigation at Solid Waste Management Unit 54, September 2002" and a certified copy of "Work Plan Addendum 14 RCRA Facility Investigation at Solid Waste Management Unit 40/71, September 2002". Your two additional copies and copies to Virginia Department of Environmental Quality (VDEQ), U.S. Army Operations Support Command, U.S. Army Environmental Center, U.S. Army Center for Health Promotion and Preventive Medicine will be sent under separate cover.

These work plans have been revised per our conference call of August 22, 2002 and are considered final. Upon your concurrence new report covers will be sent. Also enclosed are responses to EPA comments of July 22 and 25, 2002 and VDEQ comments of June 3, 2002.

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

Sincerely,

C. A. Jake

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

Enclosure

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

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

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

02-815-129
JMcKenna/JJRedder

Kenneth G. Barnes
U.S. Army Operations Support Command
Environmental Restoration Division
1 Rock Island Arsenal, Attn: AMSOS-ISR
Rock Island, IL 61299-5500

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

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

w/o enclosure
Russell Fish, P.E., EPA Region III

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

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

Coordination: J. McKenna

02-815-129
JMcKenna/JJRedder

Concerning: Work Plan Addendum 13 RCRA Facility Investigation at Solid Waste Management Unit 54, September 2002 and Work Plan Addendum 14 RCRA Facility Investigation at Solid Waste Management Unit 40/71, September 2002

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

SIGNATURE:
PRINTED NAME: Brian A. Butler
TITLE: LTC, CM, Commanding
Radford AAP

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

02-815-129
JMcKenna/JJRedder

Response to Comments
Draft RCRA Facility Investigation
Work Plan Addendum 13, SWMU 54
Radford Army Ammunition Plant
Radford, Virginia

Comments from USEPA correspondence dated 22 July 2002

GENERAL COMMENTS

1. **Conceptual Site Models**: The conceptual site model does not include a residential receptor for the risk assessment. Even though it is unlikely that a clean-up would be based upon a residential risk scenario at the Radford AAP, it is still necessary and proper to determine what risk would be posed under such a scenario. This is especially true for a determination of "clean closure", where waste is not left in-place at a site. Without including the residential risk scenario, the Army will be defaulting to a non-clean closure scenario, leaving waste "in-place", which would require long-term monitoring, maintenance, and 5-year reviews. This automatic default is not acceptable to EPA. Therefore, the residential risk scenario should be included in the conceptual site model.

> **RESPONSE:** Text has been added to the fifth paragraph of Section 1.2.4, Conceptual Site Model, stating that, "Although current and future land-use scenarios are limited to industrial operations, both industrial and residential scenarios will be considered."

SPECIFIC COMMENTS

2. **Section 1.2.3.4, Supplemental RFI Report, SWMU 54 - 1998, page 1-39**: The third paragraph of this subsection states that data generated by Millennium Science and Engineering (MSE, 1998) "should not be relied upon as a definitive data." However, Table 1-3 indicates, under "Data Usability," that the soil data can be used as definitive data for constituents of potential concern (COPC) identification and for site characterization, and that the groundwater data can be used as definitive data for COPC identification. In addition, since the MSE report did not provide the depths of samples and the discussion of the surface and subsurface soil samples in *Work Plan Addendum 13* is based on assumptions, the usability of the MSE data for site characterization appears to be inappropriate. Please revise the *Work Plan Addendum 13* (WPA) to resolve this discrepancy and discuss the usability of the MSE data for the RCRA Facility Investigation (RFI).

> **RESPONSE:** Section 1.2.3.4, 3rd Paragraph, Last Line was revised to: "Data generated by MSE (1998) can be used for site screening purposes (including

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identification of COPCs) and should not be relied upon as definitive data for characterization purposes."

3. **Section 1.2.3.5, Correspondence August 20, 1999, Subject SWMU 54 Interim Action, pages 1-46 through 1-79**: The sixth paragraph on page 1-66 states that analytical results for two backfill material samples identified as 54BF1 and 54BF2 are summarized in Appendix B. Appendix B does not contain the referenced information. Please provide the referenced data in the WPA.

> **RESPONSE:** The referenced data has been provided in Appendix B, Soil Composite Data, Parallax (2000).

3.a **The seventh paragraph on page 1-66** indicates that for excavated and backfilled cells, data for 2,4,6-TNT were adjusted to zero. Please explain why the data for 2,4,6-TNT in the backfilled cells were adjusted to zero.

> **RESPONSE:** For values that were reported as non-detect, TNT has been adjusted to zero (as opposed to using the MDL or ½ of the MDL) for the presentation of the estimated post-excavation isoconcentration map of Area A.

3.b **The fourth paragraph on page 1-77** states that groundwater results are summarized in Table 1-5. Table 1-5 summarizes soil results. Please provide the referenced summary data in the WPA.

> **RESPONSE:** The paragraph should refer the reader to Table 1-4 not 1-5. This has been corrected in the report and other references have been checked for accuracy.

4. **Section 1.2.4, Conceptual Site Model, page 1-82**: This section states that surface water and sediment are not considered in the conceptual site model (CSM) "because there are no surface water bodies in the SWMU 54 area." Surface water and sediment should not be ruled out from the CSM because the New River is located just 150 feet east of SWMU 54, and surface runoff and groundwater from SWMU 54 area discharge to the New River. In addition, the data presented in the WPA do not conclusively rule out that SWMU 54 had impacted the New River because the limits of constituent migration are currently unknown. Please revise the WPA to include surface water and sediment in the CSM.

> **RESPONSE:** A site-specific CSM has been developed for SWMU 54 to assess potential contaminant sources, exposure pathways, and human and ecological receptors (Figure 1-49). Potentially affected media include surface soil, subsurface soil, and groundwater. The SWMU 54 area is relatively level and precipitation is expected to infiltrate into the ground. A topographic high running parallel to the river and the roadbed on the southern perimeter of the site effectively capture surface runoff and eliminate the possibility of sheet flow reaching the New River. Sufficient data do not exist to establish the existence or

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absence of a complete pathway resulting from site groundwater discharge to the New River and the possible resultant pathway to surface water and sediment (via ingestion, inhalation, and/or dermal contact). The results of the investigative activities from the WPA are anticipated to facilitate the definition of the limits of constituent migration in groundwater. The completeness of the surface water and sediment migration pathways at SWMU 54 is considered unknown. Once the constituent migration limits have been assessed, the completeness of the surface water and sediment pathways will be examined

5. <u>**Section 1.2.5, Data Gap Analysis, pages 1-82 through 1-86**</u>: Perchlorate should be identified as a data gap in this section.

RESPONSE: Perchlorate has been identified in the SWMU 54 RFI Work Plan as a data gap.

6. <u>**Section 1.2.5, Data Gap Analysis**</u>: A data gap that is not identified is that no ERA has been performed. Because no ERA has been performed, potential threats to ecological receptors have yet to be identified. This data gap should be discussed, and an ERA performed for the SWMU. The Planned Field Activities (Section 1.3) should state that to fulfill this data gap, an ecological risk assessment would be performed.

RESPONSE: The results of a Baseline Risk Assessment (including an ecological risk screening) have been identified as a data gap in the WPA.

7. <u>**Section 1.3, Planned Field Activities, page 1-86**</u>: The third bullet on this page states that the data will be used to evaluate the leaching of contaminants from soil to the groundwater and the fate and transport of contaminants in groundwater. This evaluation must also determine if the migration pathway to the New River from groundwater is complete. If the pathway is found to be complete, sediment sampling in the New River is recommended.

RESPONSE: The RFI Work Plan Addendum has been modified to state that the collected data will also be utilized to assess whether the migration pathway to the New River from groundwater is complete.

8. <u>**Section 2.0, Quality Assurance Plan Addendum, pages 2-1 through 2-28**</u>: Tables 2-5 through 2-11 provide a summary of analyte method detection limits, reporting limits and screening criteria for all the analytes proposed but perchlorate. Please provide similar data for perchlorate as appropriate.

RESPONSE:

Similar data is provided for perchlorate in Table 2-11 including analyte method detection limits, reporting limits, and screening criteria.

Draft Comments from VDEQ received via e-mail attachment 3 June 2002

1. **Page 1-4,** MWP is not referenced.

   Response: The Master Work Plan is referenced at the end of paragraph 1 on page 1-1. The acronym will be defined again on page 1-4. It is also included in the References section of the WPA (Section 4.0).

2. **Figure 1-3,** is the thin lined section, near the ground water symbol and "New River", a different formation?

   Response: The incorrect fill was designated in the CADD drawing for this area of Figure 1-3. Figure 1-3 has been revised to include the correct fill in this location.

3. **Table 1-4,** what does the dashed box represent?

   Response: The dashed box represents an exceedance of the lead informal action level. The symbol for this was omitted from the Table 1-4 legend. The legend has been corrected.

4. **Figures 1-8 – 1-11,** there are some borings that have no values.

   Response: The samples collected from soil borings advanced during the Parson's 1996 study did not include shallow soil samples for 54SB9 and 54SB15. Therefore, no values are reported for these locations for shallow soils.

5. **Page 1-46, Ground water, 54MW4 was sampled along with 54MW1. The results from the sampling event indicate that there were hits in 54MW1 and 54MW4 is not mentioned. Does this mean there were no hits in 54MW4?**

   Response: Yes.

6. **Page 1-77, last paragraph,** tetrachloroethene should not be excluded from the COPCs from area B.

   Response: The single detection of tetrachloroethene (2 ug/l) was j-flagged as an estimated value between the Method Detection Limit and the Reporting Limit. The Tap Water RBC for tetrachloroethene is currently 1.1 ug/l and the MCL is 5

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ug/l. Previous sampling of groundwater with analysis for volatile organic compounds (VOCs) has not detected tetrachloroethene at concentrations above RBCs in Area B at SWMU 54. It is recommended that tetrachloroethene continue to be excluded as a COPC in Area B.

7. Table 1-10 page 1, please explain the rationale of why there will be no soil samples collected above the water table for 17A – 38B.

Response: Previous analytical results for these locations have been assessed and were found to be usable for characterization purposes. Further sampling appears unnecessary in these locations.

8. Figure 1-51, it may be advantageous to collect a soil sample in the northwest section near the SWMU boundary.

Response: This area of the site was assessed and samples were allocated to grids to assure the Data Quality Objectives are met. The northern site boundary was conservatively approximated, but previous sampling and remedial activities strongly indicate that the impacted portion of Area A is along its southern boundary. This was the rationale for surrounding this area with samples. To ensure that impacted soil did not extend to the northern portion of Area A, 54SB17, 54SB19, and 54SB22 are proposed and considered sufficient. It is recommended that the current sampling plan remain unchanged.

9. Figure 1-54, it may be advantageous to collect additional soil samples in the southwest areas where the lead levels are greater than 1000 ppm.

Response: This area of the site was assessed and samples were allocated to grids to assure the Data Quality Objectives are met. The grid sizing is relatively small (40 feet by 40 feet) and hence the area of potential lead levels exceeding 1000ppm is small. This area appears to be well bounded both by the proposed sampling locations 54SB41, 54SB42, and 54SB51; and by areas of previous excavation (shown in green shading on the figure). It is recommended that the current sampling plan remain unchanged.

10. **Table 1.7:** The RBC for pyrene can be used as a substitute for acenapthylene, benzo(ghi)perylene and phenanthrene.

Response: The comment has been incorporated into the Final Work Plan Addendum.

11. Page 1-77, last paragraph, last line. J-flagged values should not be disqualified as COPCs at this early stage of assessment.

Response: Please see response to Comment 6.

Response to Comments
Draft RCRA Facility Investigation
Work Plan Addendum 14
SWMU 40/71
Radford Army Ammunition Plant
Radford, Virginia

Comments from USEPA correspondence dated 25 July 2002
GENERAL COMMENTS

1. **Conceptual Site Models**: The conceptual site model does not include a residential receptor for the risk assessment. Even though it is unlikely that a clean-up would be based upon a residential risk scenario at the Radford AAP, it is still necessary and proper to determine what risk would be posed under such a scenario. This is especially true for a determination of "clean closure", where waste is not left in-place at a site. Without including the residential risk scenario, the Army will be defaulting to a non-clean closure scenario, leaving waste "in-place", which would require long-term monitoring, maintenance, and 5-year reviews. This automatic default is not acceptable to EPA. Therefore, the residential risk scenario should be included in the conceptual site models for SWMUs 40 & 71.

   Response: Text has been added to Section 1.2.4, Conceptual Site Model, stating that, "Although current and future land-use scenarios are limited to industrial operations, both industrial and residential scenarios will be considered."

SPECIFIC COMMENTS

2. **Section 1.2.4, Conceptual Site Model**, states that "based on previous investigations, groundwater is not present in overburden soils in the immediate vicinity of SWMU 40/71 to depths of at least 160 feet bgs [below ground surface] ...Groundwater is therefore, not considered a migration pathway at SWMU 40/71." This conclusion is not supported by the current investigative data. Groundwater was found in Well 40MW3, which is located in the vicinity of SWMU 40/71 and is screened from 97 to 117 feet bgs. All the other attempts in finding groundwater were abandoned at depths much less than the 160 feet bgs, except at borehole 40MW1A. Therefore, it is inaccurate to state that groundwater is not present to depths of at least 160 feet bgs. In addition, previous investigations (Dames & Moore, 1992; Engineering Science, 1994; Parsons 1996) have concluded that groundwater from the vicinity of SWMU 40/71 may be drained by solution-enhanced epikarstic features in the bedrock. Thus, the potential leachate as depicted in Figure 1-13 (Site Conceptual Model) can be drained by the "bedding-parallel solution features" and "fracture-type solution features," thereby impacting the groundwater. Because of the complexity of the site hydrogeology, previous investigations do not appear to be sufficient grounds for the conclusions reached in the Work Plan Addendum 14 (WPA). Revise the WPA to propose further investigation of the groundwater and include groundwater in the Conceptual Site Model (CSM).

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Response: The WPA will be revised to indicate that it is unknown whether the groundwater exposure pathway is complete. The current groundwater study in the "Horseshoe" area is scheduled for expansion into the Main Manufacturing Area (MMA) in fiscal year 2006. The expanded study area includes SWMU 40/71. This study is a result of discussions/decisions coordinated with the USEPA and VDEQ at the Installation Action Plan Workshop in May 2001.

3. **Section 1.2.5, Data Gap Analysis**, presents information on data gaps that have been identified. A data gap that is not identified is that no ERA has been performed. Because no ERA has been performed, potential threats to ecological receptors have yet to be identified. This data gap should be discussed in this section.

   Response: The results of a Baseline Risk Assessment (including an ecological risk screening) have been identified as a data gap in the WPA.

4. Although the WPA explains that 40MW2 and 40MW4 were constructed as groundwater monitoring wells, the depths at which these "wells" were completed makes them unlikely to intercept any possible high water table. For example, borehole 40MW4 was advanced to 90 feet bgs and no water was encountered. However, a groundwater monitoring well was constructed to approximately 69 ft bgs to "intercept any possible high water table at a future date." This assumes that a water table rise of over 21 feet is expected, since water was not encountered at 90 feet bgs. Revise the WPA to remove references to groundwater monitoring wells 40MW2 and 40MW4 and associated legends from all the figures, because 40MW2 and 40MW4 are not groundwater monitoring wells.

   Response: Figure 1-15, Proposed Sampling Locations, has been modified to remove the legend reference to "monitoring wells" and changed to "Dry Hole" and the symbol in the legend and on the figure have been changed to be different from those used for monitoring wells. The names of the Dry Holes have been retained as 40MW2 and 40MW4.

5. **Section 1.2.4, Conceptual Site Model, page 1-21**: The first paragraph of this section states that "based on current data available for the site, migration pathways of constituents from SWMU 40/71 likely include surface water (limited however, to during rainfall events), leaching of constituents into subsurface soils, and wind-borne dispersion of accumulated soil in the northern scarp area." However, subsequent discussions in paragraphs 1 and 2 dismiss the potential migration pathways for surface water and wind-born dispersion for both SWMUs 40 and 71. Revise the WPA to resolve these discrepancies. In addition, include the potential migration pathway for wind-borne dispersion in the CSM as the area proximal to the northern scarp shows possible wind-borne dispersion of soil particulates.

   Response: The Conceptual Site Model developed as part of the Work Plan Addendum was modified to clearly state which migration and exposure pathways are complete, incomplete, or unknown. Current conditions at the site do not support the conclusion that wind-borne dispersion of accumulated soil occurs at SWMU 40/71 and therefore, this pathway has been identified as incomplete. Storm water on the site does

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not appear to enter surface water bodies and therefore, the surface water migration pathway has also been identified as incomplete.

6. **<u>Section 1.3.2, Soil Borings, pages 1-33 through 1-35</u>:** The fifth bullet on page 1-34 indicates that Boring 71SB11 is proposed in the Flash-Burn Area. However, Figure 1-15 identifies the boring as 71SB1 and 71SB11 as a surficial soil sampling location. Please resolve this discrepancy between the text and the figure.

   Response: Figure 1-15 was corrected to show boring 71SB11 correctly.

   <u>The second paragraph on page 1-35 references Section 6.4</u> of the Master Work Plan (MWP) for the analysis of physical and geotechnical properties of soils. This information is not provided in the referenced section of the MWP. Please provide the correct reference for the information.

   Response: The reference to Section 6.4 has been corrected to Section 5.8.

7. **<u>Section 1.3.3.2, Cindered Area, page 1-36:</u>** This section identifies the two surface soil-sampling locations proposed for the Cindered Area as 40SS4 and 40SS5. However, Figure 1-15 identifies the surface soil sampling locations as 40554 and 40555. Please revise the text or the figure to use a consistent sample location designation.

   Response: The two surface soil-sampling locations have been corrected to refer to 40SS4 and 40SS5.

8. **<u>Table 1-6, Handling and Disposal of Non-hazardous Materials</u>:** This table does not appear to include soils to be stockpiled from the geophysical anomaly excavation (see Section 1.3.1). Please revise this table or the text of Section 1.3.1 to discuss how the soils stockpiled from the pit excavation will be managed and disposed. Also, correct the following in Table 1-6:

   - The title of the table should read "Handling and Disposal of Investigation-Derived Materials." Whether the materials are hazardous or non-hazardous will be determined after the actions specified in column six of the table are conducted.

   - The last column, second row, should read "soil" instead of "sediment."

   Response: The table has been modified to discuss how the soils stockpiled from the test pit excavation will be managed. The title of the table has been modified and the word sediment has been changed to soil.

9. **<u>Table 2-4, Summary: Proposed Sample Identification and Depths</u>:** The depths specified in this table for various sample locations do not match those discussed in Section 1.3 (Planned Field Activities). For example, for the surficial soil sampling the table indicates that samples will be collected from 0-6 inches. However, the text in Section 1.3.3 indicates that a sample will be collected from 0-6 inches bgs and another sample will be collected from

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6-12 inches bgs. Revise table to reflect the discussions provided in Section 1.3. Also, define "intermediate depth" in Table 2-4.

Response: Fourteen soil borings will be advanced and surface, intermediate, and base of overburden samples will be collected from these soil borings (three depths except where fill materials are encountered, and then 4 depths if encountered). Soil boring surface samples will be collected from 0-6 inches except for volatiles that will be sampled from 6-12 inches. The table has been revised to reflect the discussions provided in Section 1.3.

10. **<u>APPENDIX A, STANDARD OPERATING PROCEDURES, Standard Operating Procedure 20.4, Test Pits</u>**: Section 4.0 of this standard operating procedure (SOP) references the site-specific health safety plan for precautions during test pit excavation and backfill. This referenced information is not provided in the site-specific health and safety plan (Section 2.0). Please provide the referenced information either in this SOP or the Health and Safety Plan Addendum.

Response: Please note that WPA Section 3.0 contains the site-specific health and safety plan. WPA Section 3.2.2, <u>Project-specific Hazard Analysis</u> outlines site-specific hazards, including those that may be encountered during Test Pit excavation, such as falls, noise from heavy equipment, and overhead power lines.

<u>Draft Comments from VDEQ received via e-mail attachment 3 June 2002</u>

1. Page 1-34, Section Soil Borings, second bullet, what if the boundaries of the landfill are not found with the projected three borings?

Response: This will be further assessed in the field at the time of investigation but it appears that the boundaries of the fill material have been well characterized by the results of the geophysical investigation and an examination of aerial photographs.

2. Page 1-36, Section 1.3.3.3, surficial soil sampling is collected from 0-6 inches, however, samples 71ss11,12,13 are proposed to be collected at 6-12 inches. Will surface soil be collected in the "surface material" sample? Moreover, Table 2-4 lists the three sample locations as 0-6 inches.

Response: Surface soil samples will be collected from 0-6 inches for all analyte suites except for volatiles, which will be sampled from 6-12 inches. The text in Section 1.3.3, Surficial Soil Sampling, and Table 2-4 has been revised to clarify the specification of surface soil sampling depths.

3. Tables 2.7 and 2.8. The RBC for pyrene may be used as a substitute for acenapthylene, benzo(ghi)perylene, and phenanthrene.

Response: The comment will be incorporated into the revised WPA.

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4. Table 2-9. The RBC for Endrin may be used as a substitute for endrin sulfate, endrin ketone, and endrin aldehyde. The RBC for endosulfan I may be used for endosulfan II, and the RBC for alpha BHC may be used for delta BHC.

> **Response:** The comment will be incorporated into the revised WPA.

5. Tables 2-11 and 2-12. RBCs for tap water are listed in these tables; however, there is no mention of groundwater samples in the planned field activities or proposed sampling locations (Section 1.0). According to Figure 1-13 and the text in section 1.0, leaching of contaminants into groundwater appears to be a possible route of exposure and should be investigated. Figure 1-14 does not include groundwater as an exposure pathway.

> **Response:** The WPA will be revised to indicate that is unknown whether the groundwater exposure pathway is complete. The current groundwater study in the "Horseshoe" area is scheduled for expansion into the Main Manufacturing Area (MMA) in fiscal year 2006. The expanded study area includes SWMU 40/71. This study is a result of discussions/decisions coordinated with the USEPA and VDEQ at the Installation Action Plan Workshop in May 2001. Inclusion of the tap water RBCs in Tables 2-11 and 2-12 is strictly for reference and document completeness.

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

July 25, 2002

In reply
Refer to 3HS13

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

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

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

Re: Radford Army Ammunition Plant
SWMUs 40 & 71
Work Plan Addendum 14
Document submittal and review

Dear Mr. McKenna and Ms. Jake:

The U.S. Environmental Protection Agency (EPA) has reviewed the Army's draft *Work Plan Addendum 14* for the investigation of SWMUs 40 & 71, located at the Radford Army Ammunition Plant (RFAAP). Outlined below, please find EPA's comments based upon that review:

GENERAL COMMENTS

1. **Conceptual Site Models**: The conceptual site model does not include a residential receptor for the risk assessment. Even

though it is unlikely that a clean-up would be based upon a residential risk scenario at the Radford AAP, it is still necessary and proper to determine what risk would be posed under such a scenario. This is especially true for a determination of ``clean closure'', where waste is not left in-place at a site. Without including the residential risk scenario, the Army will be defaulting to a non-clean closure scenario, leaving waste ``in-place", which would require long-term monitoring, maintenance, and 5-year reviews. This automatic default is not acceptable to EPA. Therefore, the residential risk scenario should be included in the conceptual site models for SWMUs 40 & 71.

SPECIFIC COMMENTS

2. **Section 1.2.4, Conceptual Site Model**, states that ``based on previous investigations, groundwater is not present in overburden soils in the immediate vicinity of SWMU 40/71 to depths of at least 160 feet bgs [below ground surface] ...Groundwater is therefore, not considered a migration pathway at SWMU 40/71.'' This conclusion is not supported by the current investigative data. Groundwater was found in Well 40MW3, which is located in the vicinity of SWMU 40/71 and is screened from 97 to 117 feet bgs. All the other attempts in finding groundwater were abandoned at depths much less than the 160 feet bgs, except at borehole 40MW1A. Therefore, it is inaccurate to state that groundwater is not present to depths of at least 160 feet bgs. In addition, previous investigations (Dames & Moore, 1992; Engineering Science, 1994; Parsons 1996) have concluded that groundwater from the vicinity of SWMU 40/71 may be drained by solution-enhanced epikaristic features in the bedrock. Thus, the potential leachate as depicted in Figure 1-13 (Site Conceptual Model) can be drained by the ``bedding-parallel solution features▒ and ``fracture-type solution features,▒ thereby impacting the groundwater. Because of the complexity of the site hydrogeology, previous investigations do not appear to be sufficient grounds for the conclusions reached in the Work Plan Addendum 14 (WPA). Revise the WPA to propose further investigation of the groundwater and include groundwater in the Conceptual Site Model (CSM).

3. **Section 1.2.5, Data Gap Analysis**, presents information on data gaps that have been identified. A data gap that is not identified is that no ERA has been performed. Because no ERA has been performed, potential threats to ecological receptors have yet to be identified. This data gap should be discussed in this section.

4. Although the WPA explains that 40MW2 and 40MW4 were constructed as groundwater monitoring wells, the depths at which these ``wells'' were completed makes them unlikely to intercept any possible high water table. For example, borehole 40MW4 was advanced to 90 feet bgs and no water was encountered. However, a groundwater monitoring well was constructed to approximately 69 ft bgs to ``intercept any possible high water table at a future date.'' This assumes that a water table rise of over 21 feet is expected, since water was not encountered at 90 feet bgs. Revise the WPA to remove references to groundwater monitoring wells 40MW2 and 40MW4 and associated legends from all the figures, because 40MW2 and 40MW4 are not groundwater monitoring wells.

5. **Section 1.2.4, Conceptual Site Model, page 1-21:** The first paragraph of this section states that ``based on current data available for the site, migration pathways of constituents from SWMU 40/71 likely include surface water (limited however, to during rainfall events), leaching of constituents into subsurface soils, and wind-borne dispersion of accumulated soil in the norther scarp area.'' However, subsequent discussions in paragraphs 1 and 2 dismiss the potential migration pathways for surface water and wind-born dispersion for both SWMUs 40 and 71. Revise the WPA to resolve these discrepancies. In addition, include the potential migration pathway for wind-borne dispersion in the CSM as the area promimal to the northern scarp shows possible wind-borne dispersion of soil particulates.

6. **Section 1.3.2, Soil Borings, pages 1-33 through 1-35:** The fifth bullet on page 1-34 indicates that Boring 71SB11 is proposed in the Flash-Burn Area. However, Figure 1-15 identifies the boring as 71SB1 and 71SB11 as a surficial soil sampling location. Please resolve this discrepancy between the text and the figure.

   The second paragraph on page 1-35 references Section 6.4 of the Master Work Plan (MWP) for the analysis of physical and geotechnical properties of soils. This information is not provided in the referenced section of the MWP. Please provide the correct reference for the information.

7. **Section 1.3.3.2, Cindered Area, page 1-36:** This section identifies the two surface soil sampling locations proposed for the Cindered Area as 40SS4 and 40SS5. However, Figure 1-15 identifies the surface soil sampling locations as 40554 and 40555. Please revise the text or the figure to use a consistent sample location designation.

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8. **Table 1-6, Handling and Disposal of Nonhazardous Materials:** This table does not appear to include soils to be stockpiled from the geophysical anomaly excavation (see Section 1.3.1). Please revise this table or the text of Section 1.3.1 to discuss how the soils stockpiled from the pit excavation will be managed and disposed. Also, correct the following in Table 1-6:

   - The title of the table should read ``Handling and Disposal of Investigation-Derived Materials.'' Whether the materials are hazardous or nonhazardous will be determined after the actions specified in column six of the table are conducted.

   - The last column, second row, should read ``soil'' instead of ``sediment.''

9. **Table 2-4, Summary: Proposed Sample Identification and Depths:** The depths specified in this table for various sample locations do not match those discussed in Section 1.3 (Planned Field Activities). For example, for the surficial soil sampling the table indicates that samples will be collected from 0-6 inches. However, the text in Section 1.3.3 indicates that a sample will be collected from 0-6 inches bgs and another sample will be collected from 6-12 inches bgs. Revise table to reflect the discussions provided in Section 1.3. Also, define ``intermediate depth'' in Table 2-4.

10. **APPENDIX A, STANDARD OPERATING PROCEDURES, Standard Operating Procedure 20.4, Test Pits**: Section 4.0 of this standard operating procedure (SOP) references the site-specific health safety plan for precautions during test pit excavation and backfill. This referenced information is not provided in the site-specific health and safety plan (Section 2.0). Please provide the referenced information either in this SOP or the Health and Safety Plan Addendum.

This concludes EPA's review of the Army's draft *Work Plan Addendum 14 for* the investigation of SWMUs 40 & 71, located at the RFAAP. The referenced draft *Work Plan Addendum 14 is* disapproved by EPA in its current form, and it must be revised to reflect the comments above. Per Part II, Section E.4.e. of the EPA RCRA Corrective Action Permit, the Army is required to revise the above document and submit a revised copy to EPA for review within 60 days of the receipt of EPA comments. Part II, Section E.4.f. of the Permit allows for an additional 20 days for issuing the revised document to EPA, provided that timely notice is given, i.e. within 10 days. Additional time extensions can be requested under Part II, Section F. of the permit.

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

Sincerely,

Robert Thomson

Robert Thomson, PE
Federal Facilities Branch

cc: Russell Fish, EPA
Mark Leeper, VDEQ

McKenna, Jim

rom:	Leeper,Mark [msleeper@deq.state.va.us]
ent:	Monday, June 03, 2002 12:27 PM
To:	McKenna, Jim
Cc:	Thomson. Bob (E-mail)

raft Comments for RI.doc

Hey Jim,

Enclosed are the comments for Addendum 13 & 14. Please let me know if you have any questions.

Thanks,

<<Draft Comments for RI.doc>>

****

Mark S. Leeper
Remedial Project Manager
Federal Facilities Restoration Program
Virginia Department of Environmental Quality
804.698.4308 W
04.698.4383 F

****

1

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Draft Comments for Addendum 14

1. Page 1-34, Section Soil Borings, second bullet, what if the boundaries of the landfill are not found with the projected three borings?

2. Page 1-36, Section 1.3.3.3, surficial soil sampling is collected from 0-6 inches, however, samples 71ss11,12,13 are proposed to be collected at 6-12 inches. Will surface soil be collected in the "surface material" sample? Moreover, Table 2-4 lists the three sample locations as 0-6 inches.

3. Tables 2.7 and 2.8. The RBC for pyrene may be used as a substitute for acenapthylene, benzo(ghi)perylene, and phenanthrene.

4. Table 2-9. The RBC for Endrin may be used as a substitute for endrin sulfate, endrin ketone, and endrin aldehyde. The RBC for endosulfan I may be used for endosulfan II, and the RBC for alpha BHC may be used for delta BHC.

5. Tables 2-11 and 2-12. RBCs for tap water are listed in these tables; however, there is no mention of groundwater samples in the planned field activities or proposed sampling locations (Section 1.0). According to Figure 1-13 and the text in section 1.0, leaching of contaminants into groundwater appears to be a possible route of exposure and should be investigated. Figure 1-14 does not include groundwater as an exposure pathway.

Draft Comments for Addendum 13

1. Page 1-4, MWP is not referenced.

2. Figure 1-3, is the thin lined section, near the ground water symbol and "New River", a different formation?

3. Table 1-4, what does the dashed box represent?

4. Figures 1-8 - 1-11, there are some borings that have no values.

5. Page 1-46, Ground water, 54MW4 was sampled along with 54MW1. The results from the sampling event indicate that there were hits in 54MW1 and 54MW4 is not mentioned. Does this mean there were no hits in 54MW4?

6. Page 1-77, last paragraph, tetrachloroethene should not be excluded from the COPC's from area B.

7. Table 1-10 page 1, please explain the rationale of why there will be no soil samples collected above the water table for 17A - 38B.

8. Figure 1-51, it may be advantageous to collect a soil sample in the north west section near the SWMU boundary.

9. Figure 1-54, it may be advantageous to collect additional soil samples in the southwest areas where the lead levels are greater than 1000 ppm.

10. Table 1.7: The RBC for pyrene can be used as a substitute for acenapthylene, benzo(ghi)perylene and phenanthrene.

11. Page 1-77, last paragraph, last line. J-flagged values should not be disqualified as COPCs at this early stage of assessment.

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE ARMY
U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
5158 BLACKHAWK ROAD
ABERDEEN PROVING GROUND, MARYLAND 21010-5403

REPLY TO
ATTENTION OF

MCHB-TS-REH (40)

6 MAY 2002

MEMORANDUM FOR Radford Army Ammunition Plant (SMCRA-EN/Mr. Jim McKenna), P.O. Box 2, Route 114, Radford, VA 24141-0099

SUBJECT: Work Plan Addendum 14 RCRA Facility Investigation at Solid Waste Management Unit 40/71, April 2002

1. The US Army Center for Health Promotion and Preventive Medicine has reviewed the subject document on behalf of the Office of The Surgeon General pursuant to AR 200-1 (Environmental Protection and Enhancement) without comment.

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

FOR THE COMMANDER:

DAVID L. DAUGHDRILL
Program Manager
Environmental Health Risk
Assessment

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

McKenna, Jim

From: Jenkins, Joanne
Sent: Monday, April 22, 2002 7:53 AM
To: McKenna, Jim
Cc: Robert Davie
Subject: RE: NHPA: Work Plan Addenda 13 and 14

Jim,

Reference our meeting this date.

In accordance with 36 CFR Part 800 all RFAAP actions meet the definition of an undertaking ad are therefore subject to 106 review. However, this in itself doesn't warrant full initiation of the process. RFAAP can determine that a proposed action has "no potential to cause effect" on historic properties. If we determine that an action has "no potential to cause effect", then we have no further obligations under 106. Ground disturbing activities in areas where there are no archeological sites and the activity would not compromise the setting or feel of any other historic site in the are examples of activities that would be determined to have "no potential to cause effect".

The locations of the work identified in your request contain no archeological sites and will not compromise any other historic site. Therefore, a determination of "no potential to cause effect" is appropriate and work may proceed.

Joanne Jenkins
Industrial Specialist
Operations Division
DSN 931-7480, COM 540-639-7480

-----Original Message-----
From: McKenna, Jim
Sent: Friday, April 19, 2002 1:11 PM
To: Jenkins, Joanne
Subject: NHPA: Work Plan Addenda 13 and 14

Joanne:

1. Work Plan Addendum 13 identifies sampling work that will occur at Solid Waste Management Unit (SWMU) 54 in the Horseshoe Area. The WPA has maps that show sampling locations.

2. Work Plan Addendum 14 identifies sampling work that will occur at SWMUs 40 and 71 in the Main Manufacturing Area. The WPA has maps that show sampling locations.

Need you/us to review for possible interference with historical sites.

Thanks,
Jim

ATK
ALLIANT TECHSYSTEMS

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

April 12, 2002

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

Subject: Work Plan Addendum 13 RCRA Facility Investigation at Solid Waste Management Unit 54, April 2002
Work Plan Addendum 14 RCRA Facility Investigation at Solid Waste Management Unit 40/71, April 2002
Radford Army Ammunition Plant
EPA ID# VA1 210020730

Dear Mr. Thomson:

Enclosed is a certified copy of "Work Plan Addendum 13 RCRA Facility Investigation at Solid Waste Management Unit 54, April 2002" and a certified copy of "Work Plan Addendum 14 RCRA Facility Investigation at Solid Waste Management Unit 40/71, April 2002". Your five additional copies and copies to Virginia Department of Environmental, U.S. Army Operations Support Command, U.S. Army Environmental Center, U.S. Army Center for Health Promotion and Preventive Medicine will be sent under separate cover.

These work plans have not been submitted previously.

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

Sincerely,

C.A. Jake

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

Enclosure

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

02-815-59
JMcKenna/JJRedder

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

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

Kenneth G. Barnes
U.S. Army Operations Support Command
Environmental Restoration Division
1 Rock Island Arsenal, Attn: AMSOS-ISR
Rock Island, IL 61299-5500
Peter J. Rissell
U.S. Army Environmental Center
5179 Hoadley Road, Attn: SFIM-AEC-ERP
Aberdeen Proving Ground, MD 21010-5401

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

w/o enclosure
Russell Fish, P.E., EPA Region III

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

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

Coordination: J. McKenna
J. McKenna

02-815-59
JMcKenna/JJRedder

Concerning the following:

Work Plan Addendum 13
RCRA Facility Investigation at Solid Waste Management Unit 54,
April 2002
and
Work Plan Addendum 14
RCRA Facility Investigation at Solid Waste Management Unit 40/71
April 2002

Radford Army Ammunition Plant

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

SIGNATURE:
PRINTED NAME: Brian A. Butler
TITLE: LTC, CM, Commanding
Radford AAP

SIGNATURE:
PRINTED NAME: M. A. Miano
TITLE: Vice President Operations
Alliant Ammunition and Powder Company, LLC

02-815-59
JMcKenna/JJRedder

DELIVERY ORDER NO. 0023
ENVIRONMENTAL SERVICES
PROGRAM SUPPORT
CONTRACT DACA31-00-D-0011

RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

WORK PLAN
ADDENDUM NO. 14
RCRA Facility Investigation at Solid Waste Management Unit 40/71

FINAL DOCUMENT

September 2002

PREPARED BY:

URS

5540 Falmouth Street, Suite 201
Richmond, Virginia 23230
(804) 965-9000 main
(804) 965-9764 fax

PREFACE

A two-stage approach has been developed to facilitate and streamline Resource Conservation Recovery Act (RCRA) site investigations at Radford Army Ammunition Plant (RFAAP) pursuant to the Permit for Corrective Action and Waste Minimization (October, 2000). The approach consists of a single facility-wide Master Work Plan and multiple site-specific Work Plan Addenda.

The Master Work Plan provides comprehensive discussions of standard procedures, protocol, and methodologies that are to be followed during execution of field investigations at RCRA sites within the RFAAP. The Master Work Plan is a generic plan designed to streamline site-specific Work Plan addenda development, review, and approval.

Each Work Plan Addendum describes the site-specific information for each RCRA site, providing detailed data on past site operations, potential constituents of concern, sampling strategy, etc. Each addendum, through reference to the Master Work Plan, is developed as a concise document, focused on site-specific investigations.

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MASTER WORK PLAN ADDENUM NO. 14
SWMU 40/71 RCRA FACILITY INVESTIGATION
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Appendix A Standard Operating Procedures
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LIST OF ABBREVIATIONS AND ACRONYMS

%	Percent
AES	Atomic Emission Spectroscopy
ASTM	American Society for Testing and Materials
bgs	Below Ground Surface
BRA	Baseline Risk Assessment
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CN	Cyanide
CNCl	Cyanogen Chloride
COR	Contracting Officer's Representative
CSM	Conceptual Site Model
dBA	Decibels on the A-Weighted Scale
DC	Direct Current
DQO	Data Quality Objective
ECD	Electron Capture Detector
ELCD	Electrolytic Conductivity Detector
EM	Electromagnetic
EPIC	Environmental Photographic Interpretation Center
ERA	Ecological Risk Assessment
ERIS	Environmental Restoration Information System
ft	Feet
GC	Gas Chromatography
GPS	Global Positioning System
HAZCOM	Hazard Communication
HBN	Health-Based Number
HHRA	Human Health Risk Assessment
HMX	High-Melting Explosive
HPLC	High Performance Liquid Chromatography
HQ	Hazard Quotient
HRGC/HRMS	High-resolution Gas Chromatography/High-resolution Mass Spectrometry
HSP	Health and Safety Plan
HSPA	Health and Safety Plan Addendum
HTRW	Hazardous, Toxic, and Radioactive Waste
Hz	Hertz
ICP	Inductively Coupled Plasma
IDM	Investigation-Derived Material
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
µg/L	Micrograms Per Liter
mg/kg	Milligrams Per Kilogram
mg/L	Milligrams Per Liter
MHSP	Master Health and Safety Plan
MMA	Main Manufacturing Area
MQAP	Master Quality Assurance Plan
MS	Mass Spectrometer
MSDS	Material Safety Data Sheet

LIST OF ABBREVIATIONS AND ACRONYMS (CONTINUED)

msl	Mean Seal Level
MWP	Master Work Plan
nm	Nanometer
OSHA	Occupational Safety and Health Administration
PAH	Polynuclear Aromatic Hydrocarbon
PAO	Phenyl Arsine Oxide
PCB	Polychlorinated Biphenyl
PID	Photoionization Detector
PM	Project Manager
ppb	Parts Per Billion
PPE	Personal Protective Equipment
ppm	Parts Per Million
ppq	Parts Per Quadrillion
ppt	Parts Per Trillion
QA	Quality Assurance
QC	Quality Control
QA/QC	Quality Assurance / Quality Control
QAP	Quality Assurance Plan
QAPA	Quality Assurance Plan Addendum
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RDX	Research Development Explosive
RFA	RCRA Facility Assessment
RFAAP	Radford Army Ammunition Plant
RFI	RCRA Facility Investigation
RL	Reporting Limit
SHSO	Site Health and Safety Officer
SOP	Standard Operating Procedure
SOW	Statement of Work
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TEF	Toxicity Equivalence Factor
TEQ	Toxicity Equivalent Concentration
TOC	Total Organic Carbon
TOX	Total Organic Halogen
TPH	Total Petroleum Hydrocarbon
TWA	Time Weighted Average
URS	URS Group, Inc.
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
UV	Ultraviolet
VDEQ	Virginia Department of Environmental Quality

LIST OF ABBREVIATIONS AND ACRONYMS (CONTINUED)

VDOT	Virginia Department of Transportation
VI	Verification Investigation
VOC	Volatile Organic Compound
WPA	Work Plan Addendum

1.0 WORK PLAN ADDENDUM

In accordance with Contract Number DACA31-00-D-0011, Delivery Order No. 23, URS Group, Inc. (URS) has been tasked by the United States Army Corps of Engineers (USACE), Baltimore District to perform a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at Solid Waste Management Unit (SWMU) 40, the Sanitary Landfill and SWMU 71, the Flash-Burn Area (hereinafter collectively referred to as SWMU 40/71), located in the Main Manufacturing Area (MMA) at the Radford Army Ammunition Plant (RFAAP), Radford, Virginia (Figure 1-1). This RFI Work Plan for SWMU 40/71 is presented as an addendum (Work Plan Addendum No. 14) to, and incorporates by reference, the elements of the RFAAP Master Work Plan (MWP; URS 2002).

1.1 INTRODUCTION

The project objectives of the RFI at SWMU 40/71 are:

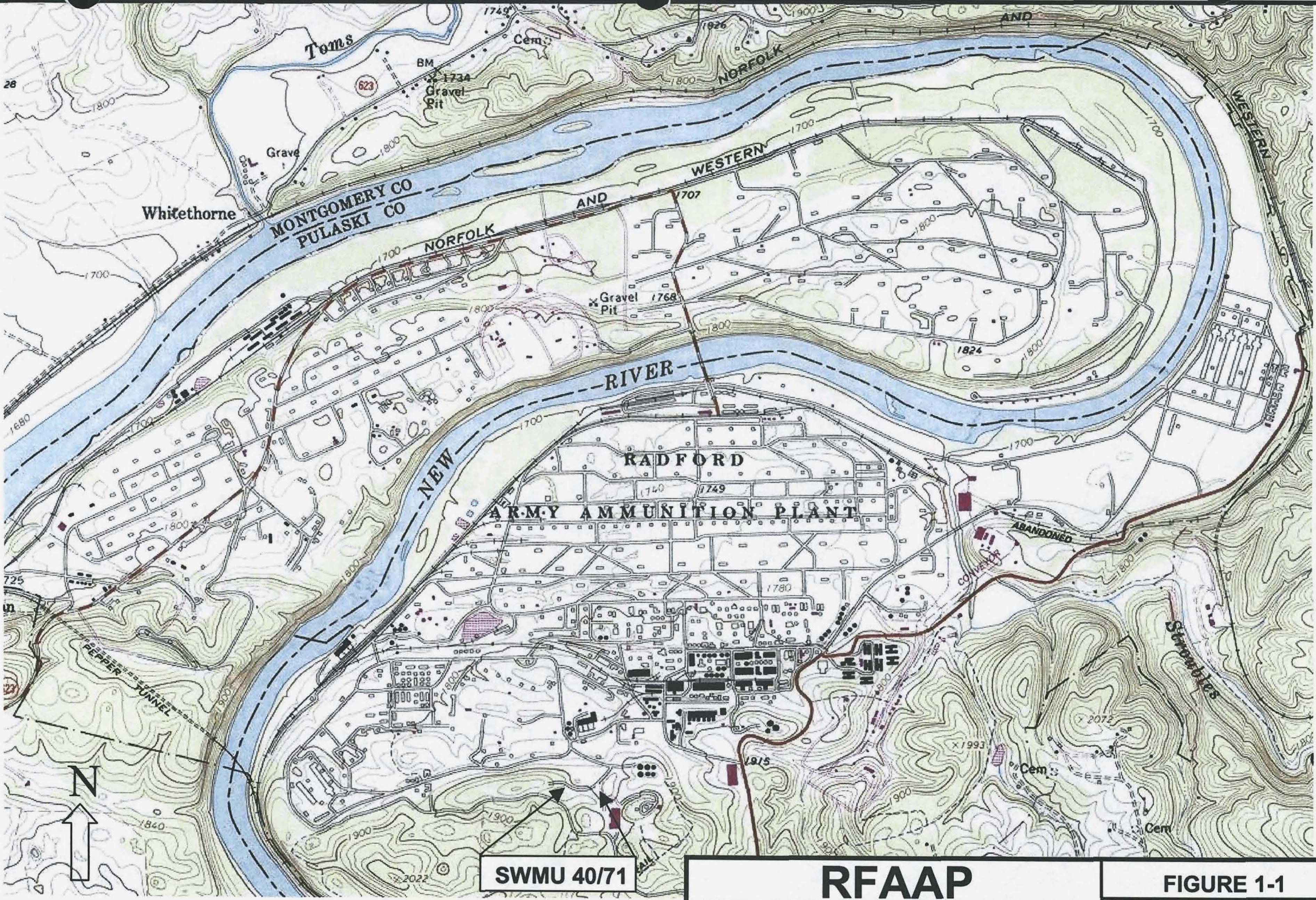
- Generate sufficient data to conclusively define and describe what risk exists toward human health and the environment;
- Define nature and extent of possible contamination on-site and possible contaminant sources; and
- Reach a final decision regarding what future action, if any, is needed.

SWMU 40/71 consists of SMWU 40, an approximately two-acre, inactive Landfill reportedly used for paper and municipal waste disposal (hereinafter referred to as the Landfill), and SWMU 71, the former Flash-Burn Area used for decontamination of metal process pipes (hereinafter referred to as the Flash-Burn Area). For the purposes of this RFI Work Plan Addendum (WPA), SWMUs 40 and 71 are considered one unit, SWMU 40/71. The Flash-Burn Area is located on the southwestern corner of the Landfill.

The RFI program at SWMU 40/71 is designed to:

- Physically investigate the areas in and around SWMU 40/71 to define the nature and extent of previous waste management practices;
- Collect and chemically analyze surface and subsurface soil samples; and
- Provide data that can be used to evaluate residual risk through comparison to United States Environmental Protection Agency (USEPA) Region III Risk-Based Concentrations (RBCs) Residential and Industrial (USEPA 2002), and the values of background concentrations developed in the Facility-Wide Background Study (IT 2002). Ultimately, data will be used to perform a Baseline Risk Assessment (BRA) that is subdivided into Human Health Risk Assessment (HHRA) and Screening-Level Ecological Risk Assessment (ERA).

This site-specific WPA provides the rationale and methods for planned field activities at SWMU 40/71 in support of the RFI. Consistent with the MWP, this addendum is composed of the following sections:



RFAAP

RFI WORK PLAN ADDENDUM: SWMU 40/71

FIGURE 1-1

SITE LOCATION MAP

Date: *MARCH 2002*	**Prepared by:** *URS Corp./TAL*
Scale: *1" = 2000'*	**File Name:** *Figure 1-1.ppt*

- Section 1, Work Plan Addendum;
- Section 2, Quality Assurance Plan (QAP) Addendum (QAPA); and
- Section 3, Health and Safety Plan (HSP) Addendum (HSPA).

This WPA specifically addresses sections and Standard Operating Procedures (SOPs) contained in the MWP for the investigation at SWMU 40/71. Relevant SOPs are included in Appendix A of this WPA. The MWP will be kept on the site and referenced during field activities.

Table 1-1 lists the specific MWP investigative activities planned. The investigative activities performed as part of this WPA will be conducted in accordance with the MWP and the SOPs contained therein and included herein as Appendix A.

Changes to the approved WPA will be documented using the Work Plan Revision Form (Form 1-1). Revisions must be reviewed and approved by the USACE Contracting Officer's Representative (COR) and the RFAAP designee prior to implementation.

Project personnel will be required to read this WPA and to sign and date a Worker Acknowledgement Form (Form 1-2). The Site Health and Safety Officer (SHSO) will retain this form onsite during investigative activities. Appropriate health and safety precautions must be taken due to the potential handling of hazardous materials, energetics, and/or their degradation compounds.

The investigation program focuses on obtaining the data needed to attain the project objectives. The program articulates project objectives, assumptions, and data use specifications. Program elements include:

- **Description of Current Conditions (Section 1.2):** This Section includes a site description of SWMU 40/71 and a discussion of previous SWMU 40/71 investigations. This Section also presents the Conceptual Site Model (CSM) and Data Gap Analysis;
- **Planned Field Activities (Section 1.3):** A site investigation will be performed to collect representative samples from SWMU 40/71 and achieve project Data Quality Objectives (DQOs). The sampling program presented for this investigation satisfies the DQOs;
- **Quality Assurance/Quality Control (QA/QC; Section 2.0):** Independent quality control (QC) checks are used to demonstrate investigation and laboratory accuracy, precision, and integrity. The QAPA provides assurance that data of known and documented quality are generated to allow the Installation to accurately characterize and evaluate SWMU 40/71 in accordance with the project objectives; and
- **Health and Safety (Section 3.0):** Site-specific training, work practices and procedures, personal protective equipment and clothing (PPE), and applicable monitoring requirements are presented as the HSPA in Section 3.0 of this WPA. These requirements provide the procedures for protection of site personnel, including government employees, regulators, contractors, and visitors, who are expected to be involved with site activities.

