*Document No. 2148*

# *Certification Docket for the Remedial Action Performed at the Ventron Site Beverly, Massachusetts*

*Department of Energy*
*Office of Assistant Manager*
*for Environmental Management*
*Oak Ridge Operations*

*March 2003*

Printed on recycled/recyclable paper.

# CERTIFICATION DOCKET

# FOR THE

# REMEDIAL ACTION PERFORMED AT THE

# VENTRON SITE IN BEVERLY, MASSACHUSETTS

March 2003

Prepared for

United States Department of Energy

Under Contract No. DACW45-98-D0028

By

Bechtel National, Inc.

Oak Ridge, Tennessee

Bechtel Job No. 14501

# CONTENTS

Page

FIGURES ..... iv

ACRONYMS ..... v

UNITS OF MEASURE ..... vi

EXECUTIVE SUMMARY ..... ES-1

EXHIBIT I: SUMMARY OF REMEDIAL ACTION PERFORMED AT THE VENTRON SITE IN BEVERLY, MASSACHUSETTS

1.0 SITE HISTORY ..... I-1
2.0 RADIOLOGICAL HISTORY AND SURVEYS ..... I-4
  2.1 RADIOLOGICAL AND CHEMICAL SURVEYS ..... I-4
  2.2 REMEDIAL ACTION GUIDELINES ..... I-4
  2.3 REGULATORY ISSUES ..... I-5
  2.4 POST-REMEDIAL ACTION STATUS ..... I-5
3.0 SUMMARY OF REMEDIAL ACTION ..... I-6
  3.1 PRE-REMEDIAL ACTION ACTIVITIES ..... I-6
  3.2 DECONTAMINATION/REMEDIAL ACTIVITIES ..... I-6
  3.3 POST-REMEDIAL ACTION MEASUREMENTS ..... I-7
  3.4 VERIFICATION ACTIVITIES ..... I-7
4.0 CONCLUSION ..... I-9

EXHIBIT II: REFERENCES FOR DOCUMENTS SUPPORTING THE CERTIFICATION OF REMEDIAL ACTION PERFORMED AT THE VENTRON SITE IN BEVERLY, MASSACHUSETTS

1.0 INTRODUCTION ..... II-1
2.0 FUSRAP GENERAL ..... II-1
3.0 DESIGNATION DOCUMENTATION ..... II-1
4.0 DECONTAMINATION CRITERIA ..... II-1
5.0 RADIOLOGICAL CHARACTERIZATION REPORTS ..... II-2
6.0 CERCLA/NEPA DOCUMENTATION ..... II-2
7.0 MEMORANDUM OF AGREEMENT AND REAL ESTATE LICENSE ..... II-3
8.0 POST-REMEDIAL ACTION AND VERIFICATION ..... II-3
9.0 CORRESPONDENCE WITH REGULATORS ..... II-3

EXHIBIT III: *FEDERAL REGISTER* DOCUMENTS

1.0 DOE STATEMENT OF CERTIFICATION ..... III-1
2.0 FEDERAL REGISTER NOTICE OF CERTIFICATION ..... III-3

# FIGURES


| Figure | Title | Page |
|---|---|---|
| I-1 | Location of the Ventron Site | I-2 |
| I-2 | Ventron Site Plan | I-3 |

# ACRONYMS

| | |
|---|---|
| ANL | Argonne National Laboratory |
| AEC | U.S. Atomic Energy Commission |
| BNI | Bechtel National, Inc. |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| DOE | U.S. Department of Energy |
| EE/CA | engineering evaluation/cost analysis |
| EPA | U.S. Environmental Protection Agency |
| FUSRAP | Formerly Utilized Sites Remedial Action Program |
| IVC | independent verification contractor |
| MED | Manhattan Engineer District |
| NRC | U.S. Nuclear Regulatory Commission |
| ORISE | Oak Ridge Institute for Science and Education |
| PIC | pressurized ionization chamber |
| SAFER | Streamlined Approach for Environmental Restoration |
| SEC | Safety and Ecology Corporation |
| USACE | U.S. Army Corps of Engineers |

## UNITS OF MEASURE

| | |
|---|---|
| cm | centimeter |
| cpm | counts per minute |
| dpm | disintegrations per minute |
| ft | foot |
| g | gram |
| gal | gallon |
| h | hour |
| in. | inch |
| lb | pound |
| m | meter |
| mi | mile |
| µCi | microcurie |
| mL | milliliter |
| µR | microroentgen |
| mrad | milliard |
| mrem | millirem |
| pCi | picocurie |
| yd | yard |
| yr | year |

## EXECUTIVE SUMMARY

The purpose of this certification docket is to document the successful decontamination of radioactively contaminated areas at the Ventron site in Beverly, Massachusetts by the U.S. Department of Energy (DOE). Remediation of the property was performed in 1996 and 1997 under DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP), a program established to identify and remediate, or otherwise control, sites where residual radioactive contamination remains from activities carried out by the Manhattan Engineer District/Atomic Energy Commission during the early years of the nation's atomic energy program.

FUSRAP was administered by DOE until October 1997, when the U.S. Congress reassigned responsibility for management of the program to the U.S. Army Corps of Engineers (USACE). Completion of the certification process was delayed pending preparation of a Memorandum of Understanding between DOE and USACE with regard to completed, remediated sites such as the Ventron site.

Bechtel National, Inc. (BNI) was the project management contractor for work conducted at the Ventron site. Thermo Nutech Services, Inc., and Safety and Ecology Corporation served as the radiological support subcontractor for analyzing, sampling, and providing health physics technological support for site activities. Science Applications International Corporation (SAIC) was the environmental studies contractor responsible for assisting DOE in preparing the project environmental documentation. Oak Ridge Institute for Science and Education (ORISE) was the independent verification contractor for the remediation work performed.

The material in this docket includes information and documents supporting certification that conditions at the property are in compliance with radiological guidelines in effect at the conclusion of remedial action. Furthermore, this certification docket substantiates that the future use of the property will not produce any significant radiological hazard or dose to the general public as a result of residual radioactivity remaining onsite that originated during activities conducted by DOE or its predecessor agencies.

Exhibit I of this docket is a summary of remedial activities conducted at the Ventron site. The exhibit provides a brief history of the origin of the contamination at the site, the radiological characterization activities conducted, the remedial actions performed, post-remedial action survey and soil sampling results, and independent verification activities. References called out in Exhibit I of this document correspond to those referenced in Exhibit II.

Exhibit II provides a listing of references documenting the entire remedial action process from designation of the site under FUSRAP to the certification that no radiological restrictions limit the future use of the site. Provided as Exhibit III is the DOE statement certifying that the property is in compliance with DOE radiological decontamination criteria and standards in effect at the conclusion of remedial action and the published *Federal Register* notice announcing the completion of remediation.

The certification docket and documents identified in Exhibit II will be available for public review at the following locations:

U.S. Department of Energy
Public Reading Room
Room 1E-19
Forrestal Building
1000 Independence Avenue, S.W.
Washington, D.C. 20585

U.S. Department of Energy
DOE Information Center
475 Oak Ridge Turnpike
Oak Ridge, Tennessee 37831

Beverly Public Library
32 Essex Street
Beverly, Massachusetts 01915.

Further information on the docket is available by contacting:

Patrick Noone, Business Management Specialist
Office of Site Closure
EM-31/CLV
1000 Independence Avenue, S.W.
U.S. Department of Energy
Washington, D.C. 20585-2040
Phone: (301) 903-2870
Fax: (301) 903-2385

# EXHIBIT I:

## SUMMARY OF REMEDIAL ACTION PERFORMED AT THE VENTRON SITE IN BEVERLY, MASSACHUSETTS

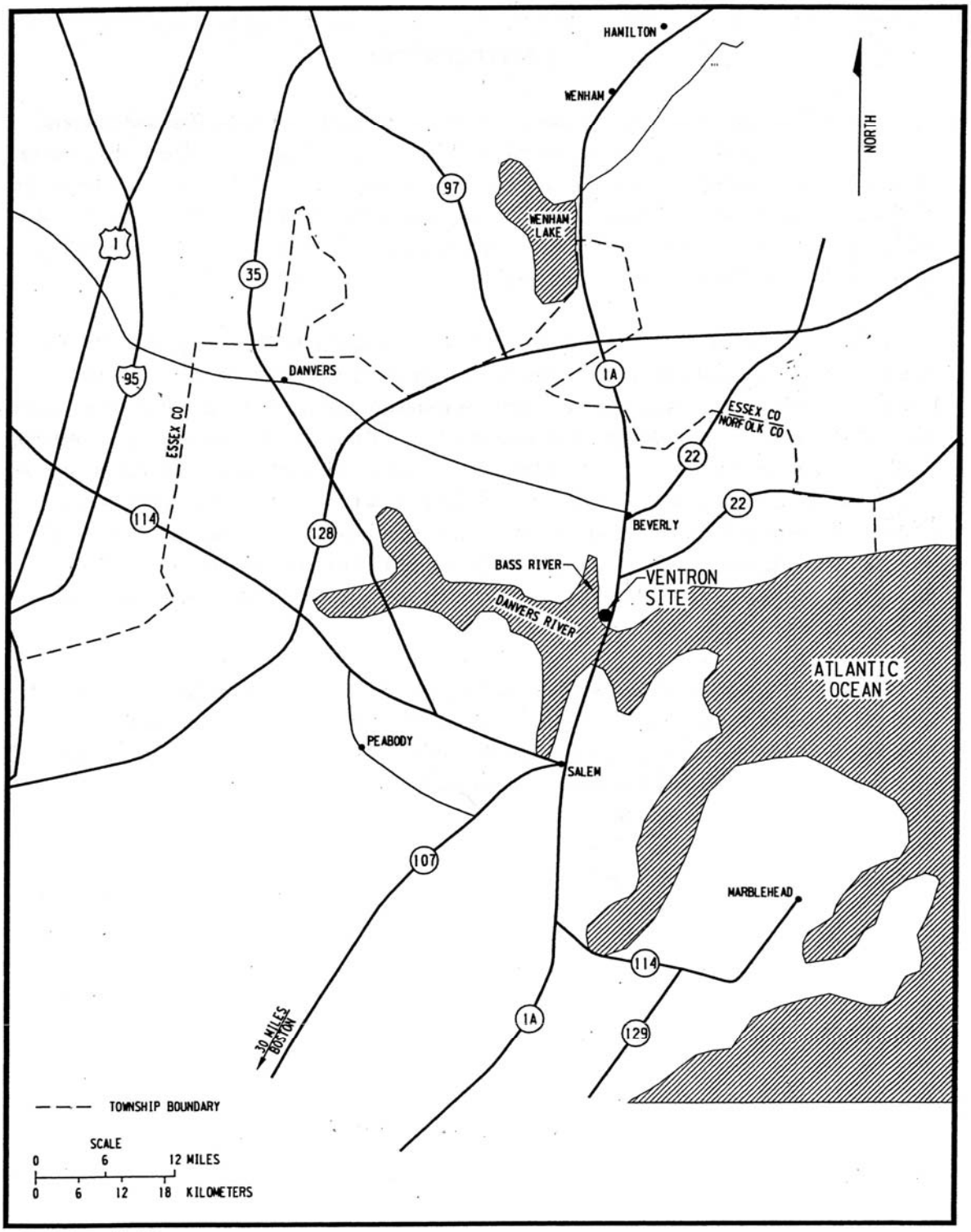
## 1.0 SITE HISTORY

The Ventron site is located on Massachusetts Bay at the confluence of the Bass and Danvers rivers; the city of Beverly is ~24 km (15 miles) northeast of Boston (Figure I-1). The 1.2-ha (3-acre) site, formerly a chemical manufacturing plant and research and development facility, currently owned by Morton International, is bordered on the north by Congress Street, on the east by the Boston and Maine Railroad, on the west by the Bass River, and on the south by the Danvers River. Surrounding land use is residential and commercial/industrial.

From 1942 to 1948, the Metal Hydrides Corporation conducted uranium processing operations under contract to the Manhattan Engineer District (MED) and its successor, the Atomic Energy Commission (AEC). MED/AEC contract operations involved conversion of uranium oxide to uranium metal powder using calcium hydride. A process used later at the facility involved reaction of uranium oxide with hydrogen fluoride to produce uranium tetrafluoride, which was mixed with magnesium and heated to produce uranium metal. MED/AEC contract work at the site involved only natural uranium; no depleted or enriched uranium was processed. Other operations at the site involved recovery of uranium from scrap and turnings resulting from operations at a fuel fabrication plant in Hanford, Washington. Uranium-238 was identified as the primary contaminant of concern associated with MED/AEC activities (Exh. II, Refs. 14,16).

Two of the original buildings, which housed foundry facilities, were demolished between 1948 and 1950 (after completion of AEC surveying and decommissioning), and two other buildings (Buildings B and F) were erected at these locations (Figure I-2). The remaining original buildings (Buildings A and A-1) contained furnaces, leaching facilities, a mixing room, a drying room, and analytical laboratories. The Alfa Building was used in later non-MED-related thorium operations, reportedly involving purification of thorium compounds. The primary radioactive contaminant resulting from this work was thorium-232.

In 1965, Metal Hydrides Corporation became the Ventron Corporation, which was acquired by the Thiokol Corporation in late 1976. In 1980, Ventron became a division of Morton Thiokol, Inc. (renamed Morton International in 1990). The site was designated for remedial action under FUSRAP in 1986 (Exh. II, Ref. 5).




127_VIC.DGN 10-4-02

Figure 1-1
Location of the Ventron Site
Beverly, MA

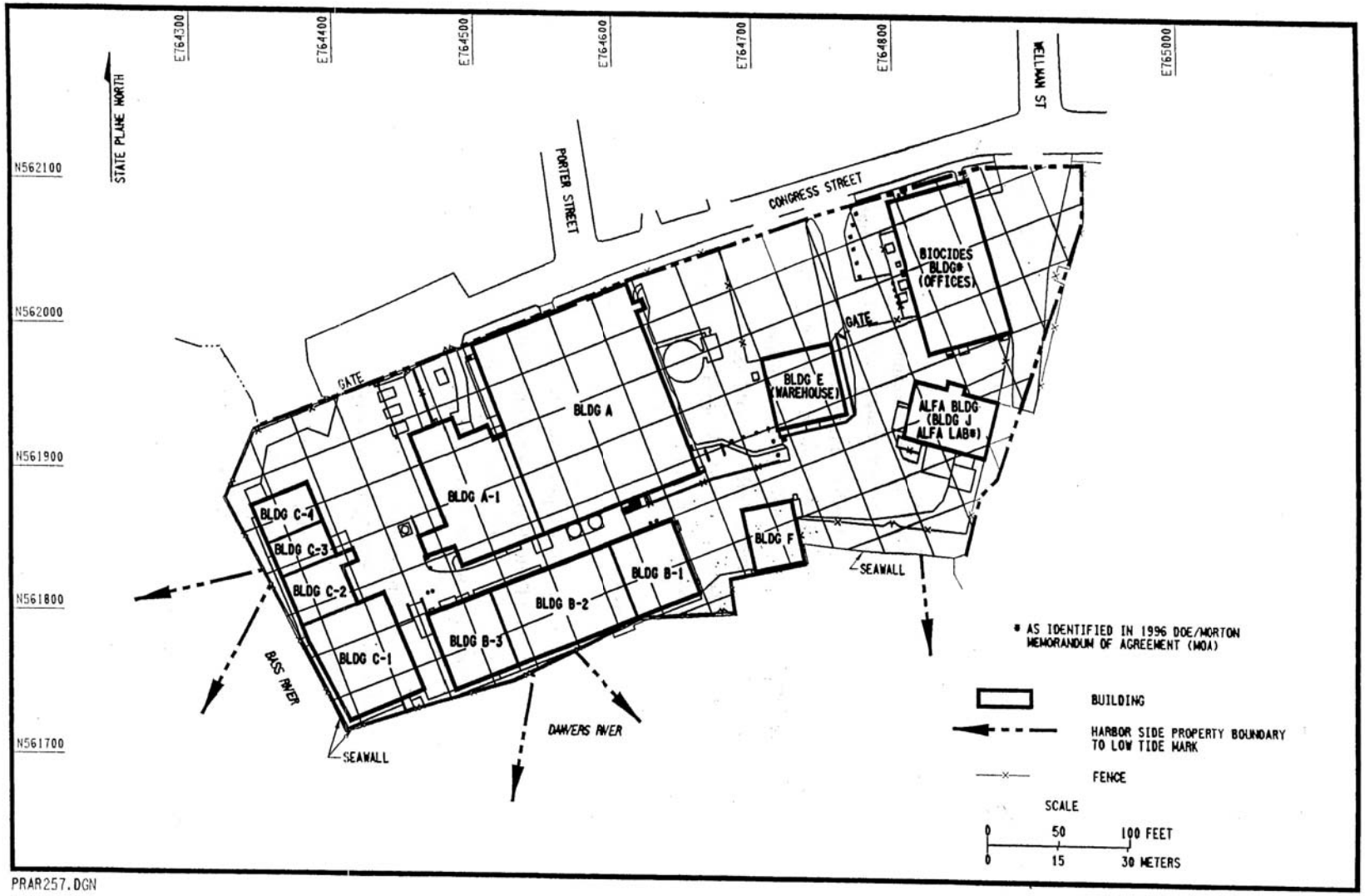



Figure 1-2
Ventron Site Plan

# 2.0 RADIOLOGICAL HISTORY AND SURVEYS

## 2.1 RADIOLOGICAL AND CHEMICAL SURVEYS

Site characterization was performed in 1992 using the Streamlined Approach For Environmental Restoration (SAFER) method, an expedited approach developed by DOE to quickly and efficiently conduct remedial investigations/feasibility studies at DOE facilities in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This approach indicated several discrete areas of contamination. Investigations at the Alfa Building were limited because the work performed in that building was not MED-related; however, during remediation, areas of contamination previously thought to be discrete proved to be contiguous, and contamination was discovered beneath the Alfa Building.

Primary radioactive contaminants were uranium-238, thorium-232, and radium-226. Residual radioactive contamination (primarily uranium) was identified in soil and in fill material beneath four buildings, and elevated surface contamination was found in two buildings (Exh. II, Ref 16). Thorium contamination was detected primarily in the vicinity of the Alfa Building; radium contamination was limited to retort tunnels beneath the Building A slab. A Memorandum of Agreement signed by DOE and Morton International in 1996 provided that FUSRAP would decontaminate all buildings containing radioactivity above DOE 5400.5 guidelines (whether of government or non-government origin) and that Morton would demolish the buildings (Exh. II, Ref. 20).

## 2.2 REMEDIAL ACTION GUIDELINES

Standards and criteria governing release of properties for radiologically unrestricted use are based on DOE Order 5400.5, "Radiation Protection of the Public and the Environment, "and related guidance applicable to FUSRAP sites (Exh. II, Refs. 7, 8, 9,10,12). Guidelines specified in DOE Order 5400.5 (Exh. II, Ref. 7) are comparable to criteria then in use by EPA and NRC.

Cleanup criteria for residual radioactive material in soil were based on application of the as-low-as-reasonably-achievable (ALARA) principle to site-specific guidance developed by Argonne National Laboratory (ANL). Site-specific guidelines for total uranium in soil averaged over the remediated area were dose-based criteria derived by ANL based on the most probable future use of the site (Exh. II, Ref. 9). Site-specific criteria for soil were 5115 pCi/g for thorium-232 and radium-226 and 100 pCi/g for total uranium (50 pCi/g for uranium-238) regardless of depth. Criteria for building decontamination were DOE 5400.5 surface criteria for unrestricted use (Exh. II, Ref. 7).

Asbestos was the only nonradioactive constituent mingled with residual radioactive materials at concentrations requiring remedial action. The asbestos-containing material was contaminated with radium-226 at concentrations >5 pCi/g. All asbestos materials containing residual radioactive material were removed from the site and transported to Envirocare of Utah, a facility licensed for disposal of radioactively contaminated waste.

## 2.3 REGULATORY ISSUES

Environmental assessments required by the National Environmental Policy Act were incorporated in CERCLA documentation prepared for the site (Exh. II, Ref 18). An investigation was performed in accordance with 10 CFR 1022. Floodplains, wetlands, and coastal tidal areas were determined to be present; however, proposed activities were determined to have minimal short-term and positive long-term environmental effects (Exh. II, Ref 19). Consultations with regulators regarding natural resources and endangered and threatened species determined that proposed activities would have no negative effect on these resources. Consultations with historic preservation officials also determined that no protected resources would be adversely affected by cleanup activities. Appropriate real estate instruments were negotiated with the site owner before remedial action began (Exh. II, Refs. 20, 21).

## 2.4 POST-REMEDIAL ACTION STATUS

After cleanup was completed in each portion of the site, radiological surveys and sampling were conducted to ensure that residual radioactive contamination had been removed to levels meeting applicable guidelines. Post-remedial action surveys to confirm removal of residual radioactive material were performed as specified in the post-remedial action survey plan for Ventron. (Exh. II, Refs. 22, 23) by the radiological support subcontractor, Safety and Ecology Corporation (SEC), on behalf of the project management contractor, Bechtel National, Inc. (BNI). These surveys included walkover gamma scans, external gamma exposure rate measurements, and soil sampling. Post-remedial action survey and sampling results are included in the post-remedial action report for the site (Exh. II, Ref. 24).

## 3.0 SUMMARY OF REMEDIAL ACTION

Remedial action was conducted during 1995-1997 at the Ventron site in Beverly, Massachusetts, under the Formerly Utilized Sites Remedial Action Program (FUSRAP). Remediation activities were performed in the harbor area during September 1995 and for the entire site from May 1996 to March 1997.

The following discussion briefly describes the remedial process and the measures taken to protect the public and the environment during this process.

### 3.1 PRE-REMEDIAL ACTION ACTIVITIES

Before remedial action began, the site was surveyed to delineate boundaries of radioactive contamination, supplement existing characterization information, and obtain radiological and chemical data needed to classify the waste generated during cleanup. Waste profile information was necessary to establish acceptability of the various waste streams at the Envirocare of Utah low-level radioactive waste disposal facility in Clive, Utah. Cleanup activities were conducted in full compliance with federal and state waste management and transportation requirements.

### 3.2 DECONTAMINATION/REMEDIAL ACTIVITIES

Initial cleanup activities in the harbor were conducted in 1995 as a time-critical removal action to support other required remediation activities at the site. The 1996-1997 excavation activities were conducted in accordance with requirements for CERCLA non-time-critical removal actions. The engineering evaluation/cost analysis (EE/CA) for the site was made available for public comment on February 12, 1996, and finalized with responses to public comments in May 1996 (Exh.II, Ref. 18). An Administrative Record was established and made available at the Beverly Public Library on November 6, 1995.

The primary technique used in remedial action at Ventron was excavation of contaminated materials. An excavator was used to break up any concrete or asphalt that was in place above the contaminated soil. In some cases, small volumes of soil were removed using hand tools. Following remedial action, areas were restored to the condition agreed upon by the property owner. Restoration primarily involved placement of sufficient buttress in adjacent areas of the seawall to maintain seawall integrity. Other restoration activities were the responsibility of the property owner, as specified in the Memorandum of Agreement (Exh. II, Ref. 20).

During remediation, approximately 7,300 m3 (9,500 yd 3) of radioactively contaminated soil was removed from the site. Excavated material was placed in intermodal containers or dump trucks and shipped to the Envirocare of Utah disposal facility.

## 3.3 POST-REMEDIAL ACTION MEASUREMENTS

After each portion of the property was decontaminated, a radiological survey of the area was conducted to confirm that all radioactive contamination above cleanup criteria had been removed. Initial post-remedial action surveys were conducted by the radiological support subcontractor, Safety and Ecology Corporation (SEC), on behalf of the project management contractor, BNI. Figures delineating the surveyed areas and tables containing complete survey results are included in the post-remedial action report for Ventron (Exh. II, Ref. 24). Techniques used during post-remediation and verification surveys included external gamma exposure rate measurements, and soil sampling. The initial post-remediation surveys were conducted in accordance with SEC procedures and BNI instruction guides. The IVC, Oak Ridge Institute for Science and Education (ORISE), performed independent verification surveys of the excavations, sea wall, and building slabs using survey techniques that were similar or identical to those used by SEC. IVC survey data for Ventron are presented in a separate verification report (Exh. II, Ref. 25).

As excavations were completed, walkover surveys were conducted to determine whether soil had been removed to levels meeting cleanup criteria. Final walkover surveys were performed with a field instrument for detecting low-energy radiation (FIDLER) and the SPA. The walkover surveys provided immediate feedback so that additional excavation could be performed if residual contamination exceeded remedial action guidelines and the objective of maintaining exposures ALARA was not met.

External gamma radiation exposure rates were measured at 91 locations. Measurements were taken at 1 m (3 ft) above the ground surface with a pressurized ionization chamber (PIC).

## 3.4 VERIFICATION ACTIVITIES

After remedial action was completed, surveys and soil sampling were conducted by Oak Ridge Institute for Science and Education (ORISE), the FUSRAP independent verification contractor (IVC) for the Ventron site, to verify that the site had been remediated to levels meeting applicable guidelines. The objective of the independent verification survey was to confirm that post-remedial action surveys, sampling and analyses provided an accurate and complete description for the radiological status of the property upon completion.

IVC activities included two types of verification reviews (types A and B), as specified in the FUSRAP verification and certification protocol (Exh. II, Ref. 4). Type A verification included reviewing post-remedial action survey results and collecting and analyzing additional samples if necessary. Type B consisted of an independent survey of the site by the IVC. In addition to reviewing the methods and results of post-remedial action surveys and soil sampling, the IVC reviewed the laboratory's quality assurance data to determine whether the measurements verified compliance with applicable cleanup guidelines. Following verification by the IVC, BNI restored the site as agreed upon with the property owner. The BNI site restoration was limited to buttressing of the seawall (Exh. II, Ref. 20).

Post-remedial action survey results and independent verification data indicated that all areas of the Ventron site that were determined to be contaminated during characterization surveys were in compliance with cleanup guidelines then in effect. After review of post-remedial action measurements, survey procedures, and quality assurance data, the IVC confirmed that the site had been decontaminated to applicable radiological criteria (Exh. II, Ref. 25).

After completing verification activities, the IVC notified DOE of its findings and recommendations, and DOE reviewed the data to determine whether the remedial action was successful. Based on this review, radiological conditions at the site were determined to be in compliance with decontamination criteria and standards to protect health, safety, and the environment, then in effect, and the site was determined to be suitable for future use without radiological restrictions.

## 4.0 CONCLUSION

Post-remedial action surveys and samples demonstrated, and DOE certified, that the locations remediated are in compliance with applicable radiological standards and criteria in effect at the conclusion of the remedial activity for protecting members of the general public as well as occupants of the site and the environment.

Spacer page

# EXHIBIT II:

## REFERENCES FOR DOCUMENTS SUPPORTING THE CERTIFICATION OF REMEDIAL ACTION PERFORMED AT THE VENTRON SITE IN BEVERLY, MASSACHUSETTS

## 1.0 INTRODUCTION

The material in Exhibit II consists of documents supporting DOE certification that conditions at the subject property are in compliance with radiological guidelines and standards in effect at the conclusion of remedial action. It consists of the letters, memos, and reports that were produced to document the entire remedial action process, from designation of the property for cleanup under FUSRAP to the certification that no radiological restrictions limit the future use of the site. Exhibit I of this docket should be consulted for a brief history of the origin of site contamination, radiological characterization, the remedial action performed, and post-remedial action verification activities.

## 2.0 FUSRAP GENERAL

1. DOE, Description of Formerly Utilized Sites Remedial Action Program, ORO-777, Oak Ridge, Tenn., September 1980.

2. DOE, "FUSRAP Summary Protocol, "CCN 35692, Oak Ridge, Tenn., March 1986. [Attachment: DOE, "U.S. Department of Energy Guidelines for Residual Radioactive Material at FUSRAP and Remote Surplus Facilities Management Program Sites, Rev. 2, "CCN 046176, Oak Ridge, Tenn., March 1987].

3. DOE, "FUSRAP Designation/Elimination Protocol, Supplement No. l to the FUSRAP Summary Protocol, "CCN 35692, Oak Ridge, Tenn., January 1986.

4. DOE, "FUSRAP Verification and Certification Protocol, Supplement No. 2 to the FUSRAP Summary Protocol, Rev. l, CCN 35692, November 1985.

## 3.0 DESIGNATION DOCUMENTATION

5. DOE, Memorandum from W. Voigt (DOE-HQ) to J. LaGrone (DOE-HQ), "Designation of Sites for Remedial Action - Metal Hydrides, Beverly, MA; Bridgeport Brass, Adrian, MI, and Seymour, CT; Guard Armory, Chicago, IL, "CCN 054358, December 17, 1985.

6. DOE, Memorandum from J. Wagoner (DOE-HQ) to A. Williams (DOE-HQ), "Designation of Beverly, Massachusetts, Vicinity Property, "CCN 096254, October 22, 1992.

## 4.0 DECONTAMINATION CRITERIA

7. DOE Order 5400.5, Radiation Protection of the Public and the Environment, Chapter IV, "Residual Radioactive Material, "Office of Environment, Safety, and Health, Washington, D.C., February 1990.

8. DOE, Design Criteria for Formerly Utilized Sites Remedial Action Program (FUSRAP) and Surplus Facilities Management Program (SFMP), 14501-00-DC-01, Rev. 2, Oak Ridge, Tenn., March 1986.

9. DOE, Memorandum from A. Williams (DOE-HQ) to L. Price (DOE-FSRD), "Uranium Guidelines for Ventron Site, Beverly, MA, "CCN 108174, September 1, 1993.

10. DOE, Memorandum from A. Johnson (DOE-HQ) to L. Price (DOE-FSRD), "Approval of Proposed Remediation Approach for Residual Radioactive Material at the Ventron Site, Beverly, Massachusetts, "CCN 1423 3 5, May 14, 1996.

11. DOE, Memorandum from J. Kopotic (DOE-FSRD) to A. Williams (DOE-HQ), "Request for Approval of Proposed Remediation Approach for Residual Radioactive Material at the Ventron Site, "CCN 127-GOA-GAM-00006, "September 22,1997.

12. DOE, Memorandum for A. Johnson (DOE-HQ) to W. Seay (DOE-FSRD), "Ratification, Confirmation, and Changes to Supplemental Standards for Residual Radioactive Material at the Ventron Site, Beverly, Massachusetts, “CCN 127-GOA-GAM-00007, September 1997.

13. DOE, Letter from J. Kopotic (DOE-FSRD) to A. Raddatz (Morton International), "Ventron Site—Disposal of Building Demolition Debris, “CCN 142976, June 1996.

## 5.0 RADIOLOGICAL CHARACTERIZATION REPORTS

14. ORNL, "Results of the Radiological Survey at the Ventron Site, Beverly, Massachusetts, “OEM-10053, CNN 053786, Oak Ridge, Tenn., May 1988.

15. DOE, Letter from J. Kopotic (DOE-FSRD) to S. Greene (Massachusetts Department of Environmental Protection (MDEP)), "Ventron Site - Transmittal of Radiological Data from Beverly Harbor, "CCN 120267, September 1994 [Attachment: ORNL, "Radiological Survey Results at Beverly Harbor (VB025), "ORNL/RASA-91129, CCN 120267, Oak Ridge, Tenn., August 1992]

16. SAIL, Characterization Report for the Ventron Site, Beverly, Massachusetts, DOE/OR/21950-1011, CCN 126002 and 138005, Oak Ridge, Tenn., December 1995.

## 6.0 CERCLA/NEPA DOCUMENTATION

17. DOE, "Action Description Memorandum, Removal of Contaminated Roofing Material From Buildings A and Al at the Ventron Site, Beverly, Mass., “CCN 139115, Oak Ridge, Tenn., November 1987.

18. DOE Engineering Evaluation/Cost Analysis for the Ventron Site, Beverly, Massachusetts, with Response to Public Comments, DOE/OR/21950-1014, CNN 141533, Oak Ridge, Tenn., May 1996 [Attachment: DOE "Ventron Site - Action Memorandum for Remedial Action," CCN 141757, May 1996].

19. DOE Notice of Floodplain and Wetland Involvement, 61 Federal Register 11621, CCN 141053, March 21, 1996, and DOE Floodplain Statement of Finding, 61 Federal Register 25656, CCN 143177, May 22, 1996.

## 7.0 MEMORANDUM OF AGREEMENT AND REAL ESTATE LICENSE

20. Memorandum from J. Kopotic (DOE-FSRD) to J. Fuerholzer (Morton International), "Ventron Site- Memorandum of Agreement, "CCN 142126, May 9,1996.

21. DOE, License Agreement Permitting Entry on Morton International Property, REORDOER Number 7-95-0160: Letter, K. Kates to J. Fuerholzer, "Real Estate License REORDOER-7-95-0160, Metal Hydrides, Inc. (Ventron Corp.), Beverly, MA, “CCN 133599 August 24,1995; Letter, D. Shook to J. Fuerholzer, "Supplemental Agreement to Real Estate License REORDOER-7-95-0160, "CCN 141131, April 15, 1996.

## 8.0 POST-REMEDIAL ACTION AND VERIFICATION

22. BNI, "FUSRAP PRASP Implementation for the Ventron Site, "CCN 144008, July 1996.

23. BNI,1995. "Post-Remedial Action Survey Plan for the Ventron Harbor, "CCN 133725 (August).

24. BNI, Post-Remedial Action Report for the Remedial Action at the Ventron Site, Beverly, Massachusetts, Document No. 2144, Oak Ridge, Tenn., March 2003.

25. Oak Ridge Institute for Science and Education (ORISE), Verification Survey of the Ventron Site, Beverly, Massachusetts, Document No. ORISE 03-0321, February 2003.

26. USACE, "Characterization of Radiation Dose and Risk Following Remediation of the Ventron Site, "CCN 127-IOA-GEV-00003, December 1997.

## 9.0 CORRESPONDENCE WITH REGULATORS

27. DOE, Letters from J. Kopotic (DOE-FSRD) to L. Alexander (MDEP) and T. O'Connell (Massachusetts Department of Health MDOH), "Ventron Site - Transmittal of Dose Calculation and Remedial Action Approach, “CCN 140242, March 15, 1996 [Attachment: BNI, "Dose Assessment for Ventron Buildings A and A-1, Calculation No.127-CV-0016, "CCN 140210, March 121996].

28. MDOH, T. O'Connell (MDOH) to J. Kopotic (DOE-FSRD), "Approval of Radiological Remediation Plans, “CCN 143840, June 21, 1996.

29. MDEP, Letter from L. Alexander (MDEP) to J. Kopotic (DOE-FSRD), "Demolition of Building A & A-1; Risk Characterization Report, "CCN 143797, June 21, 1996.

30. MDEP, Letter from L. Alexander (MDEP) to J. Kopotic (DOE-FSRD), "Review of DOE Site Characterization Report for the Ventron Site, "CCN 143180, June 5, 1996.

31. MDEP, Letter from L. Alexander (MDEP) to J. Kopotic (DOE-FSRD), "Review of DOE's May 1996 Characterization of Radiation Dose and Human Health Risk Following Remediation of the Ventron Site, "CCN 148853, November 18, 1996.

EXHIBIT III:

FEDERAL REGISTER NOTICE AND
CERTIFICATION STATEMENT

## 1.0 DOE STATEMENT OF CERTIFICATION

This section contains the statement of certification issued by the Department of Energy that the subject property is in compliance with radiological guidelines in effect at the conclusion of remedial action.

**Statement of Certification: Ventron Site in Beverly, Massachusetts**

The DOE, Oak Ridge Operations Office (OR), Office of Environmental Management, Oak Ridge Reservation, Remediation Management Group, and the U.S. DOE Office of Environmental Management (EM), Office of Site Closure (EM-30), Ohio Office (EM-31), has reviewed and analyzed the radiological data obtained following remedial action at the Ventron site in Beverly, Massachusetts, (Deed Book 10091, Page 339, in the records of Essex County, Massachusetts). Based on the analysis of all data collected, including post-remedial action surveys, DOE certifies that any residual contamination remaining onsite at the time remedial actions were completed falls within DOE radiological decontamination criteria and standards for use of the property without radiological restrictions. This certification of compliance provides assurance that reasonably foreseeable future use of the site will result in no radiological exposure above DOE radiological criteria and standards for protecting members of the general public and occupants of the property.

Property owned by: Morton International, Incorporated, 123 North Wacker Drive, Chicago, Illinois, 60606.

Issued in Germantown, Maryland. On October 7, 2003.

Sally A. Robison

Sally A. Robison, Ph.D.
Office Director, Ohio Office,
Office o f Site Closure.

## 2.0 *FEDERAL REGISTER* NOTICE OF CERTIFICATION

This section contains a copy of the published Federal Register notice announcing the completion of remedial action, with accompanying statement of certification issued by the Department of Energy.

Responses: 55.
Burden Hours: 1,100.

*Abstract:* This Annual Performance Report will allow the Department of Education to collect information required by the Reading First statute.

Requests for copies of the submission for OMB review; comment request may be accessed from *http://edicsweb.ed.gov*, by selecting the "Browse Pending Collections "link and by clicking on link number 2329. When you access the information collection, click on "Download Attachments "to view. Written requests for information should be addressed to Vivian Reese, Department of Education, 400 Maryland Avenue, SW., Room 4050, Regional Office Building 3, Washington, DC 20202-4651 or to the e-mail address *vivan.reese@ed.gov*. Requests may also be electronically mailed to the internet address *OCIO_RIMG@ed.gov* or faxed to 202-708-9346. Please specify the complete title of the information collection when making your request.

Comments regarding burden and/or the collection activity requirements should be directed to Kathy Axt at her e-mail address *Kathy.Axt@ed.gov*. Individuals who use a telecommunications device for the deaf (TDD) may call the Federal Information Relay Service (FIRS) at 1-800-877-8339.

[FR Doc. 03-26452 Filed 10-20-03; 8:45 am]
BILLING CODE 4000-01-P

## DEPARTMENT OF ENERGY

### Certification of the Radiological Condition of the Ventron Site in Beverly, MA

**AGENCY:** Department of Energy.
**ACTION:** Notice of certification.

**SUMMARY:** The Department of Energy (DOE) has completed remedial actions to decontaminate the Ventron site in Beverly, Massachusetts. This property formerly was found to contain quantities of radioactive material from activities conducted for the Manhattan Engineer District (MED) (and its successor the Atomic Energy Commission (AEC)) from 1942 to 1948. Based on the analysis of all data collected, DOE has concluded that the property is in compliance with DOE radiological decontamination criteria and standards and that no radiological restrictions on the use of the property are required.

**ADDRESSES:** The certification docket is available at the following locations:
U.S. Department of Energy, Public Reading Room, Room 1E-190, Forrestal Building, 1000 Independence Avenue, SW., Washington, DC 20585.
U.S. Department of Energy, DOE Information Center, 475 Oak Ridge Turnpike, Oak Ridge, Tennessee 37831.
Beverly Public Library, 32 Essex Street, Beverly, Massachusetts 01915.

**FOR FURTHER INFORMATION, CONTACT:** Donald Mackenzie, Health Physicist, U.S. Department of Energy, Ohio Office, Office of Site Closure, EM-31/Cloverleaf Building, 1000 Independence Avenue, SW., Washington, DC 20585-2040, Phone: (301) 903-7426, Fax: (301) 903-2385.

**SUPPLEMENTARY INFORMATION:** The U.S. DOE, Oak Ridge Operations Office (OR), Office of Environmental Management, has conducted remedial action at the Ventron site in Beverly, Massachusetts, under the Formerly Utilized Sites Remedial Action Program (FUSRAP). The objective of the program is to identify and remediate, or otherwise control, sites where residual radioactive contamination remains from activities carried out under contract to the MED/AEC during the early years of the nation's atomic energy program.

In October 1997, the Energy and Water Appropriations Act, 1998 transferred responsibility for management of FUSRAP to the U.S. Army Corps of Engineers (US ACE). Completion of the certification process was delayed pending preparation of a Memorandum of Understanding (MOU) between DOE and U.S. ACE with regard to completed, remediated sites such as the Ventron property. The MOU between the U.S. DOE and the U.S. ACE regarding Program Administration and Execution of the FUSRAP was signed by the parties in March 1999. Funding to proceed with the completion of DOE closure documentation for several FUSRAP sites, including the Ventron site, was obtained from U.S. ACE in late 2000: The closure documentation for these sites will document the cleanup and inform the public of their successful decontamination of radioactive contamination.

From 1942 to 1948, the Metal Hydrides Corporation (predecessor to the Ventron Corporation) conducted natural uranium processing operations under contract to the MED and its successor, the AEC. The MED/AEC contract operations at the Ventron site involved conversion of uranium oxide to uranium metal powder using calcium hydride. In a process used later at the facility, uranium oxide was reacted with hydrogen fluoride to produce uranium tetrafluoride, which was mixed with magnesium and heated to produce uranium metal. Other operations at the site involved recovery of uranium from scrap and turnings resulting from operations at a fuel fabrication plant in Hanford, Washington. Uranium-238 was identified as the primary contaminant of concern associated with MED/AEC activities. Two of the original buildings, which housed foundry facilities, were demolished between 1948 and 1950 (after completion of AEC surveying and decommissioning), and two other buildings (Buildings B and F) were erected at these locations. The remaining original buildings (Buildings A and A-1) contained furnaces, leaching facilities, a mixing room, a drying room, and analytical laboratories. The Alfa Building was used in later non-MED-related thorium operations, reportedly involving purification of thorium compounds. The primary radioactive contaminant resulting from this work was thorium-232.

In 1965, Metal Hydrides Corporation became the Ventron Corporation, which was acquired by the Thiokol Corporation in late 1976. In 1980, Ventron became a division of Morton Thiokol, Incorporated (renamed Morton International in 1990). The site was designated for remedial action under FUSRAP in 1986.

Site characterization was performed in 1992 using the Streamlined Approach for Environmental Restoration method, an expedited approach developed by DOE to quickly and efficiently conduct remedial investigations /feasibility studies at DOE facilities. This approach indicated several areas of contamination.

Primary radioactive contaminants were uranium-238, thorium-232, and radium-226. Residual radioactive contamination (primarily uranium) was identified in soil and in fill, material beneath four buildings, and elevated surface contamination was found in Buildings A and A-1. A Memorandum of Agreement (MOA) signed by DOE and Morton International in 1996 provided that FUSRAP would decontaminate all buildings containing radioactivity above DOE Order 5400.5 guidelines in effect at the time (whether of government or non-government origin) and that Morton would demolish the buildings.

Before remedial action began, the site was surveyed to delineate boundaries of radioactive contamination, supplement existing characterization information, and obtain radiological and chemical data needed to classify the waste generated during cleanup. Waste profile information was necessary to establish acceptability of the various waste streams

at the Envirocare of Utah low-level radioactive waste disposal facility in Clive, Utah. Cleanup -activities were conducted in full compliance with applicable Federal and State waste management and transportation requirements.

Radiological decontamination of the Ventron site by the DOE occurred in two phases: In September 1995, and from May 1996 to March 1997. Supplemental sampling of the site to verify the adequacy of radiological remediation was performed in July 1997.

In September 1995, the first phase of DOE remediation of site tidal flats (harbor) adjacent to the seawall began. During this first phase of remediation, a walkover was performed over the entire harbor down to the low-tide mark, and areas with elevated levels of radioactive materials were targeted for remediation. Elevated readings were found in three areas. Excavations were completed in the first two areas, and post-remedial action samples were collected. Excavation was halted in the third area because contamination in that area was too extensive to be removed by manual methods. During the second phase of the remedial action, this third area was remediated and post-remedial action samples were collected.

Pursuant to the MOA between DOE and Morton International, several onsite buildings were demolished and the crushed building rubble was sampled. Rubble meeting DOE guidelines contained in DOE Order 5400.5 was stockpiled and used as backfill along the seawall. Building slabs were surveyed and either decontaminated and left in place or removed and disposed of with other contaminated material.

Excavation of contaminated materials was the primary remedial action technique used at the Ventron site. Eleven discrete areas of the site were excavated and verified for compliance with radiological cleanup criteria. Excavations occurred beneath demolished buildings, in the northwest corner of the site, in the harbor area.

Post-remedial action surveys conducted in 1996 and 1997 have demonstrated, and DOE has certified, that the subject property is in compliance with DOE radiological decontamination criteria and standards in effect at the conclusion of remedial action. These criteria and standards are established to protect members of the general public and occupants of the site and to ensure that reasonably foreseeable future use of the site will result in no radiological exposure above applicable guidelines. Accordingly, this property is released from the FUSRAP program. These findings are supported by the DOE's Certification Docket for the Remedial Action Performed at the Ventron site in Beverly, Massachusetts. DOE makes no representation regarding the condition of the site as a result of activities conducted subsequent to DOE's post-remedial action surveys.

The certification docket will be available for review between 9 a.m. and 4 p.m., Monday through Friday (except Federal holidays), in the DOE Public Reading Room located in Room 1E-190 of the Forrestal Building, 1000 Independence Avenue, SW., Washington, DC. Copies of the certification docket will also be available in the DOE Information Center, 475 Oak Ridge Turnpike, Oak Ridge, Tennessee, 37831, and the Beverly Public Library, 32 Essex Street, Beverly, Massachusetts, 01915.

The DOE, through the Office Director, Ohio Office (EM-31), Deputy Assistant Secretary for Office of Site Closure (EM-30), the Assistant Secretary for the Office Environmental Management (EM), has issued the following statement:

**Statement of Certification: Ventron Site in Beverly, Massachusetts**

The DOE, Oak Ridge Operations Office (OR), Office of Environmental Management, Oak Ridge Reservation, Remediation Management Group, and the U.S. DOE Office of Environmental Management (EM), Office of Site Closure (EM-30), Ohio Office (EM-31), has reviewed and analyzed the radiological data obtained following remedial action at the Ventron site in Beverly, Massachusetts, (Deed Book 10091, Page 339, in the records of Essex County, Massachusetts). Based on the analysis of all data collected, including post-remedial action surveys, DOE certifies that any residual contamination remaining onsite at the time remedial actions were completed falls within DOE radiological decontamination criteria and standards for use of the property without radiological restrictions. This certification of compliance provides assurance that reasonably foreseeable future use of the site will result in no radiological exposure above DOE radiological criteria and standards for protecting members of the general public and occupants of the property.

Property owned by: Morton International, Incorporated, 123 North Wacker Drive, Chicago, Illinois, 60606.

Issued in Germantown

**Sally A Robison, Ph.D.**

*Office Director, Ohio Office, Office of Site Closure.*

[FR Doc. 03-26517 Filed 10-20-03; 8:45 am]

**BILLING CODE 6450-01-P**

**DEPARTMENT OF ENERGY**

**Energy Information Administration**

**Agency Information Collection Activities: Submission for OMB Review; Comment Request**

**AGENCY:** Energy Information Administration (EIA), Department of Energy (DOE).

**ACTION:** Agency information collection activities: Submission for OMB review; comment request.

**SUMMARY:** The EIA has submitted the Petroleum Supply Reporting System surveys to the Office of Management and Budget (OMB) for review and a three-year extension under section 3507(h)(1) of the Paperwork Reduction Act of 1995 (Pub. L.104-13) (44 U.S.C. 3501 et seq.).

**DATES:** Comments must be filed by November 20, 2003. If you anticipate that you will be submitting comments but find it difficult to do so within that period, you should contact the OMB Desk Officer for DOE listed below as soon as possible.

**ADDRESSES:** Send comments to Bill Nickerson, OMB Desk Officer for DOE, Office of Information and Regulatory Affairs, Office of Management and Budget. To ensure receipt of the comments by the due date, submission by FAX (202-395-7285) or e-mail (*William Nickerson@omb.eop.gov*) is recommended. The mailing address is 726 Jackson Place NW., Washington, DC 20503. The OMB DOE Desk Officer may be telephoned at 202-395-7151 (A copy of your comments should also be provided to EIA's Statistics and Methods Group at the address below.)

**FOR FURTHER INFORMATION CONTACT:** Requests for additional information should be directed to Herbert Miller. To ensure receipt of the comments by the due date, submission by FAX (202-287-1705) or e-mail (herbert.miller@eia.doe.gov) is recommended. The mailing address is Statistics and Methods Group (EI-70), Forrestal Building, U.S. Department of Energy, Washington, DC 20585-0670. Mr. Miller may be contacted by telephone at (202) 287-1711.

**SUPPLEMENTARY INFORMATION:** This section contains the following information about the energy information collection submitted to OMB for review: (1) The collection numbers and title; (2) the sponsor (i.e., the Department of Energy component); (3) the current OMB docket number (if applicable); (4) the type of request (i.e., new, revision, extension, or reinstatement); (5) response obligation

ORO-777

ORO-777 c.2

# Description of the Formerly Utilized Sites Remedial Action Program

801

BECHTEL - OAK RIDGE
LIBRARY

4575

United States
Department of Energy

## DISCLAIMER

"This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof."

This report has been reproduced directly from the best available copy.

Available from the National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22161.

Price: Paper Copy $8.00
Microfiche $3.50

ORO-777
Distribution Category UC-70

# DESCRIPTION OF THE FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM

Notice: This document contains information of a preliminary nature; it is subject to revision or correction and therefore may not represent a final report.

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations
P.O. Box E
Oak Ridge, Tennessee 37830

September 1980

CONTENTS


| | | Page |
|---|---|---|
| 1.0 | INTRODUCTION | 1 |
| 2.0 | BACKGROUND | |
| | Historical Records Review | 1 |
| | AEC/ERDA/DOE Site Survey Program | 2 |
| | Overview of MED/AEC Activities | 2 |
| 3.0 | CURRENT STANDARDS | 6 |
| 4.0 | LEGISLATIVE AUTHORITY | 7 |
| | Current Authority | 7 |
| | New Authority Needed | 9 |
| 5.0 | FUSRAP PROGRAM DESCRIPTION | 11 |
| | Objectives of Remedial Action | 11 |
| | Scope and Problem Definition | 11 |
| | Approach to Remedial Action | 11 |
| | Status of Sites | 18 |
| 6.0 | ESTIMATED COSTS FOR REMEDIAL ACTION PROGRAM | 18 |

APPENDIX A: MED/AEC SITE SUMMARY REPORTS

## FIGURES


| | | Page |
|---|---|---|
| 1 | Formerly Utilized Sites - Basic Steps Involved in the Remedial Action Program | 13 |
| 2 | Location of Sites Requiring or that May Require Remedial Action | 21 |
| 3 | Work Schedule and Funding Requirements for Remedial Action at MED/AEC Sites | 23 |
| 4 | FUSRAP Costs by State and Site | 24 |


## TABLES


| | | |
|---|---|---|
| 1 | MED/AEC Sites for Which a Determination Has Been Made That Remedial Action is Required | 19 |
| 2 | Status of Remedial Action at MED/AEC Sites | 20 |
| 3 | Estimates of Remedial Action Costs by MED/AEC Site | 22 |

# DESCRIPTION OF THE FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM*

## 1.0 Introduction

The background and the results to date of the Department of Energy program to identify and evaluate the radiological conditions at sites formerly utilized by the Corps of Engineers' Manhattan Engineer District (MED) and the U.S. Atomic Energy Commission (AEC) are summarized in section 2.0. The sites of concern were federally, privately, and institutionally owned and were used primarily for research, processing, and storage of uranium and thorium ores, concentrates, or residues. Some sites were subsequently released for other purposes without radiological restriction. Surveys have been conducted since 1974 to document radiological conditions at such sites. Based on radiological surveys, sites are identified in this document that require, or are projected to require, remedial action to remove potential restrictions on the use of the property due to the presence of residual low-level radioactive contamination. Specific recommendations for each site will result from more detailed environmental and engineering surveys to be conducted at those sites and, if necessary, an environmental impact assessment or environmental impact statement will be prepared. Section 3.0 describes the current standards and guidelines now being used to conduct remedial actions. Current authority of the U.S. Department of Energy (DOE) to proceed with remedial actions and the new authority required are summarized in section 4.0. A plan to implement the Formerly Utilized Sites Remedial Action Program (FUSRAP) in accordance with the new authority is presented in section 5.0, including the objectives, scope, general approach, and a summary schedule. Key issues affecting schedule and cost are discussed in section 6.0.

## 2.0 Background

### Historical Records Review

The original program for the development and use of atomic energy, established under the MED and later continued by the AEC, involved the development of technology and the production of nuclear materials for national defense and security. The program was conducted under very stringent security restrictions and, at contract termination of the MED/AEC activities, the sites involved were decontaminated according to the health and safety criteria and guidelines then in use and applied on a site-specific basis. However, radiological criteria for releasing these sites for unrestricted use have changed and some criteria are still being developed. Therefore, to define the radiological condition of these sites in light of the changing environmental criteria and standards, a records search was begun in 1974.

In many instances, documentation of the MED/AEC activities at these sites was destroyed in compliance with Government Records Management practices. Many of the radiological records covering the extent of cleanup actions are incomplete. Also, many of the sites have changed ownership and are presently used for other purposes. In some cases, buildings have been modified or the earlier MED/AEC facilities no longer exist.

*Much of the information presented in this document was extracted from a draft of "A Background Report for the Formerly Utilized MED/AEC Sites Remedial Action Program," prepared for the Environmental Control Technology Division, Assistant Secretary for Environment, U.S. Department of Energy, by the Aerospace Corporation, March 1980.

## AEC/ERDA/DOE Site Survey Program

In early 1974, the AEC initiated a survey program to identify all formerly utilized sites involved with nuclear materials and to determine their radiological status. The responsibility for this survey was assigned to the Division of Operational Safety. At that time, all divisions and field offices of the AEC were required to search their files to identify any such former government-owned or leased sites and facilities that had been used in the research or production activities of the MED and the AEC. In addition, the files were searched for records identifying the radiological conditions at the termination of the MED/AEC activities and/or the transfer of custodial responsibility for such sites, the current radiological condition of the sites, and the land-use and ownership data. This effort identified many additional sites for which pertinent information was lacking or was insufficient to determine their radiological conditions.

On January 19, 1975, the AEC was abolished and its programmatic responsibilities transferred to the Energy Research and Development Administration (ERDA) which continued the activities of the survey program. Contacts were made with former and current owners and site visits were conducted under the direction of the ERDA field offices to determine the need for radiological surveys. If radiological surveys were determined to be necessary, the permission of the site owners was obtained and a press release was issued to inform the public of the survey work. Subsequent survey results were also issued in a public press release and were published in a radiological survey report that analyzed the significance of the findings with respect to the potential risks to the public health.

Pursuant to the DOE Organization Act of 1977, the functions and authority of the ERDA were transferred to the DOE. In the DOE, the Assistant Secretary for the Environment (ASEV) was assigned the responsibility for the site-survey program. The results of several site surveys clearly indicated that some remedial action would be needed, not only on the former sites, but also on adjacent or remote properties that had become contaminated from the original processing site. Due to the importance of this effort, the ASEV initiated the FUSRAP and drafted a generic plan to identify all formerly utilized sites and to resolve any site radiological problems. Using this generic plan as a guide, in mid-1979 responsibility for the FUSRAP activities was divided between the ASEV and the Assistant Secretary for Energy Technology (now Assistant Secretary for Nuclear Energy [ASNE]). The ASEV is responsible for identifying the sites, characterizing the radiological condition, determining the need for remedial action at the sites, and ultimately for certifying the post-remedial action radiological condition of the FUSRAP sites. The ASNE is responsible for implementing the required remedial actions, including suitable disposal or stabilization of residual material.

## Overview of MED/AEC Activities

In 1942, under the jurisdiction of the U.S. Army, the MED was established as the agency responsible for the development of nuclear materials for national defense and security. The authority for process development, engineering design, procurement of materials, and site selection associated with the nuclear materials program was transferred to the MED from the Office of Scientific Research and Development, Department of the Army. The headquarters for the MED, originally established in New York, was transferred to Oak Ridge, Tennessee, in 1943.

On December 31, 1946, the MED was deactivated and its responsibilities were transferred to the newly constituted AEC. During the 1942 to 1946 time period, there

were more than 10 contractors and several hundred subcontractors involved in the production, research, and development operations. These contractors included indus trial concerns, universities, and other scientific organizations. In contrast to the highly centralized operation of the MED, the AEC decentralized and established five major centers of operation (New York City, New York; Santa Fe, New Mexico; Oak Ridge, Tennessee; Hanford, Washington; and Chicago, Illinois). The AEC continued the MED practice of contracting with industrial concerns and academic institutions to perform the actual operations.

The most readily available source of historical information on the early activities of the MED/AEC is A History of the United States Atomic Energy Commission, Volume I - The New World and Volume II - Forging the Atomic Shield. A synopsis of the procurement, storage, and processing of the raw materials containing uranium is presented here to give the reader a general overview of the MED/AEC activities.