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Table 1-1
Applicable MWP Activities and Related SOPs
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

Subject	MWP Section	Standard Operating Procedures (SOP[s]) MWP Appendix A and Appendix A to WPA No. 14	
Installation Description	2.0		Not Applicable
Environmental Setting	3.0		Not Applicable
Documentation	4.3	10.1 10.2 10.3 10.4	Field Logbook Surface Water, Groundwater, and Soil/Sediment Field Logbooks Boring Logs Chain-of-Custody Form
Sample Management	5.1	50.1 50.2	Sample Labels Sample Packaging
Decontamination Requirements	5.12	80.1	Decontamination
Investigation Derived Material	5.13	70.1	Investigation-Derived Material
Air Monitoring		90.1	Photoionization Detector (HNu Model PI-101 and HW-101)
Subsurface Investigation	5.2 5.8	20.3 20.4 20.11 30.1 30.6 30.7 30.9	Well and Boring Abandonment Test Pits Drilling Methods and Procedures Soil Sampling Containerized Material Sampling Strategies Collection of Soil Samples by USEPA SW-846 Method 5035 Using Disposable Samplers

Form 1-1
Work Plan Revision Form
Work Plan – Quality Assurance Plan – Health and Safety Plan – Addendum No. 14
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

SITE DESIGNATION / LOCATION:	Section: ______
Radford Army Ammunition Plant	Addendum: ______
Radford, VA	Version: ______
	Effective Date: ______
SUBJECT:	Approved by:
	Field Operations Leader
	______
	Date: ______
	Concurrence:
	Project Manager
	______
	Date ______
	Sheet ____ of ____

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Form 1-2
Worker Acknowledgement Form
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

Document: Master Work Plan/QAP/HSP and Work Plan Addendum No. 14

Version: Final

Project: Radford Army Ammunition Plant

Location: Main Manufacturing Area, SWMU 40/71

Prior to the initiation of field activities, I have been given an opportunity to read and question the contents of this Master Work Plan/QAP/HSP, this Site-Specific Addendum, and approved revisions through the number listed above. With my signature, I certify that I have read, understood, and agree to comply with the information and directions set forth in these plans. I further certify that I am in full compliance with 20 CFR 1910.120 concerning training and medical monitoring requirements.

Site Personnel:

Name (please print) **Signature** **Date**

1.2 DESCRIPTION OF CURRENT CONDITIONS

1.2.1 Site Background – Environmental Setting

Section 3.0 of the MWP presents information regarding the environmental setting of the RFAAP. This Section and Section 1.2.3 of the WPA present project-specific information.

Physiography – SWMU 40/71 is situated at approximately 1,880 to 1,900 feet (ft) above mean sea level (msl) in the south-central portion of the MMA at RFAAP (Figure 1-1). This portion of the MMA is characterized by gently to steeply sloping ridges, the presence of landforms indicative of karst topography (e.g. sinkholes) and a general slope to the northwest. SWMU 40/71 is situated topographically lower than areas to the east, south, west, and topographically higher than areas to the north (see Site Photographs, Appendix B).

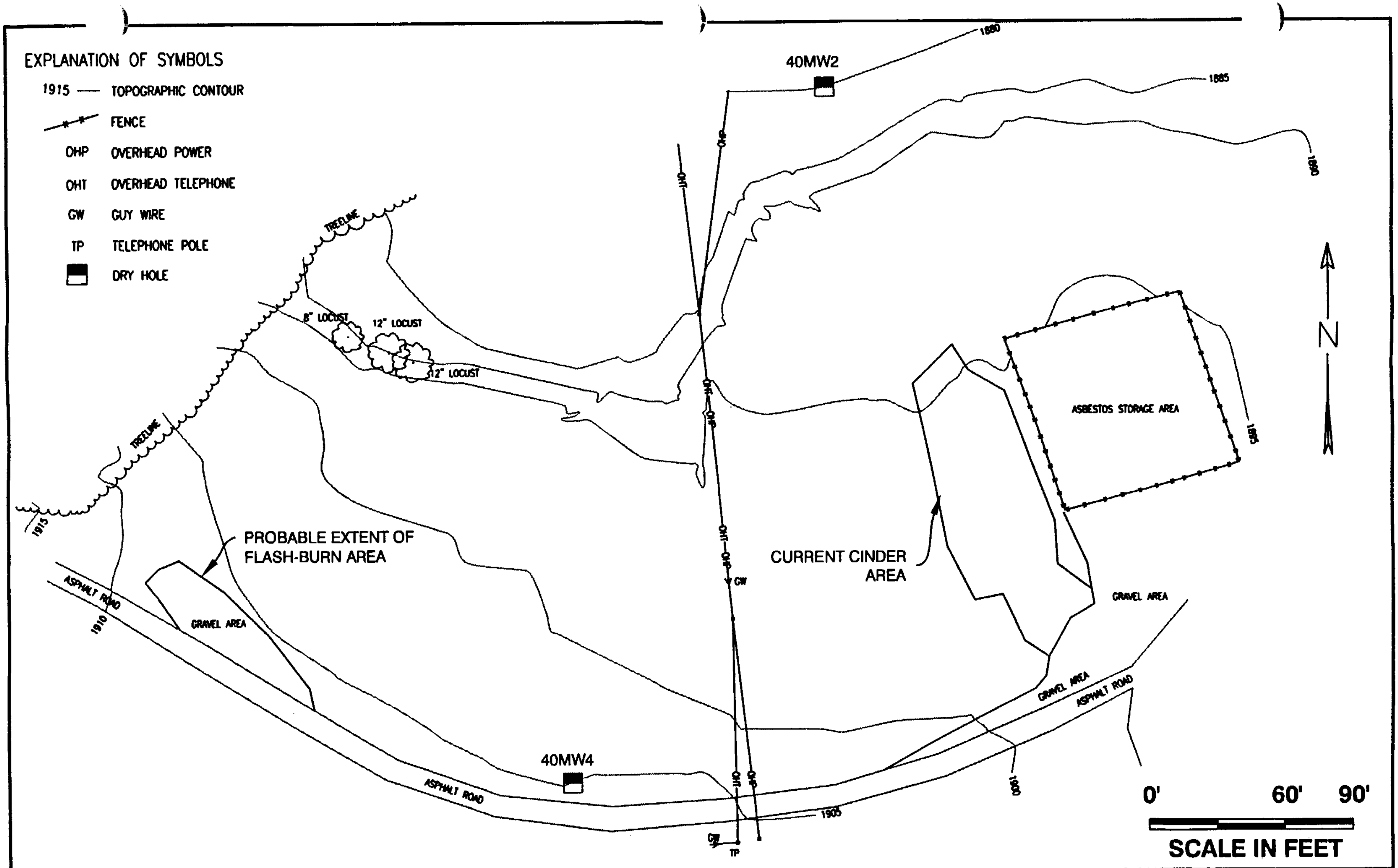
The immediate SWMU 40/71 area is grass covered and has a gentle slope towards the east and north (Figure 1-2). The southeastern portion of the SWMU 40/71 area is four to five ft below the grade of a generally east-west bearing paved road, whereas the southwestern portion of the SWMU 40/71 area is generally level and adjacent to the road. The western portion of the SWMU 40/71 area is roughly coincident with a tree line. The northern boundary of the SWMU 40/71 area is characterized by a distinct ten-ft high scarp running generally east-west (hereinafter the Northern Scarp). The eastern boundary of the SWMU 40/71 is roughly coincident with a fenced asbestos storage area and is further defined by a paved road. The Flash-Burn Area is located on the southwestern corner of SWMU 40/71 and was previously defined by an approximate 25 ft by 50 ft gravel area, portions of which are still present on the site.

Erosion features are present in the SWMU 40/71 area and consist of swales and gullies across the SWMU 40/71 area surface cutting into the Northern Scarp surface (Figure 1-2), see Site Photographs, Appendix B). Topography indicates that depositional features may be present immediately north of the scarp as small-scale deposits proximal to erosion features. Scattered metal debris is present on the SWMU 40/71 surface and is visible along the Northern Scarp.

Surface Water – Site topography suggests that surface water runoff in the SWMU 40/71 area likely flows across the SWMU 40/71 area towards the northern-central portion of SWMU 40/71 along several gullies and swales. Surface runoff likely flows in a northerly direction across the Northern Scarp and north from the SWMU 40/71 area (Figure 1-2). Surface water bodies are not present in the immediate SWMU 40/71 area. Few surface water bodies are present in the south-central portion of the MMA; however, sinkholes are abundant (USEPA 1992), suggesting that this area of the MMA may be a groundwater recharge zone. Surface drainage in the MMA primarily occurs via unlined ditches along roadways.

Geology and Soils – A detailed discussion of the geology and soils of the RFAAP is presented in Sections 3.4 through 3.7 of the MWP (URS 2002) and the Facility-Wide Background Study (IT, 2002). SWMU 40/71 is underlain by the Cambrian Elbrook Formation, medium-gray, limestone and dolomite (collectively, carbonate rock). Depth to bedrock in the immediate SWMU 40/71 area reportedly ranges from two to 17 ft below ground surface (bgs; Dames & Moore, 1992). Boring logs presented in Dames & Moore (1992) indicate the presence of mud-filled voids, typical of carbonate rock dissolution in karst terrain.

45



RFAAP

RFI WORK PLAN ADDENDUM: SWMU 40/71

FIGURE 1-2

SITE LAYOUT MAP

Date: *AUGUST 2002*	**Prepared By:** *URS Corp./TAL*
Scale: *AS SHOWN*	**File Name:** *P:\...\09604-258.WPA.1-15*

THIS DRAWING IS IN VIRGINIA STATE PLANE COORDINATE SYSTEM WHICH HAS BEEN ADJUSTED BY A COMBINED SCALE AND ELEVATION FACTOR OF 1.00013. DIVISION OF COORDINATE VALUES FROM THIS DRAWING BY THAT FACTOR WILL YIELD VIRGINIA STATE PLANE COORDINATE, NAD 83 VALUES. THE U.S. SURVEY FOOT WAS USED IN THE CONVERSION FROM METRIC TO ENGLISH UNITS.

Soils at SWMU 40/71 consist of the Unison-Urban Land Complex (IT 2002). Soil classification is not practical in urban land areas because the original soil has been physically altered or obscured. Based on information presented in the Facility-Wide Background Study (IT 2002), in an undisturbed area of SWMU 40/71, the Unison-Urban Land Complex soils have a 15-inch thick surface layer of dark brown loam and a 43-inch thick subsoil of yellowish-red, sticky plastic clay underlain by a red sandy clay loam to a depth of 58 inches. This clay-rich layer is typically underlain by brown sand to approximately ten ft bgs, which then grades into a brown clay. In general, permeability is moderate in Unison soils, natural fertility is low, and organic matter content is low to moderate. The soil is medium to strongly acidic.

Groundwater – A detailed discussion of regional and RFAAP hydrogeology is presented in Section 3.8 of the MWP (URS 2002). In the south central MMA, the groundwater flow regime is complex and is, at this time, not clearly understood. Dames & Moore advanced two boreholes and attempted construction of groundwater monitoring wells in 1992 to elevations of approximately 1,821 and 1,837 ft msl (40MW2 and 40MW4, respectively). These wells have remained dry since installation. Dames & Moore completed a boring (40MW1A) to an approximate elevation of 1,730 ft msl in which no water was encountered. A subsequent well installation at a distance greater than 350 ft north of the SWMU 40/71 (40MW3A; ES, 1994; Parsons, 1996) indicated the presence of groundwater at elevations in the range of 1,760 ft msl within the Elbrook Formation north of SWMU 40/71.

Based on information presented in Engineering Science (1994) and Parsons (1996), west-northwesterly groundwater flow to a flowing spring near the New River was directly linked to a sinkhole currently occupied by SWMU 17, which is located approximately 150 ft east of SWMU 40/71. Based on conclusions drawn by Engineering Science (1994) and Parsons (1996), a solution-enhanced fracture zone in bedrock may also drain groundwater from the vicinity of SWMU 40/71. A more detailed discussion of previous groundwater flow studies is presented in this WPA in Section 1.2.3, Nature and Extent of Contamination.

Tanks/Structures – The one structure present at SWMU 40/71 is a fenced enclosure, constructed in the northeastern corner of SWMU 40/71 in approximately 1991 (Parsons, 1996). This is utilized as an asbestos storage area. Tanks and structures composing the "Stage and Burn" portions of SWMU 17 are located approximately 150 ft southeast of SWMU 40/71.

1.2.2 Site Background – History

The RCRA Facility Assessment (RFA; USEPA 1987) identified SWMU 40/71 (the Landfill and the Flash-Burn Areas) as having the potential to release contaminants into the environment. The SWMUs were included in the RCRA Permit for Corrective Action and Incinerator Operation (USEPA 1989) as warranting investigation (revised permit effective October 31, 2000; USEPA 2000b).

The Landfill was an unpermitted landfill reportedly used in the 1970s and early 1980s for the disposal of uncontaminated paper, municipal refuse, cement, and rubber tires (USEPA 1987; USATHAMA 1976). Operations at the unit ceased and the unit was "closed" with a soil cap and scattered to sparse grass cover. Subsequently, the unit was used as an area where "clean" soils derived from construction-related activities were stockpiled. In approximately 1991, a fenced enclosure was constructed in the northeastern corner of the area. An area of burned material is present to the west of the asbestos storage area (Figure 1-2; hereinafter the Cindered Area).

Metal process pipes potentially contaminated with propellant were flash-burned from approximately 1962 to 1982 in the SWMU 40/71 Flash-Burn Area. Oil-soaked straw was reportedly used on occasion as a fuel source. The pipes were reused or sold for scrap after flash burning.

1.2.3 Nature and Extent of Contamination

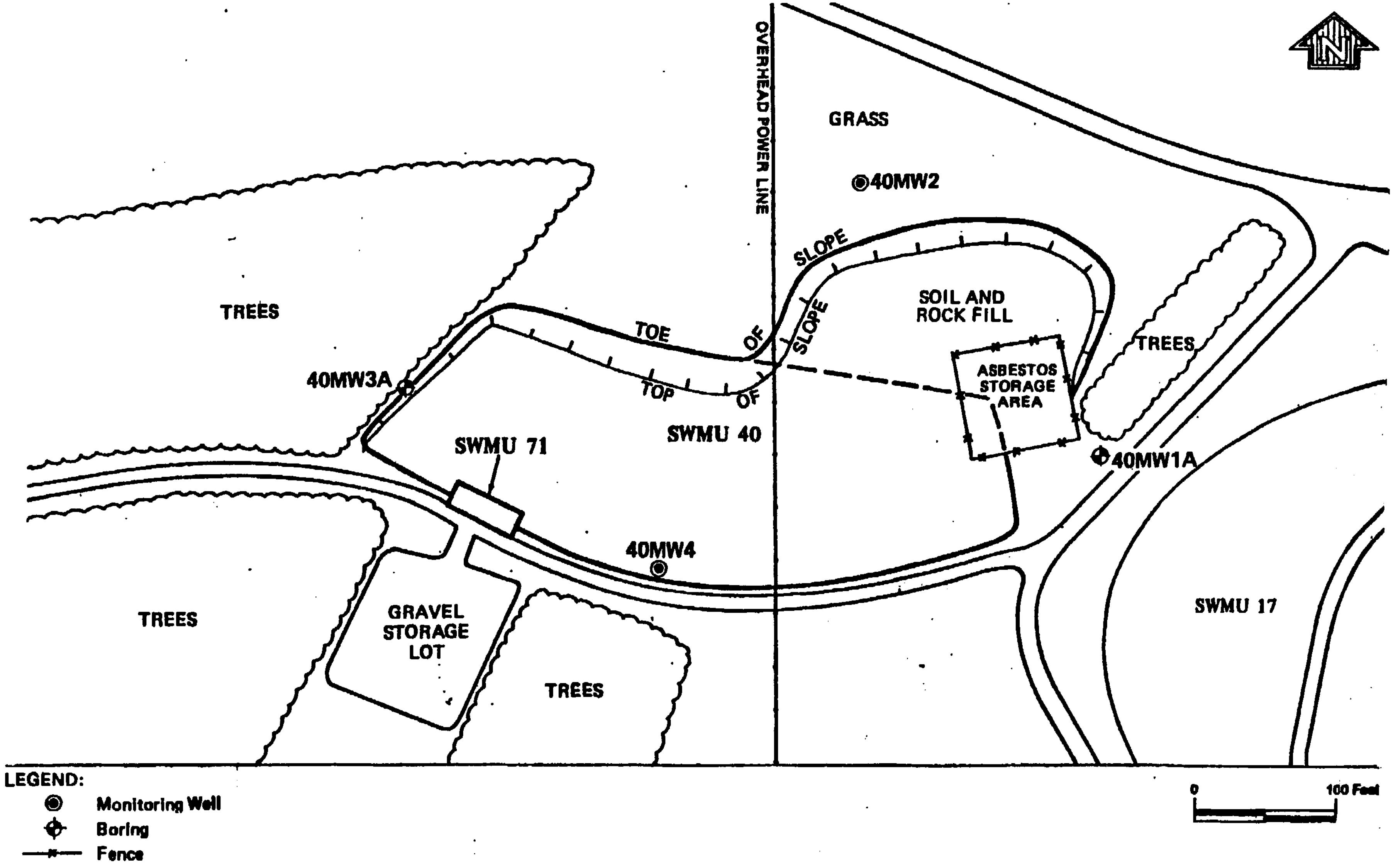
1.2.3.1 Verification Investigation – 1992

The results of a Verification Investigation (VI) were reported by Dames & Moore in 1992 (Dames & Moore 1992). The VI was performed after the RFA in 1987 (USEPA 1987) and the issuance of a RCRA permit in 1989 (USEPA 1989). The VI addressed the Landfill and Flash-Burn Areas as separate areas. The following information summarizes the VI findings.

The Landfill – Dames & Moore proposed installation of four groundwater monitoring wells near the Landfill to "evaluate whether groundwater quality has been impacted by wastes disposed of in this landfill" (Dames & Moore 1992). Four boreholes were advanced as part of the VI field program (Figure 1-3). To the east of the Landfill, borehole 40MW1A was advanced to 162 ft bgs (approximately 1,730 ft msl); however, the hole was abandoned because no water was encountered during drilling. To the north of the Landfill, borehole 40MW2 was advanced to a depth of 60 ft bgs (approximately 1,821 ft msl). Water was not encountered; however, a potential groundwater monitoring well was constructed to "intercept any possible high water table at a future date" (Dames & Moore 1992). To the west of the Landfill, borehole 40MW3A was advanced to 49 ft bgs (approximately 1,856 ft msl); however, the presence of a mud-filled cavity prevented further drilling and the location was abandoned. To the south of the Landfill, borehole 40MW4 was advanced to 90 ft bgs (approximately 1,816 ft msl). Water was not encountered during advancement of the boring. A potential groundwater monitoring well was constructed to approximately 69 ft bgs (approximately 1,837 ft msl) to "intercept any possible high water table at a future date." Note that borehole collapse occurred from approximately 69 to 90 ft bgs (Dames & Moore 1992).

Bedrock was encountered in borings 40MW1A and 40MW3A (east and west of the Landfill, respectively) at a depth of two to five ft bgs. Bedrock was encountered in borings 40MW2 and 40MW4 (north and south of the Landfill, respectively) at a depth of 15 to 17 ft bgs. Bedrock was reported to consist of argillaceous (i.e., clay rich) limestone and dolomite with abundant clayey zones (Dames & Moore 1992). Numerous zones of "intense" weathering and fracturing were also noted to be present. Samples for chemical analysis were not collected from SWMU 40/71 based on the lack of groundwater in 40MW2 and 40MW4.

Flash-Burn Area – Three surface soil samples were collected within the Flash-Burn Area as part of the VI (Dames & Moore 1992; Figure 1-4). The samples were collected to "determine whether surface soils have been impacted through the release of hazardous constituents during flashing operations" (Dames & Moore 1992). Samples were collected from zero to six inches bgs, beneath gravel or organic layers. Samples were analyzed for Target Analyte List (TAL) metals, explosives and Total Petroleum Hydrocarbons (TPH). At the time, analytical data were compared to health-based numbers (HBNs) included in the then-current RCRA Permit. For the purposes of this WPA, and because HBNs are no longer promulgated within the facility RCRA Permit (USEPA 2000b), historical data are compared herein to current USEPA Region III RBCs (April 2002) for Residential and Industrial exposure scenarios (Table 1-2). At the request of USEPA Region III, a Hazard Quotient (HQ) of 0.1 or lifetime cancer risk of 1×10^{-6} (whichever occurs at a lower concentration) is used for risk screening with RBCs.



RFAAP

RFI WORK PLAN ADDENDUM: SWMU 40/71

Date: MARCH 2002

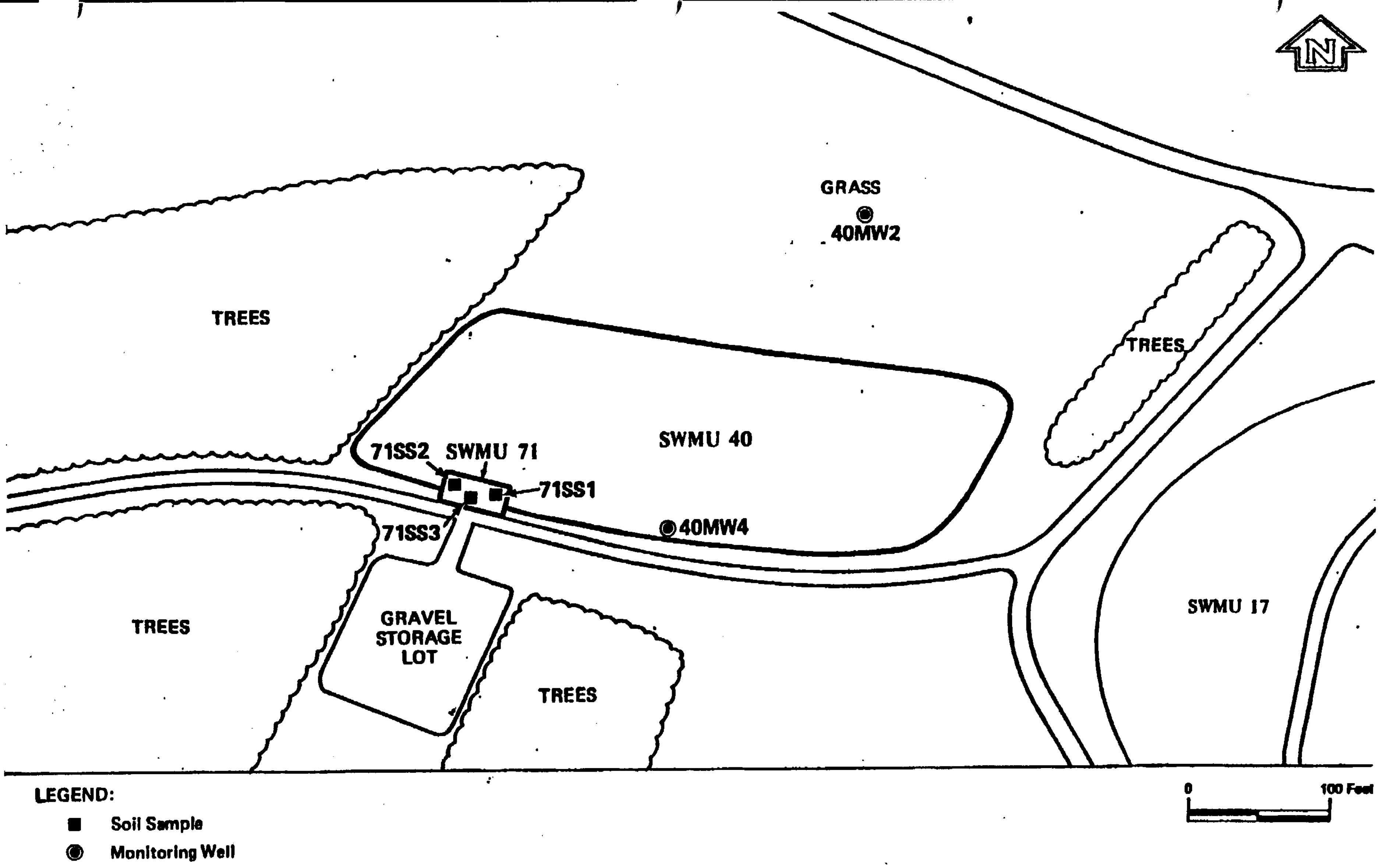
Prepared by: URS Corp./TAL

Scale: AS SHOWN

File Name: Figure 1-3.ppt

FIGURE 1-3

GROUNDWATER MONITORING WELL AND BORING LOCATIONS, SWMU 40
(Source: Dames & Moore 1992)



RFAAP

RFI WORK PLAN ADDENDUM: SWMU 40/71

Date: MARCH 2002

Prepared by: URS Corp./TAL

Scale: AS SHOWN

File Name: Figure 1-4.ppt

FIGURE 1-4

SAMPLE LOCATIONS,
SWMU 71
(Source: Dames & Moore 1992)

Table 1-2
Summary of Analytical Data For Soil Samples Collected At SWMU 71
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

SITE ID		71SS1	71SS2	71SS3		
FIELD ID		RVFS*67	RVFS*68	RVFS*69		
SAMPLE DATE		5-Feb-92	5-Feb-92	5-Feb-92	Soil	Soil
DEPTH (ft bgs)		0.5	0.5	0.5	Industrial	Residential
MATRIX	PQLs	CSO	CSO	CSO	RBC	RBC
UNITS	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
TAL Inorganics						
Aluminum	14.1	15,200	4,040	4,880	200,000	7,800
Arsenic	30	13	27	190	3.8	0.43
Barium	1	166	155	161	14,000	550
Beryllium	0.2	3.00	1.63	1.73	410	16
Calcium	100	9,130	3,130 B	10,100	–	--
Chromium	4	40.8	19.1	14	610	23 [1]
Cobalt	3	13.10	5.48	2.29	4,100	160
Copper	7	53.5	40.9	46.5	8,200	310
Iron	1000	27,600	9,720	32,700	61,000	2,300
Lead	2	97.20	76.6	147	1000	400 [2]
Magnesium	50	7,610	1,860	1,240	--	--
Manganese	0.275	463.00	127	44.7	29,000	1,100
Mercury	0.1	0.23	0.372	2.7	61	2.3 [3]
Nickel	3	18.30	11.1	7.11	4,100	160
Potassium	37.5	1,620	640	1,560	–	--
Selenium	40	<0.25	0.449	6.69	1,000	39
Silver	4	1.2	0.97	1.76	1,000	39
Sodium	150	457 B	289 B	377 B	–	--
Thallium	20	25.2	13.9	32.7	14	0.55
Vanadium	0.775	50.9	17	22.7	1,400	55
Zinc	30.2	160	80.5	43.5	61,000	2,300
Other						
TPH	NA	61.2	55.2	79.5	–	–

Modified From Dames and Moore, 1992

Notes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than ten (10) times the method blank concentration for common laboratory constituents and five (5) times for all other constituents

TPH = Total Petroleum Hydrocarbons

CSO = Chemical soil

RBC = USEPA, Region III, Risk-Based Concentration, April 2, 2002
Non-carcinogenic constituents have been adjusted to reflect an HQ of 0.1

USEPA = United States Environmental Protection Agency

NA = Not available

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method

TAL = Target Analyte List

mg/kg = Milligrams per kilogram

(1) = Chromium VI value used.

(2) = Lead screening values taken from OSWER Directive #9355.4-12 (not an RBC)

(3) = Mercuric chloride value used.

ft bgs= Feet below ground surface

☐ = Concentration above Soil Industrial RBC

▭ = Concentration above Soil Residential RB

A review of the data indicates that the TAL metals aluminum, arsenic, chromium, iron, manganese, mercury, and thallium were reported in at least one sample as present at levels above their respective 2002 Residential RBCs. In addition, arsenic and thallium were also reported as present in at least one sample at concentrations above their respective 2002 Industrial RBCs. Explosives were not detected in the samples submitted for analysis. TPH was detected in each of the three samples submitted. Note that concentrations reported were below 100 milligrams per kilogram (mg/kg), the Commonwealth of Virginia informal action level in soil (VDEQ 1999).

1.2.3.2 Installation Assessment (Air Photo Interpretation) – 1992

The Environmental Photographic Interpretation Center (EPIC), under the direction of USEPA, performed an assessment of multiple SWMUs at RFAAP using selected aerial photographs from 1937 to 1986. The objective was to "concentrate upon tracking 42 known SWMUs located in the [RFAAP], and to identify other features which may represent potential groundwater or surface water contamination sources" (USEPA 1992).

Activity was first noted at the Landfill in a 1971 photograph and was reportedly ongoing through a 1986 photograph. The 1971 photograph reportedly indicated "significant filling" with three "fill faces" interpreted in the Landfill Area (USEPA 1992; Figure 1-5). The 1986 photograph indicated that the majority of the site was re-vegetated with the exception of the northeast corner where evidence of recent filling was visible (USEPA 1992). Flash-Burn Area activity was reportedly first noted in the 1986 photograph.

A photogeologic interpretation was performed to identify solution features such as fractures and sinkholes with particular study near SWMU 40/71 and SWMU 17. USEPA (1992) identified a field of large sinkholes south of the south central MMA (Figure 1-6). The SWMU 40/71 area is depicted as being located within a sinkhole in the northern portion of the sinkhole field. USEPA (1992) concluded, "Units 17 and 40...are physically contained within sinkholes that are part of a group of comparatively large sinkholes."

1.2.3.3 Verification Investigation: Phase II – 1994

Based on the results of the 1992 VI, twelve additional soil samples were collected at the Flash-Burn Area to "better define the horizontal and vertical distribution of detected analytes" (Dames & Moore 1994). Seven samples of soil from zero to six inches bgs and five samples from four ft bgs were collected and analyzed for TAL Metals, Toxicity Characteristic Leaching Procedure (TCLP) Metals, and TPH (Figure 1-7).

A review of the data indicates that the TAL Metals, aluminum, arsenic, chromium, iron, manganese, mercury, nickel, and vanadium were reported in at least one sample as present at levels above their respective 2002 Residential RBCs (Table 1-3). In addition, arsenic and iron were also reported present in at least one sample at concentrations above its 2002 Industrial RBC. Note that thallium, identified in 1992 as present at concentrations above its 2002 Industrial RBC, was not detected during the 1994 investigation. TPH was reported at concentrations exceeding the Virginia informal action level of 100 mg/kg for TPH in four soil samples. Three of the samples were collected from zero to six inches bgs and one sample was collected from four ft bgs.

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Table 1-3
Summary of Analytical Data For Soil Samples Collected At SWMU 71
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

SITE ID		71SS4	71SS4	71SS5	71SS5(dup)	71SS5	71SS6	71SS6		
FIELD ID		RDSV-29	RDSX-30	RDSX-31	RDSX-42	RDSX-32	RDSX-33	RDSX-34		
SAMPLE DATE		15-Jul-93	15-Jul-93	15-Jul-93	15-Jul-93	15-Jul-93	15-Jul-93	15-Jul-93	Soil	Soil
DEPTH (ft bgs)		0.0	4.0	0.0	0.0	4.0	0.0	4.0	Industrial	Residential
MATRIX	PQLs	CSO	CSO	CSO	CSO	CSO	CSO	CSO	RBC	RBC
UNITS	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
TAL Metals										
Aluminum	14.1	23,300	26,900	17,400	24,300	33,100	13,600	48,300	200,000	7,800
Arsenic	30	5.3	7.4	8.3	5.7	6.9	17	8.6	3.8	0.43
Barium	1	264	87.1	80.3	99.9	56	151	111	14,000	550
Beryllium	0.2	1.27	1.75	<0.500	1.43	2.37	1.06	3.19	410	16
Cadmium	2	<0.700	<0.700	3.360	<0.700	<0.700	<0.700	<0.700	200	7.8
Calcium	500	6,280	1,360	42,800	1,860	1,730	4,700	2,000	--	--
Chromium	4	35.7	51.1	23.5	36.6	47.6	33.4	63.5	610	23 [1]
Cobalt	3	15	14.3	4.27	5.68	15.9	12.1	14.9	4,100	160
Copper	7	27.4	26.1	11.8	15.600	38.4	197	32.3	8,200	310
Iron	1,000	32,000	46,800	24,600	38,200	33,700	26,000	50,500	61,000	2,300
Lead	2	38.2	18	61.2	25.9	<10.5	51.4	21.9	1000	400 [2]
Magnesium	50	6,720	7,800	26,000	2,470	47,300	5,600	26,900	--	--
Manganese	0.275	355	351	164	131	341	381	438	29,000	1,100
Mercury	0.1	0.124	<0.050	0.133	0.179	<0.050	0.272	0.088	61	2.3 [3]
Nickel	3	22.1	31.1	7.7	11.1	41.2	323	46.2	4,100	160
Potassium	37.5	1,810	1,970	707	1,020	7,000	1,370	4,070	--	--
Selenium	40	<0.250	<0.250	<0.250	<0.250	<0.250	0.587	<0.250	1,000	39
Silver	4	<0.589	<0.589	<0.589	<0.589	<0.589	1.16	<0.589	1,000	39
Sodium	150	734	740	378	401	348	403	457	--	--
Vanadium	0.775	58.7	80.7	55.1	80.2	67.3	41.1	103	1,400	55
Zinc	30.2	79.5	59.2	23.9	34.2	56.3	95.9	76.1	61,000	2,300
Other										
TPH	NA	553	<28.7	36.7	36.1	<28.7	723	40.8	--	--
										TCLP Limits
TCLP Metals	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L		µg/L
Barium	20	895	276	407	379	347	768	339		100,000
Cadmium	1	<4.010	<4.010	<4.010	<4.010	<4.010	<4.010	<4.010		1,000

Table 1-3 (Continued)
Summary of Analytical Data For Soil Samples Collected At SWMU 71
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

SITE ID FIELD ID SAMPLE DATE DEPTH (ft bgs) MATRIX UNITS	PQLs mg/kg	71SS7 RDSX-35 15-Jul-93 0.0 CSO mg/kg	71SS7 RDSX-36 15-Jul-93 4.0 CSO mg/kg	71SS8 RDSX-37 28-Jul-93 0.0 CSO mg/kg	71SS9 RDSX-39 15-Jul-93 0.0 CSO mg/kg	71SS9 RDSX-40 15-Jul-93 4.0 CSO mg/kg	71SS10 RDSX-38 28-Jul-93 0.0 CSO mg/kg		Soil Industrial RBC mg/kg	Soil Residential RBC mg/kg
TAL Metals										
Aluminum	14.1	26,300	48,700	22,200	13,800	14,400	23,300		200,000	7,800
Arsenic	30	7.4	9.3	7.5	8.6	530	12		3.8	0.43
Barium	1	126	109	282	120	107	380		14,000	550
Beryllium	0.2	1.61	4.7	1.61	0.951	1.29	2.12		410	16
Cadmium	2	<0.700	<0.700	<0.700	<0.700	0.977	<0.700		200	7.8
Calcium	500	2,180	1,780	3,650	16,000	14,700	6,590		--	--
Chromium	4	46.2	65.7	34.9	39.8	41.7	37.4		610	23[1]
Cobalt	3	18.5	13.8	16.1	7.91	25.4	14.6		4,100	160
Copper	7	22.1	40	21.4	123	116	27		8,200	310
Iron	1,000	28,200	62,400	33,400	21,900	48,100	35,700		61,000	2,300
Lead	2	<10.500	16.8	22	78.2	133	21.7		1000	400[2]
Magnesium	50	27,000	13,900	7,540	3,050	4,840	9,520		--	--
Manganese	0.275	1,330	670	644	495	375	1,300		29,000	1,100
Mercury	0.1	<0.050	0.13	<0.050	17	6.4	0.068		61	2.3[3]
Nickel	3	28.5	57.5	22.5	11.7	52.2	26.2		4,100	160
Potassium	37.5	2,630	2,900	1,810	1,210	1,140	1,770		--	--
Selenium	40	<0.250	<0.250	<0.250	<0.250	2.16	<0.250		1,000	39
Silver	4	<0.589	<0.589	<0.589	<0.589	<0.589	<0.589		1,000	39
Sodium	150	416	433	629	639	1080	805		--	--
Vanadium	0.775	66.2	117	55.3	77.5	92.1	60.1		1,400	55
Zinc	30.2	63.8	72.9	64.7	170	223	72.6		61,000	2,300
Other										
TPH	NA	38.4	<28.7	<28.7	1,330	1,090	<28.800		--	--
TCLP Metals	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L			TCLP Limits µg/L
Barium	20	495	354	806	755	944	1,160			100,000
Cadmium	1	<4.010	<4.010	<4.010	<4.010	5.13	<4.010			1,000

Modified From: Dames & Moore, 1994

Notes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than ten (10) times the method blank concentration for common laboratory constituents and five (5) times for all other constituents

RBC = USEPA, Region III, Risk-Based Concentration, April 2, 2002 Non-carcinogenic constituents have been adjusted to reflect an HQ of 0.1

CSO = Chemical soil

NA = Not available

TCLP = Toxicity Characteristic Leaching Procedure

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method

TAL = Target Analyte List

TPH = Total Petroleum Hydrocarbons

(1) = Chromium VI value used

(2) = Lead screening values taken from OSWER Directive #9355.4-12 (not an RBC)

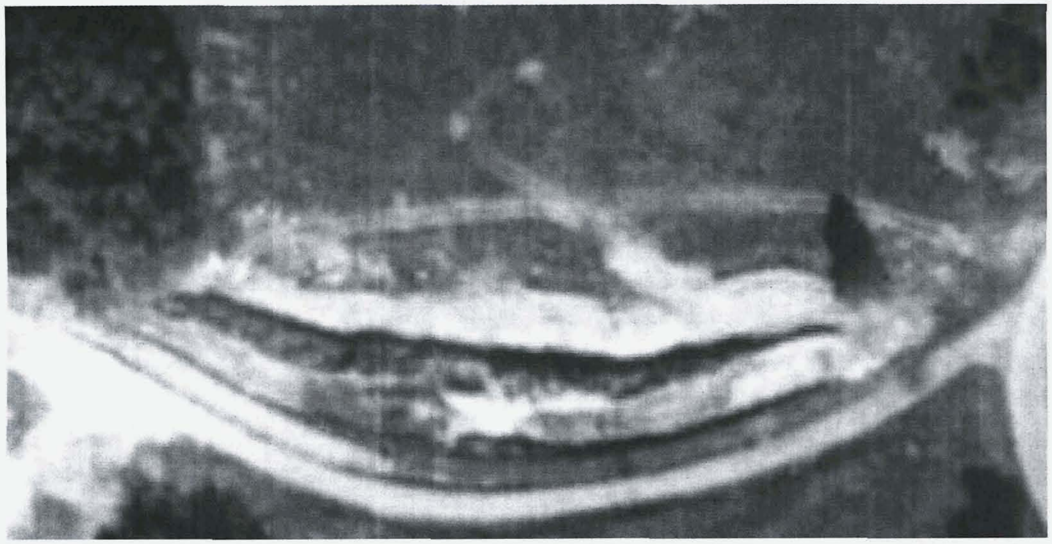
☐ = Concentration Above Soil Industrial RBC

☐ = Concentration Above Soil Residential RBC

ft bgs = Feet below ground surface

mg/kg = Milligrams per kilogram

ug/L= Microgram per liter

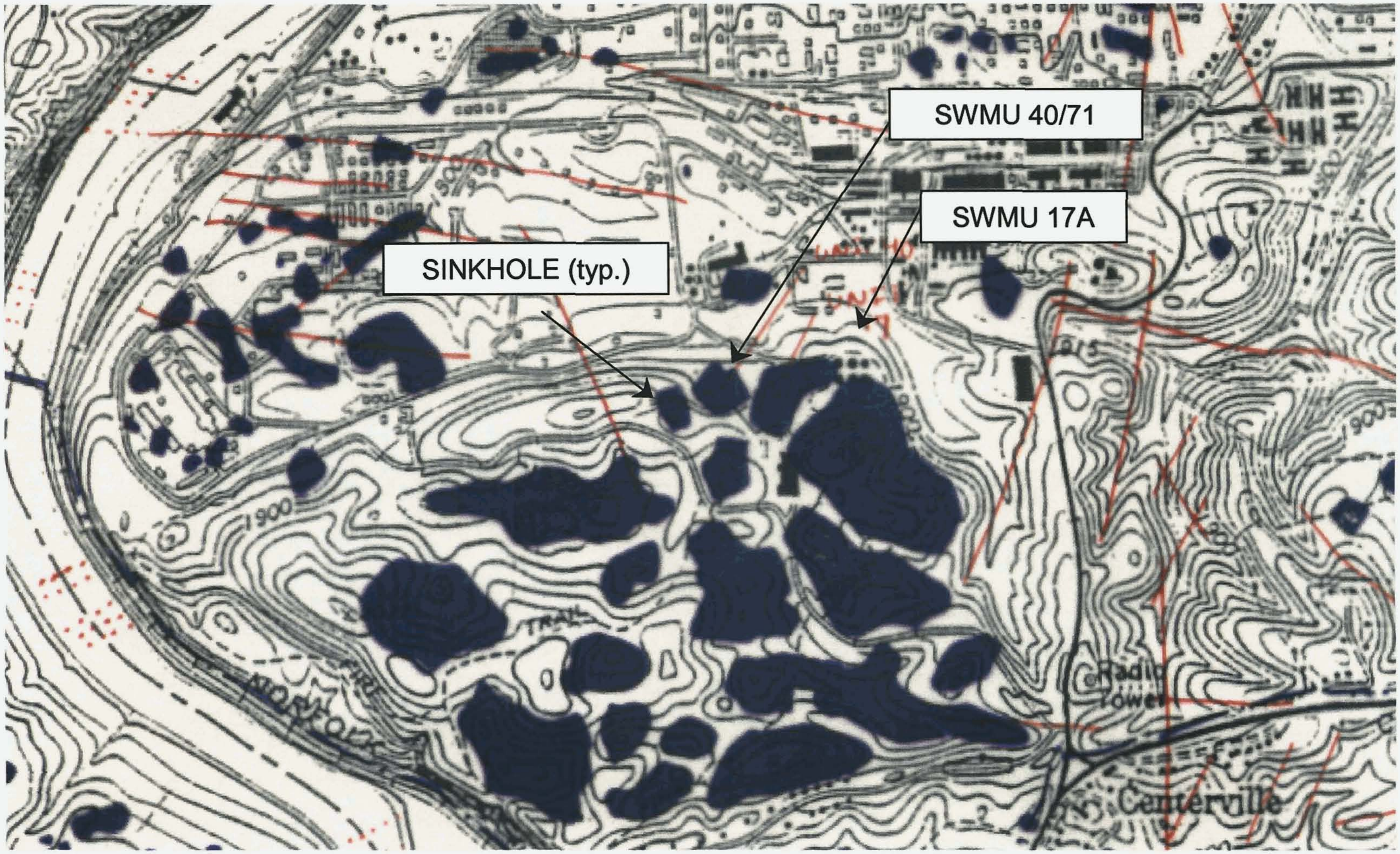


RFAAP
RFI WORK PLAN ADDENDUM: SWMU 40/71

Date: *MARCH 2002*
Prepared by: *URS Corp./TAL*
Scale: *AS SHOWN*
File Name: *Figure 1-5.ppt*

FIGURE 1-5

INTERPRETATION OF
1971 PHOTOGRAPH
(Source: USEPA 1992)



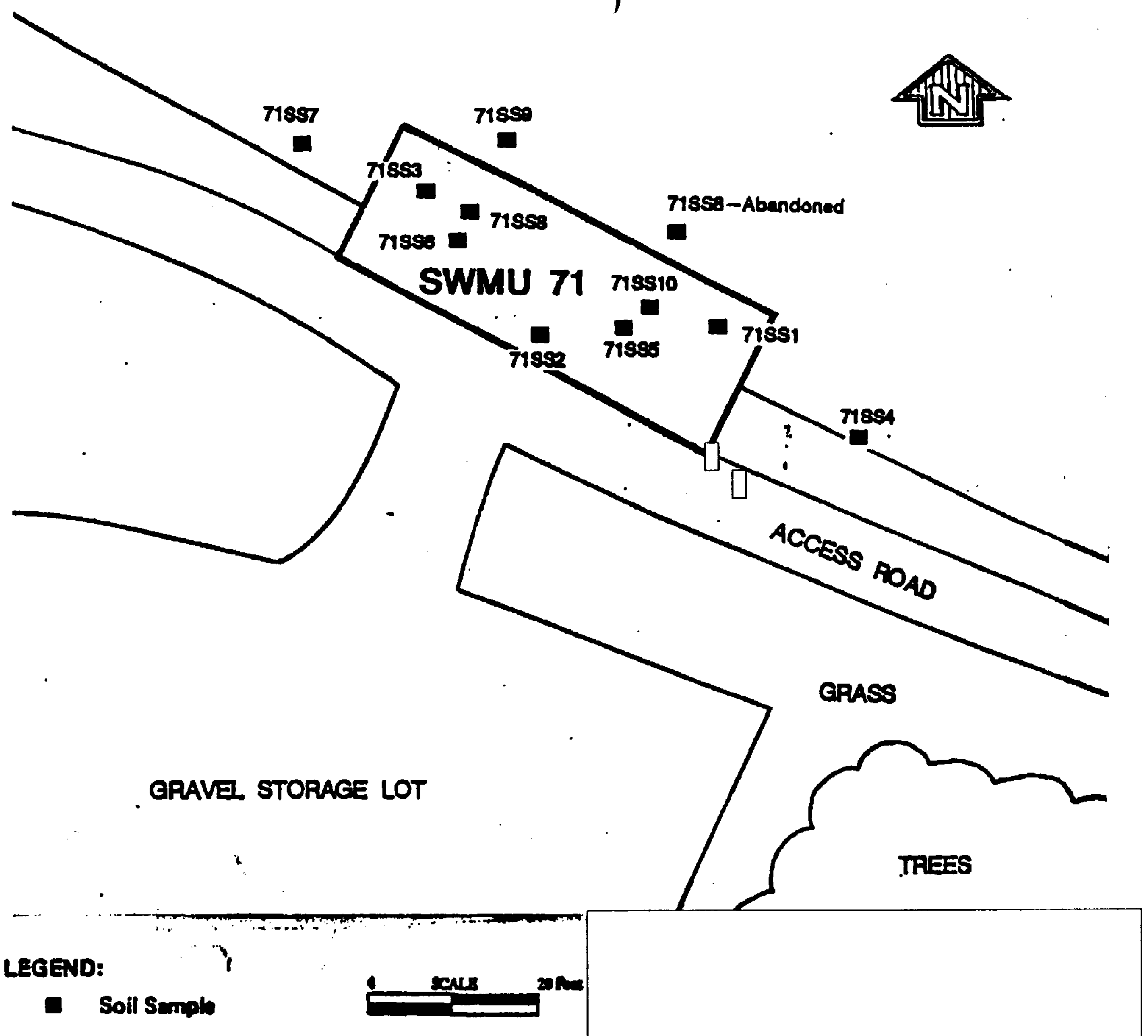
RFAAP

RFI WORK PLAN ADDENDUM: SWMU 40/71

Date: MARCH 2002
Prepared by: URS Corp./TAL
Scale: NO SCALE
File Name: Figure 1-6.ppt

FIGURE 1-6

INTERPRETATION OF SINKHOLE/FRACTURE TRACE LOCATIONS
(Source: USEPA 1992)



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RFI WORK PLAN ADDENDUM: SWMU 40/71

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MARCH 2002

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FIGURE 1-7

SAMPLE LOCATIONS,
SWMU 71
(Source: Dames & Moore 1994)

Sample results were characterized as similar to the concentrations measured in the 1992 VI study (Dames & Moore 1992; 1994) with the exception of arsenic in one sample (71SS9) collected from four ft bgs. The anomalous high concentration of arsenic reported for the sample was suggested by Dames & Moore (1994) to be the result of sampling of subsurface materials associated with SWMU 40. This is the same soil sample (71SS9) reported to contain TPH at concentrations higher than 100 mg/kg at four ft bgs.

1.2.3.4 Dye-Tracing Study – 1994

Parsons conducted a dye-tracing study to assess groundwater flow directions through the limestone aquifer in the south central MMA (vicinity of SWMU 40/71 and 17). Groundwater monitoring well 40MW3 was installed as part of the dye-tracing study. This well was installed approximately 350 ft northwest of well 40MW2, outside of the presumed limits of SWMU 40/71. The boring penetrated approximately 25 ft of silt and clay above approximately 25 ft of gravelly soil overlying bedrock (Parsons 1996). The well is screened from 97 to 117 ft bgs (approximately 1,760 to 1,740 ft msl).

The study suggested the presence of a specific flow path connecting a dye-introduction point in SWMU 17 (approximately 150 ft east of SWMU 40/71) to a spring discharging to the New River (Parsons 1996); however, dye was not detected in well 40MW3. The potential conduit reportedly follows a series of fracture traces identified by the USEPA (1992). Based on conclusions drawn by Engineering Science (1994) and Parsons (1996), a solution-enhanced fracture zone in bedrock may also drain groundwater from the vicinity of SWMU 40/71.

1.2.3.5 RFI for SWMU 17 – 1996

In 1996, Parsons submitted an RFI including SWMU 17 with SWMU 40 "because of their proximity and similar subsurface conditions" (Parsons, 1996). Groundwater monitoring well 40MW3 was sampled for total and dissolved metals, explosives, total organic carbon (TOC) and total organic halogens (TOX). Barium was reported at 54.5 micrograms per liter (µg/L) for total analysis and 31 µg/L for dissolved analyses. These values are below the current USEPA Maximum Contaminant Level (MCL) of 2,000 µg/L for barium.

Parsons (1996) noted that dye was not detected in 40MW3 during the 1994 dye-tracing study. Parsons speculated that the lack of dye detection in 40MW3 may indicate that the conduit identified by USEPA (1992) as connecting SWMU 17 to a spring at the New River may be narrow and not intercepted by 40MW3. General groundwater flow in the bedrock aquifer is presented by Parsons (1996) to be westward across the south central MMA.