Uranium Procurement. The MED relied on three sources of uranium during the war years. About two-thirds came from mines in the Belgian Congo, slightly more than one-sixth from mines near Great Bear Lake in Canada, and the remainder from American ores, which in reality were tailings from vanadium refinery operations.

African Sources. At the beginning of the nuclear program in the late 1930s and early 1940s, it was determined that, while there were significant quantities of uranium ore available in Czechoslovakia and Canada, the most important sources, by far, were in the mines of the Belgian Congo. The supplies of ore in the United States were not considered extensive and, with the growing interest in uranium, Germany ceased all sales of the Czechoslovakian ores. As a result of this, plus the German takeover of Belgium and the increased German activity in Africa, the United States, Great Britian, and Canada made an all-out effort to obtain as much of the Belgian Congo ore (pitchblende) as quickly as possible to guarantee adequate supplies of uranium for the war period. Through activities that began in September 1942, the United States was able to purchase all of the above-ground supplies of uranium ore from the Belgian Congo. This included 1,200 tons of ore (65 percent uranium) from African Metals' predecessor, Union Miniere, that had been imported to the United States in 1940 and stored in the Archer-Daniels Midland Company warehouse, Port Richmond, Staten Island, New York, and some 3,000 tons of similar ore still in the Congo. By the end of 1944, the U.S. Army had received approximately 3,700 tons of Congo ore.* The amount of ore being received far exceeded the processing capacity in North America at that time, and the ores had to be stored. The MED used three primary storage areas: Seneca Ordnance Depot, Romulus, New York; Clinton Engineer Works (now Oak Ridge National Laboratory), Clinton, Tennesssee; and Perry Warehouse (Middlesex Sampling Plant), Middlesex, New Jersey. The Perry Warehouse also became a sampling, weighing, and assaying facility.

The MED contracts with African Metals, Inc., involved only the recoverable uranium oxide ($U_3O_8$ black oxide**) in the ore. African Metals maintained ownership of the residue or tailings that contained radium and other precious metals. As a result, it was necessary for the MED to establish weighing and assaying operations. Initially, the weighing and assaying were performed at contractor facilities; however, in November 1943, the MED set up a separate sampling program at the Perry Warehouse.

*By the end of 1946, MED had contracted for approximately 3,800 tons of $U_3O_8$ from over 29,000 tons of African ore containing from 5 to 65 percent uranium oxide.

**The various steps of the uranium recovery and refining process produced various concentrations and compounds of uranium oxide, which were generally referred to by their color and chemical state.

The weighing and assaying of the ore samples were performed for the Federal Government by Lucius Pitkin, New York, New York; Frick Chemical Laboratory, Princeton University, Princeton, New Jersey; and the National Bureau of Standards (NBS), Washington, D.C. Weighing and assaying for African Metals, Inc., were performed by Ledoux and Company, New York, New York.

Following weighing and assaying, the ore was shipped to the various refineries to be processed to black oxide or sodium diuranate concentrates. Because the tailings were owned by African Metals, Inc., the MED was required to store the residues from these operations until they could be returned to the owner. These residues from ores containing greater than 10 percent $U_3O_8$ were stored at the Clinton Engineer Works or the Perry Warehouse before return shipment. Residues from ores containing less than 10 percent $U_3O_8$ were stored at the Lake Ontario Ordnance Works (LOOW). Some of this residue was returned to African Metals and some is still at U.S. storage sites.*

Canadian Sources. Negotiations to obtain Canadian ore were begun in 1942 with Eldorado Gold Mines, Ltd., (later Eldorado Mining and Refining, Ltd.). The Eldorado Gold Mines, Ltd., mined uranium ore at their Great Bear Lake mine and refined the Canadian ore at their facility at Port Hope, Ontario. By 1944, about 400 tons of the oxide had been produced and enough Canadian ore had been mined to produce an additional 500 tons of the oxide. By 1946, over 4,000 tons of ore concentrate containing over 1,100 tons of $U_3O_8$ in the form of black oxide had been delivered to the MED. Because the Canadian ore was processed to black oxide at the Eldorado facility and the entire concentrate was sold to the MED, no weighing and assaying program was set up for the Canadian ore.

Domestic Sources. Most of the uranium in the United States was in carnotite ores on the Colorado plateau, but the high-grade deposits had already been mined earlier primarily for the radium content. The heavy demand for vanadium during the war also created the potential for a practical source of uranium oxide as a by-product of the vanadium processing. However, the tailings from vanadium processing were of such low uranium content that it was necessary to concentrate them at or near the mine prior to their shipment to the processing facilities. The United States Vanadium Corporation's concentrated vanadium tailings were stockpiled at Uravan, Colorado, to produce a sludge containing 15 to 20 percent black uranium oxide. This sludge was transported directly to the Linde Refinery in Tonawanda, New York. The U.S. Vanadium Corporation also had a plant at Durango, Colorado, for processing vanadium tailings and sands to produce a sludge. The output from the Durango and Uravan facilities went to Grand Junction, Colorado,** for processing to "yellow cake" (10 to 15 percent $U_3O_8$) that, in turn, went to the Linde refinery at Tonawanda, New York.

Concurrent with the U.S. Vanadium Corporation operation, the Vanadium Corporation of America processed American ores for vanadium at its plants in Naturita, Colorado, and Monticello, Utah.** Most of the slimes (50 percent $U_3O_8$ by weight) from these plants went directly to Vitro Manufacturing Company, Canonsburg, Pennsylvania,

*Some of the African Metals residue that is still in the United States is currently stored at the Feed Materials Production Center, Fernald, Ohio.

**Uranium mills which produced concentrates for MED/AEC programs that are inactive are covered under the Uranium Mill Tailings Radiation Control Act of 1978.

for processing. A portion of the 50-percent slime tailings were sold to the government and processed at the Uravan facility. By the end of 1944, domestic ore production had yielded less than 800 tons of uranium oxide, and, by the end of 1946, over 1,300 tons of uranium oxide had been produced in various concentrations from the domestic sources.

Uranium Processing Operations and End Use. The initial refining operations consisted of mechanical grinding and crushing of the ores to a sandy material. Acid was used to dissolve and, hence, extract the uranium. The acid extract was treated with other chemicals to precipitate the majority of impurities, and the product was further treated to precipitate the uranium. A final roasting and drying operation produced a black oxide ($U_3O_8$) or sodium diuranate ($Na_2U_2O_7$) concentrate.

During World War II, the ores were refined to black oxides at the facilities of Linde and Eldorado. Vitro (at Canonsburg) refined the ores to produce sodium diuranate. Following the war, Mallinckrodt Chemical Co., Inc., also produced black oxide at its facilities in St. Louis, Missouri, and later at the AEC Weldon Spring Chemical Plant.

Black oxide and sodium diuranate were further refined to orange oxide ($UO_3$) at the Mallinckrodt Chemical Company plant, St. Louis, Missouri, and by E.I. du Pont de Nemours and Company, Deepwater, New Jersey.

At the du Pont plant, brown oxide ($UO_2$) was made from black oxide and from uranium peroxide ($UO_4 2H_2O$) obtained from uranium scrap processing. About one-half of the du Pont output was from scrap and by-product material. Brown oxide was also produced by Harshaw Chemical Company (Cleveland, Ohio), Linde, and Mallinckrodt. Brown and orange oxide were in turn refined into green salt ($UF_4$) by du Pont, Harshaw, Mallinckrodt, and Linde.*

Harshaw made uranium hexafluoride for the thermal diffusion and gaseous diffusion uranium-235 separation projects. The green salt was used mainly in metal manufacturing by du Pont; Mallinckrodt; Iowa State College (now University), Ames, Iowa; Westinghouse, Bloomfield, New Jersey; Brush Laboratories, Cleveland, Ohio; and Electromet, Niagara Falls, New York. Scrap metal recovery operations were conducted at Metal Hydrides, Inc., Beverly, Massachusetts, and Iowa State College.

Uranium metals in the form of powder were also produced directly from uranium oxides instead of green salt by Metal Hydrides. The metals manufactured by these various companies were then shipped to the Hanford Site at Richland, Washington, for use in plutonium production. The plutonium produced at Hanford was then shipped to Los Alamos for use in the weapons development program.

Quality control of various processes in the ore/metal production chain was performed by the University of Chicago, Metallurgy Laboratory, Chicago, Illinois; Princeton University, Princeton, New Jersey; Massachusetts Institute of Technology, Cambridge, Massachusetts; and the National Bureau of Standards, Washington, D.C.

---

*Following the war and after the construction of the Weldon Spring Chemical Plant, much of the AEC uranium-conversion operations were centralized and transferred to Weldon Spring under Mallinckrodt and the Feed Materials Processing Center at Fernald, Ohio, under the National Lead Company of Ohio. The latter is currently the center for uranium-conversion operations.

Activities following World War II broadened in scope. The AEC entered into a number of research, development, and production contracts to recover uranium as by-products of certain industrial processes such as phosphoric acid production. In addition, contracts were terminated or established as product needs and research needs varied.

In addition to the actual contractor-owned facilities, a number of offsite storage locations were used such as landfills for disposal of low-level contaminated soil and waste from the uranium-ore-handling operations. Examples include the St. Louis Airport Storage Site, where residue from the Mallinckrodt AEC Operations were deposited; the former Haist property, Tonawanda, New York, where material from the Linde AEC operations was deposited; the Burrell Township-Pennsylvania Railroad Landfill, where Vitro Corporation deposited residues from Canonsburg; and the Middlesex Municipal Landfill, Middlesex, New Jersey, where residues were deposited during construction activities at the Middlesex Sampling Plant. Some private properties in Middlesex also became contaminated inadvertently as a result of radionuclide migration.

The companies and locations discussed in this report were identified during the records review of the MED history conducted under the FUSRAP activities.

Thorium Operations. Operations with thorium after the war were similar to the uranium operations, but were conducted on a smaller scale. The first major research for the MED on thorium was begun early in 1946 with the procurement of thorium salt for a research project at Iowa State College. The thorium salts were supplied by Lindsay Light and Chemical Company, which was the major supplier through most of the early years of the program.* Lindsay Light and Chemical Company first received thorium from Germany and later processed monazite ores from India and Brazil. In later years, processing of monazite and other ores for the AEC was accomplished by other industrial firms such as the Davison Chemical Division of the W. R. Grace Company, Curtis Bay, Maryland; Dow Chemical Company, Walnut Creek, California; and by Iowa State College. Extractive research, metal production and handling, and research and development for both uranium and thorium was conducted at a number of companies including Mallinckrodt, Simonds Saw and Steel, Lockport, New York; Sylvania Corning Nuclear Corporation, Bayside, New York; Battelle Columbus Division, Columbus, Ohio; Brush Beryllium Company, Cleveland, Ohio; and Horizons Metal Inc., Cleveland, Ohio.

The National Bureau of Standards was involved in quality control for the thorium programs, and the Middlesex Sampling Plant was used for storage of some thorium. A major objective of the DOE FUSRAP effort currently underway is to ensure that all of the thorium sites have been identified and surveyed for radiological conditions. More in-depth record searches and personal communications with former AEC employees are also being conducted.

## 3.0 Current Standards

Throughout this report and in the site summary reports in Appendix A, reference is made to "established standards" and current guidelines for contamination and exposure levels. These standards/guidelines are as follows:

*Lindsay Light and Chemical Company was using thorium for gas mantles, catalysts, and electron tube cathodes prior to nuclear applications. Remedial action activities at this site and associated properties are being undertaken by the State of Illinois and Kerr-McGee Chemical Corporation, with assistance from the Nuclear Regulatory Commission (NRC).

- Surface Contamination

  "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for By-product, Source or Special Nuclear Material," by the USNRC, November 1976.

  The NRC Decontamination Guidelines present alpha and beta-gamma limits for surface contamination for both fixed and transferable contamination, dependent on the mixture of nuclides present.

- Radon Daughter Products and External Gamma Radiation Exposure

  A regulation based on the Surgeon General's Guidelines, "Grand Junction Remedial Action Criteria," 41FR56, 777-56, 778, December 30, 1976.

  In 1972, Congress passed P.L. 92-314 that provided remedial action in the community of Grand Junction, Colorado. Regulations implementing that law were issued by the AEC, then ERDA, as 10CFR712. P.L. 92-314 was later extended by P.L. 95-236.

  In all cases, the most restrictive guideline (that for schools or dwellings) has been used. However, it should be noted that on several of the sites where the contamination is associated with an industrial building rather than with the soil, little likelihood exists of the site being used for these more restrictive purposes.

- Air and Water Concentrations

  10CFR20, Appendix B, Table II presents, by nuclide, concentration limits in both water and air for the general public. The value of the most restrictive form, either soluble or insoluble, has been used.

The EPA has proposed regulations for private uranium mill tailing sites: 40CFR192, "Interim Cleanup Standards" and "Final Cleanup Standards for Inactive Uranium Mill Tailing Sites," 45FR27366. These standards cover cleanup of open lands and contaminated buildings associated with these sites.

## 4.0 Legislative Authority

### Current Authority

Pursuant to the First War Powers Act of 1941 and the Atomic Energy Acts of 1946 and 1954, as amended the MED and its successor, the AEC, conducted during the 1940s and 1950s a program involving research, development, processing, and production of uranium and thorium. This program also included the storage of radioactive ores and processing residues, e.g., mill tailings. Virtually all of this work was performed by private contractors for the government on land that was either federally, privately, or institutionally owned.

Due to the urgency and magnitude of the early nuclear materials programs and the limited knowledge available regarding the radioactive characteristics of uranium ore and residual material from its processing, many of these sites became contaminated with radioactivity as a result of work done for the government.

In several western states, uranium mill tailings (a waste product of the uranium mill processing operations that was not subject to regulation by the government) accumulated in large piles and contaminated private adjacent and vicinity properties by migration. In some instances, these tailings were also used as fill and construction material in various construction work in the communities. The presence of these tailings containing radium caused radon gas to collect in dwellings and in many cases produced unacceptable exposure to occupants. The government had no statutory authority to take remedial action; however, out of a sense of moral responsibility toward the affected homeowners, the Congress in 1972 passed P.L. 92-314 that provided for remedial action in the community of Grand Junction, Colorado. Regulations implementing that law were issued by the AEC and then by ERDA as 10 CFR 712. P.L. 92-314 was later extended by P.L. 95-236. Additional extensions of this program have been authorized and will be sought as needed in the annual DOE budget authorization and appropriation requests.

In 1978, Congress passed the Uranium Mill Tailings Radiation Control Act (P.L. 95-604) under which the DOE was authorized to enter into cooperative agreements with various states for undertaking remedial actions at certain designated inactive former uranium mill processing facilities in the United States. The scope of this Act was very narrowly drawn to cover, under section 101(6), the sites designated in the Act and any other former processing sites and contaminated nearby properties at which substantially all of the uranium was produced for sale to the United States Government. None of the FUSRAP sites could qualify under this definition because the uranium and thorium processed at these sites were generally owned by the government. Excluded from coverage under the Act are those sites owned or controlled as of January 1, 1978 or thereafter by a Federal agency, or under active NRC or Agreement-State license. The legislative history made it clear that this Act was not to set a precedent for the DOE to undertake other waste management remedial action programs. Pursuant to that Act, the EPA Administrator was authorized and directed to develop environmental and health standards for uranium mill tailings contamination covered by the Act.

The FUSRAP program formally began in 1974. Radiological surveys and other research work have been conducted by the AEC and its successors, the ERDA and the DOE, under the implied authority of the Atomic Energy Act of 1954, as amended. The intent of Congress, as expressed in the FY 1978 DOE Authorization Act was that, at the completion of this program, the DOE would seek additional legislative authority, pursuant to a Congressional review of findings, for the undertaking of any required remedial action work.

A survey of existing statutory authority shows that pursuant to the Atomic Energy Act of 1954, as amended, the AEC was directed to protect public health and safety during the research and production operations. In the case of those operations over which the government exercised ownership or control, the DOE's existing authority has been interpreted to include the implied authority to decontaminate such sites through remedial actions undertaken at the conclusion of contract work. Accordingly, the DOE has undertaken remedial action efforts at the Kellex site in Jersey City, New Jersey, and in Middlesex, New Jersey. However, the absence of sufficient contractual, property, or other historical records (as a result of records retention schedules and limitations) has prevented final determination of the extent of government involvement in, and implied remedial action authority over, many of the sites. In addition, explicit contractual language and/or notations in deeds under which the United States is relieved from all contractual liability raises the issue as to whether, without the proposed legislation, the government has any continuing financial or other responsibility with respect to these properties.

Existing statutory authority has been reviewed by the DOE, in addition to all available contract, property records and other files, to determine the extent to which the DOE could exercise its existing authority under the Atomic Energy Act of 1954, as amended, to perform remedial action work under the FUSRAP program. As part of this study, consideration was given to the extent to which the MED and the AEC would have been contractually responsible for the costs of decontamination, and whether the contractors and/or property transferees involved recognized the presence of the contamination when they closed out their contracts with the United States Government. This review has shown that authorization exists for remedial action at 10 sites.

Unlike the uranium mill tailings sites, none of the FUSRAP facilities were at any time licensed for conducting the MED/AEC activities because many were either in operation before licensing requirements were established or were excluded from the licensing requirements pursuant to Section 110 of the Atomic Energy Act of 1954, as amended. Three sites, Gilman Hall at the University of California, Berkeley, California; Linde Air Products at Tonawanda, New York; and the University of Chicago, are currently licensed under the NRC or the Agreement State provisions of the Atomic Energy Act of 1954, as amended, and are excluded from the FUSRAP remedial action because the NRC or the Agreement State has sufficient licensing authority to protect public health and safety.

Legislative authority will be required to clarify the DOE's authority for remedial action at 18 of the FUSRAP sites discussed in this report and for the location and acquisition of disposal sites.

The EPA is responsible for establishing radiological standards of general applicability for properties released for unrestricted use; the NRC has responsibility for establishing criteria and standards for restricted use sites that would be licensed. The NRC criteria would be basically modeled after 10CFR40 Appendix A, proposed regulations for licensed active uranium mill tailings sites.

New Authority Needed

Broader authority is needed to conduct remedial action at the formerly utilized MED/AEC sites that are determined by established criteria to pose a potential threat to the public or to the environment because of their radiological contamination. The new authority should include any location where the MED or the AEC activities resulted in residual contamination exceeding established standards, including associated properties that became contaminated from these activities. Sites that are licensed by the NRC or by an Agreement State under Section 274 of the Atomic Energy Act of 1954, as amended, should be excluded from the authorization.

The authority would not include sites currently owned or leased by the DOE since no clarification of authority is needed for these sites. However, new authority is needed for the DOE to perform remedial actions at three properties that were formerly owned or leased by the Federal Government. These properties* were transferred to the present owners by quitclaim deeds or other documents under which the present owners released the Federal government from all responsibility for claims relating to the presence of the residual radioactive material. These sites are being included in the scope of the FUSRAP in order to expedite cleanup and to provide for the long-term

*St. Louis Airport storage site, Palos Park Forest Preserve, and Ashland Oil Company.

Federal management at the site, or at new federally owned disposal sites. This approach is consistent with the recommendations of the Interagency Review Group on Nuclear Waste Management.

In addition to the formerly utilized MED/AEC sites, there are other contaminated sites that were used for processing and using of radium-containing ores. At some of these sites, work was performed for the Federal Government. Authority is needed to identify and conduct radiological surveys at all such sites known to contain radioactive material above background levels that resulted from the processing of uranium or thorium ores and/or their daughter products, including radium, for the purpose of informing Congress of the extent of contamination and of the estimated cost for remedial action.

Under the existing and proposed new authority, radiological conditions at the MED/AEC sites would be assessed, relative priorities established on the basis of the potential health hazard, and determination made to conduct remedial action if present site conditions or possible unrestricted future use would constitute a risk to the public. Restitution to the Federal Government for the costs of remedial action would be provided for if the identity of any person having legal responsibility to clean up a site could be determined. Currently, the DOE is contacting those parties it has reason to believe could be shown to be legally responsible for remedial action at a site, to secure their agreement to undertake clean-up operations, or for the reimbursement of expenses that may be incurred by the DOE for remedial actions.

For the states containing MED/AEC sites, the DOE Secretary would consult with the state to determine whether it is unreasonable to remove sufficient contaminated material from the site to release it for unrestricted use, or whether residual radioactive material could be stabilized onsite as a permanent disposition action. Initially, the DOE would acquire the MED/AEC sites for remedial action purposes and to minimize health effects or to prevent windfall profits. Any property acquired or dedicated for use as a permanent disposal site would be licensed by the NRC. Affected states in which radioactive contaminated sites are located would be responsible for locating suitable disposal sites for the residual radioactive material; initially, the DOE would acquire this property. The disposal sites could be transferred to the state by agreement to accept ownership and custodial responsibilities. The DOE would have authority to provide financial support to the state in carrying out the custodial responsibilities.

The EPA Administrator would be authorized, in consultation with the DOE Secretary, to develop health and environmental standards of general applicability for residual radioactive materials at formerly utilized sites that are to be released for unrestricted use. These general standards would supplement and be consistent with standards established by the Administrator under the Uranium Mill Tailings Radiation Control Act of 1978. Where such standards do not exist, the Administrator would be required to promulgate the needed standards within a specified time.

The DOE Secretary, in consultation with the EPA Administrator, could promulgate remedial action standards for each site at which the Secretary determines it is necessary to begin remedial action before the Administrator promulgates standards of general application.

The DOE has proposed legislation to provide the needed authority. This proposed legislation is under review by other Federal agencies and the Office of Management and Budget.

## 5.0 FUSRAP Program Description

### Objectives of Remedial Action

The objectives of the FUSRAP are to:

- Identify former MED/AEC sites
- Characterize their radiological condition
- Decontaminate sites as required and pursuant to authorization and appropriation by Congress
- Develop acceptable disposal and stabilization sites in consultation with the affected states, and ultimately
- Certify the acceptability of the sites for future use.

The effort to accomplish the first two of these objectives has been initiated. The authority sought under the legislation proposed by the DOE is necessary in most cases to accomplish the remaining objectives.

### Scope and Problem Definition

The scope of the FUSRAP program is confined to those MED/AEC sites that were formerly under contract to, or owned by, the government and were involved in the handling, processing, and storage of radioactive materials. The materials processed consisted primarily of pitchblende and carnotite ores, and other materials from which uranium and thorium were recovered as products. The products of the processing included uranium and thorium metals and compounds. Waste by-products were also produced that generally contained low levels of radioactivity due to residual quantities of uranium, thorium, and their radioactive decay products. In some cases, these contaminants have migrated offsite. Radium contamination is a major concern because it decays to a radioactive gas, radon, that diffuses into the air and can be inhaled. Furthermore, the radon decays to radioactive solid materials that can also be inhaled or ingested.

Also included in the sites discussed in this report are Palos Park, Illinois, where the remains of two research reactors are buried; Chupadera Mesa, New Mexico, which is near the location of the Trinity atom bomb test; and two other sites at Los Alamos, New Mexico, involved in the nuclear weapons development program. At the Palos Park site, the primary contaminant of concern appears to be tritium. At the sites involved in weapons development, plutonium and other nuclides such as uranium-235 and strontium-90 are of concern.

### Approach to Remedial Action

Consistent with the objectives of the FUSRAP, sites are being identified by searching through the MED/AEC records and by publishing press releases asking for public assistance in identifying the sites. After a site has been identified, it is assigned to one of the DOE national laboratories whose responsibility is to assess the site's radiological condition. This is accomplished by performing a records search, reviewing old radiological survey documents, and performing radiological surveys as required. A series of engineering studies and environmental reports, including those prescribed by the National Environmental Policy Act (NEPA), will be prepared to evaluate remedial action alternatives. After the evaluation of the alternatives, appropriate measures (remedial actions) will be selected and implemented, and the resulting contaminated wastes will be disposed of in a manner that ensures public safety and compliance with

the provisions of the Atomic Energy Act of 1954, as amended, and related NRC or Agreement State licensing requirements. In some cases, the residual radioactivity will be stabilized onsite in accordance with the provisions of a license from the NRC or Agreement State. When a site is decontaminated sufficiently to comply with the EPA standards for unrestricted use, it will be certified for release by the DOE. During the course of the investigation, the public will be informed, through press releases for example, of the nature of the MED/AEC work done at the site, the contamination potential, survey results, and remedial actions undertaken. Detailed reports of the survey findings will also be published by the DOE and, upon request, will be available to the public for a nominal fee.

The approach to identification and eventual correction of radiological contamination at the MED/AEC sites or adjacent properties is dependent upon institutional issues which, in turn, impact the steps of the generic program plan for the FUSRAP.

Institutional Issues. Three paramount issues must be addressed and solutions defined before remedial actions as outlined in the generic FUSRAP plan can be implemented:

- Legislative authority must be established by which the Federal Government (DOE) can act to correct problems of radiological contamination at formerly utilized sites. Although the DOE has implied authority at some sites, a large number of sites will require additional legislative authority.

- Radiological criteria must be developed for use as guidelines to determine the extent of decontamination required at each site, to determine if a radiological problem exists, and to establish standards for unrestricted use.

- Disposal sites must be developed for ultimate disposal of contaminated material that is removed from the MED/AEC sites.

Sequence of Events Leading to Remedial Action. Although each formerly utilized site will have certain site-specific characteristics, a general sequence of events can be outlined leading to the ultimate program objective, which is to preclude any future radiological problems at formerly utilized sites from previous MED/AEC activities.

Figure 1 is a schematic presentation of the basic steps involved in the remedial action program. Step 2 determines which sites need remedial action. Sites needing remedial action must be addressed in each of the following steps. If no remedial action is necessary, only Steps 1, 2, and 8 are required. A brief discussion of each step follows.

Step 1, Site Identification - The overall objective of this step is to identify and locate all candidate sites and to determine if any actions are required under the FUSRAP.

The activities include a records search and review of information submitted by the public or industry in response to specific requests. When a site is identified as having been exposed to radioactive materials under the MED/AEC activities, a records search will be initiated to determine the radiological condition of the site. If there is adequate documentation that indicates the site is not contaminated, the site will be certified as clean and no further action will be required. If the documentation or records are inadequate or indicate the site may be contaminated, survey efforts to determine or verify the radiological condition of the site will be initiated. These activities will be performed by the ASEV.

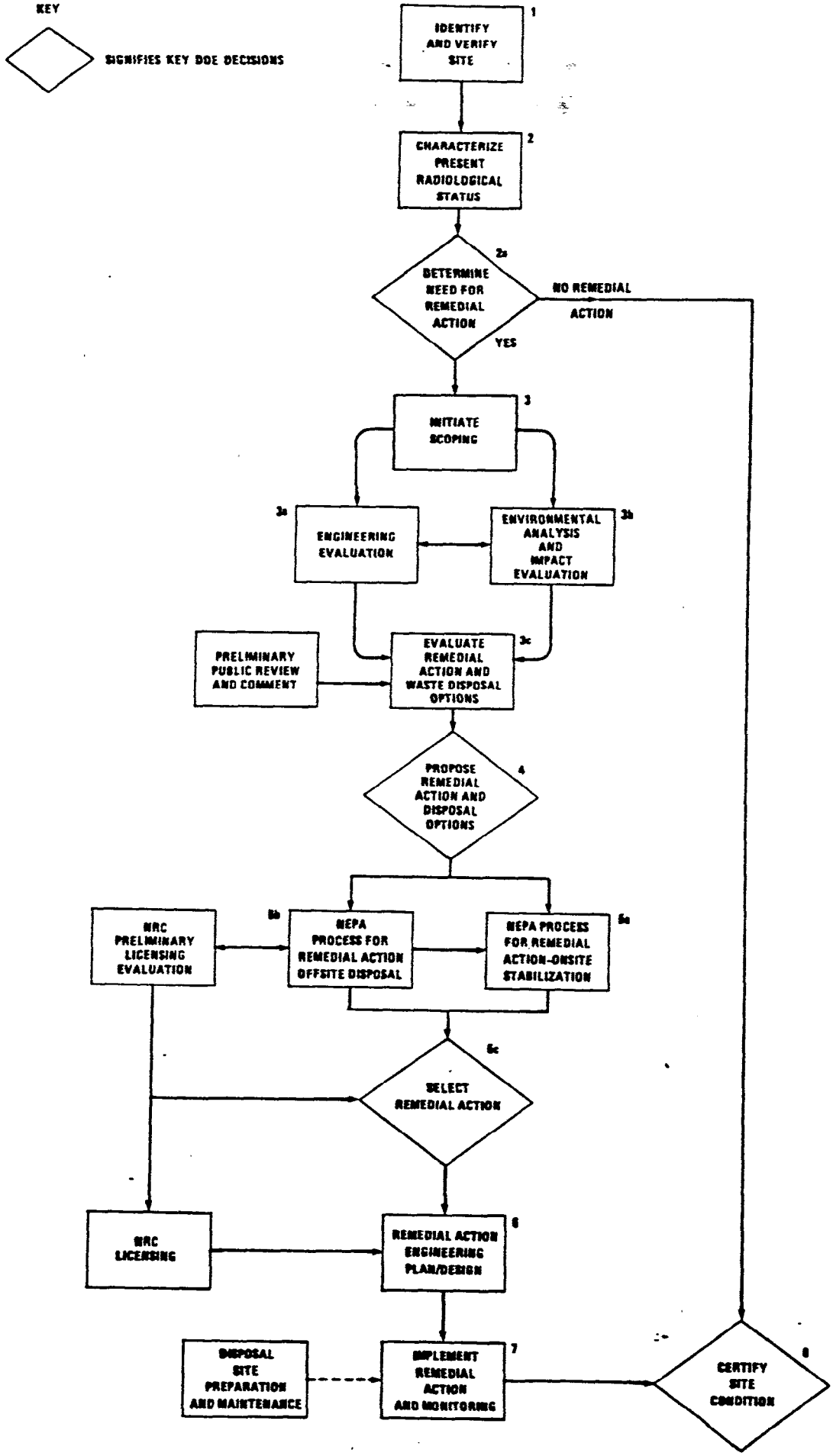



Figure 1. Formerly Utilized Sites — Basic Steps Involved in the Remedial Action Program

A large portion of this step in the FUSRAP is complete. An effort has also been initiated to identify the disposition of equipment that may have been removed from the FUSRAP sites and also to identify the subcontractors to the MED/AEC contractors. One concern is the location of material and equipment that was removed as part of the earlier AEC decontamination efforts.

Step 2, Radiological Survey - The purpose of this step is to characterize the current radiological condition of those sites determined in the preceding step to require a radiological survey. A plan for the radiological survey of a specific site will be prepared, taking into account the past and current activities at the site and associated radioactive material and potential contamination. The extent of the effort associated with a specific site survey will depend on the data available. In some cases, earlier survey reports exist and only supplemental information is required to characterize the site; in other cases, no data are available and a radiological survey is required. The elements that make up the complete radiological survey include the following:

- Measurements of fixed and transferable alpha and beta-gamma radiation on buildings and equipment surfaces
- Gamma-ray exposure rates
- Beta-gamma exposure rates
- Alpha exposure rates
- Radionuclide contamination in surface water and groundwater
- Radionuclide contamination in building drains and associated components
- Radionuclide contamination in underground drains and surface drainageways
- Surface and subsurface deposits of radioactive material
- Radionuclide concentrations in air
- Radionuclide concentrations in vegetation samples.

These activities will be performed by the ASEV.

In order to place all measurements and results in the proper perspective with the surrounding area, measurements of a similar nature will be performed in areas not affected by the former MED/AEC activities. These results will be used to represent the natural background radiation of the area. Aerial radiometric surveys will also be performed in support of the radiological assessment, independent of the ground-level radiological survey. The most important result from this effort will be the identification of any unknown offsite contamination. If the aerial survey indicates the presence of contamination not previously detected, the new area will be surveyed from the ground.

When the field work is complete, a survey report that characterizes the radiological condition of the site will be prepared. The report or report supplement will also include, for contaminated sites, an evaluation of radiation exposures to man from known radiation exposure pathways at the site. This evaluation will outline the levels of radioactivity and extent to which humans could be exposed in the course of normal site activity. These levels will be compared to levels of exposure received from normal background sources of radiation to place the exposure in perspective. The evaluations will be prepared on the basis of the conditions at the site during the radiological survey. In cases where the possibility of radiation exposure above background levels is identified, either summaries or the complete report will be submitted to appropriate state regulatory authorities, the EPA, and the NRC.

Upon public release of the report, or before, meetings will be held with affected property owners and concerned agencies to explain the results of the survey and the future DOE plans for action. Press releases will also be used to inform the public and provide an accurate basis for understanding the results of the radiological survey.

Step 2a, Determine the Need for Remedial Action - The radiological status report will be reviewed and will provide the basis for a determination by the DOE as to whether remedial action is required to remove or reduce residual radioactive materials to levels that conform to the applicable EPA, NRC, or DOE standards, including those to be developed pursuant to the proposed legislation. This determination will be performed by the ASEV and provided to the ASNE, who will be responsible for accomplishing the remedial action.

Step 3, Initiate Scoping - The purpose of this step is to begin the process of identifying the specific alternative remedial actions to be examined and, as appropriate, the candidate disposal sites. This step will involve interactions with the affected state and local authorities, the EPA, the NRC, and other appropriate agencies. The principle issues to be examined will be identified, and the responsibilities, schedule, and appropriate interfaces for conducting the necessary studies will be agreed upon. A key output is for the state to identify candidate disposal sites for subsequent study during the engineering and environmental evaluation. To obtain this information, the DOE would work with the states and support screening studies. Two disposal options will generally be evaluated: a permanent disposal site within the state where the wastes are generated, and a regional disposal site for remedial action wastes from states within the region. Regional sites that could satisfy the needs of several states is a preferred option to minimize the number of disposal sites.

Step 3a, Engineering Evaluation - Engineering evaluations will be required only for those sites for which radioactivity is found to exceed the established health and safety guidelines (e.g., see section 3.0) and/or the standards to be developed. The engineering evaluation will include assessment of existing conditions for the site as well as surrounding properties. The scope of the effort will include the following:

- Verification of property ownership
- Preparation of descriptive maps and site plans
- Analysis of radiological surveys to determine decontamination requirements and identify and collect any supplemental data needed for a sound engineering evaluation of remedial action options
- Performance of an engineering assessment of the decontamination or demolition of structures
- Engineering evaluation of removal, transport, interim storage, and permanent disposal options for contaminated soil, structures, debris, and other materials
- Evaluation of suitable means of stabilizing residual radioactivity, where appropriate, including investigation of pertinent aspects of site geology, hydrology, and meteorology
- Analysis of alternative remedial action options including preliminary project plans for the remedial action and disposal sites, specifications, and cost estimates
- Preparation of summary reports.

Step 3b, Environmental Analysis - The objective of the environmental analysis is to provide an environmental evaluation of the remedial action options covered by the engineering evaluation. The analysis will discuss the environmental impacts of the

present condition of the site, stabilization of the material onsite and/or decontamination of the site, and removal of the material to a temporary storage or to a disposal site. This analysis will provide a basis for determining whether a major Federal action is involved that may require the preparation of an environmental impact assessment or impact statement conforming to the requirements of the NEPA. Environmental analysis and comments on the analysis will be used as input to support decisions regarding the need for the NEPA process. The analysis will include a review of the impacts of the options during and after any remedial action and will cover the full scope of environmental concerns as well as radiological effects.

Step 3c, Evaluate Remedial Action and Waste Disposal Options - The engineering evaluation and environmental analysis produced in Steps 3a and 3b above will be evaluated by the DOE to identify the preferred option and reasonable alternatives. In this step, the DOE will advise the appropriate Federal, state, local agencies, and the public of the results of the preliminary engineering evaluation, the environmental analysis, and the DOE conclusions regarding the preferred option and reasonable alternatives. The DOE will seek their preliminary reviews and comments.

The risks, benefits, and costs of each remedial action and disposal option will be considered in the selection of the proposed remedial action. Factors affecting the remedial action, including environmental issues, technical issues, and public opinion, will be considered in the risk, benefit, and cost analyses. In selecting or proposing remedial action, emphasis will be given to determining the most practical and expedient means to eliminate or limit exposure to the public. If it is determined that material must be moved and no permanent disposal site is available at the time of the implementation of an action, the alternative of moving the contaminated material and stabilizing it at an interim storage site located at or near the contaminated site will be examined. It is assumed that the DOE will have ownership and maintenance responsibilities for all stabilized sites, interim storage sites, and permanent disposal sites except where the affected states agree to accept ownership and custodial responsibilities. It is also assumed that the stabilized sites, temporary storage sites, and the permanent disposal sites will be licensed by the NRC and will meet the relevant criteria of the proposed NRC regulations (basically modeled after 10 CFR 40 Appendix A). On the basis of this interagency and public review, the DOE will develop its proposals for remedial action and waste disposal options.

Step 4, Propose Remedial Action and Disposal Options - The remedial action and disposal option proposed by the DOE Secretary, and the reasonable alternatives will be identified and documented for the conduct of the NEPA process in Steps 5a, 5b, and 5c.

Step 5a, NEPA Process for Remedial Action - Onsite Stabilization - When the remedial action is proposed, the available data will be reviewed to determine if the proposed action is a major Federal action that will have a significant impact on the environment and what NEPA documentation is required. This review will also ensure that the data collected in the environmental analysis cover all environmental issues.

If required, the data developed during the environmental analysis step, along with any additional data required, will be used in the preparation of an environmental impact assessment (EIA) or an environmental impact statement (EIS). The NEPA documentation will be prepared as outlined in the CEQ NEPA Regulations (Title 40 CFR, Parts 1500-1508), the DOE NEPA guidelines (45 FR 20,594-20,701, March 28, 1980), and the DOE Order 5440.1. As noted in Figure 1 and discussed below, the NRC licensing process will be initiated in parallel with this step.

Step 5b, NEPA Process for Remedial Action - Offsite Disposal Options - In this step, the MED/AEC site and the candidate disposal sites that were identified in Step 3 by the affected state in consultation with the DOE, will be evaluated in parallel through the NEPA process to provide the basis for selecting the disposal site. The NEPA process will be conducted as outlined in the CEQ NEPA Regulations (Step 5a). As noted in Figure 1 and discussed below, the NRC licensing process will be initiated in parallel with this step.

Step 5c, Selected Remedial Action - At the conclusion of the NEPA process for both onsite remedial action or offsite disposal, the DOE will issue a Record of Decision announcing the selected remedial action and a decision as to how the radioactive materials will be permanently diposed.

The selection of the disposal site option will take into consideration the preliminary NRC licensing evaluation of the site, as appropriate.

Step 6, Remedial Action Engineering Plan - An engineering plan for the proposed action will be prepared, containing detailed plans and specifications for implementation of the selected remedial action alternative including, as appropriate, at the disposal site. The engineering plan will present detailed cost estimates, work plans, and schedules that define the engineering aspects of the remedial action and will be used to contract for the remedial action.

During this step, a license application for either stabilizing onsite or for offsite disposal will be prepared and submitted to the NRC.

Step 7, Implement Remedial Action and Monitoring - The remedial action contractor will conduct the action in accordance with the contract and as outlined in the engineering plan. Part of this step, where appropriate, will be the preparation of a disposal site. It will also include initiation of the operation, surveillance, and/or maintenance step that will continue as long as the site is used as a repository for these wastes. Independent monitoring by the DOE-ASEV will be conducted during the remedial action, and periodic status reports will be prepared.

Step 8, Certify Site Condition - During and upon completion of the remedial action, radiological surveys will be performed by the DOE-ASEV to verify the effectiveness of the remedial action, and the radiological condition of the site requiring remedial action will be documented. If the surveys verify that the levels of residual radioactive materials meet the established standards for unrestricted use, the site will be released for use without restrictions. If the surveys do not verify that the residual radioactivity meets the levels within the standards for unrestricted use, then further remedial action measures will be prescribed.

To assure control and enforcement of restrictions on "stabilized" sites, ownership by the Federal Government or the state will be required and the sites will be licensed by the NRC or the state. Disposal sites will be treated in a similar fashion. Such controls may permit some beneficial land use, such as making the area into a park where no permanent structures may be constructed, or possibly continuing the use of the site for other regulated nuclear activities. In any case, upon completion of the remedial action, a final report will be prepared documenting the entire remedial action effort and the radiological condition of the site. The final report will also note the quantity of material removed from the site and its disposition. The final report and all supporting documentation will be stored in permanent Federal Government

archives and copies or summary material will be placed in the records of appropriate local and state agencies and recorders' offices.

Status of Sites

As a result of the DOE efforts to identify the former MED/AEC sites, investigations to determine the radiological status of over 70 sites were or are being completed. Based on data collected to date, the DOE has determined that 18 sites will require some form of remedial action (as identified in Table 1) and 13 other sites are likely to require remedial action by the DOE.

Table 2 lists the 31 sites being considered and the current status of remedial action as of January 31, 1980. Figure 2 shows the location of these 31 sites. Radiological surveys of uniform character have been conducted at 20 sites, of which 19 reports have been issued in draft and 13 in final form. The remaining 11 sites have been surveyed with less rigor and will require more detailed surveys that are scheduled to be undertaken. Conceptual engineering evaluations have been initiated at five sites with final reports completed for two of those sites. Detailed engineering plans have been initiated at two sites. Remedial action has begun at a number of sites where there is existing DOE authority to conduct such actions. Implied authority for the undertaking of remedial action exists at 13 sites and must be clarified at 18 sites.

Appendix A to this document provides brief information summaries for each site.

## 6.0 Estimated Costs for Remedial Action Program

Preliminary cost estimates have been developed for remedial action for each MED/AEC site* and are summarized in Table 3, excluding those sites that are licensed by the NRC or Agreement States (Gilman Hall, University of Chicago, and Linde). These estimates are considered to be the upper bound of costs as explained below. Estimated costs for the remedial action program by work phase and by fiscal year are presented in Figure 3. Estimated costs of remedial action by site and by state are presented in Figure 4. The basis for the estimates are decontamination and restoration to unconditional public use using containers for waste transport, rather than bulk carriers and transportation of 500 miles to regional disposal sites.

Key Issues Affecting Costs and Schedule. Major factors influencing the cost of remedial action at the MED/AEC sites are:

- The option chosen for remedial action, either removal of contamination and restoration for unrestricted use by the public or permanent stabilization of existing contamination on the formerly utilized site to minimize exposure of the public with appropriate controls

- Criteria and standards for decontamination or stabilization

*"Formerly Utilized Sites Remedial Action Program - Preliminary Cost Estimates" prepared for USDOE Oak Ridge Operations Office Technical Services Division by Ford, Bacon & Davis Utah Inc., October 1979; and radiological survey, environmental monitoring, and certification cost estimates from the ASEV.

Table 1

MED/AEC SITES FOR WHICH A DETERMINATION HAS BEEN MADE THAT REMEDIAL ACTION IS REQUIRED*

| Site | Health Priority |
|---|---|
| Ashland Oil Company, Tonawanda, New York | TBD |
| Bayo Canyon Area, Los Alamos, New Mexico | L |
| Clecon Metals, Inc., Cleveland, Ohio | M/H |
| Gilman Hall, University of California, Berkeley, California** | L |
| Conserv Inc., Nichols, Florida | L/M |
| E. I. du Pont de Nemours and Company, Deepwater, New Jersey | L |
| Gardinier, Inc., Tampa, Florida | M |
| Guterl Special Steel Corporation, Lockport, New York | L |
| Kellex Research Facility, Jersey City, New Jersey | H |
| Lake Ontario Ordnance Works Associated Properties, Lewiston, New York | TBD |
| Linde Air Products, Tonawanda, New York** | L |
| Mallinckrodt, Inc., St. Louis, Missouri | H |
| Middlesex Municipal Landfill, Middlesex, New Jersey | L |
| Middlesex Sampling Plant, Middlesex and Piscataway, New Jersey | H |
| Palos Park Forest Preserve, Cook County, Illinois | M |
| St. Louis Airport, St. Louis, Missouri | TBD |
| Seaway Industrial Park, Tonawanda, New York | TBD |
| Seneca Army Depot, Romulus, New York | L |

Key: L = Low
M = Medium
H = High
TBD = To be determined

*Based upon DOE determinations completed through March 1980; determinations on 13 additional sites are in progress.

**Licensed by Agreement State provisions of the Atomic Energy Act of 1954, as amended, and excluded from FUSRAP; these licenses provide for site decontamination.

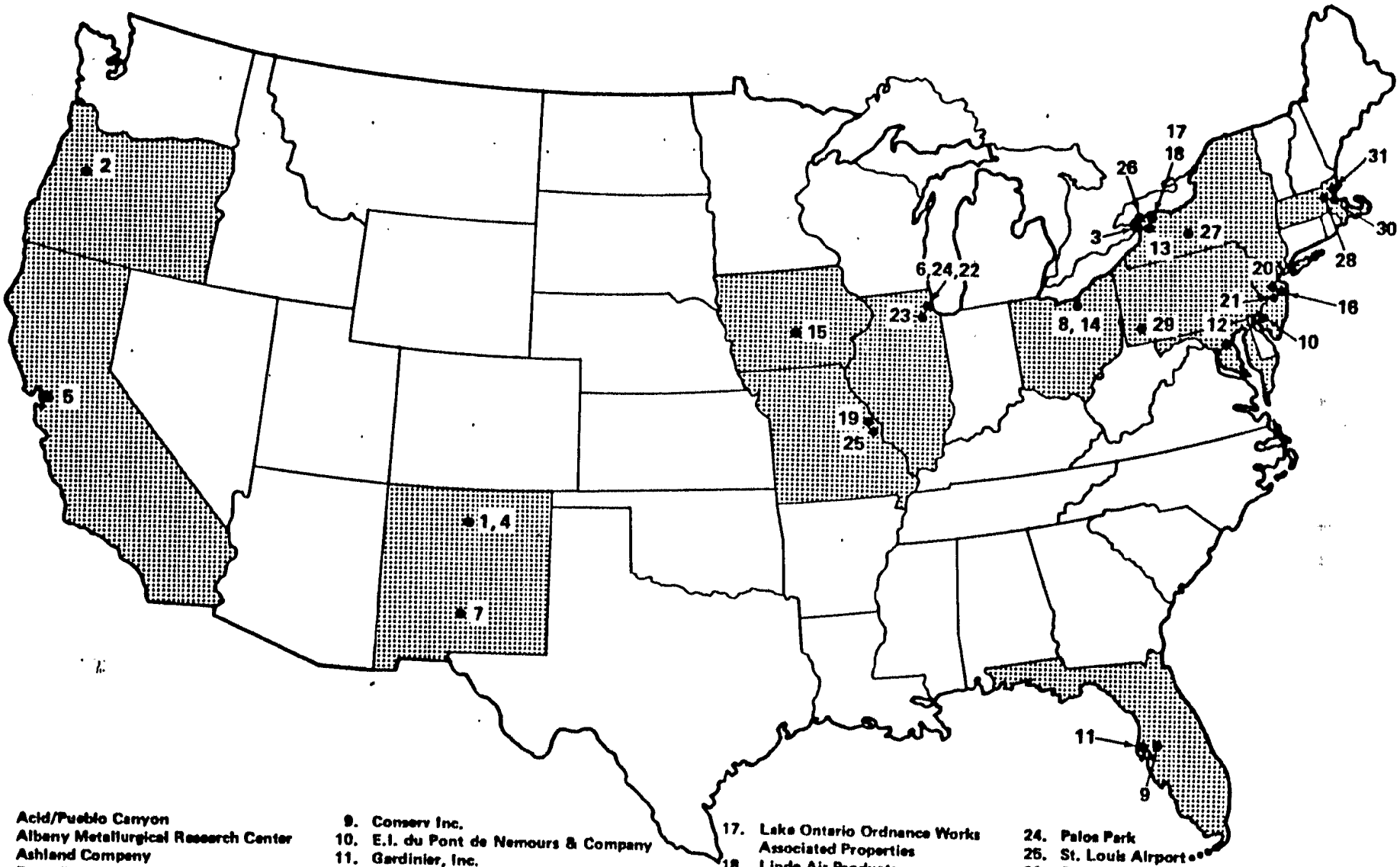
## Table 2
## Status of Remedial Action at MED/AEC Sites

| Name | State | Radiological Survey | Report Draft | Report Final | Title I Eng'r'g Initiated | Title I Eng'r'g Draft | Title I Eng'r'g Final | Title II Eng'r'g Initiated | Title II Eng'r'g Draft | Title II Eng'r'g Final | EIS | Remedial Action Req'd | Remedial Action Underway | Remedial Action Authority Req'd | Remedial Action Authority Exists ** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Acid Pueblo Canyon | NM | | | | ● | | | | | | | | | | ● |
| 2 Albany Metallurgical Research Center | OR | | | | | | | | | | | | | | ● |
| 3 Ashland Oil Company | NY | ● | ● | ● | | | | | | | | ● | | ● | |
| 4 Bayo Canyon | NM | ● | ● | ● | ● | | | | | | | ● | | | ● |
| 5 Gilman Hall, University of California | CA | ● | | | | | | | | | | ● | | | * |
| 6 University of Chicago | IL | | | | | | | | | | | | | | * |
| 7 Chupadera Mesa | NM | | | | ● | | | | | | | ✓ | | ✓ | ● |
| 8 Clecon Metals, Inc. | OH | ● | ● | ● | | | | | | | | ● | | ● | |
| 9 Conserv Inc. | FL | ● | ● | ● | | | | | | | | ● | | ● | |
| 10 E.I. du Pont de Nemours & Company | NJ | ● | ● | ● | | | | | | | | ● | | | ● |
| 11 Gardinier, Inc. | FL | ● | ● | | | | | | | | | ● | | ● | |
| 12 W. R. Grace & Company | MD | | | | | | | | | | | | | *** | |
| 13 Guteri Steel Corp. | NY | ● | ● | ● | | | | | | | | ● | | ● | |
| 14 Harshaw Chemical Company | OH | | | | | | | | | | | | | ● ✓ | |
| 15 Iowa State University | IA | | | | | | | | | | | | | ● | |
| 16 Kellex | NJ | ● | ● | | | | | ● | | | | ● | ● | | ● |
| 17 Lake Ontario Ordnance Works Associated Properties | NY | | | | | | | | | | | ● | | | ● |
| 18 Linde Air Products | NY | ● | ● | ● | | | | | | | | ● | | | * |
| 19 Mallinckrodt, Inc. | MO | ● | ● | | | | | | | | | ● | | ● | |
| 20 Middlesex Landfill | NJ | ● | ● | | ● | ● | ● | | | | | ● | | | ● |
| 21 Middlesex Sampling Plant | NJ | ● | ● | ● | ● | ● | ● | ● | | | | ● | | | ● |
| 22 National Guard Armory | IL | ● | ● | | | | | | | | | | | ● | |
| 23 Olin Chemical Company | IL | ● | ● | ● | | | | | | | | | | ● | |
| 24 Palos Park | IL | ● | ● | ● | | | | | | | | ● | | ● | |
| 25 St. Louis Airport | MO | ● | ● | ● | | | | | | | | ● | | ● | |
| 26 Seaway Industrial Park | NY | ● | ● | ● | | | | | | | | ● | | ● | |
| 27 Seneca Army Depot | NY | ● | ● | ● | | | | | | | | ● | | | ● |
| 28 Shpack Landfill | MA | | | | | | | | | | | | | *** | |
| 29 Universal Cyclops, Inc. | PA | ● | ● | | | | | | | | | | | ● | |
| 30 Ventron Corporation | MA | | | | | | | | | | | | | ● | |
| 31 Watertown Arsenal | MA | | | | | | | | | | | | | ● | |
| Totals | | 20 | 19 | 13 | 5 | 2 | 2 | 2 | | | | 18 | 1 | 18 | 13 |

* These sites have been deleted from the FUSRAP because the NRC or Agreements States have sufficient licensing authority to protect public health and safety.

** Remedial Action authority exists where such action is required to protect public health and safety.

*** A determination as to whether additional authority is required to implement remedial action is currently underway.




1. Acid/Pueblo Canyon
2. Albany Metallurgical Research Center
3. Ashland Company
4. Bayo Canyon
5. University of California
6. University of Chicago
7. Chupadera Mesa
8. Clecon Metals, Inc.
9. Conserv Inc.
10. E.I. du Pont de Nemours & Company
11. Gardinier, Inc.
12. W. R. Grace & Company
13. Guteri Steel Corp.
14. Harshaw Chemical Company
15. Iowa State University
16. Kellex
17. Lake Ontario Ordnance Works Associated Properties
18. Linde Air Products
19. Mallinckrodt, Inc.
20. Middlesex Landfill
21. Middlesex Sampling Plant
22. National Guard Armory
23. Olin Chemical Company
24. Palos Park
25. St. Louis Airport
26. Seaway Industrial Park
27. Seneca Army Depot
28. Shpak Landfill
29. Universal Cyclops, Inc.
30. Ventron Corporation
31. Watertown Arsenal

Figure 2 Location of Sites Requiring or that May Require Remedial Action

Table 3
ESTIMATES OF REMEDIAL ACTION COSTS BY MED/AEC SITE*

| | |
|---|---|
| Acid/Pueblo Canyon Area, Los Alamos, New Mexico | $ 1,900,000 |
| Albany Metallurgical Research Center, Albany, Oregon | 3,000,000 |
| Ashland Oil Company, Tonawanda, New York | 29,000,000 |
| Bayo Canyon Area, Los Alamos, New Mexico | 2,800,000 |
| Chupadera Mesa Area, White Sands Missile Range, New Mexico | 180,000 |
| Clecon Metals, Inc., Cleveland, Ohio | 2,400,000 |
| Conserv Inc., Nichols, Florida | 660,000 |
| E. I. du Pont de Nemours and Company, Deepwater, New Jersey | 3,000,000 |
| Gardinier, Inc., Tampa, Florida | 2,300,000 |
| W. R. Grace & Company, Curtis Bay, Maryland | 17,000,000 |
| Guterl Special Steel Corporation, Lockport, New York | 1,100,000 |
| Harshaw Chemical Company, Cleveland, Ohio | 9,000,000 |
| Iowa State University, Ames, Iowa | 570,000 |
| Kellex Research Facility, Jersey City, New Jersey | 1,400,000 |
| Lake Ontario Ordnance Works Associated Properties, Lewiston, New York | 3,000,000 |
| Mallinckrodt, Inc., St. Louis, Missouri | 26,000,000 |
| Middlesex Municipal Landfill, Middlesex, New Jersey | 50,000,000 |
| Middlesex Sampling Plant, Middlesex and Piscataway, New Jersey | 48,000,000 |
| National Guard Armory, Chicago, Illinois | 710,000 |
| Olin Corporation, Joliet, Illinois | 680,000 |
| Palos Park Forest Preserve, Cook County, Illinois | 7,100,000 |
| St. Louis Airport, St. Louis, Missouri | 98,000,000 |
| Seaway Industrial Park, Tonawanda, New York | 24,000,000 |
| Seneca Army Depot, Romulus, New York | 860,000 |
| Shpack Landfill, Norton, Massachusetts | 2,200,000 |
| Universal Cyclops, Inc., Aliquippa, Pennsylvania | 1,000,000 |
| Ventron Corporation, Beverly, Massachusetts | 880,000 |
| Watertown Arsenal, Watertown, Massachusetts | 630,000 |
| | $338,000,000 |

*Upper boundary of costs for removal and disposal option.

**Figure 3 Work Schedule and Funding Requirements for Remedial Action at MED/AEC Sites**

| Work Activities | Work Schedule by Fiscal Year | | | | | | | | | | Estimated Costs |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | |
| 1. Radiological Characterization, Environmental Monitoring, Certification & Overview | | | | | | | | | | | $ 22,700,000 |
| 2. Engineering Analyses, Design, and Support | | | | | | | | | | | 12,200,000 |
| 3. Environmental Analyses, Assessments, and Support | | | | | | | | | | | 13,100,000 |
| 4. Decontamination and Residue Retrieval | | | | | | | | | | | 49,000,000 |
| 5. Containerization of Residues | | | | | | | | | | | 60,900,000 |
| 6. Transportation of Residues | | | | | | | | | | | 48,000,000 |
| 7. Disposal of Residues | | | | | | | | | | | 91,000,000 |
| 8. Contingency (15% of Sum of Items 2-7) | | | | | | | | | | | 41,100,000 |
| Total | | | | | | | | | | | $338,000,000 |

NOTE: Estimate based on retrieving containerizing, transporting, and disposal of an estimated 500,000 cubic yards of soil and rubble at the following average unit costs ($/cubic yard) in FY 1981 dollars:

| | $/Cubic Yard |
|---|---|
| Contaminated residue retrieval | 112 |
| Containerization of residues | 138 |
| Transportation of residues (500 miles to regional disposal site) | 110 |
| Disposal of residues | 208 |

**Estimates of Annual Budget Authorization Requests in FY 1981 Dollars**

| Fiscal Year | Amount | Fiscal Year | Amount |
|---|---|---|---|
| 1980 | $ 9,400,000 | 1985 | $ 46,200,000 |
| 1981 | 13,800,000 | 1986 | 48,000,000 |
| 1982 | 21,300,000 | 1987 | 50,800,000 |
| 1983 | 32,600,000 | 1988 | 42,600,000 |
| 1984 | 38,000,000 | 1989 | 35,300,000 |
| | | | $338,000,000 |

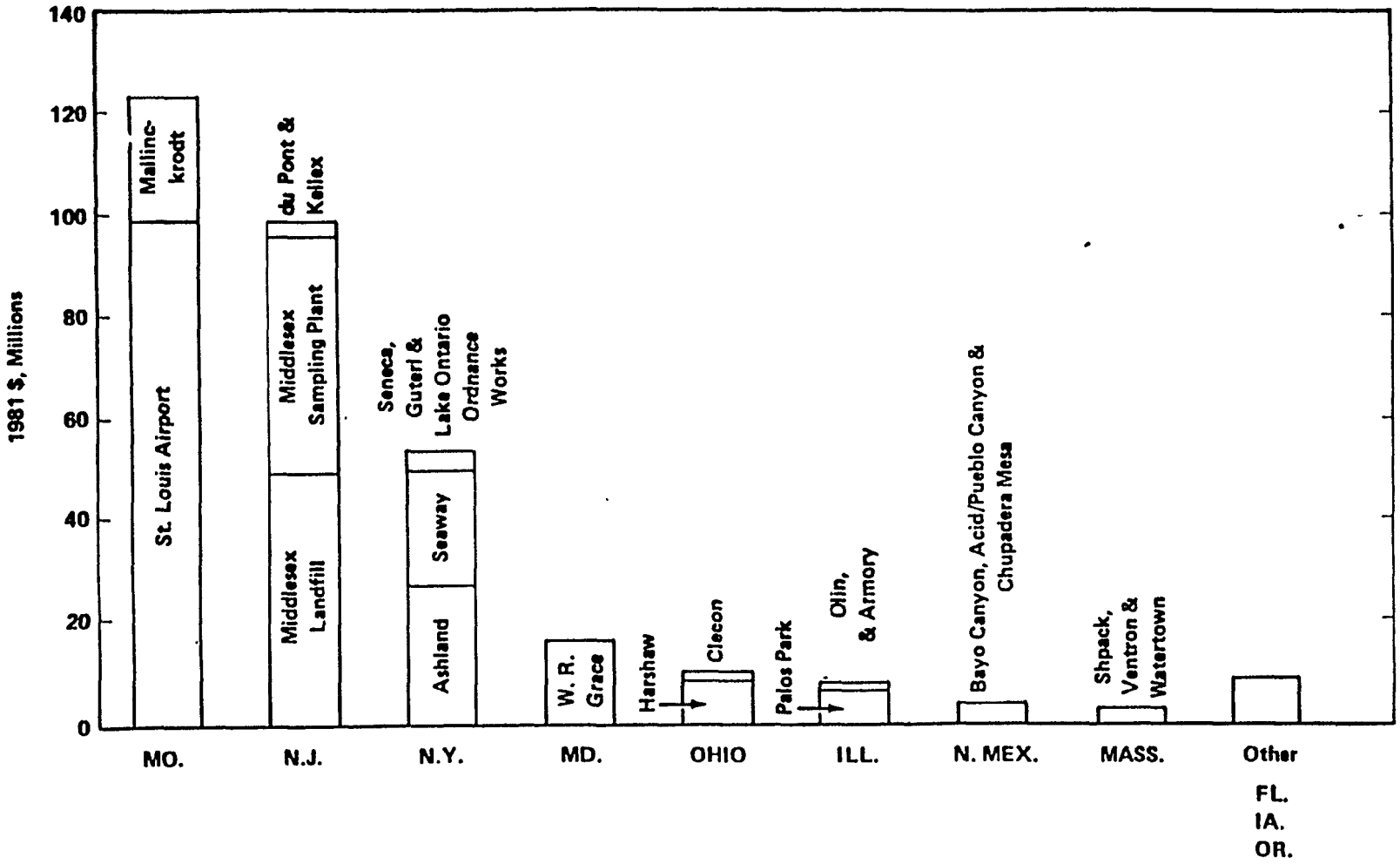



Figure 4. FUSRAP Costs by State and Site

- The method of packaging of materials for transport generated by decontamination, generally, either containerized or bulk

- Location of disposal site, either in-state or regional

- Type of disposal-site ownership (based on either government financing or commercial rates)

Remedial Action Options. Options available for remedial action at a contaminated site are either removal of contamination and restoration of the site to permit unrestricted public use, or permanent stabilization of the radioactive material on the remedial action site and restoration for restricted use. Because of the long time period required to locate and develop a disposal site, temporary remedial actions may be taken to reduce health impacts. Stabilization involves fixing of the contamination on the soil or structures such that transport offsite through such mechanisms as erosion, leaching into water supplies and aquifers, or through up-take in the biosphere does not occur and will not occur in the long term. Criteria and standards for stabilized sites will meet the intent of those criteria and standards used for the disposal sites, e.g., 10 CFR 40 Appendix A, the criteria proposed by NRC for privately owned mill tailing sites. Institutional controls have to be imposed at the stabilized site to prevent disturbance of the buried material and its subsequent release. Removal of contamination from structures, dismantling and removal of structures, and removal of soil and other contaminated material, followed by site restoration for unrestricted use by the public, is the most extensive remedial action that can be taken at a site. The costs for permanent stabilization might be a factor of 5 to 10 less than for decontamination and removal. For the purposes of providing a bounding cost of the proposed legislation, cost estimates were based upon decontamination of all the 29 MED/AEC sites and restoration for unlimited public use.

Criteria and Standards for Remedial Actions. The basis of the cost estimates provided for remedial action assumes contamination would be reduced to 5 picocuries of radium-226 per gram of soil (or comparable levels for other radionuclides), which is in the range of 2 to 10 times that of naturally occurring radium levels in the soil. If a lower value of acceptable contamination were to be imposed, substantially higher costs may result. For stabilized sites, another factor affecting cost is the depth of ground cover material that will be required by the NRC. In this cost estimate, no sites were considered for stabilization. Because the stabilization and disposal sites will be licensed by the NRC, the final criteria and standards established by the NRC will impact costs. The NRC has proposed criteria for licensed uranium mill tailings sites (10 CFR 40, Appendix A) and is developing criteria for large-volume, low-activity waste that are expected to be generally consistent with the mill tailings criteria. These criteria may be applied to the formerly utilized sites that are stabilized and to the disposal sites. In addition, the EPA has issued interim and proposed final criteria for remedial action at inactive mill tailings sites.

Method of Packaging. The packaging of contaminated material generated in the remedial action of decontaminating the MED/AEC sites can be accomplished either by use of containers such as 55-gallon drums, or bulk transporters such as large-volume trucks or railroad cars. The relative costs for the handling and transport of small containers is three to four times greater for the small containers versus bulk shipment. For the purposes of the proposed legislation, cost estimates were based upon containerization of waste residues.

Location of Disposal Sites. Transportation to a site for disposal of the contaminated material removed from the MED/AEC sites may be a significant factor in the cost of remedial action. The major factor in cost is the distance for transport of either containerized material or bulk quantities via truck or rail. Depending upon the location of the sites requiring decontamination and restoration, a suitable regional disposal site may be found that could satisfy the needs of more than one state. Cooperative efforts between states will be encouraged to jointly solve this common problem. The DOE will cooperate and support the states in this site selection activity. Cost estimates were based upon transportation costs associated with shipment of 500 miles to a regional disposal site.

Type of Disposal Sites. Sites for disposal of residues contaminated from the former MED/AEC use may be federally owned or state-owned. To ensure long-term institutional control of the disposal site, privately owned sites are not acceptable. This approach is consistent with that used in the Uranium Mill Tailings Radiation Control Act of 1978, and the criteria proposed by the NRC for the privately owned uranium mill tailings sites. Restriction of access to the site, and monitoring and surveillance requirements, will require administrative control that can be accomplished by either Federal or state ownership and custody of the site. Costs of operation of a disposal site for contaminated residues must reflect the quantities of wastes to be handled and the time period of active and passive controls.

These costs will be affected by whether the site is a single-use site or a multiple-use site.

# APPENDIX A

# MED/AEC SITE SUMMARY REPORTS

CONTENTS

SITE SUMMARY REPORTS


| | Page |
|---|---|
| Acid/Pueblo Canyon Area Los Alamos, New Mexico | A-2 |
| Albany Metallurgical Research Center, Albany, Oregon | A-4 |
| Ashland Oil Company, Tonawanda, New York | A-6 |
| Bayo Canyon Area, Los Alamos, New Mexico | A-7 |
| Gilman Hall, University of California, Berkeley, California | A-9 |
| University of Chicago, Chicago, Illinois | A-10 |
| Chupadera Mesa Area, White Sands Missile Range, New Mexico | A-12 |
| Clecon Metals, Inc., Cleveland, Ohio | A-13 |
| Conserv Inc., Nichols, Florida | A-14 |
| E. I. du Pont de Nemours and Company, Deepwater, New Jersey | A-16 |
| Gardinier, Inc., Tampa, Florida | A-18 |
| W. R. Grace & Company, Curtis Bay, Maryland | A-20 |
| Guterl Special Steel Corporation, Lockport, New York | A-21 |
| Harshaw Chemical Company, Cleveland, Ohio | A-23 |
| Iowa State University, Ames, Iowa | A-25 |
| Kellex Research Facility, Jersey City, New Jersey | A-27 |
| Lake Ontario Ordnance Works Associated Properties, Lewiston, New York | A-29 |
| Linde Air Products Division, Tonowanda, New York | A-31 |
| Mallinckrodt, Inc., St. Louis, Missouri | A-32 |
| Middlesex Municipal Landfill, Middlesex, New Jersey | A-34 |
| Middlesex Sampling Plant, Middlesex and Piscataway, New Jersey | A-36 |
| National Guard Armory, Chicago, Illinois | A-38 |
| Olin Corporation, Joliet, Illinois | A-39 |
| Palos Park Forest Preserve, Cook County, Illinois | A-40 |
| St. Louis Airport, St. Louis, Missouri | A-42 |
| Seaway Industrial Park, Tonawanda, New York | A-44 |
| Seneca Army Depot, Romulus, New York | A-45 |
| Shpack Landfill, Norton, Massachusetts | A-47 |
| Universal Cyclops, Inc., Aliquippa, Pennsylvania | A-49 |
| Ventron Corporation, Beverly, Massachusetts | A-50 |
| Watertown Arsenal, Watertown, Massachusetts | A-51 |

# SITE SUMMARY REPORTS

## INTRODUCTION

The information contained in the following MED/AEC site summary reports represents the current knowledge of radiological conditions at, and former government use of, each site. In some cases, additional work necessary for complete characterization of a site is underway or planned.

Throughout the summary reports, reference is made to "current guidelines" for contamination and exposure levels. The guidelines discussed in section 3.0 Appendix A provides brief information on each site as follows:

- Owner history - from the MED/AEC period to the present
- Site location
- Site utilization during the MED/AEC period
- Use of site since the MED/AEC period
- Radiological history - results of surveys conducted and relative contamination levels
- Remedial action options and costs
- Project status - current status of surveys, engineering studies, recommendations for remedial action, and existing or implied authority for future remedial action.

ACID/PUEBLO CANYON AREA
LOS ALAMOS, NEW MEXICO

## OWNER HISTORY

1943-1967: U.S. Government
1967-Present: Los Alamos County and U.S. Government (upper Canyon)

## SITE LOCATION

Acid and Pueblo Canyons are located adjacent to the townsite of Los Alamos in north central New Mexico, about 25 miles northwest of Santa Fe. These canyons are two of many canyons cut into the Pajarito Plateau. Acid Canyon is a tributary of Pueblo Canyon.

## MED/AEC SITE USE

These deep canyons were the discharge area for untreated radioactive liquid wastes between 1943 and 1951 resulting from research and processing at the Los Alamos Scientific Laboratory. Starting in 1951, treated radioactive effluents were discharged into the canyon from a liquid-waste-treatment facility which operated until 1964.

## POST MED/AEC SITE USE

The area is unrestricted to public access and is used on a limited basis for recreational purposes.

## RADIOLOGICAL HISTORY

Plutonium, americium, and fission products were discharged into the canyons in liquid effluents during the years 1943 to 1964. The first survey of Acid Canyon, for purposes of cleanup, was made on August 31, 1965. On October 4, 1966, work commenced on removing the waste-treatment-facility structures. Five-hundred truckloads of demolition debris and dirt from this location were removed. Ninety-four loads of debris from Acid Canyon were placed in a solid-waste disposal area within the currently operational Los Alamos Scientific Laboratory site. This decontamination activity included the removal of all drain pipes, wires, rocks, tuff, and other debris found contaminated in Acid and Pueblo Canyons. This work was completed in 1967, and it was reported that a small amount of contamination remains in inaccessible places.

In November 1973, it was reported that plutonium concentrations in filtered surface waters in Acid Canyon and the adjacent portions of Pueblo Canyon generally averaged about 20 picocuries/liter. A limited number of samples of the alluvium taken in 1970 indicated plutonium concentrations of 27 picocuries/gram in lower Acid Canyon, 4.6 picocuries/gram in Pueblo Canyon 1 mile below the Acid Canyon outlet, and 1.1 picocuries/gram 2 miles below Acid Canyon.

Some radiological and environmental surveillance evaluations have been completed and documented for Pueblo Canyon. Several hundred soil and sediment samples were collected for the present detailed radiological survey during 1977. Data show some limited areas in the canyons that exceed the EPA-proposed soil screening guides for plutonium concentrations. Measurements of penetrating radiation showed no areas that exceed radiation protection standards.

## REMEDIAL ACTION OPTIONS AND COSTS

Some form of remedial action may be required and could include stabilization and/or decontamination by excavation of the cliff face, outfall area, cliff base and channel, and the Acid Canyon stream bed. Seventeen-hundred cubic yards of contaminated material would be produced. The estimated cost is $1,900,000.

## PROJECT STATUS

Following the completion of the radiological survey report, the Assistant Secretary for Environment will determine whether the site requires remedial action. Work has been initiated on an Engineering Evaluation Report-Title I. Authority to implement a remedial action exists under the Atomic Energy Act of 1954, as amended.

## ALBANY METALLURGICAL RESEARCH CENTER
## ALBANY, OREGON

### OWNER HISTORY

The site has been and is currently owned by the Bureau of Mines, U.S. Department of the Interior.

### SITE LOCATION

The site is located in Albany, Oregon, approximately 23 miles south of Salem. Eight buildings and their surroundings were used for former MED/AEC activities.

### MED/AEC SITE USE

From 1954 to 1971, the Albany Metallurgical Research Center was engaged in metallurgical operations involving thorium. Operations included reduction, melting, machining, welding, and alloying. Research on alloys of uranium and thorium started in 1955 and continued to 1978.

### POST MED/AEC SITE USE

Research involving uranium and thorium was suspended in 1978. Onsite areas that contain contaminated soils have been fenced to restrict access. None of the buildings are currently used for uranium or thorium alloy research.

### RADIOLOGICAL HISTORY

At the time that the original AEC contract was terminated (approximately 1960), these buildings were decontaminated according to the general guidelines provided by the AEC to the Bureau of Mines. These guidelines were not as specific as later guidelines, and there is no record that the final decontamination was documented. Contaminated materials, equipment, or wastes generated under the AEC contracts were removed from the site for disposal.

The Argonne National Laboratory (ANL) conducted a radiological survey of these buildings and grounds in 1978 and found contamination that exceeded current guidelines for unrestricted use still existed on surfaces and that some areas of soil were contaminated with uranium and thorium. As an interim measure, the Bureau of Mines has fenced in areas of contaminated soil to restrict access. Some additional survey work, including an aerial radiometric survey, was conducted in 1979, and some subsurface investigations are scheduled for 1980. ANL is preparing a radiological survey report to document all survey activities.

No significant public health impact exists due to restricted use of the contaminated areas; however, potential health impacts could result if usage was changed. Interim access control measures have been employed.

### REMEDIAL ACTION OPTIONS AND COSTS

Remedial action may be required and could involve excavation of contaminated soils, decontamination of buildings and removal of structural elements and plumbing. Thirty-seven-hundred cubic yards of contaminated material could be produced. The estimated cost for remedial action is $3,000,000.

## PROJECT STATUS

A radiological survey has been completed and a final report is in preparation. Upon completion of this report, the Assistant Secretary for Environment will determine whether remedial action is required. Authority to implement remedial action exists under the Atomic Energy Act of 1954, as amended.

ASHLAND OIL COMPANY
TONAWANDA, NEW YORK

## OWNER HISTORY

| | |
|---|---|
| 1943-1944: | E. Haist et al. - leased by MED |
| 1944-1960: | U.S. Government |
| 1960-Present: | Ashland Oil Company |

## SITE LOCATION

The 10-acre site is located in a large industrial area in Tonawanda, New York. It is adjacent to the Seaway Industrial Park, another formerly utilized MED/AEC site.

## MED/AEC SITE USE

From 1943 to 1946, the site was used for disposal of uranium-processing residues from the Linde Air Products Division-Union Carbide Corporation ore refinery operations. Eight-thousand tons of residue containing approximately 0.54 percent uranium were spread over two-thirds of the site to a depth of 1 to 5 feet.

## POST MED/AEC SITE USE

In 1974, 6,000 cubic yards of residue were removed by Ashland and transported to the adjacent Seaway Industrial Park. The site was developed as an oil storage site at that time.

## RADIOLOGICAL HISTORY

A radiological survey was conducted in 1958. Following this survey, the property was released for unrestricted use without removal of the residues. A detailed survey was conducted under the FUSRAP during July and August 1976. An aerial survey was conducted in September 1979.

Results of the 1976 survey indicated that external gamma radiation exceeded applicable guidelines over fairly large areas of the site. However, the results indicated that the residues on the site "do not pose an immediate health hazard, assuming that residues remain in place and that the site continues to be used in the manner in which it is presently used." The radon daughter concentration in the onsite building is close to background level, and only small quantities of radium or uranium are carried from the site in surface runoff. Because the property is located in an industrial area, the population density surrounding the site is very low, and thus there are few people at risk. If the site use were changed and buildings constructed onsite, there could be an increase in exposure and a potential health hazard could result.

## REMEDIAL ACTION OPTION AND COSTS

Remedial action is indicated and could involve removal of approximately 48,000 cubic yards of residues and contaminated soil. The estimated cost for this remedial action is $29,000,000.

## PROJECT STATUS

A radiological survey was completed in August 1976; a final report was issued in May 1978. The Assistant Secretary for Environment has determined that the site will require remedial action. Additional authority to implement remedial action will be required.

BAYO CANYON AREA
LOS ALAMOS, NEW MEXICO

## OWNER HISTORY

1944-1967: U.S. Government
1967-Present: Los Alamos County

## SITE LOCATION

Bayo Canyon is located adjacent to the townsite of Los Alamos in north central New Mexico, about 25 miles northwest of Santa Fe. Bayo Canyon is one of many canyons cut into the Pajarito Plateau.

## MED/AEC SITE USE

Experiments with high explosives were conducted in Bayo Canyon during the period 1944 through 1961. The explosive test assemblies included natural and depleted uranium and lanthanum-140, which was used as a tracer. Strontium-90 was also present as a contaminant of the lanthanum-140. The site facilities include radiochemistry laboratories, radioactive liquid-waste disposal facilities, and solid-waste disposal facilities.

## POST MED/AEC SITE USE

The site was decommissioned in 1963. Since 1967 the canyon has been used exclusively for recreational purposes, including picnicking, trail riding, hiking, wood cutting, and pinon nut gathering. Proposed uses include residential and light commercial development.

## RADIOLOGICAL HISTORY

From 1949 through 1969, 1.355 curies of natural uranium, 1.218 curies of depleted uranium, and between 30 and 40 curies of strontium-90 were dispersed into the surface environment of the Bayo Canyon area. An additional 85 to 120 curies of strontium-90 were deposited in waste-handling facilities and some fraction migrated into the subsurface environment. Most of the activity was associated with debris that was removed in 1963, leaving a comparatively small amount of radioactivity at the surface of the site and in subsurface layers of soil. A radiological survey was conducted under the FUSRAP in 1977.

The results of this survey show that exposure of current nearby residents to airborne strontium-90 and uranium is no different than that of other northern New Mexico residents. However, dose estimates for construction workers if the area were to be developed indicate exposure levels at less than 1.5 percent of DOE guidelines. The estimated exposure of residents in the developed area would be, at most, 3 percent of DOE guidelines. Individuals presently using the area for recreational purposes receive somewhat lower exposures because of the shorter exposure period and minimal interaction with disturbed soil.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action is indicated and could take the form of stabilization of dispersed radioactivity with restrictive control over change in site use or decontamination by excavation of soil to remove radioactivity. If decontamination is performed, 3,500 cubic yards of contaminated material will be produced. The estimated cost to perform this remedial action is $2,800,000.

PROJECT STATUS

A radiological survey was completed in 1977; the final report was issued in June 1979. The Assistant Secretary for Environment has determined that the site will require remedial action. Preparation of an Engineering Evaluation Report-Title I, has been initiated. Authority to implement remedial action exists under the Atomic Energy Act of 1954, as amended.

GILMAN HALL
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

## OWNER HISTORY

University of California

## SITE LOCATION

The site is located on the Berkeley Campus of the University of California and consists of the third floor and basement of Gilman Hall.

## MED/AEC SITE USE

Laboratory facilities in Gilman Hall were used in support of the Manhattan Project and/or early AEC activities. It is believed that weapons-grade plutonium was involved.

## POST MED/AEC SITE USE

A preliminary radiological survey was completed by Lawrence Livermore Laboratory and a letter report issued in 1976. The survey was designed to document alpha contamination. However, evidence of significant cesium-137 was also found.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action is indicated and could take either one of two forms. The area could be left as is but placed under control, which would require that any future renovation and/or demolition work be performed under contamination removal and control procedures. This may require a license.

Alternatively, the area would be decontaminated by stripping away floor tile, sand blasting concrete surfaces, and removing piping. Thirty cubic yards of contaminated material would be produced. Estimated cost for this remedial action is $483,000.

## PROJECT STATUS

A preliminary radiological survey was conducted in 1976. A detailed survey will be initiated soon. The Assistant Secretary for Environment has determined that remedial action is required. Authority to implement remedial action exists under the Atomic Energy Act of 1954, as amended.

UNIVERSITY OF CHICAGO
CHICAGO, ILLINOIS

## OWNER HISTORY

The site is owned by the University of Chicago.

## SITE LOCATION

The University of Chicago buildings associated with the MED work were the New Chemistry Lab and Annex, West Stands, Ryerson Physical Lab, Eckhart Hall, Kent Chemistry Lab, Jones Lab, Ricketts Lab, and an area known as Animal Quarters. A comprehensive information search could not verify the location or even the existence of the Animal Quarters.

## MED/AEC SITE USE

The University was the site of the first successful nuclear pile and it conducted associated research required for the production of plutonium and ultimately the atomic bomb. Research was conducted under the MED and the AEC during the 1940s and 1950s.

## POST MED/AEC SITE USE

The New Chemistry Lab and Annex, the West Stands, and Ricketts Lab have been torn down. The remaining buildings are currently in use as offices, laboratories, and classrooms. Some of the laboratories are still being used for nuclear research and are under license by the NRC.

## RADIOLOGICAL HISTORY

References indicate that all of the buildings were decontaminated prior to release; however, some documentation is missing and some was inadvertently destroyed. Radiological surveys were performed during the period September 1976 to September 1977 under the FUSRAP.

Results of the 1976-1977 surveys indicate that contamination is widespread throughout the laboratories but at fairly low levels except for isolated small areas. Analysis of potential exposure conditions indicate that persons will not receive exposures exceeding current guidelines under present usage. However, remodeling or demolition activities could free fixed contamination resulting in a potential health hazard. Soil samples indicate contamination is confined to the buildings.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action may be required and could involve decontamination of the buildings involved. Seventy-five cubic yards of contaminated material would be produced. The estimated cost for this remedial action is $630,000.

## PROJECT STATUS

A radiological survey was completed in September 1977; a draft report has been issued for review. Upon issuance of the final report, the Assistant Secretary for Environment will make a determination as to whether remedial action is required. Authority to implement remedial action exists under the Atomic Energy Act of 1954, as amended.

However, as the University campus is under license by the NRC, this site would not be decontaminated under the FUSRAP program since the NRC has sufficient licensing authority to protect public health and safety.

## CHUPADERA MESA AREA
## WHITE SANDS MISSILE RANGE, NEW MEXICO

### OWNER HISTORY

The site was and continues to be private lands with multiple ownership.

### SITE LOCATION

The site is located approximately 70 miles southeast of Albuquerque, New Mexico, and immediately north of the White Sands Missile Range.

### MED/AEC SITE USE

The site area received fallout from an atomic bomb test at Trinity site in 1945.

### POST MED/AEC SITE USE

Chupadera Mesa is extensively used as grazing land. In the northern area, the land is used primarily for growing alfalfa and assorted row crops.

### RADIOLOGICAL HISTORY

The University of California, Los Angeles, conducted the first contamination survey in the 1947 to 1950 period. Thousands of soil and biological samples were obtained. Subsequently, in the 1972 to 1976 period, the Los Alamos Scientific Laboratory (LASL) collected similar samples. In 1977, LASL collected additional data around Trinity ground zero and the outlying fallout zones. The existing data are being evaluated and a radiological survey report is currently being prepared.

### REMEDIAL ACTION OPTIONS AND COSTS

It is expected that some stabilization of contamination may be required. The estimated cost is $180,000.

### PROJECT STATUS

Following the completion of the radiological survey report, the Assistant Secretary for Environment will determine whether the site requires remedial action. Work on an Engineering Evaluation Report-Title I has been initiated. Authority to implement a remedial action exists under the Atomic Energy Act of 1954, as amended.

CLECON METALS, INC.
CLEVELAND, OHIO

## OWNER HISTORY

| | |
|---|---|
| MED/AEC utilization period: | Horizons, Inc. |
| Present: | Clecon Metals, Inc. |

## SITE LOCATION

The site, encompassing approximately 3.5 acres, is located within Cleveland, Ohio, in a primarily industrial area which is sparsely populated. Two of three buildings on the site were used for processing radioactive materials.

## MED/AEC SITE USE

During the 1940s and 1950s, two buildings at the Horizons metal-handling facility were used for the production of granular thorium metal. The feed material, thorium nitrate tetrahydrate, was processed through a number of steps and ultimately converted to thorium metal by use of an electrolytic process.

## POST MED/AEC SITE USE

The plant site is currently used for the production of gaskets and for the lamination of various materials. The buildings were formerly used for processing radioactive materials, for receiving and storing nonradioactive materials, and for office space. Approximately 60 workers use these buildings.

## RADIOLOGICAL HISTORY

In December 1954, the Health and Safety Laboratory performed an air hygiene survey that revealed airborne concentrations of thorium in both buildings to be 18 to 377 times greater than the applicable guideline. A subsequent survey indicated that the contamination was either removed or covered due to construction modifications made since the thorium operations. A radiological survey was conducted under the FUSRAP during February and March 1977.

Results of the 1977 survey indicate alpha, beta, and gamma levels in excess of current guidelines in several areas of both buildings. Contamination is located mainly in storage areas, drains and under floors. Exposure is limited to a few persons for short time periods. If use of buildings changes, doses of 0.2 to 0.4 rem/year could occur.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action is indicated, and could include decontamination of building surfaces, removal of some structural elements, removal of portions of the pumping system, and excavation of soil. An estimated 800 cubic yards of contaminated material would be produced. The estimated cost for remedial action is $2,400,000.

## PROJECT STATUS

A radiological survey was conducted in February and March 1977. The final report was issued in February 1979. The Assistant Secretary for Environment has determined that the site will require remedial action. Additional authority for the ASNE to implement remedial action is required.

CONSERV INC.
NICHOLS, FLORIDA

## OWNER HISTORY

| | |
|---|---|
| 1952-1960: | Virginia-Carolina Chemical Corporation |
| 1960- : | Unidentified - changed ownership 3 times |
| Present: | Conserv Inc. |

## SITE LOCATION

The site is located at Nichols, Florida, approximately 22 miles east of Tampa. The area involved with radioactive materials is approximately 0.5 acres.

## MED/AEC SITE USE

Starting in 1952, a pilot plant was operated for the recovery of uranium from wet-process-produced phosphoric acid. This plant was disassembled in 1960. Location of equipment, tanks, piping, and building materials is unknown.

## POST MED/AEC SITE USE

| | |
|---|---|
| 1961-1968: | Phosphoric acid and other phosphate product production |
| 1969-1973: | Plant shut down |
| 1974-Present: | Phosphoric acid and other phosphate product production. The site of the former recovery plant is currently used for storage and contains a building that houses a maintenance shop, lunchroom, tool storage cage, and a small office. This building is built on the concrete pad of the former recovery plant. |

## RADIOLOGICAL HISTORY

A preliminary radiological survey, conducted in April 1977, indicated alpha, beta, and gamma contamination of the concrete pad of the former recovery plant and uranium-238 and radium-226 contamination of nearby soil. Soon after the survey, the plant operator removed approximately 4 cubic yards of contaminated soil. The soil was buried in an inactive gypsum pile located about 2,600 feet from original site and covered with 2 to 3 feet of gypsum and soil. A detailed radiological survey was conducted under the FUSRAP during December 1977.

Results of the December 1977 survey indicate contamination is primarily located in the soil around the concrete pad, on the pad outside the building, and in the area where contaminated soil was dumped. It should be noted that present site activities dealing with phosphate product production contribute significantly to elevated radiation levels at the plant site. In many areas of the plant site, the levels are unrelated to the former MED/AEC activities. No significant health hazard currently exists, principally because of infrequent occupancy. However, if the site use were changed to crop production or if a new building were constructed over the areas of higher contamination, exposures exceeding the guidelines could result.

## REMEDIAL ACTION OPTIONS AND COST

Remedial action is indicated and could involve excavation of contaminated soils near the concrete pad and in the area of dumping of previously excavated soil. Cleaning and/or removal of the concrete pad may be required. One-hundred-thirty cubic yards

of contaminated material would be produced. The estimated cost for this remedial action is $660,000.

## PROJECT STATUS

A radiological survey was completed during December 1977; the final report was issued in February 1979. The Assistant Secretary for Environment has determined that the site will require remedial action. Additional authority to implement remedial action will be required.

## E. I. du PONT de NEMOURS AND COMPANY - CHAMBERS WORKS
## DEEPWATER, NEW JERSEY

### OWNER HISTORY

The site is owned and operated by the E. I. du Pont de Nemours Company.

### SITE LOCATION

The 700-acre Chambers Works site is located adjacent to the residential communities of Deepwater, Pennsville, and Penns Grove, New Jersey. Within this site, operations involving MED/AEC activities were confined to four locations. These were three buildings and a radioactive material burial facility.

### MED/AEC SITE USE

The du Pont operations for the MED included development of a process for converting uranium oxide to uranium tetrafluoride, production of uranium peroxide from the MED scraps, production of uranium tetrafluoride, uranium metal, uranium hexafluoride, and various related research activities. Such activities took place during the period 1942 through 1947. Decontamination and radiological survey activities took place during 1948. The last portion of the site used for the MED was released to du Pont in December 1948.

### POST MED/AEC SITE USE

Of the three buildings involved in the MED activities, two have been demolished and one is still in use as a warehouse. A parking lot has been constructed on the site of one of the demolished buildings and a new building constructed at the site of the other. The radioactive material burial facility, which is approved by the State of New Jersey, possibly contains a few pieces of equipment from the demolished buildings.

### RADIOLOGICAL HISTORY

In 1948, all contaminated equipment was removed from the site. Building decontamination, conducted under the direction of the AEC, included sandblasting, vacuuming, and washing of all building surfaces. A radiation survey was made by the Health Division of the AEC and the buildings were subseqently released to du Pont. A radiological survey was conducted under the FUSRAP during March 1977.

Results of the 1977 survey indicate that elevated concentrations of uranium were found in residues from the operations building and in some surface and subsurface soil samples. Alpha and beta-gamma contamination levels in some areas of the operations buildings were above the limits of current Federal guidelines. Under current conditions of site use, this contamination does not cause employees working at the site to receive radiation exposures appreciably different from those due to background radiation. However, under different conditions of use (i.e., use of contaminated soils for growing crops or actions which involve agitation or abrasion of dry contaminated surfaces), potential radiation exposures to employees and the public could result.

### REMEDIAL ACTION OPTIONS AND COSTS

Remedial action is indicated and could involve decontamination of building surfaces and excavation of soil. Twenty-seven-hundred cubic yards of contaminated material would be produced. The estimated cost for this remedial action is $3,000,000.

PROJECT STATUS

A radiological survey was completed in March 1977; the final report was issued in December 1978. The Assistant Secretary for Environment has determined that the site will require remedial action. Authority to implement remedial action exists under the Atomic Energy Act of 1954, as amended.

GARDINIER INCORPORATED
TAMPA, FLORIDA

## OWNER HISTORY

| | |
|---|---|
| 1951-1962: | Tennessee Corporation, U.S. Phosphoric Products Division |
| 1963-1973: | Cities Service Company |
| 1974-Present: | Gardinier, Incorporated |

## SITE LOCATION

The formerly utilized site, consisting of approximately 1.5 acres, is located within the Gardinier phosphoric acid production plant boundaries in Tampa, Florida.

## MED/AEC SITE USE

During the period 1951 to 1960, Tennessee Corporation extracted uranium from phosphoric acid. This process consisted of (1) pretreatment of wet-process phosphoric acid, (2) solvent extraction of uranium, (3) precipitation of the uranium product, (4) drying and crushing, and (5) handling, packaging, and shipping. Pilot operations were carried out from 1951 through 1954 and the process plant was operated from 1956 through 1960.

## POST MED/AEC SITE USE

A three-story building which housed the process plant is currently used as a workshop, lunchroom, office space, and as a storage area for equipment remaining from the uranium-recovery operations. A former pilot plant building is currently used as office space. Approximately 30 employees use these buildings. A new uranium recovery pilot operation is conducted on the site, which operation is currently licensed by the State of Florida. This license does not cover the MED/AEC material.

## RADIOLOGICAL HISTORY

A radiation survey was conducted under the FUSRAP by Oak Ridge National Laboratory during December 1977. Some contaminated equipment was removed following the survey and transported to a licensed site.

Results of the 1977 survey indicate only slight contamination of the former pilot plant building, significant contamination of the former process building, and significant contamination of adjacent outdoor areas. Various measurements of alpha, beta, and gamma activity exceed current guidelines throughout the former process building. Highest levels of contamination were found on the second floor and are associated with stored equipment which was used in the uranium recovery process. External gamma levels measured outdoors also exceed guidelines and appear to be associated with radium-226, which has plated out in buried pipes and vessels.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action is indicated and could involve removal of stored equipment, excavation of soil and buried pipes and tanks, and decontamination of structures. Two-thousand cubic yards of contaminated material would be produced. The estimated cost for this remedial action is $2,300,000.

## PROJECT STATUS

A radiological survey was performed in December 1977; a draft of the final report is currently under review. The Assistant Secretary for Environment has determined that the site will require remedial action. Additional authority is needed for the implementation of remedial action.

W. R. GRACE & COMPANY
CURTIS BAY, MARYLAND

## OWNER HISTORY

This was and continues to be private land under the ownership of W. R. Grace & Company.

## SITE LOCATION

The site consists of 4 acres of land at the Davison Division of W. R. Grace & Company at Curtis Bay, Maryland.

## MED/AEC SITE USE

In late 1956 and early 1957, W. R. Grace assumed the license and contract of Rare Earths, Inc., to process, transfer, and use the radioactive material thorium. The thorium was shipped to Davison as a component of monazite sand. Title to the monazite and the thorium remained with the government during the performance of the work. The monazite sand was processed to remove the thorium which was shipped to GSA. Residue from the process was collected in dumpsters and emptied in a designated area of the onsite dump. The processing plant was never completed and the project was abandoned in 1957.

## POST MED/AEC SITE USE

The site is presently unoccupied, untraversed, remote, and within the fenced enclosure surrounding the entire plant but not separately enclosed.

## RADIOLOGICAL HISTORY

Radiation Management Corporation conducted a survey in 1978 to measure external radiation levels and investigate the possible migration of radioactive material from the deposit site.

It is estimated that the total volume of waste material possibly contaminated with monazite residue is 504,000 cubic feet in one location and 200,000 cubic feet in a second. There is no apparent indication of migration from the burial area. It is unclear whether or not the waste material exceeds 0.05 percent $ThO_2$. Surface radiation levels ranged from background levels to 17 mr/hr. Analysis of plant material indicated no detectable thorium daughter products. Core samples indicated thorium concentrations of $6.2 \pm 0.9$ pCi/gm at a depth of 5 feet and $97 \pm 10$ pCi/gm at 15 feet. The results assumed thorium in equilibrium with its daughters. Institutional control measures have been instituted to limit access to the disposal site.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action may be required and could involve excavation of contaminated soils and restoration. An estimated 26,000 cubic yards of contaminated material would be produced. The estimated cost for this remedial action is $17,000,000.

## PROJECT STATUS

A detailed radiological survey is scheduled for 1980. Upon completion of this survey, the Assistant Secretary for Environment will determine if remedial action is required. Determination of whether additional authority is required to implement remedial action is currently underway.

## GUTERL SPECIAL STEEL CORPORATION
## LOCKPORT, NEW YORK

### OWNER HISTORY

| | |
|---|---|
| MED/AEC utilization period: | Simonds Saw & Steel Company |
| Present: | Guterl Special Steel Corporation, Simonds Steel Division |

### SITE LOCATION

The plant site is located in an industrial area of Lockport, New York. The formerly utilized site consists of the rolling mill building, the forging shop building, and the area immediately surrounding these buildings. The area involved is approximately 4 acres.

### MED/AEC SITE USE

| | |
|---|---|
| 1948-1956 | Rolling mill operations of uranium and thorium metal; operations included weighing, heating, rolling, shearing, and quenching. |

### POST MED/AEC SITE USE

| | |
|---|---|
| 1957-Present: | Rolling mill operations of nonradioactive metals; approximately 50 persons currently work in the buildings formerly involved with radioactive materials. |

### RADIOLOGICAL HISTORY

During all operations from 1948 through 1956, the AEC was responsible for radiological monitoring and safety. Residue from the operation was returned to the AEC or National Lead of Ohio. Protective measures included the use of hoods and dust-collection equipment over the 16-inch rolling mill stands and pans in the mill pits to collect material. A radiological survey performed during November 1958 indicated highest radiation levels in the quench tank area. Decontamination was performed and consisted of removing the quench tank, covering this area with steel plate, and washing and vacuuming other areas. A resurvey was conducted in December 1958 to verify decontamination actions. A radiological survey was conducted under the FUSRAP during October 1976.

Results of the 1976 survey indicate that only small accessible areas of contamination in the rolling mill building exceed present exposure guidelines. Other areas, particularly the former quench tank, have significantly high contamination levels but do not presently contribute greatly to exposure because of inplace shielding in the form of steel plates. Under current conditions of site use, this contamination does not cause employees working at the site to receive radiation exposure appreciably different than those due to background. However, under different conditions of site use (i.e., removal of steel plates, disturbance of soil or soil floors in buildings), potential exposure to employees and the public could result.

### REMEDIAL ACTION OPTIONS AND COSTS

Remedial action is indicated and could involve excavation of outdoor soil, indoor soil floors, removal of some equipment, and cleaning of structures. Three-hundred-fifty cubic yards of contaminated material would be produced. The estimated cost for this remedial action is $1,100,000.

PROJECT STATUS

A radiological survey was completed during October 1976; the final report was issued in November 1979. The Assistant Secretary for Environment has determined that the site will require remedial action. Additional authority to implement remedial action will be required.

HARSHAW CHEMICAL COMPANY
CLEVELAND, OHIO

## OWNER HISTORY

The site has been and is currently owned by Harshaw Chemical Company.

## SITE LOCATION

The site is located within Cleveland, Ohio, and consists of three buildings and surrounding areas.

## MED/AEC SITE USE

In September 1942, the MED contracted with Harshaw for the production of green salt ($UF_4$). This work was a continuation of smaller scale work performed for the Office of Scientific Research and Development. In 1943, Harshaw also began production of uranium hexafluoride, an operation that was substantially expanded in 1947. Another MED/AEC contract involved the production of uranium tetrachloride and uranium oxyfluoride. Building G1 (Plant C) was used for the $UF_6$ production and the foundry building was used for the $UF_4$ production. Analytical work was performed in building K1. Equipment and material from the MED/AEC operations was apparently stored in those and other buildings at the site. In 1960, the facility was released to the Harshaw Chemical Company from AEC control.

## POST MED/AEC SITE USE

Building G1 is presently being used primarily as a storage warehouse, but it does contain some chemical production operations including the drying of fluorspar. The building is normally occupied by fewer than 10 people and contains a locker room area on the second floor which is used by employees working at another building on the Harshaw site. Additional personnel are present only during use of the locker room and transfer of material in and out of storage. A 60- by 200-foot addition was constructed on the north side of the building after the MED/AEC use of the facility was terminated. This addition is used for storing fluorspar.

## RADIOLOGICAL HISTORY

This site was visited by the AEC personnel on October 27 and 28, 1953, to survey the equipment and buildings for contamination and to provide the necessary actions prior to the return of the building to the contractor. A meeting with representatives from the Harshaw Chemical Company was held, and a decontamination program was agreed to. The actions taken as a result of this visit are unknown.

Another survey was conducted on November 21, 1957, by the Research and Development Division, Oak Ridge, Tennessee. The purpose of this survey was to locate any areas where residual contamination was of such magnitude that it might represent a potential radiation or contamination control problem that would require the imposition of restrictions on the use of the building. At the time of this survey, all equipment had been removed except for the Rockwell furnace, two denitration pots, and some process vessels in the recovery area. The report of this survey identified contaminated areas with recommended methods for decontamination. A supplemental agreement assigned the responsibility to the contractor for decontaminating all equipment transferred to it and for decontaminating its own premises used in the performance of the contract. Further, the decontamination effort was to be

accomplished in accordance with the recommendations contained in the report of survey. The building was released from further AEC control in 1960.

A radiation survey of the building at Harshaw was performed in May 1976 by the Chicago Operations Office to identify previously utilized MED/AEC sites. During this survey, three soil samples were taken in the area adjacent to the building. These soil samples showed readings greater than normally expected. A draft of the radiation survey report was furnished to the Harshaw Chemical Company on July 8, 1976. The results of the survey showed residual contamination remained at the building.

Soil corings were taken by the Argonne National Laboratory at selected locations around the Harshaw complex on November 10, 1976. A draft of this soil survey report was transmitted to the DOE Headquarters with a recommendation that the survey be extended. The DOE Headquarters concurred with the recommendations, and additional survey work was accomplished between August and September 1979, including an annual radiometric survey. Preliminary results indicate that there is general deposition of contamination throughout the site and it may extend beyond the Harshaw site boundary.

Based on the completed preliminary surveys, the contamination is at an acceptable level and does not represent a hazard to Harshaw personnel. However, if modifications, remodeling, cleanup, or other structural changes were to be undertaken, radioactive material now fixed in the structure could be released and lead to airborne contamination. Harshaw has indicated that they would contact the DOE prior to any such actions. Likewise, no health hazard is envisioned from the contaminated soil in its present status.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action may be required and could involve excavation of soil, decontamination of the building, and excavation of a portion of the Cuyahoga River. Ninety-two-hundred cubic yards of contaminated material would be produced. The estimated cost for this remedial action is $9,000,000.

## PROJECT STATUS

Upon completion of the currently initiated radiological survey, the Assistant Secretary for Environment will determine whether remedial action will be required. Additional authority to implement remedial action is required.

IOWA STATE UNIVERSITY
AMES, IOWA

## OWNER HISTORY

The site has been and is currently owned by Iowa State University. Additional areas that have become contaminated by activities at the University site are owned by the Municipality of Ames, Iowa.

## SITE LOCATION

Four buildings on the University campus at Ames were used for the MED/AEC activities. Three additional areas have become involved because of disposal of contaminated sewage sludge. The areas are the Ames Iowa Municipal Airport, the Grand Avenue underpass, and the Ames Municipal Cemetery.

## MED/AEC SITE USE

Early MED/AEC activities were concerned with metallurgical research, fundamental chemical and analytical research, and the development of processes to produce pure uranium and other materials. During the 1942 period, the small-scale production in the physical chemistry laboratory furnished about 2 tons of uranium for use as heart metal in the first chain-reacting pile in Chicago. About 2 million pounds of virgin uranium were produced up to January 1, 1945, at which time production at Ames was discontinued. A recovery process developed at Ames resulted in the recovery of over 600,000 pounds of metal from scrap supplied by all of the MED sites. This operation was discontinued in December 1945. In 1947, the project at Ames was declared a major research facility and a program to produce thorium metal was initiated. Prior to 1947, approximately 4,500 pounds of thorium had been produced. Approximately 65 tons were produced in total.

## RADIOLOGICAL HISTORY

Between July 1951 and August 1952, filtrates containing thorium and mesothorium were released into the sewage lines. Water-removal operations at the Water Pollution Control Plant produced a dry sludge cake that contained much of the released thorium and mesothorium (less than 1 curie). This sludge cake was collected and held at the west end of the drying beds at the Water Pollution Control Plant. In accordance with AEC recommendations, the sewage sludge cake containing mesothorium was placed on the City of Ames Municipal Airport grass runway, the Municipal Cemetery, and the grass areas of the Grand Avenue underpass.

An initial radiation survey was conducted on May 12, 1976, at the Municipal Airport of Ames, the Municipal Cemetery, the Grand Avenue underpass, and the site of buildings on the Iowa State University campus. Based on preliminary results of this survey and subsequent surveys, minor contamination of some land does exist. The Municipal Cemetery and the Grand Avenue underpass show no significant contamination. There was no discernible radiation different from the background level at the sites of Chemistry Annexes I and II. A single area in a taxi strip at the Municipal Airport shows some thorium contamination. The area west of the sludge beds at the Water Pollution Control Plant shows thorium contamination in a "ditch" area (approximately 6 times background) and a more generalized area (up to 2 times background).

None of the areas surveyed have contamination that will have a significant impact on the health of the public under current site usage. However, change of site usage could result in undesirable exposure.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action may be required and could involve excavation of contaminated soils and decontamination of building floors and surfaces. Sixty cubic yards of contaminated material would be produced. The estimated cost is $570,000.

## PROJECT STATUS

A complete radiological survey was completed in FY 1980 and a report is in preparation. Upon completion of the report, a determination will be made as to whether remedial action is required. Additional authority to implement remedial action is required.

KELLEX RESEARCH FACILITY
JERSEY CITY, NEW JERSEY

## OWNER HISTORY

| | |
|---|---|
| 1942-1951: | Kellex Corporation |
| 1951- : | Vitro Corporation of America |
| Current: | Delco-Levco and Pierpont Associates |

## SITE LOCATION

The Kellex research facility activities were conducted in one building located on the site of the M. W. Kellogg Company property in Jersey City, New Jersey.

## MED/AEC SITE USE

The Kellex Corporation was established by the M. W. Kellogg Company in 1943 in order to design and construct the first gaseous diffusion plant for uranium enrichment. The work continued to July 1952 and included research and development of purex reprocessing for spent fuel and component testing with uranium hexafluoride.

## POST MED/AEC SITE USE

The Kellex buildings were demolished around 1953 and only the concrete slab floor remains. The original area of the Kellogg facilities has been subdivided and is currently being developed as commercial properties. A supermarket and other stores have been constructed on part of the property. The location of the former Kellex building is presently unused and is owned by Pierpont Associates.

## RADIOLOGICAL HISTORY

In 1953, the Vitro Corporation of America prepared a contamination status report that detailed the findings of a radiation survey of the former Kellex building. This report indicated that most external gamma radiation readings were less than 100 microroentgens per hour, and no transferable alpha or beta-gamma contamination was observed in any of the accessible areas.

Representatives from Oak Ridge Operations and ORNL conducted a site visit and exploratory survey of the Kellex site on October 21, 1976. The survey revealed gamma ray readings in the 5- to 6-microroentgen per hour range (background). However, due to the size of the property and uncertainty as to the exact location and extent of Kellex operations, it was decided that a formal survey should be conducted. A radiological survey was conducted under the FUSRAP by ORNL during March 1977.

Results of the 1977 radiological survey indicate that the radiation and radioactive levels were indistinguishable from background levels with the exception of a few isolated and well defined spots on or near the site of the former Kellex Laboratory.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action was indicated and work was started on the site in July 1979. During the remedial action, additional contamination was discovered and the decontamination effort extended to cover the additional areas. This additional work has since been suspended in order to evaluate results in the context of the criteria appropriate to the intended use of the site. The estimated cost for remedial action is $1,400,000.

PROJECT STATUS

A radiological survey was completed in March 1977; a draft of the final report, dated September 1977, has been prepared. The Assistant Secretary for Environment has determined that remedial action is required. Remedial action is underway. Authority for completing the remedial action exists under the Atomic Energy Act of 1954, as amended.

## LAKE ONTARIO ORDNANCE WORKS ASSOCIATED PROPERTIES
## LEWISTON, NEW YORK

### OWNER HISTORY

| | |
|---|---|
| 1944-1955: | U.S. Government |
| 1955-Present: | Private |

In 1948, the AEC acquired approximately 1,511 acres of the former Lake Ontario Ordnance Works (LOOW) from the Army. In 1955, the AEC declared 1,298 acres excess and, as of 1968, this acreage had been acquired by the town of Lewiston (89 acres), Fort Conti Corporation (642 acres), Mr. M. W. Frank (199 acres), Niagara Mohawk Power Company (5 acres), The Somerset Group, Inc. (133 acres), and the Air Force (230 acres). In 1975, the ERDA declared a 22-acre sewage plant excess and transferred this plot to the town of Lewiston, New York, leaving 191 acres under DOE control.

### SITE LOCATION

The DOE storage site currently consists of 191 acres and is located about 3 miles southeast of Youngstown, 3 miles northeast of Lewiston, and 7 miles north of the City of Niagara Falls in the County of Niagara Falls, New York. However, that portion of LOOW that was declared excess by the AEC and contains residual radioactive material above background, is considered the FUSRAP site.

### MED/AEC SITE USE

This site was a portion of the former LOOW and was first used by the MED in 1944 for the storage of radioactive low-grade pitchblende residues from the nearby Tonawanda refinery. Following World War II, contaminated materials from wartime plants and some post-wartime operations were stored at the site. After April 1, 1949, part of the high-grade pitchblende residues from the St. Louis refinery were stored at the site in drums, and subsequently transferred to the 165-foot high concrete silo. In the early 1950s, the site was used as an interim storage site for incoming and outgoing uranium billets. In addition, radioactive materials from the University of Rochester and Knolls Atomic Power Laboratory (KAPL) were transferred to this storage site. The KAPL wastes were later transferred to the Oak Ridge National Laboratory burial grounds.

In about 1953, the AEC operated a boron isotope separation plant at the site. The plant was placed on standby in 1958 and was restarted in 1964 and again put on standby in July 1974.

### POST MED/AEC SITE USE

The DOE site is currently dormant and the National Lead Company of Ohio (NLO) is under contract to act as caretaker. The 191 acres of this site that remain under DOE control constitute a DOE Surplus Facility. However, in 1958, at the termination of ore procurement contracts, 25-year-storage lease agreements were negotiated with African Metals Corporation (Afrimet), the U.S. subsidiary of Union Miniere du Haut Katanga of Brussels, Belgium (owner and supplier of Belgian Congo ore), for the storage of its residues in four concrete structures on the site. Approximately 60 percent (12,000 tons) of the radioactive residues stored at the site belong to Afrimet. These storage lease agreements expire on July 1, 1983.

## RADIOLOGICAL HISTORY

In October 1970 and June 1971, radioactive surveys of the 1,298 acres formerly held by the AEC showed that about 6.5 acres exceeded the AEC criteria of 50 microroentgen per hour including background. Decontamination was carried out in 1972 and involved the removal of about 15,000 to 20,000 cubic yards of radioactive soil and debris. This contaminated material was piled on the remaining 191-acre AEC site. A final radiation survey conducted in June 1972 indicated that only a few portions of the central drainage and Sixmile Creek exceeded the 50 microroentgen per hour criteria, and beta-gamma levels measured at contact were less than 0.2 mrad/hr.

For a number of years, NLO has periodically sampled and analyzed the groundwaters and surface waters on and around the site. No significant radioactivity has been found in surface waters, and radium-226 and uranium concentrations in well samples are substantially below levels specified in guidelines for water in uncontrolled areas. In August 1978, the DOE Environmental Measurements Laboratory began offsite radon monitoring, both indoors and outdoors, to supplement the site fence-line monitoring conducted by NLO. To date, the average concentrations in residences neighboring the DOE site are within the range of indoor concentrations found in New York City and its suburbs.

## REMEDIAL ACTION OPTIONS AND COSTS

The DOE is evaluating a number of options for long-term disposition of the residue at this site. In the interim, temporary remedial measures to minimize emanation of radon from the residues are being instituted and the monitoring program is being expanded. Further remedial action may be required. Preliminary estimates of cost are approximately $3,000,000.

## PROJECT STATUS

A detailed radiological survey under the FUSRAP is underway. Remedial action to remove residual contamination from drainage areas and steps to prevent further offsite transport will be initiated during FY 1980. Authority to implement remedial action exists under the Atomic Energy Act of 1954, as amended.

LINDE AIR PRODUCTS DIVISION
TONAWANDA, NEW YORK

## OWNER HISTORY

Union Carbide Corporation - Linde Air Products Division

## SITE LOCATION

The site, which contains approximately 55 acres, is located in a partially industrialized area of Tonawanda, New York. Five buildings on this site were involved in the MED activities.

## MED/AEC SITE USE

The Linde Division was under contract with the MED to perform uranium separations during the period from 1942 through approximately 1948. Uranium oxide ($UO_2$) was produced from ores received from Colorado and the Belgian Congo and then converted to uranium tetrafluoride. All buildings involved in the MED activities were transferred back to Linde Division in 1953.

## POST MED/AEC SITE USE

Four of the five buildings involved are presently being used for either warehousing, fabrication facilities, research laboratories, or offices. Approximately 50 employees utilize these four buildings. The fifth building is presently not being used.

## RADIOLOGICAL HISTORY

A radiation survey was conducted by the AEC Health and Safety Division-NYO in November 1952 to determine disposition of equipment used in the uranium operations. All equipment was removed and decontamination took place in 1953. A radiological survey was conducted under the FUSRAP during October and November 1976. As a result of findings of this survey, Linde applied for and received an amendment to its New York State license to include the contaminated building.

## REMEDIAL ACTION OPTIONS AND COST

Remedial action is indicated and could involve extensive decontamination of buildings, excavation of soils under building floors and outdoors, and cleanup of streams and ditches onsite. Fifty-thousand cubic yards of contaminated material would be produced. Estimated cost for this remedial action is $35,000,000.

## PROJECT STATUS

A radiological survey was completed during October and November 1976. The final report was issued in May 1978. The Assistant Secretary for Environment has determined that the site will require remedial action. However, additional radiological work is required to develop engineering plans. Authority to implement remedial action exists under the Atomic Energy Act of 1954, as amended.

MALLINCKRODT, INC.
ST. LOUIS, MISSOURI

## OWNER HISTORY

The site has been and is currently owned and operated by Mallinckrodt, Inc., formerly named Mallinckrodt Chemical Works.

## SITE LOCATION

Mallinckrodt leased portions of two locations in St. Louis at Broadway Street and at Destrehan Street to the MED/AEC for the processing of uranium concentrate. About 20 existing buildings on the Mallinckrodt property at Broadway and Destrehan, plus their surroundings, were subject to radiological contamination.

## MED/AEC SITE USE

In April 1942, Mallinckrodt Chemical Works was requested by the Army to set up an industrial-scale process to produce uranium dioxide and uranium trioxide. Mallinckrodt had the processing system operating by early summer 1942 and provided uranium compounds and uranium metal for use in the research, development, and production programs of the AEC. Work also included (1) production of uranium tetrafluoride ($UF_4$), (2) production of uranium derby metal (vacuum recast of purified ingot metal), (3) machining of uranium metal rods for reactor fuel slugs, (4) reversion of uranium tetrafluoride to $UO_2$ or $U_3O_8$, (5) recovery of scrap uranium metal, (6) production of $UO_2F_2$, (7) extraction and concentration of thorium-230 from pitchblende raffinate, and (8) experimental processing of very low enrichment $UF_4$. From 1942 through 1945, uranium processing was done exclusively at the Broadway Street location. Some uranium metallurgical research continued through 1956. From 1945 to 1957, uranium ore or concentrate was processed in buildings at the Destrehan Street location. In 1957, all operations at Destrehan were terminated.