1.2.3.6 Geophysical Investigation – 2001

URS oversaw a surface and subsurface geophysical investigation (Geophex 2001) to map the extent of the SWMU 40/71 area, assess the extent of potentially conductive zones related to Landfill materials, and assess the overburden, epikarst and bedrock boundaries. Natural gamma and electromagnetic (EM) induction logging was performed on wells 40MW2 and 40MW4. URS then used magnetic, electromagnetic and direct current (DC) resistivity methods across the area of SWMU 40/71. Initially, magnetic and electromagnetic data were collected over approximately 5.4 acres to image the probable lateral extent of conductive zones. Following limited, field-based data analysis, eight DC resistivity profiles were collected to assess the depth of conductive zones. The geophysical data is considered preliminary, but will be ground truthed and confirmed during the execution of the proposed WPA field investigative program. A brief summary of the data is presented as follows, in part, because it is used to aid in development of the CSM as presented in Section 1.2.4 and in selecting sampling locations as presented in Section 1.3.

Preliminary EM data reveal a potential outline of the fill area at SWMU 40/71 (Figure 1-8). A large anomaly in the northern portion of the fill area and a smaller anomaly in the southern portion of the fill area are preliminarily interpreted as accumulations of buried ferrous materials (Geophex 2001). Figure 1-9 depicts vertical magnetic gradient and is interpreted to preliminarily indicate the presence of buried ferrous materials (Geophex 2001). Note that the vertical magnetic gradient data may indicate roughly similar possible fill geometry as distinguished by USEPA (1992). Preliminary apparent conductivity data are presented in Figure 1-10. The data appears to potentially define an area of higher conductivity in roughly the same area that the EM data indicated the presence of ferrous materials (Geophex 2001).

Preliminary data from selected resistivity profiles are presented as Figures 1-11 and 1-12. The heavy black line indicates the transition from relatively conductive to non-conductive zones. The preliminary data indicate zones of conductive materials to potential depths of at least 80 ft bgs in the central portion of SWMU 40. The data preliminarily indicate the presence of two east-west oriented zones of increased conductivity, potentially indicative of the fill geometry identified by USEPA (1992).

1.2.4 Conceptual Site Model

A CSM for SWMU 40/71 is presented as Figure 1-13. Potentially affected media include surface and subsurface soil. Based on current data available for the site, leaching of constituents into subsurface soils is likely a complete migration pathway. The surface water and sediment migration and exposure pathways are incomplete at SWMU 40/71 due to a lack of permanent surface water at the site.

Topographic relief in the immediate area is gentle to moderate, with no surface water bodies present nearby. Erosion features in the SWMU 40/71 area indicate that precipitation likely both infiltrates into the ground surface of SWMU 40/71 and flows across SWMU 40/71 and over the Northern Scarp. Deposition of soils derived from SWMU 40/71 likely occurs along the base of the Northern Scarp as indicated by topographic mounding in the area and following the geomorphic principles of deposition/erosion associated with changes in profile and grade. Following deposition during rainfall events, accumulated soil likely desiccates and should be considered as a surface-soil type of media for the purposes of migration and risk assessment. North of the scarp, based on the presence of relatively dense, grassy vegetation and gentle slope, surface runoff will likely infiltrate the ground rather than flow overland towards unlined ditches along roadways.

Based on data available for the site, groundwater is not present in overburden soils; however, this data appears to be insufficient to conclusively state that the groundwater migration pathway is incomplete. The completeness of the groundwater migration pathway at SWMU 40/71 is therefore considered unknown. During previous investigations, groundwater was not encountered in overburden soils or bedrock in the immediate vicinity of SWMU 40/71 to depths of 160 ft bgs (Dames & Moore 1992). In the area, clay-rich soils will likely result in reduced mobility of organic and inorganic constituents, if present. The current groundwater study in the "Horseshoe" area is scheduled for expansion into the Main Manufacturing Area (MMA) in fiscal year 2006. The expanded study area includes SWMU 40/71. This study is the result of discussions / decisions coordinated with the USEPA and VDEQ at the Installation Action Plan Workshop in May 2001.

The Landfill and Flash-Burn Areas are indicated on Figure 1-13 as potentially overlapping. Interpretations presented by USEPA (1992) and the results of preliminary geophysical data indicate the presence of two to three burial trenches. The diagram indicates the potential release mechanism of

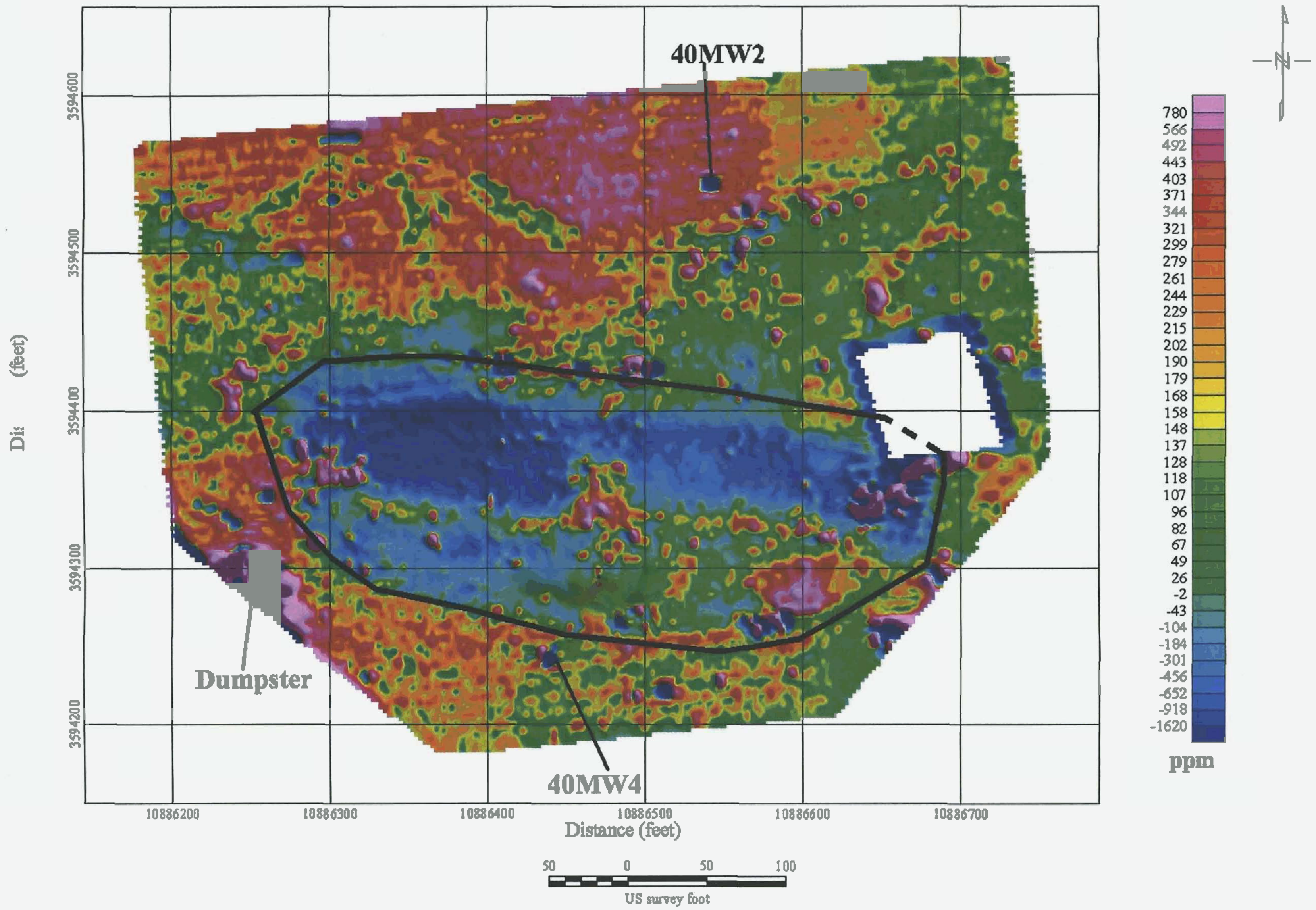

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FIGURE 1-8

**PRELIMINARY
ELECTROMAGNETIC
DATA
(1,050Hz In Phase)**

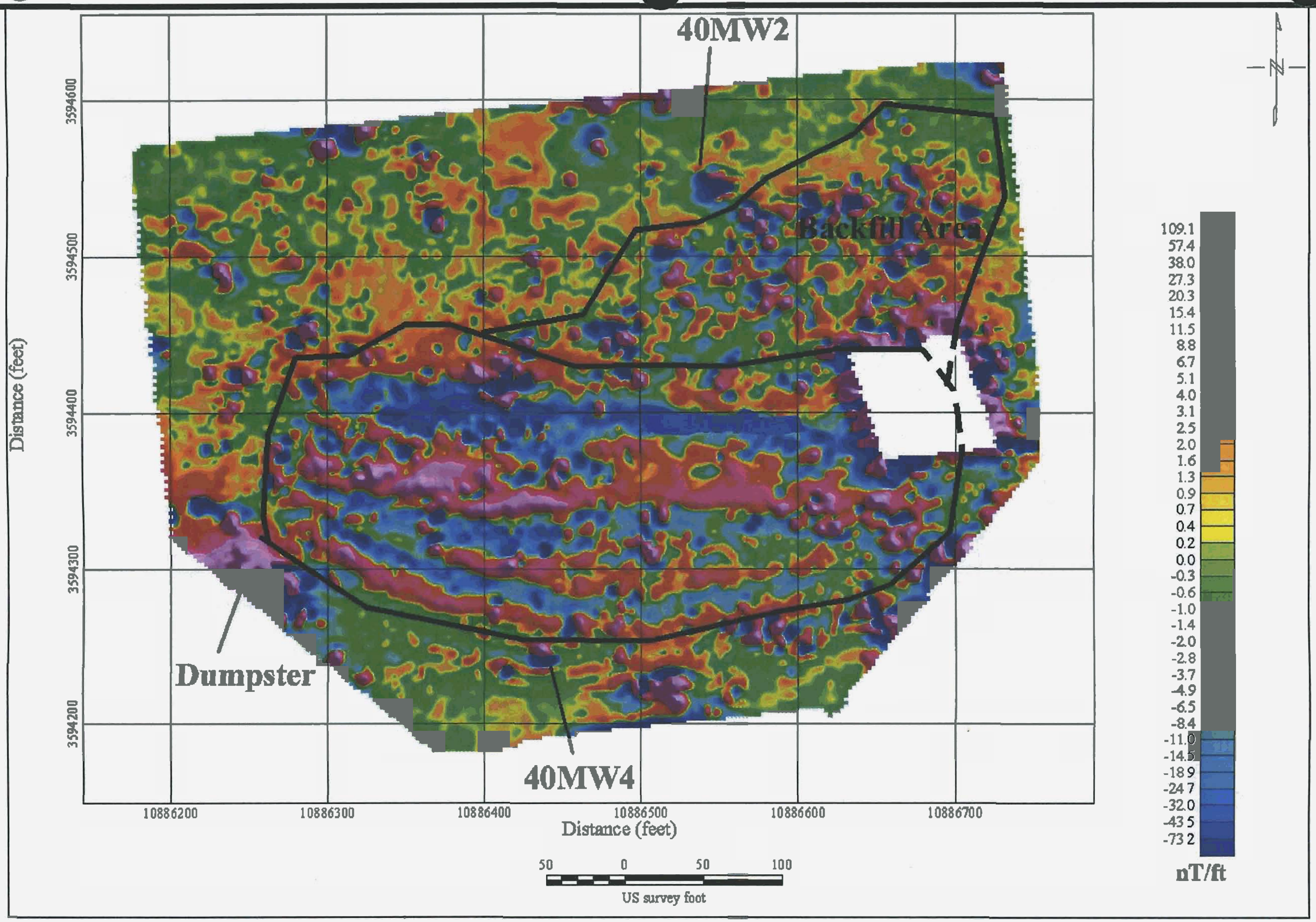

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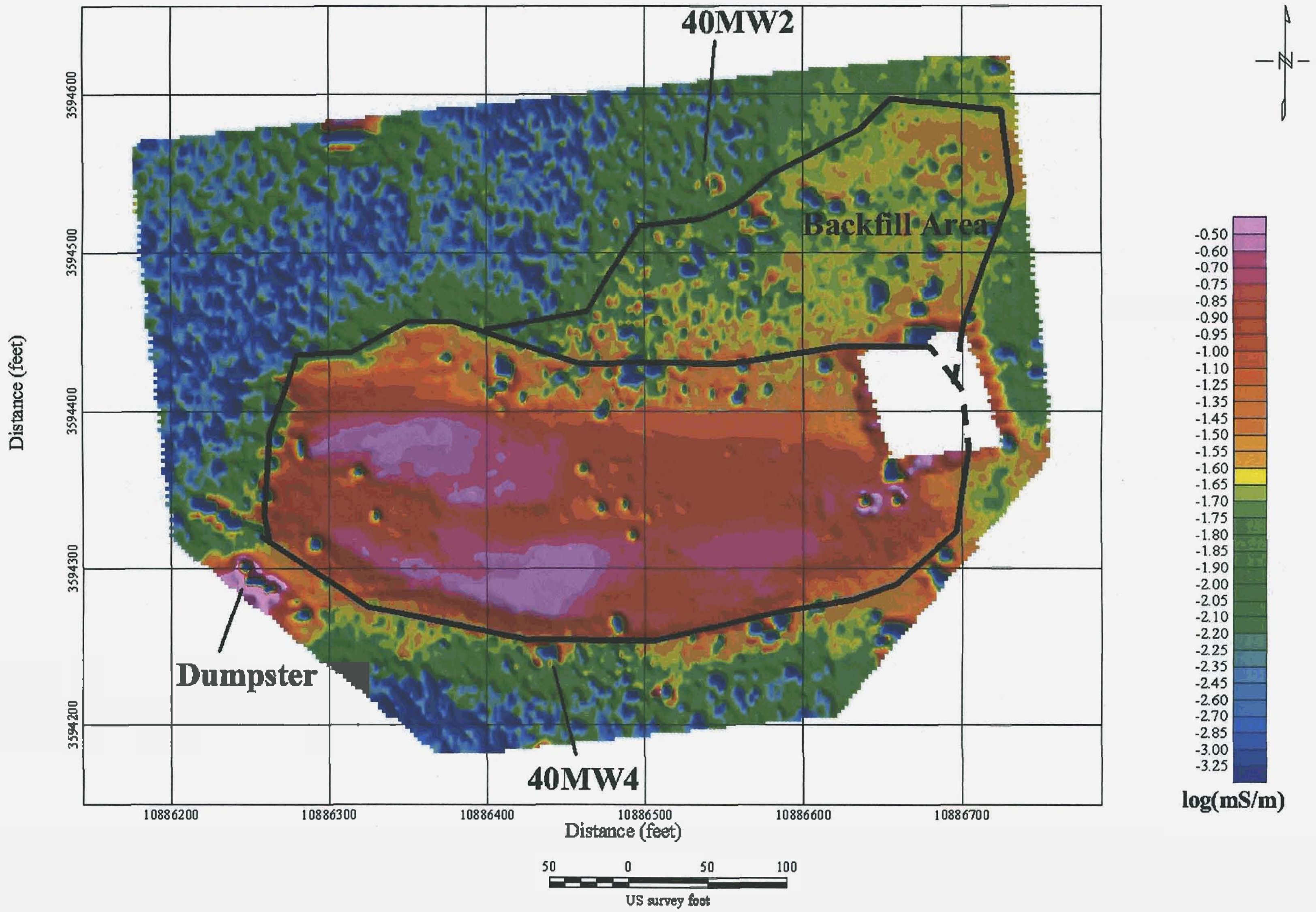
FIGURE 1-9

PRELIMINARY VERTICAL MAGNETIC GRADIENT DATA



RFAAP **RFI WORK PLAN ADDENDUM: SWMU 40/71**	**FIGURE 1-10**
Date: *MARCH 2002*	**Prepared by:** *URS Corp./TAL*
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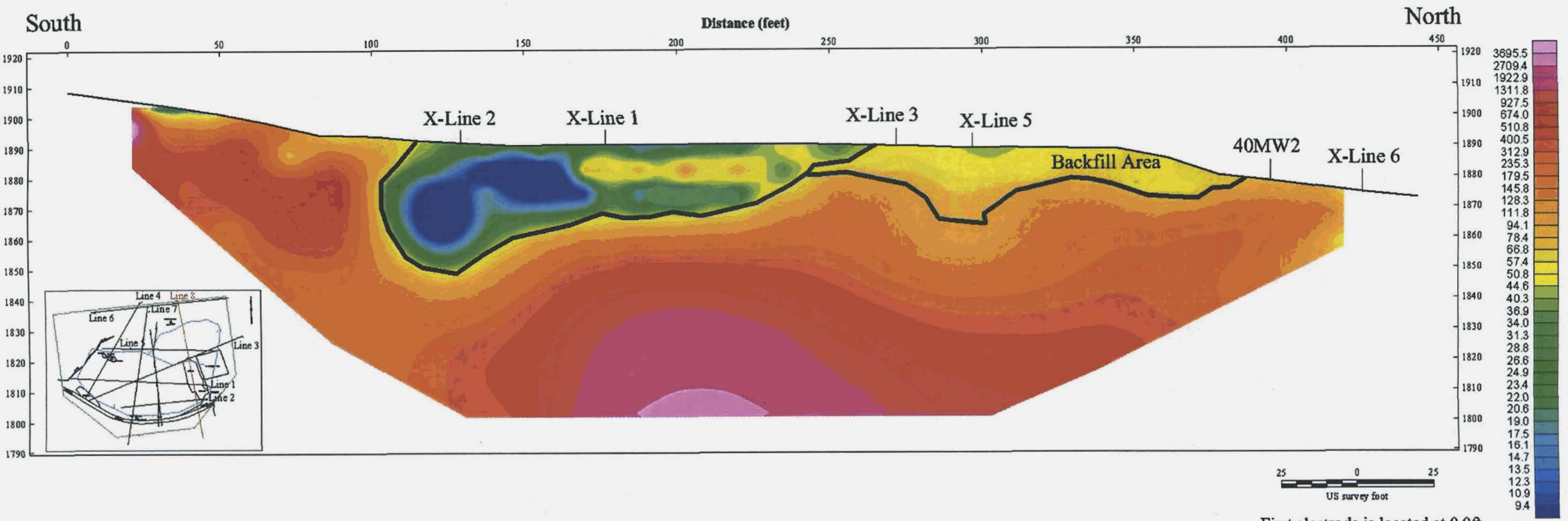
PRELIMINARY APPARENT CONDUCTIVTY DATA (4,170 Hz)



First electrode is located at 0.0ft
Last electrode is located at 442.9ft

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RFI WORK PLAN ADDENDUM: SWMU 40/71

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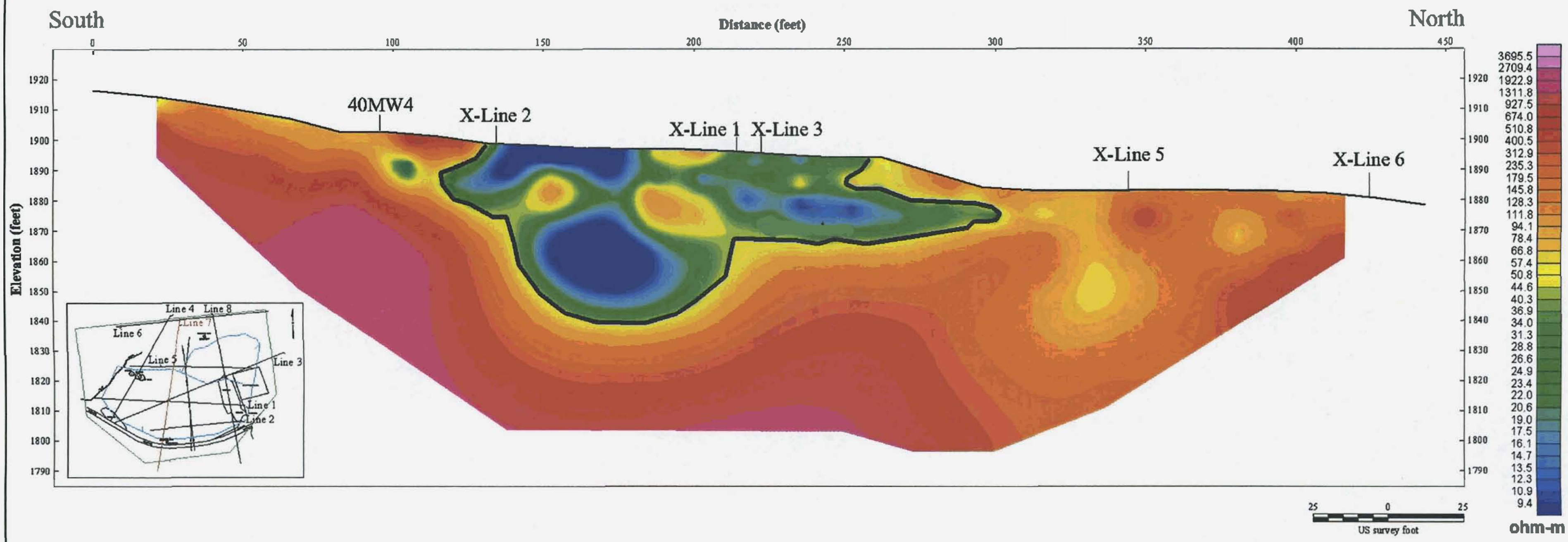
Scale: AS SHOWN

File Name: Figure 1-11.ppt

FIGURE 1-11

PRELIMINARY RESISTIVITY DATA A



First electrode is located at 0.0ft

Last electrode is located at 442.9ft

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RFI WORK PLAN ADDENDUM: SWMU 40/71

FIGURE 1-12

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MARCH 2002

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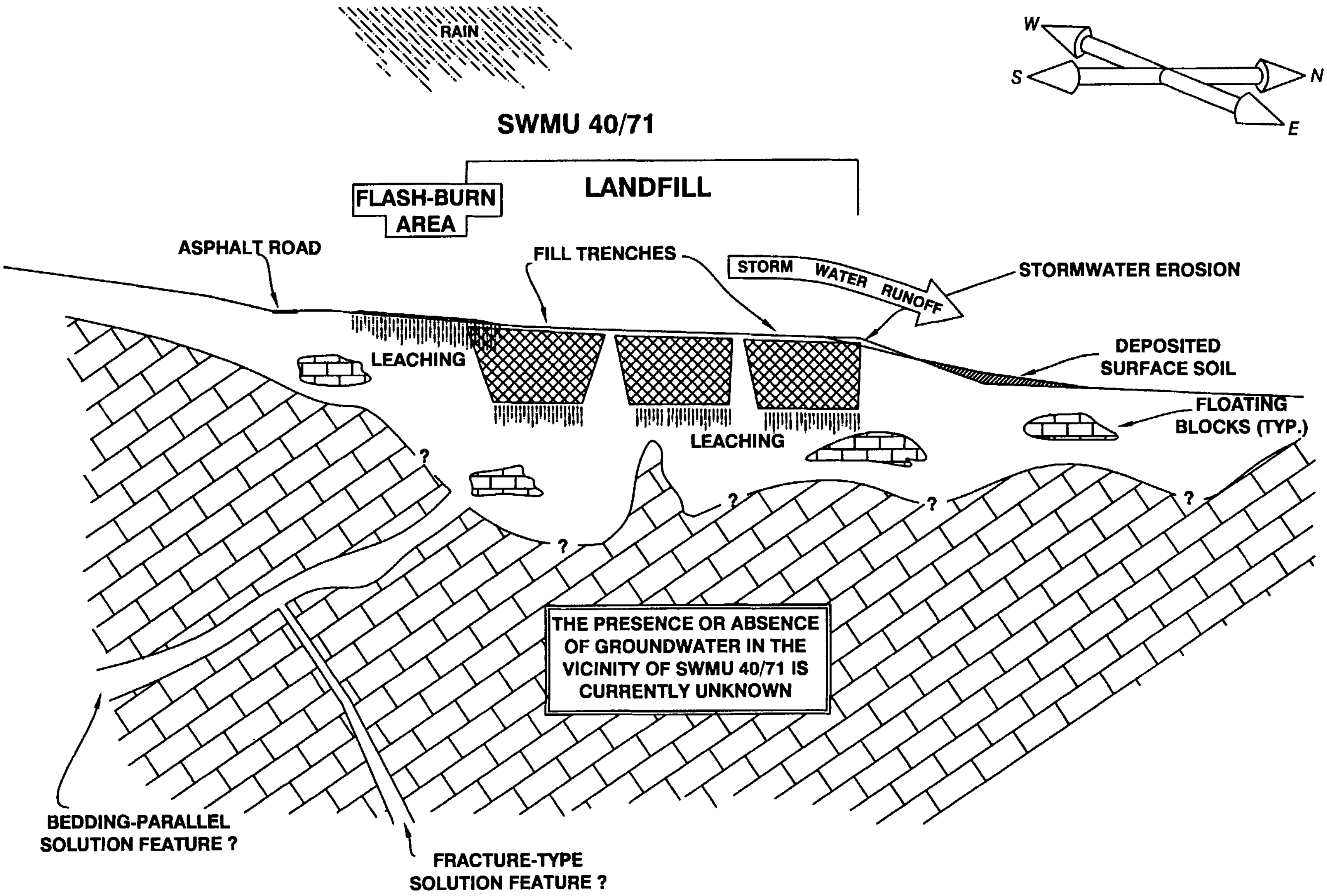
Figure 1-12.ppt

PRELIMINARY RESISTIVITY DATA B



CONCEPTUAL DRAWING, NO SCALE IMPLIED

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RFI WORK PLAN ADDENDUM: SWMU 40/71

Date: AUGUST 2002

Prepared By: URS Corp./TAL

Scale: NOT TO SCALE

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FIGURE 1-13

CONCEPTUAL SITE MODEL

leaching from these areas. The general direction of storm water runoff and potential locations of subsequent erosion and deposition are also indicated on the figure.

Depth to bedrock is shown as highly variable and unknown in the immediate SWMU 40/71 area (Dames & Moore 1992). Karstic features such as pinnacles and floating blocks are indicated on the figure; however, their existence and location are currently unknown. The figure indicates solution-enhanced epikarstic features such as solution-enhanced bedding plane and fracture features. The presence or absence of these in the immediate SWMU 40/71 area is indicated by Dames & Moore (1992).

Although current and future land-use scenarios are limited to industrial operations, both industrial and residential scenarios will be considered. Figure 1-14 presents the potential exposure pathways for each receptor. Flash burning and landfill activities potentially release constituents to the environment by direct deposition, by leaching of materials through soils, and by storm water erosion of site soils. Direct deposition affects both surficial and subsurface soils, leaching affects subsurface soils, and storm water erosion affects surface soils. Site workers and terrestrial biota are not considered potential receptors of Landfill materials due to the presence of a soil and vegetative cover. Aquatic targets are not considered potential receptors of sediment because surface water is not currently present or observed in the SWMU 40/71 area.

Potential surface and subsurface soil exposure routes typically include ingestion of soil, inhalation of soil particulate, and dermal absorption of chemicals found in soil.

1.2.5 Data Gap Analysis

Data are incomplete at SWMU 40/71 for both physical and chemical information (Table 1-4). Surface or subsurface soils sampling and/or chemical analysis have not been conducted adjacent to the Landfill. Limited soil sampling and chemical analysis have occurred in the Flash-Burn Area. Samples collected from four ft bgs have indicated the presence of contamination (arsenic and TPH); however, data regarding deeper samples (greater than four ft bgs) have not been ascertained. Chemical and physical samples of the Landfill material have not been collected. In addition, the horizontal and vertical extent of the Landfill Area and the extent to which the Landfill Area overlaps the Flash-Burn Area are currently uncertain.

Target Compound List (TCL) Volatile Organic Compounds (VOCs) – Samples were not collected for TCL VOC analysis during the previous investigations. Therefore, VOCs represent a data gap for surface and subsurface soil.

TCL Semivolatile Organic Compounds (SVOCs) / Polynuclear Aromatic Hydrocarbons (PAHs) – Oil-soaked straw was reportedly used as a fuel source in the Flash-Burn Area and TPH levels exceeding the Virginia informal action level of 100 mg/kg were reported in each of the three soil samples submitted for analysis during the VI (Dames & Moore 1992). Samples were not collected for TCL SVOC or PAH analyses during the previous investigations. Therefore, TCL SVOCs, PAHs represent a data gap for surface and subsurface soil.

TCL Polychlorinated Biphenyls (PCBs) – Samples were not collected for TCL PCB analysis during the previous investigations. Therefore, TCL PCBs represent a data gap for surface and subsurface soil.

TCL Pesticides – Samples were not collected for TCL Pesticides analysis during the previous investigations. Therefore, TCL Pesticides represent a data gap for surface soil.

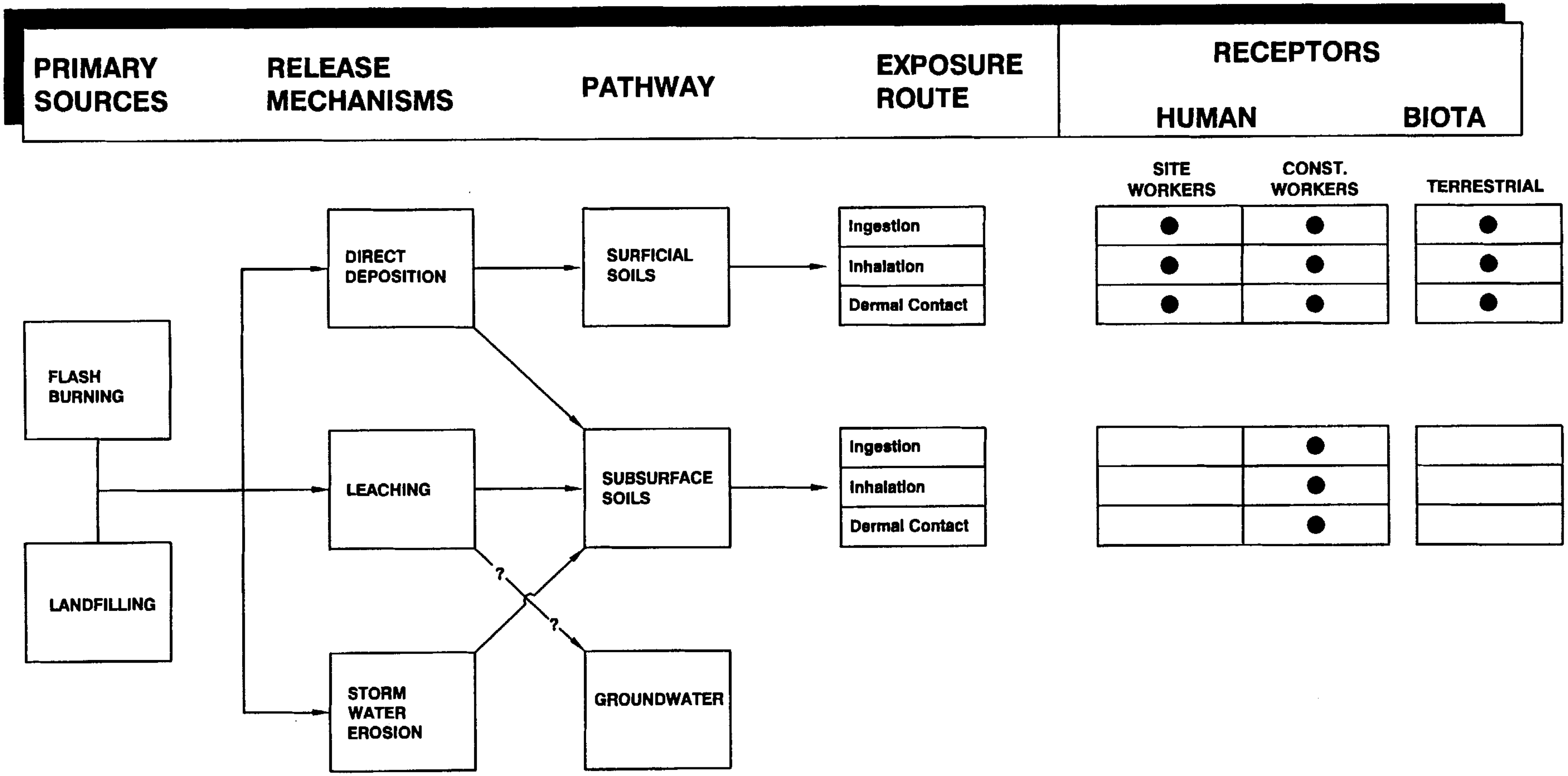

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FIGURE 1-14

CONCEPTUAL SITE MODEL

Table 1-4
Data Gap Analysis
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

	Area	Physical	Chemical
SWMU 40/71	Adjacent to Landfill	Surface Soil Samples	Chemical Data
		Subsurface Soil Samples	Chemical Data
	Flash-Burn Area	Surface Soil Samples	Chemical Data
		Subsurface Soil Samples	Chemical Data
	Landfill Material	Landfill Material Samples	Chemical Data/Waste Characteristic Data
		Fill Material Location: General and with respect to Flash-Burn Area	Not Applicable
	Site-Wide Soil Characteristics	Physical/ Geotechnical Properties	Organic Content & pH
	Presence/Absence of Sinkhole	Ground-truthed Geophysical Data, Revised Two Dimensional Resistivity Geophysics Interpretation	Not Applicable

Explosives – Explosives were not detected in three surface soil samples collected from the Flash-Burn Area during the VI (Dames & Moore 1992). Samples have not been collected and analyzed for explosives from the Landfill Area, the Cindered Area, or the Northern Scarp. Therefore, explosives represent a data gap for surface and subsurface soil.

TAL Metals – Surface soil samples collected from the Flash-Burn Area during the VI (Dames & Moore 1992) and the VI: Phase II (Dames & Moore 1994) were analyzed for TAL Metals. Results of the analyses indicated that arsenic was present at levels above the 2002 Industrial RBC. Samples have not been collected and analyzed for metals from the Landfill Area, the Northern Scarp, or the Cindered Area. Therefore, TAL Metals represent a data gap for surface and subsurface soil.

Dioxins/Furans – Dioxin/furans may be formed during combustion of a variety of chlorinated organic compounds. Previous activities documented at the site include flash burning of metal process pipes and a cindered area is evident west of the asbestos storage area. Samples were not collected for dioxin/furans analysis during the previous investigations. Therefore, dioxin/furans represent a data gap for surface and subsurface soil.

Other – An analysis of the physical properties of subsurface soil to aid in assessing the nature of possible constituent mobility has not been performed during the previous investigations. Site-wide soil physical/geotechnical and chemical properties that affect constituent mobility are unknown. Therefore, the physical properties of subsurface soil represent a data gap. Studies indicate SWMU 40/71 may overlie solution features; however, an accurate understanding of subsurface soil and geology has not been developed. Because no BRA (including ecological risk screening) has been performed, potential threats to human health and ecological receptors have yet to be identified and therefore, the results of a BRA represent a data gap.

Planned field activities in support of this RFI WPA, as presented in Section 1.3, are designed to address the data gaps presented above. Table 1-5 presents the completion plan to close the aforementioned data gaps.

Table 1-5
Data Gap Analysis Completion Plan
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

	DATA GAPS			COMPLETION PLAN
	Area	**Physical**	**Chemical**	
SWMU 40/71	Adjacent to Landfill	Surface Soil Samples	Chemical Data	Advance soil borings (§1.3.2), collect samples for chemical analysis; collect surface soil samples for chemical analysis (§1.3.3); perform BRA.
		Subsurface Soil Samples	Chemical Data	
	Flash-Burn Area	Surface Soil Samples	Chemical Data	
		Subsurface Soil Samples	Chemical Data	
	Landfill Material	Landfill Material Samples	Chemical Data	Excavate a test pit (§1.3.1), collect samples for chemical analysis; perform BRA.
		Fill Material Location: General and with Respect to Flash-Burn Area	N/A	
	Site-Wide Soil Characteristics	Physical/ Geotechnical Properties	Organic Content and pH	Collect samples for geotechnical and physical properties analysis (§1.3.2).
	Presence/Absence of Sinkhole	Ground-truthed Geophysical Data, Revised Two-dimensional Resistivity Geophysics Interpretation	N/A	Advance soil borings (§1.3.2) to characterize subsurface geology, bedrock refusal.
	N/A = Not Applicable		§ = Section Number	

1.3 PLANNED FIELD ACTIVITIES

The SWMU 40/71 RFI field program is designed to address the data gaps presented in Table 1-4 above. The selection of the locations of areas to be investigated and soil samples to be collected considered the following and follows SOP 30.7, Sampling Strategies, Section 3.2.1, Biased Sampling (included in Appendix A):

- The size and shape of SWMU 40/71;
- Evaluation of the potential for leaching of constituents through site soils;

- Generation of data that can be used to evaluate residual risk through a screening comparison to USEPA Region III RBCs (Residential and Industrial), the Facility-Wide Background Study (IT 2002) and a BRA subdivided into HHRA and Screening-Level ERA; and
- Determination of the nature of subsurface geology.

The MWP is referenced where routine activities will be performed in accordance with the MWP specifications. Variances to the specifications will be documented in this WPA.

Components of the investigation will include the following:

- Geophysical anomaly excavation;
- Surface and subsurface soil sampling and sample collection by direct push technology (Geoprobe®) methods; and
- Surface soil sampling.

Other related components of the investigation will include boring abandonment, stratigraphic logging of soil borings, sample management, portable photoionization detector (PID) screening, documentation, laboratory analysis, quality assurance practices, evaluation of the data relative to USEPA Region III RBCs (Residential and Industrial), and performance of a BRA (see MWP Sections 6.0 and 7.0). Investigative activities will be conducted in accordance with the SOPs in the MWP and in accordance with the Master Health and Safety Plan. Table 1-1 identifies the SOPs that will be followed as part of the investigation.

1.3.1 Geophysical Anomaly Excavation

Preliminary geophysical data obtained by URS (Geophex 2001) indicate the possible horizontal and vertical extent of conductive and/or metallic zones that are preliminarily interpreted as:

- The probable horizontal extent of fill materials;
- The probable depth of fill materials; and
- The probable presence of subsurface trenches.

A Test Pit will be excavated using a power excavator to ground truth portions of the geophysical data, to collect representative samples of fill materials, and to obtain physical information regarding the nature of burial and buried items at the site.

The proposed Test Pit location is presented on Figure 1-15. The location of Test Pit #1 was chosen based on the presence of preliminarily identified geophysical anomalies in each data platform (EM, vertical magnetic gradient, apparent conductivity, and resistivity) in the northwestern portion of the fill area.

This decision depends upon the assumption that the field geologist will be able to delineate Landfill material from *in situ* soil. The Test Pit may need to be offset after initial trenching based on these decision errors. Three Test Pit offsets on ten-foot centers will be allowed prior to Test Pit relocation (i.e., greater than 30 foot offset).

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Test Pit excavation will follow the protocols set forth in SOP 20.4, Test Pits. Proposed deviations from SOP 20.4 are as follows:

- The Test Pit will be ten ft long by two ft wide by five ft deep with 45-degree sloping;
- Excavated material will be placed into roll-off containers and staged on the site. Following Test Pit excavation, samples for RCRA waste characteristics (IDM, Section 1.3.5) will be collected at a rate of one composite sample per ten cubic yards of staged material;
- Three discrete samples will be collected from the Test Pit and will represent:
  - One sample of excavated "fill material";
  - One sample of sidewall material; and
  - One sample of excavation bottom material.
- Discrete samples will be collected in accordance with SOP 30.1, Section 3.2 for surface soil samples;
- Discrete samples will be analyzed for TCL VOCs, TCL SVOCs, PAHs, TCL Pesticides, TCL PCBs, explosives (including nitroglycerin), mercury and TAL Metals in accordance with the Master Quality Assurance Plan (MQAP) and Section 2.0 of this WPA;
- The Test Pit will be digitally photographed, sketched and a description will be recorded in the field notebook (SOP 10.1). In addition, the corners of the Test Pit will be surveyed by a licensed Virginia Land Surveyor, and incorporated into the existing site survey;
- Following excavation and sampling, the Test Pit will be backfilled to within two ft of existing grade with clean Virginia Department of Transportation (VDOT) #57 stone or similar material; and
- The top two ft of the excavation will be backfilled with clean soil. Appropriate geotextile filter fabric will be placed on top of the VDOT #57 stone prior to backfilling with clean soil to minimize soil infiltration into the stone backfill material. Soil will be mounded sufficiently during backfilling to compensate for potential settlement of fill over time. Placement of grass seed and straw will complete restoration of the excavation area.

1.3.2 Soil Borings

Fourteen soil borings will be advanced at SWMU 40/71, both outside of the probable limits of fill material and within the probable limits of fill materials to:

- Evaluate the possible chemical impacts of the fill material upon site soils;
- Collect soil samples for analysis of physical/geotechnical characteristics; and
- Ground truth the preliminary geophysical data.

Soil borings will be advanced to bedrock refusal using direct push technology, consistent with the procedures outlined in SOP 20.11. Bedrock is anticipated to be present at approximately 15 ft bgs. If probe refusal is encountered at less than 15 ft bgs, the unit will be offset five ft and a boring will be advanced to the point of previous refusal prior to collection of additional samples. Borings will be offset two times prior to relocation (i.e., greater than ten-ft offset from original location). A four-foot Macro-

Core® device will be used to collect the samples. Stratigraphic logs will be prepared for each boring location in accordance with the procedures outlined in SOP 10.3 in the Appendix A.

Proposed boring locations are presented on Figure 1-15:

- Borings 40SB2, 40SB4, 40SB5, 40SB7, 40SB8, 40SB11, and 40SB12 are proposed within areas preliminarily identified as having Landfill material present. These locations are designed to provide information regarding 1) the soil cover overlying the fill materials, 2) the nature and extent of the fill materials, and 3) the physical and chemical nature of *in situ* soils directly underlying fill materials and at depth (above bedrock);

- Borings 40SB1, 40SB3, and 40SB6 are proposed adjacent to areas preliminarily identified as having fill material present. These locations are designed to provide information regarding the boundaries of Landfill materials and the effect of fill materials on soils adjacent to the Landfill;

- Boring 40SB9 is proposed in the eastern-central portion of the Landfill, within an area preliminarily identified as having fill material present. Preliminary geophysical data indicates that a conductive zone may be present to depths of up to 80 ft bgs in this area. A soil boring is proposed to be advanced in this area to evaluate the nature of this deep conductive zone. This boring is designed to provide information regarding 1) the soil cover overlying the Landfill materials, 2) the nature and extent of the Landfill materials, 3) the physical and chemical nature of *in situ* soils directly underlying Landfill materials and at depth (above bedrock), and 4) physical information regarding the geophysical signature of the conductive zone and to assist in determining if constituents may have migrated downward through the conductive zone;

- Borings 40SB10 and 40SB13 are both proposed outside of areas preliminarily identified as having landfill materials present. Boring 40SB10 is located north-northeast of the SWMU 40/71 in the area identified as the "clean" construction-related soils stockpile, whereas boring 40SB13 is located within the fenced asbestos storage area. Both locations are designed to provide information regarding the Landfill boundaries and the nature of the northeastern area; and

- Boring 71SB1 is proposed in the Flash-Burn Area. This location is outside of the Landfill Area. This location is designed to provide additional data regarding possible contamination in the Flash-Burn Area for both surface and subsurface soils. Previous samples collected in the area were limited to four ft bgs.

During drilling, subsurface soil samples will be screened for the presence of VOCs using a PID consistent with SOP 90.1 included in Appendix A. Soil samples will be collected from each boring including:

- A surface sample (i.e., zero to six inches bgs, below gravel or organic layers; six to 12 inches bgs for VOCs);

- A sample from an intermediate point in the overburden or, in the event that it can be demonstrated in the field via visual observation that a boring penetrates fill materials, a fill material sample and a sample of *in situ* soil from within six to 12 inches below the presumed base of fill materials; and

- A sample from the base of the overburden above bedrock.

Thus, either three samples (if no fill penetrated) or four samples (if fill penetrated) will be generated from each boring. Samples will be analyzed for TCL VOCs, TCL SVOCs, PAHs, TCL Pesticides (surface soils), TCL PCBs, explosives (including nitroglycerin), mercury, and TAL Metals consistent with the requirements of the MQAP and Section 2.0 of this WPA. In addition, two samples collected in the Flash-Burn Area will be analyzed for dioxin/furans. The location of the soil borings will be located to the nearest meter using Global Positioning System (GPS) equipment.

In addition to samples submitted for chemical analysis, up to four soil samples representative of each major change in primary lithology (i.e., clay, silt, sand, gravel) will be collected for analysis of physical and geotechnical properties (Section 5.8 of the MWP; applicable American Society for Testing and Materials. Samples will be analyzed for the following parameters in accordance with the QAPA in Section 2.5.4 of this document:

- Grain-size analysis (ASTM D 422-98);
- Atterburg limits (ASTM D 4318-00);
- Soil moisture content (ASTM D 2216-98e1);
- Total organic content (ASTM D 2974-00);
- Soil bulk density (ASTM D 4253-00);
- Measurement of hydraulic conductivity (ASTM D 5084-00e1 and D 5856-95(2000));
- Soil porosity (ASTM D 854-00 and D 2937-00); and
- pH (ASTM D 4972-01).

These analyses are intended to enhance the understanding of the physical nature of site soils to provide data necessary for constituent migration modeling, if necessary. Proposed boring locations have been placed on or adjacent to resistivity data collection lines to facilitate ground truthing of geophysical data.

1.3.3 Surficial Soil Sampling

Surficial soil samples from the Northern Scarp, Cindered Area, and Flash-Burn Area will be analyzed for TCL VOCs, TCL SVOCs, PAHs, TCL Pesticides, TCL PCBs, explosives (including nitroglycerin), and TAL Metals consistent with the requirements of the MQAP and Section 2.0 of this WPA. In addition, one surficial sample from the Cindered Area and one surficial sample from the Flash-Burn Area will be analyzed for dioxin/furans. Each sampling location will be digitally photographed, sketched, and described. In addition, the location of the sampling points will be identified to the nearest meter using GPS equipment.

1.3.3.1 Northern Scarp

As indicated in Section 1.2.4, deposition of soil derived from the area of SWMU 40/71 likely occurs along the base of the Northern Scarp as evidenced by topographic mounding in the area and following the geomorphic principles of deposition/erosion associated with changes in profile and grade. Three surficial soil samples will be collected to address the possible migration of constituents from the SWMU

40/71 area to surficial soil via this pathway. Soil samples will be collected in accordance with SOP 30.1 (Appendix A) for surface soil samples.

Figure 1-15 presents three proposed surface soil sample locations along the Northern Scarp. Sample 40SS1 is located on a minor topographic mound that is proximal to a distinct erosion gully in the Northern Scarp. The gully appears to represent the primary drainage of the western portion of the SWMU 40/71 area, including the Flash-Burn Area. It is designed to indicate whether constituents have migrated outside of the western portion of the SWMU 40/71 Landfill and Flash-Burn Area to adjacent surficial areas via erosion and subsequent deposition.

Sample 40SS2 is located within an erosion gully below the topographic grade of the Northern Scarp. The location is proximal to a distinct erosion gully in the Northern Scarp. Based on site topography, this may be the primary drainage feature of the central SWMU 40/71 area. It is therefore designed to indicate if constituents may have migrated outside of the fill area to adjacent surficial areas via erosion and subsequent deposition.

Sample 40SS3 is on top of a topographic mound of depositional material that is proximal to a distinct erosion gully in the Northern Scarp. The gully appears to represent the primary drainage of the eastern portion of the SWMU 40/71 area. It is designed to indicate if constituents may have migrated outside of the eastern portion of the fill area to adjacent surficial areas via erosion and subsequent deposition.

1.3.3.2 Cindered Area

As indicated in Section 1.2.2, an area of burned material is present west of the asbestos storage area. Two sampling locations are proposed in this Cindered Area to address data gaps regarding the nature of burned materials and the potential for contaminant migration to subsurface soils.

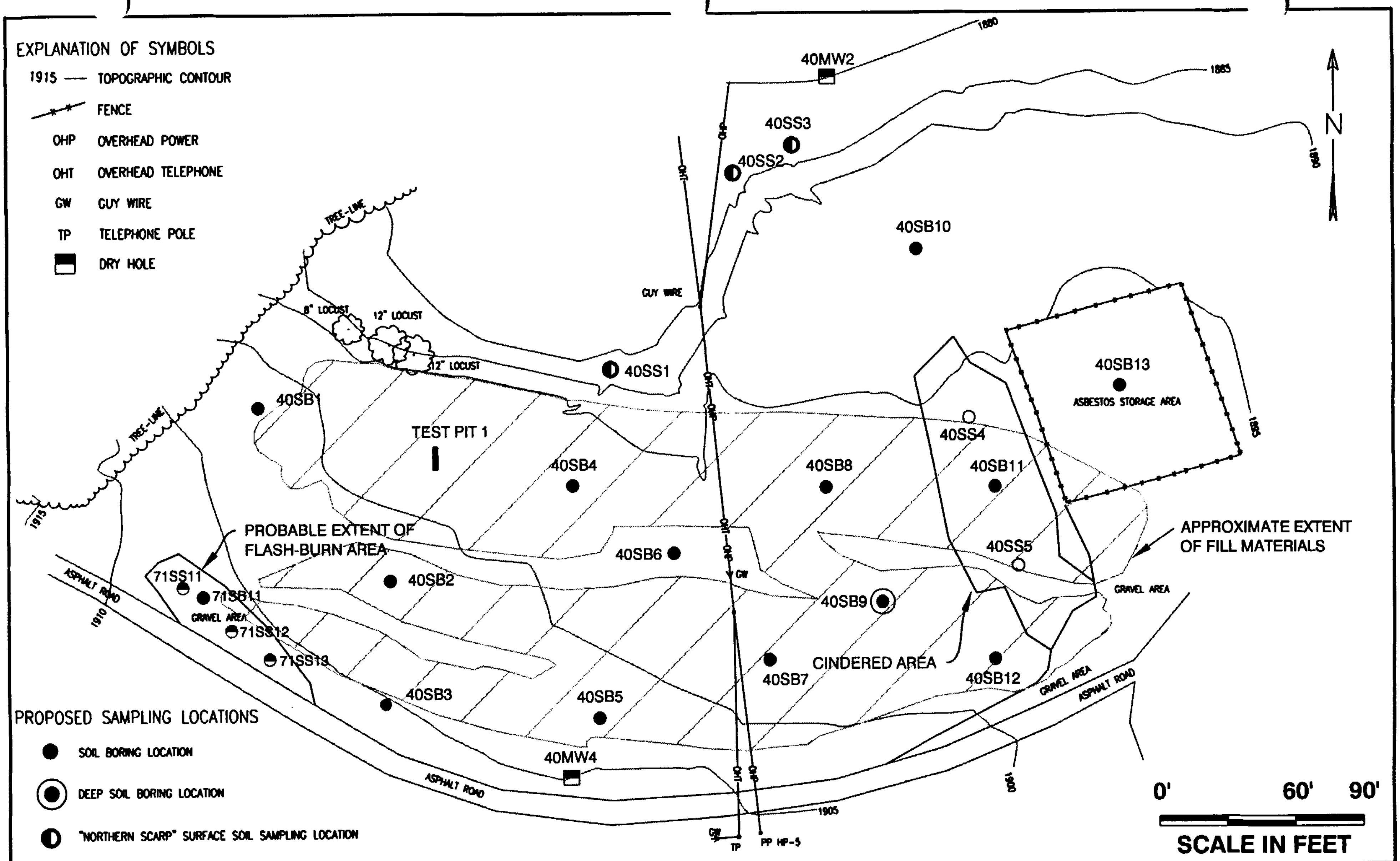
Samples 40SS4 and 40SS5 are proposed in the Cindered Area. A sample of surface material will be collected from each location in accordance with SOP 30.1 for surficial soil sampling.