## POST MED/AEC SITE USE

Since 1962, the site has been used for various commercial chemical production operations. Some of the original buildings have been torn down, some are being used as warehouses, and new buildings have been constructed. Columbian-Tantalum ore and potassium compounds are stored onsite.

## RADIOLOGICAL HISTORY

From 1948 to 1950, the main plant property was decontaminated and final contamination surveys were performed. In 1951, the main plant property was returned to Mallinckrodt for unrestricted use. Between 1957 and 1962, the Destrehan and Broadway Street properties were also decontaminated, surveyed, and released for unrestricted use. In the process, some of the buildings were removed to the AEC waste disposal sites. Contaminated earth was also removed and backfilled. Early in the program, decontamination procedures were supervised by the New York Operations Office of AEC and later by the Oak Ridge Operations Office. The AEC decontamination activities did not reduce radioactivity levels to background but reduced them only to the prevailing acceptable levels at that time. A new radiological survey of the former uranium processing areas was conducted under the FUSRAP during the summer of 1977.

Results of the 1977 survey indicate alpha and beta-gamma contamination levels inside and outside some of the buildings were above limits set by current Federal guidelines

concerning the release of property for unrestricted use. Elevated external gamma radiation levels were measured at some outdoor locations and in some of the buildings. Quantities of uranium in an amount that may require licensing were found in soil at some places, and the concentration of uranium in one water sample taken from an old waste pit was in excess of Federal water quality standards stated in 10 CFR 20. Radon and radon daughter concentrations in three buildings were in excess of current Federal guidelines for nonoccupational radiation exposure.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action is indicated and could involve extensive excavation of contaminated soil and decontamination of buildings including removal of structural elements. Forty-nine-thousand cubic yards of contaminated material would be produced. Estimated cost for this remedial action is $26,000,000.

## PROJECT STATUS

A radiological survey was completed in 1977, a draft report has been completed, and the final report is being prepared. The Assistant Secretary for Environment has determined that the site will require remedial action. Additional authority is needed to implement remedial action.

MIDDLESEX MUNICIPAL LANDFILL
MIDDLESEX, NEW JERSEY

OWNER HISTORY

Pre 1961: Borough of Middlesex
Post 1961: Borough of Middlesex and Middlesex Presbyterian Church (5 acres)

SITE LOCATION

The site is located in the Borough of Middlesex, New Jersey, approximately 35 miles northeast of Trenton. The contaminated area covers about 3 acres.

MED/AEC SITE USE

This area is a former landfill for the Borough of Middlesex. The landfill was used by the Middlesex Sampling plant for disposal of nonradioactive wastes. However, during the operation of the sampling plant, some contaminated wastes were shipped to the landfill. There is no documented material to indicate when the contamination of the landfill occurred; however, a review of operating files from 1946 to 1966 indicates that the most probable time frame was between November 1947 and October 1948. Construction of a drainage ditch and paved storage area took place during this period. It is believed that the material deposited at the landfill may have resulted from this construction effort.

POST MED/AEC SITE USE

The contaminated area is currently undeveloped and not used for any activity.

RADIOLOGICAL HISTORY

In May 1960, during a local civil defense (CD) exercise, CD monitors detected elevated radiation levels in the landfill. The matter came to public attention and received newspaper coverage. The AEC noted the issue and upon reviewing its past local activities concluded that AEC operations were the source. Upon analytical confirmation of the presence of pitchblende, a further survey of the area was made. Readings taken at that time confirmed gamma radiation levels 20 to 50 times background over a fairly consolidated area of less than one-half acre.

Following meetings with local officials in November 1960 to discuss the significance of survey findings and to offer remedial assistance, the AEC removed the part of the material nearest the surface (about 650 cubic yards). The area was covered with about 2 feet of clean dirt sufficient to shield surface radiation levels to about 50 microroentgens per hr at 1 meter. The contaminated soil was removed to the AEC New Brunswick Laboratory site. Upon receiving assurance by the AEC that no health hazard existed, Borough officials agreed that the situation was satisfactory. No official record of the residual contamination exists in available Borough records. On January 30, 1974, another meeting was held with Borough officials to request permission to resurvey the involved area to permit re-evaluation of current conditions. Location of the suspect area was confirmed by survey data; it was in the area of the boundary between the church and Borough properties. The Oak Ridge National Laboratory has conducted additional survey and assessment work during 1978. During the period May 20-27, 1978, EG&G (a DOE contractor) performed an aerial survey of Middlesex. The survey produced no new conclusions related to the landfill.

As a result of the survey findings, the following conclusions were made:

- The contaminated area in its present configuration and use presents no significant radiation exposure potential to the public. This should be the case as long as the area is undisturbed by excavation or the construction of habitable enclosures.

- The exposure of individuals at or exceeding guide levels cannot be convincingly dismissed as a credible possibility under circumstances which could exist if the area were developed in the future with residences or other habitable structures.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action is indicated. In April 1978, an engineering evaluation and environmental analysis was completed of options for various remedial actions at this site. The options range from stabilization of the material onsite to removal of all material to background radiation levels and backfilling to present condition with clean fill. Based upon the engineering evaluation of the site, it is estimated that the original 6,500 cubic yards of contaminated soil from the sampling plant have now been dispersed with other soil and landfill debris. The contaminated portion involves a volume of between 34,000 to 69,000 cubic yards of soil. There has been additional sanitary landfill activity since the radioactivity was dispersed in the landfill. An estimated 16,000 to 21,000 cubic yards of nonradioactive soil and debris currently cover the contaminated soils. The estimated cost for the removal and backfill remedial action is $50,000,000.

## PROJECT STATUS

Radiological surveys have been completed. An engineering evaluation report was issued in April 1979 and an environmental analysis was issued in July 1979. The Assistant Secretary for Environment has determined that the site will require remedial action. Authority to implement remedial action exists under the Atomic Energy Act of 1954, as amended.

MIDDLESEX SAMPLING PLANT
MIDDLESEX, NEW JERSEY

## OWNER HISTORY

1943-1950: American Marietta Company
1950-Present: U.S. Government

## SITE LOCATION

The site is located in Middlesex, New Jersey, and contains six buildings on 9.6 acres. Some portions of the adjacent and nearby properties, especially along the south border, have significantly contaminated soil. Two nonadjacent private properties have also been identified as having contaminated soil from the Middlesex Sampling Plant: the Our Lady of Mount Virgin Catholic Church at 650 Harris Avenue, Middlesex, New Jersey, and the private residence at 432 Williams Street, Piscataway, New Jersey.

## MED/AEC SITE USE

This facility, also known as Perry's Warehouse, was used for the sampling, weighing, assaying, and storage of uranium and thorium ores. The uranium sampling operations were conducted between November 1943 and February 1955. The bulk of the Belgian Congo uranium ores and other uranium ores used by the United States were handled at this site. The residue from the processing of these ores was temporarily stored at Middlesex prior to its return to the vendor. There are indications that the site was also used as an interim holding site for disposition of various research-related and decontamination wastes. Following the termination of the uranium-sampling operations, the primary AEC activities at the plant involved the sampling and storage of thorium materials and residue. All AEC activities at the site terminated in September 1967 with the conclusion of the decontamination of the site and certification of the site for unrestricted disposal.

## POST MED/AEC SITE USE

The site was used by the U.S. Marine Corps for their 6th Motor Transport Battalion reserve training from 1969 to approximately 1975. The site is presently in the custodial care of the DOE. Access is restricted by a 7-foot-high chain-link fence.

## RADIOLOGICAL HISTORY

Prior to 1967, the AEC contracted Isotopes, Inc., to decontaminate the site. The AEC Health and Nuclear Safety Branch performed a follow-up survey and additional decontamination. Upon completion of this decontamination on September 2, 1967, Oak Ridge Operations certified the site for unrestricted disposal. Decontamination required sandblasting, vacuuming, detergent and acid washing, concrete chipping, equipment removal, and in cases of severe contamination, building member removal. Waste was transported by rail to a Nuclear Fuel Services licensed burial site at West Valley, New York. A radiological survey was completed under the FUSRAP in May 1976.

Results of the 1976 survey indicate surface contamination levels on the former plant site exceed the Nuclear Regulatory Commission guidelines, and radon concentration levels exceed the nonoccupational maximum permissible concentration (10 CFR 20) in some structures. These results indicate the possible need for extensive radon and radon daughter measurements in structures both onsite and offsite over periods as recommended in 10 CFR 712 for structures in Grand Junction, Colorado. As a result

of an aerial survey conducted by EG&G for the DOE between May 20 and May 27, 1976, and followup ground surveys by ORNL, two additional properties were identified that were contaminated by material handled at the Sampling Plant.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action is indicated and could involve excavation of soil at the site and adjacent and nearby properties, and removal of buildings and equipment from the sampling plant site. The DOE has proposed a two-stage remedial action at this site and is in the process of obtaining local government and owner approval. The plan would entail the cleanup of all offsite contaminated property and interim storage of the contaminated material onsite until a disposal site is identified at which time the entire site would be decontaminated. Seventy-seven-hundred cubic yards of contaminated materials would be produced. Estimated cost for this remedial action is $48,000,000.

## PROJECT STATUS

A radiological survey was performed in May 1976. The final report was issued in November 1977. Additional offsite survey work is being conducted. The Assistant Secretary for Environment has determined that remedial action is required. An engineering evaluation report (Title I) and an environmental analysis report were issued in July 1979. The DOE has drafted preliminary remedial action plans that schedule the remedial action to begin in FY 1980 and a cooperative agreement between the DOE, the Borough of Middlesex, and the State of New Jersey was signed in December 1979. In addition, the NEPA process has been completed for remedial actions at the Williams Street and Catholic Church properties and proposed remedial actions have been approved (September 1979). Authority exists for implementation under the Atomic Energy Act of 1954, as amended.

NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

## OWNER HISTORY

The property is owned by the State of Illinois.

## SITE LOCATION

The armory is located at 52nd Street and Cottage Grove Avenue, Chicago, Illinois.

## MED/AEC SITE USE

During the MED/AEC era, uranium was apparently used at the site and it is believed that some type of uranium processing was performed. Personnel recall that the grandstand surrounding the arena was used for storage of radioactive materials. The use of the arena may have involved the chemical processing and metal casting of uranium. Use of the facility was terminated in 1951.

## POST MED/AEC SITE USE

Contaminated dirt from the arena was removed and at a later date additional dirt removed and replaced with a concrete pad. It is currently in use as offices, classrooms, and as storage and garage areas.

## RADIOLOGICAL HISTORY

A survey was conducted under the FUSRAP during September and October 1978. Surface contamination was found in 10 of over 160 rooms in the armory. Contamination was generally in small localized spots except for Room 1 where it was widespread. The highest alpha contamination was $5x10^4$ dis/min/$100cm^2$ and the highest beta-gamma was $3.5x10^3$ dis/min/$100cm^2$. Contamination was also observed in catch basins in a number of rooms. Air samples indicated radon concentrations below maximum permissable concentration for uncontrolled areas. Analyses of soil samples indicated results within the range of concentrations found in background samples.

Direct instrument and smear surveys indicate some contamination is still present within the building. All of the contamination in Room 1 exceeds guidelines for unrestricted use. Contamination in two catch basins in Room 1 exceeds guidelines. Seven other locations throughout the building exceed guidelines. Radon concentrations in air samples were normal and soil sample analyses showed no elevated readings above background levels in soils. Other radioactive items such as radium dials were also noted.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action may be indicated and could involve decontamination of building surfaces and excavation of floor areas. Twenty-five cubic yards of contaminated material would be produced. The estimated cost for this remedial action is $710,000.

## PROJECT STATUS

A radiological survey was completed in October 1978. Draft survey reports have been completed and final reports are being prepared. The Assistant Secretary for Environment will make a determination of need following the final report. Authority to implement remedial action will be required.

OLIN CORPORATION
JOLIET, ILLINOIS

## OWNER HISTORY

The site was originally owned by Blockson Chemical Company, which was sold in 1955 to Olin Mathieson Chemical Corporation, the present owner.

## SITE LOCATION

The site consists of a single building used for a pilot plant operation in Joliet, Illinois.

## MED/AEC SITE USE

The site was used during the period of 1951 to 1962 to conduct a development program for the extraction of uranium from phosphoric acid.

## POST MED/AEC SITE USE

The building (site) is presently being used to process phosphoric acid which contains elevated levels of natural uranium.

## RADIOLOGICAL HISTORY

The work at the site included operation of a small pilot plant for the extraction of uranium from phosphoric acid. A radiological survey for the FUSRAP was conducted from March to November 1978. A draft of the final report has been prepared and is undergoing review.

Natural uranium contamination was found on the floors, overhead beams, and in the tanks and equipment where chemicals were processed. Small areas exceed applicable guidelines. Some contamination of the roof was found in which radium-226 was identified. In some places contamination is easily removed. The extent to which the contamination is due to the MED/AEC work because of the present operation is not known. Radon concentrations in air samples were normal. Results of analyses of soil samples taken about the grounds adjacent to the buildings showed no elevated readings above natural background in the soil.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action may be required and would involve decontamination of building surfaces and equipment. Three-hundred cubic yards of contaminated material might be produced. Estimated cost for this remedial action is $680,000.

## PROJECT STATUS

Upon completion of the radiological survey report, the Assistant Secretary for the Environment will determine whether the site requires remedial action. Authority to implement a remedial action will be required.

PALOS PARK FOREST PRESERVE
COOK COUNTY, ILLINOIS

## OWNER HISTORY

| | |
|---|---|
| 1942-1956: | Leased by the U.S. Army Corp of Engineers from Cook County Forest Preserve District |
| 1956-Present: | Cook County Forest Preserve District |

## SITE LOCATION

The park preserve is located in Cook County, approximately 5 miles east of Lemont, Illinois. Within the park preserve, 20 acres were used for the MED/AEC activities.

## MED/AEC SITE USE

The site contained two nuclear reactors and associated buildings and laboratories and a radioactive waste burial facility. The first successful nuclear reactor, CP-1 at the University of Chicago, was rebuilt as CP-2 at the site. The first heavy-water cooled and moderated reactor, CP-3 (designated CP-3' when rebuilt) was also at the site. Among the programs carried out at this site during and after World War II were fission product separations, reactor physics, tritium recovery from irradiated lithium, and studies of the metabolic effects of radionuclides on laboratory animals.

## POST MED/AEC SITE USE

The site is currently utilized as part of the entire park forest preserve for recreational activities.

## RADIOLOGICAL HISTORY

In 1956, the Federal Government returned all of the 20 acres to the Forest Preserve District. Before that time, the research reactors were decommissioned, radioactive materials were removed from the site and remaining radioactive components, including the reactor vessel, were encased in concrete and buried onsite. The empty buildings were surveyed, decontaminated if necessary, and demolished. The waste burial site was decommissioned by digging 8-foot-deep trenches around the perimeter and filling them with concrete. A 1-foot-thick concrete pad was poured over the top. The plot was then covered with soil and seeded. By the summer of 1956, decommissioning was complete, and the area was surveyed with state-of-the-art portable survey equipment. No detectable surface contamination was found. A limited environmental monitoring program was begun at the Palos site in 1954, continuing about every other year until 1975.

An extensive radiological survey was conducted under the FUSRAP during 1977 which showed that tritium was migrating from the former waste burial site.

Results of the 1977 survey indicate that the only significant pathway for exposure to the public is tritiated water moving from the former waste burial site to a dolomite aquifer and being consumed by individuals using the picnic wells on the preserve. The possible dose to people from this pathway is estimated to be 0.7 mrem/year.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action is indicated and could involve excavation of contaminated material and restoration. Estimated cost for this remedial action is $7,100,000.

## PROJECT STATUS

A radiological survey was completed during 1977 and the final report was issued in April 1978. The Assistant Secretary for Environment has determined that the site will require remedial action. Both an environmental analysis report and an engineering evaluation report-Title I have been completed and were issued in September 1979. Additional authority is required to implement remedial action.

ST. LOUIS AIRPORT
ST. LOUIS, MISSOURI

## OWNER HISTORY

1946-1973: U.S. Government
1973-Present: City of St. Louis, Airport Authority

## SITE LOCATION

The storage site is a 21.7-acre tract located adjacent to the north boundary of the Lambert-St. Louis International Airport. The site is approximately 15 miles northwest of St. Louis.

## MED/AEC SITE USE

The site was used for storage of residues and contaminated scrap and equipment generated by the Mallinckrodt Chemical Corporation, Destrehan Street Plant uranium-processing operations during the period 1946 to 1953. Various residues were stored above ground and in the open, above ground in steel drums, and below ground in an open concrete pit. Contaminated scrap and equipment were buried and later covered with clean fill. During 1966 and 1967, all residues were removed from the site.

## POST MED/AEC SITE USE

The site has remained unused since 1967 with access controlled by the airport manager. Decontamination activities have taken place during 1969. Proposals have been made by the NRC to relocate contaminated material from the formerly licensed Latty Avenue site in Hazelwood, Missouri; and the St. Louis Airport Authority has recommended development of the site as a driver-training course for the police academy.

## RADIOLOGICAL HISTORY

Wastes generated from uranium processing and other activities between 1947 and 1967 were stored onsite. In addition, 60 truck loads of contaminated scrap metal and a contaminated vehicle were buried onsite. During 1966 and 1967, most of the stored residues were sold and removed from the site. All onsite structures were razed and buried onsite. Contaminated soil in the residue storage area was removed and 1 to 3 feet of clean fill spread over the site. A radiological survey for the FUSRAP was conducted in August and November of 1978. Present access to the site is limited and it is used to receive clean rocks and fill.

Contamination of the site is due to buried deposits of naturally occurring radionuclides, namely uranium-238, radium-226, and thorium-230. Average concentrations of radon and radon daughters in air were well below guideline values for the general public. Surface radiation guidelines are exceeded at 10 onsite locations and 2 offsite locations in a ditch on the site side of an adjacent road north of the site. Soil along the northern fence has been disturbed by burrowing animals and eroded by water drainage. This contamination is the cause of the elevated surface beta-gamma and external gamma radiation exposures found in these ditches. The guidelines for external gamma exposure would be exceeded at five locations at the site if the area were frequently occupied. Currently, access to the site is limited.

## REMEDIAL ACTION OPTIONS AND COSTS

Two remedial action options have been proposed. The first is stabilization and control for which a cost estimate ranging from 1.5 to 3 million dollars has been developed. The second is removal of 180,000 cubic yards of the contaminated material and restoration of the site at an estimated cost of $98,000,000.

## PROJECT STATUS

A radiological survey was conducted in August and November 1978; the final report was issued in September 1979. An environmental impact analysis was issued in July 1979 addressing proposed and alternative actions. No Title I design has been done. Additional authority for the Assistant Secretary for Nuclear Energy to implement remedial action is required.

SEAWAY INDUSTRIAL PARK
TONAWANDA, NEW YORK

## OWNER HISTORY

Seaway Industrial Park Development Company, Inc.

## SITE LOCATION

The site, covering 100 acres, is located in Tonawanda, New York, adjacent to the Niagara River. It is primarily used as a landfill. Approximately 13 acres of the landfill has been used for storage of radioactive materials. It is adjacent to the Ashland Oil Company property, another formerly utilized MED/AEC site.

## SITE USE

In 1974, approximately 6,000 cubic yards of uranium-processing residue, comprised essentially of low-grade uranium ore tailings, were excavated from the adjacent Ashland Oil, Inc., property and dumped onto three areas of the landfill.

## RADIOLOGICAL HISTORY

Since their initial transport to the site, the residues have been somewhat scattered and mixed with clean soil by earthmoving and spreading associated with the landfill operation. A radiological survey was conducted under the FUSRAP during August 1976. The survey indicated that radioactive material is being transported off-site by surface runoff. An aerial survey was conducted in September 1979.

Results of the 1976 survey indicate external gamma, radon, and radon daughter levels exceed guideline values over small areas of the landfill. However, these levels do not present a health hazard under the current site use because of low exposure time to landfill workers in the vicinity of the residues.

Potential health hazards could result from either conversion of the site use by construction of buildings or from use of residues for fill at another site or as a construction material. If a building were constructed in certain portions of the site, radon daughter levels of 0.15 or higher could develop in the building.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action is indicated and could involve excavation of the residues from the site, including a stream and drainage ditch. Thirty-nine-thousand cubic yards of contaminated material would be produced. The estimated cost for this remedial action is $24,000,000.

## PROJECT STATUS

A radiological survey was completed in August 1976; the final report was issued in May 1978. The Assistant Secretary for Environment has determined that the site will require remedial action. Additional authority for the Assistant Secretary for Nuclear Energy to implement remedial action is required.

SENECA ARMY DEPOT
ROMULUS, NEW YORK

## OWNER HISTORY

The site is owned and operated by the U.S. Army.

## SITE LOCATION

The depot consists of approximately 10,000 acres, of which approximately 20 acres were involved in the MED activities. This area consists of 11 munitions bunkers and surrounding areas over which material was transported.

## MED/AEC SITE USE

About 2,000 barrels of pitchblende ore were stored in 11 munitions bunkers during a short period in the 1940s.

## POST MED/AEC SITE USE

Upon removal of the ore, the bunkers reverted back to storage sites for ammunition and have continued in this function since that time.

## RADIOLOGICAL HISTORY

Since the original short-term storage of uranium ore in munitions bunkers, some contamination of the interior surfaces of at least eight bunkers has been present. A radiological survey was conducted under the FUSRAP during September 1976. The survey indicated that the interior surfaces of at least eight of the bunkers have been contaminated with uranium ore and as a consequence, natural uranium and its daughters, including radium-226, may be found on these surfaces and on outdoor surfaces near the entrances to these bunkers.

Results of the 1976 survey indicate that the interior surfaces of at least eight of the bunkers were contaminated with uranium ore. Direct alpha readings exceeded the maximum guideline in some areas of each of the eight bunkers and transferable alpha exceeded the maximum guideline in six. Transferable beta contamination in excess of the guidelines was found in one area of the floor of one bunker. Radon daughter concentrations exceed 0.03WL in six bunkers but all were less than 0.048WL. External gamma radiation levels at one meter were below guideline values. The only contaminated soil was found near the surface in small areas near bunker entrances. No health hazard exists because of the very low occupancy time of the bunkers.

Potential health hazards could result from exposure to radon and radon daughters concentrations in the bunkers if occupancy times were to increase. While no crops are currently grown on site, use of the contaminated soil for such a purpose could produce additional human exposure.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action is indicated and could involve thoroughly cleaning all floors, walls, ceilings, vents, and drains. Contaminated soil outside the bunkers could be excavated. Four-hundred cubic yards of contaminated material would be produced. The estimated cost for this remedial action is $860,000.

PROJECT STATUS

A radiological status survey was completed during September 1976; the final report was issued in February 1979. The Assistant Secretary for Environment has determined that the site will require remedial action. Authority to implement remedial action exists under the Atomic Energy Act of 1954, as amended.

# SHPACK LANDFILL
# NORTON, MASSACHUSETTS

## OWNER HISTORY

The property is presently owned by Mrs. Isadore Shpack and had been owned by the Shpack family before the suspected date of contamination.

## SITE LOCATION

The site is located in Norton, Massachusetts, near the common corporate boundary of Norton and Attleboro. Norton is approximately 15 miles northeast of Providence, Rhode Island. The area of concern comprises approximately 5 acres.

## MED/AEC SITE USE

The Shpack Landfill was a private landfill that received "industrial" wastes from local operations. A NRC investigation determined that the former M&C Nuclear, Inc., Attleboro, Massachusetts (merged with Texas Instruments, Inc., in 1959) had used the Shpack Landfill area for the disposal of trash and other material, including burning zirconium ashes, associated with nuclear fuel operations conducted at the facility from 1957 to 1966. The NRC investigation concluded that it is possible that the aforementioned facility was the source of the major portion of the radioactive material.

## POST MED/AEC SITE USE

The landfill is now closed and the area is undeveloped. The surface presently contains metal, brick, concrete, blocks, iron drums, plastics, and miscellaneous debris. The area is poorly drained and covered with water part of the year.

## RADIOLOGICAL HISTORY

On September 22, 1978, the NRC Region I Office was contacted by a concerned citizen who had identified elevated (above background) radiation levels at the Shpack Landfill site. A special investigation by the NRC from October through December 1978 verified the presence of radioactivity above background levels at the Shpack Landfill. Gross alpha measurements of well water from the Shpack residence were found to be within EPA Drinking Water Standards. An independent study conducted by Brown University students produced results which were orders of magnitude higher than the gross alpha measurements of the NRC study and far in excess of EPA standards. The NRC, in conjunction with the State of Massachusetts, collected a number of additional water samples and had them analyzed at a number of independent laboratories. The results verified that well water in the area was not affected as all well samples were below EPA standards. As a result, the NRC determined contamination at the landfill posed no immediate hazard to human health but potential for exposure did exist. Representatives from the DOE and ORNL visited the site and performed a preliminary ground survey and EG&G, Inc., performed an aerial radiological survey. The ground survey (July 24, 1979) concluded that the site was contaminated with uranium- and radium-bearing materials and that the uranium was primarily depleted uranium. A full radiological survey was recommended. The aerial survey (August 8 and 9, 1979) did not detect any radiation levels significantly above those due to natural background.

Results of studies completed to date indicate that the current use of the landfill does not pose an immediate hazard to human health but potential for exposure does exist.

## REMEDIAL ACTION OPTIONS AND COST

Remedial action may be required and could include excavation of contaminated soil. A preliminary estimate indicated that approximately 4,500 cubic yards of contaminated material would be produced. The estimated cost for this remedial action is $2,200,000.

## PROJECT STATUS

The DOE has asked ORNL to develop and implement a survey plan for the Shpack landfill site. Upon completion of these efforts, a determination will be made by the Assistant Secretary for Environment as to whether remedial action is required. A determination as to whether additional authority is required to implement remedial action is currently underway.

UNIVERSAL CYCLOPS, INC.
ALIQUIPPA, PENNSYLVANIA

## OWNER HISTORY

| | |
|---|---|
| 1942-1955: | Vulcan Crucible Steel Company |
| 1955-1960: | Vulcan Crucible Steel of H. K. Porter |
| 1960-1966: | Vulcan-Kidd Steel of H. K. Porter |
| 1966-Present: | Vulcan Cyclops, Inc. |

## SITE LOCATION

The site is located in Aliquippa, Pennsylvania, and consists of one building and surrounding areas.

## MED/AEC SITE USE

Uranium billets were received, rolled into rods, boxed, and shipped out. This site consisted of a rolling mill, two furnaces for heating, and cutting and extruding equipment. The finished rods were stored in boxcars after being transferred to the receiving and shipping room for weighing. The building is one story over 30 feet high with part concrete, part dirt, and part metal floor.

## POST MED/AEC SITE USE

Portions of the building are presently leased to Heritage Box Company and Precision-Kidd for use as storage areas.

## RADIOLOGICAL HISTORY

During February 1949, dust samples at the mill were collected by representatives of the New York Operations Office-AEC. From data obtained from these samples, it was apparent that the entire group of employees was exposed to concentrations of alpha-emitting dust that were above the preferred level. Recommended corrective actions were provided to the Vulcan Crucible Steel Company. A follow-up survey was made and required decontamination and equipment disposition defined. Decontamination was completed by March 1950. A radiological survey was conducted under the FUSRAP during May 1978.

Results of the 1978 survey indicate some contamination is still present in the building. Floor areas and overhead beams showed transferable natural uranium contamination. Radon concentrations in air were normal. Only one soil sample contained elevated levels of uranium. Current use of the building does not present a health hazard. However, cleaning or demolition of the building could cause significant exposure.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action may be required and could involve excavation of a small amount of soil and decontamination of one building. Fifty-five cubic yards of contaminated material would be produced. The estimated cost for this remedial action is $1,000,000.

## PROJECT STATUS

A radiological survey was completed in May 1978. A draft report has been issued and is undergoing review. Upon issuance of the final report, a determination will be made by the Assistant Secretary for Environment as to whether remedial action is required. Additional authority to implement remedial action is required.

VENTRON CORPORATION
BEVERLY, MASSACHUSETTS

## OWNER HISTORY

| | |
|---|---|
| 1942-1965: | Metal Hydrides Corporation |
| 1965-1976: | Ventron Corporation |
| 1976-Present: | Thiokol Corporation |

## SITE LOCATION

The site is located in Beverly, Massachusetts, approximately 15 miles northeast of Boston. Three buildings were used for MED/AEC-related work.

## MED/AEC SITE USE

From 1942 to 1948, Metal Hydrides Corporation was under contract to the MED and the AEC for conversion of uranium oxide to uranium metal powder, using calcium hydride. The method was proven at Metal Hydrides Corporation earlier in 1941. As better methods for production of uranium metal were developed, Metal Hydrides Corporation shifted their operations toward recovering uranium scrap and turnings from the slug fabrication plant at Hanford. Two wooden buildings that contained the foundry facilities were demolished some time between 1948 and 1950. Two other buildings have been erected at these locations. The remaining original building contained furnace and leaching facilities, a mixing room, a drying room, and analytical laboratories.

## RADIOLOGICAL HISTORY

A radiation survey conducted in 1948 listed as contaminated the two foundry buildings and various pieces of equipment. As a result of that survey, it was recommended that painted surfaces be cleaned by sandblasting and contaminated concrete floor and platform materials be removed.

A visit to the site for exploratory measurements was made in January 1977 by Oak Ridge Operations and ORNL personnel. It was determined, based on the results of the exploratory measurements, that a complete radiological survey of the entire site should be performed.

Based on the 1977 exploratory measurements, soil and building contamination above background levels exist at the site. The degree and extent of the contamination will be determined from a complete radiological survey.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action may be required and could involve excavation of contaminated soil and decontamination of building floors and surfaces. A preliminary estimate indicated that 100 cubic yards of contaminated material would be produced. The estimated cost for this remedial action is $880,000.

## PROJECT STATUS

A radiological survey is scheduled. Upon completion of the survey, a determination will be made by the Assistant Secretary for Environment as to whether remedial action is required. Additional authority to implement remedial action is required.

WATERTOWN ARSENAL
WATERTOWN, MASSACHUSETTS

## OWNER HISTORY

1946-1967: U.S. Government
1967-Present: Watertown Redevelopment Corporation

## SITE LOCATION

The site is located adjacent to the current boundary of the Watertown Arsenal in Watertown, Massachusetts, approximately 5 miles west of Boston. Only one building has been confirmed as being utilized for the the AEC activities; however, several additional buildings may have been.

## MED/AEC SITE USE

The Massachusetts Institute of Technology (MIT) operated a laboratory and a uranium ore testing facility for the AEC in a now-demolished building at the Watertown Arsenal. A modified ion exchange technique for production of $U_3O_8$, which employed a fluidized bed system, was developed at this site. Initial research on African ores was conducted at MIT in Cambridge. The activity was transferred to the Watertown Arsenal (building 421) in 1946. MIT conducted the research activities until 1950 at which time American Cyanamid took responsibility for the functions of the site. In 1953, the AEC activities at Watertown Arsenal, building 421, were transferred to a new facility.

## POST MED/AEC SITE USE

The site has been transferred to the Watertown Redevelopment Corporation and is presently unused. Only the concrete pad of building 421 remains. Operations involving uranium are continuing in other areas of the arsenal.

## RADIOLOGICAL HISTORY

The AEC Chicago Operations and Argonne National Laboratory (ANL) completed a comprehensive radiological survey of the portion of the arsenal (building 421 and surrounding area) used for the AEC activities. Direct instrument surveys of the pad of building 421 and south wall of building 331 (nearest building to the pad) identified three small spots on the pad that exceed the proposed ANSI standard No. N13.12. Smears indicated that the contamination was fixed and the analysis of one sample identified the contamination to be from natural uranium. Other direct instrument measurements taken showed no readings above natural background. Analyses of soil samples, water samples, and measurements of radon in the air gave no indication of radiation above natural background.

During the ANL radiological assessment of the building 421 site, it was discovered that several additional buildings and facilities were involved in uranium operations during the MED/AEC era. This included buildings 34 and 41, which have been razed. Both building sites are within the confines of the arsenal area, though they have been turned over to the Watertown Redevelopment Corporation. There is no evidence of a radiological survey being performed for these two buildings. In addition, there is an area on the north side of Arsenal Street that had been used for uranium storage and as a burn area. A survey was made in this area by Watertown Arsenal Radiation Safety personnel in 1973. Their investigation revealed a significant amount of contamination on the pad and a need for a more comprehensive survey of the area. The DOE plans to

survey the area north of Arsenal Street and the pads of buildings 34 and 41 during 1980. These areas were used by the Army for uranium storage and as a burn area.

Based on the preliminary surveys, the contamination is at an acceptable level and does not represent a hazard to the general population. However, if site use is changed, there is a potential for excessive exposure.

## REMEDIAL ACTION OPTIONS AND COSTS

Remedial action may be required and could involve excavation of soil and decontamination of the concrete pad. Two-hundred-sixty cubic yards of contaminated material would be produced. Estimated cost for this remedial action is $630,000.

## PROJECT STATUS

Additional radiological survey work is scheduled for FY 1980. Upon completion of this survey, the Assistant Secretary for Environment will determine whether remedial action is required. Additional authority to implement remedial action is required.

★U.S. GOVERNMENT PRINTING OFFICE: 1980-640-351/018

Admin Rec. : MX-002
35E92

**Department of Energy**
Oak Ridge Operations
P. O. Box E
Oak Ridge, Tennessee 37831

March 24, 1986

Mr. Joseph F. Nemec
Program Manager - FUSRAP
Bechtel National, Inc.
P.O. Box 350
Oak Ridge, TN 37831

Dear Mr. Nemec:

FUSRAP PROTOCOLS

Enclosed for your information and use is one copy each of the current revisions of the FUSRAP summary protocol, the FUSRAP designation/elimination protocol, and the FUSRAP verification and certification protocol. These documents, in combination with the latest revision of the Energy Systems Acquisition Project Plan for FUSRAP, detail procedures, requirements, and responsibilities for each phase of the remedial action program effort.

If there are any questions, please call me.

Sincerely,

E. L. Keller

E. L. Keller, Director
Technical Services Division

CE-53:Keller

Enclosures:
As stated
cc w/encls.:

P. Merry-Libby, ANL
W. Latham, AD-421

35692

# FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM

## SUMMARY PROTOCOL
## IDENTIFICATION - CHARACTERIZATION - DESIGNATION - REMEDIAL ACTION - CERTIFICATION

JANUARY 1986

U.S. DEPARTMENT OF ENERGY

OFFICE OF NUCLEAR ENERGY
DIVISION OF FACILITY AND SITE
DECOMMISSIONING PROJECTS

# CONTENTS


| | Page |
|---|---|
| List of Figures | iv |
| Introduction | 1 |
| Summary Protocol | 3 |
| Preliminary Analysis Phase | 3 |
| Radiological Evaluation and Designation Phase | 12 |
| Engineering and Remedial Action Phase | 18 |
| Certification of Site Conditions Phase | 21 |
| Bibliography of DOE Supporting Guidance Documents | 24 |
| APPENDIX A. Flowchart for FUSRAP Protocol | A-1 |
| APPENDIX B. Department of Energy Interim Residual Contamination and Waste Control Guidelines For FUSRAP and SFMP Sites | B-1 |
| APPENDIX C. Procedure for Assigning Site Priorities on the Basis of Health Effects | C-1 |
| APPENDIX D. Certification Docket | D-1 |
| APPENDIX E. Basic Steps Involved in the Remedial Action Program | E-1 |
| APPENDIX F. Public Availability and Archiving of FUSRAP Records | F-1 |

# LIST OF FIGURES


| Figure | | Page |
|---|---|---|
| I | Summary Flow Sheet for Preliminary Analysis of FUSRAP Remedial Action Protocol | 4 |
| II | Summary of Flow Sheet for Radiological Characterization Phase of the FUSRAP Remedial Action Protocol | 14 |
| III | Summary Flow Sheet for the Engineering and Remedial Action Phase and Certify Site Condition Phase of FUSRAP Remedial Action Protocol | 20 |
| A-1 | Flow Chart for FUSRAP Protocol | A-1 |
| C-1 | DOE Prioritization Procedure | C-2 |
| E-1 | General Flowchart of Engineering and Remedial Action Phase | E-1 |

# SUMMARY PROTOCOL
# IDENTIFICATION - DESIGNATION
# REMEDIAL ACTION - CERTIFICATION

## INTRODUCTION

This summary protocol describes those activities necessary for accomplishing the Formerly Utilized Sites Remedial Action Program objective, which is to ensure that sites formerly used by the Manhattan Engineer District and the Atomic Energy Commission are not contaminated with radioactive residues that may present a radiological hazard to the general public. This summary protocol is presented in four phases: Preliminary Analyses (identifying potentially contaminated sites), Radiological Evaluation and Designation (evaluating the radiological condition of the site and determining if remedial action is needed), Engineering and Remedial Action* (site characterization and planning, selecting, engineering, and implementing the action), and Certification of Site Conditions (verifying site conditions and archiving the records that document the results of remedial action). Additional guidance is provided on the first two phases and the fourth phase respectively in two supplements to this protocol entitled FUSRAP Designation/Elimination Protocol (Supplement No. 1) and the FUSRAP Verification and Certification Protocol (Supplement No. 2). Additional details regarding implementation of the third phase of the program are provided in the report Energy Systems Acquisition Project Plan-FUSRAP (Revision 1)" April 1985, and subsequent revisions.

---

*Remedial action may involve decontamination or stabilization and restricted use through institutional control or physical modifications.

Appendix A is a flow diagram with decision points and assignment of responsibilities for specific program activities. All phases except the Engineering and Remedial Action Phase are outlined in some detail and covered in the enclosed flow charts. Only a brief discussion of the Engineering and Remedial Action Phase is contained in this protocol (see "Energy Systems Acquisition Project Plan--Formerly Utilized Sites Remedial Action Program, Revision 1," Steps 3 through 7, April 1985).

This protocol places the primary emphasis on contaminated sites or potentially contaminated sites for which there is existing authority that will permit DOE to perform remedial action at the site. However, the section on the first phase of this protocol also discusses the actions taken with regard to sites for which DOE is unable to establish remedial action authority. In the interest of efficiency and economy of operation, this protocol limits the amount of radiological survey data collected during the first two phases of the protocol to the minimum needed to determine if a site should be included in the program or eliminated from it. Any additional radiological data needed for project engineering will be accomplished during the engineering and remedial action phase of the operation. Similar guidance is provided for engineering of the remedial action to ensure that the magnitude and cost of the engineering, planning, and environmental reviews do not exceed the worth or the beneficial effect of the action. Throughout this process, the professional judgment of the radiological survey personnel and the engineering and project management personnel is utilized, with guidance from the DOE Division of Facility and Site Decommissioning Projects (DFSD) to determine the level of survey, engineering, and/or environmental work required to achieve the associated goals.

In order to ensure that any remedial action completed is preformed to comply with and meet appropriate standards and guidelines, the last phase, Certification Phase, includes a verification activity. The

goal of this phase is also to ensure through proper documentation that each remedial action is adequately documented and archived so that a permanent record of its final radiological condition will always be available.

## SUMMARY PROTOCOL

The following narrative was prepared, along with Figure I--Preliminary Analyses, Figure II--Radiological Evaluation and Designation and Figure III--Engineering and Remedial Action and Certification of Site Condition (attached), to describe DOE protocols for determining if a site warrants consideration for remedial action. The narrative is subdivided to follow these figures. As can be noted in Figures I, II, and III, the decision point that is the transition from one phase to the next is repeated on these figures but is discussed in the narrative in the earlier of the two phases.

## PRELIMINARY ANALYSES PHASE

During this phase of the program, sites are identified and evaluated to determine if they can be designated (included in) or eliminated from the remedial action program, or if a radiological survey of the site is required to more clearly define the radiological condition of the site to support this decision. This phase has five steps that include two decision points. This phase of the program is conducted by DOE-DFSD with assistance from a technical support contractor, a radiological survey contractor, and an aerial survey contractor as appropriate.

### Step 1 - Data Collection and Site Identification

During this step, information sources are identified and investigated by the DOE-DFSD Technical Support Contractor. These sources include input from individuals or organizations and historical

FIGURE I

## SUMMARY FLOW SHEET FOR PRELIMINARY ANALYSES PHASE OF FUSRAP REMEDIAL ACTION PROTOCOL

### STEP 1 — DATA COLLECTION AND SITE IDENTIFICATION

IDENTIFY RECORDS SOURCES

USE INPUT FROM THE GENERAL PUBLIC AND OTHER SOURCES

CONDUCT RECORDS SEARCHES

- Assemble and Maintain a List of Sites
- Assemble Available
- Assemble Operating Records
- Assemble Radiological Data of Health and Safety Studies
- Assemble Ownership Data
- Identify Licenses
- Interview Knowledgeable

### STEP Z — HISTORICAL DATA ANALYSIS

DETERMINE POTENTIAL FOR CONTAMINATION

CONTAMINATION POTENTIAL SIGNIFICANT IF

- Large Operation (Quantity and Time)
- History of Burial
- Radiological Data Suggest Contamination
- Input from Cognizant Individuals Suggest Contamination

CONTAMINATION POSSIBLE IF

- Historical Data Indicates AEC Operations Could Have Resulted in Contamination or that Onsite Residue may be Present
- Little or no Information is Available to Indicate Site Clean-Up Completed

CONTAMINATION POTENTIAL LOW IF

- Only Small Quantities of Material Were Handled
- Site Operated for a Short Time
- Previous Surveys Adequately Demonstrate Clean-up

DETERMINE DOE AUTHORITY FOR REMEDIAL ACTION

DOE HAS AUTHORITY IF

- Contractual Records Indicate
- An Imminent Health Hazard May Exist (Must Be Confirmed By Site Visit and/or Survey)*
- Authority has been Provided by Legislation*

DOE AUTHORITY IS NEGATED IF

- Site is Currently Licensed to Conduct the Same Activities Conducted under the AEC/MED Contracts
- Site is Clearly under the Jurisdiction of Another Remedial Action Program (NRC Formerly Licensed Sites, Mill Tailings Act, Super Fund)

### STEP 3 — DECISION POINT: DOE Division of Facility and Site Decommissioning Projects (DFSD) Determines Need for Additional Investigations

CATEGORIZE SITES

SCHEDULE SITE VISITS FOR SITES WHERE

- DOE has Authority for Remedial Action and Potential for Contamination is Significant
- DOE has Authority for Remedial Action and Contamination is Possible
- An Imminent Hazard May Exist

SCHEDULE WIDE-AREA SURVEYS (AERIAL OR SCANNING) IF

- Records or Survey Data Indicate Presence of Offsite Contamination and
- Contamination is such that it can be Identified by Wide-Area Surveys

HOLD SITES FOR FUTURE CONSIDERATION IF

- Contamination is Possible
- Insufficient Data Collected to Date to Establish Authority or
- Sites not Covered Under Another Program

(These Sites are Periodically Reviewed for Reclassification and/or Inclusion Through Legislation)

TERMINATE ACTIVITIES IF

- Potential for Contamination is Low
- DOE has no Authority for Remedial Action
- Site is Covered by Other Program or
- Site is Licensed

### STEP 4 — INITIAL INVESTIGATIONS

COMPLETE REQUIRED SITE VISITS

- Determine Site Use
- Identify if Imminent Hazard Exists
- Conduct Screening Survey
- Prepare Preliminary Survey Report

Offsite Contamination

IMPLEMENT MOBILE GAMMA SCANS OR AERIAL SURVEYS

- Analyze Data
- Determine if Offsite Contamination is Present

No Contamination

Document Findings

### STEP 5 — DECISION POINT: DOE Division of Facility and Site Decommissioning Projects (DFSD) Determines Need for Survey Data or Remedial Action and Priority

INCLUDE IN REMEDIAL ACTION PROGRAM IF

- Imminent Hazard Exists or
- Records Indicate Significant Potential for Contamination, Survey Data Indicates Radiation Clearly Above Guidelines, and DOE has Authority

INCLUDE IN RADIOLOGICAL SURVEY PROGRAM AND SCHEDULES

First Priority if DOE has Authority and (1) Survey Data Indicates Contamination is Possible and Records Suggest Potential for Significant Contamination or (2) Survey Data Identifies Radiation Clearly Above Background and Records Indicate Contamination could be due to MED AEC Work

Second Priority if DOE has Authority and Survey Data Indicates Contamination may be Present and Records Indicate Contamination due to MED AEC Work may be Possible

Third Priority if Records have not Clearly Established DOE Authority but Survey Data Identifies Radiation Levels Clearly Above Background and Records Indicate Potential for Contamination is Significant and may be due to MED AEC Work

TERMINATE ACTIVITIES IF SCREENING SURVEY IS SUFFICIENT TO CERTIFY CONDITION OF SITE IS SUITABLE FOR UNRESTRICTED USE, IS OTHERWISE LICENSED OR CONTROLLED BY APPROPRIATE RESTRICTIONS OR IF NO DOE AUTHORITY FOR REMEDIAL ACTION EXISTS.

records. While input from individuals and organizations is actively sought and has provided much useful data, MED/AEC operating records provide, by far, the more usable data. Records associated with MED and AEC operations stored at various DOE and contractor records centers, the National and Regional Archives, and other agency records centers (such as NRC license records) located throughout the country, are scanned to determine if they are pertinent to the FUSRAP investigations. Records groups identified as possible sources of data are reviewed and available contracts, operating records, and records of previous radiological surveys are assembled. The level or detail of the reviews for specific groups of records depends on the importance of the records to the program. The more likely that new or additional data will be found in a specific set or group of records the more detailed the review of the records will be. Information from these sources is used to develop a list of potential FUSRAP sites that is updated as new data is collected. Ownership data are collected, wherever possible, especially for those sites determined to be highly probable candidates for FUSRAP.

In some cases, copies of pertinent materials are made and maintained for the record; in other cases, the location and a general description of the records are recorded. A data management system is utilized to keep track of records reviewed, identified, and collected.

Step 2 - Historical Data Analysis

During this step, site-specific data collected during records searches and investigations are reviewed and analyzed by the contractor to determine the potential for contamination and DOE authority to conduct remedial action at the site. Potential for contamination is considered significant if the records indicated that: (1) the MED/AEC onsite operations were large, that is conducted over many years and/or the contractor processed large quantities of material; (2) the site had a history of onsite burial of radioactive

material; or (3) radiological data suggests the site is contaminated and/or input from cognizant individuals suggests that the site is contaminated. Contamination is considered possible if the historical data indicates AEC operations could have resulted in the site being contaminated and there is little or no data to indicate the site was ever decontaminated. Potential for contamination is considered low or improbable if only small quantities of radioactive materials were handled, work on the site for MED/AEC for a very short period of time, and/or previous surveys adequately demonstrate decontamination was accomplished. Experience suggests that, for the most part, the potential for contamination is somewhat proportional to the quantities of data or records identified for a specific site, i.e. the more material processed at a site the more records were generated during shipping, billing, processing, etc. As a result, unless there is evidence to suggest otherwise, if only small amounts of information can be identified on a specific site, it is normally assumed that the site only operated for a short period of time or used small quantities of active material.

Generally, only sites in the first two categories will be considered for radiological survey or the remedial action program. Those sites having low potential for contamination will normally be eliminated from the program.

The contractor will also review and analyze the records and assemble materials that provide information regarding DOE authority for remedial action. The contractor will interface with DOE General Counsel to obtain guidance regarding pertinent material needed to determine if authority exists and will provide available records to the General Counsel's office to obtain preliminary findings to be used in the contractor's recommendation for inclusion. The recommendation report will include a brief description of the former activities conducted at the site and those data used as a basis for the recommendations provided in the report. Those recommendations or

findings of the contractor will indicate the potential for residual radioactive material being found at the site and if DOE has existing authority to conduct remedial action at the site. Sites for which there is potential for contamination but no DOE authority has been established are handled in several ways or categories. The first category of sites are those for which it is clear that DOE has no existing authority or that it is unlikely that additional records review will identify any information to provide such authority. The states and or other Federal agencies, as appropriate, are provided information on the sites in this category so that they can take appropriate actions. These sites are eliminated from FUSRAP. The other group includes those sites for which continuing records reviews may provide additional data on which to base an authority determination. Sites in this category are held until there is sufficient data to provide authority or until the likelihood of identifying additional pertinent records is sufficiently low that the site is placed in the first group. The contractor will also search records to determine if a needed action should be covered by programs other than FUSRAP.

Step 3 - Decision Point: DOE Division of Facility and Site Decommissioning Projects (DFSD) Determines Need for Additional Investigation

During this step, DOE-DFSD staff utilize the information assembled and developed by the Technical Support Contractor to determine if the site should be visited and a preliminary onsite survey and/or mobile gamma scan or aerial survey conducted, if activities regarding the site should be terminated, or if the site should be held for future consideration.

Site visits and preliminary surveys will be conducted at sites that could be contaminated with material from MED/AEC operations and for which DOE has authority to conduct remedial action if it is determined to be necessary and/or where an imminent hazard may exist.

Wide area surveys (aerial or mobile gamma scans) will be conducted at sites where records or survey data indicate offsite areas may have been affected and the potential contamination is such that wide area surveys will detect it. Sites are handled as discussed above if contamination is possible but DOE has no authority for remedial action.

DOE may terminate investigations and close files on a site if the potential for contamination is low or the site is clearly under the jurisdiction of a program other than FUSRAP. Similarly, if the site is currently licensed for the same activities conducted under MED/AEC and contamination resulting from licensed work is indistinguishable from that caused by MED/AEC, DOE activities relating to the site will be terminated.

If during this step DOE determines that initial radiological investigations are required, the Technical Support Contractor is tasked to identify the current site owner and a site contact if the information is not already available. DOE selects and assigns a survey contractor(s) to conduct the required onsite investigations, then notifies the owner and makes arrangements for site visits. For sites in the Hold for Future Consideration or Terminate Activity categories, no owner contact will be needed unless the owner was previously made aware of the investigations. Sites in the Hold for Future Considerations category will be assessed as more data are available and recategorized as appropriate.

Step 4 - Initial Radiological Investigations

This step involves site visits and wide area surveys at the sites identified in Step 3 that require additional investigation. These activities are necessary to assemble data required to include or eliminate the site from the program or to determine the need for a more comprehensive radiological evaluation of the site, and to

determine if there is offsite contamination. Site visits are conducted to determine current site use, to determine if an imminent hazard exists, to obtain a preliminary assessment of the radiological condition of the site, and collect data that will be used by DOE to determine if the site can be eliminated from or included in the program without implementing a more comprehensive survey.

The site visit is a multipurpose operation conducted by the assigned survey contractor and, in some cases, a DOE representative. During this visit, the owners or lessees are provided a brief description of the program and the purpose of the investigation. The survey team determines the current use of the site and any expected changes in use. A cursory walk over survey is performed to aid DOE in determining if further activity is needed at the site to ensure that the health and safety of the public is protected, and to ensure that there is no imminent hazard resulting from former MED/AEC operations. The cursory survey may involve gamma, alpha, and/or beta-gamma measurements and some air, water, or soil sampling if felt necessary by onsite survey personnel. The survey contractor should collect sufficient data to provide descriptions of the facility's physical and radiological condition to support a survey plan (if DOE determines that a radiological evaluation survey is needed) or a designation for remedial action (if it is appropriate). This effort should be limited to 1 day or less if possible. Following the visit, the survey contractor will be responsible for providing a draft preliminary survey report to DOE within 1 month (unless otherwise directed) after the visit. The report should contain the contractor's suggestions regarding need for additional surveys.

For those areas determined to need wide area surveying to determine if offsite surveys are needed, two types of surveys may be utilized, aerial and mobile gamma scanning. The aerial survey is conducted using a helicopter or fixed wing aircraft and covers very large areas and identifies the general area(s) of contamination. The

gamma scan is a mobile-based survey conducted along streets, alleys, and other accessible roadways throughout the area. Individual properties having radiological anomalies can be identified using mobile gamma scanning techniques. Following completion of wide area surveys, the survey contractor will prepare a report providing the results of the survey and recommendations concerning the potential for offsite contamination. If there is no indication of offsite contamination, the aerial and/or mobile gamma survey reports may suffice to document the findings and offsite survey efforts will be terminated. If the wide area surveys provide positive indications of the presence of offsite contamination potentially due to DOE predecessor activities, DOE will determine if further radiological characterization is required, or if the area can be designated on the basis of wide area survey data alone. Where additional offsite investigations are required the survey contractor or technical assistance contractor, as appropriate, will be tasked by DOE to identify owners of the properties involved. DOE will notify the owner of the findings and proposed actions if necessary.

Step 5 - Decision Point: DOE Division of Facility and Site Decommissioning (DFSD) Projects Determines Need for Survey Data or Remedial Action

Upon receipt of the site visit and preliminary survey report, DOE reviews the report and recommendations, and, giving due consideration to those data provided by the records searches, will categorize each site either for inclusion in the radiological survey program, or direct inclusion in the remedial action program, or elimination from the program.

Sites will be included for remedial action if DOE has authority for remedial action and data indicate that the potential for contamination is significant and the preliminary survey demonstrates that the contamination is clearly above guidelines. In this case, any additional survey work will be performed during the engineering phase of the task.

If DOE-DFSD determines the site visit and preliminary survey results, along with the historical data are sufficient to verify that the radiological condition of the site is within appropriate guidelines or that the site conditions are controlled by license or appropriate restrictions, the site is eliminated from the program. Sites in this category are processed for elimination and the findings that the radiological condition of the site is acceptable for unrestricted use or, as necessary, for controlled use, are documented and archived.

Sites that can neither be included or eliminated from the remedial action program are scheduled for preinclusion site radiological evaluation surveys to better characterize their radiological condition. When DOE-DFSD assigns a radiological survey contractor to complete the survey, DOE-DFSD will provide the contractor a survey priority for the subject site. Three categories are proposed for assigning survey priorities to sites. First priority sites (those to be scheduled for survey first) are sites for which DOE has authority (through the Atomic Energy Act or Congressional mandate) for remedial action and:

- Preliminary survey data indicate that the site may be contaminated and records suggest the potential for contamination from MED/AEC operations is significant; or
- Survey data identify radiation clearly above background and records indicate it resulted from MED/AEC operations.

Second priority is assigned to sites for which DOE has authority and preliminary survey data indicate contamination is related to MED/AEC work and may be present in quantities that can exceed guidelines.

Third priority is assigned to those sites where that the preliminary data indicate radiation levels are clearly above background; but it is not clear from the data collected that the

radioactivity is from former MED/AEC operations; that is, DOE authority to conduct remedial action is not clear cut. Surveys at third priority sites will be conducted to confirm authority as well as to determine the need for remedial action. If authority is confirmed, the site will be forwarded to the next appropriate step. If the site is contaminated and authority is not confirmed, DOE activities will be terminated, and the appropriate State or Federal agency having jurisdiction will be notified.

## RADIOLOGICAL EVALUATION AND DESIGNATION PHASE

The purpose of this phase is to further evaluate the radiological conditions of the site by more comprehensive surveys, to compare the conditions to applicable guidelines and standards, to determine the potential for exposure and, ultimately, to determine if there is a need for remedial action.

During this phase, the radiological surveys are conducted at sites where those data collected during the Preliminary Analysis Phase are not sufficient to include or eliminate sites from the program. As with previous activities, every effort is made to conduct only as much survey work as is necessary to obtain sufficient data to make a designation determination. Determining the extent of survey activity is the responsibility of the radiological survey team leader. In addition, an engineering contractor representative(s) may work with the survey contractor(s) both before and during the survey(s) to ensure the data collected will be of use for engineering work that may be needed. In some cases, where agreed upon between DOE-DFSD and the DOE Oak Ridge Operations Office Technical Services Division (OR-TSD), the comprehensive survey will be thorough enough to provide the basis for the engineering bid request for remedial action.

The radiological evaluation and designation phase of the program contains two steps: the Radiological Evaluation Survey for

Designation and the Decision Point (see Figure II, Step 1 and Step 2). However, the radiological evaluation survey is further divided into two subelements.