1.3.3.3 Flash-Burn Area

Three sampling locations are proposed to further characterize surficial soils in the Flash-Burn Area. Samples 71SS11, 71SS12, and 71SS13 are proposed in the Flash-Burn Area (Figure 1-15). A sample of surface material will be collected from each location in accordance with SOP 30.1 for surficial soil sampling.

1.3.4 Investigation-Derived Material Handling and Disposal

Activities conducted during this investigation will comply with the relevant Occupational Safety and Health Administration (OSHA) and USEPA regulations regarding the identification, handling, and disposal of non-hazardous and hazardous Investigation-Derived Material (IDM). Activities will be performed in accordance with the Installation safety rules, protocols, and SOP 70.1. Table 1-6 summarizes the suspected nature (hazardous versus non-hazardous) of the materials that are expected to be produced during investigative activities.



PROPOSED SAMPLING LOCATIONS

● SOIL BORING LOCATION

◉ DEEP SOIL BORING LOCATION

◐ "NORTHERN SCARP" SURFACE SOIL SAMPLING LOCATION

○ "CINDERED AREA" SURFACE SOIL SAMPLING LOCATION

⊖ FLASH-BURN AREA SURFACE SOIL SAMPLING LOCATION

▮ TEST PIT LOCATION

THIS DRAWING IS IN VIRGINIA STATE PLANE COORDINATE SYSTEM WHICH HAS BEEN ADJUSTED BY A COMBINED SCALE AND ELEVATION FACTOR OF 1.00013. DIVISION OF COORDINATE VALUES FROM THIS DRAWING BY THAT FACTOR WILL YIELD VIRGINIA STATE PLANE COORDINATE, NAD 83 VALUES. THE U.S. SURVEY FOOT WAS USED IN THE CONVERSION FROM METRIC TO ENGLISH UNITS.

RFAAP

RFI WORKPLAN ADDENDUM: SWMU 40/71

Date: *AUGUST 2001*	**Prepared By:** *URS Corp./TAL*
Scale: *AS SHOWN*	**File Name:** *P:\...\09604-258.WPA.1-15*

FIGURE 1-15

PROPOSED SAMPLING LOCATIONS

Table 1-6
Handling and Disposal of Investigation-Derived Materials
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

Area	Material	Description	Quantity	Concern	Action	Expected Nature of Material
SWMU 40/71	Soil cuttings	From 14 borings	Approx. two 55-gal drums	COCs	TCLP VOCs, TCLP SVOCs, Ignitability, Corrosivity, Reactivity and Paint Filter Liquids	Non-hazardous. Concentrations are not expected to exceed TCLP, or pH limits.
SWMU 40/71	Decontamination water	Aqueous IDM	Approx. three 55-gal drums	IDM	TCLP VOCs, TCLP SVOCs, Ignitability, Corrosivity, Reactivity and Paint Filter Liquids	Non-hazardous. Concentrations are not expected to exceed TCLP, or pH limits.
Geophysical Anomoly Excavation Test Pit	Soil	Soil Stockpiled from Trench Excavation	Approx. 10-20 cubic yards	IDM	TCLP VOCs, TCLP SVOCs, Ignitability, Corrosivity, Reactivity and Paint Filter Liquids	Non-hazardous. Concentrations are not expected to exceed TCLP, or pH limits.
SWMU 40/71	PPE	Miscellaneous IDM	Approx. three 55-gal drums	IDM	--	Non-hazardous material. Will be disposed as IDM.

Notes:
SWMU = Solid Waste Management Unit
Approx. = Approximately
COC = Chemical of Concern
IDM = Investigation-Derived Material
TCLP = Toxicity Characteristics Leaching Procedure
COD = Chemical Oxygen Demand
PPE = Personal Protective Equipment and Clothing
SVOC = Semivolatile Organic Compound
VOC = Volatile Organic Compound
gal = Gallon

2.0 QUALITY ASSURANCE PLAN ADDENDUM

2.1 INTRODUCTION

This QAPA establishes function-specific responsibilities and authorities to ensure data quality for investigative activities at RFAAP. The project objectives will be met through the execution of the SOPs included in the MWP and appended to this document. The applicable SOPs are referenced below. Specific QC requirements include development of DQOs, performance of internal QC checks, and execution of appropriate analytical procedures during investigative activities. This QAPA is designed to be used in conjunction with the MQAP. Table 2-1 provides a list of general quality assurance (QA) measures that will be implemented as specified in the MQAP.

Table 2-1
Quality Assurance Measures Discussed in the MQAP
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

Quality Assurance Measure	Section in MQAP	SOP No. (MWP Appendix A and Appendix A of WPA No. 14)
Project Organization and Responsibilities	2.0	--
Lines of Authority	2.2	--
Chemical Data Measurements	3.2	--
Levels of Concern	3.3	--
Site Investigation	4.0/5.0	20.1, 20.3, 20.4, 20.11 30.1, 30.7, 30.9, 50.1, 50.2, 70.1, 80.1
Documentation Requirements	5.6	10.1, 10.2, 10.3, 50.1
Chain-of-Custody Requirements	5.7	10.4, 50.2
Calibration Procedures	7.0	90.1
Data Reduction, Validation, Reporting, and Management	9.0	--
Corrective Action	10.0	--
Quality Assessments	11.0	--

The distribution list for submittals associated with the RFI Program at SWMU 40/71 is defined in the Facility Permit (USEPA, 2000b) and is as follows:

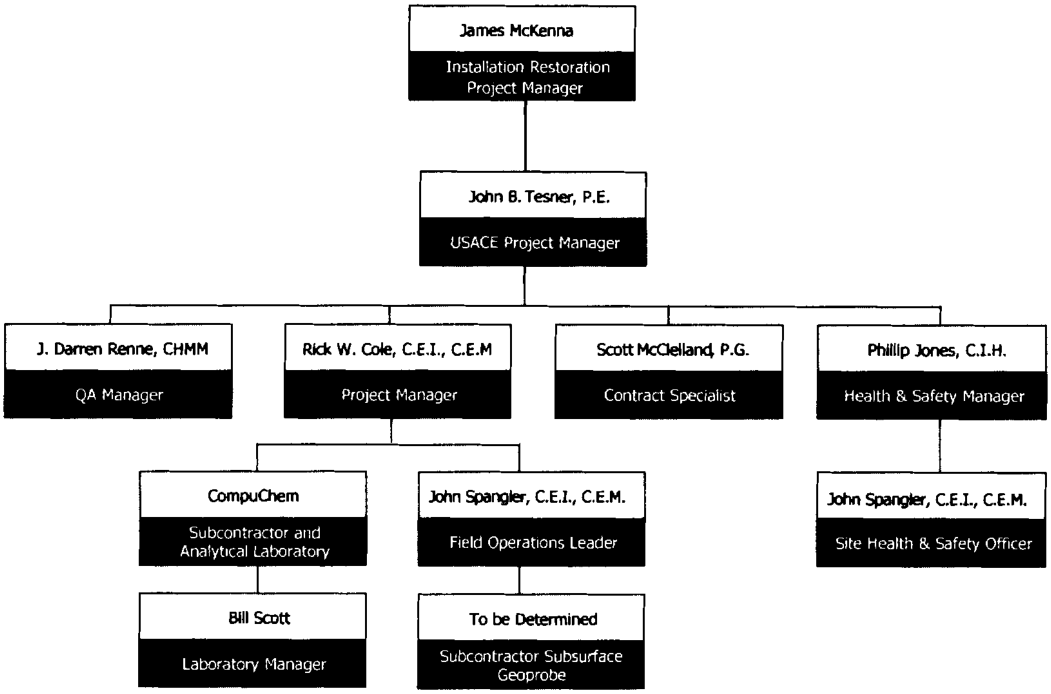
> At least six copies of draft documents and three copies of the final plans, reports, notifications, or other documents submitted as part of the SWMU 40/71 RFI are to be submitted to the USEPA Regional Administrator, and shall be sent Certified Mail, Return Receipt Requested, overnight mail, or hand-carried to:
>
> Federal Facilities Branch (3HS13)
> USEPA Region III
> 1650 Arch Street
> Philadelphia, Pennsylvania 19103
>
> In addition, one copy each of such submissions shall be sent to both:
>
> Commonwealth of Virginia
> Department of Environmental Quality
> Waste Division
> P.O. Box 10009
> Richmond, Virginia 23240
>
> And
>
> Commonwealth of Virginia
> Department of Environmental Quality
> West Central Regional Office
> Executive Office Park, Suite D
> 5338 Peters Creek Road
> Roanoke, - 24109

2.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

2.2.1 Contractor and Subcontractor Responsibilities

Contractor and subcontractor personnel requirements for implementing the technical, quality, and health and safety programs are described in Section 2.1 of the MQAP. Figure 2-1 presents the identification and the organization of project management personnel.

Figure 2-1
Project Organizational Chart
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia



2.2.2 Key Points of Contact

Table 2-2 provides the names and points of contact for URS personnel and subcontractors.

The Project Manager (PM) is responsible for ensuring that activities are conducted in accordance with contractual specifications, the Statement of Work (SOW), and approved work plans. The PM will also provide technical coordination with the Installation's designated counterpart. The PM is responsible for management of operations conducted for this project. In addition, the PM will ensure that personnel assigned the project, including subcontractors, will review the technical plans prior to initiation of each task associated with the project. The PM will monitor the project budget and schedule and will ensure availability of necessary personnel, equipment, subcontractors, and services. The PM will participate in the development of the field program, evaluation of data, reporting, and the development of conclusions and recommendations.

The QA Manager is responsible for ensuring that the QA procedures and objectives in the project-specific work plans are met, reviewing field and analytical data to ensure adherence to QA/QC procedures, and approving the quality of data prior to inclusion in associated reports. This may include the performance of field and laboratory audits during the investigation. In addition, the QA Manager will be responsible for the review, evaluation, and validation of analytical data for the project and will participate in interpreting and presenting analytical data. QC coordination is under the technical guidance of the QA Manager to direct the task leaders on a day-to-day or as-needed basis to ensure the application of QA/QC procedures.

Table 2-2
Contractor and Subcontractor Key Points of Contact
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

Contractor	Key Point of Contact
Project Manager, Rick Cole e-mail: rick_cole@urscorp.com	URS Group, Inc. 5540 Falmouth Street, Suite 201 Richmond, Virginia 23230 Tel: 804.474.5417; Fax: 804.965.9764
Health and Safety Manager, Phillip Jones e-mail: phillip_l_jones@urscorp.com	URS Group, Inc. 1400 Union Meeting Road, Suite 202 Blue Bell, Pennsylvania 19422-1972 Tel: 215.619.4160; Fax: 215.542.3888
Quality Assurance Manager, J. Darren Renne e-mail: darren_renne@urscorp.com	URS Group, Inc. 5540 Falmouth Street, Suite 201 Richmond, Virginia 23230 Tel: 804.474.5449; Fax: 804.965.9764
Contracts Specialist, Scott McClelland e-mail: scott_mcclelland@urscorp.com	URS Group, Inc. 5540 Falmouth Street, Suite 201 Richmond, Virginia 23230 Tel: 804.474.5449; Fax: 804.965.9764
Field Operations Leader and Site Health and Safety Officer, John Spangler e-mail: john_spangler@urscorp.com	URS Group, Inc. 5540 Falmouth Street, Suite 201 Richmond, Virginia 23230 Tel: 804.474.5419; Fax: 804.965.9764
Subcontractor	**Key Point of Contact**
Analytical Laboratory Services CompuChem Laboratories, Inc. e-mail: bscott@compuchemlabs.com	Bill Scott Cary, North Carolina Tel: 919.679.4024; Fax: 919.379.4050
Subsurface (Geoprobe®) Not yet identified	Not Applicable

The Health and Safety Manager will review and internally approve the HSPA, which will be tailored to the specific needs of the project in the task specific addendum. In consultation with the PM, the Health and Safety Manager will ensure that an adequate level of personal protection exists for anticipated potential hazards for field personnel. On-site health and safety will be the responsibility of the SHSO who will work in coordination with the PM and the project Health and Safety Manager.

The Field Operations Leader will provide management of the field activities during the fieldwork. The Field Operations Leader is responsible for ensuring that technical matters pertaining to the field program are addressed. They will participate extensively in data interpretation, report writing, and preparation of deliverables, and will ensure that work is being conducted as specified in the technical plans. In addition, the Field Operations Leader is responsible for field QA/QC procedures, and for safety-related issues. Prior to initiation of field activities, the Field Operations Leader will conduct a field staff orientation and briefing to acquaint project personnel with the sites and assign field responsibilities

The Contract Specialist is responsible for tracking funds for labor and materials procurement and oversight of the financial status of the project. Responsibilities include:

- Preparation of monthly cost reports and invoices;
- Administration of equipment rental, material purchases, and inventory of supplies;
- Administration and negotiation of subcontracts and interaction with the Administrative Contracting Officer and Procurement Contracting Officer on contract and subcontract issues;
- Preparation of project manpower estimates;
- Administration of contract documents.

2.3 QUALITY ASSURANCE OBJECTIVES

QA is defined as the overall system of activities for assuring the reliability of data produced. Section 2.1, of this WPA, references investigative, chemical, and regulatory measures associated with the Quality Assurance Objectives of this project. Conformance with appended SOPs will ensure attainment of QA objectives. The system integrates the quality planning, assessment, and corrective actions of various groups in the organization to provide the independent QA program necessary to establish and maintain an effective system for collection and analysis of environmental samples and related activities. The program encompasses the generation of complete data with its subsequent review, validation and documentation.

The Data Quality Objective (DQO) process is a strategic planning approach to ensure environmental data is of the appropriate type, quantity, and quality for decision making. Project-specific DQOs are included in Table 2-3 for investigative activities.

The overall QA objective is to develop and implement procedures for sample and data collection, shipment, evaluation, and reporting that will allow reviewers to assess whether the field and laboratory procedures meet the criteria and endpoints established in the DQOs. DQOs are qualitative and quantitative statements that outline the decision-making process and specify the data required to support corrective actions. DQOs specify the level of uncertainty that will be accepted in results derived from environmental data. *Guidance for the Data Quality Objectives Process* (USEPA 1994), and *Data Quality Objective Process for Hazardous Waste Sites* (USEPA 2000a) formed the basis for the DQO process and development of RFAAP data quality criteria and performance specifications.

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Table 2-3
Summary of Project Data Quality Objectives
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

DQO Element	Project DQO Summary
Problem Statement	• The nature and extent of potential contamination of the Landfill Area at SWMU 40/71 is currently unknown. • Possible risks to human health and the environment are currently unknown.
Identify Decision/Study Question	• Analyze geophysical data in conjunction with excavation of Landfill Area. • Collect samples representative of Landfill materials. • Conduct surface/subsurface soil sampling outside the Landfill Area to characterize potential impact to surrounding soils. • Collect subsurface soil samples for analysis of physical properties to aid in determining the nature of possible constituent migration.
Decision Inputs	• Geophysical Data: EM, magnetic gradient, down-hole logging, resistivity. • Field investigation data: soil borings and samples. • Chemical analyses: submit soil samples to USACE-approved off-site analytical laboratory for analyses.
Study Boundaries	• Physical horizontal boundary of SWMU 40/71 will be defined within the scope of the RFI by combining geophysical and soil boring information. • Sample points designed to collect samples representative of fill materials, nearby, and potentially affected soils.
Decision Rule	• Comparison between USEPA Region III RBC, Industrial Soil (USEPA 2002); as modified for risk screening). • Geophysical data will be calibrated to soil boring data and Test Pit data and will then be used to estimate the extent of Landfill materials.
Tolerable Limits on Decision Errors	• Analytical SW-846 Test Methods (USEPA 1997) reporting limits. USEPA Contract Laboratory Program (CLP)-like raw data package (Level IV) suitable for validation. • Improper estimate of the location of Landfill material. The Test Pit may need to be relocated after initial trenching based on these decision errors.
Optimize the Design for Obtaining Data	• Test Pit, Soil Borings, and Soil Sampling locations have been placed to provide the most information. • Ground truthing of geophysical data will provide for calibrated geophysical data; a more accurate CSM will be developed.

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The DQO process consists of the seven steps specified below.

1. **State the Problem:** Define the problem to focus the study. Specific activities conducted during this process step include (1) the identification of the planning team, (2) identification of the primary decision-maker, and (3) statement of the problem.

   1) The planning team consists of the RFAAP, USACE, USEPA, Virginia Department of Environmental Quality (VDEQ), the RFAAP operating contractor, and URS;

   2) Relative to the implementation of this Work Plan Addendum, the primary decision-maker is RFAAP, in consultation with USACE, USEPA, VDEQ, and URS; and

   3) RFAAP seeks to define the nature and extent of Landfill materials at SWMU 40/71 and to describe what risk to human health and the environment exists at SWMU 40/71.

2. **Identify the Decision:** Define the decision statement that the study will attempt to resolve. Activities conducted during this step of the process involve (1) identification of the principal study question(s) and (2) definition of resultant alternative actions.

   1) What is the nature and extent of Landfill materials at SWMU 40/71? How has the presence of those materials affected human health or the environment based upon comparison of site conditions to levels established in the USEPA Region RBCs?

   2) Resultant alternative actions include:

      - Analyze geophysical data in conjunction with excavation and soil borings completed within and around Landfill and Flash-Burn Areas;
      - Collect and chemically analyze samples representative of Landfill materials;
      - Collect and chemically analyze surface/subsurface soil sampling outside of and beneath the Landfill Area to characterize potential impact to surrounding soils;
      - Collect and chemically analyze surface soil samples; and
      - Collect and analyze subsurface soil samples for physical properties to aid in determining the nature of possible constituent migration.

3. **Identify Inputs to the Decision**: Identify information inputs required for resolving the decision statement and determining which inputs require environmental measures. This step of the process includes identification of the data that will be required to make the decision, determination of the information source, identification of data required for study action levels, and confirmation of appropriate field sampling and analytical methods.

   1) Excavation of selected areas within the Landfill:

      - Excavate one Test Pit within the Landfill Area to define the nature of Landfill materials; and

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- Collect soil/fill samples representative of Landfill materials and potentially affected media.

2) Collection of field soil data from SWMU 40/71:

   - Collect discrete soil samples from the vertical column in each of 14 boring locations in the SWMU 40/71 area. Continuous intact cores will be collected from each boring. Soil samples will be collected from the surface, an intermediate point, and from the base (above bedrock) of each boring. Boring logs will be developed from information gathered during core collection;

   - Collect three samples of surface soil adjacent to erosion gullies in the northern part of the SWMU 40/71; and

   - Collect surface and shallow soil (zero to six inches bgs) from the Flash-Burn Area and the Cinder Area.

3) Ground truth preliminary geophysical data:

   - Advance one deep soil boring. The boring will be located in the area where preliminary geophysical data indicate the presence of the deepest zones of higher conductivity materials;

   - Compare Test Pit data (Part 1 of Step 3 above) to geophysical data.

   - Locate soil boring (Part 2 of Step 3 above) along resistivity profiles to match geophysical signature of bedrock to boring refusal depth and signature of soil types to soil types encountered.

4) Conduct field sampling in accordance with the MWP, attached SOPs, and approved deviation presented herein. Following proper sample collection and handling defined herein, submit samples to a USACE-approved analytical laboratory for evaluation of analytes defined herein using USEPA SW-846 Test Methods.

4. **Define the Boundaries:** Define decision statement spatial and temporal boundaries. This step specifies (1) the spatial boundary, (2) the population characteristics, applicable geographic areas and associated homogeneous characteristics, and (3) the constraints on sample collection.

   1) Physical horizontal boundary of SWMU 40/71 will be defined within the scope of the RFI by combining geophysical and soil boring information;

   2) Sample points designed to collect samples representative of fill materials, nearby, and potentially affected soils; and

   3) Subsurface karst features (pinnacles, floating blocks, etc.) pose a constraint. Boring refusal may be encountered on "false bedrock" and appropriate boring offsets should be made if refusal is encountered at significantly shallower depths than anticipated.

5. **Develop a Decision Rule:** Define (1) the parameters of interest, (2) the action levels, and (3) develop a decision rule.

   1) Parameters of interest include:

      - TAL Metals, mercury, TCL SVOCs, PAHs, TCL VOCs, TCL Pesticides, TCL PCBs, explosives and dioxin/furans; and

      - Depth to bedrock for soil borings.

   2) Action levels include:

      - To evaluate the potential risk of exposure to soil at SWMU 40/71, the discrete soil sampling data will be compared to USEPA Region III 2002 RBCs for Residential soil (at the request of USEPA Region III) and Industrial soil;

      - At the request of USEPA Region III, a HQ of 0.1 or lifetime cancer risk of $1x10^{-6}$ (whichever occurs at a lower concentration) will be used for risk screening with RBCs;

      - The RBCs will be used along with available background data to identify constituent concentrations of potential concern. Constituent concentrations that are above the RBCs will be statistically compared to the available background concentrations. Constituent concentrations less than background (95 percent (%) upper tolerance or prediction limit of pooled background samples) will be considered to be in the range of naturally occurring inorganics and, thereby, do not present additional risk greater than that from exposure to naturally occurring concentrations in background soils at the Installation; and

      - Bedrock is anticipated to be approximately 15 ft bgs.

   3) Decision rules include:

      - Analytical laboratory decision rules are presented in the laboratory QAP. These include specific action levels and decision rules based on accuracy and precision;

      - If boring refusal is encountered less than 15 ft bgs, the boring will be offset five ft and advanced to the depth of previous refusal prior to collection of additional samples; and

      - Geophysical data will be calibrated to soil boring data and Test Pit data and will then be used to estimate the extent of Landfill materials.

6. **Specify Acceptable Limits on Decision Errors:** Specify the decision-maker's tolerable limits on decision errors. This step includes identification of (1) parameter range of interest, (2) decision errors, (3) potential parameter values and probability tolerance for decision errors.

   1) Method Detection Limits (MDLs) and Reporting Limits (RLs) are established for each analyte within the suite of parameters sought. MDLs and RLs below the RBCs will ensure the data meets the DQOs. The contract laboratory will provide a CLP-like raw data package

(Level IV). Data validation will be conducted based on the MQAP, the USACE Shell Document, and USEPA Region III guidance;

2) The main baseline condition decision error is to decide that the true mean concentration of a site-related contaminant does not exceed the action level for further study when in fact the mean concentration exceeds the action level and further action is needed (Type I, false rejection). Conversely, consequences of incorrectly deciding that the true mean concentration of a site-related contaminant is above the action level when in fact the mean concentration is below the action level include spending un-necessary resources to study further or remediate a site with insignificant risk (Type II, false acceptance). Another potential decision error includes improper estimation of the location of Landfill material. This decision depends upon the assumption that the field geologist will be able to delineate Landfill material from *in situ* soil. The Test Pit may need to be offset after initial trenching based on these decision errors. Three Test Pit offsets on ten-ft centers will be allowed prior to Test Pit relocation (i.e., greater than 30 foot offset); and

3) Information from previous studies and physical features of the areas surrounding SWMU 40/71 were used to develop a sampling plan design and measurements that allow for a low probability of decision error.

7. **Optimize Data Design:** Identify data collection activities commensurate with data quality specifications. This final step in the process consists of (1) reviewing DQO outputs and existing environmental data, (2) developing data collection design alternatives, and (3) documentation of operational details and theoretical assumptions.

    1) DQO outputs will be reviewed based on the data collection activities; the validity of the data could be verified if necessary based on the review;

    2) Data collection is based upon site-specific characteristics and the end use of the data; and

    3) This addendum contains the proposed sampling design program based on the DQOs. Project documentation will be implemented in accordance with the MWP.

2.4 SAMPLE MANAGEMENT

Sample management objectives will be met through adherence to the sample identification procedures (identification convention), documentation requirements, and chain-of-custody procedures in the MWP.

2.4.1 Number and Type

Table 2-4 includes the number and types of environmental samples proposed during this investigation.

2.4.2 Sample Containers, Preservation, and Holding Times

Table 2-5 identifies analytical parameters, container and preservation requirements, and holding times.

Table 2-4
Summary of Proposed Sample Identifications and Depths
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

Sample Location	Sample Designation	SAMPLE DEPTH				
		0- 6 inches bgs*	Intermediate Depth ^A	Fill Material	Below Fill Material	Above Bedrock
LANDFILL AREA	40TP1S					
	40TP1F			x		
	40TP1PB					
	40SB1A	x				
	40SB1B		x			
	40SB1C					x
	40SB2A	x				
	40SB2F			x		
	40SB2B				x	
	40SB2C					x
	40SB3A	x				
	40SB3B		x			
	40SB3C					x
	40SB4A	x				
	40SB4F			x		
	40SB4B				x	
	40SB4C					x
	40SB5A	x				
	40SB5F			x		
	40SB5B				x	
	40SB5C					x
	40SB6A	x				
	40SB6B		x			
	40SB6C					x
	40SB7A	x				
	40SB7F			x		
	40SB7B				x	
	40SB7C					x
	40SB8A	x				
	40SB8F			x		
	40SB8B				x	
	40SB8C					x

Table 2-4 (Continued)
Summary of Proposed Sample Identifications and Depths
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

Sample Location	Sample Designation	SAMPLE DEPTH				
		0- 6 inches bgs*	Intermediate Depth ^A	Fill Material	Below Fill Materiel	Above Bedrock
LANDFILL AREA	40SB9A	x				
	40SB9F			x		
	40SB9B				x	
	40SB9C					x
	40SB10A	x				
	40SB10B		x			
	40SB10C					x
	40SB11A	x				
	40SB11F			x		
	40SB11B				x	
	40SB11C					x
	40SB12A	x				
	40SB12F			x		
	40SB12B				x	
	40SB12C					x
	40SB13A	x				
	40SB13B		x			
	40SB13C					x
	40SS1**	x				
	40SS2**	x				
	40SS3**	x				
	40SS4A**	x				
	40SS5A**	x				
FLASH-BURN AREA	71SB1A	x				
	71SB1B		x			
	71SB1C					x
	71SS11**	x				
	71SS12**	x				
	71SS13**	x				

Notes:

bgs = Below ground surface
TP =Test pit
SB = Soil boring
SS = Surface soil

F = Fill material
S = Sidewall
PB = Pit bottom
* = 6-12 inches for volatile organic compounds

A = Intermediate depth samples will be collected approximately mid-way between the surface sample and bedrock.

Table 2-5
Summary of Sample Container and Sample Preservation Requirements
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

PARAMETER	SAMPLE CONTAINER		PRESERVATION METHODS	HOLDING TIMES
	Quantity	Type		
SOLID SAMPLES				
Volatile Organic Compounds	3	5-g EnCore samplers, zero headspace	Cool to 4 ± 2°C	48 hours (must be analyzed within 48 hours or transferred to soil vial within 48 hours)
Volatile Organic Compounds – Sodium Bisulfate Preservation (Low Level)	3	60-mL glass vial, septum sealed for screening and dry weight determination; 2, 40-ml screw cap, PTFE lined, septum-sealed for analysis.	Cool to 4 ± 2°C, methanol pH <2 (except dry weight aliquot)	--
Volatile Organic Compounds – Methanol Preservation (High Level)	3	60-mL glass vial, septum sealed for screening and dry weight determination; 2, 40-ml screw cap, PTFE lined, septum-sealed for analysis.	Cool to 4 ± 2°C	14 days
Semivolatile Organic Compounds	1	250-mL wide-mouth glass container, Teflon®-lined cap	Cool to 4 ± 2°C	Extraction: 7 days Analysis: 40 days
Pesticides/Aroclors	2	250-mL wide-mouth glass container, Teflon®-lined cap	Cool to 4 ± 2°C	Extraction: 7 days Analysis: 40 days
Explosives	1	250-mL wide-mouth glass container, Teflon®-lined cap	Cool to 4 ± 2°C	Extraction: 7 days Analysis: 40 days
Metals*	1	200-g polyethylene or glass container, Teflon®-lined cap	Cool to 4 ± 2°C	6 months
Mercury*	1	500-mL polyethylene or glass container, Teflon®-lined cap	Cool to 4 ± 2°C	28 days
Dioxin/Furans	1	250-mL wide-mouth glass container, Teflon®-lined cap	Cool to 4 ± 2°C, Dark	Extraction: 30 days Analysis: 45 days
Total Organic Carbon	1	100-mL glass container, Teflon®-lined cap	Cool to 4 ± 2°C	28 days
Reactivity (percent explosive material)	1	250-mL wide-mouth glass container, Teflon®-lined cap	--	--
SOLID WASTE CHARACTERIZATION				
TCLP VOCs	1	250-mL wide-mouth glass container, Teflon®-lined cap	Cool to 4 ± 2°C	Leaching: 14 days Analysis: 14 days
TCLP SVOCs	1	250-mL wide-mouth glass container, Teflon®-lined cap	Cool to 4 ± 2°C	Leaching: 14 days Extraction: 7 days Analysis: 40 days
TCLP Pesticides	1	250-mL wide-mouth glass container, Teflon®-lined cap	Cool to 4 ± 2°C	Leaching: 14 days Extraction: 7 days Analysis: 40 days

Table 2-5 (Continued)
Summary of Sample Container and Sample Preservation Requirements
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

PARAMETER	SAMPLE CONTAINER		PRESERVATION METHODS	HOLDING TIMES
	Quantity	Type		
SOLID WASTE CHARACTERIZATION (continued)				
TCLP Herbicides	1	250-mL wide-mouth glass container, Teflon®-lined cap	Cool to 4 ± 2°C	Leaching: 14 days Extraction: 7 days Analysis: 40 days
TCLP Metals	1	250-mL wide-mouth glass container, Teflon®-lined cap	Cool to 4 ± 2°C	Leaching: 14 days Analysis: 6 months Mercury analysis: 28 days
Corrosivity, Paint Filter	1	250-mL wide-mouth glass container, Teflon®-lined cap	Cool to 4 ± 2°C	Corrosivity: 7 days Reactivity: 7 days
Reactivity (percent explosive material)	1	250-mL wide-mouth glass container, Teflon®-lined cap	–	--
AQUEOUS SAMPLES				
Volatile Organic Compounds	2	40-mL glass vials, Teflon®-lined septum cap	HCl to pH<2, Cool to 4 ± 2°C	14 days
Semivolatile Organic Compounds	2	1-liter narrow-mouth amber glass, Teflon®-lined cap	Cool to 4 ± 2°C	Extraction: 7 days Analysis: 40 days
Pesticides/Aroclors	4	1-liter narrow-mouth amber glass, Teflon®-lined cap	Cool to 4 ± 2°C	Extraction: 7 days Analysis: 40 days
Explosives	1	1-liter narrow-mouth amber glass, Teflon®-lined cap	Cool to 4 ± 2°C	Extraction: 7 days Analysis: 40 days
Metals	1	1-liter polyethylene container	HNO_3 to pH<2, Cool to 4 ± 2°C	6 months
Dioxin/Furans	2	1-liter narrow-mouth amber glass, Teflon®-lined cap	Cool to 4 ± 2°C	Extraction: 30 days Analysis: 45 days
Mercury	1	1-liter polyethylene container	HNO_3 to pH<2, Cool to 4 ± 2°C	28 days

Notes:
* = Metals and mercury sample for soil will be combined into one 500-mL bottle
VOC = Volatile Organic Compound
SVOC = Semivolatile Organic Compound
PTFE = Poly Teflon
TCLP = Toxicity Characteristic Leaching Procedure
mL = milliliter
°C = Celsius
g = gram
HCL = Hydrochloric Acid
HNO_3 = Nitric Acid

2.4.3 Sample Identification

The sample identification number will conform to past nomenclature at SWMU 40/71. The identification will consist of an alphanumeric designation related to the sampling location, media type, and sequential order according to the sampling event. The identification number will not exceed thirty-two characters for entry into Environmental Restoration Information System (ERIS). Samples will be coded in the following order to ensure a unique identification.

Site Location Code: The first two characters will be the SWMU number (i.e., 40 for SWMU 40/71).

- **Sample/Media Type:** The next two characters will be the sample/media types. In this case, the characters will be SB for soil boring, SS for surface soil, TP for Test Pit.
- **Sampling Location Number**: The next one or two characters will be the number of the sampling location (e.g., 3, 4, 5).
- **Sample Depth:** The sample representing zero to six inches bgs will be designated with an "A" after the boring number. The sample collected from intermediate depths of the boring, or from below fill materials, will be designated with a "B" following the boring number. Samples representative of fill materials will be designated with an "F." Samples collected from above bedrock, at the base of the boring will be designated with a "C." For the Test Pit samples, additional qualifiers will include "S" for sidewall and "PB" for pit bottom.
- **Duplicate:** Duplicate samples will be identified with a "D" designation followed by a numeric designation corresponding to the sequence of duplicates collected (e.g., D-1). A record of the sample that corresponds to the duplicate will be kept in the field logbook. In this manner, duplicates will be submitted as blind duplicates, eliminating the potential for laboratory bias in analysis.

Sample Identification Examples:

1) A subsurface soil sample collected above the termination depth of boring location four at SWMU 40/71 would be identified as sample 40SB4C (for SWMU 40, soil boring four, and "C" which stands for the soils above bedrock at that location).
2) Quality Control Samples: QC samples will be identified by date (month, day, year), followed by QC sample type, and sequential order number at one digit. The QC sample types include Matrix Spike (MS), Matrix Spike Duplicate (MSD), Rinse Blank (R), and Trip Blank (T).

2.4.4 Documentation

SOPs 10.1 and 10.2 in Appendix A and Section 9.8 of the MQAP specify documentation protocols.

2.5 ANALYTICAL PROCEDURES

CompuChem Laboratory, Inc. will perform off-site analytical activities. Analytical methods to be used and associated MDLs and RLs are identified in Table 2-6 through 2-13. Laboratory analyses will be in accordance with USEPA SW-846 Test Methods for the analysis of the following:

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Table 2-6
Summary of Analyte Method Detection Limits, Reporting Limits, and Risk Screening Criteria for TCL VOCs
Soil and Water Samples
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

Compound	CAS Number	Laboratory-Specific Method Detection and Reporting Limits				USEPA Region III Risk-Based Concentrations				
		Soil		Water						
		MDL mg/kg	Reporting Limit mg/kg	MDL µg/L	Reporting Limit µg/L	C/N	Soil RBC (Industrial) mg/kg	Adjusted Soil RBC (Industrial) mg/kg	Soil RBC (Residential) mg/kg	Adjusted Soil RBC (Residential) mg/kg
1,1,1-Trichloroethane	71-55-6	4.9E-04	5.0E-03	0.60	5	N	5.7E+05	5.7E+04	2.2E+04	2.2E+03
1,1,2,2-Tetrachloroethane	79-34-5	7.3E-04	5.0E-03	1.3	5	C	2.9E+01	2.9E+01	3.2E+00	3.2E+00
1,1,2-Trichloroethane	79-00-5	5.5E-04	5.0E-03	1.6	5	C	1.0E+02	1.0E+02	1.1E+01	1.1E+01
1,1-Dichloroethane	75-34-3	4.4E-04	5.0E-03	0.67	5	N	2.0E+05	2.0E+04	7.8E+03	7.8E+02
1,1-Dichloroethene	75-35-4	8.3E-04	5.0E-03	0.44	5	C	9.5E+00	9.5E+00	1.1E+00	1.1E+00
1,2-Dichloroethane	107-06-2	1.6E-04	5.0E-03	0.92	5	C	6.3E+01	6.3E+01	7.0E+00	7.0E+00
1,2-Dichloroethene (total)	540-59-0	9.1E-04	2.0E-02	1.7	10	N	1.8E+04	1.8E+03	7.0E+02	7.0E+01
1,2-Dichloropropane	78-87-5	3.0E-04	5.0E-03	0.84	5	C	8.4E+01	8.4E+01	9.4E+00	9.4E+00
2-Butanone	78-93-3	7.2E-04	1.3E-02	2.1	13	N	1.2E+06	1.2E+05	4.7E+04	4.7E+03
2-Hexanone	591-78-6	7.7E-04	1.3E-02	2.0	13	N	8.2E+04	8.2E+03	3.1E+03	3.1E+02
4-Methyl-2-pentanone	108-10-1	4.0E-04	1.3E-02	2.7	13	N	1.6E+05	1.6E+04	6.3E+03	6.3E+02
Acetone	67-64-1	9.2E-04	1.3E-02	2.7	13	N	2.0E+05	2.0E+04	7.8E+03	7.8E+02
Benzene	71-43-2	1.1E-04	5.0E-03	0.68	5	C	1.0E+02	1.0E+02	1.2E+01	1.2E+01
Bromodichloromethane	75-27-4	3.1E-04	5.0E-03	0.94	5	C	9.2E+01	9.2E+01	1.0E+01	1.0E+01
Bromoform	75-25-2	6.0E-04	5.0E-03	1.5	5	C	7.2E+02	7.2E+02	8.1E+01	8.1E+01
Bromomethane	74-83-9	6.1E-04	5.0E-03	0.98	5	N	2.9E+03	2.9E+02	1.1E+02	1.1E+01
Carbon disulfide	75-15-0	3.2E-04	5.0E-03	0.76	5	N	2.0E+05	2.0E+04	7.8E+03	7.8E+02
Carbon tetrachloride	56-23-5	6.5E-04	5.0E-03	0.78	5	C	4.4E+01	4.4E+01	4.9E+00	4.9E+00
Chlorobenzene	108-90-7	5.0E-04	5.0E-03	0.88	5	N	4.1E+04	4.1E+03	1.6E+03	1.6E+02
Chloroethane	75-00-3	6.8E-04	5.0E-03	0.46	5	C	2.0E+03	2.0E+03	2.2E+02	2.2E+02
Chloroform	67-66-3	3.2E-04	5.0E-03	0.95	5	N	2.0E+04	2.0E+03	7.8E+02	7.8E+01
Chloromethane	74-87-3	7.6E-04	5.0E-03	0.64	5	C	4.4E+02	4.4E+02	4.9E+01	4.9E+01
cis-1,3-Dichloropropene[1]	10061-01-5	3.1E-04	5.0E-03	0.68	5	C	5.7E+01	5.7E+01	6.4E+00	6.4E+00
trans-1,3-Dichloropropene[1]	10061-02-6	3.2E-04	5.0E-03	1.5	5	C	5.7E+01	5.7E+01	6.4E+00	6.4E+00
Dibromochloromethane	124-48-1	4.8E-04	5.0E-03	1.5	5	C	6.8E+01	6.8E+01	7.6E+00	7.6E+00
Ethylbenzene	100-41-4	7.5E-04	5.0E-03	1.1	5	N	2.0E+05	2.0E+04	7.8E+03	7.8E+02
Methylene chloride	75-09-2	1.6E-03	5.0E-03	1.7	5	C	7.6E+02	7.6E+02	8.5E+01	8.5E+01
Styrene	100-42-5	5.5E-04	5.0E-03	0.72	5	N	4.1E+05	4.1E+04	1.6E+04	1.6E+03
Tetrachloroethene	127-18-4	6.4E-04	5.0E-03	1.1	5	C	1.1E+02	1.1E+02	1.2E+01	1.2E+01
Toluene	108-88-3	5.0E-04	5.0E-03	1.1	5	N	4.1E+05	4.1E+04	1.6E+04	1.6E+03
Trichloroethene	79-01-6	5.3E-04	5.0E-03	0.97	5	C	1.4E+01	1.4E+01	1.6E+00	1.6E+00
Vinyl Chloride[2]	75-01-4	8.7E-04	5.0E-03	0.52	5	C	7.9E+00	7.9E+00	9.0E-02	9.0E-02
Xylenes	1330-20-7	1.3E-03	1.0E-02	2.9	10	N	4.1E+06	4.1E+05	1.6E+05	1.6E+04

Notes:

CAS = Chemical Abstract Service

MDL = Method Detection Limit

Method Detection and Reporting Limits provided by CompuChem

mg/kg = Milligram per kilogram

µg/L = Microgram per liter

RBC = Risk-Based Concentration

USEPA Region III Risk-Based Concentration (RBC) values from the April 2, 2002 RBC Table

C/N = Carcinogenic or Non-carcinogenic status

C = Carcinogenic

CI = Carcinogen with a hazard quotient of 0.1; see USEPA Region III guidance

N = Non-carcinogenic

Adjusted RBCs = a Hazard Quotient (HQ) of 0.1 applied to non-carcinogens

(1) = RBC value is for 1,3-Dichloropropene

(2) = RBCs presented are for early-life, except industrial soil RBC, which is for adult

TCL = Target Compound List

Table 2-7

Summary of Analyte Method Detection Limits, Reporting Limits, and Risk Screening Criteria for TCL SVOCs
Soil and Water Samples
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammuniton Plant, Radford, Virginia

Compound	CAS Number	Laboratory-Specific Method Detection and Reporting Limits				USEPA Region III Risk-Based Concentrations				
		Soil		Water						
		MDL mg/kg	Reporting Limit mg/kg	MDL µg/L	Reporting Limit µg/L	C/N	Soil RBC (Industrial) mg/kg	Adjusted Soil RBC (Industrial) mg/kg	Soil RBC (Residential) mg/kg	Adjusted Soil RBC (Residential) mg/kg
1,2,4-Trichlorobenzene	120-82-1	4.2E-02	3.3E-01	1.2	10	N	2.0E+04	2.0E+03	7.8E+02	7.8E+01
1,2-Dichlorobenzene	95-50-1	3.3E-02	3.3E-01	0.96	10	N	1.8E+05	1.8E+04	7.0E+03	7.0E+02
1,3-Dichlorobenzene	541-73-1	3.4E-02	3.3E-01	1.1	10	N	6.1E+04	6.1E+03	2.3E+03	2.3E+02
1,4-Dichlorobenzene	106-46-7	2.9E-02	3.3E-01	0.95	10	C	2.4E+02	2.4E+02	2.7E+01	2.7E+01
2,2'-oxybis(1-Chloropropane)	108-60-1	4.0E-02	3.3E-01	0.93	10	C	8.2E+01	8.2E+01	9.1E+00	9.1E+00
2,4,5-Trichlorophenol	95-95-4	5.0E-02	3.3E-01	1.5	10	N	2.0E+05	2.0E+04	7.8E+03	7.8E+02
2,4,6-Trichlorophenol	88-06-2	6.5E-02	3.3E-01	1.9	10	C	5.2E+02	5.2E+02	5.8E+01	5.8E+01
2,4-Dichlorophenol	120-83-2	2.2E-02	3.3E-01	0.70	10	N	6.1E+03	6.1E+02	2.3E+02	2.3E+01
2,4-Dimethylphenol	105-67-9	3.0E-02	3.3E-01	1.5	10	N	4.1E+04	4.1E+03	1.6E+03	1.6E+02
2,4-Dinitrophenol	51-28-5	1.6E-01	1.7E+00	3.5	50	N	4.1E+03	4.1E+02	1.6E+02	1.6E+01
2,4-Dinitrotoluene	121-14-2	1.3E-02	3.3E-01	0.43	10	N	4.1E+03	4.1E+02	1.6E+02	1.6E+01
2,6-Dinitrotoluene	606-20-2	2.4E-02	3.3E-01	0.73	10	N	2.0E+03	2.0E+02	7.8E+01	7.8E+00
2-Chloronaphthalene	91-58-7	3.3E-02	3.3E-01	0.74	10	N	1.6E+05	1.6E+04	6.3E+03	6.3E+02
2-Chlorophenol	95-57-8	3.6E-02	3.3E-01	1.0	10	N	1.0E+04	1.0E+03	3.9E+02	3.9E+01
2-Methylnaphthalene	91-57-6	3.8E-02	3.3E-01	0.93	10	N	4.1E+04	4.1E+03	1.6E+03	1.6E+02
2-Methylphenol	95-48-7	2.9E-02	3.3E-01	0.92	10	N	1.0E+05	1.0E+04	3.9E+03	3.9E+02
2-Nitroaniline	88-74-4	2.5E-02	6.7E-01	0.46	20	--	--	--	--	--
2-Nitrophenol	88-75-5	3.0E-02	3.3E-01	0.77	10	--	--	--	--	--
3,3'-Dichlorobenzidine	91-94-1	1.6E-02	6.7E-01	1.2	10	C	1.3E+01	1.3E+01	1.4E+00	1.4E+00
3-Nitroaniline	99-09-2	2.5E-02	6.7E-01	1.1	20	--	--	--	--	--
4,6-Dinitro-2-methylphenol	534-52-1	3.4E-02	6.7E-01	0.86	20	N	2.0E+03	2.0E+02	7.8E+01	7.8E+00
4-Bromophenyl-phenylether	101-55-3	2.7E-02	3.3E-01	0.84	10	--	--	--	--	--
4-Chloro-3-Methylphenol	59-50-7	3.1E-02	3.3E-01	0.51	10	--	--	--	--	--
4-Chloroaniline	106-47-8	9.5E-03	3.3E-01	1.6	10	N	8.2E+03	8.2E+02	3.1E+02	3.1E+01
4-Chlorophenyl-phenylether	7005-72-3	2.3E-02	3.3E-01	0.61	10	--	--	--	--	--
4-Methylphenol	106-44-5	2.8E-02	3.3E-01	0.90	5	N	1.0E+04	1.0E+03	3.9E+02	3.9E+01
4-Nitroaniline	100-01-6	1.9E-02	6.7E-01	0.76	20	--	--	--	--	--
4-Nitrophenol	100-02-7	5.1E-02	6.7E-01	2.7	20	N	1.6E+04	1.6E+03	6.3E+02	6.3E+01
Acenaphthene	83-32-9	2.2E-02	3.3E-01	0.55	10	N	1.2E+05	1.2E+04	4.7E+03	4.7E+02
Acenaphthylene**	208-96-8	2.6E-02	3.3E-01	0.72	10	N	6.1E+04	6.1E+03	2.3E+03	2.3E+02
Anthracene	120-12-7	2.5E-02	3.3E-01	0.61	10	N	6.1E+05	6.1E+04	2.3E+04	2.3E+03
Benzo(a)anthracene	56-55-3	2.4E-02	3.3E-01	0.46	10	C	7.8E+00	7.8E+00	8.7E-01	8.7E-01
Benzo(a)pyrene	50-32-8	2.6E-02	3.3E-01	0.58	10	C	7.8E-01	7.8E-01	8.7E-02	8.7E-02
Benzo(b)fluoranthene	205-99-2	2.4E-02	3.3E-01	0.51	10	C	7.8E+00	7.8E+00	8.7E-01	8.7E-01
Benzo(g,h,i)perylene**	191-24-2	3.3E-02	3.3E-01	0.85	10	N	6.1E+04	6.1E+03	2.3E+03	2.3E+02
Benzo(k)fluoranthene	207-08-9	3.6E-02	3.3E-01	0.74	10	C	7.8E+01	7.8E+01	8.7E+00	8.7E+00
Bis(2-chloroethoxy)methane	111-91-1	3.6E-02	3.3E-01	0.79	10	--	--	--	--	--
Bis(2-chloroethyl)ether	111-44-4	3.0E-02	3.3E-01	0.93	10	C	5.2E+00	5.2E+00	5.8E-01	5.8E-01
Bis(2-ethylhexyl)phthalate	117-81-7	3.9E-02	3.3E-01	0.65	10	C	4.1E+02	4.1E+02	4.6E+01	4.6E+01
Butylbenzylphthalate	85-68-7	2.1E-02	3.3E-01	0.52	10	N	4.1E+05	4.1E+04	1.6E+04	1.6E+03
Carbazole	86-74-8	2.5E-02	3.3E-01	0.78	10	C	2.9E+02	2.9E+02	3.2E+01	3.2E+01

Table 2-7 (Continued)
Summary of Analyte Method Detection Limits, Reporting Limits, and Risk Screening Criteria for TCL SVOCs
Soil and Water Samples
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammuniton Plant, Radford, Virginia