Step 1 - Radiological Evaluation Survey for Designation

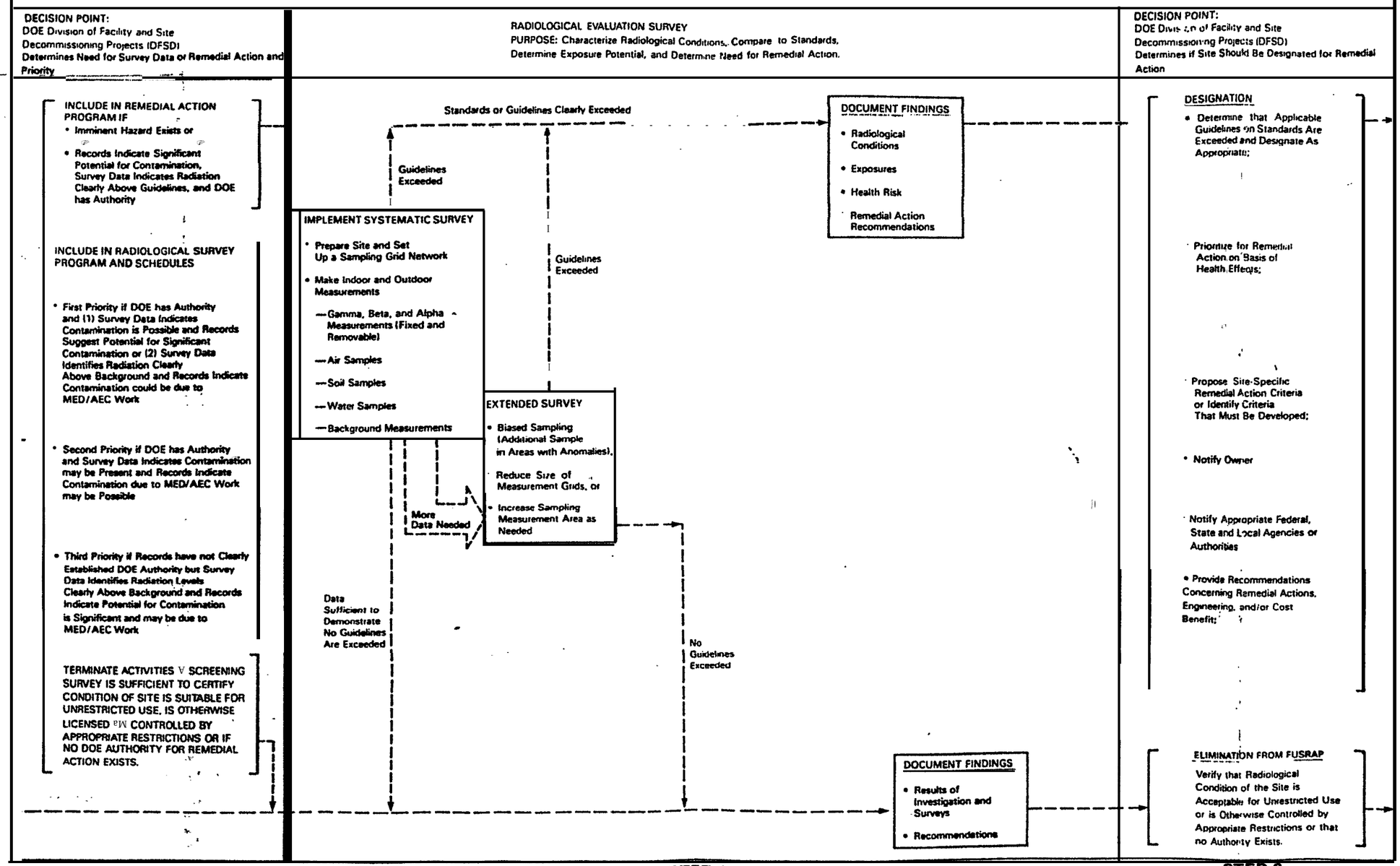
The radiological evaluation survey is subdivided into (1) Systematic and Extended Survey, the onsite survey effort; and (2) Document Findings, the report preparation effort. The onsite survey effort is organized in stages that increase in complexity as they proceed from left to right on the flow chart (Figure II). Each stage represents a part of the survey program and, if conducted, are conducted as part of the same onsite survey. The radiological survey team leader is responsible for the decision to implement more comprehensive stages of the survey activity. This responsibility includes the decision to conduct the extended survey (i.e., biased measurements) in selected areas of the site or to remove minor contamination as part of the survey.

Systematic and Extended Survey. The systematic stage of the survey is, as its name implies, a radiological survey involving systematic and preplanned sampling and direct radiation measurements over a predesigned grid network. These surveys may be of structures or outside areas. The measurements taken can include:

- Gamma, beta, and alpha scans and grid point measurements (fixed and removable); (grounds, buildings, and/or equipment)
- Air samples and analyses (Grab samples);
- Soil samples and analyses; (surface and subsurface)
- Water samples and analyses; (surface and ground water)and
- Background measurements.

FIGURE II

## SUMMARY FLOW SHEET FOR RADIOLOGICAL EVALUATION AND DESIGNATION PHASE OF THE FUSRAP REMEDIAL ACTION PROTOCOL



While the survey may include all or any combination of these measurements, it will primarily be the judgment of the radiological survey team leader to determine which and how many measurements are needed. The survey team leader will interact with the engineering contractor representative* as required in planning the survey and will provide a survey plan to DOE-DFSD prior to the survey. This plan will document the measurements to be performed during the systematic survey and briefly indicate under what conditions the extended effort (biased sampling) will be completed. Whenever possible, survey results will be forwarded for final analysis and recommendations as to inclusion or elimination based on the results of the systematic stage of the survey. This decision will be based on or guided by pre-established criteria approved by DOE-DFSD (Appendix B). For isotopes other than radium-226 and thorium isotopes, the soil concentration limits must be calculated (Appendix B). This calculation is done by the radiological support contractor with the assistance of the criteria development contractor (ANL). At some future time, EPA is expected to issue guidelines or standards for residual radioactive materials in the environment. These guidelines will be applied as appropriate.

Where systematic surveys do not provide sufficient data to support this decision, based on indicated action levels, the survey will be extended. The decision whether or not to subject the property to more comprehensive data collection (biased sampling) is made in the field by the radiological survey team leader. These judgments by the radiological survey team leader are important to the success of this approach to the survey process and require the presence of a well-qualified survey team leader.

*Engineering contractor is the Formerly Utilized Sites Remedial Action Program Management Contractor (PMC).

As indicated, the survey is extended to include more detailed measurement techniques only when the systematic effort cannot provide sufficient data to determine if the site exceeds applicable guidelines. The extended survey may include:

- Additional gamma and beta-gamma measurements over a smaller grid to more clearly identify the extent of the contamination;
- Alpha measurements (fixed and removable) of floors and walls and, in some cases, ceilings to define contamination in or on building materials to provide information regarding surface contamination;
- Sampling of building material to assist in defining the source of the contamination and in determining if it is derived from MED/AEC activities;
- Radon and radon daughter monitoring or sampling for other radionuclides in the air over several days to determine if action levels are exceeded;
- Additional soil sampling and subsurface sampling in areas where anomalies may exist;
- Surface and ground water sampling on and/or off the site; and
- Air sampling on and off the site.

It is essential that the extended survey be detailed enough to determine if the condition of the site can be certified to meet guidelines or if the site must be included in the remedial action program.

Document Findings. If, after the evaluation survey the survey contractor believes the site radiological conditions meet established criteria for the site, the contractor should document its findings, including the results of the survey and the description of any material removed from the site. The report should include the survey contractor's recommendations regarding additional DOE or government involvement at the site. The survey contractor will similarly document the results of the surveys for the sites that contain

radioactive residues that exceed appropriate guidelines or standards. In addition to documenting the sites radiological condition and remedial action recommendations, these reports should briefly assess the potential for human exposure and associated health effects or risks.

Step 2 - Decision Point: DOE-Division of Facility and Site Decommissioning (DFSD) Projects Determines if Site Should Be Designated for Remedial Action

During this step, DOE-DFSD staff will review all the data collected on each site and determine whether the site should be included or eliminated from the remedial action program.

If DOE-DFSD determines that radiation levels at the site exceed applicable guidelines or standards, the site will be designated for remedial action by notification from the Director of the Office of Remedial Action and Waste Technology to the Manager of Oak Ridge Operations Office. This designation provides the FUSRAP office in Oak Ridge (OR-TSD) the authority to proceed with the remedial action process. Remedial measures to be considered for a designated site will include restricted use and stabilization on site as well as decontamination of the site. As part of the designation provided to OR-TSD, DOE-DFSD will assign a remedial action priority to the site.* Other guidance will be provided by DOE-DFSD to OR-TSD with the site

*Headquarters will assign each designated site a high, medium, or low priority for remedial action. (see Appendix C) These priorities are assigned considering the potential for public exposure to radiation (dose), the potential for migration of the contaminants, and property use. The final remedial action scheduling priorities determined by OR-TSD with approval from DOE-DFSD take into account the designation priorities as well as other factors including but not limited to: Congressional mandates, availability of a disposal site, coincidence (proximity of projects), available funding and so forth.

designation as may be appropriate; e.g., criteria for remedial action, remedial action options to be considered, and cost/benefit considerations. Simultaneous with designation of the site, DOE-DFSD will notify the owner of the site and appropriate state, local, and Federal agencies and authorities of the findings and plans. In all cases the Department will notify the Environmental Protection Agency of designation actions.

If DOE-DFSD determines from review of the survey data that the site meets the applicable guidelines the findings will be documented and archived according to this protocol. If the site does not meet the DOE criteria but for one of the reasons stated above cannot be included in FUSRAP, the appropriate Federal or state agency will be notified to insure that proper consideration will be given to the site under other assessment efforts.

## ENGINEERING AND REMEDIAL ACTION PHASE

The Engineering and Remedial Action Phase of this protocol encompasses conceptual and preliminary engineering activities as well as other activities necessary for the completion of the remedial action and establishment of the disposal site. The activities are to:

- Define and evaluate options for remedial action;
- Obtain required site-specific environmental and radiological characterization data;
- Select the preferred and alternative remedial actions to be assessed during the National Environmental Policy Act (NEPA) analysis;
- Identify environmental impacts and mitigating measures to be assessed during the NEPA analysis;
- Select the preferred remedial action option;
- Prepare the final engineering design (Title II) of the options;

- Implement the selected remedial action and waste disposal action; and

- Prepare the final report and assemble material for the certification docket (see Appendix D).

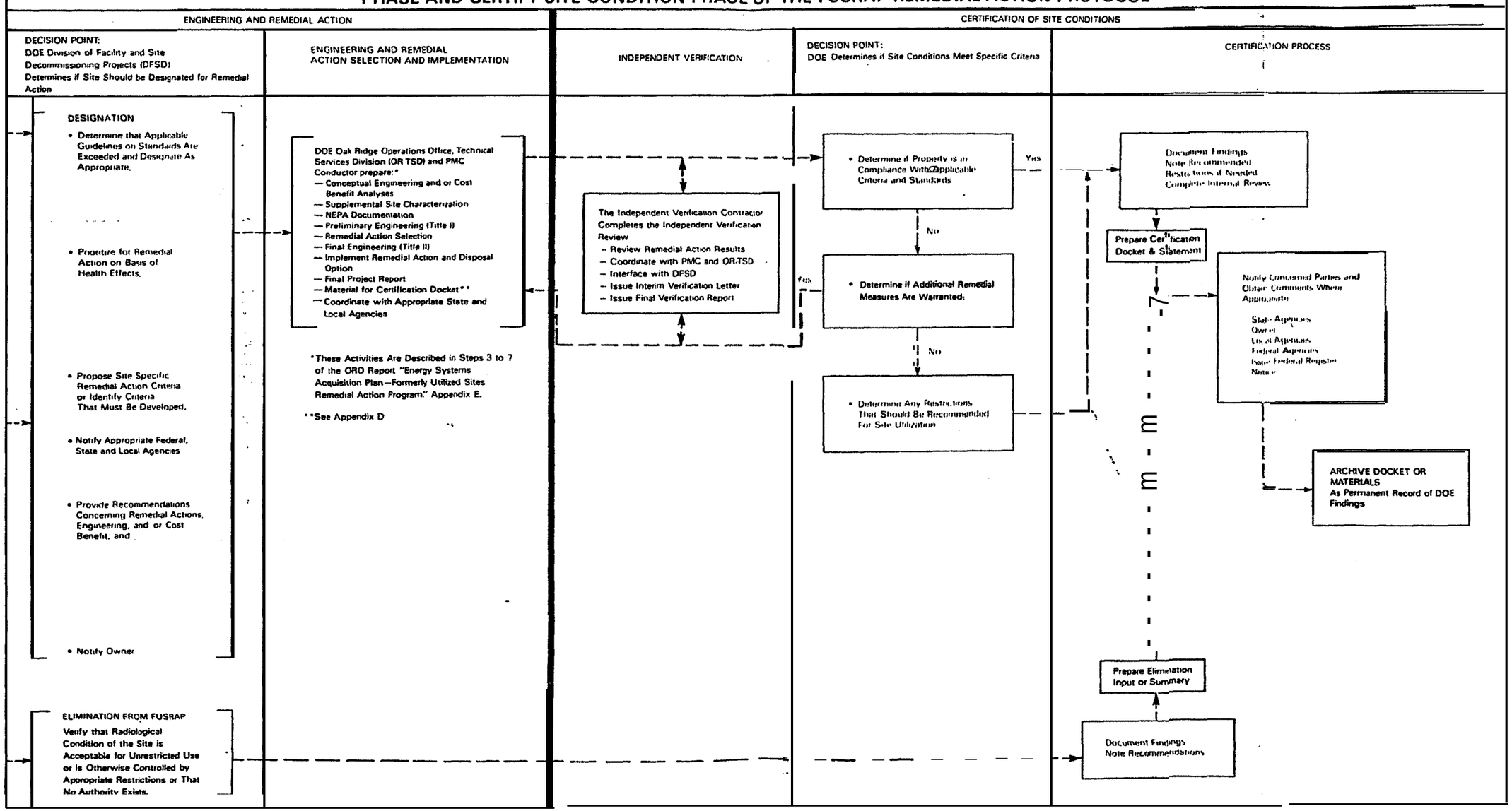
Implementation of this phase (Figure III) is the responsibility of the OR-TSD, the FUSRAP Project Management Contractor (PMC), and the FUSRAP NEPA Process Contractor. More detail is presented in the OR report, "Energy Acquisition Project Plan - Formerly Utilized Sites Remedial Action Program." The general flow chart of activities associated with this phase are shown in Appendix E (steps 3 through 7). The need for and level of preremedial action analyses and preliminary engineering is dependent on many factors including institutional and other nontechnical factors that may dictate the final selection of remedial action options. In such cases, the preparation of certain documents and/or such things as geological investigations may not be required. Decisions regarding the level and need for site-specific studies will be made by OR-TSD with input as needed from DFSD. OR-TSD will provide DOE-DFSD a site-specific project completion report for each remedial action project and prepare a certification docket* for the site.

OR-TSD will interface with DOE-DFSD on all key decisions such as remedial action selection and will supply periodic program status reports. Accomplishment of site decontamination to meet unrestricted use criteria or the achievement of site restrictions and adequate institutional control of residual contamination is the responsibility of OR-TSD.

*The contents of the certification docket are discussed in Appendix D and in the FUSRAP Certification/Verification Supplemented Protocol.

FIGURE III

## SUMMARY FLOW SHEET FOR THE ENGINEERING AND REMEDIAL ACTION PHASE AND CERTIFY SITE CONDITION PHASE OF THE FUSRAP REMEDIAL ACTION PROTOCOL



## CERTIFICATION OF SITE CONDITION PHASE

The Certification Phase is the responsibility of DOE-DFSD and OR-TSD. It utilizes data from the Remedial Action Phase as well as the other phases of the protocol especially the post-remedial action report or project completion report and involves three interrelated steps:

- o Independent verification of the remedial action
- o Decision on the adequacy of the remedial action
- o Certification process
  - Notification of concerned parties and the issuing of a Federal Register Notice and
  - Completion of the Certification Docket and archiving of the docket

These activities are described in detail in the Verification and Certification Protocol (Supplement 2 to this Protocol).

### Step 1 - Independent Verification

An Independent Verification Contractor (IVC) contracted by DFSD, reviews the remedial action activities and conducts verification surveys as necessary to confirm the adequacy of the remedial action and/or the procedures used by the PMC to certify the site's condition. The IVC coordinates with the PMC and OR-TSD during the verification activity, but, is managed and contracted by DFSD to maintain independence and insure no conflict of interest. An interim verification letter is provided by the contractor to OR-TSD and DFSD upon completion of the initial analysis of the remedial action at a specific site within four weeks after completion of the remedial action. The final verification report is submitted sometime thereafter.

Step 2 - Decision Point: DOE Determines If Site Conditions Meet Specific Criteria for the Remedial Action

On the basis of the data provided during and after the remedial action by the PMC including the Post-Remedial Action Report and the information provided by the IVC, OR-TSD, with approval from DFSD, determines if the site was adequately decontaminated and meets DOE guidelines. This decision point is actually a continuous process that is conducted in conjunction with the verification activity and the certification process steps. DOE interacts regularly with the PMC and the IVC during the conduct of the remedial action and the post-remedial action and verification reviews and surveys. This interaction is necessary to insure that any conflicts or discrepencies that are identified are expeditiously resolved. The preparation of the certification docket, certification statement and associated draft Federal Register notice is conducted during the decision process. Any changes required in these documents as a result of the decision are implemented as part of the certification process step.

If the remedial action was accomplished adequately, the site certification process is completed. If the remedial action did not bring the site in compliance with criteria, DOE will determine whether further remedial action is needed or warranted and will provide appropriate direction to the PMC.

Step 3 - Certification Process

As soon as possible after the determination is made that the site will be certified (the remedial action is complete), OR-TSD provides the owner of the site with interim notification that the remedial action is complete and that a certification package is being prepared. In general, the notification of the concerned parties is the responsibility of OR-TSD as is the preparation of the certification statement (required to officially approve the remedial

action) and the draft Federal Register notice. Once approved by the DOE Oak Ridge Chief Counsel's Office and DOE Headquarters (the Office of Management and Administration (MA) and DFSD) the Federal Register notice is issued through DFSD in Washington.

The Certification Docket (Appendix D) is prepared by OR-TSD and the certification statement is signed at the Oak Ridge Field Office. Final approval is required through DFSD. DFSD will arrange to archive the Certification Docket and supporting data as a permanent record of the DOE findings and radiological condition of the site. DFSD will also have the information placed in the DOE Public Reading Room in Washington, D.C., for general availability to the public. Distribution of the dockets to other agencies (Federal, state, or local) as necessary, is made by OR-TSD. The Verification and Certification Protocol (Supplement No. 2 to this protocol) and Appendix F (Public Availability and Archiving of FUSRAP Records) provide additional information.

# BIBLIOGRAPHY OF DOE SUPPORTING GUIDANCE DOCUMENTS

Formerly Utilized Sites Remedial Action Program, Designation/Elimination Protocol--Supplement No. 1 to the FUSRAP Summary Protocol, November 1985.

Formerly Utilized Sites Remedial Action Program, Verification and Certification Protocol--Supplement No. 2 to the FUSRAP Summary Protocol, January 1986.

U.S. DOE Energy Acquisition Project Plan (ESAPP), Formerly Utilize MED/AEC Sites Remedial Action Program (FUSRAP) (Revision 1), April 1985, and subsequent revisions.

# NOTE

When this Summary Protocol was issued, Appendix B was Revision 1, dated July 1985 of the DOE Guidelines for Residual Radioactivity at FUSRAP and Remote SFMP Sites. Revision 2 (March 1987) of these guidelines have been issued subsequently, and it may be found as Communication Control Number (CCN) 046176.

J. C. Kaffer 3/29/89

J. C. KAFFER
Bechtel National, Inc.
Oak Ridge, TN 37831

046176

**Department of Energy**
Washington, DC 20545

JUN 26 1987

Dr. Stanley Lichtman
Office of Radiation Programs (ANR-460)
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Dear Dr. Lichtman:

Enclosed for your information is a copy of the revised "U.S. Department of Energy (DOE) Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program (FUSRAP) and Surplus Facilities Management Program (SFMP) Sites." These guidelines are used for DOE remedial actions and decommissioning projects conducted under FUSRAP and SFMP. Also enclosed is a summary of the changes between these guidelines dated March 1987 and the previous version dated July 1985. The changes are primarily procedural in nature and were made to simplify field implementation of the guidelines. The guidelines still encompass an annual dose of 100 mrem as the primary dose limit and incorporate the Department's as low as reasonably achievable (ALARA) philosophy through all aspects of the program.

We are presently updating the manual for implementing the residual radioactivity guidelines and hope to have it completed later this year. In the interim, the Department will continue to use the September 1985 version of the manual along with interim guidance for implementing the updated hot spot criteria. If you have any questions regarding these guidelines and their implementation, call Andrew Wallo of my staff at 301-353-5439.

Sincerely,

J. Fiore

James J. Fiore, Director
Division of Facility and Site
Decommissioning Projects
Office of Nuclear Energy

2 Enclosures

Summary of Changes to:
U.S. Department of Energy Guidelines for Residual Radioactive Material at FUSRAP and Remote SFMP Sites.

INTRODUCTION:

The revised U.S. DOE Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program (FUSRAP) and Remote Surplus Facilities Management Program (SFMP) Sites dated March 1987, comply with DOE's standards for protecting the public and are effectively the same as the previous version of the Guidelines. They are consistent with recommendations of the International Commission on Radiological Protection (ICRP) and relevant and applicable Federal/state rules or regulations. The Guidelines encompass:

- Basic Dose Limits to be applied to remedial action projects.
- Residual Radioactive Material Guidelines for Remedial Actions.
  - --Generic and derived guidelines for concentrations of radionuclides in soil.
  - --Hot Spot Limits for radionuclides in soil.
  - --Radon in air guidelines.
  - --External Gamma radiation guidelines.
  - --Surface contamination guidelines for buildings and equipment.
  - --Air and water guidance.
- Authorized Limits for remedial actions (Site Specific Cleanup Limits).
- Guidance for Control of Residual Radioactive Material.
  - --Interim Storage.
  - --Long-term Management.
- Provisions for Supplemental Limits and Exceptions.
- Sources and references for guidelines.

Differences between the March 1987, version and the previous version of the guidelines are generally procedural in nature or are editorial changes made to clarify certain aspects of the guidelines that have been misinterpreted in the past. The procedural changes relate to the implementation of guidance for limiting hot spots and the exceptions or supplemental limit provisions of the document. The guidance for hot spots were modified to include an approach that is more conservative but can be more easily implemented in the field. The exceptions section of the previous version was changed to differentiate exceptions (deviations from the generic or derived guidelines that require restrictions on site use to ensure compliance with DOE standards) from supplemental limits (deviations from site specific generic or derived guidelines that occur due to specific considerations and do not require restrictions on site use to ensure compliance with DOE standards).

General discussion and considerations:

The guidelines for radionuclides in soil are generic or derived depending on the radionuclides of concern. For radium and thorium, generic guidelines have been adopted from the EPA Standards (40 CFR 192) for uranium mill tailings remedial actions. These EPA standards were determined to be appropriate for many FUSRAP sites and are generally applied at sites contaminated with uranium and thorium ores or tailings. Conditions at the FUSRAP site are sufficiently similar to uranium mill tailings sites and associated vicinity properties being remediated under the Uranium Mill Tailings Remedial Action Program (UMTRAP) to ensure equivalent levels of protection. However, in the Residual Radioactive Material Guidelines, the Department has recognized the limitations of the EPA standards for radium and thorium in soil in certain contamination situations. These DOE Guidelines provide specific guidance for the treatment of hot spots and take into account multiples or mixtures of radionuclides for situations when radionuclides other than or in addition to radium or thorium and their associated decay products are present. These additions effectively result in a more conservative guideline. In addition, the Department's guidance requires application of the As Low As Reasonably Achievable (ALARA) philosophy in the field which may be applied but is not required under the UMTRA standards.

In other areas as with soil contamination, the guidelines are consistent with UMTRAP and other EPA standards; however, the use of UMTRAP standards is not defacto. Care is taken to ensure appropriate application of standards or limits. Dose evaluations and engineering alternative analyses are applied to storage and disposal sites. In general, materials of higher concentrations are provided greater isolation as required to ensure the dose standards and other appropriate limits are consistently achieved. Similarly, application of the exceptions provisions of the DOE Guidelines require equal and in some cases more detailed analysis and evaluation than is required for UMTRAP Sites under EPA Standards. In order to obtain approval for a specific exception or supplemental limit, dose evaluations, assessments of potential impacts, and/or cost-benefit analyses are required. These analyses must go through a formal approval procedure which include multiple reviews to by DOE field offices and headquarters ensure that the public and environment are adequately protected.

The derived limits established via procedures described in the Guidelines and supporting material comply with DOE Standards for protecting the public and are consistent with ICRP guidance which is generally being applied to most areas of radiation protection. ICRP states that the lifetime dose to a member of the general public should correspond to a maximum 100 mrem/year limit of life-long whole body exposure from all sources, excluding background and medical related doses. ICRP-26 indicates that in most cases that limit can be achieved by application of the 500 mrem/year dose limit. The report suggests that the application of the 500 mrem/year limit is likely to produce dose equivalents of less than 50 mrem/year. The report also indicates that maximizing assumptions usually made in selecting the critical groups result in actual doses to the most highly exposed individuals of values less than that postulated.

The Department's Guidelines use the 100 mrem/year value as a limit for life time exposure (instead of the 500 mrem/year limit) and derive allowable concentrations postulating worse case plausible use scenarios. In general, while plausible, these scenarios are highly unlikely and actual or likely use scenarios would produce potential doses much less than 100 mrem/year, probably on the order of a few mrem/year. As the intent of the ICRP guidance is to ensure that actual doses to the general public do not exceed 100 mrem/year over a lifetime and not to limit potential worst case doses, the Department's Guidelines clearly achieve this goal. The application of ALARA to the Guidelines, reduce exposures to levels that are still further below the postulated limit.

In summary, the DOE Guidelines represent implementable limits for residual radioactivity in the environment that comply with DOE Standards for protecting the public, meet the intent of ICRP guidance, and are consistent with existing guidelines and standards. The DOE Guidelines for residual radioactive material also conform to the DOE policy for implementing radiation protection activities in a manner that is as low as reasonably achievable.

Major Changes:

As indicated previously the primary changes to the Guidelines occurred in two areas. These changes are outlined below.

Hot Spot Criteria:

The July 1985 version of the Departments residual radioactive material guidelines required that "guidelines for local concentrations" be applied to all areas less than 30 square meters found to exceed an authorized limit or guideline for a 100 square meter area by a factor of 3 or greater. The factor of 3 requirement was not a clean-up limit, but rather a screening or action level. Basically, specific dose calculations were required for each area less than 30 square meters if the area exceeded 3 times the 100 square meter soil concentration guideline or limit. These calculations were found to be impractical for field application due to the requirement to perform dose calculations in the field.

In addition, analysis of the screening value (factor of 3) indicated there was a remote possibility that that value would not provide adequate protection of the general public for certain radionuclides for areas of contamination exceeding about 15 square meters. As a result the Department established a working group whose purpose was to develop hot spot criteria that would:

- Protect the public and environment.
- Be consistent with the guidelines.
- Facilitate field implementation.

The working group recommended that the hot spot criteria be defined as a multiple of the soil guidelines or authorized limits which represent the general soil concentration for radionuclides permitted over a 100 square

meter area, and that the factor be the squareroot of (100/A) where A is the area of the hot spot. This factor was applied to several typical radionuclides found at DOE remedial action sites including selected alpha, beta, and gamma emmitters using the dose estimating methodology provided in the procedures manual, the "supplement" to the Guidelines. The assessment indicated that the $(100/A)^{1/2}$ factor is sufficiently conservative to ensure the basic 100 mrem/year dose limit is maintained. For field application, the working group recommended that the hot spot limit be implemented in four discrete steps as shown in the attached table. The use of discrete steps adds further conservatism to the approach as well as simplifying field application. The attached table provides a summary of the working groups recommendations for the criteria and its implementation. Theoretically, the $(100/A)^{1/2}$ limit could allow very small areas of contamination to have high concentrations of radionuclides. While this does not, in general, pose a problem to most DOE remedial action sites due to the nature of the residues and DOE's ALARA philosophy, a maximum factor of 30 times the authorized limit was established as limit for small areas of contamination.

On December 2, 1986, the Department approved the revised hot spot criteria and directed that it be incorporated in the FUSRAP and SFMP Guidelines for residual radioactivity. The revised guidelines adopted this procedure, but also allow for the use of the specific dose calculations where it is appropriate.

Supplemental Limits and Exceptions:

The intent and mechanism for applying the exceptions provisions of the previous guidelines were in some cases confusing. The revision of this section and the separation of exception provisions into two categories exceptions (areas requiring controlled or restricted use to comply with the 100 mrem/year dose limit) and supplemental limits (for areas requiring no restrictions to comply with the dose limit) were done in an attempt to clarify the process. The revision stresses the following points:

-Exceptions or supplemental limits are generally for use at a portion of a site or vicinity property where specific circumstances dictate the guidelines or authorized limit established for the entire site and vicinity properties are not appropriate for the specific area of concern.

-Every effort should be made to minimize the use of exceptions or supplemental limits.

-Supplemental limits must be justified on a case-by-case basis using site specific data and must consider ALARA policy.

# APPLICATION OF HOT SPOT GUIDELINE

1. The method for determining Hot Spot Limits, which is based on the 100 mrem/year Dose Limit, as described in the FUSRAP procedures manual, shall still be applicable for determining allowable concentrations of radionuclides under inhomogeneous soil contamination conditions. However, the following approach, more appropriate for field applications, may be used in place of the Dose Limit method and is recommended for general applications.

2. For the alternative approach, the basic Hot Spot Limits will be calculated for each specific site by (see attached figure):

   $Shg = Sg * (100\ m^2/A)^{1/2}$

   where, Shg = the Hot Spot Limit (pCi/gram)
   Sg = the Authorized Limit for a specific site (pCi/gram)
   A = the area of the hot spot in square meters
   $(100/A)^{1/2}$ is the hot spot multiplication factor.

3. The limits shall be applied in the field over ranges of area with the factors being constant over a given area. The ranges and factors to be used are:

| Range | Factor (Multiple of Authorized Limit) |
|---|---|
| <1 $m^2$ | 10* |
| 1 - <3 $m^2$ | 6 |
| 3 - <10 $m^2$ | 3 |
| 10 - 25 $m^2$ | 2 |

   *Areas less than one square meter are to be averaged over the one square meter and that average shall not exceed ten times the Authorized Limit.

4. The average Authorized Limit is considered adequate to protect the public for areas larger than 25 square meters; hence, no special Hot Spot Limits are required for areas larger than 25 square meters.

5. Averaging of hot spots less than or equal to 25 square meters shall be done only over the local hot spot area.

6. Every reasonable effort shall be made to identify and remove any source which has a concentration of a radionuclide exceeding 30 times the Authorized Limit irrespective of area.

# U.S. DEPARTMENT OF ENERGY GUIDELINES FOR RESIDUAL RADIOACTIVE MATERIAL AT FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM AND REMOTE SURPLUS FACILITIES MANAGEMENT PROGRAM SITES

(Revision 2, March 1987)

## A. INTRODUCTION

This document presents U.S. Department of Energy (DOE) radiological protection guidelines for cleanup of residual radioactive materials and management of the resulting wastes and residues. It is applicable to sites identified by the Formerly Utilized Sites Remedial Action Program (FUSRAP) and remote sites identified by the Surplus Facilities Management Program (SFMP).* The topics covered are basic dose limits, guidelines and authorized limits for allowable levels of residual radioactive material, and requirements for control of the radioactive wastes and residues.

Protocols for identification, characterization, and designation of FUSRAP sites for remedial action; for implementation of the remedial action; and for certification of a FUSRAP site for release for unrestricted use are given in a separate document (U.S. Department of Energy 1986) and subsequent guidance. More detailed information on applications of the guidelines presented herein, including procedures

---

* A remote SFMP site is one that is excess to DOE programmatic needs and is located outside a major operating DOE research and development or production area.

for deriving site-specific guidelines for allowable levels of residual radioactive material from basic dose limits, is contained in "A Manual for Implementing Residual Radioactive Material Guidelines" (U.S. Department of Energy 1987) referred to herein as the "supplement".

"Residual radioactive material" is used in these guidelines to describe radioactive materials derived from operations or sites over which the Department of Energy has authority. Guidelines or guidance to limit the levels of radioactive material to protect the public and environment are provided for: (1) residual concentrations of radionuclides in soil material, (2) concentrations of airborne radon decay products, (3) external gamma radiation level, (4) surface contamination levels, and (5) radionuclide concentrations in air or water resulting from or associated with any of the above.

A "basic dose limit" is a prescribed standard from which limits for quantities that can be monitored and controlled are derived; it is specified in terms of the effective dose equivalent as defined by the International Commission on Radiological Protection (ICRP 1977, 1978). The basic dose limits are used for deriving guidelines for residual concentrations of radionuclides in soil material. Guidelines for residual concentrations of thorium and radium in soil, concentrations of airborne radon decay products, allowable indoor external gamma radiation levels, and residual surface contamination concentrations are based on existing radiological protection standards or guidelines (U.S. Environmental Protection Agency 1983; U.S. Nuclear Regulatory Commission 1982; and Departmental Orders). Derived guidelines or limits based on the basic dose limits for those quantities are only used when the guidelines provided in the existing standards cited above are shown to be inappropriate.

A "guideline" for residual radioactive material is a level of radioactivity or of the radioactive material that is acceptable if the use of the site is to be unrestricted. Guidelines for residual radioactive material presented herein are of two kinds: (1) generic,

site-independent guidelines taken from existing radiation protection standards, and (2) site-specific guidelines derived from basic dose limits using site-specific models and data. Generic guideline values are presented in this document. Procedures and data for deriving site-specific guideline values are given in the supplement. The basis for the guidelines is generally a presumed worst case plausible scenario for a site.

An "Authorized Limit" is a level of residual radioactive material or radioactivity that must not be exceeded if the remedial action is to be considered completed and the site is to be released for unrestricted use. The Authorized Limit for a site will include limits for each radionuclide or group of radionuclides, as appropriate, associated with the residual radioactive material in the soil or in surface contamination of structures and equipment, and in the air or water, and, where appropriate, a limit on external gamma radiation resulting from the residual material. Under normal circumstances, expected to occur at most sites, Authorized Limits for residual radioactive material or radioactivity are set equal to guideline values. Exceptional conditions for which Authorized Limits might differ from guideline values are specified in Sections D and F. A site may be released for unrestricted use only if the conditions do not exceed the Authorized Limits or approved supplemental limits as defined in Section F.1 at the time remedial action is completed. Restrictions and controls on use of the site must be established and enforced if the site conditions exceed the approved limits, or if there is potential to exceed the dose limit if the site use was not restricted (Section F.2). The applicable controls and restrictions are specified in Section E.

DOE policy requires that all exposures to radiation be limited to levels that are as low as reasonably achievable (ALARA). For sites to be released for unrestricted use, the intent is to reduce residual radioactive material to levels that are as far below Authorized Limits as reasonable considering technical, economic, and social factors. At sites where the residual material is not reduced to levels that permit release for unrestricted use, ALARA policy is implemented by establishing controls to reduce exposure to levels that are as low as reasonably achievable. Procedures for implementing ALARA policy are discussed in the supplement. ALARA policies,

procedures, and actions shall be documented and filed as a permanent record upon completion of remedial action at a site.

## B. BASIC DOSE LIMITS

The basic dose limit for the annual radiation dose received by an individual member of the general public is 100 mrem/year. The internal committed effective dose equivalent, as defined in ICRP Publication 26 (ICRP 1977) and calculated by dosimetry models described in ICRP Publication 30 (ICRP 1978), plus dose from penetrating radiation sources external to the body shall be used for determining the dose. This dose shall be described as the "Effective Dose Equivalent". Every effort shall be made to ensure that actual doses to the public are as far below the dose limit as is reasonably achievable.

Under unusual circumstances it will be permissible to allow potential doses to exceed 100 mrem/year where such exposures are based upon scenarios which do not persist for long periods and where the annual life time exposure to an individual from the subject residual radioactive material would be expected to be less than 100 mrem/year. Examples of such situations include conditions that might exist at a site scheduled for remediation in the near future or a possible, but improbable, one-time scenario that might occur following remedial action. These levels should represent doses that are as low as reasonably achievable for the site. Further, no annual exposure should exceed 500 mrem.

## C. GUIDELINES FOR RESIDUAL RADIOACTIVE MATERIAL

### C.1 Residual Radionuclides in Soil

Residual concentrations of radionuclides in soil shall be specified as above-background concentrations averaged over an area of 100 sq meters. Generic guidelines for thorium and radium are specified below. Guidelines for residual concentrations of other radionuclides shall be derived from the basic dose limits by means of an environmental pathway analysis using

site-specific data where available. Procedures for these derivations are given in the supplement.

If the average concentration in any surface or below surface area less than or equal to 25 sq meters exceeds the Authorized Limit or guideline by a factor of $(100/A)^{1/2}$, where A is the area of the elevated region in square meters, limits for "Hot Spots" shall also be applicable. These Hot Spot Limits depend on the extent of the elevated local concentrations and are given in the supplement. In addition, every reasonable effort shall be made to remove any source of radionuclide that exceeds 30 times the appropriate soil limit irrespective of the average concentration in the soil.

Two types of guidelines are provided, generic and derived. The generic guidelines for residual concentrations of the Ra-226, Ra-228, Th-230, and Th-232 are:

- 5 pCi/g, averaged over the first 15 cm of soil below the surface
- 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface

These guidelines take into account ingrowth of Ra-226 from Th-230 and of Ra-228 from Th-232, and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the appropriate guideline is applied as a limit to the radionuclide with the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that 1) the dose for the mixtures will not exceed the basic dose limit, or 2) the sum of the ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed 1 ("unity"). Explicit formulas for calculating residual concentration guidelines for mixtures are given in the supplement.

C.2 Airborne Radon Decay Products

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property

that are intended for unrestricted use; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, and a reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.* In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions by DOE are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive materials are not the cause.

C.3 External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site to be released for unrestricted use shall not exceed the background level by more than 20 μR/h and shall comply with the basic dose limit when an appropriate use scenario is considered. This requirement shall not necessarily apply to structures scheduled for demolition or to buried foundations. External gamma radiation levels on open lands shall also comply with the basic dose limit considering an appropriate use scenario for the area.

C.4 Surface Contamination

The generic guidelines provided in the Table 1, Surface Contamination Guidelines are applicable to existing structures and equipment. These guidelines are adapted from standards of the U.S. Nuclear Regulatory

* A working level (WL) is any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of $1.3 \times 10^5$ MeV of potential alpha energy.

TABLE 1 SURFACE CONTAMINATION GUIDELINES

| Radionuclides [2] | Allowable Total Residual Surface Contamination (dpm/100 $cm^2$) [1] | | |
|---|---|---|---|
| | Average [3, 4] | Maximum [4, 5] | Removable [4, 6] |
| Transuranics, Ra-225, Ra-228, Th-230 Th-228, Pa-231, Ac-227, I-125, I-129 | 100 | 300 | 20 |
| Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133 | 1,000 | 3,000 | 200 |
| U-Natural, U-235, U-238, and associated decay products | 5,000 α | 15,000 α | 1,000 α |
| Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above | 5,000 β-γ | 15,000 β-γ | 1,000 β-γ |

1 As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

2 Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

3 Measurements of average contamination should not be averaged over an area of more than 1 $m^2$. For objects of less surface area, the average should be derived for each such object.

4 The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

5 The maximum contamination level applies to an area of not more than 100 $cm^2$.

6 The amount of removable radioactive material per 100 $cm^2$ of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 $cm^2$ is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

Commission (1982)* and will be applied in a manner that provides a level of protection consistent with the Commission's guidance. These limits apply to both interior and exterior surfaces. They are not directly intended for use on structures to be demolished or buried, but, should be applied to equipment or building components that are potentially salvageable or recoverable scrap. If a building is demolished, the guidelines in Section C.1 are applicable to the resulting contamination in the ground.

C.5 Residual Radionuclides in Air and Water

Residual concentrations of radionuclides in air and water shall be controlled to levels required by DOE Environmental Protection Guidance and Orders, specifically DOE Order 5480.1A and subsequent guidance. Other Federal and/or state standards shall apply when they are determined to be appropriate.

D. AUTHORIZED LIMITS FOR RESIDUAL RADIOACTIVE MATERIAL

The Authorized Limits shall be established to: 1) ensure that, as a minimum, the Dose Limits specified in Section B will not be exceeded under the worst case plausible use scenario consistent with the procedures and guidance provided, or 2) where applicable generic guidelines are provided, be consistent with such guidelines. The Authorized Limits for each site and vicinity properties shall be set equal to the generic or derived guidelines except where it can be clearly established on the basis of site specific data, including health, safety and socioeconomic considerations, that the guidelines are not appropriate for use at the specific site. Consideration

* These guidelines are functionally equivalent to Section 4 - Decontamination for Release for Unrestricted Use of NRC Regulatory Guide 1.86, but are applicable to Non-Reactor facilities.

should also be given to ensure that the limits comply with or provide an equivalent level of protection as other appropriate limits and guidelines (i.e., state, or other Federal). Documentation supporting such a decision should be similar to that required for supplemental limits and exceptions (Section F), but should be generally more detailed because it covers an entire site.

Remedial actions shall not be considered complete unless the residual radioactive material levels comply with the Authorized Limits. The only exception to this requirement will be for those special situations where the supplemental limits or exceptions are applicable and approved as specified in Section F. However, the use of supplemental limits and exceptions should only be considered if it is clearly demonstrated that it is not reasonable to decontaminate the area to the Authorized Limit or guideline value. The Authorized Limits are developed through the project offices in the field (Oak Ridge Technical Services Division for FUSRAP) and approved by the headquarters program office (the Division of Facility and Site Decommissioning Projects).

## E. CONTROL OF RESIDUAL RADIOACTIVE MATERIAL AT FUSRAP AND REMOTE SFMP SITES

Residual radioactive material above the guidelines at FUSRAP and remote SFMP sites must be managed in accordance with applicable DOE Orders. The DOE Order 5480.1A and subsequent guidance or superceding orders require compliance with applicable Federal, and state environmental protection standards.

The operational and control requirements specified in the following DOE Orders shall apply to interim storage, interim management, and long-term management.

a. 5440.1C, Implementation of the National Environmental Policy Act

b. 5480.1A, Environmental Protection, Safety, and Health Protection Program for DOE Operations as revised by DOE 5480.1 change orders and the 5 August 1985 memorandum from Vaughan to Distribution

c. 5480.2, Hazardous and Radioactive Mixed Waste Management

d. 5480.4, Environmental Protection, Safety, and Health Protection Standards

e. 5482.1A, Environmental Safety, and Health Appraisal Program

f. 5483.1A, Occupational Safety and Health Program for Government-Owned Contractor-Operated Facilities

g. 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements

h. 5000.3, Unusual Occurrence Reporting System

i. 5820.2, Radioactive Waste Management

E.1 Interim Storage

a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 50 years and, in any case, at least 25 years.

b. Above-background Rn-222 concentrations in the atmosphere above facility surfaces or openings shall not exceed: (1) 100 pCi/L at any given point, (2) an annual average concentration of 30 pCi/L over the facility site, and (3) an annual average concentration of 3 pCi/L at or above any location outside the facility site (DOE Order 5480.1A, Attachment XI-1).

c. Concentrations of radionuclides in the groundwater or quantities of residual radioactive materials shall not exceed existing Federal, or state standards.

d. Access to a site shall be controlled and misuse of onsite material contaminated by residual radioactive material shall be prevented through appropriate administrative controls and physical barriers--active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These control features should be designed to ensure, to the extent reasonable, an effective life of at least 25 years. The Federal government shall have title to the property or shall have a long-term lease for exclusive use.

## E.2 Interim Management

a. A site may be released under interim management when the residual radioactive material exceeds guideline values if the residual radioactive material is in inaccessible locations and would be unreasonably costly to remove, provided that administrative controls are established to ensure that no member of the public shall receive a radiation dose exceeding the basic dose limit.

b. The administrative controls, as approved by DOE, shall include but not be limited to periodic monitoring as appropriate, appropriate shielding, physical barriers to prevent access, and appropriate radiological safety measures during maintenance, renovation, demolition, or other activities that might disturb the residual radioactivity or cause it to migrate.

c. The owner of the site or appropriate Federal, state, or local authorities shall be responsible for enforcing the administrative controls.

## E.3 Long-Term Management

### Uranium, Thorium, and Their Decay Products

a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 1,000 years and, in any case, at least 200 years.

b. Control and stabilization features shall be designed to ensure that Rn-222 emanation to the atmosphere from the waste shall not: (1) exceed an annual average release rate of 20 $pCi/m^2/s$, and (2) increase the annual average Rn-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L. Field verification of emanation rates is not required.

c. Prior to placement of any potentially biodegradable contaminated wastes in a long-term management facility, such wastes shall be properly conditioned to ensure that (1) the generation and escape of biogenic gases will not cause the requirement in paragraph b. of this section (E.3) to be exceeded, and (2) biodegradation within the facility will not result in premature structural failure in violation of the requirements in paragraph a. of this section (E.3).

d. Groundwater shall be protected in accordance with Appropriate Departmental orders and Federal and state standards, as applicable to FUSRAP and remote SFMP sites.

e. Access to a site should be controlled and misuse of onsite material contaminated by residual radioactive material should be prevented through appropriate administrative controls and physical barriers--active and passive controls as described by the U S. Environmental Protection Agency (1983--p. 595). These controls should be designed to be effective to the extent reasonable for at least 200 years. The Federal government shall have title to the property.

Other Radionuclides

f. Long-term management of other radionuclides shall be in accordance with Chapters 2, 3, and 5 of DOE Order 5820.2, as applicable.

## F. SUPPLEMENTAL LIMITS AND EXCEPTIONS

If special site specific circumstances indicate that the guidelines or Authorized Limits established for a given site are not appropriate for a portion of that site or a vicinity property, then the field office may request that supplemental limits or an exception be applied. In either case, the field must justify that the subject guidelines or Authorized Limits are not appropriate and that the alternative action will provide adequate protection giving due consideration to health and safety,

environment and costs. The field office shall obtain approval for specific supplemental limits or exceptions from headquarters as specified in Section D of these guidelines and shall provide to headquarters those materials required for the justification as specified in this section and in the FUSRAP and SFMP protocols and subsequent guidance documents. The field office shall also be responsible for coordination with the state or local government of the limits or exceptions and associated restrictions as appropriate. In the case of exceptions, the field office shall also work with the state and/or local governments to insure that restrictions or conditions of release are adequate and mechanisms are in place for their enforcement.

F1. Supplemental Limits

The supplemental limits must achieve the basic dose limits set forth in this guideline document for both current and potential unrestricted uses of the site and/or vicinity property. Supplemental limits may be applied to a property or portion of a property or site if, on the basis of a site specific analysis, it is determined that certain aspects of the property or portion of the site were not considered in the development of the established Authorized Limits and associated guidelines for the site, and as a result of these unique characteristics, the established limits or guidelines either do not provide adequate protection or are unnecessarily restrictive and costly.

F2. Exceptions

Exceptions to the Authorized Limits defined for unrestricted use of the site may be applied to a portion of a site or a vicinity property when it is established that the Authorized Limits cannot be achieved and restrictions on use of the site or vicinity property are necessary to provide adequate protection of the public and environment. The field office must clearly demonstrate that the exception is necessary, and the restrictions will provide the necessary degree of protection and that they comply with the requirements for control of residual radioactive material as set forth in Part E of these guidelines.

F3. Justification for Supplemental Limits and Exceptions

Supplemental limits and exceptions must be justified by the field office on a case by case basis using site specific data. Every effort should be made to minimize the use of the supplemental limits and exceptions. Examples of specific situations that warrant the use of supplemental standards and exceptions are:

a. Where remedial actions would pose a clear and present risk of injury to workers or members of the general public, notwithstanding reasonable measures to avoid or reduce risk.

b. Where remedial actions--even after all reasonable mitigative measures have been taken--would produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near affected sites, now or in the future. A clear excess of environmental harm is harm that is long-term, manifest, and grossly disproportionate to health benefits that can reasonably be anticipated.

c. Where it is clear that the scenarios or assumptions used to establish the Authorized Limits do not under plausible current or future conditions, apply to the property or portion of the site identified and where more appropriate scenarios or assumptions indicate that other limits are applicable or necessary for protection of the public and the environment.

d. Where the cost of remedial actions for contaminated soil is unreasonably high relative to long-term benefits and where the residual radioactive materials do not pose a clear present or future risk after taking necessary control measures. The likelihood that buildings will be erected or that people will spend long periods of time at such a site should be considered in evaluating this risk. Remedial actions will generally not be necessary where only minc. quantities of residual radioactive

materials are involved or where residual radioactive materials occur in an inaccessible location at which site-specific factors limit their hazard and from which they are costly or difficult to remove. Examples are residual radioactive materials under hard-surface public roads and sidewalks, around public sewer lines, or in fence-post foundations. A site-specific analysis must be provided to establish that it would not cause an individual to receive a radiation dose in excess of the basic dose limits stated in Section B, and a statement specifying the residual radioactive material must be included in the appropriate state and local records.

e. Where there is no feasible remedial action.

## G. SOURCES

| Limit or Guideline | Source |
|---|---|
| **Basic Dose Limits** | |
| Dosimetry Model and Dose Limits | International Commission on Radiological Protection (1977, 1978) |
| **Generic Guidelines for Residual Radioactivity** | |
| Residual Concentrations of Radium and Thorium in Soil Material | 40 CFR 192 |
| Airborne Radon Decay Products | 40 CFR 192 |
| External Gamma Radiation | 40 CFR 192 |
| Surface Contamination | Adapted from U.S. Nuclear Regulatory Commission (1982) |
| **Control of Radioactive Wastes and Residues** | |
| Interim Storage | DOE Order 5480.1A and subsequent guidance |
| Long-Term Management | DOE Order 5480.1A and subsequent guidance; 40 CFR 192; DOE order 5820.2 |

## H. REFERENCES

International Commission on Radiological Protection, 1977. Recommendations of the International Commission on Radiological Protection (Adopted January 17, 1977). ICRP Publication 26. Pergamon Press, Oxford. [As modified by "Statement from the 1978 Stockholm Meeting of the ICRP." Annals of the ICRP, Vol. 2, No. 1, 1978.]

International Commission on Radiological Protection, 1978. Limits for Intakes of Radionuclides by Workers. A Report of Committee 2 of the International Commission on Radiological Protection. Adopted by the Commission in July 1978. ICRP Publication 30. Part 1 (and Supplement), Part 2 (and Supplement), Part 3 (and Supplements A and B), and Index. Pergamon Press, Oxford.

U.S. Evironmental Protection Agency, 1983. Standards for Remedial Actions at Inactive Uranium Processing Sites; Final Rule (40 CFR 192). Federal Register 48(3):590-604 (January 5, 1983).

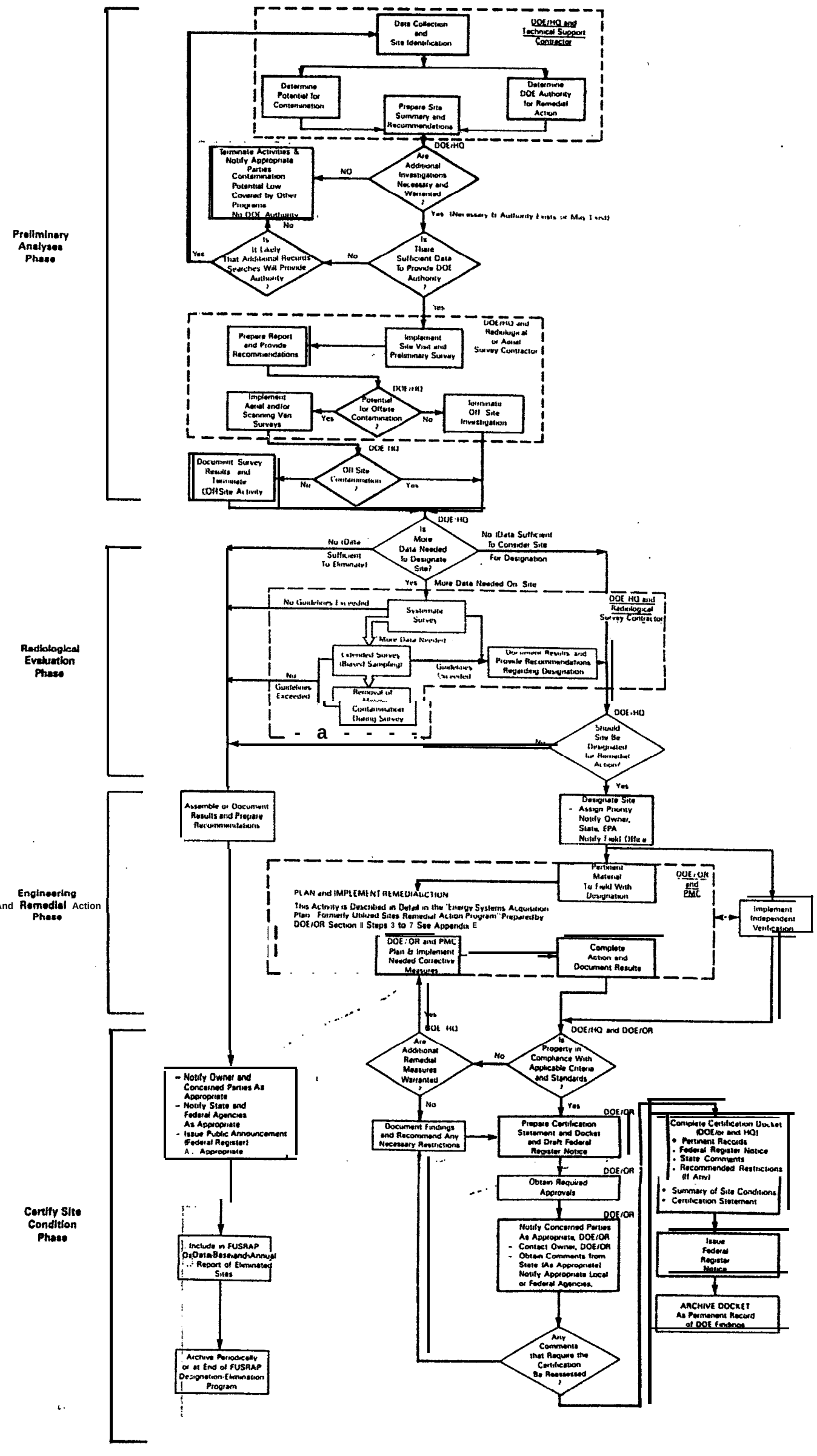
U.S. Department of Energy, 1984. Formerly Utilized Sites Remedial Action Program. Summary Protocol: Identification - Characterization - Designation - Remedial Action - Certification. Office of Nuclear Energy, Office of Terminal Waste Disposal and Remedial Action, Division of Remedial Action Projects. April 1984.

U.S. Department of Energy, 1987. Supplement to U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites. A Manual for Implementing Residual Radioactivity Guidelines. Prepared by Argonne National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, and Pacific Northwest Laboratory for the U.S. Department of Energy.

U.S. Nuclear Regulatory Commission, 1982. Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material. Division of Fuel Cycle and Material Safety, Washington, D.C. July 1982.

U.S. Atomic Energy Commission, 1974. Regulatory Guide 1.86, Termination of Operating Licenses for Nuclear Reactors, June 1974

## APPENDIX A
## FLOWCHART FOR FUSRAP PROTOCOL






35692

# APPENDIX C. DOE FUSRAP PROCEDURE FOR ASSIGNING SITE PRIORITIES

The assessment of potential health effects and the ranking of contaminated sites are complex and must take into account many influencing factors. The major hazard due to radiological contaminants is their potential to increase either the long or short term risk of cancer. The nature of these contaminants must be clearly defined. Furthermore, the risk from all pathways to an exposed individual or population group, as well as such exposure parameters as occupancy factors associated with the contaminated living or working areas and the population density around a contaminated site must be evaluated. Potential for migration of contaminants to the surrounding environs either through the air, water, soil, and the ecosystem and ultimately to man is of major importance.