Compound	CAS Number	Laboratory-Specific Method Detection and Reporting Limits				USEPA Region III Risk-Based Concentrations				
		Soil		Water						
		MDL mg/kg	Reporting Limit mg/kg	MDL µg/L	Reporting Limit µg/L	C/N	Soil RBC (Industrial) mg/kg	Adjusted Soil RBC (Industrial) mg/kg	Soil RBC (Residential) mg/kg	Adjusted Soil RBC (Residential) mg/kg
Chrysene	218-01-9	2.8E-02	3.3E-01	0.65	10	C	7.8E+02	7.8E+02	8.7E+01	8.7E+01
Dibenz(a,h)anthracene	53-70-3	2.9E-02	3.3E-01	0.80	10	C	7.8E-01	7.8E-01	8.7E-02	8.7E-02
Dibenzofuran	132-64-9	2.9E-02	3.3E-01	0.66	10	N	8.2E+03	8.2E+02	3.1E+02	3.1E+01
Diethylphthalate	84-66-2	1.5E-02	3.3E-01	0.58	10	N	1.6E+06	1.6E+05	6.3E+04	6.3E+03
Dimethylphthalate	131-11-3	2.2E-02	3.3E-01	0.56	10	N	2.0E+07	2.0E+06	7.8E+05	7.8E+04
Di-n-butylphthalate	84-74-2	2.0E-02	3.3E-01	0.80	10	N	2.0E+05	2.0E+04	7.8E+03	7.8E+02
Di-n-octylphthalate	117-84-0	1.9E-02	3.3E-01	0.68	10	N	4.1E+04	4.1E+03	1.6E+03	1.6E+02
Fluoranthene	206-44-0	1.6E-02	3.3E-01	0.70	10	N	8.2E+04	8.2E+03	3.1E+03	3.1E+02
Fluorene	86-73-7	1.7E-02	3.3E-01	0.56	10	N	8.2E+04	8.2E+03	3.1E+03	3.1E+02
Hexachlorobenzene	118-74-1	2.9E-02	3.3E-01	0.75	10	C	3.6E+00	3.6E+00	4.0E-01	4.0E-01
Hexachlorobutadiene	87-68-3	3.3E-02	3.3E-01	1.1	10	CI	7.3E+01	7.3E+01	8.2E+00	8.2E+00
Hexachlorocyclopentadiene	77-47-4	6.7E-02	3.3E-01	1.0	10	N	1.2E+04	1.2E+03	4.7E+02	4.7E+01
Hexachloroethane	67-72-1	3.7E-02	3.3E-01	1.4	10	CI	4.1E+02	4.1E+02	4.6E+01	4.6E+01
Indeno(1,2,3-cd)pyrene	193-39-5	3.0E-02	3.3E-01	0.85	10	C	7.8E+00	7.8E+00	8.7E-01	8.7E-01
Isophorone	78-59-1	3.0E-02	3.3E-01	0.67	10	C	6.0E+03	6.0E+03	6.7E+02	6.7E+02
Naphthalene	91-20-3	3.5E-02	3.3E-01	0.90	10	N	4.1E+04	4.1E+03	1.6E+03	1.6E+02
Nitrobenzene	98-95-3	4.3E-02	3.3E-01	1.0	10	N	1.0E+03	1.0E+02	3.9E+01	3.9E+00
N-Nitrosodi-n-propylamine	621-64-7	3.3E-02	3.3E-01	0.77	10	C	8.2E-01	8.2E-01	9.1E-02	9.1E-02
N-Nitrosodiphenylamine	86-30-6	3.2E-02	3.3E-01	0.71	10	C	1.2E+03	1.2E+03	1.3E+02	1.3E+02
Pentachlorophenol	87-86-5	4.6E-02	6.7E-01	1.2	20	C	4.8E+01	4.8E+01	5.3E+00	5.3E+00
Phenanthrene**	85-01-8	2.4E-02	3.3E-01	0.67	10	N	6.1E+04	6.1E+03	2.3E+03	2.3E+02
Phenol	108-95-2	3.5E-02	3.3E-01	1.2	10	N	1.2E+06	1.2E+05	4.7E+04	4.7E+03
Pyrene	129-00-0	2.7E-02	3.3E-01	0.59	10	N	6.1E+04	6.1E+03	2.3E+03	2.3E+02

Notes:

CAS = Chemical Abstract Service

MDL = Method Detection Limit

Method Detection and Reporting Limits provided by CompuChem

mg/kg = Milligram per kilogram

µg/L = Microgram per liter

RBC = Risk-Based Concentration

USEPA Region III Risk-Based Concentration (RBC) values from the April 2, 2002 RBC Table

SVOC = Semivolatile Organic Compound

TCL = Target Compound List

C/N = Carcinogenic or Non-carcinogenic status

C = Carcinogenic

CI = Carcinogen with a hazard quotient of 0.1; see USEPA Region III guidanc

N = Non-carcinogenic

Adjusted RBCs = a Hazard Quotient (HQ) of 0.1 applied to non-carcinogens

-- = No RBC available

** = RBC for pyrene used as a substitute for acenapthylene, benzo(ghi)pyrylene, and phenanthrene

Table 2-8
Summary of Method Detection Limits, Reporting Limits, and Risk Screening Criteria
PAHs (by EPA Method 8310)
Soil and Water Samples
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

Compound	CAS Number	Laboratory-Specific Method Detection and Reporting Limits				USEPA Region III Risk-Based Concentrations				
		Soil		Water						
		MDL mg/kg	Reporting Limit mg/kg	MDL µg/L	Reporting Limit µg/L	C/N	Soil RBC (Industrial) mg/kg	Adjusted Soil RBC (Industrial) mg/kg	Soil RBC (Residential) mg/kg	Adjusted Soil RBC (Residential) mg/kg
Acenaphthene	83-32-9	2.2E-02	4.2E-02	0.31	1.25	N	1.2E+05	1.2E+04	4.7E+03	4.7E+02
Acenaphthylene**	208-96-8	6.9E-03	4.2E-02	0.41	1.25	N	6.1E+04	6.1E+03	2.3E+03	2.3E+02
Anthracene	102-12-7	5.9E-03	4.2E-02	0.14	1.25	N	6.1E+05	6.1E+04	2.3E+04	2.3E+03
Benzo(a)anthracene	56-55-3	2.0E-03	8.3E-03	0.02	0.25	C	7.8E+00	7.8E+00	8.7E-01	8.7E-01
Benzo(a)pyrene	50-32-8	2.7E-03	8.3E-03	0.03	0.25	C	7.8E-01	7.8E-01	8.7E-02	8.7E-02
Benzo(b)fluoranthene	205-99-2	4.0E-03	8.3E-03	0.03	0.25	C	7.8E+00	7.8E+00	8.7E-01	8.7E-01
Benzo(ghi)perylene**	191-24-2	1.7E-03	8.3E-03	0.01	0.25	N	6.1E+04	6.1E+03	2.3E+03	2.3E+02
Benzo(k)fluoranthene	207-08-9	1.8E-03	8.3E-03	0.023	0.25	C	7.8E+01	7.8E+01	8.7E+00	8.7E+00
Chrysene	218-01-9	3.1E-03	8.3E-03	0.23	0.25	C	7.8E+02	7.8E+02	8.7E+01	8.7E+01
Dibenzo(a,h)anthracene	53-70-3	4.5E-03	8.3E-03	0.05	0.25	C	7.8E-01	7.8E-01	8.7E-02	8.7E-02
Fluoranthene	206-44-0	6.3E-03	1.7E-02	0.22	0.50	N	8.2E+04	8.2E+03	3.1E+03	3.1E+02
Fluorene	86-73-7	1.4E-02	4.2E-02	0.97	1.25	N	8.2E+04	8.2E+03	3.1E+03	3.1E+02
Indeno(1,2,3-cd)pyrene	193-39-5	1.1E-03	8.3E-03	0.089	0.25	C	7.8E+00	7.8E+00	8.7E-01	8.7E-01
Naphthalene	91-20-3	1.1E-02	4.2E-02	0.60	1.25	N	4.1E+04	4.1E+03	1.6E+03	1.6E+02
Phenanthrene**	85-01-8	5.5E-03	4.2E-02	0.12	0.50	N	6.1E+04	6.1E+03	2.3E+03	2.3E+02
Pyrene	129-00-0	8.3E-03	1.7E-02	0.08	0.50	N	6.1E+04	6.1E+03	2.3E+03	2.3E+02

Notes:

CAS = Chemical Abstract Service
MDL = Method Detection Limit
Method Detection and Reporting Limits provided by CompuChem
mg/kg = Milligram per kilogram
µg/L = Microgram per liter
RBC = Risk-Based Concentration
USEPA Region III Risk-Based Concentration (RBC) values from the April 2, 2002 RBC Table
TCL = Target Compound List
PAH = Polynuclear Aromatic Hydrocarbons

C/N = Carcinogenic or Non-carcinogenic status
C = Carcinogenic
Cl = Carcinogen with a hazard quotient of 0.1; see USEPA Region III guidance
N = Non-carcinogenic
Adjusted RBCs = a Hazard Quotient (HQ) of 0.1 applied to non-carcinogens
-- = No RBC available
** = RBC for pyrene used as a substitute for
acenapthylene, benzo(ghi)pyrylene, and phenanthrene

Table 2-9
Summary of Analyte Method Detection Limits, Reporting Limits, and Risk Screening Criteria for TCL Pesticides (by EPA Method 8081A)
Soil and Water Samples
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

Compound	CAS Number	Laboratory-Specific Method Detection and Reporting Limits				USEPA Region III Risk-Based Concentrations				
		Soil		Water						
		MDL mg/kg	Reporting Limit mg/kg	MDL µg/L	Reporting Limit µg/L	C/N	Soil RBC (Industrial) mg/kg	Adjusted Soil RBC (Industrial) mg/kg	Soil RBC (Residential) mg/kg	Adjusted Soil RBC (Residential) mg/kg
4,4'-DDD	72-54-8	1.2E-03	3.3E-03	0.025	0.10	C	2.4E+01	2.4E+01	2.7E+00	2.7E+00
4,4'-DDE	72-55-9	7.8E-04	1.7E-03	0.014	0.050	C	1.7E+01	1.7E+01	1.9E+00	1.9E+00
4,4'-DDT	50-29-3	1.1E-03	5.0E-03	0.017	0.15	C	1.7E+01	1.7E+01	1.9E+00	1.9E+00
Aldrin	309-00-2	3.9E-04	8.3E-04	0.016	0.025	C	3.4E-01	3.4E-01	3.8E-02	3.8E-02
alpha-BHC	319-84-6	5.9E-04	8.3E-04	0.015	0.025	C	9.1E-01	9.1E-01	1.0E-01	1.0E-01
alpha-Chlordane[1]	5103-71-9	5.4E-04	8.3E-04	0.010	0.050	C	1.6E+01	1.6E+01	1.8E+00	1.8E+00
gamma-Chlordane[1]	5103-74-2	3.7E-04	8.3E-04	0.0069	0.025	C	1.6E+01	1.6E+01	1.8E+00	1.8E+00
beta-BHC[2]	319-85-7	1.4E-03	1.7E-03	0.027	0.050	C	3.2E+00	3.2E+00	3.5E-01	3.5E-01
delta-BHC	319-86-8	7.8E-04	8.3E-04	0.015	0.025	C	9.1E-01	9.1E-01	1.0E-01	1.0E-01
Dieldrin	60-57-1	7.3E-04	1.7E-03	0.019	0.050	C	3.6E-01	3.6E-01	4.0E-02	4.0E-02
Endosulfan I	959-98-8	3.1E-04	1.7E-03	0.013	0.050	N	1.2E+04	1.2E+03	4.7E+02	4.7E+01
Endosulfan II[3]	33213-65-9	9.4E-04	3.3E-03	0.020	0.10	N	1.2E+04	1.2E+03	4.7E+02	4.7E+01
Endosulfan sulfate[4]	1031-07-8	1.1E-03	3.3E-03	0.020	0.10	N	6.1E+02	6.1E+01	2.3E+01	2.3E+00
Endrin	72-20-8	7.4E-04	3.3E-03	0.018	0.10	N	6.1E+02	6.1E+01	2.3E+01	2.3E+00
Endrin aldehyde [4]	7421-93-4	1.6E-03	3.3E-03	0.028	0.10	N	6.1E+02	6.1E+01	2.3E+01	2.3E+00
Endrin ketone[4]	53494-70-5	9.7E-04	8.3E-03	0.023	0.25	N	6.1E+02	6.1E+01	2.3E+01	2.3E+00
gamma-BHC (Lindane)	58-59-9	6.3E-04	8.3E-04	0.018	0.025	C	4.4E+00	4.4E+00	4.9E-01	4.9E-01
Heptachlor	76-44-8	4.8E-04	8.3E-04	0.018	0.025	C	1.3E+00	1.3E+00	1.4E-01	1.4E-01
Heptachlor epoxide	1024-57-3	4.4E-04	8.3E-04	0.0067	0.025	C	6.3E-01	6.3E-01	7.0E-02	7.0E-02
Methoxychlor	72-43-5	2.7E-03	8.3E-03	0.078	0.25	N	1.0E+04	1.0E+03	3.9E+02	3.9E+01
Toxaphene	8001-35-2	2.7E-02	1.7E-01	0.70	5.0	C	5.2E+00	5.2E+00	5.8E-01	5.8E-01

Notes:
CAS = Chemical Abstract Service
Method Detection and Reporting Limits provided by CompuChem
MDL = Method Detection Limit
mg/kg = Milligram per kilogram
µg/L = Microgram per liter
-- = RBC not available
RBC = Risk Based Concentration
USEPA Region III Risk-Based Concentration (RBC) values from the April 2, 2002 RBC Table
TCL = Target Compound List
USEPA = Environmental Protection Agency

C/N = Carcinogenic or Non-carcinogenic status
C = Carcinogenic
CI = Carcinogen with a hazard quotient of 0.1; see USEPA Region III guidance
N = Non-carcinogenic
Adjusted RBCs = a Hazard Quotient (HQ) of 0.1 applied to non-carcinogens
(1) = Chlordane value is for sum of isomers
(2) = alpha-BHC RBC used as a substitute for beta-BHC
(3) = Endosulfan I RBC used as a substitute for Endosulfan II
(4) = Endrin RBC used as a substitute for
Endosulfan sulfate, Endrin aldehyde, and Endrin ketone

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Table 2-10
Summary of Analyte Method Detection Limits, Reporting Limits, and Risk Screening Criteria for TCL PCBs (by EPA Method 8082)
Soil and Water Samples
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

Compound	CAS Number	Laboratory-Specific Method Detection and Reporting Limits				USEPA Region III Risk-Based Concentrations				
		Soil		Water						
		MDL mg/kg	Reporting Limit mg/kg	MDL µg/L	Reporting Limit µg/L	C/N	Soil RBC (Industrial) mg/kg	Adjusted Soil RBC (Industrial) mg/kg	Soil RBC (Residential) mg/kg	Adjusted Soil RBC (Residential) mg/kg
Aroclor 1016	12674-11-2	1.4E-02	6.30E-02	0.51	2.0	CI	8.2E+01	8.2E+01	5.5E+00	5.5E+00
Aroclor 1221	11104-28-2	1.9E-02	8.30E-02	0.94	3.0	C	2.9E+00	2.9E+00	3.2E-01	3.2E-01
Aroclor 1232	11141-16-5	1.3E-02	6.30E-02	0.27	2.0	C	2.9E+00	2.9E+00	3.2E-01	3.2E-01
Aroclor 1242	53469-21-9	1.5E-02	4.20E-02	0.42	2.0	C	2.9E+00	2.9E+00	3.2E-01	3.2E-01
Aroclor 1248	12672-29-6	1.4E-02	4.20E-02	0.38	2.0	C	2.9E+00	2.9E+00	3.2E-01	3.2E-01
Aroclor 1254	11097-69-1	8.3E-03	4.20E-02	0.18	2.0	C	2.9E+00	2.9E+00	3.2E-01	3.2E-01
Aroclor 1260	11096-82-5	6.8E-03	6.30E-02	0.52	2.0	C	2.9E+00	2.9E+00	3.2E-01	3.2E-01

Notes:

CAS = Chemical Abstract Service

MDL = Method Detection Limit

Method Detection and Reporting Limits provided by CompuChem

mg/kg = Milligram per kilogram

µg/L = Microgram per liter

RBC = Risk-Based Concentration

USEPA Region III Risk-Based Concentration (RBC) values from the April 2, 2002 RBC Table

TCL = Target Compound List

PCB = Polychlorinated Biphenyls

C/N = Carcinogenic or Non-carcinogenic status

C = Carcinogenic

CI = Carcinogen with a hazard quotient of 0.1; see USEPA Region III guidance

N = Non-carcinogenic

Adjusted RBCs = a Hazard Quotient (HQ) of 0.1 applied to non-carcinogens

USEPA = Environmental Protection Agency

Table 2-11
Summary of Analyte Method Detection Limits, Reporting Limits, and Risk Screening Criteria for Explosives (by EPA Methods 8330 and 8332)
Soil and Water Samples
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

Compounds by Method 8330	CAS Number	Laboratory-Specific Method Detection and Reporting Limits				USEPA Region III Risk-Based Concentrations				
		Soil		Water						
		MDL mg/kg	Reporting Limit mg/kg	MDL µg/L	Reporting Limit µg/L	C/N	Soil RBC (Industrial) mg/kg	Adjusted Soil RBC (Industrial) mg/kg	Soil RBC (Residential) mg/kg	Adjusted Soil RBC (Residential) mg/kg
1,3,5-Trinitrobenzene	99-35-4	0.18	1.0	1.03	3.0	N	6.1E+04	6.1E+03	2.3E+03	2.3E+02
1,3-Dinitrobenzene	99-65-0	0.13	1.0	1.04	3.0	N	2.0E+02	2.0E+01	7.8E+00	7.8E-01
2,4,6-Trinitrotoluene	118-96-7	0.31	1.0	0.61	3.0	Cl	1.9E+02	1.9E+02	2.1E+01	2.1E+01
2,4-Dinitrotoluene	121-14-2	0.30	1.0	0.47	3.0	N	4.1E+03	4.1E+02	1.6E+02	1.6E+01
2,6-Dinitrotoluene	606-20-2	0.27	1.5	0.59	4.0	N	2.0E+03	2.0E+02	7.8E+01	7.8E+00
2-Amino-4, 6-dinitrotoluene	35572-78-2	0.23	1.5	0.86	4.0	N	1.2E+02	1.2E+01	4.7E+00	4.7E-01
2-Nitrotoluene	88-72-2	0.53	1.5	1.16	3.0	N	2.0E+04	2.0E+03	7.8E+02	7.8E+01
3-Nitrotoluene	99-08-1	0.53	1.5	0.96	3.0	N	4.1E+04	4.1E+03	1.6E+03	1.6E+02
4-Amino-2,6-dinitrotoluene	19046-51-0	0.42	1.5	0.78	4.0	N	1.2E+02	1.2E+01	4.7E+00	4.7E-01
4-Nitrotoluene	99-99-0	0.70	1.5	1.31	3.0	N	2.0E+04	2.0E+03	7.8E+02	7.8E+01
HMX (Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)	2691-41-0	0.20	1.5	1.07	4.0	N	1.0E+05	1.0E+04	3.9E+03	3.9E+02
Nitrobenzene	98-95-3	0.20	1.0	0.36	3.0	N	1.0E+03	1.0E+02	3.9E+01	3.9E+00
RDX (Hexahydro-1,3,5-trinitro-1,3,5-triazine)	121-82-4	0.34	1.0	0.88	3.0	C	5.2E+01	5.2E+01	5.8E+00	5.8E+00
Tetryl (Methyl-2,4,6-trinitrophenylnitramine)	479-45-8	0.55	1.5	0.91	4.0	N	2.0E+04	2.0E+03	7.8E+02	7.8E+01
Compound by Method 8332										
Nitroglycerin	55-63-0	1.99	10	20.0	60	C	4.1E+02	4.1E+02	4.1E+01	4.1E+01

Notes:

CAS = Chemical Abstract Service
MDL = Method Detection Limit
Method Detection and Reporting Limits provided by CompuChem
mg/kg = Milligram per kilogram
µg/L = Microgram per liter
RBC = Risk-Based Concentration
EPA Region III Risk-Based Concentration (RBC) values from the April 2, 2002 RBC Table

C/N = Carcinogenic or Non-carcinogenic status
C = Carcinogenic
Cl = Carcinogen with a hazard quotient of 0.1; see EPA Region III guidance
N = Non-carcinogenic
Adjusted RBCs = a Hazard Quotient (HQ) of 0.1 applied to non-carcinogens
-- = No RBC available
USEPA = Environmental Protection Agency

Table 2-12
Summary of Analyte Method Detection Limits, Reporting Limits, and Risk Screening Criteria for Dioxins/Furans (by EPA Method 8290)
Soil and Water Samples
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

Compound	CAS Number	Laboratory-Specific Method Detection and Reporting Limits				EPA Region III Risk Based Concentrations						
		Soil		Water								
		MDL mg/kg	Reporting Limit mg/kg	MDL µg/L	Reporting Limit µg/L	C/N	Tap Water RBC µg/L	Adjusted Tap Water RBC µg/L	Soil RBC (Industrial) mg/kg	Adjusted Soil RBC (Industrial) mg/kg	Soil RBC (Residential) mg/kg	Adjusted Soil RBC (Residential) mg/kg
2,3,7,8-TCDD	1746-01-6	0.072	0.5	1.91	10	C	4.5E-07	4.5E-07	3.8E-05	3.8E-05	4.3E-06	4.3E-06
1,2,3,7,8-PeCDF	57117-41-6	0.097	2.5	2.18	50	--	--	--	--	--	--	--
1,2,3,4,7,8-HxCDD	39227-28-6	0.119	2.5	3.20	50	--	--	--	--	--	--	--
1,2,3,6,7,8-HxCDD	57653-85-7	0.131	2.5	4.12	50	--	--	--	--	--	--	--
1,2,3,7,8,9-HxCDD	19408-74-3	1.187	2.5	4.67	50	--	--	--	--	--	--	--
1,2,3,4,6,7,8-HpCDD	35822-39-4	0.173	2.5	7.86	50	--	--	--	--	--	--	--
OCDD	3268-87-9	0.679	5.0	33.7	100	--	--	--	--	--	--	--
2,3,7,8-TCDF	51207-31-9	0.146	0.5	0.91	10	--	--	--	--	--	--	--
1,2,3,7,8-PeCDF	57117-41-6	0.170	2.5	3.06	50	--	--	--	--	--	--	--
2,3,4,7,8-PeCDF	57117-31-4	0.291	2.5	2.00	50	--	--	--	--	--	--	--
1,2,3,4,7,8-HxCDF	70646-26-9	0.181	2.5	2.33	50	--	--	--	--	--	--	--
1,2,3,6,7,8-HxCDF	57117-44-9	0.251	2.5	2.54	50	--	--	--	--	--	--	--
2,3,4,6,7,8-HxCDF	60851-34-5	0.222	2.5	4.90	50	--	--	--	--	--	--	--
1,2,3,7,8,9-HxCDF	72918219	0.279	2.5	4.99	50	--	--	--	--	--	--	--
1,2,3,4,6,7,8-HpCDF	67562-39-4	0.208	2.5	4.92	50	--	--	--	--	--	--	--
1,2,3,4,7,8,9-HpCDF	55673-89-7	0.288	2.5	6.20	50	--	--	--	--	--	--	--
OCDF	39001-02-0	0.273	5.0	5.23	100	--	--	--	--	--	--	--

<u>Notes:</u>

CAS = Chemical Abstract Service
MDL = Method Detection Limit
Method Detection and Reporting Limits provided by CompuChem
mg/kg = Milligram per kilogram
µg/L = Microgram per liter

EPA Region III Risk-Based Concentration (RBC) values from the April 2, 2002 RBC Table
USEPA = Environmental Protection Agency
RBC = Risk-Based Concentration
--' = No Criteria Available

Table 2-13
Summary of Analyte Method Detection Limits, Reporting Limits, and Risk Screening Criteria for TAL Metals
Soil and Water Samples
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

Compound	CAS Number	Laboratory-Specific Method Detection and Reporting Limits				USEPA Region III Risk-Based Concentrations				
		Soil		Water				Adjusted		Adjusted Soil
		MDL mg/kg	Reporting Limit mg/kg	MDL µg/L	Reporting Limit µg/L	C/N	Soil RBC (Industrial) mg/kg	Soil RBC (Industrial) mg/kg	Soil RBC (Residential) mg/kg	RBC (Residential) mg/kg
Aluminum	7429-90-5	8.9E-01	1.0E+01	1.7E+01	1.0E+02	N	2.0E+06	2.0E+05	7.8E+04	7.8E+03
Antimony	7440-36-0	8.9E-02	1.0E+00	1.3E+00	1.0E+01	N	8.2E+02	8.2E+01	3.1E+01	3.1E+00
Arsenic	7440-38-2	2.7E-01	1.0E+00	3.5E+00	1.0E+01	C	3.8E+00	3.8E+00	4.3E-01	4.3E-01
Barium	7440-39-3	3.2E-02	1.0E+00	2.8E-01	1.0E+01	N	1.4E+05	1.4E+04	5.5E+03	5.5E+02
Beryllium	7440-41-7	3.9E-02	5.0E-01	1.1E-01	5.0E+00	N	4.1E+03	4.1E+02	1.6E+02	1.6E+01
Cadmium	7440-43-9	2.0E-02	5.0E-01	2.3E-01	5.0E+00	N	2.0E+03	2.0E+02	7.8E+01	7.8E+00
Calcium (food)	7440-70-2	3.1E+00	1.0E+02	2.8E+01	1.0E+03	--	--	--	--	--
Chromium (VI)	7440-47-3	4.5E-02	5.0E-01	6.5E-01	5.0E+00	N	6.1E+03	6.1E+02	2.3E+02	2.3E+01
Cobalt	7440-48-4	3.6E-02	5.0E-01	2.8E-01	5.0E+00	N	4.1E+04	4.1E+03	1.6E+03	1.6E+02
Copper	7440-50-8	5.0E-02	5.0E-01	3.1E-01	5.0E+00	N	8.2E+04	8.2E+03	3.1E+03	3.1E+02
Iron	7439-89-6	3.6E+00	1.0E+01	1.0E+01	1.0E+02	N	6.1E+05	6.1E+04	2.3E+04	2.3E+03
Lead[1]	7439-92-1	1.1E-01	3.0E-01	1.2E+00	3.0E+00	--	1.0E+03	1.0E+03	4.0E+02	4.0E+02
Magnesium	7439-95-4	6.4E-01	1.0E+02	3.6E+00	1.0E+03	--	--	--	--	--
Manganese (non-food)	7439-96-5	3.7E-02	1.0E+00	2.7E-01	1.0E+01	N	4.1E+04	4.1E+03	1.6E+03	1.6E+02
Mercury[2]	7439-97-6	1.1E-01	2.0E-01	3.3E-03	2.0E-02	N	6.1E+02	6.1E+01	2.3E+01	2.3E+00
Nickel	7440-02-0	7.8E-02	5.0E-01	6.3E-01	5.0E+00	N	4.1E+04	4.1E+03	1.6E+03	1.6E+02
Potassium	7440-09-7	4.7E+00	1.0E+02	1.8E+01	1.0E+03	--	--	--	--	--
Selenium	7782-49-2	1.7E-01	5.0E-01	3.5E+00	5.0E+00	N	1.0E+04	1.0E+03	3.9E+02	3.9E+01
Silver	7440-22-4	8.2E-02	5.0E-01	5.7E-01	5.0E+00	N	1.0E+04	1.0E+03	3.9E+02	3.9E+01
Sodium	7440-23-5	1.8E+01	2.0E+02	1.6E+02	2.0E+03	--	--	--	--	--
Thallium	7440-28-0	4.2E-01	1.0E+00	2.1E+00	1.0E+01	N	1.4E+02	1.4E+01	5.5E+00	5.5E-01
Vanadium	7440-62-2	2.8E-02	2.0E+00	2.5E-01	2.0E+01	N	1.4E+04	1.4E+03	5.5E+02	5.5E+01
Zinc	7440-66-6	3.9E-01	2.0E+00	4.9E+00	2.0E+01	N	6.1E+05	6.1E+04	2.3E+04	2.3E+03

Notes:

CAS = Chemical Abstract Service
Method Detection and Reporting Limits provided by CompuChem
MDL = Method Detection Limit
mg/kg = milligram per kilogram
µg/L = microgram per liter
RBC = Risk-Based Concentration
USEPA Region III Risk-Based Concentration (RBC) values from the April 2, 2002 RBC Table
USEPA = Environmental Protection Agency

C/N = Carcinogenic or Non-carcinogenic status
C = Carcinogenic
CI = Carcinogen with a hazard quotient of 0.1; see EPA Region III guidance
N = Non-carcinogenic
Adjusted RBCs = a Hazard Quotient (HQ) of 0.1 applied to non-carcinogens
(1) = Lead screening values (not an RBC)
(2) = Mercuric chloride value used
-- = No RBC available

- TAL metals;
- TCL VOCs;
- TCL SVOCs;
- TCL Pesticides/PCBs;
- PAHs;
- Explosives including nitroglycerin; and
- Dioxin/furans.

Note that Triangle Laboratories has been subcontracted, under CompuChem Laboratory, Inc., to perform the analysis of dioxin/furans.

Samples of IDM (decontamination water and soil) will be characterized for disposal purposes by analyzing for the following:

- TCLP VOCs;
- TCLP SVOCs;
- Ignitability;
- Corrosivity;
- Reactivity; and
- Paint Filter Test (solids).

2.5.1 Organics

The following techniques will be used for determination of organic constituents.

2.5.1.1 VOCs by SW8260B

The aqueous samples are prepared for analysis by purge-and-trap Method 5030 and the solid samples are prepared by purge-and-trap Method 5035. The volatile compounds are introduced into the gas chromatograph by the purge-and-trap method or by other methods (see Section 1.2 of Method SW8260B). The analytes are introduced directly to a wide-bore capillary column or cryofocused on a capillary pre-column before being flash evaporated to a narrow-bore capillary for analysis. The column is temperature-programmed to separate the analytes, which are then detected with a mass spectrometer (MS) interfaced to the gas chromatograph (GC). Analytes eluted from the capillary column are introduced into the mass spectrometer via a jet separator or a direct connection. (Wide-bore capillary columns normally require a jet separator, whereas narrow-bore capillary columns may be directly interfaced to the ion source.) Identification of target analytes is accomplished by comparing their mass spectra with the electron impact (or electron impact-like) spectra of authentic standards. Quantitation is accomplished by comparing the response of a major (quantitation) ion relative to an internal standard using a five-point calibration curve.

2.5.1.2 SVOCs by SW8270C

The samples are prepared for analysis by GC/MS using Method 3520C for aqueous media and Method 3540C for solid media, or other appropriate methods. The semivolatile compounds are introduced into the GC/MS by injecting the sample extract into a GC with a narrow-bore fused-silica capillary column. The GC column is temperature-programmed to separate the analytes, which are then detected with a MS, connected to the gas chromatograph. Analytes eluted from the capillary column are introduced into the mass spectrometer via a jet separator or a direct connection. Identification of target analytes is accomplished by comparing their mass spectra with the electron impact (or electron impact-like) spectra of authentic standards. Quantitation is accomplished by comparing the response of a major (quantitation) ion relative to an internal standard using a five-point calibration curve.

2.5.1.3 Pesticides by SW8081A

A measured volume or weight of sample (approximately one liter for liquids, and two to 30 grams for solids) is extracted using the appropriate matrix-specific sample extraction technique. Liquid samples are extracted at neutral pH with methylene chloride using Method 3520C (continuous liquid-liquid extractor), or other appropriate technique. Solid samples are using Method 3540C (Soxhlet) or other appropriate technique. A variety of cleanup steps may be applied to the extract, depending on the nature of the matrix interferences and the target analytes. Suggested cleanups include alumina (Method 3610), Florisil (Method 3620), silica gel (Method 3630), gel permeation chromatography (Method 3640), and sulfur (Method 3660). After cleanup, the extract is analyzed by injecting a one microliter (µL) sample into a gas chromatograph with a narrow- or wide-bore fused silica capillary column and electron capture detector (ECD) or an electrolytic conductivity detector (ELCD).

2.5.1.4 PCBs by SW8082

A measured volume or weight of sample (approximately one liter for liquids, and two to 30 grams for solids) is extracted using the appropriate matrix-specific sample extraction technique. Aqueous samples are extracted at neutral pH Method 3520C (continuous liquid-liquid extractor), or other appropriate technique. Solid samples are extracted Method 3540C (Soxhlet) or other appropriate technique. Extracts for PCB analysis may be subjected to a sulfuric acid/potassium permanganate cleanup (Method 3665) designed specifically for these analytes. This cleanup technique will remove (destroy) many single component organochlorine or organophosphate pesticides. Therefore, Method 8082 is not applicable to the analysis of those compounds. Instead, use Method 8081. After cleanup, the extract is analyzed by injecting a 2 µL aliquot into a gas chromatograph with a narrow- or wide-bore fused silica capillary column and ECD. The chromatographic data may be used to identify the seven Aroclors found in Section 1.1 of Method SW8082, individual PCB congeners, or total PCBs.

2.5.1.5 Dioxin and Furans by SW8290

Method 8290 provides procedures for the detection and quantitative measurement of polychlorinated dibenzo-p-dioxins (tetra- though octa-chlorinated homologues; PCDDs) and polychlorinated dibenzofurans (tetra- though octa-chlorinated homologues; PCDFs) in a variety of environmental matrices and at parts-per-trillion (ppt) to parts-per-quadrillion (ppq) concentrations. A specified amount of sample is spiked with a solution containing specified amounts of each of the nine isotopically ($^{13}C_{12}$) labeled PCDDs/PCDFs. The sample is then extracted according to a matrix specific extraction procedure. The samples are prepared for analysis by high-resolution gas chromatography/high-resolution mass spectrometry (HRGC/HRMS) using the matrix specific extraction (refer to Method 8290) and analyte specific cleanup procedures (refer to Method 8290). A high-resolution capillary column (60 m DB-5, J&W Scientific, or equivalent) is used in this method. However, no single column is known to resolve all isomers.

In order to ascertain the concentration of the 2,3,7,8-TCDF (if detected on the DB-5 column), the sample extract must be reanalyzed on a column capable of 2,3,7,8-TCDF isomer specificity (e.g., DB-225, SP-2330, SP-2331, or equivalent). Quantitation of the individual congeners, total PCDDs and total PCDFs is achieved in conjunction with the establishment of a multi-point (five points) calibration curve for each homologue, during which each calibration solution is analyzed once. The identification of 1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD) and nine of the fifteen 2,3,7,8- substituted congeners, for which a ^{13}C-labeled standard is available in the sample fortification and recovery standard solutions, is based on their elution at their exact retention time (within 0.005 retention time units measured in the routine calibration) and simultaneous detection of the two most abundant ions in the molecular ion region. The remaining six 2,3,7,8-substituted congeners (i.e., 2,3,4,7,8-PeCDF; 1,2,3,4,7,8-HxCDD; 1,2,3,6,7,8-HxCDF; 1,2,3,7,8,9-HxCDF; 2,3,4,6,7,8-HxCDF, and 1,2,3,4,7,8,9-HpCDF), for which no carbon-labeled internal standards are available in the sample fortification solution, and other identified PCDD/PCDF congeners are identified by their relative retention times from the routine calibration data, and the simultaneous detection of the two most abundant ions in the molecular ion region. The identification of 1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF) is based on its retention time relative to $^{13}C_{12}$-OCDD and the simultaneous detection of the two most abundant ions in the molecular ion region. Confirmation is based on a comparison of the ratios of the integrated ion abundance of the molecular ion species to their theoretical abundance ratios. A calculation of the toxicity equivalent concentration (TEQ) of each sample is made using international consensus toxicity equivalence factors (TEFs), and the TEQ is used to identify if the concentrations of target compounds in the sample are high enough to warrant confirmation of the results on a second GC column.

2.5.1.6 PAHs by SW8310

Method 8310 provides high performance liquid chromatographic (HPLC) conditions for the detection of parts per billion (ppb) levels of certain PAHs in water, soil and sediment matrix. Aqueous samples are extracted at neutral pH with methylene chloride using Method 3520C (continuous liquid-liquid extractor), or other appropriate technique. Solid samples are extracted using Method 3540C (Soxhlet) or other appropriate technique. Prior to HPLC analysis, the extraction solvent must be exchanged to acetonitrile. To achieve maximum sensitivity with this method, the extract must be concentrated to one milliliter. If interferences prevent proper detection of the analytes of interest, the method may also be performed on extracts that have undergone cleanup using silica gel column cleanup (Method 3630). A five to 25 µL aliquot of the extract is injected into an HPLC, and compounds in the effluent are detected by ultraviolet (UV) and fluorescence detectors.

2.5.1.7 Explosives by SW8330 and SW8332

Test Methods 8330 and 8332 provide HPLC conditions for the detection of ppb levels of certain explosives residues in water, soil and sediment matrices. Before use of these methods, sample preparation techniques must be used. Two sample preparation techniques are available:

1) Low-Level Salting-out Method with No Evaporation: Aqueous samples of low concentration are extracted by a salting-out extraction procedure with acetonitrile and sodium chloride. The small volume of acetonitrile that remains un-dissolved above the salt water is drawn off and transferred to a smaller volumetric flask. It is back-extracted by vigorous stirring with a specific volume of salt

water. After equilibration, the phases are allowed to separate and the small volume of acetonitrile residing in the narrow neck of the volumetric flask is removed using a Pasteur pipette. The concentrated extract is diluted 1:1 with reagent grade water. An aliquot is separated on a C-18 reverse phase column, analyzed at 254 nanometers (nm), and confirmed on a CN reverse phase column.

2) High-Level Direct Injection Method: Aqueous samples of higher concentration can be diluted 1:1 (v/v) with methanol or acetonitrile, filtered, separated on a C-18 reverse phase column, analyzed at 254 nm, and confirmed on a CN reverse phase column. If cyclotetramethylene-tetranitramine (HMX) is an important target analyte, methanol is preferred. Soil and sediment samples are extracted using acetonitrile in an ultrasonic bath, filtered and gas-chromatographed as described above.

2.5.2 Inorganics

The following techniques will be used for determination of inorganic constituents.

2.5.2.1 Metals by ICP

Prior to analysis, samples are prepared by Method 3010A for aqueous media and Method 3050B for solid media, or other appropriate methods. When analyzing groundwater samples for dissolved constituents, acid digestion is not necessary if the samples are filtered and acid preserved before analysis. This method describes multi-elemental determinations by Inductively Coupled Plasma (ICP) - Atomic Emission Spectroscopy (AES) using sequential or simultaneous optical systems and axial or radial viewing of the plasma. The instrument measures characteristic emission spectra by optical spectrometry. Samples are nebulized and the resulting aerosol is transported to the plasma torch. Element-specific emission spectra are produced by radio-frequency inductively coupled plasma. The spectra are dispersed by a grating spectrometer, and the intensities of the emission lines are monitored by photosensitive devices.

Background correction is required for trace element determination. Background must be measured adjacent to analyte lines on samples during analysis. The position selected for the background-intensity measurement, on either or both sides of the analytical line, will be defined by the complexity of the spectrum adjacent to the analyte line. In one mode of analysis the position used should be as free as possible from spectral interference and should reflect the same change in background intensity as occurs at the analyte wavelength measured. Background correction is not required in cases of line broadening where a background correction measurement would actually degrade the analytical result. The possibility of additional interferences named in Section 3.0 of Method 3050B should also be recognized and appropriate corrections made; tests for their presence are described in Section 8.5 of Method 3035B. Alternatively, users may choose multivariate calibration methods. In this case, point selections for background correction are superfluous since whole spectral regions are processed.

2.5.2.2 Mercury by SW7470 (aqueous samples) and SW7471 (soil/solid samples)

Prior to analysis, the liquid, solid, or semi-solid samples must be prepared according to the procedure discussed in the method. Methods 7470 and 7471, cold-vapor atomic absorption techniques, are based on the absorption of radiation at 253.7 nm by mercury vapor. The mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an atomic absorption spectrophotometer. Absorbence (peak height) is measured as a function of mercury concentration.

2.5.3 Waste Samples

2.5.3.1 TCLP Extraction

For liquid wastes (i.e., those containing less than 0.5% dry solid material), the waste, after filtration through a 0.6 to 0.8-micrometer (μm) glass fiber filter, is defined as the TCLP extract. For wastes containing greater than or equal to 0.5% solids, the liquid, if present, is separated from the solid phase and stored for later analysis; the particle size of the solid phase is reduced, if necessary. The solid phase is extracted with an amount of extraction fluid equal to 20 times the weight of the solid phase. The extraction fluid employed is a function of the alkalinity of the solid phase of the waste. A special extractor vessel is used when testing for volatile analytes. Following extraction, the liquid extract is separated from the solid phase by filtration through a 0.6 to 0.8-μm glass fiber filter. If compatible (i.e., multiple phases will not form on combination), the initial liquid phase of the waste is added to the liquid extract, and these are analyzed together. If incompatible, the liquids are analyzed separately and the results are mathematically combined to yield a volume-weighted average concentration. Extracts are analyzed using the analytical methods described above.

2.5.3.2 Ignitability

For liquid wastes, the sample is heated at a slow, constant rate with continual stirring. A small flame is directed into the cup at regular intervals with simultaneous interruption of stirring. The flash point is the lowest temperature at which application of the test flame ignites the vapor above the sample. For solid wastes, in a preliminary test, the test material is formed into an unbroken strip or powder train 250 millimeters (mm) in length. An ignition source is applied to one end of the test material to learn whether combustion will propagate along 200 mm of the strip within a specified time. Materials that propagate burning along a 200-mm strip within the specified time are then subjected to a burning rate test. Materials that do not ignite or propagate combustion as described above do not require further testing. In the burning rate test, the burning time is measured over a distance of 100 mm and the rate of burning is calculated. The test method described here is based on the test procedure adopted by the U.S. Department of Transportation from the United Nations regulations for the international transportation of dangerous goods and is contained in Appendix E to Part 173 of Title 49 of the Code of Federal Regulations (CFR).

2.5.3.3 Corrosivity

The corrosivity of a sample will be based on its pH. The pH of a liquid sample is either analyzed electrometrically using a glass electrode in combination with a reference potential or a combination electrode. The measuring device is calibrated using a series of standard solutions of known pH. For soil/solid waste samples, the sample is mixed with reagent water, and the pH of the resulting aqueous solution is measured. The same procedure is used for pH determination of water and soil samples.

2.5.3.4 Reactivity

An aliquot of acid is added to a fixed weight of waste in a closed system. The generated gas is swept into a scrubber. The analyte is quantitated for cyanide and sulfide as follows. (1) In the colorimetric measurement, the cyanide is converted to cyanogen chloride (CNCl) by reaction of cyanide with chloramine-T at a pH less than eight. After the reaction is complete, color is formed on the addition of pyridine-barbituric acid reagent. The absorbence is read at 578 nm for the complex formed with pyridine-barbituric acid reagent and CNCl. To obtain colors of comparable intensity, it is essential to have the same salt content in both the sample and the standards. The titration measurement uses a standard solution of silver nitrate to titrate cyanide in the presence of a silver sensitive indicator.

(2) Sulfide is extracted from the sample by a preliminary distillation procedure and precipitated in a zinc acetate scrubber as zinc sulfide. The sulfide is oxidized to sulfur by adding a known excess amount of iodine. The excess iodine is quantified by titration with a standard solution of phenyl arsine oxide (PAO) or sodium thiosulfate until the blue iodine starch complex disappears. As the use of standard sulfide solutions is not possible because of oxidative degradation, quantitation is based on the PAO or sodium thiosulfate.

2.5.4 Physical/Geotechnical Analysis

As discussed in Section 1.3.2, four soil samples will be collected for analysis of physical/geotechnical parameters. Analysis will be conducted by a USACE-approved laboratory. Analyses will be conducted for the following:

- Grain-size analysis (ASTM D 422-98);
- Atterburg limits (ASTM D 4318-00);
- Soil moisture content (ASTM D 2216-98e1);
- Total organic content (ASTM D 2974-00);
- Soil bulk density (ASTM D 4253-00);
- Measurement of hydraulic conductivity (ASTM D 5084-00e1 and D 5856-95(2000));
- Soil porosity (ASTM D 854-00 and D 2937-00); and
- pH (ASTM D 4972-01).

2.6 INTERNAL QUALITY CONTROL CHECK

Internal QC components that will be used by URS during operations at RFAAP are presented in Section 8.0 of the MQAP. The internal quality components include the field QC samples and the laboratory QC elements to be followed.

2.7 DATA COLLECTION AND VALIDATION

Analyses will be conducted by a USACE-certified analytical laboratory. Level IV CLP-like raw data will be provided along with the Form 1. Data validation will be conducted based on the MQAP (Section 9.5), the USACE Shell Document, and USEPA Region III guidance. Mr. John Kearns in the URS Linthicum, Maryland office will oversee the performance of data validation functions.

URS will direct the overall data management. Data activity for the sampling program will be divided between URS and CompuChem Laboratories. Each firm has the equipment needed to perform the required data management functions. The laboratory will perform data entry and manipulation operations associated with the analysis of raw analytical data and provisions of chemical analysis results by sampling location. These data will be transmitted to URS for evaluation and interpretation. URS will also review boring logs and sample location maps.

3.0 HEALTH AND SAFETY PLAN ADDENDUM

3.1 INTRODUCTION

This site-specific HSPA was developed to provide the requirements for protection of site personnel, including government employees, URS personnel, regulators, subcontractors, and visitors, that are expected to be involved with soil boring advancement/sampling at SWMU 40/71.

This HSPA addresses project-specific hazards, which include physical hazards, biological hazards, and chemical hazards, as identified in Section 3.2.2, below.

This addendum addresses site-specific training, PPE, and air monitoring requirements. General health and safety issues that are also applicable to this scope of work are addressed in Master Health and Safety Plan (MHSP), as shown in Table 3-1.

Table 3-1
Health and Safety Issues Discussed in the MHSP
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

Health and Safety Issue	Section in MHSP
Site Safety and Health Documentation	1.4
Safety Statement	1.5
Health and Safety Personnel and Responsibilities	2.1
Hazard Assessment and Hazard Control	3.0
Training Plan	4.0
Medical Surveillance Plan	5.0
Site Safety and Control	6.0
PPE	7.0
Personnel and Equipment Decontamination	8.0
Monitoring Plan	9.0
Emergency Response and Contingency Plan	10.0

URS, subcontractor personnel, and site visitors will read this HSPA and will be required to follow its protocols as minimum standards. This HSPA is written for the site-specific conditions at SWMU 40/71 and must be amended if conditions change. A copy of this HSPA will be available at each work site.

The contractor will provide a safe work environment for personnel involved in RFAAP investigative activities. The contractor will emphasize the importance of personnel injury and illness prevention at the work site.

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3.2 TRAINING PLAN

Training will be used to review important topics outlined in this addendum and to inform URS personnel and subcontractor personnel of the hazards and control techniques associated with facility-wide conditions.

Site personnel will be informed of the specific PPE that will be worn during field activities. This includes, at a minimum, steel-toed boots, safety glasses with side shields, gloves, and hardhat. Each field person will also have a respirator on the site, in the event that an emergency occurs and a respirator is necessary for site evacuation, or if the use of a respirator is necessary based on air monitoring results. Prior to initiation of fieldwork, the staff will be required to review the manual *Safety, Security and Environmental Rules for Contractors and Subcontractors* (ATK 2000). Additional training, which will be conducted during daily safety "tailgate" meetings, will include emergency and evacuation procedures, general safety rules, and use of automobiles. Written documentation of safety briefings will be kept on the site.

3.2.1 Hazard Information Training

Hazard information training will be presented to URS and subcontractor personnel to provide a description of the Hazardous, Toxic, and Radioactive Waste (HTRW) with the potential to be found at SWMU 40/71. Training will also be provided on the potential biological, chemical, and physical hazards to be found at the Installation. The URS SHSO will conduct this training based on information provided by the operating contractor.

3.2.2 Project-Specific Hazard Analysis

The following hazards must be recognized and controlled during applicable investigative activities:

(1) Physical Hazards

- Cold stress – refer to Section 3.2.2 of the MHSP;
- Falls, open excavation, confined-space entry;
- Noise from heavy equipment;
- Cuts, abrasions, and lacerations;
- Manual lifting – refer to Section 3.2.4 of the MHSP;
- Slips, trips and falls associated with walking through heavily vegetated areas – refer to Section 6.1.1 of the MHSP;
- Heavy equipment – refer to Section 6.1.2.1 of the MHSP; and
- Main Manufacturing Area – overhead power lines.

(2) Biological Hazards (refer to Section 3.3 of the MHSP)

- Insect bites and stings;

- Tick bites;
- Snake, rodent, or other animal bites; and
- Dangerous plants.

(3) Chemical Hazards

- Potential exposure to toxic chemicals; and
- Potential exposure to dangerous fumes in case of a nearby release or spill of acids, resulting in the creation of a fume cloud.

3.2.3 Hearing Conservation Training

Site personnel involved in heavy equipment operation in addition to other operations involving exposure to noise levels exceeding 85 decibels on the A-weighted scale (dBA) eight-hour time-weighted average (TWA) shall be trained according to 29 CFR 1910.95. This training shall address the effects of noise on hearing, the purpose, advantages, disadvantages, and selection of hearing protection devices, and the purpose and explanation of Audiometric test procedures.

3.2.4 Hazard Communication Training

In order to comply with the requirements of the OSHA Hazard Communication (HAZCOM) Standard, 29 CFR 1910.1200, URS will have a written HAZCOM Program in place. The written hazard communication program addresses training (including potential safety and health effects from exposure), labeling, current inventory of hazardous chemicals on the site, and the location and use of Material Safety Data Sheets (MSDSs). The SHSO will arrange HAZCOM training for site personnel at the time of initial site assignment. Whenever a new hazardous substance is introduced into the work area or an employee changes job locations where new chemicals are encountered, supplemental HAZCOM training shall be scheduled and presented. HAZCOM training shall be documented by the SHSO using a HAZCOM Employee Training Record. This documentation and the URS HAZCOM Program will be maintained on the site for the duration of the project, and later incorporated in the employees' personal training file.

3.2.5 Confined Space Entry Training

Confined space entry training will not be required for fieldwork, as there will be no confined spaces entered during this investigation.

3.3 PERSONAL PROTECTIVE EQUIPMENT AND CLOTHING

The minimum and initial level of PPE for these activities will be Level D. The initial selection of PPE is based on a hazard assessment, including the review of existing analytical data and related toxicological information with respect to the proposed field activities. PPE assignments are subject to change based upon site conditions and task variation. The SHSO will review the required level of protection and safety equipment for each task with the sampling crew. The decisions on which protective level is most appropriate will be made by the SHSO.

In accordance with 29 CFR 1910.134, URS personnel working on the site will be required to participate in the written URS respiratory protection program. Personnel slated for fieldwork will have a qualitative

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fit test performed at least once per year or more frequently as required by law. Site personnel will be trained on the use, limitations, maintenance, inspection, and cleaning of respirators.