Analyses to date have identified no site under current use conditions where there is an immediate health hazard; however, over the long term, the potential for accumulated exposure and unacceptable increases in risk do exist.[a] It should be noted, however, that dose and risk estimates completed as part of the assigning of priorities procedure are not absolute estimates. These estimates are

---

(a) An unacceptable increase has been tentatively defined as an annual increased risk of getting a fatal cancer in excess of 5 chances in 100,000 per year of exposure. The values represent the approximate increase in risk of contracting a fatal cancer as a result of continuous exposure to the recommended guidelines (500 mrem/y) value for short term exposure (DOE-85) using a dose risk conversion factor of $10^{-7}$ effects/mrem of dose (ICRP-26). Because this procedure assumes risk to be proportional to dose, the equivalent whole body dose calculated as the sum of weighted internal and external doses (recommendation ICRP-26) can be directly compared to the 500 mrem limit to determine a priority. The short term guideline is appropriate rather than the long term guideline of 100 mrem/year because the implementation of remedial actions to remove material causing the potential exposures are expected to begin in a short period (about 5 years or less following designation).

relative comparisons of the potential for exposure at the specific sites and are intended to be compared to estimates at other designated sites for the purpose of assigning a remedial action priority. The health effects or dose estimates are not intended or necessarily applicable for other uses.

The Department is using a three-category system for ranking contaminated sites based on health effects (see Figure C-1). The categories are:

High

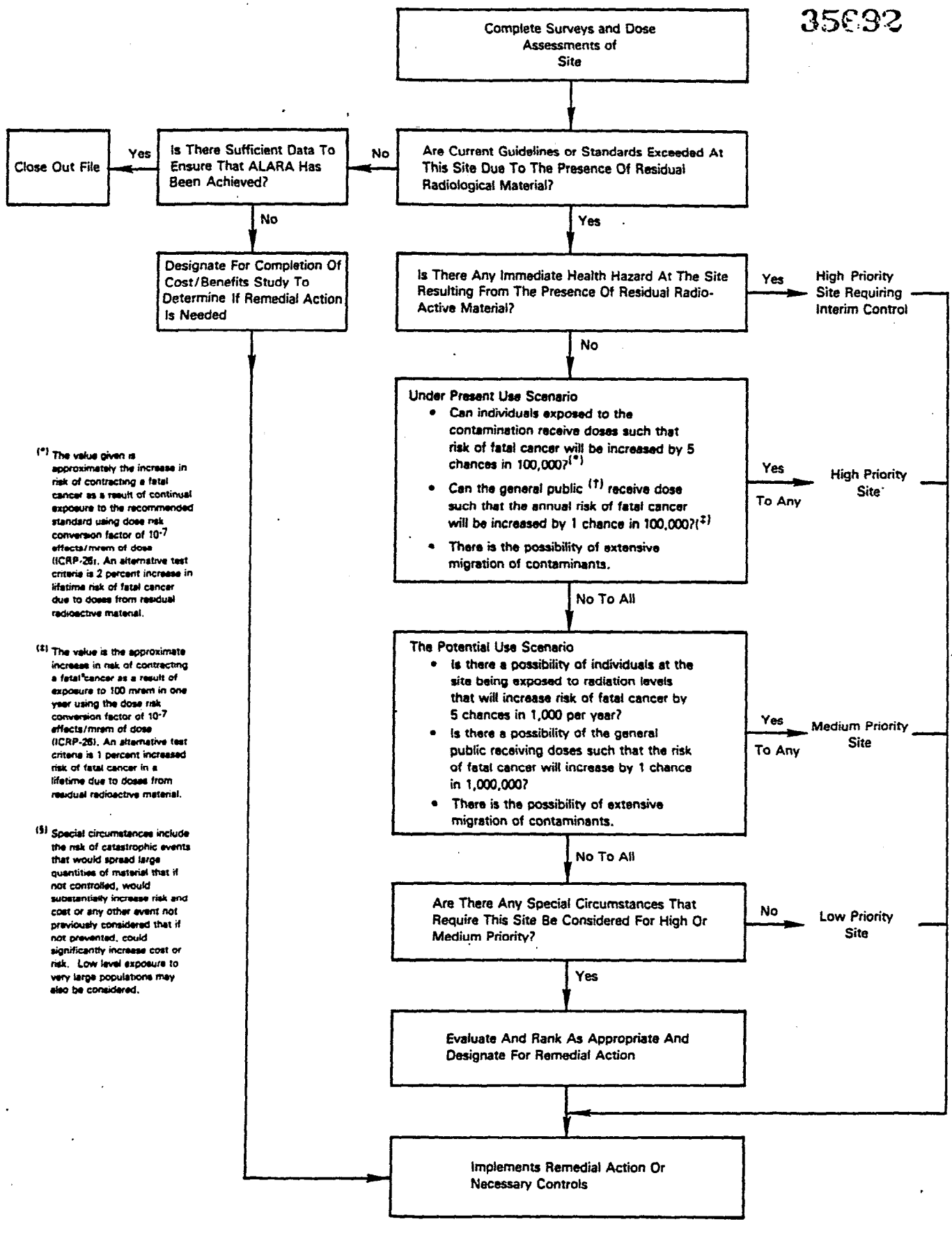
- o Ranking a site as a high priority indicates that the site is contaminated above guidelines, and
  - there is potential for individuals at a site under present use conditions to receive an unacceptable increase in cancer risk,[a] or
  - there is significant potential for a larger group of individuals not directly associated with a site to be exposed to levels of radiation that could increase the number of expected cancers to an unacceptable level,[b] or

(a) See Note (a) on previous page

(b) An unacceptable increase to a group of individuals has been tentatively defined as an annual increased risk of getting a fatal cancer in excess of 1 in 100,000. This value, as the similar one defined for individual risk, is preliminary; it is based on the increased risk that would occur if a group of persons were exposed to the standard for large groups (100 mrem/y, FRC* 1960) over their entire lives. This is the approximate annual risk estimated using the 100 mrem/y standard and a dose risk conversion factor of $10^{-7}$ effects/mrem of dose from ICRP-26. Because the procedure assumes risk to be proportional to dose, the equivalent whole body dose calculated as recommended in ICRP-26 (the sum of weight internal and external doses) can be directly compared to the 170 mrem dose limit to determine priorities.

*Recommendations of the Federal Radiation Counsel.

35692




(*) The value given is approximately the increase in risk of contracting a fatal cancer as a result of continual exposure to the recommended standard using dose risk conversion factor of $10^{-7}$ effects/mrem of dose (ICRP-26). An alternative test criteria is 2 percent increase in lifetime risk of fatal cancer due to doses from residual radioactive material.

(‡) The value is the approximate increase in risk of contracting a fatal cancer as a result of exposure to 100 mrem in one year using the dose risk conversion factor of $10^{-7}$ effects/mrem of dose (ICRP-26). An alternative test criteria is 1 percent increased risk of fatal cancer in a lifetime due to doses from residual radioactive material.

(§) Special circumstances include the risk of catastrophic events that would spread large quantities of material that if not controlled, would substantially increase risk and cost or any other event not previously considered that if not prevented, could significantly increase cost or risk. Low level exposure to very large populations may also be considered.

Figure C-1. DOE Prioritization Procedure

- there is extensive migration or there is significant potential for extensive migration of the contamination into the surrounding environs.

Medium o Ranking a site as medium priority indicates the site is contaminated above guidelines, and

- there is no immediate hazard to individuals at a site under current use conditions, but there is potential (due to possible change in use or occupancy) for individuals to be exposed to levels of radiation that may increase the risk of cancer above an acceptable level,[a] or

- there is potential for a site to be exposed to levels of radiation that could increase the number of cancers to an unacceptable level[b] if the present use conditions of the site were to change, or

- there is a moderate possibility that contamination may migrate offsite and result in exposure to individuals around the site.

Low o Ranking a site as low priority indicates that the site is contaminated above guidelines; however,

- the exposure level is very close to the level where no discernible increase in cancer risk to individuals under current or near term (10 year period) future use of the site is expected, or

- there is no foreseeable chance of the surrounding population being exposed to levels of radiation that would increase their risk of cancer, or

- there is little or no chance of, or little significance in, migration of contamination from the site.

Dose/Health effects based priorities are only one factor in determining a sites remedial action priority. Other factors (discussed in the text of the protocol) will be assessed by the OR/TSD and DFSD after designation and are used along with health effects priorities to provide the overall remedial action priorities. It is also important to note that the dose/health effects calculations are used in determining priorities but designations are base on comparison of the site to DOE guidelines.

# REFERENCES

DOE-85, U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites, Rev. 1, July 1985.

ICRP-26, Annuals of the ICRP Report, November 26, January 7, 1977.

# APPENDIX D. CERTIFICATION DOCKET

The purpose of the Certification Docket is to provide a consolidated and permanent record of DOE activities at the specific site and of this site's radiological condition at the time of certification. This record will be placed in the DOE Public Reading Room in Washington, D.C., and subsequently will be microfilmed for Federal Archives. The certification package will contain a summary of DOE (and predecessor agencies) activities at the site, the supporting documentation, and a bibliography of relevant documents that are not included in the docket. The outline for the final docket is:

(A) Introduction to the Docket

(1) Purpose and Contents of the Docket

(2) Property Identification (general description and drawings of property being certified)

(B) Exhibit I - Summary of Activities at the Specific Site

(1) Site History (MED/AEC use; ownership history and use; and FUSRAP activities at site)

(2) Site Description (past and current)

(3) Radiological History and Status (survey and monitoring information, and criteria for determining need for remedial action)

(4) Selection of Remedial Action (option selected; criteria for the remedial action; cost-benefit analysis; and health effects evaluation)

(5) Summary of Remedial Action (what was done; waste volume and waste types; costs; and occupational and public exposures)

(C) Exhibit II - Documents Supporting the Certification of the Site

These include but are not limited to:

(1) Decontamination or Stabilization Criteria

(2) NEPA Documents

(3) Agreements (with owner, state, and so forth)

(4) Post Remedial Action Survey and Monitoring Data

(5) State, County, and Local Comments On Adequacy of Remedial Action (and others as appropriate)

(6) Recommended Restrictions and Actions Taken to Implement

(7) Federal Register Notice

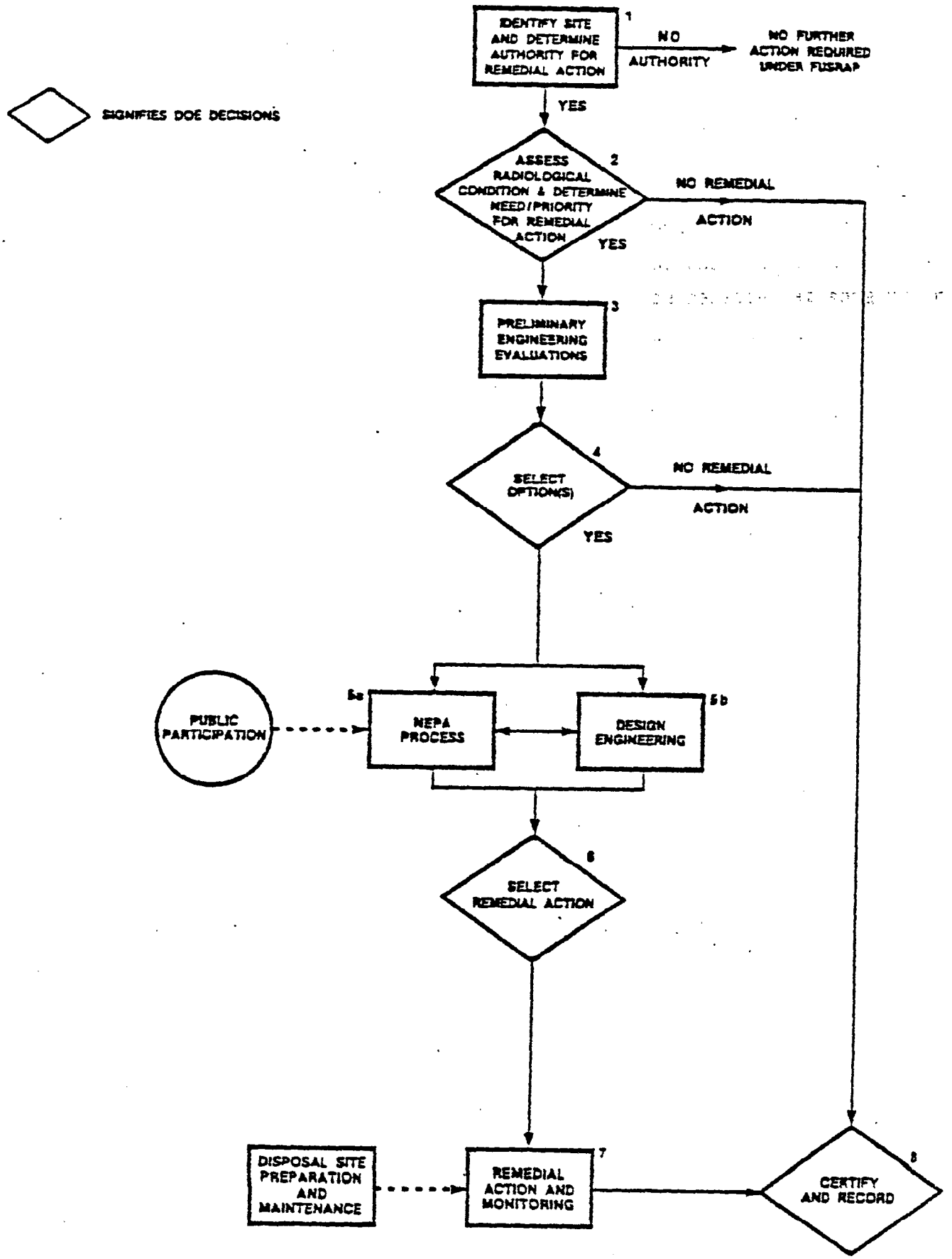
(8) Approved Certification Statement

(D) Exhibit III - Diagrams and/or Figures or Tables Supporting the Certification

(E) List of Relevant Documents

The Certification Docket shall be prepared by OR-TSD for each completed remedial action and will include state, county, and local comments (as appropriate), Federal Register notice, and Approved Certification Statement. The certification statement is signed at DOE Oak Ridge Operations and is approved at Headquarters. OR-TSD drafts and obtains the required concurrences for the Federal Register notice which is issued by Headquarters.

# APPENDIX E. BASIC STEPS INVOLVED IN THE REMEDIAL ACTION PROGRAM (FUSRAP ESAPP, APRIL 1985)



# APPENDIX F. PUBLIC AVAILABILITY AND ARCHIVING OF FUSRAP RECORDS

## Introduction

Documentation on all FUSRAP site investigations and activities (for eliminated as well as certified sites) will be prepared and archived by the Department of Energy as permanent records of the program. This activity is required by this protocol for the purpose of ensuring that investigations completed under FUSRAP do not have to be repeated at some future date. It is DFSD's responsibility to ensure that actions are taken to permanently preserve these records.

Throughout the FUSRAP project DFSD, with its technical assistance contractors and the FUSRAP project office (OR-TSD), will maintain records that document program activities including site identification, characterization, designation or elimination, and site remedial action planning, implementation, and certification. DFSD and the Technical Assistance Contractor will maintain these records documenting site identification, characterization, and designation or elimination activities. DFSD and the FUSRAP Project Office (OR-TSD) will maintain those records documenting remedial action planning, implementation, and certification activities at each site. The certification dockets assembled by OR-TSD as described in Appendix D will be the primary record for those sites designated for remedial action. Elimination reports, including authority reviews and supporting documentation, assembled by the DFSD Technical Support Contractor will be the primary record for sites identified but not included in the remedial action program. In addition, the primary record file will include general information regarding program policy, decisions, and other pertinent information required to reflect as complete as possible history or chronology of activities associated with each FUSRAP site.

Temporary Public Access

The Certification Dockets, major FUSRAP announcements, press releases and, where appropriate, elimination reports will be made available at the Department of Energy Public Reading Room in Washington, D.C. Upon receipt of the primary records assembled by OR-TSD and/or the Technical Assistance Contractor, DFSD will transfer copies of the subject documents to the reading room through a memorandum to the Department's Public Information Office (MA-232.1). The official record copies will be maintained by DFSD or the program office until they are archived. The memorandum will request that MA-232.1 make the copies of the documents available to the public at the reading room for a period from 3 to 5 years, after which time they will be destroyed.

Permanent Archiving of FUSRAP Records

At the termination of FUSRAP, or at an appropriate interval to be determined, DFSD will assemble and prepare these records in accordance with pertinent records management procedures for transfer to the National Archives for permanent retention. The Office of Nuclear Energy Records Liaison Office (NE-73), at the request of DFSD, will coordinate with the Department Records Officer (MA-232.3) to have the records identified for permanent retention by the National Archives. The records will then be available to interested parties through the National Archives.

35692

# FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM

## DESIGNATION/ELIMINATION PROTOCOL--
## SUPPLEMENT NO. 1 TO THE
## FUSRAP SUMMARY PROTOCOL

January 1986

Division of Facility and Site Decontamination Projects
Office of Nuclear Energy
U.S. Department of Energy

35632

# CONTENTS


| | Page |
|---|---|
| INTRODUCTION | 1 |
| DESIGNATION/ELIMINATION PROTOCOL | 1 |
| Data Collection | 1 |
| Designation/Elimination Analyses | 3 |
| Activities Following Designation/Elimination | 11 |


## FIGURES


| | | |
|---|---|---|
| 1. | Decision Tree for the Designation/Elimination Process--Alternative 1--Authority Review Completed First | 4 |
| 2. | Decision Tree for the Designation/Elimination Process--Alternative 2--Site Characterization Review Completed First | 5 |
| 3. | Information Collected and Utilized in the Designation/Elimination Process | 7 |
| 4. | Factors Considered in Authority Reviews | 8 |

# FUSRAP DESIGNATION/ELIMINATION PROTOCOL
## SUPPLEMENT TO THE FUSRAP SUMMARY PROTOCOL

## INTRODUCTION

This supplement to the Formerly Utilized Sites Remedial Action Program (FUSRAP) Summary Protocol provides additional detail regarding the designation/elimination process, It is intended as an amplification of the information provided in the FUSRAP Summary Protocol and relates to those activities conducted prior to Step 2, Figure II, of that document (the final decision for designation into or elimination from FUSRAP). This supplement is to be used along with the guidance provided in the summary protocol and not in place of it.

The primary objective of the designation/elimination activity is to determine if specific sites are in need of and eligible for remedial action under FUSRAP. Basically, the investigations must provide evidence that a site is contaminated above the current FUSRAP guidelines with radioactive material that resulted from past DOE predecessor activities and that there is authority under the Atomic Energy Act of 1954 as amended (AEA) to conduct remedial action at the site. If these criteria are met, the site is included in FUSRAP. The activities involved in making this determination and the criteria used for the determination are explained in this protocol. A brief discussion of the data collection activities that precede the preparation of the designation or elimination report is also included. The initiation of the designation/elimination activity for a given site is totally dependent on the data collection process.

## DESIGNATION/ELIMINATION PROTOCOL

### Data Collection

Data to support the designation or elimination activities are derived from several sources. Historical information required to support findings related to the potential for contamination of the site (characterize the radiological condition of the site) and to establish if the Department has authority under the AEA to conduct any necessary remedial actions at a site, is primarily obtained through records searches and also through interviews with cognizant individuals (such as former facility or Atomic Energy Commission employees). In addition, as required and appropriate, new radiological data and/or site specific information are collected through site visits or surveys or contacts with owners.

Records Searches and Interviews. There are essentially two types of records searches that are employed to support the designation/

elimination activity. The first is the systematic review. The Department as part of its site identification and characterization effort has investigated the Manhattan Engineer District (MED) and Atomic Energy Commission (AEC) records stored at various records centers and records storage locations to identify records that are or may be pertinent to FUSRAP. The investigations involve several stages of screening to identify records that require detailed review. As part of the systematic reviews, the pertinent records are examined to determine their subject area, the sites they address, and to obtain copies of material that would support the designation/elimination reviews. The material is reviewed and copied as appropriate for all sites addressed. In addition, notes are taken on the particular records reviewed so that if materials that are not needed for designation/elimination actions are later necessary for other purposes (litigation or Freedom of Information Act responses) their location is easily determined and the required records can be easily retrieved. The systematic approach is the most efficient and cost effective because, the records need only be reviewed once. However, the method does not allow easy or accurate scheduling of results. Because the records are not well categorized and are not generally filed by site [records are in most cases stored by date (FY43 and so forth and by departmental division (Feed Materials Division and so forth)], there is no way of determining when or if enough information will be assembled on any one site until enough material has been collected or all the records have been reviewed.

The second type of search is the site specific review. Under this type of review all the records identified that may contain material on a selected site are screened to attempt to locate those records that probably contain information on that site. These high probability records are then scanned to identify site specific records and only the site specific records are reviewed for designation/elimination information. This search method produces relatively fast site specific results with reasonable probability that all the important facts pertaining to a specific site are identified. Searches completed in this manner can also be scheduled somewhat more precisely than can the results of systematic searches. However, the site specific reviews produce useful information for only one site at a time and result in a more costly and less effective review because the same records groups have to be visited and reviewed several times to extract all the useful data from them.

Though it has the scheduling drawbacks the systematic search is generally the favored approach for the site identification and characterization effort. The site specific searches are only conducted when there are priority requirements to complete investigations on a specific site.

Interviews are generally conducted toward the end of an investigation on a specific site or when it appears that the records will not

be sufficient on their own to support a designation or elimination. As a result, most interviews are site or subject specific; however, at the time of the interview the cognizant individuals are also interrogated for information on other sites or subject for future reference.

Site Visits and Preliminary Surveys. Visits or preliminary surveys are normally only conducted when there is significant probability of residual contamination being present at a site and if there is authority to conduct remedial action at the site if the radiological conditions are found to be unacceptable. The primary purpose of the visits or surveys is to obtain information needed for the site designation or elimination which can not be obtained through the records search activity.

Additional details regarding the implementation of the site visit and survey activities and the records search actions are provided in the Preliminary Analyses Phase section of the general FUSRAP protocol.

## Designation/Elimination Analyses

The designation or elimination analyses are completed in two parallel analyses. The site data are reviewed (1) to determine if the sites are contaminated above DOE guidelines or if there is potential contamination on the site due to DOE predecessor operations and (2) to determine if the Department has authority to correct any unacceptable radiological conditions that might be identified at the site. The two analyses are different and require somewhat different supporting data; however, much of the analyses is interdependent and as a result, the reviews are implemented in a manner that requires significant interaction.

A positive determination must be made on both reviews for a site to be included or designated into FUSRAP; the site must be potentially contaminated above guidelines with residual material resulting from DOE predecessor operations and there must be authority for DOE to conduct any required remedial actions. If either of the reviews produce a negative finding (no authority or no potential for contamination) the site is eliminated from consideration for inclusion in FUSRAP. Figure 1 and Figure 2 outline the decision tree for the designation/elimination process. Figure 1 shows the paths and options in a case where the authority is determined first, while Figure 2 represents the case where the potential for contamination (or site characterization) is determined first.

The potential for contamination is determined through the review of the operating history of the site and considers such things as type of operation, length of time the facility operated under AEC contract, quantity of material processed, methods of disposal of wastes, radiological data and so forth. It has been found that sites at which

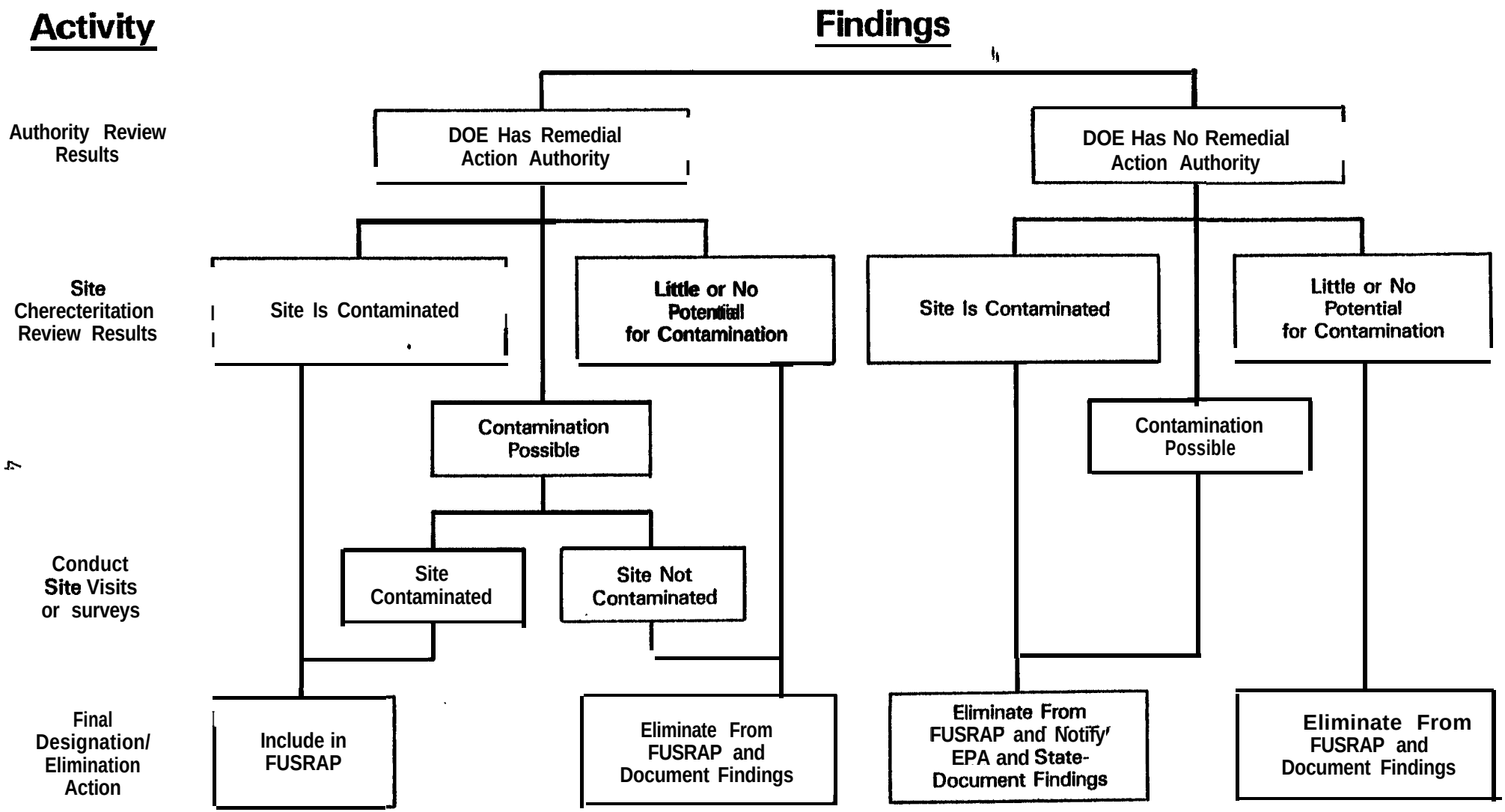



**Figure 1. Decision Tree for the Designation/Elimination Process — Alternative 1 — Authority Review Completed First**

35692

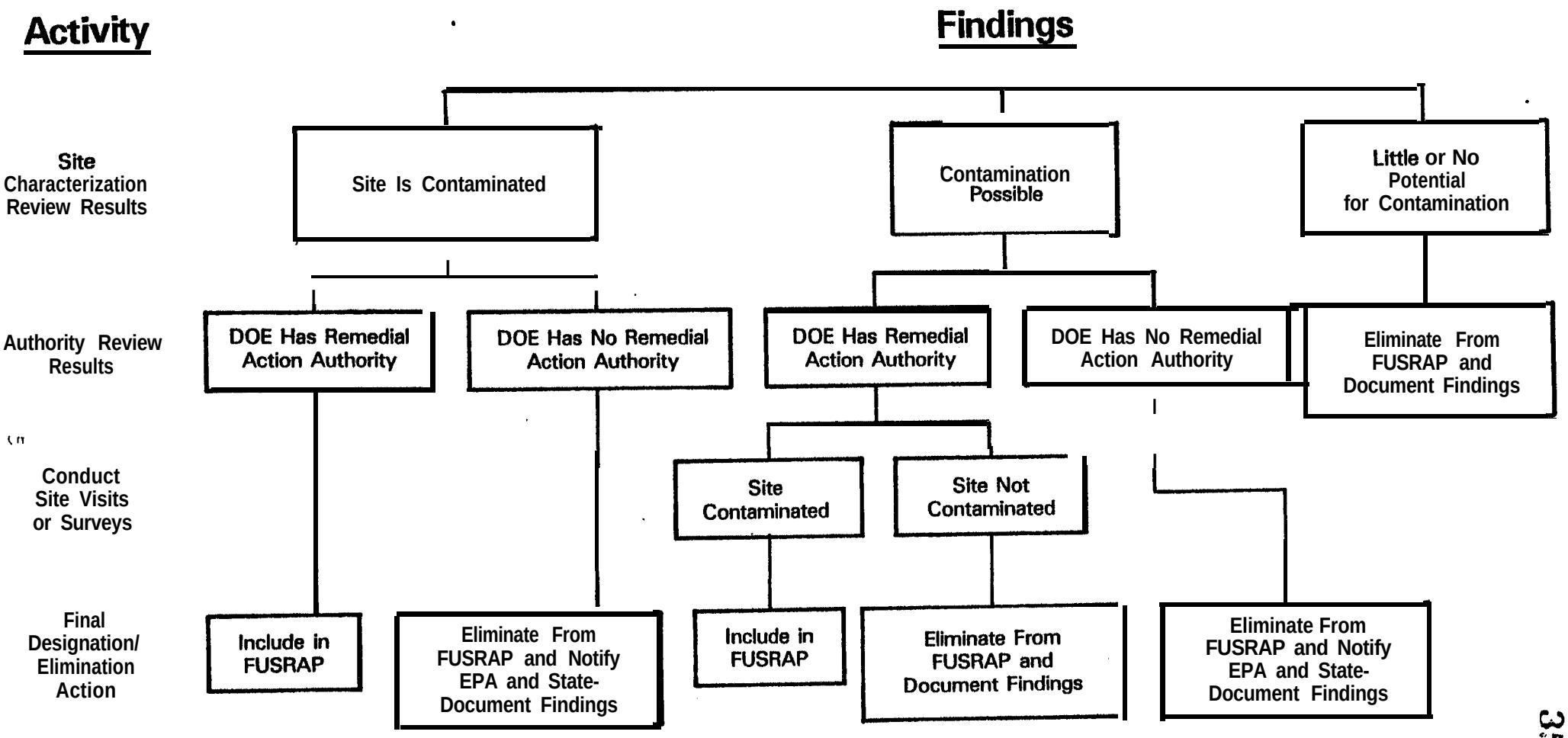



**Figure 2. Decision Tree for the Designation/Elimination Process — Alternative 2 — Site Characterization Review Completed First**

35692

little work or only small quantities of material were handled, in general, have fewer records in the files and the larger facilities handling significant amounts of radioactive materials are referenced frequently in the records. Therefore, the frequency of reference in the old records is also used as an indicator of potential for contamination.

· The authority review considers the contractual agreements and final close-out information, the DOE predecessors involvement in the facility and its operation, and health and safety responsibilities. Other important factors considered, include the license status of the site, types and amounts of commercial or other governmental work conducted at the site and current site activities. The types of records or information used in each of the authority and site characterization analyses are outlined in Figure 3 along with some of. the references normally sought during the records searches.

The criteria for determining if DOE will have authority to conduct remedial action at a given site are a series of questions derived by Division of Facility and Site Decommissioning Projects (DFSD) and the Office of General Counsel. The site specific answers to these five generic questions and the supporting reference material are used as the basis to determine if there is DDE authority for remedial action and if the site needs to be considered for FUSRAP. The five questions are listed in Figure 4. The first two questions are generally answered solely on the basis of historical data. The last three questions, however, assume that there is contamination on the site. Therefore, the review of radiological conditions must be completed before the final responses to the authority questions can be developed and the final designation decision made. Initially, if the review or evaluation of radiological condition is not complete, the last three questions are answered tentatively, assuming the site was contaminated with materials associated with past AEC/MED operations. Then a preliminary authority determination is made with the condition that it would have to be shown that the site was contaminated with residues from DOE predecessor operations before a final decision supporting authority can be made. A negative authority finding at the initial stage (prior to a final determination regarding site contamination) will generally result in the site being eliminated from the program. However, if on the basis of this draft authority review the answers to the questions indicate that DOE might have authority for remedial action at the site, additional investigations which may include site visits and/or surveys and contacts with the owner, are implemented as required to provide additional material to support the review. The final authority determination is then made on the basis of the final answers developed using the additional information.

The authority review is an iterative process. Ideally, the authority determination is done with the minimal amount of records review as is possible and practical. As soon as there appears to be

- Site Description
  - Location (address and maps)
  - Facility size
    - Entire site
    - MED/AEC portion
    - Area around the site (population and environs)
- Contractual information (MED/AEC)
  - Size of contract
  - Length of contract
  - Type of contract
  - Products
  - Areas utilized for contractual activities
  - Health and safety provisions
  - Closeout provisions
  - Special provisions
  - Contracting Division or organization
- Contractual information (non-DOE predecessors)
  - Same as above including estimates of fraction of facility and work that was not MED/AEC related
- License information
  - Type of license
  - Length of license
  - Areas and work covered under license
  - Violations
  - Current status
- History of MED/AEC operations
  - Type of operation (materials processed, quantities, waste disposal practices and so forth)
  - DDE predecessor control and involvement at the site
    - Ownership of lands, buildings, or equipment
    - Personnel stationed at the site
    - Frequency of visits to monitor or manage operations
    - Health and safety inspections and so forth
  - Periods of operations and stand-by status
  - Size of staff (production, research, engineering, health and safety and so forth) and portion of time spent on non-MED/AEC operations
  - Final closeout
    - Surveys
    - Property Transfer
    - Status and final releases
- Current status of site
  - Radiological status
  - Current and planned or future uses
  - Proximity of active areas and summary of operations
- Typical References
  - Contracts
  - Processing records
  - Surveys and health and safety reports
  - Correspondence with MED/AEC managers on pertinent issues
  - Closeout records
  - Licenses and inspections
  - interviews

**Figure 3. Information Collected and Utilized in the Designation/Elimination Process**

## Five Questions Used to Evaluate Authority for Remedial Action

1. Was the site/operation owned by a DOE predecessor or did a DOE predecessor have significant control over the operations or site?

2. Was a DOE predecessor agency responsible for maintaining or ensuring the health, safety, and environment of the site (i.e., were they responsible for cleanup)?

3. Is *the* waste, residual, or radioactive material on the site the result of DOE predecessor related operations?

4. Is the site in need of further cleanup and was the site left in unacceptable condition as a result of DOE predecessor related activities?

5. Did the present owner accept responsibility for the site with knowledge of its contaminated condition and that additional remedial measures are necessary before the site is acceptable for unrestricted use by the general public?

Figure 4. Factors Considered in Authority Reviews

sufficient data to answer the five questions (at least tentatively) and to make a determination, a draft authority *review* package is prepared and submitted to the Office of General Counsel (GC). The authority review package contains:

1. A summary of the site's operation,

2. Available information on the current condition of the site,

3. Specific answers to the questions in Figure 4; and

4. Copies of pertinent documents supporting the answers.

If GC recommends that there is insufficient data to 'make a' determination, efforts are made to identify and collect the required materials. However, if the searches prove unsuccessful and it is unlikely that any additional useful information will be derived from future records searches the authority review and determination are completed on the basis of the available information. In general, insufficient data will result in a no authority determination.

If GC recommends that the data provided is sufficient to make an authority determination, then the authority finding is made, the authority review is finalized and the next step in the process is implemented. The next step depends on the status of the site radiological evaluation effort. If the potential for contamination has been established through historical data or survey data then the elimination or designation package is prepared. If it has not, then additional investigations are conducted.

If the finding is for no authority and there is, or is potential for, contamination at the site, an elimination report is issued. The site owner, appropriate state agencies, EPA, and other appropriate Federal agencies are notified that there is (or is potential for) contamination at the site and that DOE has no authority under the AEA to conduct any remedial actions at the particular site if they are found necessary. The elimination report is made available to the owner, state agencies, EPA, and the other appropriate Federal agencies. The report is placed in the DOE Public Reading Room for at least a Z-year period and is permanently archived by DOE in accordance with procedures described in Appendix F of the FUSRAP Summay Protocol.

If the finding is for authority, the radiological and operating data are summarized to determine if additional radiological characterizations are needed to determine if the site should be considered for remedial action. If additional data are needed the site survey is planned and implemented and a designation package *(or* elimination package as appropriate) is prepared after the survey is completed. If adequate information is already available, then the designation or elimination package is prepared. The owner and the

appropriate state agencies are notified of the designation of the site for remedial action.

In those situations where the potential for contamination is low or non-existent, the sites are eliminated from the program irrespective of the DOE authority. If the authority issue has not been resolved at the time that the determination of no potential for remedial action is made, then the authority review is terminated.

Designation/Elimination Reports. Designation/elimination reports are prepared to document the analysis and to summarize the data available on a specific site. The draft designation report and supporting material is used as the basis for the designation determination. In order for a site to be included in FUSRAP the report must indicate that:

- The site is potentially contaminated (above FUSRAP criteria) with radioactive residues that resulted from DOE predecessor operations, and
- DOE has authority to conduct remedial action at the site.

The site will not be included in FUSRAP if it is already included under some other remedial action program or is under NRC or state license.

The contents of the designation reports vary slightly from site to site and may include the following types of materials:

1. A summary which discusses the past operations at the site, the current status of the site, disposal practices, radiological history and so forth.
2. A description of the current status-of the site and its location and size.
3. A summary of the authority review completed on the site.
4. An analysis of potential doses that might be received by members of the general public as a result of exposure to contamination on the site (using available radiological data).
5. A comparison of the levels of residual radioactive material on the site and potential doses to guidelines and standards.
6. A preliminary ranking of the site on the basis of potential health effects using the DOE/FUSRAP prioritization procedure (only for those sites that are designated), and
7. References and supporting data.

Elimination reports may also contain similar information, however, depending on circumstances will generally be much briefer. The elimination may be based on a finding from historical records of little potential for contamination or that the site is covered under another remedial action program and so forth. In cases where the authority review is completed first and the finding is that DOE has no authority, the authority review may be used in place of the elimination report.

## Activities Following Designation/Elimination

Designated Sites. Once a determination is made that a site qualifies for designation under FUSRAP, the DOE Oak Ridge Operations Office Manager and the Technical Services Division (OR-TSD) Director are notified by the Director of the Office of Remedial Action and Waste Technology (the superior office for DFSD) that remedial action is authorized under FUSRAP. OR-TSD (the FUSRAP project office) is then responsible for taking appropriate steps to complete any necessary characterization of the site and remedial actions determined to be required. The remedial action process is outlined in more detail in the FUSRAP Summary Protocol. Following completion of the remedial action the site is certified in accordance with procedures also outlined in the FUSRAP Summary Protocol and Supplement No. 2 to the FUSRAP Summary Protocol (verification/certification) November 1985.

Eliminated Sites. Sites eliminated from consideration for FUSRAP are in two general categories:

1. Sites that have little or no potential for being contaminated with radioactive residues for which DOE either does or does not have authority for remedial action.

2. Sites for which DOE has no authority for remedial action that are or are potentially contaminated with radioactive residues or material.

For a site in the first category, the elimination report is issued and filed and the information on the site is updated in the FUSRAP sites data base. At the end of each'year a summary report documenting the status of all the sites reviewed during the past year is prepared. This report along with the supporting elimination information are eventually archived to ensure that a record of the investigations will be permanently available.

Similar reports are prepared for the sites in the second category, and the information is documented in a similar manner. However, in order to ensure the attention of appropriate government agencies to conditions that may impact negatively on the general public or the environment, DOE notifies EPA and other appropriate Federal and/or state agencies of the findings and potential hazards associated with

the site. DOE is available to assist these agencies in the state in interpreting results or in assessing data on the sites; however, unless DOE is provided authority for the site through another mechanism (such as a legislative mandate) all activities excepting assistance to other agencies are terminated.

35692

# FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM

## VERIFICATION AND CERTIFICATION PROTOCOL--
## SUPPLEMENT NO. 2 TO THE
## FUSRAP SUMMARY PROTOCOL

NOVEMBER 1985
REVISION 1


Division of Facility and
Site Decommissioning Projects

Office of Nuclear Energy

U.S. DEPARTMENT OF ENERGY

# CONTENTS


| | | Page |
|---|---|---|
| INTRODUCTION | | 1 |
| CERTIFICATION | | 1 |
| | Remedial Action Measurements | 7 |
| | Independent Verification by DOE | 7 |
| | Independent Verificationby Others | 9 |
| | Certification Docket Preparation and Review | 9 |
| APPENDIX I | Procedure for Independent Verification of Remedial Action and Correction of Discrepancies at FUSRAP and Vicinity Properties | I-1 |
| APPENDIX 11 | Certification and Verification Sample Maintenance and Archiving Process | If-l |

# INTRODUCTION

This supplement to the general Formerly Utilized Sites Remedial Action Program (FUSRAP) protocol outlines the procedures for the verification of remedial action and the ultimate certification of a FUSRAP site's radiological condition. This supplement is intended as an amplification of the description of the certification process presented in the "Certification of Site Conditions Phase" section of the FUSRAP Summary Protocol. The certification process includes the collection of data necessary to confirm the compliance of the remedial action with applicable radiological guidelines and the preparation of materials required to permanently document the radiological condition of the site following completion of remedial action activities.

The verification and certification activities involve several elements including (1) post-remedial action measurement, (2) independent verification (independent verification of results and/or procedures by the Department of Energy (DOE) and/or others as appropriate), (3) interaction with and/or notification of concerned parties, and (4) final project documentation.

The various activities and subelements of the certification process are managed and implemented by the FUSRAP project office at the DOE Oak Ridge Operations (Technical Services Division, OR-TSD) and their contractors. The discussion to follow outlines the activities within the certification process and discusses responsibilities.

## CERTIFICATION

The discussion of the certification process is divided into three general types of activities in the discussions to follow:

- Remedial Action Measurements
- Independent Verification (by DOE and others)
- Certification Docket (Federal Register Notice and Owner Notification)

  Preparation,
  Review, and
  Distribution

The first activity is the final step in the remedial action phase of FUSRAP and is the major source of data supporting the certification effort. The other two elements makeup the portion of FUSRAP known as

the certification phase. Figure 1 is a conceptual diagram of the process and its relationship to the remedial action phase. Figure 2 is a conceptual time line showing the relative time relationships of these activities. Figure 3 is a conceptual flow chart of the certification process.

The process outlined in this supplement begins with activities conducted durin the remedial action Phase by the Project Management Contractor (PMC4. These activities involve excavation/decontamination control measurements, supportive sampling and analyses, and preparation of the post-remedial action report. They are implemented by the PMC and managed and overviewed by OR-TSD.

The independent verification activities, for the most part, run parallel with remedial action and post-remedial action activities, The reviews, surveys, measurements and documentation prepared during this element of the certification process are prepared by an independent DOE contractor not involved in the remedial action activity. Additional information may be received from state or other Federal agencies. As with the DOE independent verification activity, the State and other Federal agency activities may involve independent review of the remedial action contractors reports as well as independent measurements.

The draft certification docket is compiled by the OR/TSD (FUSRAP Project Office) and includes a summary of the action, documentation supporting the compliance with criteria, a copy of the interim letter to the property owner, the draft certification statement, and the draft Federal Register Notice. The complete draft docket is sent to Division of Facility and Site Decommissioning (DFSD) for review and comment. The final certification statement is approved by the field office and the final Federal Register notice is signed and issued by DOE Headquarters (Figure 4).

FUSRAP remedial actions involve activities to clean-up or stabilize radioactively contaminated land and structures. While the remedial actions are conducted.in a manner that would insure that no user of the site would receive doses in excess of those allowable (reference FUSRAP and Remote SFMP Criteria and Guidelines), the criteria for clean-up of structures differ from those used for the clean-up of land. Criteria used in the decontamination of structures are primarily surface contamination guidelines and external gamma limits.* Maximum permissible concentrations of radionuclides in the air and radon/radon daughter limits are also used.* For open areas or land, allowable soil concentration guidelines are used as remedial action criteria.* As a result of the differences in the types of

---

*The U.S. Department of Energy Guidelines for residual radioactivity at Formerly Utilized Sites Remedial Action Program and remote Surplus Facilities Management Program Sites (Rev. 1, July 1985).

**FIGURE 1.** Conceptual Diagram of the **Certification** and Its **Relationship** to the Remedial **Action** Phase

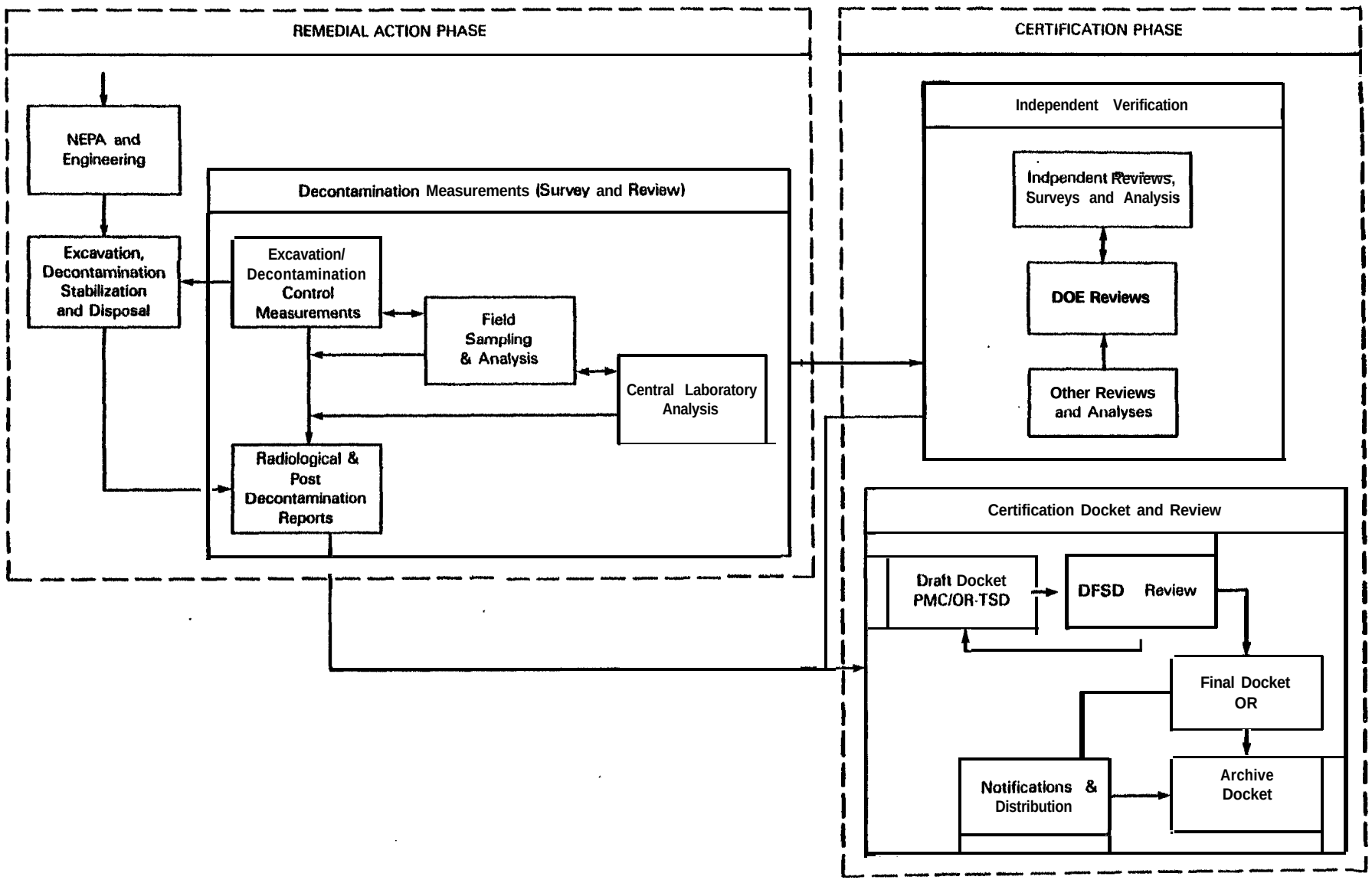
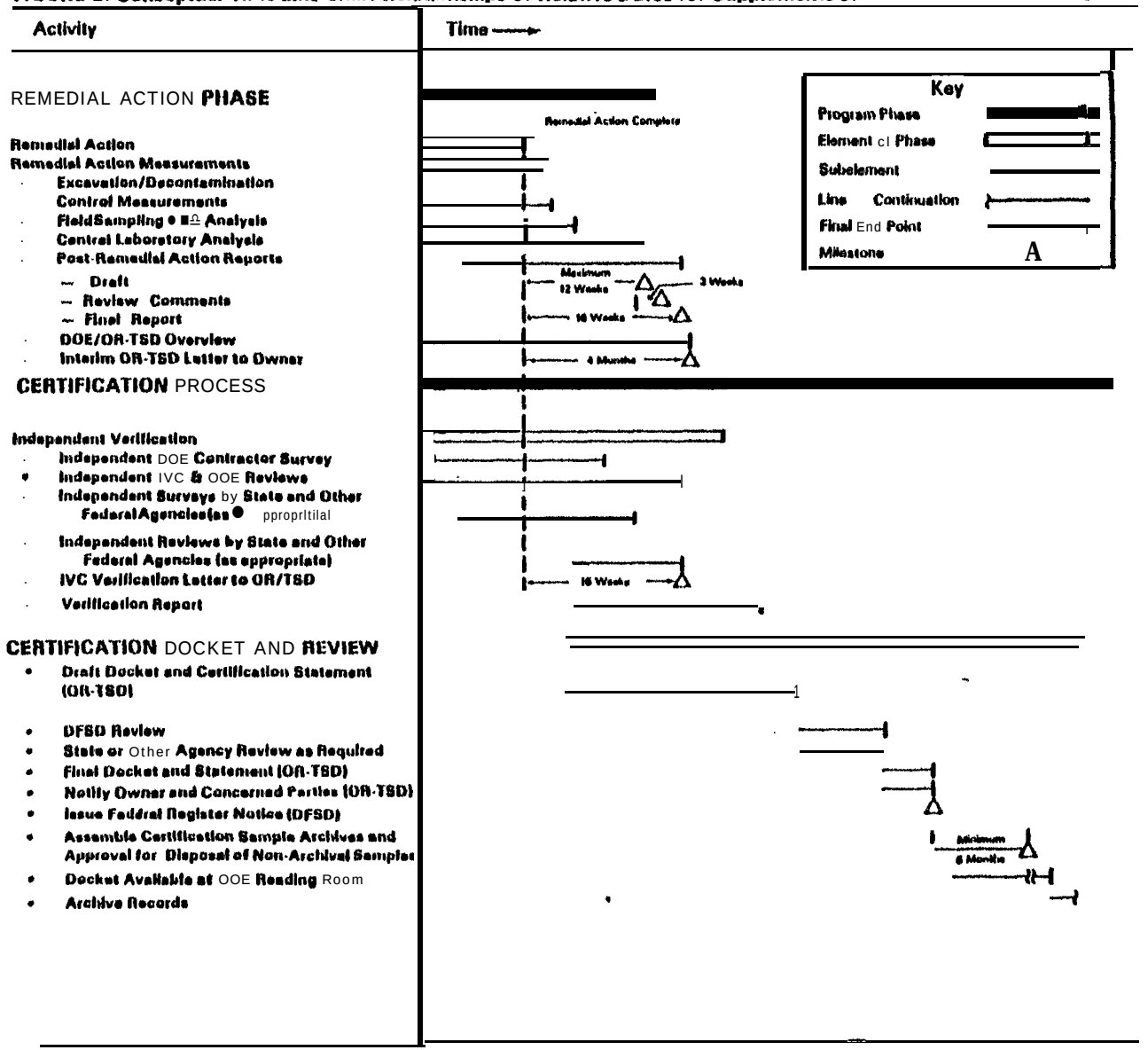


**FIGURE 2. Conceptual Time Line Chart-Relationships of Relative Dates for Supplements of the Certification Process***




*Actual Time Units Are Remedial Action Specific This Chart Is Presented to Identify Relative Initiation and Completion Times of Various Subelements of the Certification Process.



05032

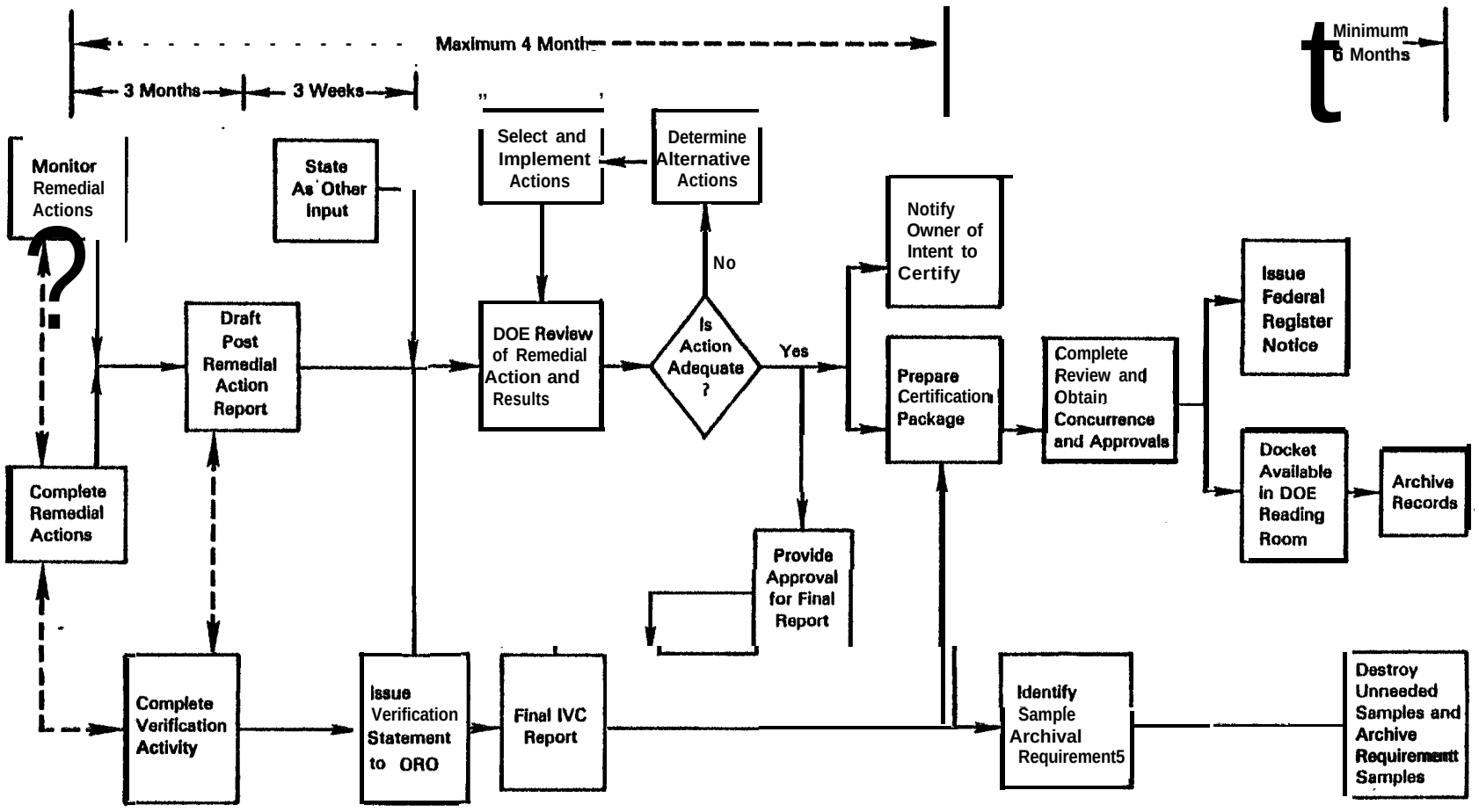



**Figure 3.** GENERAL FLOW CHART FOR CERTIFICATION PROCESS



356392

Sequence for Final Docket Sign-Off and Assembly

1. The Field obtains approval of the certification statement and the Federal Register Notice from the Field Office Chief Counsel. The Federal Register Notice submitted for approval should include a copy of the concurrence chain.

2. The Field obtains approval of the draft Federal Register Notice from DOE Headquarters MA-213.13.

3. The following is transmitted to NE-23 for final approval after Chief Counsel concurrence of the certification statement and MA concurrence of the Federal Register Notice:

   a. Memorandum for signature (to NE-20 from NE-23 recommending certification).

   b. Federal Register Notice for signature by NE-20.

   c. Bound certification docket.

   d. Published documents referenced in Exhibit 11 of the bound docket. (Items a, b, and c include DOE F 1325.10, Official File Copy, to indicate appropriate concurrence.)

   A copy of the memorandum (a) will be included in the final docket as is the signed certification statement and signed Federal Register Notice.