3.4 MONITORING PLAN

During sampling activities, the SHSO will monitor the site initially and periodically for potentially hazardous airborne constituents or physical hazards. The SHSO will use a PID to detect volatile organic vapors. SOP 90.1 describes the calibration of the PID that the SHSO will conduct daily. The action levels for volatile organic compounds at sustained concentrations in the breathing zone are as follows:

PID Readings	Action
Background plus 5 ppm	Investigate
Five ppm to 25 ppm	Upgrade to Level C (full face air-purifying respirator with organic vapor/acid gas cartridges), and investigate
Greater than 25 ppm	Suspend work, depart area, and investigate
ppm = Parts Per Million	

3.5 EMERGENCY RESPONSE PLAN

Emergency response will follow the protocols set fort in MHSP, Section 10.0. Table 3-2 presents the current emergency telephone numbers applicable to activities performed at RFAAP.

Table 3-2
Emergency Telephone Numbers
SWMU 40/71 RCRA Facility Investigation
Radford Army Ammunition Plant, Radford, Virginia

Contact	Telephone Number
Emergency Response Services	
Installation Fire Department**	16 (on post)
Installation Security Police**	7325 (on post) (540) 639-7325 (off post)
Installation Safety Department**	7294 (on post) (540) 639-7294 (off post)
Installation Spill Response**	7323, 7324 or 7325 (on post) (540) 639-7323, 7324, or 7325 (off post)
Installation Medical Facility** (RFAAP Hospital)	7323 or 7325 (on post) (540) 639-7323 or 7325 (off post)
Local Police Department	911
New River Valley Medical Center	(540) 731-2000 - General Telephone Number
National Poison Control Center	(800) 222-1222
National Response Center	(800) 424-8802
Regional USEPA Emergency Response	(215) 814-9016
Chemical Manufacturers Association Chemical Referral Center	(800) 262-8200

Directions from the Main Gate:

New River Valley Medical Center
2900 Lamb Circle
Christiansburg, VA 24073

Take Route 114 toward Radford to first traffic light. Take US Route 11 South and go across the bridge over the New River. Turn left after crossing the bridge and go to Virginia Route 177 South and turn right. Proceed on VA 177 South and cross over Interstate 81. New River Valley Medical Center is on the left.

** These telephone numbers are referenced from *Safety, Security and Environmental Rules for Contractors and Subcontractors* (ATK 2000).

U.S. Environmental Protection Agency (USEPA). 2000a. *Guidance for Data Quality Objectives for Hazardous Waste Sites.* EPA/300/R-00/007. Office of Solid Waste and Emergency Response.

U.S. Environmental Protection Agency (USEPA). 2000b. *Permit for Corrective Action and Waste Minimization; Pursuant to the Resource Conservation and Recovery Act as Amended by the Hazardous and Solid Waste Amendments of 1984, Radford Army Ammunition Plant, Radford, Virginia, VA1210020730.*

U.S. Environmental Protection Agency (USEPA). 2002. *USEPA Region III Risk-Based Concentration Table.* April 02, 2002.

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APPENDIX A

STANDARD OPERATING PROCEDURES

Standard Operating Procedures

SOP SERIES	TITLE
10.0	**DOCUMENTATION**
10.1	Field Logbook
10.2	Surface Water, Groundwater, and Soil/Sediment Field Logbooks
10.3	Boring Logs
10.4	Chain-of-Custody Forms
20.0	**SUBSURFACE INVESTIGATION**
20.3	Well and Boring Abandonment
20.4	Test Pits
20.11	Drilling Methods and Procedures
30.0	**SAMPLING**
30.1	Soil Sampling
30.6	Containerized Material
30.7	Sampling Strategies
30.9	Collection of Soil Samples By USEPA SW-846 Method 5035 Using Disposable Samplers
50.0	**SAMPLE MANAGEMENT**
50.1	Sample Labels
50.2	Sample Packaging
70.0	**INVESTIGATION-DERIVED MATERIAL**
70.1	Investigation-Derived Material
80.0	**DECONTAMINATION**
80.1	Decontamination
90.0	**AIR MONITORING EQUIPMENT**
90.1	Photoionization Detector (HNu Model PI-101 and HW-101)

STANDARD OPERATING PROCEDURE 10.1
FIELD LOGBOOK

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to delineate protocols for recording daily site investigation activities.

Records should contain sufficient information so that anyone can reconstruct the sampling activity without relying on the collector's memory.

2.0 MATERIALS

- Field Logbook;
- Indelible ink pen; and
- Clear tape.

3.0 PROCEDURE

Information pertinent to site investigations will be recorded in a bound logbook. Each page/form will be consecutively numbered, dated, and signed. All entries will be made in indelible ink, and all corrections will consist of line out deletions that are initialed and dated. If only part of a page is used, the remainder of the page should have an "X" drawn across it. At a minimum, entries in the logbook will include but not be limited to the following:

- Project name (cover);
- Name and affiliation of personnel on site;
- Weather conditions;
- General description of the field activity;
- Sample location;
- Sample identification number;
- Time and date of sample collection;
- Specific sample attributes (e.g., sample collection depth flow conditions or matrix);
- Sampling methodology (grab or composite sample);
- Sample preservation, as applicable;
- Analytical request/methods;
- Associated quality assurance/quality control (QA/QC) samples;

- Field measurements/observations, as applicable; and
- Signature and date of personnel responsible for documentation.

4.0 MAINTENANCE

Not applicable.

5.0 PRECAUTIONS

None.

6.0 REFERENCES

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STANDARD OPERATING PROCEDURE 10.2
SURFACE WATER, GROUNDWATER, AND SOIL/SEDIMENT FIELD LOGBOOKS

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to delineate protocols for recording surface water, groundwater, and soil/sediment sampling information, as well as instrument calibration data in field logbooks.

2.0 MATERIAL

- Applicable field logbook (see attached forms); and
- Indelible ink pen.

3.0 PROCEDURE

All information pertinent to surface water, groundwater, or soil/sediment sampling will be recorded in the appropriate logbook. Each page/form of the logbook will be consecutively numbered. All entries will be made with an indelible ink pen. All corrections will consist of line out deletions that are initialed and dated.

3.1 SOIL/SEDIMENT

3.1.1 Field Parameters/Logbook (Form 10.2-a)

1. HIGH CONCENTRATION EXPECTED?: Answer "Yes" or "No.";
2. HIGH HAZARD?: Answer "Yes" or "No.";
3. INSTALLATION/SITE: Record the complete name of the installation or site;
4. AREA: Record the area designation of the sample site;
5. INST. NAME: Record the two-letter installation name for Radford Army Ammunition Plant – "RD";
6. SAMPLE MATRIX CODE: Record the appropriate sample matrix code. Common codes are "SD" for solid - sediment, "SI" for soil - gas, "SL for solid sludge, "SO" for surface other, "SS" for solid – soil, "SW" for surface wipe, "WD" for water – potable, "WG" for water – ground, "WS" water – surface, "WT" – water treated and "WW" water -waste;
7. SITE ID: Record a code up to 20 characters or numbers that is unique to the site;
8. ENV. FIELD SAMPLE IDENTIFIER: Record a code up to 20 characters specific for the sample;
9. DATE: Enter the date the sample was taken;
10. TIME: Enter the time (12-hour or 24-hour clock acceptable as long as internally consistent) the sample was taken;

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11. AM PM: Circle "AM" or "PM" to designate morning or afternoon (12-hour clock);
12. SAMPLE PROG: Record "RFI" (RCRA Facility Investigation) or other appropriate sample program;
13. DEPTH (TOP): Record the total depth sampled;
14. DEPTH INTERVAL: Record the intervals at which the plug will be sampled;
15. UNITS: Record the units of depth (feet, meters);
16. SAMPLE MEASUREMENTS: Check the appropriate sampling method;
17. CHK: Check off each container released to a laboratory;
18. ANALYSIS: Record the type of analysis to be performed on each sample container;
19. SAMPLE CONTAINER: Record the sample container type and size;
20. NO.: Record the number of containers;
21. REMARKS: Record any remarks about the sample;
22. TOTAL NUMBER OF CONTAINERS FOR SAMPLE: Record the total number of containers;
23. SITE DESCRIPTION: Describe the location where the sample was collected;
24. SAMPLE FORM: Record the form of the sample (i.e., clay, loam, etc.) using The Unified Soil Classification System (USCS);
25. COLOR: Record the color of the sample as determined from standard Munsell Color Charts;
26. ODOR: Record the odor of the sample or "none";
27. PID: Record the measured PID values or other similar measurement instrument value;
28. UNUSUAL FEATURES: Record anything unusual about the site or sample;
29. WEATHER/TEMPERATURE: Record the weather and temperature; and
30. SAMPLER: Record your name.

3.1.2 Map File Form (refer to form 10.2-c)

1. SITE ID: Record the Site ID from the field parameter form;
2. POINTER: Record the field sample number for the sample being pointed to;
3. DESCRIPTION/MEASUREMENTS: Describe the location where the sample was taken, along with distances to landmarks;
4. SKETCH/DIMENSIONS: Diagram the surroundings and record the distances to landmarks;
5. MAP REFERENCE: Record which U.S.G.S. Quad Map references the site;
6. COORDINATE DEFINITION: Write the compass directions and the X- and Y-coordinates of the map run;
7. COORDINATE SYSTEM: Write "UTM" (Universal Transverse Mercator);
8. SOURCE: Record the 1-digit code representing the Map Reference;
9. ACCURACY: Give units (e.g., write "1-M" for 1 meter);
10. X-COORDINATE: Record the X-coordinate of the sample site location;
11. Y-COORDINATE: Record the Y-coordinate of the sample site location;

12. UNITS: Record the units used to measure the map sections;
13. ELEVATION REFERENCE: Record whether topography was determined from a map or a topographical survey;
14. ELEVATION SOURCE: Record the 1-digit code representing the elevation reference;
15. ACCURACY: Record the accuracy of the map or survey providing the topographical information;
16. ELEVATION: Record the elevation of the sampling site;
17. UNITS: Write the units in which the elevation is recorded; and
18. SAMPLER: Write your name.

3.2 SURFACE WATER

3.2.1 Field Parameter Logbook (Forms 10.2-b and 10.2-c)

1. CAL REF: Record the calibration reference for the pH meter;
2. pH: Record the pH of the sample;
3. TEMP: Record the temperature of the sample in degrees Celsius;
4. COND: Record the conductivity of the water;
5. Description of site and sample conditions (refer to 10.2-b);
6. Map File Form (refer to Section 3.1.2).

3.3 GROUNDWATER (FORMS 10.2- D)

3.3.1 Field Parameter Logbook (Form 10.2.b)

Refer to Section 3.2.1.

3.3.2 Map File and Purging Forms

1. WELL NO. OR ID: Record the abbreviation appropriate for where the sample was taken. Correct abbreviations can be found on pages 18-21 of the IRDMIS User's Guide for chemical data entry;
2. SAMPLE NO.: Record the reference number of the sample;
3. WELL/SITE DESCRIPTION: Describe the location where the sample was taken, along with distances to landmarks;
4. X-COORD AND Y-COORD: Record the survey coordinates for the sampling site;
5. ELEV: Record the elevation where the sample was taken;
6. UNITS: Record the units the elevation was recorded in;
7. DATE: Record the date in the form MM/DD/YY;
8. TIME: Record the time, including a designation of AM or PM;
9. AIR TEMP.: Record the air temperature, including a designation of C or F (Celsius or Fahrenheit);
10. WELL DEPTH: Record the depth of the well in feet and inches;
11. CASING HEIGHT: Record the height of the casing in feet and inches;
12. WATER DEPTH: Record the depth (underground) of the water in feet and inches;

3. WELL WENT DRY? Write "YES" or "NO";
4. PUMP TIME: Record pump time that made the well go dry;
5. VOLUME REMOVED: Record the volume of water (gal) removed before the well went dry;
6. RECOVERY TIME: Record the time required for the well to refill;
7. PURGE AGAIN?: Answer "YES" or "NO";
8. TOTAL VOL. REMOVED: Record the total volume of water (in gallons) removed from the well;
9. CAL REF.: Record the calibration reference for the pH meter;
10. TIME: Record time started (INITIAL T(0)), 2 times DURING the sampling and the time sampling ended (FINAL);
11. pH: Record the pH at start of sampling (INITIAL), twice DURING the sampling, and at the end of sampling (FINAL);
12. TEMP: Record the water temperature (Celsius) at the start of sampling, twice DURING the sampling, and at the end of sampling (FINAL);
13. COND: Record the conductivity of the water at the start of sampling, twice DURING the sampling, and at the end of sampling (FINAL);
14. D.O.: Record the dissolved oxygen level in the water at the start of sampling, twice DURING the sampling, and at the end of sampling (FINAL);
15. TURBIDITY: Record the readings from the turbidity meter (nephelometer) and units at the start of sampling, twice DURING the sampling, and at the end of sampling (FINAL);
16. ORD: Record the oxidation/reduction (RedOx) potential of the water sample at the start of sampling, twice DURING the sampling, and at the end of sampling (FINAL);
17. HEAD SPACE: Record any positive readings from organic vapor meter reading taken in well headspace before sampling;
18. NAPL: Record the presence and thickness of any non-aqueous phase liquids (LNAPL and DNAPL)
19. COMMENTS: Record any pertinent information not already covered in the form; and
20. SIGNATURE: Sign the form.

3.4 FIELD CALIBRATION FORMS (REFER TO FORM 10.2-E)

1. Record time and date of calibration;
2. Record calibration standard reference number;
3. Record meter ID number;
4. Record initial instrument reading, recalibration reading (if necessary), and final calibration reading on appropriate line;
5. Record value of reference standard (as required);
6. COMMENTS: Record any pertinent information not already covered on form; and
7. SIGNATURE: Sign form.

4.0 MAINTENANCE

Not applicable.

5.0 PRECAUTIONS

None.

6.0 REFERENCE

USEPA. 1991. *User's Guide to the Contract Laboratory Program.* EPA/540/O-91/002, Directive 9240.0-01D, Office of Emergency and Remedial Response, January.

FIELD PARAMETER/LOGBOOK FORM 10.2-a
SOIL AND SEDIMENT SAMPLES

HIGH CONCENTRATION EXPECTED? ________________ HIGH HAZARD?

INSTALLATION/SITE ____________________________________ AREA ________________

INST NAME _________ FILE NAME ____________________________________

SAMPLE MATRIX CODE __________ SITE ID ____________
ENV. FIELD SAMPLE IDENTIFIER ________________

DATE (MM/DD/YY) __/__/__ TIME _________ AM PM SAMPLE PROGRAM

DEPTH (TOP) _____ DEPTH INTERVAL ____________ UNIT ___________

SAMPLING METHOD:

SPLIT SPOON __ AUGER __ SHELBY TUBE __ SCOOP __ OTHER

CHK	ANALYSIS	SAMPLE CONTAINER	NO.	REMARKS

TOTAL NUMBER OF CONTAINERS FOR SAMPLE_____

DESCRIPTION OF SITE AND SAMPLE CONDITIONS

SITE DESCRIPTION:____

____

____

SAMPLE FORM __________________ COLOR ____________ ODOR ___________
PID (HNu)__________________ UNUSUAL FEATURES___________________

____

WEATHER/TEMPERATURE

SAMPLER ________________

FIELD PARAMETER/LOGBOOK FORM 10.2-b
GROUNDWATER AND SURFACE WATER SAMPLES

HIGH CONCENTRATION EXPECTED? ______________ HIGH HAZARD?

INSTALLATION/SITE ____________________ AREA

INST CODE _________ FILE NAME __________________ SITE TYPE

SITE ID _________________ FIELD SAMPLE NUMBER

DATE (MM/DD/YY) __/__/__ TIME _________ AM PM SAMPLE PROG.

DEPTH (TOP) _________ DEPTH INTERVAL __________ UNITS

SAMPLING MEASUREMENTS

CAL REF. ____ pH ____ TEMPERATURE °C ____ CONDUCTIVITY ____ REDOX ____

DISSOLVED OXYGEN ____ TURBIDITY ____ OTHER

CHK	ANALYSIS	SAMPLE CONTAINER	NO.	REMARKS

TOTAL NUMBER OF CONTAINERS FOR SAMPLE_____

DESCRIPTION OF SITE AND SAMPLE CONDITIONS

SITE DESCRIPTION____

SAMPLING METHOD__________________________________

SAMPLE FORM ________________ COLOR _______ ODOR _______

PID (HNu)____________________________________

UNUSUAL FEATURES__________________________

WEATHER/TEMPERATURE_____________________________________ SAMPLER ______________

EXAMPLE MAP FILE LOGBOOK FORM 10.2-c
SURFACE WATER, SOIL, AND SEDIMENT SAMPLES

SITE ID____________________ POINTER________________

DESCRIPTION/MEASUREMENTS____

SKETCH/DIMENSIONS :

MAP REFERENCE_________________________________

COORDINATE DEFINITION (X is _____________ Y is __________)

COORDINATE SYSTEM _____________ SOURCE _____________ ACCURACY________________

X-COORDINATE __________ Y-COORDINATE __________ UNITS________

ELEVATION REFERENCE____________________________

ELEVATION SOURCE ______________ ACCURACY ____________ELEVATION_______________

UNITS_____________

SAMPLER________

EXAMPLE MAP FILE AND PURGING LOGBOOK FORM 10.2-d
GROUNDWATER SAMPLES

WELL COORD. OR ID ____________________ SAMPLE NO.____________

WELL/SITE DESCRIPTION____

____

X-COORD. _______ Y-COORD. _____________ ELEV. ________ UNITS

DATE ___/___/___ TIME _______________ AIR TEMP.

WELL DEPTH ____________ FT. _____ IN. CASING HT. _____ FT. _____ IN.

WATER DEPTH ______ FT. ______ IN. WELL DIAMETER ________ IN.

WATER COLUMN HEIGHT _______ FT. _____ IN. SANDPACK DIAM. _____ IN.

EQUIVALENT VOLUME OF STANDING WATER ______________ (GAL) (L)

VOLUME OF BAILER _______ (GAL) (L) or PUMP RATE _________ (GPM) (LPM)

TOTAL NO. OF BAILERS (5 EV) _________ or PUMP TIME ________ MIN.

WELL WENT DRY? [Yes] [No] NUM. OF BAILERS ________ or PUMP TIME

VOL. REMOVED _____________ (GAL) (L) RECOVERY TIME

PURGE AGAIN? [Yes] [No] TOTAL VOL. REMOVED __________ (GAL) (L)

DATE & TIME	QUANTITY REMOVED	TIME REQ'D	pH	Cond	Temp	ORD	Turb	DO	Character of water (color / clarity / odor / partic.)
(before)									
(during)									
(during)									
(during									
(after)									

COMMENTS____

SIGNATURE_____________________________

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EXAMPLE FIELD CALIBRATION FORM 10.2-e FOR pH, CONDUCTIVITY, TEMPERATURE, TURBIDITY, ORD, AND DISSOLVED OXYGEN METERS

INITIAL CALIBRATION	**FINAL CALIBRATION**
DATE:	**DATE:**
TIME:	**TIME:**

pH METER CALIBRATION

CALIBRATION STANDARD REFERENCE NO:________________

METER ID__________________

pH STANDARD	**INITIAL READING**	**RECALIB. READING**	**FINAL READING**
7.0			
10.0			
4.0			

CONDUCTIVITY METER CALIBRATION

CALIBRATION STANDARD REFERENCE NO:________________

METER ID__________________

COND. STANDARD	**INITIAL READING**	**RECALIB. READING**	**FINAL READING**

TEMPERATURE METER CALIBRATION

METER ID__________________

TEMP. STANDARD	**INITIAL READING**	**RECALIB. READING**	**FINAL READING**
ICE WATER			
BOILING WATER			
OTHER ________			

EXAMPLE FIELD CALIBRATION FORM 10.2-e
FOR pH, CONDUCTIVITY, TEMPERATURE, TURBIDITY, ORD, AND DISSOLVED OXYGEN METERS

TURBIDITY METER CALIBRATION

CALIBRATION STANDARD REFERENCE NO:________________

METER ID__________________

STANDARD	INITIAL READING	RECALIB. READING	FINAL READING

ORD METER CALIBRATION

CALIBRATION STANDARD REFERENCE NO:________________

METER ID__________________

STANDARD	INITIAL READING	RECALIB. READING	FINAL READING

DISSOLVED OXYGEN METER CALIBRATION

CALIBRATION STANDARD REFERENCE NO:________________

METER ID__________________

STANDARD	INITIAL READING	RECALIB. READING	FINAL READING

COMMENTS____

SIGNATURE__________________________________

STANDARD OPERATING PROCEDURE 10.3
BORING LOGS

1.0 INTRODUCTION

The purpose of this standard operating procedure (SOP) is to describe the methods to be followed for classifying soil and rock, as well as preparing borehole logs and other types of soil reports.

2.0 MATERIALS

The following equipment is required for borehole logging:

- HTRW ENG Form 5056-R and 5056A-R boring log forms;
- Daily inspection report forms;
- Chain-of-custody forms;
- Request for analysis forms;
- ASTM D 2488 classification flow chart;
- Soil and/or Rock color chart (i.e., Munsell®);
- Grain size and roundness chart;
- Graph paper;
- Engineer's scale;
- Previous reports and boring logs;
- Pocketknife or putty knife;
- Hand lens;
- Dilute hydrochloric acid (10% volume);
- Gloves;
- Personal protective clothing and equipment, as described in work plan addenda health and safety plan;
- Photoionization detector or other appropriate monitoring equipment per site-specific health and safety plan; and
- Decontamination supplies (SOP 80.1).

3.0 PROCEDURE

Each boring log should fully describe the subsurface environment and the procedures used to obtain this description.

Boring logs should be prepared in the field on USACE Engineer Form 5056-R and 5056-R. Logs should be recorded in the field directly on the boring log form and not transcribed from a field book.

A "site geologist" should conduct borehole logging and soil/rock identification and description or other professional trained in the identification and description of soil/rock.

3.1 BORING LOG INFORMATION

As appropriate, the following information should be recorded on the boring log during the course of drilling and sampling activities:

- Project information including name, location, and project number;
- Each boring and well should be uniquely numbered and located on a sketch map as part of the log;
- Type of exploration;
- Weather conditions including events that could affect subsurface conditions;
- Dates and times for the start and completion of borings, with notations by depth for crew shifts and individual days;
- Depths/heights in feet and in decimal fractions of feet;
- Descriptions of the drilling equipment including rod size, bit type, pump type, rig manufacturer and model, and drilling personnel;
- Drilling sequence and descriptions of casing and method of installation;
- Description and identification of soils in accordance with ASTM Standard D 2488;
- Descriptions of each intact soil sample for the parameters identified in Section 3.2;
- Descriptions and classification of each non-intact sample (e.g., wash samples, cuttings, auger flight samples) to the extent practicable;
- Description and identification of rock;
- Description of rock (core(s)) for the parameters identified in Section 3.7;
- Scaled graphic sketch of the rock core (included or attached to log) according to the requirements identified in Section 3.7;
- Lithologic boundaries, with notations for estimated boundaries;
- Depth of water first encountered in drilling, with the method of first determination (any distinct water level(s) below the first zone will also be noted);
- Interval by depth for each sample taken, classified, and/or retained, with length of sample recovery and sample type and size (diameter and length);
- Blow counts, hammer weight, and length of fall for driven samplers;

- Rate of rock coring and associated rock quality designation (RQD) for intervals cored;
- Drilling fluid pressures, with driller's comments;
- Total depth of drilling and sampling;
- Drilling fluid losses and gains should be recorded;
- Significant color changes in the drilling fluid returned;
- Soil gas or vapor readings with the interval sampled, with information on instrument used and calibration;
- Depth and description of any in-situ test performed; and
- Description of other field tests conducted on soil and rock samples.

3.2 SOIL PARAMETERS FOR LOGGING

In general, the following soil parameters should be included on the boring log when appropriate:

- Identification per ASTM D 2488 with group symbol;
- Secondary components with estimated percentages per ASTM D 2488;
- Color;
- Plasticity per ASTM D 2488;
- Density of non-cohesive soil or consistency of cohesive soil;
- Moisture condition per ASTM D 2488 (dry, moist, or wet);
- Presence of organic material;
- Cementation and HCL reaction testing per ASTM D 2488;
- Coarse-grained particle description per ASTM D 2488 including angularity, shapes, and color;
- Structure per ASTM D 2488 and orientation;
- Odor; and
- Depositional environment and formation, if known.

ASTM D 2488 categorizes soils into 13 basic groups with distinct geologic and engineering properties based on visual-manual identification procedures. The following steps are required to classify a soil sample:

1. Observe basic properties and characteristics of the soil. These include grain size grading and distribution, and influence of moisture on fine-grained soil.
2. Assign the soil an ASTM D 2488 classification and denote it by the standard group name and symbol.
3. Provide a written description to differentiate between soils in the same group if necessary.

Many soils have characteristics that are not clearly associated with a specific soil group. These soils might be near the borderline between groups, based on particle distribution or plasticity characteristics. In such a case, assigning dual group names and symbols (e.g., GW/GC or ML/CL) might be an appropriate method of describing the soil. The two general types of soils, for which classification is performed, coarse- and fine-grained soils, are discussed in the following sections.

3.3 COURSE-GRAINED SOIL IDENTIFICATION

For soils in the coarse-grained soils group, more than half of the material in the soil matrix will be retained by a No. 200 sieve (75-μm).

1. Coarse-grained soils are identified on the basis of the following:
   a) Grain size and distribution;
   b) Quantity of fine-grained material (i.e., silt and clay as a percentage); and
   c) Character of fine-grained material.
2. The following symbols are used for classification:

Basic Symbols	Modifying Symbols
G = gravel	W = well graded
S = sand	P = poorly graded
	M = with silty fines
	C = with clayey fines

3. The following basic facts apply to coarse-grained soil classification.

- The basic symbol G is used if the estimated percentage of gravel is greater than that for sand. In contrast, the symbol S is used when the estimated percentage of sand is greater than the percentage of gravel.
- Gravel ranges in size from 3-inch to 1/4-inch (No. 4 sieve) diameter. Sand ranges in size from the No. 4 sieve to No. 200 sieve. The Grain Size Scale used by Engineers (ASTM Standards D 422-63 and D 643-78) is the appropriate method to further classify grain size as specified by ASTM D 2488.
- Modifying symbol W indicates good representation of all particle sizes.
- Modifying symbol P indicates that there is an excess or absence of particular sizes.
- The symbol W or P is used only when there are less than 15% fines in a sample.
- Modifying symbol M is used if fines have little or no plasticity (silty).
- Modifying symbol C is used if fines have low to high plasticity (clayey).

Figure 10.03a is a flowchart for identifying coarse-grained soils by ASTM D 2488.

3.4 FINED-GRAINED SOIL IDENTIFICATON

If one-half or more of the material will pass a No. 200 sieve (75 μm), the soil is identified as fine-grained.

1. Fine-grained soils are classified based on dry strength, dilatancy, toughness, and plasticity.
2. Classification of fine-grained soils uses the following symbols:

Basic Symbols	Modifying Symbols
M = silt (non plastic)	L = low liquid limit (lean)
C = clay (plastic)	H = high liquid limit (fat)
O = organic	
Pt = peat	

3. The following basic facts apply to fine-grained soil classification:
   - The basic symbol M is used if the soil is mostly silt, while the symbol C applies if it consists mostly of clay.
4. Use of symbol O (group name OL/OH) indicates that organic matter is present in an amount sufficient to influence soil properties. The symbol Pt indicates soil that consists mostly of organic material.

- Modifying symbols (L and H) are based on the following hand tests conducted on a soil sample:
  - — Dry strength (crushing resistance).
  - — Dilatancy (reaction to shaking).
  - — Toughness (consistency near plastic limit).
- Soil designated ML has little or no plasticity and can be recognized by slight dry strength, quick dilatency, and slight toughness.
- CL indicates soil with slight to medium plasticity, which can be recognized by medium to high dry strength, very slow dilatancy, and medium toughness.

Criteria for describing dry strength per ASTM D 2488 are as follows:

Description	Criteria
None	Dry sample crumbles into powder with pressure of handling
Low	Dry specimen crumbles into powder with some finger pressure
Medium	Dry specimen breaks into pieces or crumbles with considerable finger pressure
High	Dry specimen cannot be broken with finger pressure but will break into pieces between thumb and a hard surface
Very high	Dry specimen cannot be broken between the thumb and a hard surface stiffness

Criteria for describing dilatancy per ASTM D 2488 are as follows:

None	No visible change in the sample
Slow	Water appears slow on the surface of the sample during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the sample during shaking and disappears quickly upon squeezing

Criteria for describing toughness per ASTM D 2488 are as follows:

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit and the thread and lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit and the thread and lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit and the thread and lump have very high stiffness

Figure 10.03b is a flowchart for identifying fine-grained soils by ASTM D 2488.

3.5 DENSITY AND CONSISTENCY

Relative density for coarse-grained soils and consistency for fine-grained soils can be estimated using standard penetration test blow count data (ASTM D 1586). The number of blows required for each 6 inches of penetration or fraction thereof is recorded. If the sampler is driven less than 18 inches, the number of blows per each complete 6-inch interval and per partial interval is recorded.

For partial increments, the depth of penetration should be recorded to the nearest 1 inch. If the sampler advances below the bottom of the boring under the weight of rods (static) and/or hammer, then this information should be recorded on the log.

The following are some "rule-of-thumb" guidelines for describing the relative density of coarse-grained soils:

Blow Count	Relative Density for Sand
0–4	Very loose
4–10	Loose
10–30	Medium dense
30–50	Dense
>50	Very Dense

The following are some "rule-of-thumb" guidelines for describing the consistency of fine-grained soils:

Blow Count	Consistency for Clays	Description
0–2	Very Soft	Sample sags or slumps under its own weight
2–4	Soft	Sample can be pinched in two between the thumb and forefinger
4–8	Medium Stiff	Sample can be easily imprinted with fingers
8–16	Stiff	Sample can be imprinted only with considerable pressure of fingers
16–32	Very Stiff	Sample can be imprinted very slightly with fingers
>32	Hard	Sample cannot be imprinted with fingers; can be pierced with pencil

3.6 OTHER DESCRIPTIVE INFORMATION

The approximate percentage of gravel, sand, and fines (use a percentage estimation chart) should be recorded per ASTM D 2488 as follows:

Modifiers	Descriptions
Trace	Less than 5%
Few	5%–10%
Little	15%–25%
Some	30%–45%
Mostly	50%–100%

Color/discoloration should be recorded and described using a soil color chart, such as the Munsell® Soil Color Charts. A narrative and numerical description should be given from the color chart, such as Brown 10 YR, 5/3 (Munsell®). Odor should be described if organic or unusual.

Plasticity should be described as follows:

Description	Criteria
Non-plastic	A 1/8-inch thread cannot be rolled at any water content
Low	Thread can barely be rolled and lump cannot be formed when drier than plastic limit.
Medium	Thread is easy to roll; plastic limit can be reached with little effort and lump crumbles when drier than plastic limit.
High	Considerable time is required to reach the plastic limit and lump can be formed without crumbling when drier than plastic limit

Moisture condition should be recorded as dry (absence of moisture), moist (damp but no visible water) or wet (visible free water).

Cementation should be recorded (carbonates or silicates) along with the results of HCL reaction testing. The reaction with HCL should be described as none (no visible reaction), weak (some reaction with slowly forming bubbles) or strong (violent reaction with bubbles forming immediately).

Particle description information for coarse-grained soil should be recorded where appropriate per ASTM D 2488 including maximum particle size, angularity (angular, subangular, subrounded, or rounded), shape (flat, elongated or flat and elongated), and color.

Structure (along with orientation) should be reported using the following ASTM D 2488 descriptions:

Description	Criteria
Stratified	Alternating layers of varying material or color with layers greater than 6 millimeters thick
Laminated	Alternating layers of varying material or color with layers less than 6 millimeters thick
Fissured	Breaks along definite planes of fracture with little resistance
Slickensided	Fracture planes that appear polished or glossy, can be striated
Blocky	Inclusion of small pockets of different soils
Homogeneous	Same color and appearance throughout

3.7 ROCK CORE PARAMETERS FOR LOGGING

In general, the following parameters should be included on the boring log when rock coring is conducted:

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- Rock type;
- Formation;
- Modifier denoting variety;
- Bedding/banding characteristics;
- Color;
- Hardness;
- Degree of cementation;
- Texture;
- Structure and orientation;
- Degree of weathering;
- Solution or void conditions;
- Primary and secondary permeability including estimates and rationale; and
- Lost core interval and reason for loss.

A scaled graphic sketch of the core should provided on or attached to the log, denoting by depth, location, orientation, and nature (natural, coring-induced, or for fitting into core box) of all core breaks. Where fractures are too numerous to be shown individually, their location may be drawn as a zone.

The RQD values for each core interval (run) should be calculated and included on the boring log. The method of calculating the RQD is as follows per ASTM D 6032:

RQD = [Σ length of intact core pieces > 100 mm (4-inches)] x 100%/total core length.

3.8 PROCEDURES FOR ROCK CLASSIFICATION

For rock classification record mineralogy, texture, and structural features (e.g., biotite and quartz fine grains, foliated parallel to relict bedding oriented 15 to 20 degrees to core axis, joints coated with iron oxide). Describe the physical characteristics of the rock that are important for engineering considerations such as fracturing (including minimum, maximum, and most common and degree of spacing), hardness, and weathering.

1. The following is to be used as a guide for assessing fracturing:

<u>AEG Fracturing</u>	<u>Spacing</u>
Crushed	up to 0.1 foot
Intense	0.1–0.5 foot
Moderate	0.5 foot–10 feet
Slight	1.0 foot–3.0 feet
Massive	>3.0 feet

2. Record hardness using the following guidelines:

Hardness	Criteria
Soft	Reserved for plastic material
Friable	Easily crumbled by finger pressure
Low	Deeply gouged or carved with pocketknife
Moderate	Readily scratched with knife; scratch leaves heavy trace of dust
Hard	Difficult to scratch with knife; scratch produces little powder and is often faintly visible
Very Hard	Cannot be scratched with knife

3. Describe weathering using the following guidelines:

Weathering	Decomposition	Discoloration	Fracture Condition
Deep	Moderate to complete alteration of minerals feldspars altered to clay, etc.	Deep and thorough	All fractures extensively coated with oxides, carbonates, or clay
Moderate	Slight alteration of minerals, cleavage surface lusterless and stained	Moderate or localized and intense	Thin coatings or stains
Weak	No megascopic alteration of minerals	Slight and intermittent and localized	Few strains on fracture surfaces
Fresh	Unaltered, cleavage, surface glistening		

3.9 PROCEDURE FOR LOGGING REFUSE

The following procedure applies to the logging of subsurface samples composed of various materials in addition to soil as may be collected from a landfill or other waste disposal site.

1. Observe refuse as it is brought up by the hollow stem auger, bucket auger, or backhoe.

2. If necessary, place the refuse in a plastic bag to examine the sample.

3. Record observations according to the following criteria:

   - Composition (by relative volume), e.g., paper, wood, plastic, cloth, cement, or construction debris. Use such terms as “mostly” or “at least half.” Do not use percentages;
   - Moisture condition: dry, moist, or wet;
   - State of decomposition: highly decomposed, moderately decomposed, slightly decomposed, etc.;
   - Color: obvious mottling and/or degree of mottling;
   - Texture: spongy, plastic (cohesive), friable;
   - Odor;

- Combustible gas readings (measure down hole and at surface); and
- Miscellaneous: dates of periodicals and newspapers, ability to read printed materials, degree of drilling effort (easy, difficult, and very difficult).

3.10 SUBMITTAL REQUIREMENTS

Each original boring log should be submitted to the Contracting Officer Representative (CRO) after completion of the boring. When a monitoring well will be installed in a boring, the boring log and well installation diagram should be submitted together.

4.0 MAINTENANCE

Not applicable.

5.0 PRECAUTIONS

Not applicable.

6.0 REFERENCES

ASTM Standard D 1586–84 (1992). 1992. *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils.*

ASTM Standard D 2488-93. 1993. *Standard Practice for Description and Identification of Soils Visual-Manual Procedure).*

ASTM Standard D 5434-93. 1993. *Guide for Field Logging of Subsurface Explorations of Soil and Rock.*

ASTM Standard D 6032-96. 1996. *Standard Test Method for Determining Rock Quality Designation (RQD) of Rock Core.*

Compton, R. R. 1962. *Manual of Field Geology.* John Wiley & Sons, Inc., New York.

USACE. 1998. *Monitoring Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Waste Sites.* EM 1110-1-4000, 1, November.

U.S. Department of the Interior. 1989. *Earth Manual.* Water and Power Resources Service, Washington, DC.

STANDARD OPERATING PROCEDURE 10.4
CHAIN-OF-CUSTODY FORM

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to delineate protocols for use of the chain-of-custody form. An example is provided as part of this SOP. Other formats with similar levels of detail are acceptable.

2.0 MATERIALS

- Chain-of-custody form; and
- Indelible ink pen.

3.0 PROCEDURE

1. Record the project name and number.
2. Record the project contact's name and phone number.
3. Print sampler's names in "Samplers" block.
4. Enter the Field Sample No.
5. Record the sampling dates for all samples.
6. List the sampling times (military format) for all samples.
7. Indicate, "grab" or "composite" sample with an "X."
8. Record matrix (e.g., aqueous, soil).
9. List the analyses/container volume across top.
10. Enter the total number of containers per Field Sample No. in the "Subtotal" column.
11. Enter total number of containers submitted per analysis requested.
12. State the carrier service and airbill number, analytical laboratory, and custody seal numbers.
13. List any comments or special requests in the "Remarks" section.
14. Sign, date, and time the "Relinquished By" section when the cooler is relinquished to the next party.
15. Upon completion of the form, retain the shipper copy and place the forms and the other copies in a zip seal bag to protect from moisture. Affix the zip seal bag to the inside lid of the sample cooler to be sent to the designated laboratory.

4.0 MAINTENANCE

Not applicable.

5.0 PRECAUTIONS

None.

6.0 REFERENCES

USEPA. 1990. *Sampler's Guide to the Contract Laboratory Program.* EPA/540/P-90/006, Directive 9240.0-06, Office of Emergency and Remedial Response, Washington, DC, December 1990.

USEPA. 1991. *User's Guide to the Contract Laboratory Program.*. EPA/540/O-91/002, Directive 9240.0-01D, Office of Emergency and Remedial Response, January 1991.

USEPA. 1998. *EPA Requirements for Quality Assurance Project Plans.* EPA/600/R-98/018, QA/R5, Final, Office of Research and Development, Washington, D.C.

FIGURE 10.4-a
EXAMPLE CHAIN-OF-CUSTODY FORM

<table>
<tr><td>Project Number</td><td colspan="4">Project Name</td><td rowspan="4">Matrix</td><td colspan="8">ANALYSES</td><td rowspan="4">Subtotal</td><td><u>LAB :</u></td></tr>
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STANDARD OPERATING PROCEDURE 20.3
WELL AND BORING ABANDONMENT

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to establish the protocols by which all borings and wells will be abandoned. The primary objective of boring or well abandonment activities is to permanently abandon the boring or well so that the natural migration of groundwater or soil vapor is not significantly influenced.

2.0 MATERIALS

- Well abandonment equipment including appropriate grout mixing/placement equipment, and heavy equipment as appropriate (drill rig, crane, backhoe, etc.);
- Pure sodium bentonite powder with no additives (bentonite);
- Bentonite pellets (seal);
- Cement (Portland Type II); and
- Approved source water.

3.0 PROCEDURE

The volume of grout required for borehole or well abandonment should be calculated prior to proceeding with abandonment. These calculations should consider loss of material to the formation, changes in borehole diameter, potential zones of washout, and shrinkage of material. Calculations should be recorded on an abandonment record (see Section 3.1.4).

In general, cement grout should be used for boring and well abandonment per the specifications in Section 3.1 and procedures identified in the following sections. Specialized narrow diameter soil borings (3-inches or less) associated with direct push methods or hand augers may be abandoned using bentonite pellets or chips (see Section 3.5).

Any replacement borings or wells associated with the abandonment should be offset at least 20 feet from any abandoned site in a presumed up- or cross-gradient direction.

3.1 GROUT

Grout used in construction will be composed by weight of the following:

- Type II Portland cement (Type IV Portland Cement if sulfate concentrations are greater than 1,500 ppm);
- Bentonite (2 to 5% dry bentonite per 94-lb sack of dry cement); and
- A maximum of 6 to 7 gallons of approved water per 94-lb sack of cement.

Neither additives nor borehole cuttings will be mixed with the grout. Bentonite will be added after the required amount of cement is mixed with the water.

All grout material will be combined in an aboveground container and mechanically blended to produce a thick, lump-free mixture. The mixed grout will be recirculated through the grout pump before placement.

Grout placement will be performed using a commercially available grout pump and a rigid tremie pipe. Removal and grouting will be accomplished in stages, aquifer by aquifer, sealing the boring from the bottom to ground surface. This will be accomplished by placing a grout pipe to the bottom and pumping grout through the pipe until undiluted grout reaches the bottom of the next higher section of casing or, for the top-most section, until grout flows from the boring at ground surface.

After 24 hours, the abandoned drilling site will be checked for grout settlement. Any settlement will be filled with grout and rechecked 24 hours later. This process will be repeated until firm grout remains at the ground surface.

3.2 BORINGS

The term "borings" as used in this SOP applies to any drilled hole made that is not completed as a well. This includes soil test borings, soil sampling borings, and deep stratigraphic borings. Whether completed to the planned depth or aborted for any reason before reaching that depth, borings will be grouted and will be normally closed within 12 hours.

To achieve an effective seal, the borehole to be abandoned should be free of debris and foreign matter that may restrict the adhesion of the grout to the borehole wall. Borehole flushing with a tremie pipe may be required to remove such materials prior to grouting.

Each boring to be abandoned should be sealed by grouting from the bottom of the boring to the ground surface. This will be accomplished by placing a tremie pipe to the bottom of the borehole and pumping grout through the pipe at a steady rate. The grouting should be completed slowly and continuously to prevent channeling of material. The tremie pipe should be raised when pumping pressure increases significantly or when undiluted grout reaches the surface.

After 24 hours of completing the abandonment, the abandoned boring or well should be checked for any grout settlement. The settlement depression should be filled with grout and rechecked 24 hours later. Grout should be placed with a tremie pipe if the open hole is 15 feet or deeper or if the hole is not dry. Otherwise, the grout may be poured from the surface.

3.3 NARROW BORINGS

Narrow borings, those with diameter less than 3 inches, advanced by hand auger or direct push methods, may be sealed using bentonite pellets or chips rather than a grout mixture. Often times a grout pump is not available to mix the grout when these methods have been used. Bentonite pellets or chips will be poured into the boring from the ground surface. Then bentonite will hydrate by absorbing moisture from the ground; unapproved water should not be added to the boring. After 24 hours, the abandoned boring will be checked, and any grout settlement will be topped off with more bentonite. The process will be repeated until bentonite remains at ground surface unless site condition indicates otherwise.

3.4 WELLS

The following procedure applies to wells aborted before completion and existing wells determined to be ineffective or otherwise in need of closure.

General Considerations

A number of techniques are available for abandoning monitoring wells and other monitoring devices including:

- Abandonment in place by grouting the well screen and casing in place;
- Removal of the well by pulling; and
- Overdrilling.

The particular method used for abandonment should be specified in the work plan addenda developed for a site-specific investigation. Several factors must be considered when selecting the appropriate abandonment technique including well construction, well condition, and subsurface conditions.
In general the preferred method for abandonment of wells is to remove all existing well materials to:

- Reduce the potential for the formation of a vertical conduit to occur at the contact between the casing and annular seal;
- Reduce the potential for well materials interfering with the abandonment procedures; and
- Decrease the potential for reaction between the well materials and grout used for abandonment.

In general, all well materials will be removed during abandonment (including screen and casing) by either pulling out the casing, screen, and associated materials or by overdrilling using a rotary or hollow stem auger drilling procedure.

Abandonment with Well Materials In Place

In the event that it is not possible to remove the casing and screen, the casing and screen will be perforated using a suitable tool. A minimum of four rows of perforations several inches long and a minimum of five perforations per linear foot of casing or screen is recommended.

After the screen and casing have been appropriately perforated, the well should be abandoned by grouting from the bottom of the well to the ground surface using a tremie pipe as described in Section 3.2. The tremie pipe should be raised when pumping pressure increases significantly or when undiluted grout reaches the surface.

After 24 hours of completing the abandonment, the abandoned well should be checked for any grout settlement. The settlement depression should be filled with grout and rechecked 24 hours later. Grout should be placed with a tremie pipe if the open hole is 15 feet or deeper or if the hole is not dry. Otherwise, the grout may be poured from the surface.

Abandonment by Removal

Site conditions permitting, relatively shallow monitoring wells may be successfully abandoned by removal providing that the well is generally good condition and sections of casing (including screen) can be successfully removed with materials intact.

This method of abandonment is generally accomplished by removing (pulling) sections of casing and screen out of the subsurface using a drill rig, backhoe, crane, etc. of sufficient capacity. Materials with lower tensile strength such as polyvinyl chloride (PVC) generally cannot be removed by pulling if they have been appropriately cemented in place.

Once the well materials have been removed from the borehole, the borehole should be abandoned by grouting in the same manner discussed for borings in Section 3.2. If the borehole collapses after removal of well materials, then the borehole should be over drilled to remove all material and then grouted to the surface.

Overdrilling

With this method of abandonment, the well materials are removed by overdrilling (overreaming) the well location. Overdrilling using rotary techniques may be accomplished using an overreaming tool. This tool consists of a pilot bit that is approximately the same size as the inner diameter of well casing and a reaming bit that is slightly larger than the diameter of the borehole. As drilling proceeds, all well materials are destroyed and returned to the surface. After completion of the overdrilling, the borehole should be immediately grouted with a tremie pipe as described in Section 3.2.

In the case of overburden wells, a hollow stem auger may be used for overdrilling providing that this method of drilling appropriate for the subsurface conditions. The hollow stem auger should be equipped with outward facing carbide-cutting teeth with a diameter 2 to 4 inches larger than the well casing. With this method, the casing guides the cutting head and remains inside the auger. When the auger reaches the bottom of the well boring and the well materials have been removed, the borehole may be grouted with a tremie pipe (Section 3.2) through the augers as the augers are gradually withdrawn.

Considerations for Fractured Bedrock and Karst Wells

Multi-cased wells completed into bedrock as screened wells, open wells, or open-lined wells may be abandoned with the outer casing left in place providing that the integrity of this casing and associated annular seal is good. A cement bond log (acoustic amplitude boring geophysical log) may be used to evaluate the integrity of the casing and annular seal, if the outer casing is to be left in place.

Borings or wells completed in karst zones may be difficult to abandon because of the potential presence of large conduits, which may make it difficult to grout. Where large conduits exist or difficulties are encountered when abandoning a boring or well, fill the portion of the borehole penetrating the solution cavity with inert gravel (quartz, claystone, etc.). Packers can be used to isolate critical intervals for filling with grout above and below these zones.

3.5 RESTORATION

All work areas around the borings or wells abandoned should be restored to a condition essentially equivalent to that before the borings and wells were installed.

3.6 INVESTIGATION-DERIVED MATERIAL

Investigation-derived material should be managed in accordance with the requirements of SOP 70.1 and the work plan addenda associated with the site investigation

3.7 DOCUMENTATION

For each abandoned boring or well, a record should be prepared to include the following as appropriate:

- Project and boring/well designation;
- Location with respect to replacement boring well (if any);

- Open depth of well/annulus/boring prior to grouting;
- Casing or items left in hole by depth, description, composition, and size;
- Copy of the boring log;
- Copy of construction diagram for abandoned well;
- Reason for abandonment;
- Description and total quantity of grout used initially;
- Description and daily quantities of grout used to compensate for settlement;
- Disposition of investigation-derived material;
- Water or mud level prior to grouting and date measured; and
- Remaining casing above ground surface, height above ground surface, size, and disposition of each.

Daily investigation activities at the site related to boring and well abandonment should be recorded in field logbooks as described in SOPs 10.1 and 10.2.

4.0 PRECAUTIONS

Refer to the health and safety plan associated with the Work Plan Addenda and the Master Health and Safety Plan.

5.0 REFERENCES

ASTM Standard D 5299-92. 1992. *Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities.*

USACE. 1998. *Monitoring Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Waste Sites.* EM 1110-1-4000, 1 November.

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STANDARD OPERATING PROCEDURE 20.4
TEST PITS

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to delineate protocols for the excavation of test pits and provide general guidelines for sample collection from the test pits.

Test pit excavations are conducted to investigate and identify possible areas of contamination. Thus, samples taken from the excavation will be positively biased according to visual inspection (i.e., soil discoloration, soil staining) and field screening. Areas showing evidence of possible contamination will be sampled directly. If no evidence of contamination is present during excavation, then samples will be collected in two equally spaced intervals or at intervals specified in work plan addenda for site-specific investigations. In either case, no less than two representative samples per excavation site should be collected. Excavation (and sampling) shall terminate if the water table is encountered before terminal depth.

2.0 MATERIALS

- Master Work Plan;
- Work Plan Addenda;
- Field log books;
- Appropriate health and safety equipment for monitoring conditions in the work zone and excavation area including a photoionization detector (PID) or other types of monitoring equipment;
- Personal protective equipment and clothing (PPE) per the site-specific health and safety plan;
- Backhoe and associated equipment;
- Appropriate soil sampling equipment such as stainless steel scoops, trowels, spoons, and bowls/trays SOP 30.1);
- Appropriate sample bottles, labels, chain-of-custody forms, and sample shipping supplies etc;
- Tarps or plastic sheeting;
- Measuring tape;
- Camera and film; and
- Decontamination equipment and supplies.

3.0 PROCEDURE

3.1 DOCUMENTATION

Field activities and sampling information should be recorded in the field logbooks as outlined in SOPs 10.1 and 10.2.

Cross-sections and sketches of the layout will be prepared upon completion of the excavation. The sketches will indicate soil horizons and geologic observations. Soil horizons will be differentiated based upon variations in soil color (i.e., Munsell Chart), texture, coarse fragment content, structure, and consistence. Refer to SOP 10.3 for boring log completion procedures. In addition, depth and thickness of horizontal depth to bedrock (if encountered) and indicators of seasonal high water table (presence of redoximorphic features) will be recorded. Sketches will also indicate the location of any samples collected. Photographs of the excavation will be taken and locations noted on the field map.

3.2 DECONTAMINATION

Decontamination of the backhoe, trowels or spoons, bowls, field tape measure, and other associated equipment will be carried out before use and between each test pit as outlined in work plan addenda and SOP 80.1.

3.3 SITE PREPARATION

Mark out dimensions of excavation and possible hazards (e.g., utilities, former structures). The backhoe must be equipped with a protective shield and the operator properly trained in the use of level B respiratory and dermal protection. The backhoe bucket and arm must be thoroughly decontaminated by steam cleaning before use and between each test pit location as described in work plan addenda and SOP 80.1. Discuss all hazards with equipment operator before any intrusive activities.

Set up exclusion zone with caution tape and position backhoe upwind of excavation site. All activities must be conducted in accordance with the health and safety plan developed for work plan addenda.

3.4 EXCAVATION AND SAMPLING

The backhoe operator shall be directed to excavate until the sampler indicates the desired depth has been reached. If the pit is less than 3 ft deep, the sampler can enter the pit and collect the samples using a decontaminated stainless steel trowel or spoon as described in SOP 30.1. As the pit becomes deeper, the sampler will collect the soil samples directly from the center of the bucket of the backhoe in an area not in contact with the sides of the bucket. The samples will then be transferred from the bucket into the appropriate sample container following sampling techniques outlined in SOP 30.1. Screening processes and analytical parameters for field screening soil samples will vary from site to site as specified per scope of work.

Begin excavating in increments of 6 to12 inches per pass. Deeper passes may be necessary if the soil is rocky. Total excavation width will be of adequate dimensions to visually characterize the soil profile as observed on the excavation walls, typically not exceeding the width of the backhoe bucket. However, total width of the excavation will be dependent on the depth of the excavation, thus wider dimensions may be necessary for characterization of deeper pits. Excavation will be continuously monitored with health and safety monitoring equipment. Safety measures must be exercised when working near and around the backhoe arm and excavation pit. Health and safety procedures and any installation safety procedures must be strictly followed.

All soil removed during excavation shall be placed on a tarp or plastic sheeting. Soil exhibiting signs of contamination based on visual or olfactory observations, as well as monitoring results, will be separated from uncontaminated soil and containerized for site removal.

Samples will be collected at desired intervals as specified in work plan addenda. Sampling procedures will follow the requirement of work plan addenda and SOP 30.1.

3.5 BACK FILL

Once the terminal depth of the excavation is reached or the water table is encountered and all samples are collected, the trench will be backfilled with certified clean fill. Soils removed during excavation shall be containerized and disposed of at an approved landfill or moved to an approved storage area for subsequent disposal. All backfilled material will be tamped to a proper compacted level to ensure no major settling will occur. After all backfilling and compacting procedures are complete, the area will be raked and seeded or resurfaced with asphalt, as appropriate. When the area is properly secured, decontamination procedures shall begin.

4.0 PRECAUTIONS

Refer to the site-specific health and safety plan.

5.0 REFERENCE

USEPA. 1987. *A Compendium of Superfund Field Operations Methods.* December.

STANDARD OPERATING PROCEDURE 20.11
DRILLING METHODS AND PROCEDURES

1.0 SCOPE AND APPLICATION

The use of an appropriate drilling procedure is contingent upon the existing conditions at the project site. The purpose of this standard operating procedure (SOP) is to outline procedures for the various methods of soil and rock drilling identified in the Master Work Plan. In addition it provides procedures for using sampling devices commonly used during soil and rock drilling such as split-barrel sampling, thin walled tube sampling, direct push samplers, and rock coring. For a particular site investigation, the associated work plan addendum will identify the appropriate drilling method and method of sampling, along with proposed sampling depths and intervals and any special procedures or methods.

2.0 MATERIALS

The following types of materials are generally appropriate for drilling:

2.1 SPLIT-BARREL SAMPLING

- Split barrel sampler;
- Borehole logging materials per SOP 10.3 and sampling equipment and materials, as appropriate per SOP 30.1;
- Containers to manage investigation-derived material per SOP 70.1; and
- Decontamination supplies and equipment per SOP 80.1.

2.2 THIN WALLED TUBE SAMPLING

- Thin walled tubes;
- Sealing materials for sample such as sealing wax, metal disks, wood disks, tape, cheesecloth, caps, etc;
- Borehole logging materials per SOP 10.3 and sampling equipment and materials, as appropriate per SOP 30.1;
- Containers to manage investigation-derived material per SOP 70.1; and
- Decontamination supplies and equipment per SOP 80.1.

2.3 DIRECT PUSH SAMPLING

- Direct push unit with hydraulic ram, hammer, etc;
- Sample collection devices, associated equipment and expendable supplies such as sample liners, sample retainers, appropriate lubricants, etc;
- Hollow extension rods;
- Auxiliary tools for handling, assembling, and disassembling tools and samplers;

- Borehole logging materials per SOP 10.3 and sampling equipment and materials, as appropriate per SOP 30.1;
- Containers to manage investigation-derived material per SOP 70.1; and
- Decontamination supplies and equipment per SOP 80.1.

2.4 HOLLOW-STEM AUGER DRILLING

- Drill rig and associated equipment;
- Hollow stem auger assemblies for drilling to appropriate depth including auger heads, drive assembly, pilot assembly, and hollow-stem auger sections;
- Auxiliary devices such as wrenches, auger forks, hoisting hooks, swivels, and adaptors;
- Borehole logging materials per SOP 10.3 and sampling equipment and materials, as appropriate per SOP 30.1;
- Containers to manage investigation-derived material per SOP 70.1; and
- Decontamination supplies and equipment per SOP 80.1.

2.5 DIRECT AIR ROTARY DRILLING

- Drill rig with rotary table and Kelly or top-head drive unit;
- Drill rods, bits, and core barrels (as appropriate);
- Casing;
- Sampling devices and equipment, as appropriate;
- Air compressor and filters, pressure lines, discharge hose, swivel, dust collector, and air-cleaning device (cyclone separator);
- Auxiliary tools for handling, assembling, and disassembling tools and samplers;
- Borehole logging materials per SOP 10.3 and sampling equipment and materials, as appropriate per SOP 30.1;
- Containers to manage investigation-derived material per SOP 70.1; and
- Decontamination supplies and equipment per SOP 80.1.

2.6 DRILL-THROUGH CASING DRIVER

- Drill rig equipped with a mast-mounted, percussion driver;
- Casing, drill rods, and drill bits or hammers;
- Air compressor and filters, pressure lines, discharge hose, swivel, dust collector, and air-cleaning device (cyclone separator);
- Sampling devices and equipment, as appropriate;
- Auxiliary tools for handling, assembling, and disassembling tools and samplers;
- Welding equipment and materials for installation of casing;

- Borehole logging materials per SOP 10.3 and sampling equipment and materials, as appropriate per SOP 30.1;
- Containers to manage investigation-derived material per SOP 70.1; and
- Decontamination supplies and equipment per SOP 80.1.

2.7 DIRECT WATER-BASED ROTARY DRILLING

- Drill rig with derrick, rotary table and Kelly or top-head drive unit;
- Drill rods, bits, and core barrels (as appropriate);
- Casing;
- Water based drilling fluid, with approved additives as appropriate;
- Mud tub, suction hose, cyclone de-sander(s), drilling fluid circulation pump, pressure hose, and swivel;
- Auxiliary tools for handling, assembling, and disassembling tools and samplers;
- Borehole logging materials per SOP 10.3 and sampling equipment and materials, as appropriate per SOP 30.1;
- Containers to manage investigation-derived material per SOP 70.1.
- Decontamination supplies and equipment per SOP 80.1.

2.8 DIRECT ROTARY WIRELINE-CASING ADVANCEMENT DRILLING

- Drill rig with either hollow spindle or top-head drive;
- Drill rods, coring or casing bits, overshot assembly, pilot bit, and core barrel;
- Water based drilling fluid, with approved additives as appropriate;
- Mud tub, suction hose, drilling fluid circulation pump, pressure hose, and swivel;
- Auxiliary tools for handling, assembling, and disassembling tools and samplers;
- Borehole logging materials per SOP 10.3 and sampling equipment and materials, as appropriate per SOP 30.1;
- Containers to manage investigation-derived material per SOP 70.1; and
- Decontamination supplies and equipment per SOP 80.1.

2.9 DIAMOND CORE DRILLING

- Direct rotary drill rig and associated equipment (see Sections 2.4, 2.5 or 2.6);
- Core barrels and core bits;
- Core lifters;
- Core boxes, engineers scale, permanent marking pen, and camera for photographing cores;
- Auxiliary tools for handling, assembling, and disassembling tools and samplers;
- Borehole logging materials per SOP 10.3 and sampling equipment and materials, as appropriate per SOP 30.1;

- Containers to manage investigation-derived material per SOP 70.1; and
- Decontamination supplies and equipment per SOP 80.1.

3.0 PROCEDURES

3.1 PENETRATION TEST AND SPLIT-BARREL SAMPLING OF SOILS

The following general procedure may be followed as outlined in ASTM Standard Test Method D 1586-84.

1. Advance the boring to the desired sampling depth using an appropriate drilling method (see sections below) and remove excessive cuttings from the borehole.
2. Attach the split-barrel sampler to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.
3. Position the hammer above and attach the anvil to the top of the drilling rods.
4. Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the boring and apply a seating blow. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and rods from borehole and remove the cuttings.
5. Mark the drill rods in three successive 6-inch increments so that the advance of the sampler can be observed.
6. Drive the sampler with blow from the 140 pound hammer and count the number of blows applied in each 6-inch increment until:
    a. Fifty (50) blows have been applied during one of the three 6-inch increments.
    b. A total of 100 blows have been applied.
    c. There is no observed advance of the sampler during the application of 10 successive blows of the hammer.
7. The sampler is advanced the complete 18-inches without the limiting blow counts occurring as described above.
8. Record the number of blows that is required to achieve each 6-inch increment of penetration or fraction of this increment on the boring.
    a. The first 6 inches is considered the seating driver.
    b. The sum of the second and third 6-inch penetration intervals is termed the "standard penetration resistance" or "N-value."
    c. If the sampler is driven less than 18 inches as discussed in No. 6, then the number of blow for each partial increment will be recorded.
    d. For partial increments, the depth of penetration should be recorded to the nearest 1-inch on the boring log.
    e. If the sampler advances below the bottom of the boring under the weight of rods (static) and/or hammer, then this information will be recorded on the boring log.
9. The raising and dropping of the 140 pound hammer may be accomplished by:
    a. Using a trip, automatic, or semi-automatic hammer drop system that lifts the hammer and allows it to drop 30± 1 inches.

b. Using a cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 inches. The cathead should be operated at a minimum speed of rotation of 100 revolutions per minute. No more than 2-1/4 rope turns on the cathead may be used when conducting the penetration test.

10. For each hammer blow, a 30-inch lift and drop shall be used.
11. After completing the penetration test, retrieve the sampler and open. Record the percent recovery or the length of sample recovered. Following the procedures outlined in SOP 30.1 when collecting environmental soil samples.
12. Borehole logging should be completed per SOP 10.3.
13. Split-barrel samples must be decontaminated before and after each use per the requirements of SOP 80.1.

3.2 THIN WALLED TUBE SAMPLING

The following general procedure may be followed for collection of relatively undisturbed, thin walled tube samples (e.g., Shelby tube) as outlined in ASTM Standard Practice D 1587-94.

1. Clean out the borehole to targeted sampling depth using most appropriate method, which avoids disturbing the material to be sampled. If groundwater is encountered, maintain the liquid level in the borehole at or above the groundwater level during sampling.
2. Place the sample tub so that its bottom rests on the bottom of the borehole.
3. Advance the sampler without rotation by a continuous relatively rapid motion.
4. Determine the length of the advance by the resistance and condition of the formation, the length of the advance should never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clay.
5. When the formation is too hard for push type of sampling, the tube may be driven or the practice used for ring-lined barrel sampling may be used per ASTM Standard D 3550-84 (1995). When a sample is driven, the weight and fall of the hammer must be recorded along with the penetration achieved.
6. The maximum length of sample advance will be no longer than the sample-tube length minus an allowance for the sample head and a minimum of 3-inches for sludge-end cuttings.
7. Upon removal of the tube, measure the length of the sample in the tube. Remove the disturbed material in the upper end of the tube and re-measure the sample length.
8. Remove at least one-inch of material from the lower end of the tube for soil description and identification per SOP 10.3. Measure the overall sample length. Seal the lower end of the tube. If directed, the material from the end of the tube will not be removed for soil identification and description; in this case the tube will be sealed promptly.
9. Prepare sample labels and affix (or markings) on the tube.

3.3 DIRECT PUSH SOIL BORING

The following general procedures outlined in this section may be followed as described in ASTM Standard Test Method D 6282-98.

General considerations for this method include the following:

- A variety of direct push drive systems may be used to advance soil borings based on the intended sampling depths and subsurface conditions and include the following:

  Shallower Depths and Less Difficult Conditions

  - Percussive driving systems – use hydraulically operated hammers and mechanically operated hammers.
  - Static push drive systems – use hydraulic rams to apply pressure and exert static pull (e.g., cone penetrometer systems).
  - Vibratory/sonic systems – use a vibratory device, which is attached to the top of the sampler extension rods.

  Greater Depths and More Difficult Conditions

  - Sonic or resonance drilling systems – use a high power vibratory system to advance larger diameter single or dual tube systems.
  - Rotary drilling equipment – use hydraulic system of drill rig for direct push.
- The equipment used for direct push must be capable of apply sufficient static force, or dynamic force, or both, to advance the sampler to the required depth of collection. Additionally, this equipment must have adequate retraction force to remove the sampler and extension/drive rods once the sample has been collected.
- Avoid using excessive down pressure when advancing the drilling tools/sampler. Excessive pressure may cause the direct push unit to offset from the boring location and may damage drilling tools and samplers.
- Sample liners should be compatible with the material being sampled and the type of analysis to be conducted on the sample. Sealing of liners for submittal to the laboratory for physical testing should be accomplished according to ASTM Standard D 4220-95 (Standard Practice for Preserving and Transporting Soil Samples).
- The general procedure for completing direct push soil borings is the following:

1. Stabilize direct push unit and raise mast at desired location.
2. Attach the hammer assembly to the drill head if not permanently attached. Attach the anvil assembly in the prescribed manner, slide the direct push unit the position over the borehole, and ready the tools for insertion.
3. Inspect the direct push tools before and after use. Decontaminate all down hole tools before and after use per SOP 80.1.
4. Inspect drive shoes for damaged cutting edges, dents or thread failures and these conditions could cause loss of sample recovery and slow the rate of advancement.
5. Assemble samplers and install where required, install sample retainers where needed, and install and secure sampler pistons to ensure proper operation where needed (see Steps 14 through 20 for the various sampler assembly procedures, etc.).
6. After sampler has been appropriately installed (see Steps 14 through 20 for installation procedures, etc.) advance the boring to the target sampling depth using an appropriate direct push technique, as identified above under general considerations.
7. Collect the soil sample from the target sampling depth using one of the methods identified in Steps 14 through 20.

8. Retrieve the sampler and appropriately process the soil sample as identified in Steps 14 through 20 below and in SOP 30.1.
9. Log the borehole per the requirements of SOP 10.3.
10. If collecting another soil sample, decontaminate the sampler for reuse per the requirements of SOP 80.1 or use another decontaminated sampler.
11. Appropriately manage investigation-derived material (discarded samples, decontamination fluids, etc.) per SOP 70.1.
12. Upon completion of the boring and collection of the desired soil samples, abandon the boring per the requirements of SOP 20.2.
13. The following single tube sampling systems (generally piston rod) may be used to collect soil samples (see Steps 14 through 16 below):
    a. Open Solid Barrel Sampler;
    b. Closed Solid Barrel Sampler (e.g. Geoprobe Macro-Core® Piston Rod Sampler); and
    c. Standard Split Barrel Sampler (see Section 3.1).
14. The following two tube sampling systems may be used to collect soil samples (see Steps 17 through 20 below):
    a. Split Barrel Sampler;
    b. Thin Wall Tubes;
    c. Thin Wall Tube Piston Sampler; and
    d. Open Solid Barrel Samplers.
15. Sampling with the single tube, open solid barrel sampler:
    a. Attach the required liner to the cutting shoe by insertion into the machined receptacle are or by sliding over the machined tube.
    b. Insert the liner and shoe into the solid barrel and attach the shoe.
    c. Attach the sampler head to the sampler barrel.
    d. Attach the sampler assembly to the drive rod and the drive head to the drive rod.
    e. Position the sampler assembly under the hammer anvil and advance the sampler assembly into the soil at a steady rate slow enough to allow the soil to be cut by the shoe and move up into the sample barrel.
    f. At the completion of the sampling interval, removal the sampler from the borehole. Remove the filled sampler liner from the barrel by unscrewing the shoe. Cap the liner for laboratory testing or split open for field processing (see SOP 30.1).
    g. Log the borehole per the requirements of SOP 10.3.
16. Sampling with the closed, solid barrel sampler (e.g., Macro-Core® sampler).
    a. Insert or attach the sample liner to the shoe and insert the assembly into the solid barrel sampler. Install the sample, retaining basket, if desired.
    b. Attach the latch coupling or sampler head to the sampler barrel, and attach the piston assembly with point and "O" rings if free water is present, to the latching mechanism.
    c. Insert the piston or packer into the liner to its proper position so that the point leads the sampler shoe. Set latch, charge packer, or install locking pin, and attach assembled sampler to drive rod.
    d. Add drive head and position under the hammer anvil. Apply down pressure, and hammer if needed, to penetrate the soil strata above the targeted sampling interval.

e. When the sampling interval is reached, insert the piston latch release and recovery tool, removing the piston, or insert the locking pin removal/extension rods through the drive rods, turn counter clockwise, and remove the piston locking pin so the piston can float on top of the sample, or release any other piston holding device.

f. Direct push or activate the hammer to advance the sampler the desired interval.

g. Retrieve the sampler from the borehole by removing the extension/drive rods. Remove the shoe, and withdraw the sample line with sample for processing (see SOP 30.1).

h. Clean and decontaminate the sampler, reload as described above and repeat the same procedure for collection of addition samples.

i. Log the borehole per the requirements of SOP 10.3.

17. Sampling with standard split barrel (split spoon) sampler generally consists of the following:

    a. Attach the split barrel sampler to an extension rod or drill rod.

    b. Using a mechanical or hydraulic hammer drive the ampler into the soil the desired interval. The maximum interval that should be driven is equal to the sample chamber length of the split barrel sampler, which is either 18-inches or 24-inches.

    c. Retrieve the sampler from the borehole by removing the extension/drive rods.

    d. Split the sampler open for field processing (see SOP 30.1).

    e. Clean and decontaminate the sampler (SOP 80.1), re-attach and repeat the same procedure for collection of additional samples.

    f. Log the borehole per the requirements of SOP 10.3.

18. Sampling with a two tube, split barrel sampler generally consists of the following:

    a. Assemble the outer casing with the drive shoe on the bottom, attach the drive head to the top of the outer casing, and attach the sampler to the extension rods.

    b. Connect the drive head to the top of the sampler extension rods, and insert the sampler assembly into the outer casing.

    c. The cutting shoe of the sampler should contact the soil ahead of the outer casing to minimize sample disturbance.

    d. The sample barrel should extend a minimum of 0.25 inches ahead of the outer casing.

    e. Mark the outer casing to identify the required drive length, position the outer casing and sampler assembly under the drill head.

    f. Move the drill head downward to apply pressure on the tool string. Advance the casing assembly into the soil at a steady rate, which is slow enough to allow the soil to be cut by the shoe and move up inside the sample barrel.

    g. Occasional hammer action during the push may assist recovery.

    h. If smooth push advancement is not possible because of subsurface conditions, use the hammer to advance the sampler.

    i. Stop the application of pressure or hammering when target interval has been sampled. Move the drill head off the drive head. Attach a pulling device to the extension rods or position the hammer bail and retrieve the sampler from the borehole.

    j. At the surface, remove the sampler from the extension rods and process the sample per Section 3.01 and SOP 30.1.

    k. Log the borehole per the requirements of SOP 10.3.

19. Sampling with a two tube, thin wall tube sampler generally consists of the following:
    a. Attach the tube to the tube head using removable screws.
    b. Attach the tube assembly to the extension rods and position at the base of the outer casing shoe protruding a minimum of 0.25 inches to contact the soil ahead of the outer casing.
    c. Advance the tube with or without the outer casing at a steady rate.
    d. After completing the sampling interval, let the tube remain stationary for one minute. Rotate the tube slowly two revolutions to shear off the sample.
    e. Remove the tube from the borehole and measure the recovery, and log the borehole per the requirements of SOP 10.3.
    f. For field processing, extrude the sample from the tube sampler and process per SOP 30.1. Alternatively, the tube may be sealed and shipped to the laboratory.
20. Sampling with two tube, thin wall tube, piston sampler generally consists of the following:
    a. Check the fixed piston sampling equipment for proper operation of the cone clamping assembly and the condition of the "O" rings.
    b. Slide the thin wall tube over the piston, and attach it to the tube head. Position the piston at the sharpened end of the thin wall tube just above the sample relief bend.
    c. Attach the tube assembly to the extension rods and lower the sampler into position through the outer casing. Install the actuator rods through the extension rod, and attach to the actuator rod in the sampler assembly.
    d. Attach a holding ring to the to top of the actuator rod string and hook the winch cable or other hook to the holding ring to hold the actuator rods in a fixed position.
    e. Attach the pushing fork to the drill head/probe hammer and slowly apply downward pressure to the extension rods advancing the thin wall tube over the fixed piston into the soil for the length of the sampling interval.
    f. After completing the sampling interval, let the tube remain stationary for one minute. Rotate the tube slowly one revolution to shear off the sample.
    g. Remove the tube sampler from the borehole and measure the recovery, and log the borehole per the requirements of SOP 10.3.
    h. For field processing, extrude the sample from the tube sampler and process per SOP 30.1.
21. Sampling with an two tube, open solid barrel sampler generally consists of the following:
    a. This sampling technique may be used when soil conditions prevent advancement of a split barrel sampler or advancement of an outer casing.
    b. The solid, single, or segmented barrel sampler requires the use of a liner.
    c. Use sampler in advance of outer casing when this casing cannot be advanced.
    d. Follow the procedures outlined for two tube, split barrel sampling.

3.4 HOLLOW-STEM AUGER DRILLING

The following general procedure may be followed as outlined in ASTM Standard Guide D 5784.

1. Stabilize drill rig and raise mast at desired location.
2. Attach an initial assembly of hollow-stem auger components (hollow stem auger, hollow auger head, center rod and pilot assembly, as appropriate) to the rotary drive of the drill rig.
3. Push the auger assembly below the ground surface and initiate rotation at a low velocity.

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4. Decontamination of auger head may be necessary after this initial penetration if this surface soil is contaminated.
5. Continue drilling from the surface, usually at a rotary velocity of 50 to 100 rotations per minute to the depth where sampling or in-situ testing is required or until the drive assembly is within approximately 6- to 18 inches of the ground surface.
6. As appropriate, collect a soil sample from the required depth interval. The sample may be conducted by
    a. Removing the pilot assembly, if used, and inserting and driving a sampler through the hollow stem auger of the auger column; or
    b. Using a continuous sampling device within the lead auger section, where the sampler barrel fills with material as the auger is advanced.
7. Additional sections of hollow stems augers may be added to drill to a greater depth. After these auger sections are added, rotation of the hollow-stem auger assembly may be resumed.
8. When drilling through material suspected of being contaminated, the installation of single or multiple (nested) outer casings may be required to isolate zones suspected contamination (see SOP 20.1). Outer casings may be installed in a pre-drilled borehole or using a method in which casing is advanced at the same of drilling.

   Monitoring wells or piezometers may be installed using hollow-stem augers by:
    a. Drilling with or without sampling to the target depth.
    b. Removal of the pilot assembly, if used, and insertion of the monitoring well (or piezometer) assembly.
    c. The hollow stem auger column should be removed incrementally as the monitoring well (or piezometer) completion materials are placed (see SOP 20.1 for grouting).
9. If materials enter the bottom of the auger hollow stem during the removal of the pilot assembly, it should be removed with a drive sampler or other appropriate device.
10. If sampling or *in-situ* testing is not required during completion of the boring, the boring may be advanced with an expendable knock out plate or plug of an appropriate material instead of a pilot assembly.
11. Drill cuttings should be appropriately controlled and contained as IDM per SOP 70.1. It may be necessary to drill through a hole of sheet of plywood or similar material to prevent cuttings from contacting the ground surface.
12. The hollow-auger assembly and sampling devices must be decontaminated before and after each use per the methods specified in SOP 80.1.
13. Borehole logging should be completed per SOP 10.3.
14. Borehole abandonment, when required, should be conducted according to SOP 20.3.

3.5 DIRECT AIR ROTARY DRILLING

The following general procedure may be followed as outlined in ASTM Standard Guide D 5784-95.

1. Stabilize drill rig and raise mast at desired location. Appropriately position the cyclone separator and seal it to the ground surface considering the prevailing wind direction (exhaust).
2. Establish point for borehole measurements.
3. Attach an initial assembly of a bit, down hole hammer, or core barrel with a single section of drill rod, below the rotary table or top-head drive unit, with the bit placed below the top of the dust collector.
4. Activate the air compressor to circulate air through system.

5. Initiate rotation of bit.
6. Continue with air circulation and rotation of the drill-rod column to the depth where sampling or in-situ testing is required or until the length of the drill rod section limits further penetration.
7. Monitor air pressure during drilling operations. Maintain low air pressure at bit to prevent fracturing of surrounding material.
8. Stop rotation and lift the bit slightly off the bottom of the hole to facilitate removal of drill cuttings and continue air circulation until the drill cuttings are removed from the borehole annulus.
9. Open reaching a desired depth of sampling, stop the air circulation and rest bit on bottom of hole to determine the depth. Record the borehole depth and any resultant caving in. If borehole caving is apparent set a decontaminated casing to protect the boring.
10. When sampling, remove the drill rod column from the borehole or leave the drill rod assembly in place if the sampling can be performed through the hollow axis of the drill rods and bit.
11. Compare the sampling depth to clean-out depth by first resting the sampler on the bottom of the hole and compare that measurement with the clean-out depth measurement.
12. If bottom-hole contamination is apparent (indicated by comparison of sample depth to clean-out depth), it is recommended that the minimum depth below the sampler/bit be 18 inches for testing. Record the depth of sampling or in-situ testing and the depth below the sampler/bit.
13. The procedure described in Steps 8 through 12 should be conducted for each sampling or testing interval.
14. Drilling to a greater depth may be accomplished by attaching an additional drill rod section to the top of the previously advanced drill-rod column and resuming drilling operations as described above.
15. When drilling through material suspected of being contaminated, the installation of single or multiple (nested) outer casings may be required to isolate zones suspected contamination (see SOP 20.1 for grouting requirements). Outer casings may be installed in a pre-drilled borehole or using a method in which casing is advanced at the same of drilling.
16. Monitoring wells or piezometers may be installed by:
    - a. Drilling with or without sampling to the target depth.
    - b. Removal of the drill rod assembly and insertion of the monitoring well (or piezometer) assembly.
    - c. Addition of monitoring well (or piezometer) completion materials (see SOP 20.1).
17. Drill cuttings should be appropriately controlled and contained as IDM per SOP 70.1.
18. The drill rod assembly, sampling devices, and other drilling equipment contacting potentially contaminated material must be decontaminated before and after each use per the methods specified in SOP 80.1.
19. Borehole logging should be completed per SOP 10.3.
20. Borehole abandonment, when required, should be conducted according to SOP 20.3

3.6 DRILL-THROUGH CASING DRILLING

The following general procedure may be followed as outlined in ASTM Standard Guide D 5872-95.

1. Stabilize drill rig and raise mast at desired location. Appropriately position the cyclone separator and seal it to the ground surface considering the prevailing wind direction (exhaust).
2. Establish point for borehole measurements.
3. Attach an initial assembly of a bit or down hole hammer with a single section of drill rod and casing to the top-head drive unit.

4. Activate the air compressor to circulate air through system.
5. Drilling may be accomplished by
    a. Method 1- the casing will fall, or can be pushed downward behind the bit.
    b. To drill using Drive the casing first followed by drilling out the plug inside the casing.
    c. Method 2 - Advancing the casing and bit as a unit, with the drill bit or hammer, extending up to 12-inches below the casing.
6. Method 3 - Under reaming method where bit or hammer pens a hole slightly larger than the casing so that Method 1, drive the casing first and drill out the plug in the casing by moving the bit or hammer beyond the casing and then withdrawing it into the casing. Air exiting the bit will remove the cuttings up the hole. Separate cuttings from the return air with a cyclone separator or similar device.
7. To drill using Method 2, advance casing and bit as unit with the bit or hammer extending up to 12-inches beyond the casing depending on the conditions. While drilling, occasionally stop the casing advancement, retract the bit or hammer inside the casing to clear and maintain air circulation to clear cuttings.
8. To drill using Method 3, use a special down hole bit or hammer to open a hole slightly larger than the outside diameter of the casing so that the casing will fall or can be pushed downward immediately behind the bit. After advancing the casing, retract the radial dimension of the drill bit to facilitate removal of the down hole bit or hammer and drill tools inside the casing. Cuttings are removed from the borehole with the air that operates the bit or hammer and can be separated from the air with a cyclone separator or similar device.
9. Monitor air pressure during drilling operations. Maintain low air pressure at bit or hammer to prevent fracturing of surrounding material.
10. Continue air circulation and rotation of the drill rod column until drilling is completed to the target depth (for sampling, in-situ sampling, etc.) or until the length of the drill-rod section limits further penetration.
11. Stop rotation and lift bit or hammer slightly off the bottom of the hole to facilitate removal of drill cuttings and continue air circulation until the drill cuttings are removed from the borehole annulus.
12. After reaching a desired depth of sampling, stop the air circulation and rest the bit on bottom of hole to determine the depth. Record the borehole depth and any resultant caving in. If borehole caving is apparent set a decontaminated casing to protect the boring.
13. When sampling, remove the drill rod column from the borehole. Compare the sampling depth to clean-out depth by first resting the sampler on the bottom of the hole and compare that measurement with the clean-out depth measurement.
14. If bottom-hole contamination is apparent (indicated by comparison of sample depth to clean-out depth), it is recommended that the minimum depth below the sampler/bit be 18 inches for testing. Record the depth of sampling or in-situ testing and the depth below the sampler/bit.
15. The procedure described in Steps 11 through 14 should be conducted for each sampling or testing interval.
16. Drilling to a greater depth may be accomplished by attaching an additional drill rod section and casing section to the top of the previously advanced drill-rod column/casing and resuming drilling operations as described above.
17. Monitoring wells or piezometers may be installed by:
    a. Casing advancement in increments, with or without sampling to the target depth.
    b. Removal of the drill rods and the attached drill bit while the casing is temporarily left in place to support the borehole wall.

    c. Insertion of the monitoring well (or piezometer) assembly.
    d. Addition of monitoring well (or piezometer) completion materials (see SOP 20.1).

18. Drill cuttings should be appropriately controlled and contained as IDM per SOP 70.1.
19. The drill rod assembly, casing, sampling devices, and other drilling equipment contacting potentially contaminated material must be decontaminated before and after each use per the methods specified in SOP 80.1.
20. Borehole logging should be completed per SOP 10.3.
21. Borehole abandonment, when required, should be conducted according to SOP 20.3.

3.7 DIRECT WATER-BASED ROTARY DRILLING

The following general procedure may be followed as outlined in ASTM Standard Guide D 5783-95.

1. Stabilize drill rig and raise mast at desired location. Appropriately position the mud tub and install surface casing and seal at the ground surface.
2. Establish point for borehole measurements.
3. Attach an initial assembly of a bit or core barrel with a single section of drill rod, below the rotary table or top-head drive unit, with the bit placed with the top of the surface casing.
4. Activate the drilling-fluid circulation pump to circulate drill fluid through the system.
5. Initiate rotation of bit and apply axial force to bit.
6. Document drilling conditions and sequence (fluid loss, circulation pressures, depths of lost circulation, etc.) as described in SOP 10.3.
7. Continue with drill fluid circulation as rotation and axial force are applied to the bit until drilling to the depth
    a) Where sampling or in-situ testing is required;
    b) Until the length of the drill rod section limits further penetration; or
    c) Until core specimen has completely entered the core barrel (when coring) or blockage has occurred.
8. Stop rotation and the lift bit slightly off the bottom of the hole to facilitate removal of drill cuttings and continue fluid circulation until the drill cuttings are removed from the borehole annulus.
9. After reaching a desired depth of sampling, stop the fluid circulation and rest the bit on bottom of hole to determine the depth. Record the borehole depth and any resultant caving in. If borehole caving is apparent set a decontaminated casing to protect the boring.
10. When sampling, drill rod removal is not necessary if the sampling can be performed through the hollow axis of the drill rods and bit.
11. Compare the sampling depth to clean-out depth by first resting the sampler on the bottom of the hole and compare that measurement with the clean-out depth measurement.
12. If bottom-hole contamination is apparent (indicated by comparison of sample depth to clean-out depth), it is recommended that the minimum depth below the sampler/bit be 18 inches for testing. Record the depth of sampling or in-situ testing and the depth below the sampler/bit.
13. The procedure described in Steps 8 through 11 should be conducted for each sampling or testing interval.
14. Drilling to a greater depth may be accomplished by attaching an additional drill rod section to the top of the previously advanced drill-rod column and resuming drilling operations as described above.

15. When drilling through material suspected of being contaminated, the installation of single or multiple (nested) outer casings may be required to isolate zones suspected contamination (see SOP 20.1 for grouting requirements). Outer casings may be installed in a pre-drilled borehole or using a method in which casing is advanced at the same of drilling.
16. Monitoring wells or piezometers may be installed using hollow-stem augers by:
    a. Drilling with or without sampling to the target depth.
    b. Removal of the drill rod assembly and insertion of the monitoring well (or piezometer) assembly.
    c. Addition of monitoring well (or piezometer) completion materials (see SOP 20.1).
17. Drill cuttings and fluids should be appropriately controlled and contained as IDM per SOP 70.1.
18. The drill rod assembly, sampling devices, and other drilling equipment contacting potentially contaminated material must be decontaminated before and after each use per the methods specified in SOP 80.1.
19. Borehole logging should be completed per SOP 10.3.
20. Borehole abandonment, when required, should be conducted according to SOP 20.3.

3.8 DIRECT ROTARY WIRELINE CASING ADVANCEMENT DRILLING

The following general procedure may be followed as outlined in ASTM Standard Guide D 5876-95.

1. Stabilize drill rig and raise mast at desired location. Appropriately position the mud tub (for water based rotary) and install surface casing and seal at the ground surface.
2. Record the hole depth by knowing the length of the rod-bit assemblies and comparing its position relative to the established surface datum.
3. Attach an initial assembly of a lead drill rod and a bit or core barrel below the top-head drive unit, with the bit placed with the top of the surface casing.
4. Activate the drilling-fluid circulation pump to circulate drill fluid through the system.
5. Initiate rotation of bit and apply axial force to bit.
6. Document drilling conditions and sequence (fluid loss, circulation pressures, depths of lost circulation, down feed pressures etc.) as described in SOP 10.3.
7. In general, the pilot bit or core barrel can be inserted or removed at any time during the drilling process and the large inside diameter rods can act as a temporary casing for testing or installation of monitoring devices.
8. Continue with drill fluid circulation as rotation and axial force are applied to the bit until drilling to the depth
    a) Where sampling or in-situ testing is required;
    b) Until the length of the drill rod section limits further penetration; or
    c) Until core specimen has completely entered the core barrel (when coring) or blockage has occurred.
9. Stop rotation and lift the bit slightly off the bottom of the hole to facilitate removal of drill cuttings and continue fluid circulation until the drill cuttings are removed from the borehole annulus.
10. After reaching a desired depth of sampling, stop the fluid circulation and rest the bit on bottom of hole to determine the depth. Record the borehole depth and any resultant caving in. If borehole caving is apparent set a decontaminated casing to protect the boring.

11. When sampling, drill rod removal is not necessary if the sampling can be performed through the hollow axis of the drill rods and bit.
12. Compare the sampling depth to clean-out depth by first resting the sampler on the bottom of the hole and compare that measurement with the clean-out depth measurement.
13. If bottom-hole contamination is apparent (indicated by comparison of sample depth to clean-out depth), it may be necessary to further clean the hole by rotary recirculation.
14. Continuous sampling may be conducted with a soil core barrel or rock core barrel (see Section 1.7).
15. The pilot bit or core barrel may need to be removed during drilling such as when core barrels are full or there is evidence of core blocking. Before the drill string is reinserted, the depth of the boring should be rechecked to evaluate hole quality and determine whether casing may be required.
16. Water testing may be performed in consolidated deposits by pulling back on the drill rods and passing inflatable packer(s) with pressure fitting to test the open borehole wall (see ASTM Standards D 4630 and D 4631).
17. Drilling to a greater depth may be accomplished by attaching an additional drill rod section to the top of the previously advanced drill-rod column and resuming drilling operations as described above.
18. When drilling through material suspected of being contaminated, the installation of single or multiple (nested) outer casings might be required to isolate zones suspected contamination (see SOP 20.1 for grouting requirements). Outer casings may be installed in a pre-drilled borehole or using a method in which casing is advanced at the same of drilling.
19. Monitoring wells or piezometers may be installed by:
    a. Drilling with or without sampling to the target depth.
    b. Removal of the pilot bit or core barrel and insertion of the monitoring well (or piezometer) assembly.
    c. Addition of monitoring well (or piezometer) completion materials (see SOP 20.1).
20. Drill cuttings and fluids should be appropriately controlled and contained as IDM per SOP 70.1.
21. The drill rod assembly, sampling devices, and other drilling equipment contacting potentially contaminated material must be decontaminated before and after each use per the methods specified in SOP 80.1.
22. Borehole logging should be completed per SOP 10.3.
23. Borehole abandonment, when required, should be conducted according to SOP 20.3.

3.9 DIAMOND CORE DRILLING

The following general procedure may be followed as outlined in ASTM Standard Practice D 2113-83 (1993).

1. Use core-drilling procedures, such as the water-rotary drilling method outlined in Section 3.6.
2. Seat the casing on bedrock or firm formation to prevent raveling of the borehole and to prevent loss of drilling fluid. Level the formation that the casing will be seated on as needed.
3. Begin core drilling using an N-size double-tube, swivel-type core barrel or other approved size or type. Continue core drilling until core blockage occurs or until the net length of the core has been drilled.
4. Remove the core barrel from the borehole, and dis-assemble the core barrel as necessary to remove the core.
5. Reassemble the core barrel and return it to hole.
6. Continue core drilling.

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7. Place the recovered core in the core box with the upper (surface) end of the core at the upper-left corner of the core box. Wrap soft or friable cores, etc. as needed or required. Use spacer blocks or slugs properly marked to indicate any noticeable gap in recovered core that might indicate a change or void in the formation. Fit fracture, bedded, or jointed pieces of core together as they naturally occurred.
8. The core within each completed box should be photographed after core surface has been cleaned or peeled, as appropriate, and wetted. Each photo should be in sharp focus and contain a legible scale in feet and tenths of feet (or metric if appropriate). The core should be oriented so that the top of the core is at the top of the photograph. A color chart should be included in the photograph frame as a check on photographic accuracy. The inside lid of the box should also be shown.
9. The inside of the box lid should be labeled at a minimum with the facility name, project name, boring number, box number, and core interval.
10. A preliminary field log of the core must be completed before the core box has been packed for transport (see SOP 10.3). Detailed logging may be conducted at a later time providing the core is appropriately handled and transported.
11. Four levels of sample protection may be used depending on character of the rock and the intended use of the rock core including:
    a. *Routine care* – for rock cored in 5 to 10 foot runs. Consists of placing in structurally sound boxes. Lay flat tubing may be used prior to placing the core.
    b. *Special care* – for rock samples to be tested that are potentially moisture sensitive, such as shale. This care consists of sealing with a tight fitting wrapping of plastic film and application of wax at the ends of the sample.
    c. *Critical care* – for rock samples that may be sensitive to shock and vibration and/or temperature. Protect by encasing each sample in cushioning material, such as sawdust, rubber, polystyrene, foam, etc. A minimum one-inch thick layer of cushioning material should be used. Thermally insulate samples that are potentially sensitive to changes in temperature.
    d. Soil-Like care – handle per ASTM Standard D 4220-95.
12. Drilling conditions and sequence (fluid loss, circulation pressures, depths of lost circulation, down feed pressures, core blockage etc.) should be documented on the boring log as described in SOP 10.3.
13. Drill cuttings and fluids should be appropriately controlled and contained as investigation-derived material per SOP 70.1.
14. The drill rod assembly, sampling devices, and other drilling equipment contacting potentially contaminated material must be decontaminated before and after each use per the methods specified in SOP 80.1.
15. Borehole logging should be completed per SOP 10.3.
16. Borehole abandonment, when required, should be conducted according to SOP 20.3.

4.0 MAINTENANCE

Not applicable.

5.0 PRECAUTIONS

Refer to site-specific health and safety plan included in work plan addenda.

6.0 REFERENCES

ASTM Standard D 2113-83 (1993). 1993. *Standard Practice for Diamond Core Drilling for Site Investigation.*

ASTM Standard D 1586-84 (1992). 1992. *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils.*

ASTM Standard D 1587-94. 1994. *Standard Practice for Thin-Walled Tube Geotechnical Sampling of Soils.*

ASTM Standard D 4220-95. 1995. *Standard Practices for Preserving and Transporting Soil Samples.*

ASTM Standard D 5079-90. 1995. *Standard Practices for Preserving and Transporting Rock Core Samples.*

ASTM Standard D 5782-95. 1995. *Standard Guide for Use of Direct Air-Rotary Drilling for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices.*

ASTM Standard D 5783-95. 1995. *Standard Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices.*

ASTM Standard D 5784-95. 1995. *Standard Guide for Use of Hollow-Stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices.*

ASTM Standard D 5872-95. 1995. *Standard Guide for Use of Casing Advancement Drilling Methods for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices.*

ASTM Standard D 5876-95. 1995. *Standard Guide for Use of Direct Rotary Wireline Casing Advancement Drilling Methods for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices.*

ASTM Standard D 6282-98. 1998. *Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations.*

USACE. 1998. *Monitoring Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Waste Sites.* EM 1110-1-4000. 1, November.

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STANDARD OPERATING PROCEDURE 30.1
SOIL SAMPLING

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to delineate protocols for sampling surface and subsurface soils.

2.0 MATERIALS

- Stainless steel scoop, spoon, trowel, knife, spatula, (as needed);
- Split-spoon, Shelby tube, or core barrel sampler;
- Hand auger or push tube sampler;
- Drill rig and associated equipment (subsurface soil);
- Stainless steel bowls;
- Photoionization detector or other appropriate instrument as specified in site-specific health and safety plan;
- Sampling equipment for collection of volatile organic samples;
- Appropriate sample containers;
- Appropriate sample labels and packaging material.;
- Personal protective equipment and clothing (PPE) per site-specific health and safety plan; and
- Decontamination equipment and supplies (SOP 80.1).

3.0 PROCEDURE

3.1 DOCUMENTATION

Soil sampling information should be recorded in the field logbooks as described in SOPs 10.1 and 10.2.

3.2 SURFICIAL SOIL SAMPLES

The targeted depths for surficial soil samples (surface and near surface) will be specified in the work plan addenda developed for site-specific investigations.

1. All monitoring equipment should be appropriately calibrated before beginning sampling according to the requirements of the work plan addenda and SOP 90.1 or 90.2.
2. All sampling equipment should be appropriately decontaminated before and after use according to the requirements of the work plan addendum and SOP 80.1.
3. Use a spade, shovel, or trowel or other equipment (manufactured from material, which is compatible with the soil to be sampled) to remove any overburden material present (including vegetative mat) to the level specified for sampling.
4. Measure and record the depth at which the sample will be collected with an engineers scale or tape.

5. Remove the thin layer that was in contact with the overburden removal equipment using a clean stainless steel scoop or equivalent and discard it.
6. Begin sampling with the acquisition of any discrete sample(s) for analysis of volatile organic compounds (VOCs), with as little disturbance as possible. VOC samples will not be composited or homogenized.
7. When a sample will not be collected with a core type of sampler (push tube, split spoon, etc.), the sample for VOC analysis will be collected from freshly exposed soil. The method of collection will follow the procedures specified in SOP 30.8 (Methanol Preservation Method) or 30.9 (En Core® Method) based on the requirements of the work plan addenda.
8. Field screen the sample with properly calibrated photoionization detector (PID) or other appropriate instrument. Cut a cross-sectional slice from the core or center of the sample and insert the monitoring instrument(s). Based on the screening results, collect the VOC fraction, as applicable.
9. Collect a suitable volume of sample from the targeted depth with a clean stainless steel scoop (or similar equipment), push tube sampler, or bucket auger
10. For core type of samplers, rough trimming of the sampling location surface should be considered if the sampling surface is not fresh or other waste, different soil strata, or vegetation may contaminate it. Surface layers can be removed using a clean stainless steel, spatula, scoop, or knife. Samples collected with a bucket auger or core type of sampler should be logged per the requirements of SOP 10.3.
11. If homogenization or compositing of the sampling location is not appropriate for the remaining parameters, the sample should be directly placed into appropriate sample containers with a stainless steel spoon or equivalent.
12. If homogenization of the sample location is appropriate or compositing of different locations is desired, transfer the sample to a stainless steel bowl for mixing. The sample should be thoroughly mixed with a clean stainless steel spoon, scoop, trowel, or spatula and then placed in appropriate sample containers per the requirements for containers and preservation specified in work plan addenda. Secure the cap of each container tightly.
13. Appropriately, label the samples (SOP 50.1), complete the chain-of-custody (SOP 10.4), and package the samples for shipping (SOP 50.2).
14. Return any remaining unused soil to the original sample location. If necessary, add clean sand to bring the subsampling areas back to original grade. Replace the vegetative mat over the disturbed areas.

3.3 SUBSURFACE SAMPLES

All sampling equipment should be appropriately decontaminated before and after use according to the requirements of the work plan addendum and SOP 80.1.

1. All monitoring equipment should be appropriately calibrated before sampling according to the requirement of the work plan addendum and SOP 90.1 or SOP 90.2.
2. All sampling equipment should be appropriately decontaminated before and after use according to the requirements of the work plan addendum and SOP 80.1.
3. Collect split-spoon; core barrel, Shelby tube, sonic core or other similar samples during drilling.
4. Upon opening sampler or extruding sample, immediately screen soil for VOCs using a PID or appropriate instrument. If sampling for VOCs, determine the area of highest concentration; use a

stainless steel knife, trowel, or lab spatula to cut the sample; and screen for VOCs with monitoring instrument(s).

5. Log the sample on the boring log before extracting from the sampler per the requirements of SOP 10.3.
6. Any required VOC samples will be collected first followed by the other parameters. VOC samples will not be composited or homogenized and will be collected from the area exhibiting the highest screening level. The method of VOC sample collection will follow the procedures specified in SOP 30.8 (Methanol Preservation Method) or 30.9 (En Core® Method) based on the requirements of the work plan addenda.
7. Field screen the sample with properly calibrated photoionization detector (PID) or other appropriate instrument. Cut a cross-sectional slice from the core or center of the sample and insert the monitoring instrument(s). Based on the screening results, collect the VOC fraction, as applicable.
8. Rough trimming of the sampling location surface should be considered if the sampling surface is not fresh or other waste, different soil strata, or vegetation may contaminate it. Surface layers can be removed using a clean stainless steel, spatula, scoop, or knife.
9. If homogenization or compositing of the sampling location is not appropriate for other parameters, the sample should be directly placed into appropriate sample containers with a stainless steel spoon or equivalent.
10. If homogenization of the sample location is appropriate or compositing of different locations is desired, transfer the sample to a stainless steel bowl for mixing. The sample should be thoroughly mixed with a clean stainless steel spoon, scoop, trowel, or spatula and placed in appropriate sample containers per the requirements for containers and preservation specified in work plan addenda. Secure the cap of each container tightly.
15. Appropriately, label the samples (SOP 50.1), complete the chain-of-custody (SOP 10.4), and package the samples for shipping (SOP 50.2).
16. Discard any remaining sample into the drums used for collection of cuttings.
17. Abandon borings according to procedures outlined in SOP 20.2.

3.4 INVESTIGATION-DERIVED MATERIAL

Investigation-derived material will be managed in accordance with procedures defined in the work plan addenda for the site being investigated and SOP 70.1.

NOTES: If sample recoveries are poor, it may be necessary to composite samples before placing them in jars. In this case, the procedure will be the same except that two split-spoon samples (or other types of samples) will be mixed together. The boring log should clearly state that the samples have been composited, which samples were composited, and why the compositing was done. In addition, VOC fraction should be collected from the first sampling device.

When specified, samples taken for geotechnical analysis (e.g., percent moisture, density, porosity, and grain size) will be undisturbed samples, such as those collected using a thin-walled (Shelby tube) sampler, sonic core sampler, etc.

4.0 MAINTENANCE

Not applicable.

5.0 PRECAUTIONS

Refer to the site-specific health and safety plan.

Soil samples will not include vegetative matter, rocks, or pebbles unless the latter are part of the overall soil matrix.

6.0 REFERENCES

ASTM Standard D 1586-84. 1984. *Penetration Test and Split-Barrel Sampling of Soils.*

ASTM Standard D 1587-83. 1983. *Thin Walled Sampling of Soils.*

ASTM Standard D 5633-94. 1994. *Standard Practice for Sampling with a Scoop.*

USACE. 2001. *Requirements for the Preparation of Sampling and Analysis Plans.* EM 200-1-3. 1 February.

STANDARD OPERATING PROCEDURE 30.6
CONTAINERIZED MATERIAL

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to delineate protocols for the opening and sampling of containerized liquids of potentially unknown substances.

2.0 MATERIALS

- Work Plans;
- Field logbooks;
- Personal protective equipment and clothing per the site-specific health and safety plan;
- Monitoring instruments per the site-specific health and safety plan;
- Decontamination equipment and supplies (SOP 80.1);
- Tools;
- Historical data, if available;
- Sampling tube; and
- Remote samplers, as required.

3.0 PROCEDURE

Sealed containers with unknown contents represent potential severely hazardous situations for sampling teams. Even when the original identity of the contents is reasonably certain, contents may be under pressure or in a decomposed state and may readily react (sometimes violently) with air or water vapor in the atmosphere.