4. NE-20 signs the Federal Register Notice.

   a. Copies of the signed Federal Register Notice are transmitted to the field for inclusion in the final docket.

   b. The original plus two copies or two signed duplicate originals of the Federal Register Notice and DOE F 1325.10 (Official File Copy) are sent to MA-213.13 by DFSD for publication.

5. The Field inserts copies of the signed memorandum, the Certification Statement and the Federal Register Notice into the bound docket and makes distribution, as appropriate, to the local public document room, state, etc. {Five copies of the bound docket, along with the referenced published documents, are sent to DFSD for entry into DOE public document room at Washington, D.C., and headquarters distribution.)

6. The Field Office will be responsible for notifying the State and local governments, as necessary, and property owners of the certification action. The state will be requested to insert a notice in land record offices if appropriate.

Figure 4. The Certification Procedure/Chronological Outline

criteria and guidelines applied to building and land decontamination, the requirements for verification sampling and analyses vary somewhat for buildings and land. These differing requirements are discussed in this protocol.

Remedial Action Measurements. Excavation/decontamination control measurements (using portable gamma-, beta-gamma-, and, where necessary, alpha-measuring instruments) will be used by field personnel to guide the remedial action and to make the preliminary determination as to the extent of the excavation and/or decontamination required. For cases of soil contamination, upon. completion Of each planned segment of a remedial action (as determined by the excavation control measurements and prior to backfilling activities) the on-site radiological contractor will take representative soil samples and analyze them at the field laboratory. If these analyses confirm that the remedial action criteria have been achieved, the backfilling can proceed. If the samples indicate that additional material must be- removed, the remedial action contractor will be informed of the requirements and take appropriate action.

A representative number of the remedial action soil samples will also be sent to a central laboratory for final sample confirmation. The results of these analyses will be compared with the field data to ensure compliance with the remedial action criteria.

Compliance with criteria in structure or building decontaminations will be demonstrated by field measurements except in those cases where air sampling is required. Surface contamination and gamma measurements will be taken to ensure compliance with the FUSRAP criteria and guidelines or standards referenced in that criteria document. As appropriate, representative samples will be taken from the air, water, and residue samples that were' analyzed in the field and used to support the confirmation of the site's condition. Again, as appropriate, samples will be sent to a central laboratory for confirmatory analyses.

These activities will also include the review of radiological data after the completion of the remedial action by DOE/OR. The results of the radiological support contractors surveys and confirmatory analyses will be documented and included as part of the PMC's post-remedial action report. A draft of the report will be issued for DOE and Independent Verification Contractor (IVC) review within 3 months of the completion of the remedial action. The final report will be issued about 1 month later presuming DOE and IVC comments are provided within a 3-week period after receipt of the draft report.

Independent Verification by DOE. DFSD will provide an independent overview evaluation of the remedial action through review of the reports prepared by the PMC. Independent measurements, sampling and analyses and review of procedures and remedial action survey results will be completed by a DOE contractor (IVC) not directly associated

with the remedial action. The IVC will have primary responsibility for the scope of its field investigation. The IVC will prepare a generic plan outlining the procedures to be used during verification activities. The plan will be submitted to the Field Office and DFSD for approval. The IVC will then provide DSFD and the Field Office with only a brief outline of site specific plans for sites selected for verifications. The outline will reference the generic plan and note special concerns. The generic plan will describe the types of verification actions that may be taken and the reasons for applying certain procedures to specific types of sites. The IVC may conduct two types of verification reviews (types A and 3) at a site or group of properties. Type A verifications will include review of the remedial action and radiological contractors data and possibly the analyses of some split samples. Type B verifications will include an on-site visit and survey involving direct measurements and sampling and/or split sample analyses. The primary purpose of both of these actions is to confirm the adequacy of the procedures and methods used by the remedial action and radiological contractors. In the field, the IVC may increase or decrease the scope of the independent verification survey on the basis of field data. Appendix I outlines the procedures to be used by the IVC for independent verification of remedial action and procedures to correct for any discrepancies found during the verification process. The OR/TSD will be responsible, through their management function, to assure that the verification activities are consistent with this protocol.

Independent verification will be accomplished on all FUSRAP remedial action sites. The level of verification required will be decided by DOE with input from the IVC. Off-site or vicinity property remedial actions may be verified in groups where so recommended by the IVC and approved by the DOE. These independent evaluations will further verify that the remedial action was accomplished in accordance with standards and criteria appropriate for the project. Within 4 months after the completion of a remedial action, the verification contractor will issue a verification statement and provide copies to DFSD and OR/TSD. In the case were vicinity properties were grouped and verifications were only completed on selected properties, the verification statement shall be written to cover all the properties in the group on the basis of the results of the selected properties. Upon receipt of this verification statement, OR/TSD will send an interim letter (notification of intent to certify) to each of the site or property owners.

The results of the verification survey will be presented in a final report, and like the post-remedial action report, will be reviewed by DOE-Headquarters, OR/TSD, and, as appropriate, the state and other Federal agencies. In addition to the final reports, representative samples from the remedial action survey and the verification survey will be properly labeled, retained and archived for an appropriate period (see Appendix II). The samples shall not be discarded until such time as the final certification package for the specific site is

completed, undergoes review, and is archived following an appropriate period of availability at the DOE public document reading room (see Appendix II). Throughout the planning, implementation, reporting and archival activities associated with this process, the IVC and PMC will work closely to optimize overall performance. The IVC and PMC will make every effort to resolve scheduling conflicts and expedite information exchange and on-site activities. Procedures to handle minor discrepancies in the field shall be developed and agreed upon by the IVC, PMC, and remedial action contractor. DOE (DFSD and OR/TSD) should be notified of any problem that cannot be handled by the contractors as far in advance of the verification statement as possible, and will take expeditious actions to insure that the remedial action and verification are adequately implemented.

If it is determined by the IVC that the remedial action was not successfully completed or that the radiological data and supporting information or procedures are not adequate to allow certification of the site, such findings will be reported to DOE immediately. OR/TSD, with assistance from DFSD, will review the problems and take appropriate steps to have deficiencies corrected or resolve the IVC defined problems. The 4 month maximum time period from completion of remedial action to notification of the owner by OR/TSD will not be in effect in cases where adequacy of certification data is in question. The time limitation will again be in effect once the issue is resolved.

Independent Verification By Others. Upon request made to DOE in advance of the initiation of remedial actions, qualified Federal, state, and local agencies will be given the opportunity to perform independent measurements and analyses or to analyze split samples taken during DOE radiological surveys. Each agency will also be given the opportunity to review the radiological support contractors measurement, sample collection and preparation and analytical procedures and the resulting data. Local groups desiring to implement such actions will have to do so through their state or local governments.

Certification Docket Preparation and.Review. Following completion Of the post-remedial action report and the verification statement, DOE/OR-TSD will be responsible for (1) providing the owner, within 4 months after completion of a remedial action activity, an interim notification of DOE's intent to certify the remedial action; and (2) the draft certification docket for the specific site (outlined in the Certification of Site Conditions Phase section of the FUSRAP Summary Protocol). The final docket (see Figure 5) and certification statement will be issued after completion of the docket review cycle also discussed in the FUSRAP protocol. The draft certification docket shall be prepared by OR-TSD for each completed remedial action. The dockets may be prepared by phase (if the remedial action is conducted in phases) and may include groups of vicinity properties as appropriate. A docket is to include the items discussed above and

Certification Docket

(A) Introduction to the Docket

(1) Purpose and Contents of the Docket
(2) Property Identification (general description and drawings of property being certified)

(B) Exhibit I - Summary of Activities at the Specific Site

(1) Site History (MED/AEC use; ownership history and use; and FUSRAP activities at site)
(2) Site Description (past and current)
(3) Radiological History and Status (survey and monitoring information, and criteria for determining need for remedial action)
(4) Selection of Remedial Action (option selected; criteria for the remedial action; cost-benefit analysis; and health effects evaluation, where appropriate)
(5) Summary of Remedial Action (what was done; how it was done; waste volume and waste types; disposal location; cost breakdown; and occupational and public exposures)

(C) Exhibit II - Documents Supporting the Certification of the Site

These include but are not limited to:

(1) Decontamination or Stabilization Criteria
(2) Designation or Authorization Documentation
(3) Characterization Report
(4) NEPA Documents
(5) Agreements {with owner, state, and so forth)
(6) Post Remedial Action Survey and Monitoring Report
(7) Verification report and interim verification letter to the owner.
(8) State, County, and Local Comments On Remedial Action {and others as appropriate)
(9) Recommended Restrictions and Actions Taken to Implement Them
(10) Federal Register Notice
(11) Approved Certification Statement

(D) Exhibit III - Diagrams and/or Figures or Tables Supporting the Certification

(E) Relevant Documents

Figure 5. Certification Docket Contents and Outline

listed in Figure 5. The final Federal Register notice, and approved Certification Statement will be included in the docket and any required changes will be made to the text summaries at the time of DOE DFSD review of the draft docket.

The certification statement will be forwarded by the field office (OR/TSD) to the property owner and the state in which the property is located. A notice will also be published by DOE headquarters in the Federal Register. The state or local government as appropriate will be requested to have the land records annotated to indicate completion of the remedial action and to establish a public record of the certification that the remedial action criteria, guidelines or standards have been achieved or that restrictions are required for continued use of the site. Upon publication of the Federal Register notice, the certification docket containing a complete historical record of the remedial action, including the certification statement and the final project reports, will be placed in the DOE public document room at Washington., D.C., and the Field Office locations for a suitable period of time before it is permanently archived.

# APPENDIX I

## Procedure for Independent Verification of Remedial Action and Correction of Discrepancies at FUSRAP and Vicinity Properties

### INTRODUCTION

Independent verifications will be carried out for FUSRAP sites and vicinity properties in order to provide additional assurance for certification that the authorized limits for the remedial action have been achieved. The FUSRAP remedial action activities are managed by the DOE Oak Ridge Operations Technical Services -Division (OR/TSD). Onsite verification surveys will be carried out for some vicinity properties and for all sites. Heavily contaminated vicinity properties, or properties where independent surveys are requested by the owner, local or State officials, will have onsite verification surveys. The procedure for conducting. and reporting the independent verification is described below.

### INDEPENDENT VERIFICATION PROCEDURE

The Independent Verification Contractor (IVC) will perform all or some of the following verification activities: (1) review the site characterization survey, the remedial action plan, available progress reports, and data for the remedial action and restoration of each property or site; (2) schedule a visit to the selected property or site immediately following remedial action, without significantly delaying or interrupting the restoration efforts or some time after the restoration of the site; (3) perform gamma scans for selected locations where excavation has occurred; (4) perform discrete gamma measurements at specific grid locations for comparison with remedial action authorized limits; (5) perform beta-gamma and alpha measurements as required to verify decontamination of structures and/or equipment; (6) perform independent soil sampling and analysis of excavated areas for comparison with remedial action authorized . limits; (7) perform independent environmental sampling and analysis as required to confirm that radionuclides in air and water are within required limits for the specific remedial action; (8) perform independent analyses of soil samples selected from the contractor's archives for the vicinity properties at which independent gamma surveys or soil sampling were not performed; the selection of the archive samples for independent analysis will be based on statistical . guidelines as determined by the IVC; (9) prepare a verification letter.

The number of these activities'and the detail to which they are conducted will depend on the type of verification activity being implemented. Type A verifications in general will include the review of the radiological and remedial action contractor results and, in some cases, an analysis of split samples. Where necessary to confirm results after the restoration, a visit to the site may be warranted. Type B verification will be more thorough and may include all of the nine activities depending on the site conditions and magnitude of the action. The verification letter and report are prepared for both type of surveys.

## Review of Remedial Action

All site designation and characterization reports, remedial action plans, progress reports, and survey data pertaining to the specific site of interest will be made available to the IV& for review. These reviews will be conducted as part of Type A verifications and to plan the Type B verification surveys and to determine whether the remedial action plans were changed during the course of remedial action in a manner which would affect the site conditions or the conduct of the verification survey. Post-remedial action data will also be provided to and reviewed by the IVC for both Type A and Type B surveys. The post-remedial action data will be provided to the IVC in a timely manner such that review of the information can be completed and the verification letter sent within 3 months of the completion of remedial action.

## Site Visits

A visit will be scheduled to a selected vicinity property or site undergoing remedial action prior to restoration or immediately following the remedial action. Every effort will be made to establish an open communication by both the IVC and the remedial action contractor to avoid interruption or delay of the construction schedule. The IVC will notify OR and/or the PMC of those vicinity properties and site areas which will be sampled or surveyed for verification prior to closure. OR or PMC, as appropriate, will notify the IVC at least 72-hours prior to closure of these selected sites. The notice may be given on the basis of a group of properties, not necessarily for each vicinity property. The IVC is responsible to accomplish any verification survey and sampling without interference with the construction schedule providing at least a 72-hour advance notice is given.

## Gamma Scanning and Discrete Measurements

A gamma scan and possibly a set of discrete measurements will be performed on either excavated vicinity properties or site areas. The survey will be performed to the site characterization and remedial action survey grids and will be performed in accordance with

ORNL/TM-8600*, its equivalent, or other guidance provided through the field office and approved by DFSD. The exposure rates will be recorded on a map of the property or site area for comparison with the data taken by the remedial action contractor. This map will be compared with the authorized limits.

Other Direct Measurements

Beta-gamma and alpha measurements performed, as required, in areas, structures, and/or equipment affected by the remedial action or decontamination, will be tied to previous remedial action related surveys. These measurements and scans will be performed in accordance with procedures in ORNL/TM-8600 or its equivalent. The results will be recorded on maps, drawings, or tables of the structures, equipment, or areas and compared to authorized limits.

Soil Samples

About five verification soil samples will be taken from a selected 'excavated vicinity property or site area on a systematic pattern. This number may change according to the size of the vicinity property or site area and the contamination pattern. The soil samples will be obtained from the surface ( 15 cm depth) or subsurface ( 15 cm depth) of the decontaminated area. These soil samples will be analyzed by the IVC for the radionuclides specified in the remedial action plan and will be compared with the authorized limits. If no soil sample is taken from a property or area by the IVC, an independent analysis will be performed by the IVC using selected soil samples taken from the remedial action contractor's archive. The samples will be selected and analyzed in accordance with the procedures in ORNL/TM-8600, its equivalent, or other guidance provided through the field office and approved by DFSD.

Air and Water Samples

Representative verifications samples of air or water will be collected and analyzed when determined necessary through reviews of the site data. Sufficient samples will be collected at discrete locations by the IVC to confirm the remedial action contractors results and verify compliance with the appropriate criteria. The samples will be collected and analyzed in accordance with procedures in ORNL/TM-8600, its equivalent, or other guidance provided by the field office and approved by DFSD.

*ORNL/TM-8600, "Procedure Manual for the ORNL Remedial Action Survey and Certification Activities (RASCA) Program"

## Comparison of Results

Procedures for comparison of IVC results to those of the radiological contractor will be discussed in the IVC's generic plan. In general, comparison of split samples will be done on a sample to sample basis. The IVC and remedial action contractors results should agree within the expected statistical deviations of the analysis methods used. IVC survey results (direct measurements, sampling and analysis) should be compared to the remedial action contractor results on the basis of the criteria, taking into account averaging requirements as well as sampling and analysis considerations.

## Corrective Action for Discrepancies

If the IVC verification survey or sample analyses show that any result is above authorized limits for the remedial action (a discrepancy), a corrective action to resolve this discrepancy must be taken by OR. The IVC will notify DFSD (NE-23) and OR of the discrepancy as soon as possible. OR will determine and instruct the remedial action contractor whether additional cleanup action will be taken or an exception will be requested as specified in the FUSRAP/Remote SFMP Guidelines. The IVC will re-verify the property or site area after corrective action. The corrective action and any exception will be recorded in a corrective action section of the final report or closeout report prepared by the remedial action contractor.

## Verification for Post-Remedial Action Report

After the completion of the post-remedial action, verification survey or review, radiological survey and laboratory analyses of soil samples, a verification letter and report will be prepared by the IVC for each vicinity property or site. The authorized limits and the background levels of radiation will be compared to the verification results. The verification letter will address the comparative results of the verification activities and include a statement of verification. The verification report will include the field and laboratory analyses results and any anomalies that were noted during independent verification survey and any reverification survey. Appropriate tables and a listing of results will be included as well as illustrations of the areas surveyed; i.e., soil sample locations and identifications, gamma levels, etc. In the case of the Type A verifications the report will summarize the basis for the IVC's finding of the adequacy of the action (or discrepancy) and reference supporting data or reports. The conclusion of the verification report, whether Type A or B verification, will be a finding of whether the authorized limits for the remedial action were met and a statement of any exceptions.

Where data are available, the post-remedial action report will include (summarize) the findings of the verification report or, as appropriate, reference the verification report and/or letter.

# APPENDIX II

## Certification and Verification Sample Maintenance and Archiving Process

All samples collected by the remedial action contractor and the DOE Independent Verification Contractor for the purposes of certifying a specific site or property will be logged and maintained by them until the certification process is complete.

Six months following the issuance of the Federal Register notice of certification and the availability of the docket in the public document room, the certification/verification sample archival process will be initiated. At that time or thereafter, the IVC will assemble, log, and archive a representative number (as defined below) of certification *or* verification samples (at least 500g/sample, if possible) to be maintained over a 5-year period. These samples will be held as evidence of the adequacy of the remedial action and to backup the certification docket. All other samples may be disposed of (in an appropriate manner) by the contractors following the establishment of the sample archives for the particular site and/or vicinity properties.

The majority of the archival samples are expected to be derived from the IVC collection of samples; however, the IVC will review his samples and those of the remedial action radiological contractor to determine if any of these samples should be consolidated into the archives.

The IVC will provide the remedial action contractor with guidelines and specific directions regarding samples required for the archive from his inventory. The remedial action contractor will be 'responsible for the correct labeling, packaging, and transmittal of these samples to the IVC and for providing information accurately identifying the locations where the samples were derived. Guidance with regard to sample collection, handling, labeling, and storage is available in documents prepared or referenced in the generic verification plan by the IVC.

The IVC will take similar actions with their samples and will consolidate the two sets of samples into one group with common keys and legends identifying the sampling locations. These samples will then be archived by the IVC. The IVC may then take steps to appropriately dispose of any excess samples and will notify the remedial action contractor that they are free to do the same. The archived samples will be held for a minimum period of five years and the IVC will notify DOE and obtain approval prior to disposal of the archived samples.

SAMPLE SELECTION

The selection of samples for the archives will be done in a systematic manner. Approximately 10 percent, but not less than five samples, of all certification or verification samples taken for each site, vicinity property, or each group of properties will be archived. Proper care shall be taken to ensure that adequate samples are taken for each site. Grouping of vicinity properties for the purpose of sample archiving is permissible in cases where many small vicinity properties are located near one another, contamination removed from the area were of a similar nature, or the remedial actions were completed during the same construction period or season without any significant interruptions. Samples from a site and vicinity properties which are contiguous with the site and were decontaminated during the same period may also be included in the same sample selection process and archived together.

In general, samples will be selected out of the total sample population with the only restriction being that the samples should provide a representative areal cross section of the site or properties being certified.

For cases where some special circumstances exist, a greater number of samples may be selected to better represent the post-remedial action conditions at the location of interest. Examples of such locations include:

Areas that had exceptionally high concentrations of radionuclides prior to remedial action.

Areas that were the subject of some conflict, question, or discrepancy between DOE and other groups, including owners, states, other Federal agencies, or local groups.

Areas at which the IVC and the radiological contractors data initially disagreed or areas where the independent verification survey identified discrepancies that had to be resolved.

Areas for which exceptions to the designated site criteria were requested.

The number of samples archived will be proportional to the area of the site. If the area of concern covered a large area (several hundred square meters) and was very non-uniform in nature (varied isolated depths, varied concentrations and nuclide make-up) extra samples should be preserved.

# memorandum

054358

DATE: DEC 17 1985

REPLY TO ATTN OF: NE-20

SUBJECT: Designation of Sites for Remedial Action - Metal Hydrides, Beverly, MA; Bridgeport Brass, Adrian, MI and Seymour, CT; National Guard Armory, Chicago, IL

TO: Joe LaGrone, Manager
Oak Ridge Operations Office

Based on the attached radiological survey data (Attachments 1 through 3) and an appropriate authority review, the following properties are being authorized for remedial action. It should be noted that the attached survey data are for designation purposes only and that Bechtel National, Inc. (BNI) should conduct appropriate comprehensive characterization studies to determine the extent and magnitude of contamination on these properties.

| Site | Location | Priority |
|---|---|---|
| Former Bridgeport Brass Co. (General Motors) | Adrian, MI | Low |
| Former Bridgeport Brass Co. (Seymour Wire Specialty) | Seymour, CT | Low |
| National Guard Armory | Chicago, IL | Low |
| Former Metal Hydrides, Inc. (Ventron Div., Thiokol Corp.) | Beverly, MA | Med/Low |

At the Bridgeport Brass Sites in Adrian, Michigan, and Seymour, Connecticut, the radioactive material is inaccessible, and if not disturbed, poses no threat to anyone, i.e., in drains, sewers, in concrete covered pits, etc. This being the case, OR/BNI should give serious consideration to leaving the radioactive material in place and arranging for institutional control until modification of the facilities occurs for other reasons. This approach was used for some of the contamination at Gilman Hall, Berkeley, California, and the University of Chicago, Chicago, Illinois. However, there may be other areas of contamination due to Manhattan Engineer District/Atomic Energy Commission activities below the floor at the General Motors plant in Adrian, Michigan, that have not been discovered because there are no as-built drawings or other drawings that show "underground" drains, pits, etc. This possibility should be considered by the BNI staff in planning the characterization survey.

A summary of the Ventron Corporation radiological survey report is attached (Attachment 4). The full report will be sent to you when it is finalized by ORNL. The data in the summary is the radiological basis for conducting remedial action at this facility.

904/2
3.2.3.2

If there are any questions, please call me on FTS 233-4716 or call Arthur Whitman of my staff on FTS 233-5439.

/S/ VOIGT

William R. Voigt, Jr.
Director
Office of Remedial Action
and Waste Technology
Office of Nuclear Energy

NE-23
Whitman
12/16/85
NE-23
DeLaney
12/16/85
NE-20
Baublitz
12/16/85
NE-20
Voigt
12/16/85

Attachments
1. Radiological Survey of the National Guard Armory, Chicago, IL
2. Radiological Survey of the Former Bridgeport Brass Co., Adrian, MI
3. Follow-up Survey of Bridgeport Brass Co., Seymour, CT
4. Preliminary Report of Ventron Site, Beverly, MA

bcc:
E. Keller, OR, w/attach.
B. Berven, ORNL, w/o attach.
J. Berger, ORAU, w/o attach.
A. Whitman, NE-23, w/o attach.
Aerospace, w/o attach.

Baublitz RF
Whitman RF
NEG (4)

NE-23:AWhitman:ph:353-W5439:12/16/85:IBM:346/62:3.21.3
3.22
3.7
3.13.4

904/3

DOE F 1325.8
(8-89)
EFG (07-90)

096254

United States Government

Department of Energy

# memorandum

DATE: OCT 22 1992

REPLY TO ATTN OF: EM-421 (W. A. Williams, 903-8149)

SUBJECT: Designation of Beverly, Massachusetts, Vicinity Property

TO: L. Price, OR

Pursuant to radiological surveys conducted by the Oak Ridge National Laboratory (ORNL), the portion of Beverly Harbor adjacent to the Ventron Plant described in survey report ORNL/RASA-91/29 is designated for remedial action as a vicinity property. The harbor portions of properties located at 14, 18, and 20 Cliff Street are not designated for remedial action because significant concentrations of residual uranium were not found on those properties.

Based on the referenced survey reports, the following properties are not designated for remedial action:

| Address | Reference |
|---|---|
| 2 Cliff Street | ORNL/RASA-91/23 |
| 5 Cliff Street | ORNL/RASA-91/17 |
| 6 Cliff Street | ORNL/RASA-92/2 |
| 8 Cliff Street | ORNL/RASA-91/3 |
| 9 Cliff Street | ORNL/RASA-91/18 |
| 10 Cliff Street | ORNL/RASA-91/14 |
| 12 Cliff Street | ORNL/RASA-91/24 |
| 13 Cliff Street | ORNL/RASA-91/19 |
| 14 Cliff Street | ORNL/RASA-91/25 |
| 15 Cliff Street | ORNL/RASA-91/28 |
| 18 Cliff Street | ORNL/RASA-91/26 |
| 20 Cliff Street | ORNL/RASA-91/27 |
| 30 Cliff Street | ORNL/RASA-91/11 |
| 2 Porter Street | ORNL/RASA-91/22 |
| 5 Porter Street | ORNL/RASA-91/16 |
| 9 Porter Street | ORNL/RASA-91/15 |
| 9 and 11 Congress Street | ORNL/RASA-91/13 |
| 13 Congress Street | ORNL/RASA-91/20 |
| 15 Congress Street | ORNL/RASA-91/21 |
| 17 Congress Street | ORNL/RASA-91/30 |
| Porter Street Park | ORNL/RASA-91/12 |
| 34 School Street | ORNL/RASA-91/9 |
| 19 Wellman Street | ORNL/RASA-91/10 |

ORNL has provided you with copies of the referenced survey reports. Questions regarding this designation decision should be directed to Alexander Williams at 301-903-8149.

James W. Wagoner II
Director
Division of Off-Site Programs
Office of Eastern Area Programs
Office of Environmental Restoration

cc:
T. Perry, OR
P. Blom, EM-421

# U.S. Department of Energy

**Washington, D.C.**

# ORDER

DOE 5400.5

2-8-90

Change 2: 1-7-93

**SUBJECT:** RADIATION PROTECTION OF THE PUBLIC AND THE ENVIRONMENT

1. PURPOSE. To establish standards and requirements for operations of the Department of Energy (DOE) and DOE contractors with respect to protection of members of the public and the environment against undue risk from radiation.

2. SUPERSESSION. DOE 5480.1A, ENVIRONMENTAL PROTECTION, SAFETY, AND HEALTH PROGRAM FOR DOE OPERATIONS, of 8-13-81, Chapter XI that addressed public and environmental radiation protection standards and control practices.

3. SCOPE. The provisions of this Order apply to all Departmental Elements and contractors performing work for the Department as provided by law and/or contract and as implemented by the appropriate contracting officer.

4. IMPLEMENTING PROCEDURES AN D REQUIREMENTS. This Order becomes effective 5-8-90. Within 2 months from the date of issuance of the Order (2-8-90), the DOE Field Office Manager shall provide to the appropriate Program Office, with a copy to EH-1 for review and comment: a. a certification for those areas covered by the Order for which field elements are in compliance; and/or b. a request for exemption for areas not yet in compliance that includes a Plan for achieving compliance. Within 3 months of issuance, the appropriate Program Office will submit to EH-1 the certification and/or the request for exemption(s). The compliance plan accompanying the request for exemption shall include schedules of activities which will lead to compliance with the requirements of this Order.

5. POLICY. It is the policy of DOE to implement legally applicable radiation protection standards and to consider and adopt, as appropriate, recommendations by authoritative organizations, e.g., the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP). It is also the policy of DOE to adopt and implement standards generally consistent with those of the Nuclear Regulatory Commission (NRC) for DOE facilities and activities not subject to licensing authority.

6. OBJECTIVES.

   a. Protecting the Public. It is DOE's objective to operate its facilities and conduct its activities so that radiation exposures to members of the public are maintained within the limits established in this Order and to control radioactive contamination through the management of real and personal property. It is also a DOE objective that potential exposures to members of the public be as far below the limits as is reasonably achievable (ALARA) and that DOE facilities have the capabilities, consistent with the types of operations conducted, to monitor routine and non-routine releases and to assess doses to members of the public.

**DISTRIBUTION:** All Departmental Elements

**INITIATED BY:** Office of Environment, Safety and Health

Vertical line denotes change.

TABLE OF CONTENTS

CHAPTER I - GENERAL

1. Background . . . . . I-1
2. Dose Standards and Terminology . . . . . I-1
   a. International Commission on Radiological Protection . . . . . I-1
   b. Other Sources of Regulations and Guidance . . . . . I-1
3. Dose Limit Selection . . . . . I-2
4. As Low As Reasonably Achievable . . . . . I-2
5. Liquid Wastes and Effluents . . . . . I-2
   a. Protection of Resources . . . . . I-2
   b. Treatment of Liquid Radioactive Waste Streams . . . . . I-2
6. Environmental Protection . . . . . I-2
7. Discharges to Sanitary Sewerage . . . . . I-3
8. Effluent Monitoring and Environmental Surveillance . . . . . I-3
   a. Demonstration of Compliance . . . . . I-3
   b. Monitoring and Surveillance Requirements . . . . . I-3
9. Residual Radioactive Material . . . . . I-3
10. Dose Evaluations . . . . . I-3
   a. Standard Methods . . . . . I-3
   b. Supplemental Documents . . . . . I-4
   c. EPA Models . . . . . I-4
11. Reporting . . . . . I-4

CHAPTER II - REQUIREMENTS FOR RADIATION PROTECTION OF THE PUBLIC AND THE ENVIRONMENT

1. Public Dose Limits . . . . . II-1
   a. DOE Public Dose Limit--All Exposure Modes, All DOE Sources of Radiation . . . . . II-1
   b. Airborne Emissions Only,--All DOE Sources of Radionuclides II-3
   c. All Exposure Modes, Sources from Management, and Storage of Spent Nuclear Fuel, High-Level, and Transuranic Wastes at Disposal Facilities . . . . . II-4
   d. Drinking Water Pathway Only, All DOE Sources of Radionuclides . . . . . II-5
2. The ALARA Process . . . . . II-5
   a. Considerations . . . . . II-5
   b. Evaluations . . . . . II-6
3. Management and Control of Radioactive Materials in Liquid Discharges and Phaseout of Soil Columns . . . . . II-6
   a. Discharges of Liquid Waste to Surface Waters . . . . . II-6
   b. Discharges of Liquid Waste to Aquifers and Phaseout of Soil Columns . . . . . II-8
   c. Management of Soil Columns, Natural Draining Systems, and Ground Water at Inactive Sites Previously Contaminated with Radioactive Material . . . . . II-9
   d. Discharges of Liquid Waste to Sanitary Sewerage . . . . . II-9
   e. Exceptions for Liquid Waste Control Requirements . . . . . II-10

4. Management of Low-Level Radioactive Solid Waste . . . . . II-10
5. Release of Property Having Residual Radioactive Material . . . II-10
   a. Release of Real Property . . . . . II-10
   b. Release of Personal Property . . . . . II-10
   c. Release of Materials and Equipment . . . . . II-11
6. Demonstration of Compliance with the Dose Limits . . . . . II-12
   a. Monitoring and Surveillance . . . . . II-12
   b. Dose Evaluations . . . . . II-12
7. Reporting Requirements . . . . . II-14
8. Records . . . . . II-15
   a. Content . . . . . II-15
   b. Retention . . . . . II-15
9. Units . . . . . II-15

CHAPTER III - DERIVED CONCENTRATION GUIDES FOR AIR AND WATER

1. Purpose . . . . . III-1
2. Basis . . . . . III-1
   a. Exposure Conditions for Ingestion of Water and Inhalation . . . . . III-1
   b. Exposure Conditions for Air Immersion . . . . . III-2
   c. Application to Mixtures of Radionuclides . . . . . III-3
3. Limitations . . . . . III-3
Figure III-1 - Derived Concentration Guides for Members of the Public from Ingested Water and Inhalation Resulting in 100 mrem/yr . . . . . III-4
Figure III-2 - Alternative Absorption Factors and Lung Retention Classes for Specific Compounds . . . . . III-27
Figure III-3 - Derived Concentration Guides for Members of the Public from External Exposure During Immersion in a Contaminated Atmospheric Cloud . . . . . III-36

CHAPTER IV - RESIDUAL RADIOACTIVE MATERIAL

1. Purpose . . . . . IV-1
2. Implementation . . . . . IV-1
   a. Residual Radioactive Material . . . . . IV-1
   b. Basic Dose Limit . . . . . IV-2
   c. Guideline . . . . . IV-2
   d. Authorized Limit . . . . . IV-2
   e. ALARA Applications . . . . . IV-3
3. Basic Dose Limits . . . . . IV-3
   a. Defining and Determining Dose Limits . . . . . IV-3
   b. Unusual Circumstances . . . . . IV-3
4. Guidelines for Residual Radioactive Material . . . . . IV-3
   a. Residual Radionuclides in Soil . . . . . IV-3
   b. Airborne Radon Decay Products . . . . . IV-4
   c. External Gamma Radiation . . . . . IV-5
   d. Surface Contamination . . . . . IV-5
   e. Residual Radionuclides in Air and Water . . . . . IV-5

5. Authorized Limits for Residual Radioactive Material . . . . . IV-5
a. Establishment of Authorized Limits . . . . . IV-5
Figure IV-1 - Surface Contamination Guidelines . . . . . IV-6
b. Application of Authorized Limits . . . . . IV-7
6. Control of Residual Radioactive Material . . . . . IV-7
a. Operational and Control Requirements . . . . . IV-7
b. Interim Storage . . . . . IV-8
c. Interim Management . . . . . IV-8
d. Long-Term Management . . . . . IV-9
7. Supplemental Limits and Exceptions . . . . . IV-9
a. Supplemental Limits . . . . . IV-10
b. Exceptions . . . . . IV-10
c. Justification for Supplemental Limits and Exceptions . . . . IV-10
8. Sources . . . . . IV-11
a. Basic Dose Limits . . . . . IV-11
b. Generic Guidelines for Residual Radioactive Material . . . . IV-11
c. Control of Radioactive Wastes and Residues . . . . . IV-12

# CHAPTER IV

## RESIDUAL RADIOACTIVE MATERIAL

1. PURPOSE. This chapter presents radiological protection requirements and guidelines for cleanup of residual radioactive material and management of the resulting wastes and residues and release of property. These requirements and guidelines are applicable at the time the property is released. Property subject to these criteria includes, but is not limited to sites identified by the Formerly Utilized Sites Remedial Action Program (FUSRAP) and the Surplus Facilities Management Program (SFMP). The topics covered are basic dose limits, guidelines and authorized limits for allowable levels of residual radioactive material, and control of the radioactive wastes and residues. This chapter does not apply to uranium mill tailings or to properties covered by mandatory legal requirements.

2. IMPLEMENTATION. DOE elements shall develop plans and protocols for the implementation of this guidance. FUSRAP sites shall be identified, characterized, and designated, as such, for remedial action and certified for release. Information on applications of the guidelines and requirements presented herein, including procedures for deriving specific property guidelines for allowable levels of residual radioactive material from basic dose limits, is contained in DOE/CH 8901, "A Manual for Implementing Residual Radioactive Material Guidelines, A Supplement to the U.S. Department of Energy Guidelines for Residual Radioactive Material at FUSRAP and SFMP Sites," June 1989.

   a. Residual Radioactive Material. This chapter provides guidance on radiation protection of the public and the environment from:

      (1) Residual concentrations of radionuclides in soil (for these purposes, soil is defined as unconsolidated earth material, including rubble and debris that might be present in earth material);
      (2) Concentrations of airborne radon decay products;
      (3) External gamma radiation;
      (4) Surface contamination; and
      (5) Radionuclide concentrations in air or water resulting from or associated with any of the above.

   b. Basic Dose Limit. The basic dose limit for doses resulting from exposures to residual radioactive material is a prescribed standard from which limits for quantities that can be monitored and controlled are derived; it is specified in terms of the effective dose equivalent as defined in this Order. The basic dose limits are used for deriving guidelines for residual concentrations of radionuclides in soil. Guidelines for residual concentrations of thorium and radium in soil, concentrations of airborne radon decay products, allowable indoor external gamma radiation levels, and residual surface contamination concentrations are based on existing radiological protection standards (40 CFR Part 192; NRC Regulatory Guide 1.86 and subsequent NRC guidance on residual radioactive material). Derived guidelines or limits based on the basic dose limits for those quantities are used only when the guidelines provided in the existing standards are shown to be inappropriate.

c. Guideline. A guideline for residual radioactive material is a level of radioactive material that is acceptable for use of property without restrictions due to residual radioactive material. Guidelines for residual radioactive material presented herein are of two kinds, generic and specific. The basis for the guidelines is generally a presumed worst-case plausible-use scenario for the property.

(1) Generic guidelines, independent of the property, are taken from existing radiation protection standards. Generic guideline values are presented in this chapter.
(2) Specific property guidelines are derived from basic dose limits using specific property models and data. Procedures and data for deriving specific property guideline values are given by DOE/CH-8901.

d. Authorized Limit. An authorized limit is a level of residual radioactive material that shall not be exceeded if the remedial action is to be considered completed and the property is to be released without restrictions on use due to residual radioactive material.

(1) The authorized limits for a property will include:

(a) Limits for each radionuclide or group of radionuclides, as appropriate, associated with residual radioactive material in soil or in surface contamination of structures and equipment;
(b) Limits for each radionuclide or group of radionuclides, as appropriate, in air or water; and
(c) Where appropriate, a limit on external gamma radiation resulting from the residual material.

(2) Under normal circumstances expected at most properties, authorized limits for residual radioactive material are set equal to, or below, guideline values. Exceptional conditions for which authorized limits might differ from guideline values are specified in paragraphs IV-5 and IV-7.

(3) A property may be released without restrictions if residual radioactive material does not exceed the authorized limits or approved supplemental limits, as defined in paragraph IV.7a, at the time remedial action is completed. DOE actions in regard to restrictions and controls on use of the property shall be governed by provisions in paragraph IV.7b. The applicable controls and restrictions are specified in paragraph IV.6 and IV.7.c.

e. ALARA Applications. The monitoring, cleanup, and control of residual radioactive material are subject to the ALARA policy of this Order. Applications of ALARA policy shall be documented and filed as a permanent record.

3. BASIC DOSE LIMITS.

a. Defining and Determining Dose Limits. The basic public dose limits for exposure to residual radioactive material, in addition to natural occurring "background" exposures, are 100 mrem (1 mSv) effective dose equivalent in a year, as specified in paragraph II.1a.

b. Unusual Circumstances. If, under unusual circumstances, it is impracticable to meet the basic limit based on realistic exposure scenarios, the respective project and/or program office may, pursuant to paragraph II.1a(4), request from EH-1 for a specific authorization for a temporary dose limit higher than 100 mrem (1 mSv), but not greater than 500 mrem (5 mSv), in a year. Such unusual circumstances may include temporary conditions at a property scheduled for remedial action or following the remedial action. The ALARA process shall apply to the selection of temporary dose limits.

4. GUIDELINES FOR RESIDUAL RADIOACTIVE MATERIAL.

a. Residual Radionuclides in Soil. Generic guidelines for thorium and radium are specified below. Guidelines for residual concentrations of other radionuclides shall be derived from the basic dose limits by means of an environmental pathway analysis using specific property data where available. Procedures for these derivations are given in DOE/CH-8901. Residual concentrations of radioactive material in soil are defined as those in excess of background concentrations averaged over an area of 100 $m^2$.

(1) Hot Spots. If the average concentration in any surface or below-surface area less than or equal to 25 $m^2$, exceeds the limit or guideline by a factor of $(100/A)^{0.5}$, [where A is the area (in square meters) of the region in which concentrations are elevated], limits for "hot-spots" shall also be developed and applied. Procedures for calculating these hot-spot limits, which depend on the extent of the elevated local concentrations, are given in DOE/CH-8901. In addition, reasonable efforts shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit for soil, irrespective of the average concentration in the soil.

(2) Generic Guidelines. The generic guidelines for residual concentrations of Ra-226, Ra-228, Th-230, and Th-232 are:

(a) 5 pCi/g, averaged over the first 15 cm of soil below the surface; and
(b) 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface.

(3) Ingrowth and Mixtures. These guidelines take into account ingrowth of Ra-226 from Th-230 and of Ra-228 from Th-232, and assume secular equilibrium. If both Th-230 and Ra-226 or both Th-232 and Ra-228 are present and not in secular equilibrium, the appropriate guideline is applied as a limit for the radionuclide with the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that either the dose for the mixtures will not exceed the basic dose limit or the sum of the ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed 1. Explicit formulas for calculating residual concentration guidelines for mixtures are given in DOE/CH-8901.

b. Airborne Radon Decay Products. Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for release without restriction; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR Part 192) is: In any occupied or habitable building, the objective of remedial action shall be, and a reasonable effort shall be made to achieve, an annual average (or equivalent) radon

decay product concentration (including background) not to exceed 0.02 WL. [A working level (WL) is any combination of short-lived radon decay products in 1 L of air that will result in the ultimate emission of $1.3 \times 10^5$ MeV of potential alpha energy.] In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions by DOE are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive material is not the source of the radon concentration.

c. External Gamma Radiation. The average level of gamma radiation inside a building or habitable structure on a site to be released without restrictions shall not exceed the background level by more than 20 μR/h and shall comply with the basic dose limit when an "appropriate-use" scenario is considered. This requirement shall not necessarily apply to structures scheduled for demolition or to buried foundations. External gamma radiation levels on open lands shall also comply with the basic limit and the ALARA process, considering appropriate-use scenarios for the area.

d. Surface Contamination. The generic surface contamination guidelines provided in Figure IV-1 are applicable to existing structures and equipment. These guidelines are generally consistent with standards of the NRC (NRC 1982) and functionally equivalent to Section 4, "Decontamination for Release for Unrestricted Use," of Regulatory Guide 1.86, but apply to nonreactor facilities. These limits apply to both interior equipment and building components that are potentially salvageable or recoverable scrap. If a building is demolished, the guidelines in paragraph IV.6a are applicable to the resulting contamination in the ground.

e. Residual Radionuclides in Air and Water. Residual concentrations of radionuclides in air and water shall be controlled to the required levels shown in paragraph II.1a and as required by other applicable Federal and/or State laws.

5. AUTHORIZED LIMITS FOR RESIDUAL RADIOACTIVE MATERIAL.

a. Establishment of Authorized Limits. The authorized limits for each property shall be set equal to the generic or derived guidelines unless it can be established, on the basis of specific property data (including health, safety, practical, programmatic and socioeconomic considerations), that the guidelines are not appropriate for use at the specific property. The authorized limits shall be established to (1) provide that, at a minimum, the basic dose limits of in paragraph IV.3, will not be exceeded under the "worst-case" or "plausible-use" scenarios, consistent with the procedures and guidance provided in DOE/CH-8901, or (2) be consistent with applicable generic guidelines. The authorized limits shall be consistent with limits and guidelines established by other applicable Federal and State laws. The authorized limits are developed through the project offices in the field and are approved by the Headquarters Program Office.

## Figure IV-1

## Surface Contamination Guidelines

| Radionuclides [2] | Allowable Total Residual Surface Contamination (dpm/100 cm$^2$)[1] Average[3,4] | Maximum[4,5] | Removable[4,6] |
|---|---|---|---|
| Transuranics, I-125, I-129, Ra-226, Ac-227, Ra-228, Th-228, Th-230, Pa-231 | ~~RESERVED~~ 100* | ~~RESERVED~~ 300* | ~~RESERVED~~ 20* |
| Th-Natural, Sr-90, I-126, I-131, I-133, Ra-223, Ra-224, U-232, Th-232 | 1,000 | 3,000 | 200 |
| U-Natural, U-235, U-238, and associated decay product, alpha emitters | 5,000 | 15,000 | 1,000 |
| Beta-gamma emitters(radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.[7] | 5,000 | 15,000 | 1,000 |

[1] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[2] Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

[3] Measurements of average contamination should not be averaged over an area of more than 1 m$^2$. For objects of less surface area, the average should be derived for each such object.

[4] The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

[5] The maximum contamination level applies to an area of not more than 100 cm$^2$.

[6] The amount of removable material per 100 cm$^2$ of surface area should be determined by wiping an area of that size with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wiping with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm$^2$ is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.

[7] This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90 which has been separated from the other fission products or mixtures where the Sr-90 has been enriched.

**Because no values are presented in this order, FUSRAP uses the values shown based on "DOE Guidelines for Residual Radioactive Materials at FUSRAP and Remote SFMP Sites," Revision 2, March 1987 (CCN 046176).*

b. Application of Authorized Limits. Remedial action shall not be considered complete until the residual radioactive material levels comply with the authorized limits, except as authorized pursuant to paragraph IV.7 for special situations where the supplemental limits and exceptions should be considered and it is demonstrated that it is not appropriate to decontaminate the area to the authorized limit or guideline value.

6. CONTROL OF RESIDUAL RADIOACTIVE MATERIAL. Residual radioactive material above the guidelines shall be managed in accordance with Chapter II and the following requirements.

a. Operational and Control Requirements. The operational and control requirements specified in the following Orders shall apply to interim storage, interim management, and long-term management.

(1) DOE 5000.3B, Occurrence Reporting and Processing of Operations Information

(2) DOE 5440.1E, National Environmental Policy Act Compliance Program

(3) DOE 5480.4, Environmental Protection, Safety, and Health Protection Standards

(4) DOE 5482.1B, Environmental, Safety, and Health Appraisal Program

(5) DOE 5483.1A, Occupational Safety and Health Program for DOE Employees at Government-Owned, Contractor-Operated Facilities

(6) DOE 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements

(7) DOE 5820.2A, Radioactive Waste Management.

b. Interim Storage.

(1) Control and stabilization features shall be designed to provide, to the extent reasonably achievable, an effective life of 50 years with a minimum life of at least 25 years.

(2) Controls shall be designed such that Rn-222 concentrations in the atmosphere above facility surfaces or openings in addition to background levels, will not exceed:

(a) 100 pCi/L at any given point;
(b) An annual average concentration of 30 pCi/L over the facility site; and
(c) An annual average concentration of 3 pCi/L at or above any location outside the facility site.
(d) Flux rates from the storage of radon producing wastes shall not exceed 20 pCi/sq.m-sec., as required by 40 CFR Part 61.

(3) Controls shall be designed such that concentrations of radionuclides in the groundwater and quantities of residual radioactive material will not exceed applicable Federal or State standards.

(4) Access to a property and use of onsite material contaminated by residual radioactive material should be controlled through appropriate administrative and physical controls such as those described in 40 CFR Part 192. These control features should be designed to provide, to the extent reasonable, an effective life of at least 25 years.

c. Interim Management.

(1) A property may be maintained under an interim management arrangement when the residual radioactive material exceeds guideline values if the residual radioactive material is in inaccessible locations and would be unreasonably costly to remove provided that administrative controls are established by the responsible authority (Federal, State, or local) to protect members of the public and that such controls are approved by the appropriate Program Secretarial Officer.

(2) The administrative controls include but are not limited to periodic monitoring as appropriate; appropriate shielding; physical barriers to prevent access; and appropriate radiological safety measures during maintenance, renovation, demolition, or other activities that might disturb the residual radioactive material or cause it to migrate.

(3) The owner of the property should be responsible for implementing the administrative controls and the cognizant Federal, State, or local authorities should be responsible for enforcing them.

d. Long-Term Management.

(1) Uranium, Thorium, and Their Decay Products.

(a) Control and stabilization features shall be designed to provide, to the extent reasonably achievable, an effective life of 1,000 years with a minimum life of at least 200 years.

(b) Control and stabilization features shall be designed to limit Rn-222 emanation to the atmosphere from the wastes to less than an annual average release rate of 20 pCi/m2/s and prevent increases in the annual average Rn-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L. Field verification of emanation rates shall be in accordance with the requirements of 40 CFR Part 61.

(c) Before any potentially biodegradable contaminated wastes are placed in a long-term management facility, such wastes shall be properly conditioned so that the generation and escape of biogenic gases will not cause the requirement in paragraph IV.6d(1)(b) to be exceeded and that biodegradation within the facility will not result in premature structural failure in violation of the requirements in paragraph IV.6d(1)(a).

(d) Ground water shall be protected in accordance with legally applicable Federal and State standards.

(e) Access to a property and use of onsite material contaminated by residual radioactive material should be controlled through appropriate administrative and physical controls such as those described in 40 CFR Part 192. These controls should be designed to be effective to the extent reasonable for at least 200 years.

(2) Other Radionuclides. Long-term management of other radionuclides shall be in accordance with Chapters II, III, and IV of DOE 5820.2A, as applicable.

7. SUPPLEMENTAL LIMITS AND EXCEPTIONS. If special specific property circumstances indicate that the guidelines or authorized limits established for a given property are not appropriate for any portion of that property, then the DOE Field Office Manager may request, through the Program Office, that supplemental limits or an exception be applied. The responsible DOE Field Office Manager shall document the decision that the subject guidelines or authorized limits are not appropriate and that the alternative action selected will provide adequate protection, giving due consideration to health and safety, the environment, costs, and public policy considerations. The DOE Field Office Manager shall obtain approval for specific supplemental limits or exceptions from Headquarters as specified in paragraph IV.5, and shall provide to the Headquarters Program Office those materials required by Headquarters for the justification as specified in this paragraph and in the FUSRAP and SFMP protocols and subsequent guidance documents. The DOE Field Office Manager shall also be responsible for coordination with the State and local government regarding the limits or exceptions and associated restrictions as appropriate. In the case of exceptions, the DOE Field Office Manager shall be responsible for coordinating with the State and/or local governments to ensure the adequacy of restrictions or conditions of release and that mechanisms are in place for their enforcement.

a. Supplemental Limits. Any supplemental limits shall achieve the basic dose limits set forth in Chapter II of this Order for both current and potential unrestricted uses of a property. Supplemental limits may be applied to any portion of a property if, on the basis of a specific property analysis, it is demonstrated that

(1) Certain aspects of the property were not considered in the development of the established authorized limits for that property; and

(2) As a result of these certain aspects, the established limits either do not provide adequate protection or are unnecessarily restrictive and costly.

b. Exceptions to the authorized limits defined for a property may be applied to any portion of the property when it is established that the authorized limits cannot reasonably be achieved and that restrictions on use of the property are necessary. It shall be demonstrated that the exception is justified and that the restrictions will protect members of the public within the basic dose limits of this Order and will comply with the requirements for control of residual radioactive material as set forth in paragraph IV.6.

c. Justification for Supplemental Limits and Exceptions. The need for supplemental limits and exceptions shall be documented by the DOE Field Office on a case-by-case basis using specific property data. Every reasonable effort should be made to minimize the use of supplemental limits and exceptions. Examples of specific situations that warrant DOE use of supplemental standards and exceptions are:

(1) Where remedial action would pose a clear and present risk of injury to workers or members of the public, notwithstanding reasonable measures to avoid or reduce risk.

(2) Where remedial action, even after all reasonable mitigative measures have been taken, would produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near affected properties, now or in the future. A clear excess of environmental harm is harm that is long-term, manifest, and grossly disproportionate to health benefits that may reasonably be anticipated.

(3) Where it is determined that the scenarios or assumptions used to establish the authorized limits do not apply to the property or portion of the property identified, or where more appropriate scenarios or assumptions indicate that other limits are applicable or appropriate for protection of the public and the environment.

(4) Where the cost of remedial action for contaminated soil is unreasonably high relative to long-term benefits and where the residual material does not pose a clear present or future risk after taking necessary control measure. The likelihood that buildings will be erected or that people will spend long periods of time at such a property should be considered in evaluating this risk. Remedial action will generally not be necessary where only minor quantities of residual radioactive material are involved or where residual radioactive material occurs in an inaccessible location at which specific property factors limit its hazard and from which it is difficult or costly to remove. Examples include residual radioactive material under hard-surfaced public roads and sidewalks, around public sewer lines, or in fence-post foundations. A specific property analysis shall be provided to establish that the residual radioactive material would not cause an individual to receive a radiation dose in excess of the basic dose limits stated in paragraph IV.3, and a statement specifying the level of residual radioactive material shall be provided to the appropriate State and/or local agencies for appropriate action, e.g., for inclusion in local land records.

(5) Where there is no feasible remedial action.

8. SOURCES.

a. Basic Dose Limits. Dosimetry model and dose limits are defined in Chapter II of this Order.

b. Generic Guidelines for Residual Radioactive Material. Residual concentrations of radium and thorium in soil are defined in 40 CFR Part 192. Airborne radon decay products are also defined in 40 CFR Part 192, as are guidelines for external gamma radiation. The surface contamination definition is adapted from NRC (1982).

c. Control of Radioactive Wastes and Residues. Interim storage is guided by this Order and DOE 5820.2A. Long-term management is guided by this Order, 40 CFR Part 192, and DOE 5820.2A.

14501-00-DC-01

REV. 1

# DESIGN CRITERIA FOR FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM [FUSRAP] AND SURPLUS FACILITIES MANAGEMENT PROGRAM [SFMP]

FEBRUARY 1986

Prepared by
U.S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE

14501-00-DC-01-15

Rev. 1

# DESIGN CRITERIA
# FOR
# FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM (FUSRAP)
# AND
# SURPLUS FACILITIES MANAGEMENT PROGRAM (SFMP)

(ISSUED FOR CLIENT APPROVAL)

FEBRUARY 1986

Approved by: E. L. Keller, Director
Technical Services Division
Oak Ridge Operations Office

2-24-86
Date

Approved by: John T. Milloway
Assistant Manager for
Construction and Engineering
Oak Ridge Operations Office

2-24-86
Date

# PREFACE TO DESIGN CRITERIA

These design criteria have been written in a generic form that summarizes criteria applicable for remedial action and long-term management activities associated with the radioactive wastes at the FUSRAP and SFMP sites. Site-specific information is provided in the appendices to this generic document. As a specific scope of work for a site is determined, design bases and work plans for each of the sites will be developed.

Appendix A contains definitions of terms used in these design criteria and referenced documents. Appendix B provides a listing of FUSRAP and SFMP sites by WBS number and contains estimated waste quantities at the sites. Appendix C contains the residual contamination and waste control criteria. Appendix D lists site information for specific sites which will be required as a remedial action for the specific site is developed. This information will be included in the work plan for each site.

The design criteria will be referenced by the designation 14501-00-DC-01.

These design criteria will be periodically revised, as appropriate, to reflect new practices, additional information, revisions of applicable regulations, and standard revisions.

TABLE OF CONTENTS


| | Rev. | Date |
|---|---|---|
| Design Criteria for Formerly Utilized Sites Remedial Action Program (FUSRAP) and Surplus Facilities Management Program (SFMP) | 1 | 02/24/86 |

1.0 INTRODUCTION

- 1.1 Scope
- 1.2 Objective
- 1.3 Definitions
- 1.4 Changes to Criteria

2.0 APPLICABLE DOCUMENTS

- 2.1 General
- 2.2 Federal Orders and Regulations
- 2.3 State and Local Regulations
- 2.4 Design Codes, Guides, and Standards

3.0 DESIGN REQUIREMENTS

- 3.1 General
- 3.2 Radiological Design Criteria
- 3.3 Specific Site Conditions

APPENDICES

| | | |
|---|---|---|
| Appendix A - Definitions | 0 | 07/02/85 |
| Appendix B - List of FUSRAP and SFMP Sites and Estimated Waste Quantities | 0 | 07/02/85 |
| Appendix C - Interim Residual Contamination and Waste Control Guidelines for FUSRAP and SFMP Sites | 1 | 09/13/85 |
| Appendix D - Site Information for Specific Sites | 0 | 07/02/85 |

# 1.0 INTRODUCTION

## 1.1 SCOPE

This document defines the design criteria for the identification of materials, evaluation of remedial action alternatives, selection of design parameters for site cleanup remedial actions and interim storage, and long-term management methods for handling FUSRAP and SFMP radioactive wastes.

## 1.2 OBJECTIVE

The primary objective of the Formerly Utilized Sites Remedial Action Program (FUSRAP) and Surplus Facilities Management Program (SFMP) projects is to stabilize, decontaminate, and/or dispose of FUSRAP and SFMP derived wastes in such a manner as to minimize the radiological risks posed by these wastes and to enable certification of the cleaned up FUSRAP and SFMP sites for unrestricted future use. At some sites, remedial action may be in situ long-term management with monitoring as necessary to detect any contaminant migration from the site in excess of radiological design criteria. At other sites, an interim storage program may be established until a decision for final disposition is made.

## 1.3 DEFINITIONS

Appendix A contains definitions of terms that are used in these design criteria as well as in the referenced documents.

## 1.4 CHANGES TO CRITERIA

The criteria for FUSRAP and SFMP remedial actions set forth in this document are based on elements of various federal orders, regulations, and standards that may be subject to change. This document will be revised to reflect changed criteria as authorized and approved by DOE.

# 2.0 APPLICABLE DOCUMENTS

## 2.1 GENERAL

The intent of these design criteria is to use DOE Orders where applicable. Applicable orders, regulations and standards, and sections thereof, as well as industry standards, will be investigated on a site-specific basis to formulate the design bases for the specific site.

## 2.2 FEDERAL ORDERS, REGULATIONS, AND STANDARDS

The following federal orders, regulations, and standards contain elements that are generally applicable to the FUSRAP and SFMP projects, and are summarized for these criteria.