Only hazardous material specialists that have appropriate training and experience will inspect and sample unidentifiable drums or containers. Specialist team members will use extreme caution and care when opening sealed drums or cans of unknown content for purposes of inspection and sampling.

Efforts will be made to determine the identity of the contents, through markings, history of activities at the site, and similarity and proximity to containers of known contents. The range of possible hazards will dictate which specific procedure will be followed, and specific procedures will be identified in work plan addenda. All predetermined procedures will be strictly followed as designated by the site-specific conditions.

Using this SOP and appropriate health and safety protocols, field personnel will use extreme caution and care in opening sealed drums or cans of unknown contents for purposes of inspection and sampling. Specific activities include the following:

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- Determine the identity of the contents through markings, history of activities at the site, and similarity and proximity to containers of known contents. The range of possible hazards will dictate which specific procedure should be followed.
- Handle containers as little as possible; however, if it is necessary to reorient a drum to allow access to a bung or cap, perform this activity using remote-handling forklift equipment with special drum-holding attachments.
- If contents are deemed to be under pressure, highly reactive, or highly toxic (or if these possibilities cannot be disproven), perform initial opening of the container remotely.
- Air monitoring stations will be established as necessary, using the following procedures:
    1. Affix a remote bung opener to the drum.
    2. Evacuate personnel to a safe distance or station them behind a barricade.
    3. Activate the non-sparking motor of the opener.
    4. After the bung is removed, monitor the drum for potential activity of the contents, such as vapor emission, smoking, or audible reaction.
    5. Approach cautiously while monitoring for toxic levels of airborne contaminants.
- If the contents of the drum pose acceptable hazards, accomplish opening (or inspection if previously opened remotely) and sampling with one of three approved devices. The preferred method is to use a clean glass tube, with or without bottom stopper, which can be placed in the drum (breaking it if necessary) after sampling is complete. Alternately (if a bung has been removed), a well sampler such as a Kemmererbailer can be used (but would require removal and cleaning or disposal according to the nature of the waste). By opening either of these devices at a desirable depth, stratified sampling can be performed. Also, the sampling tubes can be made with a plunger rod and O-ring seals at selected intervals, allowing simultaneous collection of multiple samples in a stratified medium.
- Following sampling, the drum will be resealed and/or overpacked to prevent any possibility of leakage while analysis determines the identity of the contents.
- Drums that do not have removable bungs may be opened remotely with a solenoid-activated punch (this requires that the drum be recontainerized or overpacked after sampling is complete).

4.0 MAINTENANCE

Not applicable.

5.0 PRECAUTIONS

Not applicable.

6.0 REFERENCE

USEPA, 1989. A Compendium of Superfund Field Operation Methods. EPA/540/P-87/001. December.

STANDARD OPERATING PROCEDURE 30.7
SAMPLING STRATEGIES

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to delineate sampling strategies for sampling various media.

2.0 MATERIALS

- Historical site data;
- Site topography;
- Soil types; and
- Sampled media.

3.0 PROCEDURE

The primary goal of any investigation is to collect samples representative of existing site conditions. Statistics are generally used to ensure samples are as representative as possible. Sampling plans may employ more than one approach to ensure project data quality objectives are adequately addressed. A comparison of sampling strategies is presented in Table 1.

3.1 CLASSICAL STATISTICAL SAMPLING

Classical statistical sampling strategies are appropriately applied to either sites where the source of contamination is known or small sites where the entire area is remediated as one unit. Primary limitations of this sampling approach include (1) inability to address media variability; (2) inadequate characterization of heterogenous sites; and (3) inadequate characterization of sites with unknown contamination characteristics.

3.1.1 Simple Random Sampling

Simple random sampling is generally more costly than other approaches because of the number of samples required for site characterization. This approach is generally used when minimal site information is available and visible signs of contamination are not evident and includes the following features:

- Sampling locations are chosen using random chance probabilities.
- This strategy is most effective when the number of sampling points is large.

3.1.2 Stratified Random Sampling

This sampling approach is a modification to simple random sampling. This approach is suited for large site investigations that encompass a variety of soil types, topographic features, and/or land uses. By dividing the site into homogenous sampling strata based on background and historical data, individual random sampling techniques are applied across the site. Data acquired from each stratum can be used to determine the mean or total contaminant levels and provide these advantages:

- Increased sampling precision results due to sample point grouping and application of random sampling approach.

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- Control of variances associated with contamination, location, and topography.

3.1.3 Systematic Grid

The most common statistical sampling strategy is termed either systematic grid or systematic random sampling. This approach is used when a large site must be sampled to characterize the nature and extent of contamination.

Samples are collected at predetermined intervals within a grid pattern according to the following approach:

- Select the first sampling point randomly; remaining sampling points are positioned systematically from the first point.
- Determine the grid design: one or two-dimensional. One-dimensional sample grids may be used for sampling along simple man-made features. Two-dimensional grid systems are ideal for most soil applications.
- Determine the grid type: square or triangular. Sampling is usually performed at each grid-line intersection. Other strategies include sampling within a grid center or obtaining composite samples within a grid.
- Each stratum is sampled based on using the simple random sampling approach but determined using a systematic approach.

3.1.4 Hot-Spot Sampling

Hot spots are small, localized areas of media characterized by high contaminant concentrations. Hot-spot detection is generally performed using a statistical sampling grid. The following factors should be addressed:

- Grid spacing and geometry. The efficiency of hot-spot searches is improved by using a triangular grid. An inverse relationship exists between detection and grid point spacing, e.g., the probability of hot-spot detection is increased as the spacing between grid points is decreased.
- Hot-spot shape/size. The larger the hot spot, the higher the probability of detection. Narrow or semicircular patterns located between grid sampling locations may not be detected.
- False-negative probability. Estimate the false negative (β-error) associated with hot-spot analysis.

3.1.5 Geostatistical Approach

Geostatistics describe regional variability in sampling and analysis by identifying ranges of correlation or zones of influence. The general two-stage approach includes the following:

- Conducting a sampling survey to collect data defining representative sampling areas.
- Defining the shape, size, and orientation of the systematic grid used in the final sampling event.

3.2 NON-STATISTICAL SAMPLING

3.2.1 Biased Sampling

Specific, known sources of site contamination may be evaluated using biased sampling. Locations are chosen based on existing information.

3.2.2 Judgmental Sampling

This sampling approach entails the subjective selection of sampling locations that appear to be representative of average conditions. Because this method is highly biased, it is suggested that a measure of precision be included through the collection of multiple samples.

4.0 MAINTENANCE

Not applicable.

5.0 REFERENCES

USACE. 2001. *Requirements for the Preparation of Sampling and Analysis Plans.* EM200-1-3. 1 February.

TABLE 1
SAMPLING STRATEGIES

SAMPLING STRATEGY	DESCRIPTION	APPLICATION	LIMITATIONS
Classical Statistical Sampling Strategies			
Simple Random Sampling	Representative sampling locations are chosen using the theory of random chance probabilities.	Sites where background information is not available and no visible signs of contamination are present.	May not be cost-effective because samples may be located too close together. Does not take into account spatial variability of media.
Stratified Random Sampling	Site is divided into several sampling areas (strata) based on background or site survey information.	Large sites characterized by a number of soil types, topographic features, past/present uses, or manufacturing storage areas.	Often more cost-effective than random sampling. More difficult to implement in the field and analyze results. Does not take into account spatial variability of media.
Systematic Grid Sampling	Most common statistical strategy; involves collecting samples at predetermined, regular intervals within a grid pattern.	Best strategy for minimizing bias and providing complete site coverage. Can be used effectively at sites where no background information exists. Ensures that samples will not be taken too close together.	Does not take into account spatial variability of media.
Hot-Spot Sampling	Systematic grid sampling strategy tailored to search for hot spots.	Sites where background information or site survey data indicate that hot spots may exist.	Does not take into account spatial variability of media. Tradeoffs between number of samples, chance of missing a hot spot, and hot spot size/shape must be weighed carefully.
Geostatistical Approach	Representative sampling locations are chosen based on spatial variability of media. Resulting data are analyzed using kriging, which creates contour maps of the contaminant concentrations and the precision of concentration estimates.	More appropriate than other statistical sampling strategies because it takes into account spatial variability of media. Especially applicable to sites where presence of contamination is unknown.	Previous investigation data must be available and such data must be shown to have a spatial relationship.
Non-Statistical Sampling Strategies			
Biased Sampling	Sampling locations are chosen based on available information.	Sites with known contamination sources.	Contaminated areas can be overlooked if background information or visual signs of contamination do not indicate them. Best used if combined with a statistical approach, depending on the project objectives.
Judgmental Sampling	An individual subjectively selects sampling locations that appear to be representative of average conditions.	Homogenous, well-defined sites.	Not usually recommended due to bias imposed by individual, especially for final investigations.

STANDARD OPERATING PROCEDURE 30.9
COLLECTION OF SOIL SAMPLES BY USEPA SW 846 METHOD 5035 USING DISPOSABLE SAMPLERS

1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) outlines the recommended protocol and equipment for collection of representative soil samples to monitor potential volatile organic contamination in soil samples.

This method of sampling is appropriate for surface or subsurface soils contaminated with low to high levels of volatile organic compounds (VOCs). This sampling procedure may be used in conjunction with any appropriate determinative gas chromatographic procedure, including, but not necessarily limited to, SW-846 Method 8015, 8021, and 8260.

2.0 MATERIALS

- Work Plans;
- Field Logbook;
- Photoionization Detector (PID) or other monitoring instrument(s) per site-specific health and safety plan;
- Personal protective equipment and clothing per site-specific health and safety plan;
- Soil sampling equipment, as applicable (SOP 30.1);
- Disposable sampler;
- T-handle and/or Extrusion Tool; and
- Decontamination equipment and supplies (SOP 80.1).

3.0 PROCEDURE

3.1 METHOD SUMMARY

Disposable samplers are sent to the field to be used to collect soil samples. Three samplers must be filled for each soil sampling location, two for the low-level method (sodium bisulfate preservation) and one for the high level method (methanol preservation). After sample collection, disposable samplers are immediately shipped back to the laboratory for preservation (adding soil sample into methanol and sodium bisulfate solution). The ratio of volume of methanol to weight of soil is 1:1 as specified in SW-846 Method 5035 (Section 2.2.2). The amount of preservative in the solution corresponds to approximately 0.2 g of preservative for each 1 g of sample. Enough sodium bisulfate should be present to ensure a sample pH of ≤ 2.

If quality assurance/quality control (QA/QC) samples are needed, seven samplers will be needed for the original, matrix spike, and matrix spike duplicate analysis. Soil samples are collected in the field using the disposable samplers, sealed and returned to the laboratory. A separate aliquot of soil is collected in a 125-mL container for dry weight determination.

3.2 SAMPLE CONTAINERS, PRESERVATION, HANDLING AND STORAGE

After sample collection, the disposable samplers must be cooled to and maintained at 4°C. The contents of the samplers will be analyzed using EPA methods 8015, 8021, and/or 8260. The **disposable** sampler is a single use device. It cannot be cleaned and/or reused.

Disposable samplers have a 48 hour holding time from sample collection to sample preparation in the laboratory. Return the samplers to the laboratory immediately after sampling.

3.3 SAMPLE PROCEDURES

Before sampling, the disposable sampler should be prepared as follows:

1. Unpack the cooler/sampling kit received from the laboratory. Disposable samplers are packed in sealed aluminized bags. These should be over packed in plastic zip lock bags. A T-Handle will also be needed to collect samples with the disposable sampler.
2. Hold coring body and push plunger rod down until small 0-ring rests against tabs. This will assure that plunger moves freely.
3. Depress locking lever on the sampler T-Handle (or other extraction device). Place coring body, plungers end first, into the open end of the T-Handle, aligning the two slots on the coring body with the two locking pins in the T-Handle. Twist the coring body clockwise to lock the pins in the slots. Check to ensure the sampler is locked in place. Sampler is ready for use.

The following procedure should be followed when using a disposable sampler to sample for VOCs in soil:

1. After the soil-sampling device (split spoon, corer, etc.) is opened, the sampling process should be completed in a minimum amount of time with the least amount of disruption.
2. Visual inspection and soil screening should be conducted after the sampler is opened and a fresh surface is exposed to the atmosphere. Soil screening should be conducted with an appropriate instrument (PID or FID).
3. Rough trimming of the sampling location surface should be considered if the sampling surface is not fresh or other waste, different soil strata, or vegetation may contaminate it. Surface layers can be removed using a clean stainless steel, spatula, scoop, or knife.
4. Orient the T-Handle with the T-up and the coring body down. This positions the plunger bottom flush with bottom of coring body (ensure that plunger bottom is in position). Using T-Handle, push sampler into soil until the coring body is completely full taking care not to trap air behind the sampler. When full, the small o-ring will be centered in the T-Handle viewing hole. Remove sampler from soil. Wipe excess soil from coring body exterior with a clean disposable paper towel.
5. Cap coring body while it is still on the T-Handle. ***Push*** cap over flat area of ridge ***and twist*** to lock cap in place. ***Cap must be seated to seal sampler.***
6. Remove the capped sampler by depressing locking lever on T-Handle while twisting and pulling sampler from T-Handle.
7. Lock plunger by rotating extended plunger rod fully counterclockwise until wings rest firmly against tabs.
8. Fill the 125-mL wide mouth jar for the non-preserved portion of the sample to be used for a moisture determination. These may be in a cardboard box. Retain all packaging to return the samples.

9. The disposable sampler should collect approximately 5 grams of soil (not necessary to weigh in the field). After a sample has been collected and capped, tear off the identification tag found at the bottom of the label on the aluminized bag. This tag is added to the sampler on the cap used to seal the sampler.
10. Place the sampler back in the aluminized bag and seal the top (a zip-lock seal). Make sure all the appropriate information is on the label. Record the sampler ID number on the chain-of-custody. Make sure each sampler and 125-mL container is labeled with the same location identification. The sampler should be placed inside the plastic zip-lock bags.
11. Place the 125-mL wide mouth jars in the cooler with the sampler on top. These should be sandwiched between bags of ice to maintain the correct temperature. If sent with the jars and samplers, a temperature bottle (used to evaluate the temperature on receipt) should be placed in the middle of the jars. The sample temperature should be 4°C during shipment.
12. Ship the samples so that they will be received within 24 hours of sampling. The laboratory must receive the sampler within 40 hours of the collection so that they can be correctly preserved.

3.4 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

1. All data must be documented on chain-of-custody forms, field data sheets and in the field logbook.
2. An equipment blank is a QA/QC sample that will determine potential contamination from sampling equipment used to collect and transfer samples from the point of collection to the sample container. An equipment blank is performed by pouring demonstrated analyte free water from one sample container, over a sampler, and into a separate set of identical sample containers. The equipment blank is optional when sampling with the methanol preservation technique. It may be required on a site-specific basis if elevated analytical results are suspected to be due to cross contamination from sampling equipment.
3. A trip blank is a QA/QC sample, which will determine additional sources of contamination that may potentially influence the samples. The sources of the contamination may be from the laboratory, sample containers, or during shipment. The laboratory prepares a trip blank at the same time and in the same manner as the sample containers. The trip blank must accompany the sample containers to the field and back to the laboratory along with the collected samples for analysis. It must remain sealed at all times until it is analyzed at the laboratory. The frequency of collection for the trip blank must be at a rate of one per sample shipment.

3.5 LIMITATIONS IN SAMPLING

This sampling protocol will not be applicable to all solid environmental matrices, such as those that cannot be cored including non-cohesive granular material, gravel, or hard dry clay. In this case, the procedure for collecting VOC samples using Methanol Preservation should be used (see SOP 30.8).

4.0 MAINTENANCE

Not applicable.

5.0 PRECAUTIONS

None.

6.0 REFERENCES

En Novative Technologies, Inc. 2000. Users Manual for En Core® Sampler. February 2001.

USACE. 2001. *Requirements for the Preparation of Sampling and Analysis Plans.* EM 200-1-3, 1 February.

USEPA. 1997. *Test Methods for Evaluating Solid Waste, Volume IB: Laboratory Manual Physical/Chemical Methods,* Third Edition, (as updated through update IIIA). Office of Solid Waste and Emergency Response, Washington, DC.

STANDARD OPERATING PROCEDURE 50.1
SAMPLE LABELS

1.0 SCOPE AND APPLICATION

Every sample will have a sample label uniquely identifying the sampling point and analysis parameters. The purpose of this standard operating procedure (SOP) is to delineate protocols for the use of sample labels. An example label is included as Figure 50.1-A. Other formats with similar levels of detail are acceptable.

2.0 MATERIALS

- Sample label; and
- Indelible marker.

3.0 PROCEDURE

The use of preprinted sample labels is encouraged and should be requested from the analytical support laboratory during planning activities.

As each sample is collected, fill out a sample label ensuring the following information has been collected:

- Project name;
- Sample ID: enter the SWMU number and other pertinent information concerning where the sample was taken. This information should be included in site-specific work plan addenda;
- Date of sample collection;
- Time of sample collection;
- Initials of sampler(s);
- Analyses to be performed (NOTE: Due to number of analytes, details of analysis should be arranged with lab *a priori*); and
- Preservatives (water samples only).

Double-check the label information to make sure it is correct. Detach the label, remove the backing and apply the label to the sample container. Cover the label with clear tape, ensuring that the tape completely encircles the container.

4.0 MAINTENANCE

Not applicable.

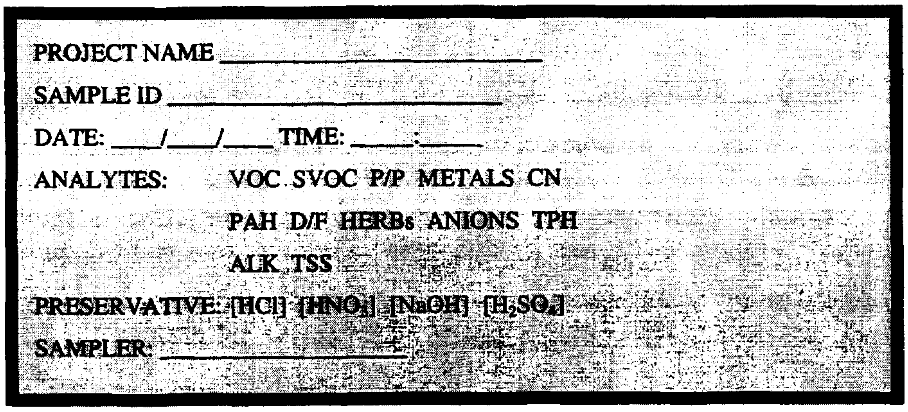
5.0 PRECAUTIONS

None.

6.0 REFERENCES

USEPA. 1998. *EPA Requirements for Quality Assurance Project Plans.* EPA/600/R-98/018, QA/R5, Final, Office of Research and Development, Washington, D.C.

FIGURE 50.1-A
SAMPLE LABEL



PROJECT NAME ______________________

SAMPLE ID ______________________

DATE: ___/___/___ TIME: ____:____

ANALYTES: VOC SVOC P/P METALS CN

PAH D/F HERBs ANIONS TPH

ALK TSS

PRESERVATIVE: [HCl] [HNO_3] [NaOH] [H_2SO_4]

SAMPLER: ________________

STANDARD OPERATING PROCEDURE 50.2
SAMPLE PACKAGING

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to delineate protocols for the packing and shipping of samples to the laboratory for analysis.

2.0 MATERIALS

- Waterproof coolers (hard plastic or metal);
- Metal cans with friction-seal lids (e.g., paint cans);
- Chain-of-custody forms;
- Chain-of-custody seals (optional);
- Packing material;
- Sample documentation;
- Ice;
- Plastic garbage bags;
- Clear Tape;
- Zip-top plastic bags; and
- Temperature blanks provided by laboratory for each shipment.

3.0 PROCEDURE

1. Check cap tightness and verify that clear tape covers label and encircles container.
2. Wrap sample container in bubble wrap or closed cell foam sheets. Samples may be enclosed in a secondary container consisting of a clear zip-top plastic bag. Sample containers must be positioned upright and in such a manner that they will not touch during shipment.
3. Place several layers of bubble wrap, or at least 1 in. of vermiculite on the bottom of the cooler. Line cooler with open garbage bag, place all the samples upright inside the garbage bag and tie.
4. Double bag and seal loose ice to prevent melting ice from soaking the packing material. Place the ice outside the garbage bags containing the samples.
5. Pack shipping containers with packing material (closed-cell foam, vermiculite, or bubble wrap). Place this packing material around the sample bottles or metal cans to avoid breakage during shipment.
6. A temperature blank (provided by laboratory) will be included in each shipping container to monitor the internal temperature. Samples should be cooled to 4 degrees C on ice immediately after sampling.

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7. Enclose all sample documentation (i.e., Field Parameter Forms, Chain-of-Custody forms) in a waterproof plastic bag and tape the bag to the underside of the cooler lid. If more than one cooler is being used, each cooler will have its own documentation. Add the total number of shipping containers included in each shipment on the chain-of-custody form.
8. Seal the coolers with signed and dated custody seals so that if the cooler were opened, the custody seal would be broken. Place clear tape over the custody seal to prevent damage to the seal.
9. Tape the cooler shut with packing tape over the hinges and place tape over the cooler drain.
10. Ship all samples via overnight delivery on the same day they are collected if possible.

4.0 MAINTENANCE

Not applicable.

5.0 PRECAUTIONS

5.1 PERMISSIBLE PACKAGING MATERIALS

- Non-absorbent
  - Bubble wrap; and
  - Closed cell foam packing sheets.
- Absorbent
  - Vermiculite.

5.2 NON-PERMISSIBLE PACKAGING MATERIALS

- Paper;
- Wood shavings (excelsior); and
- Cornstarch "peanuts".

6.0 REFERENCES

USEPA. 1990. *Sampler's Guide to the Contract Laboratory Program.* EPA/540/P-90/006, Directive 9240.0-06, Office of Emergency and Remedial Response, Washington, D.C., December 1990.

USEPA. 1991. *User's Guide to the Contract Laboratory Program.* EPA/540/O-91/002, Directive 9240.0-01D, Office of Emergency and Remedial Response. January 1991.

USEPA. 1998. *EPA Requirements for Quality Assurance Project Plans.* EPA/600/R-98/018, QA/R5, Final, Office of Research and Development, Washington, D.C

STANDARD OPERATING PROCEDURE 70.1
INVESTIGATION-DERIVED MATERIAL

1.0 SCOPE AND APPLICATION

Management of investigation-derived material (IDM) minimizes the potential for the spread of waste material onsite or offsite through investigation activities. The purpose of this standard operating procedure (SOP) is to provide general guidelines for appropriate management of potentially contaminated materials derived from the field investigations. Specific procedures related to the transportation and disposal of hazardous waste are beyond the scope of this SOP.

2.0 INTRODUCTION

Investigation derived material (IDM) consists of waste materials that are known or suspected to be contaminated with waste substances through the actions of sample collection or personnel and equipment decontamination. These materials include decontamination solutions, disposable equipment, drill cuttings and fluids, and water from groundwater monitoring well development and purging. To the extent possible, the site manager will attempt to minimize the generation of these materials through careful design of decontamination schemes and groundwater sampling programs. Testing conducted on soil and water investigation-derived material will show if they are also hazardous wastes as defined by RCRA. This will determine the proper handling and ultimate disposal requirements.

The criteria for designating a substance as hazardous waste according to RCRA is provided in 40 CFR 261.3. If IDM meet these criteria, RCRA requirements will be followed for packaging, labeling, transporting, storing, and record keeping as described in 40 CFR 262.34. Those materials that are judged potentially to meet the criteria for a regulated solid or hazardous waste will be placed in DOT-approved 55-gallon steel drums or another type of DOT approved container; based on waste characteristics and volume.
Investigation-derived material will be appropriately placed in containers, labeled, and tested to determine disposal options in accordance with RCRA regulations and Virginia Hazardous Waste Management Regulations.

3.0 INVESTIGATION-DERIVED MATERIAL MANAGEMENT

Procedures that minimize potential for the spread of waste material include minimizing the volume of material generated, material segregation, appropriate storage, and disposal according to RCRA requirements.

3.1 WASTE MINIMIZATION

In the development of work plan addenda, each aspect of the investigation will be reviewed to identify areas where excess waste generation can be eliminated. General procedures that will eliminate waste include avoidance of unnecessary exposure of materials to hazardous material and coordination of sampling schedules to avoid repetitious purging of wells and use of sampling equipment.

3.2 WASTE SEGREGATION

Waste accumulation and management procedures to be used depend upon the type of material generated. For this reason, IDM described below are segregated into separate 55-gallon storage drums or other appropriate DOT containers. Waste materials that are known to be free of potential hazardous waste contamination (such as broken sample bottles or equipment containers and wrappings) must be collected separately for disposal to municipal systems. Large plastic garbage or "lawn and leaf" bags are useful for collecting this trash. Even "clean" sample bottles or Tyvek should be disposed of with care. Although they are not legally a problem, if they are discovered by the public they may cause concern. Therefore, items that are known to be free from contamination but are also known to represent "hazardous or toxic waste" to the public must not be disposed of in any public trash receptacle, such as found at your hotel or park.

3.2.1 Decontamination Solutions

Solutions considered investigation-derived materials range from detergents, organic solvents, and acids used to decontaminate small hand samplers to steam-cleaning rinsate used to wash drill rigs and other large equipment. These solutions are to be placed in 55-gallon drums with bolt-sealed lids or other appropriate DOT approved containers. Residual liquid IDM from decontamination pads will be removed and appropriately placed in container(s) at the end of each field day.

3.2.2 Soil Cuttings and Drilling Muds

Soil cuttings are solid to semi-solid soils generated during trenching activities or drilling for the collection of subsurface soil samples or the installation of monitoring wells. Depending on the type of drilling, drilling fluids known as "muds" may be used to remove soil cuttings. Drilling fluids flushed from the borehole must be directed into a settling section of a mud pit. This allows reuse of the decanted fluids after removal of the settled sediments. Drill cuttings, whether generated with or without drilling fluids, are to be removed with a flat-bottomed shovel and placed in 55-gallon drums with bolt-sealed lids or other appropriate DOT containers, as conditions or volume of IDM dictate.

3.2.3 Well Development and Purge Water

Well development and purge water is removed from monitoring wells to repair damage to the aquifer following well installation, obtain characteristic aquifer groundwater samples, or measure aquifer hydraulic properties. The volume of groundwater to be generated will determine the appropriate container to be used for accumulation of IDM.

For well development and purging, 55-gallon drums are typically an efficient container for accumulation. When larger volumes of water are removed from wells, such as when pumping tests are conducted, the use of large-volume portable tanks such as "Baker Tanks" should be considered for IDM accumulation.

Analytical data for groundwater samples associated with the well development and purge water will be used to assist in characterizing IDM and evaluating disposal options.

3.2.4 Personal Protective Equipment and Disposable Sampling Equipment

Personal protective equipment and clothing (PPE) may include such items as Tyvek coveralls, gloves, booties, and APR cartridges. Disposable sampling equipment may include such items as plastic sheeting, bailers, disposable filters, disposable tubing and paper towels. PPE and disposable sampling equipment that have or may have contacted contaminated media (soil, water, etc.) will be segregated and placed in 55-gallon drums separate from soil and water IDM. Disposition of this type of IDM will be determined by the results of IDM testing of the media in which the PPE and sampling equipment contacted.

3.3 MATERIAL ACCUMULATION

The IDM in containers must be placed in an appropriate designated RCRA container accumulation area at RFAAP, where it is permissible to accumulate such waste. IDM placed into a designated 90-day accumulation area will be properly sealed, labeled and covered. All drums will be placed on pallets.

A secure and controlled waste staging area will be designated by the installation prior the commencement of field sampling activities. Per the facility's requirements as a RCRA large quantity generator, waste accumulation cannot exceed 90 days for materials presumed or shown to be RCRA-designated hazardous wastes; waste which is known not to be RCRA-designated waste should be promptly disposed to municipal waste systems or appropriate facility.

3.3.1 IDM Accumulation Containers

Containers will be DOT-approved (DOT 17H 18/16GA OH unlined) open-head steel drums or other DOT approved container, as appropriate.

Container lids should lift completely off be secured by a bolt ring (for drum). Order enough containers to accumulate all streams of expected IDM including soil, PPE and disposable sampling equipment, decontamination water, purge water, etc.

Solid and liquid waste streams will not be mixed in a container. PPE and expendable sampling equipment will be segregated from other IDM and placed in different containers than soil. Containers inside containers are not permitted. PPE must be placed directly in a drum not in a plastic bag.

Pallets are often required to allow transport of filled drums to the staging area with a forklift. Normal pallets are 3×4 ft and will hold two to three 55-gallon drums depending on the filled weight. If pallets are required for drum transport or storage, field personnel are responsible for ensuring that the empty drums are placed on pallets before they are filled and that the lids are sealed on with the bolt-tighten ring after the drums are filled. Because the weight of one drum can exceed 500 lbs, under no circumstances should personnel attempt to move the drums by hand.

3.3.2 Container Labeling

Each container that is used to accumulate IDM will be appropriately labeled at the time of accumulation and assigned a unique identification number for tracking purposes. The following information will be written in permanent marker on a drum label affixed on the exterior side at a location at least two-thirds of the way up from the bottom of the drum.

- Facility name.
- Accumulation start date and completion date.
- Site identifier information (SWMU, boring, well, etc.).
- Description of IDM.
- Drum ID No.

4.0 MATERIAL CHARACTERIZATION AND DISPOSAL

IDM will be characterized and tested to determine whether it is a hazardous waste as defined by 40 CFR Part 261 and to determine what disposal options exist in accordance with RCRA regulations and the Virginia Hazardous Waste Management Regulations (VHWMR).

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In general, IDM will be considered a hazardous waste if it contains a listed hazardous waste or if the IDM exhibits a characteristic of hazardous waste.

Work plan addenda will identify the appropriate characterization and testing program for IDM based on the following:

- Site-specific conditions related to chemicals of concern, etc.
- The nature and quantity of expected IDM to be generated during site-specific investigations.
- Applicable Federal, State, and local regulations, such as RCRA, VHWMR regulations and policies and procedures, and Army Regulation 200-1.
- RFAAP specific requirements and policies for IDM characterization and disposal at the time of the investigation.

In general, appropriate USEPA SW 846 Test Methods for Evaluating Solid Waste will be used for testing IDM and will be specified in work plan addenda. Other appropriate test methods may be specified by RFAAP in addition to SW 846 Methods that are specific to installation operations, the site of interest (percent explosive content, reactivity, etc.), or requirements for disposal at RFAAP water treatment facilities or publicly owned treatment works.

Responsibility for the final disposal of IDM will be determined before field activities are begun and will be described in work plan addenda. Off-site disposal of IDM will be coordinated with RFAAP (generator) to ensure appropriate disposition. The contractor will coordinate IDM transportation and disposal activities for RFAAP (generator).

At the direction of RFAAP, appropriate waste manifests will be prepared by the USACE contractor or Alliant Techsystems subcontractor for transportation and disposal. Alliant Techsystems or other appropriate RFAAP entity will be listed as the generator and an appointed representative from RFAAP will review and sign the manifest for offsite disposal.

RFAAP will make the final decision on the selection of the transporter, storage, and disposal facility (TSDFs) or recycling facility. RFAAP will provide the contractor a listing of previously used TSDFs for priority consideration. Proposed facilities that are not included on the listing are required to provide a copy of the TSDFs most recent state or federal inspection to the installation. Waste characterization and testing results will be submitted to RFAAP (generator) for review and approval before final disposition of the material.

Hazardous waste: Prior to final disposition, a hazardous waste manifest will be furnished by the TSDF to accompany transport to the disposal facility. Following final disposition, a certificate of disposal will be furnished by the disposal facility. Copies of the manifests and certificates of disposal are to be provided to RFAAP and retained on file by the contractor or subcontractor.

4.0 PRECAUTIONS

- Because the weight of one drum can exceed 500 lbs, under no circumstances should personnel attempt to move drums by hand.
- Refer to the site-specific health and safety plan when managing IDM.

5.0 REFERENCES

Safety Rules for Contractors and Subcontractors, 1995. Alliant Techsystems, Incorporated, Radford Army Ammunition Plant.

STANDARD OPERATING PROCEDURE 80.1
DECONTAMINATION

1.0 SCOPE AND APPLICATION

Before leaving the site, all personnel or equipment involved in intrusive sampling or having entered a hazardous waste site during intrusive sampling must be thoroughly decontaminated to prevent adverse health effects and minimize the spread of contamination. Equipment must be decontaminated between sites to preclude cross-contamination. Decontamination water will be free of contaminants as evidenced through either chemical analyses or certificates of analysis. This standard operating procedure (SOP) describes general decontamination requirements for site personnel and sampling equipment. Decontamination procedures for contaminants requiring a more stringent procedure, e.g., dioxins/furans, will be included in site-specific addenda.

2.0 MATERIALS

- Plastic sheeting, buckets or tubs, pressure sprayer, rinse bottles, and brushes;
- U.S. Army Corps of Engineers or installation approved decontamination water source;
- Deionized ultra-filtered, HPLC-grade organic free water (DIUF);
- Non-phosphate laboratory detergent;
- Nitric Acid, 0.1 Normal (N) solution;
- Pesticide-grade solvent, Methanol;
- Aluminum foil;
- Paper towels;
- Plastic garbage bags; and
- Appropriate containers for management of investigation-derived material (IDM).

3.0 PROCEDURE

3.1 SAMPLE BOTTLES

At the completion of each sampling activity the exterior surfaces of the sample bottles must be decontaminated as follows:

- Be sure that the bottle lids are on tight.
- Wipe the outside of the bottle with a paper towel to remove gross contamination.

3.2 PERSONNEL DECONTAMINATION

Review the site-specific health and safety plan for the appropriate decontamination procedures.

3.3 EQUIPMENT DECONTAMINATION

3.3.1 Drilling Rigs

Drilling rigs and associated equipment, such as augers, drill casing, rods, samplers, tools, recirculation tank, and water tank (inside and out), will be decontaminated before site entry, after over-the-road mobilization and immediately upon departure from a site after drilling a hole. Supplementary cleaning will be performed before site entry. There is a likelihood that contamination has accumulated on tires and as spatter or dust en route from one site to the next.

1. Place contaminated equipment in an enclosure designed to contain all decontamination residues (water, sludge, etc.).
2. Steam-clean equipment until all dirt, mud, grease, asphaltic, bituminous, or other encrusting coating materials (with the exception of manufacturer-applied paint) has been removed.
3. Water used will be taken from an approved source.
4. When cross-contamination from metals is a concern, rinse sampling components such as split spoons, geo-punch stems, and augers with nitric acid, 0.1N.
5. Rinse with DIUF water.
6. When semi-volatile and non-volatile organics may be present, rinse the sampling components with pesticide-grade solvent methanol.
7. Double rinse the sampling components with DIUF water.
8. Decontamination residues and fluids will be appropriately managed as IDM per work plan addenda and SOP 80.1.

3.3.2 Well Casing and Screen

Prior to use, well casing and screen materials will be decontaminated. This activity will be performed in the leak proof, decontamination pad, which will be constructed prior to commencement of the field investigation. The decontamination process will include:

- Steam cleaning with approved source water.
- Rinse with DUIF water.
- Air-dry on plastic sheeting.
- Wrap in plastic sheeting to prevent contamination during storage/transit.

3.3.3 Non Dedicated Submersible Pumps Used for Purging and Sampling

1. Scrub the exterior of the pump to remove gross (visible) contamination using appropriate brushes, approved water, and non-phosphate detergent (steam cleaning may be substituted for detergent scrub).
2. Pump an appropriate amount of laboratory detergent solution (minimum 10 gallons) to purge and clean the interior of the pump.
3. Rinse by pumping no less than 10 gallons of approved water to rinse.
4. Rinse the pump exterior with approved decontamination water.
5. When cross-contamination from metals is a concern, rinse the pump exterior with approved nitric acid 0.1N solution.
6. Rinse the pump exterior with DIUF water.

7. When semi-volatile and non-volatile organics may be present, rinse the pump exterior with pesticide-grade solvent methanol.
8. Double rinse the pump exterior with DIUF water.
9. Air-dry on aluminum foil or clean plastic sheeting.
10. Wrap pump in aluminum foil or clean plastic sheeting, or store in a clean, dedicated PVC or PTFE storage container.
11. Solutions and residuals generated from decontamination activities will be managed appropriately as IDM per work plan addenda and SOP 80.1.

3.3.4 Sample Equipment and Measuring Water Level Devices

1. Scrub the equipment to remove gross (visible) contamination using appropriate brush (es), approved water, and non-phosphate detergent.
2. Rinse with approved source water.
3. When cross-contamination from metals is a concern, rinse the sampling equipment with approved nitric acid 0.1N solution.
4. Rinse equipment with DIUF water.
5. When semi-volatile and non-volatile organics may be present, rinse the sampling equipment with pesticide-grade solvent methanol.
6. Double rinse the sampling equipment with DIUF water.
7. Air-dry on aluminum foil or clean plastic sheeting.
8. Wrap in aluminum foil, clean plastic sheeting, or zip top bag or store in a clean, dedicated PVC or PTFE storage container.
9. Solutions and residuals generated from decontamination activities will be managed appropriately as IDM per work plan addenda and SOP 80.1.

3.3.5 Other Sampling and Measurement Probes

Temperature, pH, conductivity, Redox, and dissolved oxygen probes will be decontaminated according to manufacturer's specifications. If no such specifications exist, remove gross contamination and triple-rinse probe with DIUF water.

4.0 PRECAUTIONS

- Manage IDM appropriately according to the requirements specified in work plan addenda.
- Follow appropriate procedures as specified in the site-specific health and safety plan.

5.0 REFERENCES

USACE. 2001. Requirements for the Preparation of Sampling and Analysis Plans. EM 200-1-3. 1 February.

STANDARD OPERATING PROCEDURE 90.1
PHOTOIONIZATION DETECTOR (HNu Model PI–101 and HW–101)

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to delineate protocols for field operations with a photoionization detector (HNu Systems Model PI–101 or HW–101). The photoionization detector (PID) detects total ionizables; hence it is used to monitor both organic and inorganic vapors and gases to determine relative concentrations of air contaminants. This information is used to establish level of protection and other control measures such as action levels. The PID cannot effectively detect compounds having ionization potentials above the photon energy level of the lamp used; therefore, methane, which has an ionization potential of 12.98 eV, is undetectable by PIDs because the lamps produce 9.5, 10.2, or 11.7 eV.

Use of brand names in this SOP is in not intended as an endorsement or mandate that a given brand be used. Alternate equivalent brands of detectors, sensors, meters, etc., are acceptable. If alternate equipment is to be used, the contractor shall provide applicable and comparable SOPs for its maintenance and calibration.

2.0 MATERIALS

- HNu Systems Model PI–101 or HW–101 survey probe with 9.5, 10.2, or 11.7 eV lamp;
- Lead-acid gel-cell battery;
- Calibration gas (e.g., isobutylene, 101 ppm) with regulator;
- Tygon tubing;
- Tedlar bag (optional);
- Instrument logbook; and
- Field logbook.

3.0 PROCEDURE

These procedures are to be followed when using the HNu in the field.

3.1 STARTUP

1. Before attaching the probe, check the function switch on the control panel to ensure that it is in the off position. Attach the probe by plugging it into the interface on the top of the readout module.
2. Turn the function switch to the battery check position. The needle on the meter should read within or above the green battery arc on the scale; if not, recharge the battery. If the red indicator light comes on, the battery needs recharging or service may be indicated.
3. Turn the function switch to any range setting. Listen for the hum of the fan motor. Check meter function by holding a solvent-based marker pen near the sample intake. If there is no needle deflection, look briefly into the end of the probe (no more than 1 or 2 sec) to see if the lamp is on; if it is on, it will give a purple glow. Do not stare into the probe any longer than 2 sec. Long-term exposure to UV light can damage the eyes. (See further information in Section 5.)

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4. To zero the instrument, turn the function switch to the standby position and rotate the zero adjustment until the meter reads zero. A calibration gas is not needed since this is an electronic zero adjustment. If the span adjustment setting is changed after the zero is set, the zero should be rechecked and adjusted if necessary. Allow the instrument to warm up for 3–5 min to ensure that the zero reading is stable. If necessary, readjust the zero.

3.2 OPERATIONAL CHECK

Follow the startup procedure in Section 3.1.
With the instrument set on the 0–20 range, hold a solvent-based marker near the probe tip. If the meter deflects upscale, the instrument is working.

3.3 FIELD CALIBRATION PROCEDURE

1. Follow the startup procedures in Section 3.1 and the operational check in Section 3.2.
2. Set the function switch to the range setting for the concentration of the calibration gas.
3. Attach a regulator HNu P/N 101-351 or equivalent (flow = 200 to 300 ml/min) to a disposable cylinder of isobutylene (HNu 101-351 or equivalent). Connect the regulator to the probe of the HNu with a piece of clean Tygon tubing. Turn on the valve of the regulator.
4. After 5 sec, adjust the span dial until the meter reading equals the benzene concentration of the calibration gas used, corrected to its equivalence, which should be marked on the canister (Isobutylene ~0.7X benzene).
5. Record in the field log the instrument ID No., serial No., initial and final span settings, date, time, location, concentration and type of calibration gas used, and the signature of the person who calibrated the instrument.
6. If the HNu does not function or calibrate properly, the project equipment manager is to be notified as soon as possible. Under no circumstances is work requiring monitoring with a PI–101 or HW–101 to be done with a malfunctioning instrument.

3.4 CALIBRATION TO A GAS OTHER THAN ISOBUTYLENE

The HNu may be calibrated to any certified calibration gas. However, after calibration, all subsequent instrument readings will be relative to the calibration gas used. General procedures include the following:

1. Calibrate according to procedure 3.3.
2. Partially fill and flush one-to-two times a gas bag (Tedlar recommended) with the certified National Institute of Standards and Technology (NIST) (formerly NBS) traceable calibration gas. Then fill the bag with 1–3 L of the calibration gas. If the gas is toxic, this must be done in a fume hood.
3. Feed the calibration gas into the probe with the range set for the value of the gas. After 5 sec, adjust the span control until the meter reads the value of the calibration gas.
4. Record the results of the calibration on the calibration/maintenance log and attach a new calibration sticker (if available) or correct the existing sticker to reflect the new calibration data. All subsequent readings will be relative to the new calibration gas.

3.5 OPERATION

1. Follow the startup procedure, operational check, and calibration check (refer to Section 3.1).

2. Set the function switch to the appropriate range. If the concentration of gas vapors is unknown, set the function switch to 0-20 ppm range. Adjust if necessary.
3. Prevent exposing the HNu to excessive moisture, dirt, or contaminant while monitoring the work activity as specified in the Site Health and Safety Plan.
4. When the activity is completed, or at the end of the day, carefully clean the outside of the HNu with a damp disposable towel to remove all visible dirt. Return the HNu to a secure area and place on charge. Charge after each use; the lead acid batteries cannot be ruined by over charging.
5. With the exception of the probe's inlet and exhaust, the HNu can be wrapped in clear plastic to prevent it from becoming contaminated and to prevent water from getting inside in the event of precipitation. If the instrument becomes contaminated, make sure to take necessary steps to decontaminate it. Call the Equipment Administrator if necessary; under no circumstances should an instrument be returned from the field in a contaminated condition.

4.0 MAINTENANCE

Calibration/maintenance logs are to be filled in completely whenever a PI-101 or HW-101 receives servicing. This is true of both contractor-owned and rental instruments.

The equipment manager should be called to arrange for a fresh instrument when necessary. The contractor's equipment facility is responsible for arranging all repairs that cannot be performed by the project equipment manager.

4.1 ROUTINE SERVICE

The PID's performance is affected by a number of factors. These include but are not limited to the decay of the UV lamp output over time and the accumulation of dust and other particulate material and contaminates on the lamp and in the ion chamber. Because of these factors, the PID should not be left in the field for a period of more than 2 weeks before being replaced with a fresh instrument. If a site is going to be inactive for a period of more than a week, all monitoring instruments are to be returned to the project equipment manager or his trained designee for servicing and/or reassignment. The following procedures are to be performed at the designated intervals for routine service.

Procedure	Frequency
Operational check	Before use and at instrument return
Field calibration	Before use and at instrument return
Full calibration	Bi-weekly (return instrument to equipment manager for replacement with a fresh unit)
Clean UV lamp and	Bi-weekly or as needed ion chamber
Replace UV Lamp	As needed

4.1.1 UV Lamp and Ion Chamber Cleaning

During periods of analyzer operation, dust and other foreign materials are drawn into the probe forming deposits on the surface of the UV lamp and in the ion chamber. This condition is indicated by meter readings that are low, erratic, unstable, non-repeatable, or drifting and show apparent moisture sensitivity. These

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deposits interfere with the ionization process and cause erroneous readings. Check for this condition regularly to ensure that the HNu is functioning properly. If the instrument is malfunctioning, call your equipment manager to arrange to have a fresh replacement.

4.1.2 Lamp eV Change

If different applications for the analyzer would require different eV lamps, separate probes, each with its own eV lamp, must be used. A single readout assembly will serve for any of the probes (9.5, 10.2, and 11.7 eV). A change in probe will require resetting of the zero control and recalibrating the instrument. The 11.7 eV lamp will detect more compounds than either of the two lower eV lamps. However, the 11.7 eV probe needs more frequent calibration; it burns out much faster than the lower eV lamps.

5.0 PRECAUTIONS

- The HNu PI–101 and HW–101 are designed to sample air or vapors only. *Do not allow any liquids or low boiling vapors to get into the probe or meter assembly.*
- High concentrations of any gas can cause erroneous readings. High humidity can also cause the instrument readings to vary significantly from the actual concentration of gases or vapors present. This is true even through the HNu cannot react to water vapor.
- High humidity, dust, and exposure to concentrations of low boiling vapors will contaminate the ion chamber, causing a steady decrease in sensitivity.
- Continued exposure to ultraviolet light generated by the light source can be harmful to eyesight. If a visual check of the UV lamp is performed *do not look at the light source from a distance closer than 6 inches with unprotected eyes.* Use eye protection (UV-blocking sunglasses or safety glasses). Only look briefly—never more than about 2 sec.

Place the instrument on charge after each use; the lead batteries cannot be ruined by over charging.

- If at any time the instrument does not check out or calibrate properly in the field, the equipment manager is to be notified immediately and a replacement obtained for the malfunctioning instrument. Under no circumstances should fieldwork requiring continuous air monitoring for organic vapors and/or gases be done with a malfunctioning Hnu or without a HNu or an approved comparable instrument.

6.0 REFERENCES

Manufacturer's Equipment Manual.

APPENDIX B
SITE PHOTOGRAPHS

PHOTO 1: Panoramic view looking southwest to west (left to right) across SWMU 40/71. Monitoring well 40MW4 is visible in center of photograph. Note the gentle slope of the SWMU surface relative to the surrounding landscape.

PHOTO 2: View looking west across northern scarp of SWMU 40/71. Note that land surface slopes gently from the SWMU area.

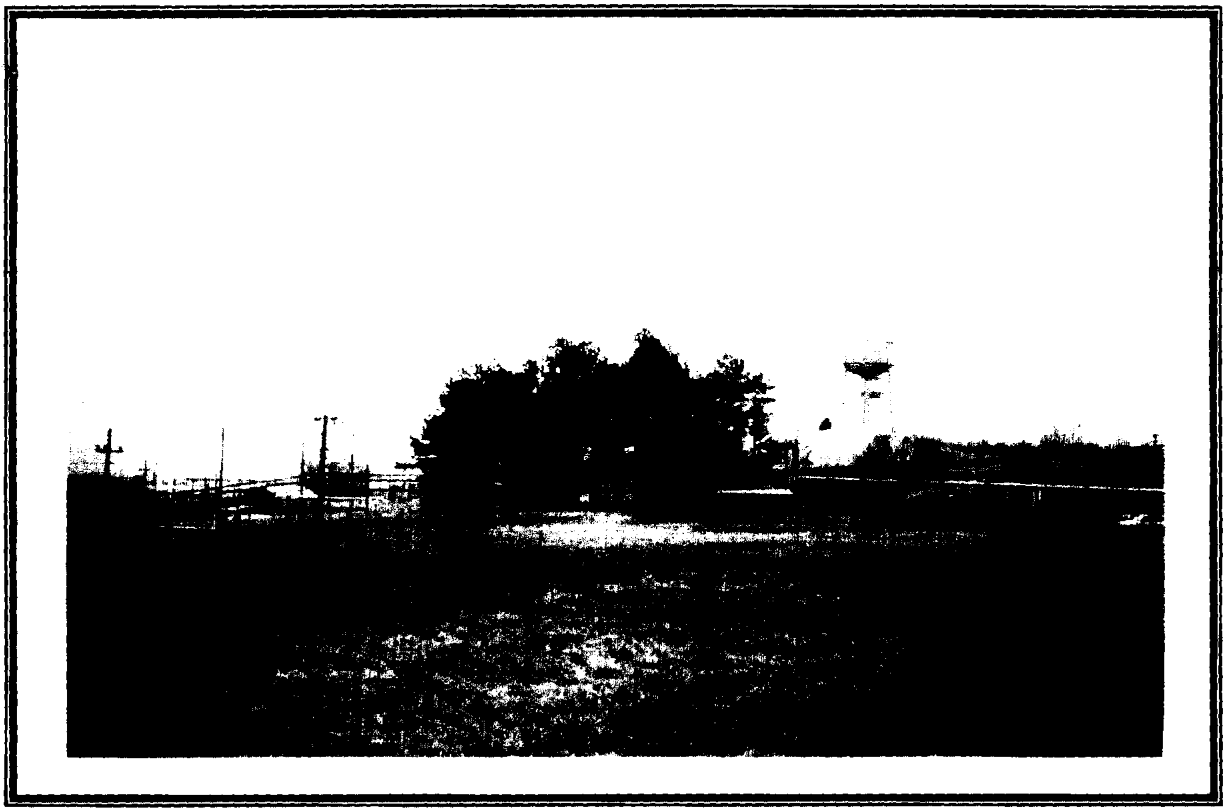

PHOTO 3: View looking east across SWMU 40/71 and the northern scarp. The asbestos storage area is visible in the middle ground.