### 2.2.1 Quality Assurance

DOE Order 5700.6A--Quality Assurance and DOE/OR-FUSRAP-82-001 Plan for Quality Assurance. The Project Quality Assurance Program complies with DOE Order 5700.6A, and the FUSRAP Plan for Quality Assurance (DOE/OR-FUSRAP-82-001).

For each remedial action site, and interconnecting activities (such as transportation), a formal evaluation (Quality Assurance Assessment) will be made of the consequences of failure of equipment and facilities to perform satisfactorily in service. This Assessment, which will be an adjunct to design engineering with subsequent modifications as may be required, will give full consideration to safety, environment, costs, schedule delays, programmatic goals, public reaction, or any other factor important to achieving project objectives.

When the formal evaluation indicates that consequences of failure may be unacceptable, significant, or unknown and the probability of failure is high or unknown, additional deliberate actions to find

and prevent quality problems are mandatory. The additional actions to assure quality of design and engineering, and particularly to assure implementation of that design and engineering, will be documented using a Quality Action Plan.

### 2.2.2 Radiation Protection

DOE Order 5480.1A. This order establishes control over the environmental protection, safety, and health protection programs. Chapter XI, Requirements for Radiation Protection, Attachment XI-1, defines radiation protection guides for concentration in air and water above natural background which will be used as criteria for releases from DOE's FUSRAP and SFMP operations. Chapter XII, Prevention, Control, and Abatement of Environmental Pollution, provides requirements for the control of sources of environmental pollution in accordance with the substantive and procedural aspects of all applicable federal, state, and local pollution control standards.

DOE Order 5480.2--Hazardous and Radioactive Mixed Waste Management. This order establishes hazardous waste management procedures for facilities operated under authority of the Atomic Energy Act of 1954, as amended (AEA). The procedures will follow, to the extent practicable, regulations issued by the Environmental Protection Agency (EPA) pursuant to the Resource Conservation and Recovery Act of 1976 (RCRA).

DOE Order 5481.1--Safety Analysis and Review System. This DOE Order establishes requirements for the preparation and review of safety analyses for each DOE operation, including: identification of hazards and their elimination or control; assessment of risk; documented management authorization of operation; and transportation of hazardous materials.

### 2.2.3 Land Disposal of Radioactive Wastes

Elements of the DOE Orders and federal regulations mentioned in the following sections provide technical guidelines for long-term, near-surface land burial facilities and ancillary facilities.

DOE Order 6430.1--General Design Criteria Manual. This order contains basic architectural and engineering design requirements for new DOE facilities; provides technical specification requirements; and outlines planning and design requirements for new facilities, facility additions, facility alterations, and building acquisitions to achieve economy of construction, operation, and maintenance.

40 CFR 192--Standards for Remedial Action at Inactive Uranium Processing Sites. This regulation defines remedial action criteria for inactive uranium processing sites. Some elements of these standards are applicable to the FUSRAP and SFMP programs. Service life of a mill tailings disposal site is defined in this regulation and has been adopted for FUSRAP and SFMP projects. Specific service life and release control requirements for interim storage sites and long-term management sites are noted in Section 3.2 of these Design Criteria.

### 2.2.4 Handling, Transportation, and Storage

DOE Order 1540.1--Materials Transportation and Traffic Management. Hazardous materials at FUSRAP and SFMP sites shall be shipped in accordance with DOE Order 1540.1. This document outlines DOE's policies and procedures for the management of materials transportation to ensure that it is accomplished in a manner commensurate with:

(1) Operational requirements for transportation services

(2) Established practices and procedures for transportation safety, economy, efficiency, and cargo security

(3) The National Transportation Policy as established by Congress and cognizant federal agencies

(4) Applicable federal, state, local, and international transportation regulations.

Intra-building and intra-site transfers are excluded from the provisions of this order.

DOE Order 5480.1A--Environmental Protection, Safety, and Health Protection Program for DOE Operations. Chapter 3 of this Order contains safety requirements for packaging of fissile and radioactive material. It also defines the requirements for design, evaluation, and testing of containers used for the transport of DOE's fissile and radioactive materials.

49 CFR 171-179--Transportation of Hazardous Materials. These regulations specify requirements for bulk shipments of uranium or thorium ores and physical or chemical concentrations of those ores and uranium metal or natural thorium metal, or alloys of these materials.

### 2.2.5 Health and Safety

Occupational Safety and Health Administration (OSHA) 29 CFR 1910. This section contains the health and safety regulations for general industry.

Occupational Safety and Health Administration (OSHA) 29 CFR 1926. This section establishes the general health and safety regulations for construction.

### 2.2.6 Surveys

Surveys for characterization and remedial action will be performed in accordance with the following specifications.

National Oceanic and Atmospheric Administration (NOAA).

- "Classification, Standards of Accuracy, and General Specifications of Geodetic Control Surveys"
- "Specification to Support Classification, Standards of Accuracy, and General Specifications of Geodetic Control Surveys"
- "Manual of Geodetic Triangulation," "Specification Publication No. 247

U.S. Department of Interior (USDI) "Manual of Instructions for the Survey of Public Lands of the United States," 1973, Bulletin 6.

### 2.2.7 Weather

National Oceanic and Atmospheric Administration. "Comparative Climatic Data for the United States through 1982," 1983.

## 2.3 STATE AND LOCAL REGULATIONS

State and local regulations governing handling, transportation, and storage of radioactive materials generally follow federal orders and regulations, but may vary depending on whether the particular state is an "Agreement State" under the Atomic Energy Act of 1954, as amended. DOE regulations will be followed, and state and local regulations will be reviewed on a site-specific basis.

## 2.4 DESIGN CODES, GUIDES, AND STANDARDS

The following industry and national codes, standards, and guides, as applicable, will also serve as guidelines for the Design Criteria for FUSRAP and SFMP:

- American Association of State Highway and Transportation Officials (AASHTO)
- American Concrete Institute (ACI)

- American Conference of Government Industrial Hygienists (ACGIH)
- American Institute of Steel Construction (AISC)
- American National Standards Institute (ANSI)
- American Nuclear Society (ANS)
- American Petroleum Institute (API)
- American Railway Engineering Association (AREA)
- American Society for Testing and Materials (ASTM)
- American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)
- American Society of Mechanical Engineers (ASME)
- American Water Works Association (AWWA)
- American Welding Society (AWS)
- Institute of Electrical and Electronic Engineers (IEEE)
- Interstate Commerce Commission (ICC)
- Illuminating Engineering Society (IES)
- National Electrical Code (NEC)
- National Electrical Manufacturers' Association (NEMA)
- National Electrical Safety Code (NESC)
- National Fire Protection Association (NFPA) "National Fire Code"
- National Geodetic Survey (NGS)
- National Standard Plumbing Code (NSPC)
- Occupational Safety and Health Standards (OSHA)
- Underwriters' Laboratory (UL)
- Uniform Building Code (UBC)
- U.S. Army Corps of Engineers Dredging Documents
- U.S. Geological Survey (USGS)

# 3.0 DESIGN REQUIREMENTS

## 3.1 GENERAL

FUSRAP work may involve remedial action at a number of sites. The currently designated FUSRAP and SFMP sites are listed in Appendix B; waste characteristics and estimated volumes at each site are also given.

Additional sites may be added or deleted with passage of federal legislation; therefore, the list of sites may be subject to revision. The specific type and quantity of contaminated material at each site, as well as geologic, meteorologic, and other site conditions affecting the design and design approach, differ from site to site.

## 3.2 RADIOLOGICAL DESIGN CRITERIA

The proposed DOE Interim Residual Contamination and Waste Control Guidelines for FUSRAP and SFMP sites are summarized in Appendix C. This criteria should be followed in defining cleanup requirements, developing remedial action plans, and performing and verifying field remedial actions.

## 3.3 SPECIFIC SITE CONDITIONS

The following information is required for each site and will be completed before or during detailed design and engineering of disposal facilities.

### 3.3.1 Scope of Work

The Scope of Work for the needed remedial actions must be clearly defined. This may be initiated with the preparation of the Preliminary Engineering Evaluation Report for each site with a

Design Basis, or as a separate document. It will be in accordance with the waste management plan outlined in Section 3.3.4 of these Design Criteria.

### 3.3.2 State and Local Regulations

In consultation with appropriate DOE-ORO personnel, applicable state and local regulations and ordinances will be reviewed to determine requirements to achieve compliance with health, safety, and environmental regulations. Construction permits and local property access agreements will be obtained as required. Any permits, licenses, or other authorization required by federal, state, or local environmental protection statutes, or any other legal authorizations required by DOE, will be obtained by DOE, Oak Ridge Operations.

### 3.3.3 Site Information

Define the site conditions for each site as necessary for design decisions. Parameters that may be needed include the following (see Appendix D for detailed requirements):

- Property surveys, easements, and datum
- Water levels
- Precipitation
- Humidity
- Groundwater table
- Frost penetration
- Ice conditions
- Air temperature
- Noise levels
- Winds
- Seismology

- Soil and foundation conditions
- Site historical information (including past and current use; as-built design drawings of buried utilities, structures, and systems; and existing monitoring systems).

### 3.3.4 Waste Characterization

Complete information on the type, quantity, and existing disposition of the radioactive wastes at any given site will usually be required prior to initiation of the Preliminary Engineering Evaluation Report or detailed design. If data and information in existing reports is not complete, or possibly out of date, additional characterization survey work may be required. Examples of additional characterization, to be planned by Bechtel and approved by DOE on a site specific basis and according to a predetermined need, include the following:

- Location and depth of buried wastes.
- Radiological, physical, and chemical characteristics of wastes in ponds, under surface water, and/or in groundwater.
- Extent of radiological migration, groundwater flow patterns, and seasonal variations.
- Wastes/contamination in building structures that may be scheduled for dismantlement or demolition.

### 3.3.5 Support Facilities

The identification of the needed temporary and/or permanent support facilities will be made and may include the following:

- Security
- Contamination control
- Structures
- Equipment
- Water treatment and control

- Utilities
- Access routes
- Monitoring system
- Document control
- Administration

### 3.3.6 Waste Transportation

The following facets for transporting the waste materials will be investigated as applicable:

- Waste form and quantity to be transported
- Mode of transportation
- Packaging and control
- Transportation routes
- Local traffic patterns and impact on community.

# APPENDIX A

## DEFINITIONS

| Abbreviations/Terms | Definitions |
|---|---|
| AEC | Atomic Energy Commission |
| alpha particle | A positively charged particle emitted from certain radioactive material. It consists of two protons and two neutrons, hence is identical with the nucleus of the helium atom. It is the least penetrating of common radiation, hence is not dangerous unless alpha-emitting substances have entered the body. |
| background radiation | Naturally occurring low-level radiation to which all life is exposed. Background radiation levels vary from place to place on the earth. |
| beta particle | A particle emitted from some atoms undergoing radioactive decay. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a position. Beta radiation can cause skin damage, and beta emitters are harmful if they enter the body. |
| BNI | Bechtel National, Inc. |

| | |
|---|---|
| buffer zone | A portion of the land disposal site that is controlled by the licensee and that lies between the disposal unit and the boundary of the site. |
| CFR | Code of Federal Regulations |
| Ci | Curie (the unit of radioactivity of any nuclide, which decays at a rate of $3.7 \times 10^{10}$ disintegrations/second) |
| contamination | The radioactive substance which is not a portion of the material into and onto which it is now dispersed. |
| daughter product | The nuclide remaining after a radioactive atom (parent) has undergone radioactive decay. A daughter atom also may be radioactive, producing further daughter products. |
| decontamination | The removal of radioactive material by chemical or mechanical means from an undesirable location and placement of the removed radioactive material in an acceptable form and location. |
| dismantlement | The organized manner by which a system or structure is segmented into component pieces which can be managed. |

| | |
|---|---|
| disposal | Isolation of waste from the biosphere with no intent of retrieval in a manner which does not permit easy access to the waste after its emplacement, and does not require perpetual maintenance and monitoring. |
| disposal site | A portion of a land disposal facility which is used for disposal of waste. It consists of disposal units and a buffer zone. |
| disposal unit | For near-surface disposal, a "disposal unit" means a discrete portion of the disposal site into which waste is placed for disposal. |
| DOE | Department of Energy |
| dpm | Disintegrations per minute |
| egr | External gamma radiation (gamma radiation emitted from a source(s) external to the body, as opposed to internal gamma radiation emitted from ingested or inhaled sources) |
| engineered barrier | Man-made structures or devices that are intended to prevent an intruder from inadvertent exposure to radiation from certain waste or to prevent escape of radionuclides to the environment. |
| EPA | Environmental Protection Agency |
| exposure | Magnitude of radiation. It is defined and measured in terms of electrical charge produced per unit mass of air. |

| | |
|---|---|
| FUSRAP | Formerly Utilized (MED/AEC) Sites Remedial Action Program |
| gamma background | Natural gamma ray activity everywhere present, originating from two sources: (1) cosmic radiation bombarding the earth's atmosphere continually, and (2) terrestrial radiation. Whole body absorbed dose equivalent in the U.S. due to natural gamma background ranges from about 60 to 125 mrem/yr. |
| gamma ray | High energy electromagnetic radiation emitted from the nucleus of a radioactive atom, with specific energies for the atoms of different elements and having high penetrating power. |
| ground water | Subsurface water in the zone of full saturation. |
| half-life | The period of time required for one-half of the original amount of a radioisotope to decay into a daughter product. |
| health effect | An adverse physiological response to environmental pollutants. While physiological responses include sickness, genetic defects, and death, for FUSRAP/SFMP one health effect is defined as one death resulting from cancer caused by exposure to radiation. |

| | |
|---|---|
| hydrogeologic unit | Any soil or rock unit or zone which, by virtue of its porosity or permeability or lack thereof, has a distinct influence on the storage or movement of ground water. |
| inadvertent intruder | A person who might occupy the disposal site unknowingly after closure and engage in normal activities, such as agriculture, dwelling construction, and other pursuits in which the person might be exposed to radiation from the waste. |
| interim storage | A short-term disposal having control and stabilization features designed to ensure, to the extent reasonably achievable, an effective life of 50 years and, in any case, at least 25 years at which time ultimate disposal will be made. |
| intruder barrier | A sufficient depth of cover over the waste that exposure to radiation by an inadvertent intruder will meet the standards for protection against radiation specified in DOE Manual 5820.1 and in 10 CFR 61, or engineered structures that provide equivalent protection to the inadvertent intruder. |
| land disposal facility | The land, buildings, and equipment which are intended to be used for the disposal of radioactive wastes beneath the surface of the land. |

| | |
|---|---|
| long-term management | A form of ultimate disposal and storage involving near-surface burial of FUSRAP and SFMP radioactive wastes. Includes monitoring and corrective action, as necessary, to ensure that contaminants are not migrating from the site in excess of design criteria, and an institutional control period not less than that specified in 40 CFR 192. Control and stabilization features are designed to ensure to the extent reasonably achievable, an effective life of 1,000 years and, in any case, at least 200 years. |
| LSA | Low Specific Activity - A class of radioactive material as defined in 49 CFR 173.389(c). |
| umhos/cm | Micromhos per centimeter ($10^{-6}$ mho/cm) |
| uR/hr | Microroentgens per hour ($10^{-6}$ R/hr) |
| mR/hr | Milliroentgens per hour ($10^{-3}$ R/hr) |
| mrad/hr | Millirads per hour ($10^{-3}$ rad/hr) |
| MED | Manhattan Engineer District |
| mho | A unit of electrical conductance, the reciprocal of electrical resistance. |
| MPC | Maximum permissible concentration as defined per 10 CFR 20.103. |

| | |
|---|---|
| near-surface disposal facility | A land disposal facility in which radioactive waste is disposed within the upper 15-20 meters of the earth's surface. |
| NEPA | National Environmental Policy Act |
| NRC | Nuclear Regulatory Commission |
| nuclide | A general term applicable to all atomic forms of the elements; nuclides comprise all the isotopic forms of all the elements. Nuclides are distinguished by their atomic number, atomic mass, and energy state. |
| pCi/l | Picocurie per liter ($10^{-12}$ Ci/l) |
| R | Roentgen (a unit of exposure to ionizing radiation). It is that amount of gamma or x-rays required to produce an electrical charge that is numerically equal to 2.58 x $10^{-4}$ coulombs/kg. |
| rad | The basic unit of absorbed dose of ionizing radiation. A dose of one rad means the absorption of 100 ergs of radiation energy per gram of absorbing material. |
| radioactivity | The spontaneous decay or disintegration of an unstable atomic nucleus, usually accompanied by the emission of ionizing radiation. |

| | |
|---|---|
| radioactive decay chain | A succession of nuclides, each of which transforms by radioactive disintegration into the next, until a stable nuclide results. The first member is called the parent, the intermediate members are called daughters, and the final stable member is called the end product. |
| radon | A radioactive, chemically inert gas having a half-life of 3.8 days (radium-222); formed as a daughter product of radium (radium-226). |
| radon background | Low levels of radon gas found in an area due to the presence of uranium or radium in soil and building materials. |
| radon daughter | One of the several short-lived radioactive daughter products of radon. (Several of the daughters emit alpha particles.) |
| remedial action | Steps and processes that are undertaken to physically identify, decontaminate, stabilize, or otherwise provide long-term management of radioactive materials to permit certification for unrestricted public use of the area or site. |
| rdc | Radon daughter concentration (the concentration in air of short-lived radon daughters, usually expressed in pCi/l; also measured in terms of working level (WL). |

| | |
|---|---|
| rem | Roentgen equivalent man. The unit of dose equivalence for all types of ionizing radiation which expresses the effectiveness of the absorbed dose on a common scale. The rem is the basic unit used to record the accumulated dose equivalent to personnel. |
| site closure and stabilization | Those actions that are taken upon completion of operations that prepare the disposal site for custodial care and that assure that the disposal site will remain stable and will not need ongoing, active maintenance. |
| SFMP | Surplus Facilities Management Program |
| surveillance | Observation of the disposal site for purposes of visual detection of need for maintenance, custodial care, evidence of intrusion, and compliance with other license and regulatory requirements. |
| WL | Working level. A unit of radon daughter exposure, equal to any combination of short-lived radon daughters in 1 liter of air, that will result in the ultimate emission of $1.3 \times 10^5$ MeV of potential alpha energy. This level is equivalent to the energy produced in the decay of the daughter products that are present under equilibrium conditions in a liter of air containing 100 pCi of radium-222. It does not include decay of lead-210 (22-year half-life) and subsequent daughter products. |

| | |
|---|---|
| WLM | Working Level Month - An exposure to a one-WL concentration for 170 hours per month. |
| WBS NO. | Work Breakdown Structure identification sequence number designated by DOE. (See Appendix B for list of identification numbers for the specific sites.) |

# APPENDIX B

## LIST OF FUSRAP AND SFMP SITES

## AND

## ESTIMATED WASTE QUANTITIES(7/82)

FUSRAP SITES

| MRS No. | Site Name | State | Radioisotope | Estimated Volume ($yd^3$) | Concentration (pCi/g) | Radioactivity (Ci) | References | Remarks |
|---|---|---|---|---|---|---|---|---|
| 101 | Acid/Pueblo | NM | Plutonium-239 | 390* | 110 | $4.8 \times 10^{-2}$ | Remedial Action Completed | Soils |
| 102 | Albany Research | OR | Natural Uranium<br>Uranium-238<br>Natural Uranium<br>Radium-226 | 3,000[b] | a | a | b | Radiological characterization not complete |
| 104 | Mayo Canyon | NM | Strontium-90 | 1,520* | - | - | FB6DU 409-317 | No Excavation Required - Marker Placed |
| 105 | Chupadera | NM | - | N/A | - | - | Remedial Action Not Required | |
| 108 | E. I. duPont | NJ | Uranium-238<br>Uranium-238<br>Uranium-238 | 7,000 | 1,400<br>1,100<br>6,600 | 2.7<br>0.5<br>0.9 | DOE/EV-0005/8 | Contam. Soils & Drainage Ditch |
| 114 | Kellex | NJ | - | 175* | - | - | | Completed |
| 115 | Niagara Falls Vicinity Properties | NY | Radium-226 | 48,000 | a | a | BMI-2045, 2061, 2074 | |
| 117 | Middlesex Landfill | NJ | Radium-226 | 33,000 | 11 | 1.4 | DOE/EV-0005/20 | |
| 118 | Middlesex Sampling Plant | NJ | Radium-226<br>Radium-226 | -<br>57,000 | -<br>- | 3.5<br>10.5<br>- | DOE/EV-0005/1 | |
| 121 | Palos Park | IL | Hydrogen-3 | 4,030 | - | $3.0 \times 10^3$ | DOE/EV-0005/7 | |
| 151 | St. Louis Airport | MO | Radium-226 | 86,000 | 30 | 3.8 | DOE/EV-0005/16 | |

APPENDIX B (Cont'd)

FUSRAP SITES

| HRS No. | Site Name | State | Radioisotope | Estimated Volume ($yd^3$) | Concentration (pCi/g) | Radioactivity (Ci) | References | Remarks |
|---|---|---|---|---|---|---|---|---|
| 125 | Shpack | MA | Radium-226<br>Uranium-238 | 400 | 109<br>125 | 5.5<br>6.3 | ORNL-5799<br>DOE/EV-0005/31 | |
| 126 | Universal Cyclops | PA | - | 30 | - | - | ORO-777 | |
| 129 | Linde Air Products | NY | Radium-226<br>Uranium-238<br>Actinium-227 | 26,000 | 9.3<br>349<br>2.3 | $8.0 \times 10^{-2}$<br>2.80<br>$2.0 \times 10^{-2}$ | DOE/EV-0005/5<br>FB&DU 409-329 | |
| 130 | Univ. of Calif. | CA | - | 30* | - | - | Completed 9/82 | |
| 131 | Univ. of Chicago | IL | - | 75* | - | - | | |
| 134 | SLAPSS (Vic. Prop) | MO | - | 13,000 | - | - | | |
| 137 | Wayne/Pequannock | NJ | Uranium-238<br>Thorium-232<br>Thorium-228<br>Radium-226 | 50,000 | a | a | | |
| 138 | Maywood | NJ | Uranium-238<br>Uranium-235<br>Uranium-234<br>Thorium-230<br>Thorium-232<br>Thorium-228<br>Radium-226 | 210,000 | a | a | | |
| 139 | Colonie | NY | Uranium-238 | 30,000 | a | a | | Radiological Characterization Not Complete |
| 140 | Hazelwood | MO | Thorium-230<br>Radium-226<br>Uranium-238<br>Uranium-235<br>Uranium-234 | 61,000 | a | a | | Radiological Survey Not Available |
| | | | Total Volume FUSRAP | 630,650 | | | | |

APPENDIX B (Cont'd)

SFMP SITES

| WBS No. | Site Name | State | Radioisotope | Estimated Volume ($yd^3$) | Concentration (pCi/g) | Radioactivity (Ci) | References | Remarks |
|---|---|---|---|---|---|---|---|---|
| 201 | Weldon Spring Storage Site | MO | | | | | | |
| | o Raffinate Pits | | Natural Uranium and Thorium, Radium-226 | 220,500 | - | 824 | DOE/OR/20722-5 | Sludge volume |
| | o Quarry | | Natural Uranium and Thorium, Radium-226 | 130,800 | - | - | - | |
| | o Vicinity Properties | | Natural Uranium Radium-226 | 102,00 | - | - | - | |
| 202 | Niagara Falls Storage Site | NY | Radium-226 Uranium-238 | 218,000 | - | 940 | DOE/OR/20722-1 | (Includes contaminated residues, soils and rubble) |
| | | Total Volumes SFMP | | 671,300 | | | | |

[a]Actual waste volume

[b]Volumes are from Project Plan

[c]Information is unknown at this time.

30860

APPENDIX C

# U.S. DEPARTMENT OF ENERGY GUIDELINES FOR RESIDUAL RADIOACTIVITY AT FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM AND REMOTE SURPLUS FACILITIES MANAGEMENT PROGRAM SITES

(Rev. 1, July 1985)

## A. INTRODUCTION

This document presents U.S. Department of Energy (DOE) radiological protection guidelines for cleanup of residual radioactive materials and management of the resulting wastes and residues. It is applicable to sites identified by the Formerly Utilized Sites Remedial Action Program (FUSRAP) and remote sites identified by the Surplus Facilities Management Program (SFMP).* The topics covered are basic dose limits, guidelines and authorized limits for allowable levels of residual radioactivity, and requirements for control of the radioactive wastes and residues.

Protocols for identification, characterization, and designation of FUSRAP sites for remedial action; for implementation of the remedial action; and for certification of a FUSRAP site for release for unrestricted use are given in a separate document (U.S. Dept. Energy 1984). More detailed information on applications of the guidelines presented herein, including procedures for deriving site-specific guidelines for allowable levels of residual radioactivity from basic dose limits, is contained in a supplementary document--referred to herein as the "supplement" (U.S. Dept. Energy 1985).

"Residual radioactivity" includes: (1) residual concentrations of radionuclides in soil material,** (2) concentrations of airborne radon decay products, (3) external gamma radiation level, and (4) surface contamination. A "basic dose limit" is a prescribed standard from which limits for quantities that can be monitored and controlled are derived; it is specified in terms of the effective dose equivalent as defined by the International Commission on Radiological Protection (ICRP 1977, 1978). Basic dose limits are used explicitly for deriving guidelines for residual concentrations of radionuclides in soil material, except for thorium and radium. Guidelines for

*A remote SFMP site is one that is excess to DOE programmatic needs and is located outside a major operating DOE research and development or production area.

**The term "soil material" refers to all material below grade level after remedial action is completed.

residual concentrations of thorium and radium and for the other three quantities (airborne radon decay products, external gamma radiation level, and surface contamination) are based on existing radiological protection standards (U.S. Environ. Prot. Agency 1983; U.S. Nucl. Reg. Comm. 1982). These standards are assumed to be consistent with basic dose limits within the uncertainty of derivations of levels of residual radioactivity from basic limits.

A "guideline" for residual radioactivity is a level of residual radioactivity that is acceptable if the use of the site is to be unrestricted. Guidelines for residual radioactivity presented herein are of two kinds: (1) generic, site-independent guidelines taken from existing radiation protection standards, and (2) site-specific guidelines derived from basic dose limits using site-specific models and data. Generic guideline values are presented in this document. Procedures and data for deriving site-specific guideline values are given in the supplement.

An "authorized limit" is a level of residual radioactivity that must not be exceeded if the remedial action is to be considered completed. Under normal circumstances, expected to occur at most sites, authorized limits for residual radioactivity are set equal to guideline values. Exceptional conditions for which authorized limits might differ from guideline values are specified in Sections D and F. A site may be released for unrestricted use only if the residual radioactivity does not exceed guideline values at the time remedial action is completed. Restrictions and controls on use of the site must be established and enforced if the residual radioactivity exceeds guideline values. The applicable controls and restrictions are specified in Section E.

DOE policy requires that all exposures to radiation be limited to levels that are as low as reasonably achievable (ALARA). Implementation of ALARA policy is specified as procedures to be applied after authorized limits have been set. For sites to be released for unrestricted use, the intent is to reduce residual radioactivity to levels that are as far below authorized limits as reasonable considering technical, economic, and social factors. At sites where the residual radioactivity is not reduced to levels that permit release for unrestricted use, ALARA policy is implemented by establishing controls to reduce exposure to levels that are as low as is reasonably achievable. Procedures for implementing ALARA policy are described in the supplement. ALARA policies, procedures, and actions must be documented and filed as a permanent record upon completion of remedial action at a site.

## B. BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 500 mrem/yr for a period of exposure not to exceed 5 years and an average of 100 mrem/yr over a lifetime. The committed effective dose equivalent, as defined in ICRP Publication 26 (ICRP 1977) and calculated by dosimetry models described in ICRP Publication 30 (ICRP 1978), shall be used for determining the dose.

## C. GUIDELINES FOR RESIDUAL RADIOACTIVITY

### C.1 Residual Radionuclides in Soil Material

Residual concentrations of radionuclides in soil material shall be specified as above-background concentrations averaged over an area of 100 $m^2$. If the concentration in any area is found to exceed the average by a factor greater than 3, guidelines for local concentrations shall also be applicable. These "hot spot" guidelines depend on the extent of the elevated local concentrations and are given in the supplement.

The generic guidelines for residual concentrations of Th-232, Th-230, Ra-228, and Ra-226 are:

- 5 pCi/g, averaged over the first 15 cm of soil below the surface
- 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface

These guidelines take into account ingrowth of Ra-226 from Th-230 and of Ra-228 from Th-232, and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that the dose for the mixtures will not exceed the basic dose limit. Explicit formulas for calculating residual concentration guidelines for mixtures are given in the supplement.

The guidelines for residual concentrations in soil material of all other radionuclides shall be derived from basic dose limits by means of an environmental pathway analysis using site-specific data. Procedures for deriving these guidelines are given in the supplement.

### C.2 Airborne Radon Decay Products

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for unrestricted use; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.* In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive materials are not the cause.

### C.3 External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site to be released for unrestricted use shall not exceed the background level by more than 20 μR/h.

---

*A working level (WL) is any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of $1.3 \times 10^5$ MeV of potential alpha energy.

## C.4 Surface Contamination

The following generic guidelines, adapted from standards of the U.S. Nuclear Regulatory Commission (1982), are applicable only to existing structures and equipment that will not be demolished and buried. They apply to both interior and exterior surfaces. If a building is demolished and buried, the guidelines in Section C.1 are applicable to the resulting contamination in the ground.

| Radionuclides†[2] | Allowable Total Residual Surface Contamination (dpm/100 cm²)†[1] | | |
|---|---|---|---|
| | Average†[3],†[4] | Maximum†[4],†[5] | Removable†[4],†[6] |
| Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129 | 100 | 300 | 20 |
| Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133 | 1,000 | 3,000 | 200 |
| U-Natural, U-235, U-238, and associated decay products | 5,000α | 15,000α | 1,000α |
| Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above | 5,000β-γ | 15,000β-γ | 1,000β-γ |

†[1] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

†[2] Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

†[3] Measurements of average contamination should not be averaged over an area of more than 1 m². For objects of less surface area, the average should be derived for each such object.

†[4] The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

†[5] The maximum contamination level applies to an area of not more than 100 cm².

†[6] The amount of removable radioactive material per 100 cm² of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm² is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

D. AUTHORIZED LIMITS FOR RESIDUAL RADIOACTIVITY

The remedial action shall not be considered complete unless the residual radioactivity is below authorized limits. Authorized limits shall be set equal to guidelines for residual radioactivity unless: (1) exceptions specified in Section F of this document are applicable, in which case an authorized limit may be set above the guideline value for the specific location or condition to which the exception is applicable; or (2) on the basis of site-specific data not used in establishing the guidelines, it can be clearly established that limits below the guidelines are reasonable and can be achieved without appreciable increase in cost of the remedial action. Authorized limits that differ from guidelines must be justified and established on a site-specific basis, with documentation that must be filed as a permanent record upon completion of remedial action at a site. Authorized limits differing from the guidelines must be approved by the Director, Oak Ridge Technical Services Division, for FUSRAP and by the Director, Richland Surplus Facilities Management Program Office, for remote SFMP--with concurrence by the Director of Remedial Action Projects for both programs.

E. CONTROL OF RESIDUAL RADIOACTIVITY AT FUSRAP AND REMOTE SFMP SITES

Residual radioactivity above the guidelines at FUSRAP and remote SFMP sites must be managed in accordance with applicable DOE Orders. The DOE Order 5480.1A requires compliance with applicable federal, state, and local environmental protection standards.

The operational and control requirements specified in the following DOE Orders shall apply to interim storage, interim management, and long-term management.

a. 5440.1B, Implementation of the National Environmental Policy Act

b. 5480.1A, Environmental Protection, Safety, and Health Protection Program for DOE Operations

c. 5480.2, Hazardous and Radioactive Mixed Waste Management

d. 5480.4, Environmental Protection, Safety, and Health Protection Standards

e. 5482.1A, Environmental, Safety, and Health Appraisal Program

f. 5483.1, Occupational Safety and Health Program for Government-Owned Contractor-Operated Facilities

g. 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements

h. 5484.2, Unusual Occurrence Reporting System

i. 5820.2, Radioactive Waste Management

E.1 Interim Storage

a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 50 years and, in any case, at least 25 years.

b. Above-Background Rn-222 concentrations in the atmosphere above facility surfaces or openings shall not exceed: (1) 100 pCi/L at any given point, (2) an annual average concentration of 30 pCi/L over the facility site, and (3) an annual average concentration of 3 pCi/L at or above any location outside the facility site (DOE Order 5480.1A, Attachment XI-1).

c. Concentrations of radionuclides in the groundwater or quantities of residual radioactive materials shall not exceed existing federal, state, or local standards.

d. Access to a site shall be controlled and misuse of onsite material contaminated by residual radioactivity shall be prevented through appropriate administrative controls and physical barriers--active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These control features should be designed to ensure, to the extent reasonable, an effective life of at least 25 years. The federal government shall have title to the property.

E.2 Interim Management

a. A site may be released under interim management when the residual radioactivity exceeds guideline values if the residual radioactivity is in inaccessible locations and would be unreasonably costly to remove, provided that administrative controls are established to ensure that no member of the public shall receive a radiation dose exceeding the basic dose limit.

b. The administrative controls, as approved by DOE, shall include but not be limited to periodic monitoring, appropriate shielding, physical barriers to prevent access, and appropriate radiological safety measures during maintenance, renovation, demolition, or other activities that might disturb the residual radioactivity or cause it to migrate.

c. The owner of the site or appropriate federal, state, or local authorities shall be responsible for enforcing the administrative controls.

E.3 Long-Term Management

Uranium, Thorium, and Their Decay Products

a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 1,000 years and, in any case, at least 200 years.

b. Control and stabilization features shall be designed to ensure that Rn-222 emanation to the atmosphere from the waste shall not: (1) exceed an annual average release rate of 20 pCi/m$^2$/s, and (2) increase the annual average Rn-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L. Field verification of emanation rates is not required.

c. Prior to placement of any potentially biodegradable contaminated wastes in a long-term management facility, such wastes shall be properly conditioned to ensure that (1) the generation and escape of biogenic gases will not cause the requirement in paragraph b of this section (E.3) to be exceeded, and (2) biodegradation within the facility will not result in premature structural failure in violation of the requirements in paragraph a of this section (E.3).

d. Groundwater shall be protected in accordance with 40 CFR 192.20(a)(2) and 192.20(a)(3), as applicable to FUSRAP and remote SFMP sites.

e. Access to a site should be controlled and misuse of onsite material contaminated by residual radioactivity should be prevented through appropriate administrative controls and physical barriers--active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These controls should be designed to be effective to the extent reasonable for at least 200 years. The federal government shall have title to the property.

Other Radionuclides

f. Long-term management of other radionuclides shall be in accordance with Chapters 2, 3, and 5 of DOE Order 5820.2, as applicable.

## F. EXCEPTIONS

Exceptions to the requirement that authorized limits be set equal to the guidelines may be made on the basis of an analysis of site-specific aspects of a designated site that were not taken into account in deriving the guidelines. Exceptions require approvals as stated in Section D. Specific situations that warrant exceptions are:

a. Where remedial actions would pose a clear and present risk of injury to workers or members of the general public, notwithstanding reasonable measures to avoid or reduce risk.

b. Where remedial actions--even after all reasonable mitigative measures have been taken--would produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near affected sites, now or in the future. A clear excess of environmental harm is harm that is long-term, manifest, and grossly disproportionate to health benefits that may reasonably be anticipated.

c. Where the cost of remedial actions for contaminated soil is unreasonably high relative to long-term benefits and where the residual radioactive materials do not pose a clear present or future risk after taking necessary control measures. The likelihood that buildings will be erected or that people will spend long periods of time at such a site should be considered in evaluating this risk. Remedial actions will generally not

be necessary where only minor quantities of residual radioactive materials are involved or where residual radioactive materials occur in an inaccessible location at which site-specific factors limit their hazard and from which they are costly or difficult to remove. Examples are residual radioactive materials under hard-surface public roads and sidewalks, around public sewer lines, or in fence-post foundations. In order to invoke this exception, a site-specific analysis must be provided to establish that it would not cause an individual to receive a radiation dose in excess of the basic dose limits stated in Section B, and a statement specifying the residual radioactivity must be included in the appropriate state and local records.

d. Where the cost of cleanup of a contaminated building is clearly unreasonably high relative to the benefits. Factors that shall be included in this judgment are the anticipated period of occupancy, the incremental radiation level that would be effected by remedial action, the residual useful lifetime of the building, the potential for future construction at the site, and the applicability of remedial actions that would be less costly than removal of the residual radioactive materials. A statement specifying the residual radioactivity must be included in the appropriate state and local records.

e. Where there is no feasible remedial action.

G. SOURCES

| Limit or Guideline | Source |
|---|---|
| **Basic Dose Limits** | |
| Dosimetry Model and Dose Limits | International Commission on Radiological Protection (1977, 1978) |
| **Generic Guidelines for Residual Radioactivity** | |
| Residual Concentrations of Radium and Thorium in Soil Material | 40 CFR 192 |
| Airborne Radon Decay Products | 40 CFR 192 |
| External Gamma Radiation | 40 CFR 192 |
| Surface Contamination | Adapted from U.S. Nuclear Regulatory Commission (1982) |
| **Control of Radioactive Wastes and Residues** | |
| Interim Storage | DOE Order 5480.1A |
| Long-Term Management | DOE Order 5480.1A; 40 CFR 192 |

## H. REFERENCES

International Commission on Radiological Protection. 1977. Recommendations of the International Commission on Radiological Protection (Adopted January 17, 1977). ICRP Publication 26. Pergamon Press, Oxford. [As modified by "Statement from the 1978 Stockholm Meeting of the ICRP." Annals of the ICRP, Vol. 2, No. 1, 1978.]

International Commission on Radiological Protection. 1978. Limits for Intakes of Radionuclides by Workers. A Report of Committee 2 of the International Commission on Radiological Protection. Adopted by the Commission in July 1978. ICRP Publication 30. Part 1 (and Supplement), Part 2 (and Supplement), Part 3 (and Supplements A and B), and Index. Pergamon Press, Oxford.

U.S. Environmental Protection Agency. 1983. Standards for Remedial Actions at Inactive Uranium Processing Sites; Final Rule (40 CFR Part 192). Fed. Regist. 48(3):590-604 (January 5, 1983).

U.S. Department of Energy. 1984. Formerly Utilized Sites Remedial Action Program. Summary Protocol: Identification - Characterization - Designation - Remedial Action - Certification. Office of Nuclear Energy, Office of Terminal Waste Disposal and Remedial Action, Division of Remedial Action Projects. April 1984.

U.S. Department of Energy. 1985. Supplement to U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites. A Manual for Implementing Residual Radioactivity Guidelines. Prepared by Argonne National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, and Pacific Northwest Laboratory for the U.S. Department of Energy. (In preparation.)

U.S. Nuclear Regulatory Commission. 1982. Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material. Division of Fuel Cycle and Material Safety, Washington, DC. July 1982.

# APPENDIX D

## SITE INFORMATION FOR SPECIFIC SITES
(See Design Criteria, Section 3.3.3)

## 1.0 GENERAL

This appendix is a general outline of the information that will be obtained for a FUSRAP/SFMP site through historical research and/or field investigation activities during site characterization. This information will be used as a starting point for preparation of Design Bases for the sites. The data unique to a particular site are enclosed between single asterisks (*..*).

## 2.0 SURVEYS AND DATUM

Information on site description, surveys, plant coordinates, plant datum, plant grade, horizontal and vertical survey control points, plant grid north, site boundary, access roads, railroads, etc., will be obtained.

## 3.0 WATER LEVELS

For sites located on rivers, lakes, or at the ocean, the probable maximum and minimum water levels and their fluctuations will be obtained. The design maximum flood elevations, as noted below, will be investigated and recorded for the site:

| | Elevation Above Mean Sea Level (MSL) (*..*) |
|---|---|
| Maximum recorded high water | ft |
| 100-year projected flood | ft |
| Probable maximum flood | ft |
| Maximum projected water level for plant safety | ft |
| Design high water | ft |
| Design low water | ft |

(In general, the 100-year flood shall be used for design.)

4.0 PRECIPITATION (*..*)

Rainfall

| | |
|---|---|
| Average annual | in. |
| Daily maximum | in. |
| Design hourly maximum (100-year storm) | in. |
| Probable maximum precipitation (PMP) per hour | in. |

Flash floods caused by thunderstorm may occur and are to be considered in the design. (Note value to be used in flood design as *..* in. per hour.)

SNOWFALL (*..*)

| | |
|---|---|
| Average annual | in. |
| Season maximum | in. |
| Maximum for month of *..* | in. |
| Daily maximum | in. |
| Design snow load | lb/sq. ft. |

## 5.0 GROUNDWATER TABLE

The high water table to be used in design will be stated.

For the design of all underground structures, the high water table will be assumed as elevation *..* ft.

Average groundwater level is approximately at *..* ft.

## 6.0 FROST PENETRATION

Depth below grade *..* in.

## 7.0 ICE

If applicable, ice pack formation will be described giving appropriate design loads.

## 8.0 AIR TEMPERATURE (*..*)

| | |
|---|---|
| Maximum design | °F |
| Minimum design | °F |
| Average annual | °F |
| Average wet bulb | °F |
| Average dry bulb | °F |

## 9.0 NOISE LEVELS

Noise level measurement and monitoring during construction will be maintained for sites as required by local authorities.

## 10.0 WINDS

Based on 100-year recurrence interval, the design wind velocity shall be *..* mph at *..* feet above grade in accordance with the Uniform Building Code (UBC). The prevailing wind is in *..* direction. Wind velocity will be adjusted as appropriate for structure height and gust factors. The effects of tornadoes will be investigated as required by site conditions.

## 11.0 SEISMOLOGY

The site is in UBC Zone *..*. Seismic loads shall be considered in accordance with Section 2312 of UBC criteria.

Verification of whether a higher zoning than that required by UBC may be more appropriate for the particular site will be made.

## 12.0 GEOTECHNICAL INVESTIGATIONS

Subsurface investigations will provide a description of the soil and geological and hydrological conditions and other data for the preparation of "Soil and Geological Investigation Report". The design basis will list from the report the hydraulic gradient of ground water, soil profile, location of bedrock, determination of confined and unconfined aquifers, establishment of monitoring wells, test results of soil and rock properties, allowable bearing and/or pile capacities (as applicable) for foundation design, active and passive lateral earth pressure, etc. Compaction criteria and maximum slopes for excavation will also be specified.

## 13.0 GUIDELINES FOR RESIDUAL RADIOACTIVITY

To be developed for each site. Refer to Appendix C.

DOE F 1325.8
(8-89)
EFG (07-90)

108174

United States Government

Department of Energy

# memorandum

DATE: SEP 1 1993

1993 SEP -3 PM 1:50

REPLY TO ATTN OF: EM-421 (W. A. Williams, 903-8149)

SUBJECT: **Uranium Guidelines for the Ventron Site, Beverly, Massachusetts**

TO: L. Price, OR

This is in response to the request for approval of uranium guidelines for the Ventron Site of the Formerly Utilized Sites Remedial Action Program (FUSRAP), pursuant to DOE Order 5400.5. This site is located in Beverly, Massachusetts, and was used by the Department of Energy's (DOE) predecessor for producing uranium metal. Oak Ridge requested approval of a residual uranium guideline of 100 picoCuries per gram of total uranium for the site. These recommendations were made based on a supporting analysis by Argonne National Laboratory (ANL) and estimates of the waste volume which would result from different uranium guidelines.

Basic Dose Requirement:

The Ventron Site is located directly on a tidal estuary of the Atlantic Ocean and is presently used for industrial research and metal production. The ANL analysis calculated a maximum residual concentration of total uranium in soil of 480 picoCuries per gram (pCi/g) to 3100 pCi/g, depending on future land use. These concentrations are equivalent to 100 millirem per year for various land uses. The recommended 100 pCi/g is equivalent to 6 millirem per year for an industrial worker (Scenario A in the ANL Report). For recreational use, the exposure is less than 4 millirem per year (Scenario B). For residential farming use, the recommended guideline is 21 millirem per year, assuming that off-site water is used for drinking water purposes (Scenario C).

In the ANL analysis, the use of an on-site well for drinking water purposes was not considered because this assumption is not plausible. The site is immediately adjacent to a tidal estuary and the water is saline. For this reason, any water from an on-site well would be saline and not potable.

Based on the ANL analysis, the recommended value of 100 pCi/g of total uranium is within DOE's dose guideline of 100 millirem per year, which must be met under all worst case, plausible scenarios, including the assumed residential and recreational use.

ALARA Analysis:

In addition to meeting the basic radiation protection guideline, any remediation guideline must be analyzed to keep exposures as low as reasonably achievable (ALARA). In the application of ALARA, practical considerations, costs, and benefits are also taken into account. For practical considerations, it is likely that the contaminated areas will be remediated to a level below whatever guideline is established. This is

likely for two reasons. First, in order to remove all material above the guideline, some soil contaminated below the guideline will be removed. This will have the practical effect of lowering the guideline as it is applied during remediation operations. Second, during remediation operations, it is difficult to precisely delineate the point at which contamination above the guideline ends. As a result, remediation personnel will remove all suspect materials to avoid repeated remediation operations on the same property. For these reasons, it is likely that remediation will be accomplished at some level lower than the approved remediation guideline.

A final practical consideration is the use of clean fill material to replace excavated materials. This will cause a shielding and covering effect on the remaining soils, reducing gamma ray, dust, and radon exposures. If the site were to be used for residential or agricultural use in the future, the clean fill would also reduce the projected doses by diluting the residual contamination. The ANL analysis does not assume that there is any clean fill or cover placed over the site after remediation. For this reason, the doses calculated in the ANL report are clearly a worst case scenario. In the actual application of a remediation guideline, it is very likely that a remediation level substantially below the established guideline will be achieved.

A further ALARA consideration is that of costs and benefits. A review of the contaminated soil volume as a function of the remediation guideline indicates an increasing volume of contaminated soil as the guideline becomes smaller.

Between the remediation guidelines of 460 and 200 pCi/g of total uranium, the volume of contaminated soil increases by 1,700 cubic yards. For the current industrial use of the site, this increase in waste volume and cost is equivalent to a reduction in the calculated dose from 26 millirem per year to 11. A reduction from 200 to the recommended 100 pCi/g decreases the dose for the current industrial use from 11 millirem per year to less than 6. This same reduction increases waste volume by another 1,080 cubic yards. Reducing the guideline to 70 pCi/g will reduce the dose for industrial use to less than 4 millirem per year and increase waste volume by 1,550 cubic yards. Further reductions to 40 and 20 pCi/g increase waste volume by an additional 4,100 and 3,000 cubic yards, respectively.

If the costs of excavating, packaging, transporting, and disposing the soil are estimated to be more than $500 per cubic yard, the reduction in the guideline from the recommended 100 pCi/g to 70 pCi/g would cost more than $540,000 with little benefit. Further reductions to 40 and 20 pCi/g will increase costs further with even less benefit.

The possible residential and agricultural use of the site in the future must be also considered. Scenario C examines this possible use and assumes a resident farmer will:

(1) reside at the site after remediation;
(2) drink water from an uncontaminated, off-site source;

(3) eat plant foods grown in the decontaminated area;
(4) drink milk and eat meat from cattle grown on the site; and
(5) ingest 100 milligrams of soil at the site.

These assumptions are very unlikely but may be plausible in the distant future. The recommended guideline of 100 pCi/g is equivalent to an annual exposure of 36 millirem per year under these assumptions. A review of the ANL report indicates that the significant pathway for this scenario is via inhalation of contaminated dust. The mass loading factor used for airborne dust in the calculations (200 micrograms per cubic meter) is much higher than would be expected at the site under ambient conditions and reflects the level of dust loading expected from plowing or digging in the soil. Such a high dust load is unlikely on a continual basis.

Summary and Approval:

Based on the above considerations, a guideline of 100 pCi/g for total uranium above background levels is approved for use in the remediation of the Ventron Site, pursuant to DOE Order 5400.5, Chapter IV, Section 5a. Please provide ANL with post-remedial action data to permit the preparation of another dose estimate report to reflect the actual doses after completion of the remediation.

We also recommend that your staff discuss the site characterization data and the approved guidelines with the State and EPA staff at an appropriate time.

James W. Wagoner II
Director
Division of Off-Site Programs
Office of Eastern Area Programs
Office of Environmental Restoration

cc:
T. Perry, OR
C. Yu, ANL
J. Berger, ORISE

DOE F 1325.8
(8-89)
EFG (07-90)

142335

United States Government **Department of Energy**

# memorandum

MAY 17 12 29 PM '96

DATE: MAY 14 1996

REPLY TO ATTN OF: EM-42 (W. A. Williams, 301-903-8149)

SUBJECT: Approval of Proposed Remediation Approach for Residual Radioactive Material at the Ventron Site, Beverly, Massachusetts

TO: L. Price, OR

This is to approve the approach proposed for remediation of the Ventron Site in Beverly, Massachusetts. The proposed approach is for minimal decontamination of Buildings A and A1 structural surfaces on the basis of predicted dose and ultimate disposition of these buildings.

Proposal:

The site contains residual radioactive material from the production of uranium metal in the early 1940s and uranium recovery efforts in the mid- to late 1940s. Residual uranium remains on a number of overhead horizontal surfaces, walls, and floors in buildings A and A1; other buildings onsite have no interior uranium. The site owner is currently in the process of demolishing all buildings on the site. The non-metal/masonry material will be crushed and used as backfill or disposed of in an industrial landfill. The steel/metal building components will be removed and either recycled or disposed in a landfill for construction/industrial material.

The proposed remediation approach would be as follows:

1) provide health physics support to the owner during building demolition, including radiation surveys of some building components with gross decontamination as appropriate; and

2) remove all soil contamination in excess of the authorized limits for this site.

Independent verification of surface contamination levels is not proposed for the building surfaces due to the plans for demolition of all on-site buildings by the site owner. After the owner demolishes the building, the Department of Energy (DOE) would excavate soil to meet the authorized limits for residual radioactivity. The independent verification contractor would confirm the remediated status of the site grounds.

The proposal would leave residual radioactive material in the masonry rubble, metal surfaces, and other material comprising demolition rubble. As demonstrated in the dose calculations (CCN 140242) for the different building components, this approach is consistent with the dose limits and procedures in DOE Order 5400.5, Chapter IV. Supplemental standards would be applied in lieu of the surface guidelines as stated in Figure IV-1 of DOE Order 5400.5, since the materials would either be crushed or smelted and recycled rather than remain as a structural surface. Materials not suitable for recycle would be disposed in a landfill for construction

debris. The Operations Office will coordinate with the State, the owner, and other affected parties regarding this approach.

Review of Proposal:

Our review of the proposal has identified several issues which were not discussed in the proposal. While these issues are not a significant concern at the Ventron site, they need to be addressed in the approval of the proposal.

Ground-water protection can be significant at some sites. However, at the Ventron site, there is not a sufficient inventory of uranium within the building structure to constitute a significant ground-water threat. Further, the ground water at the site location is saline because of its location immediately adjacent to a tidal estuary of the Atlantic Ocean. As a result, ground-water degradation is not significant.

Cumulative doses are very small because of the small inventory of radioactive material and limited size of the site. These are estimated to be less than one person-rem per year.

The proposal is consistent with two important documents. The first of these is a memorandum from Raymond F. Pelletier to numerous addressees, dated November 17, 1995, and entitled "Application of DOE 5400.5 requirements for release and control of property containing residual radioactive material." The second document is the current manual for the RESRAD computer code: ANL/EAD/LD-2, Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD Version 5.0, published by Argonne National Laboratory (ANL) and prepared by ANL and DOE staff, September 1993.

Some calculations in the proposal are overly conservative and significantly overestimate the potential exposure and potential dose to hypothetical recipients. For example:

- In the potential sandblasting of steel on page 10, an inhalation dose is calculated with no respiratory protection assumed; yet the sandblasting would be conducted to remove lead paint from the steel prior to recycling. Because of the hazardous nature of lead, it is likely that respiratory protection would be used, and the potential exposure of workers would be much lower than the estimate in the proposal. In addition, the removal of uranium from the steel surface by sandblasting would minimize any potential for lead to be present in the slag from recycling of the steel.

- In the evaluation for uranium in slag from the recycling of steel on page 11, the concentration of uranium is over-estimated. It is not reasonable to assume that the steel from the building is recycled with no other steel. The estimated mass of steel is about 35 metric tons, and it is very likely that this steel would be recycled with other steel from uncontaminated sources. Although the concentration of the U-238 was estimated to be over 90 pCi/g, this concentration should be

considered as a worst case estimate and not as a reasonable or likely estimate. At the very least, the steel from the contaminated buildings would be mixed with the steel from the uncontaminated buildings on the site during the recycling process. If this reasonable assumption were made, the calculated concentration of uranium in the slag would be reduced by a factor of two to five.

- Baghouse dust from the recycling of steel needs to be examined. If the concentration of uranium in the dust particles is similar to that in the slag and if one assumes that the dust is mixed with dust from other production not involving uranium, it is evident that the average concentration of uranium in the dust is reduced significantly below that of the slag. As a result, the likely doses will not be significant.

In summary, although a number of minor issues in the documentation were identified, the proposal is in compliance with the applicable DOE requirements and guidance.

Regulatory Issue:

Using the proposed remediation approach, any uranium shipped in metal for recycle would be less than the general license quantity established by the U.S. Nuclear Regulatory Commission (NRC) at 10 CFR 40.22. Pursuant to an agreement with the NRC, Massachusetts is expected to acquire this regulatory authority. As a result, the proposed approach is generally consistent with the *de minimis* regulatory limits established by NRC; coordination with the State assures that the approach will meet State requirements when the State assumes the regulatory authority.

Cost Benefit Issues:

Specific compliance to the surface contamination limits in DOE Order 5400.5, Chapter IV, would involve significant incremental costs in excess of $500,000, with avoided dose to a hypothetical maximum dose to an individual of five millirem per year. The cost of additional cleanup is not justified. In the event of new information or changed circumstances, Departmental policy permits you, your staff, and your supporting contractors to conduct additional decontamination to achieve radiation exposures "as low as reasonably achievable."

Approval:

This is to approve the approach of using Supplemental Limits for Buildings A and A1 structural surfaces in the cleanup of the Ventron site, pursuant to DOE Order 5400.5, Chapter IV. The approval is based on the planned demolition of the buildings, the small dose reduction that would be achieved from additional remediation and/or decontamination efforts, and State regulatory coordination and participation.

The maximum estimated dose of five millirem is well below the basic dose limit of 100 millirem per year for all plausible exposure conditions. In

addition, the site, the recycled metal, and any slag from recycling will meet the State criteria of ten millirem per year as stated in 105 CMR 120.291, even though this requirement is not directly applicable to DOE.

The following conditions apply to this approval:

(1) The Post Remedial Action Report should document the ultimate disposition by the property owner of the demolished structures and include a dose assessment of the actual disposition for the recycled materials.

(2) Continuous air monitoring should be performed during demolition activities to document the concentration of radionuclides in air.

(3) Coordination with the State regarding this approach shall be documented in writing.

In addition, it is recommended that masonry from Buildings A and A1 be handled and crushed separately to permit the measurement of residual uranium levels prior to mixing with soil or crushed masonry from other buildings.

By copy of this memorandum, we are requesting that ANL prepare a dose assessment for a future site occupant, based on post remedial data collected after remediation.

Please call me if you have any questions.

Albert S. Johnson
Team Leader
FUSRAP Team
Office of Eastern Area Programs
Office of Environmental Restoration

cc: J. Kopotic, DOE/OR
A. Wallo III, EH-232/DOE-HQ
C. Yu, ANL

DOE F 1325.8
(4/93)

127-GQA-GAM-00006 -97-302

United States Government **Department of Energy**

Oak Ridge Operations Office

# memorandum

DATE: September 22, 1997

REPLY TO ATTN OF: EW-93:Kopotic

SUBJECT: **REQUEST FOR APPROVAL OF PROPOSED REMEDIATION APPROACH FOR RESIDUAL RADIOACTIVE MATERIAL AT THE VENTRON SITE**

TO: Alexander Williams, Designation and Certification Manager, DOE-GTN, EM-421

The purpose of this memorandum is to request your approval for a revision to conditions specified in the memorandum "Approval of Proposed Remediation Approach for Residual Radioactive Material at the Ventron Site". The memorandum approved supplemental limits for Buildings A and A1 structural surfaces and required that continuous air monitoring be performed during demolition activities to document the concentration of radionuclides in air. In addition, the memorandum recommended that measurement of residual uranium levels in the masonry from the two buildings be performed.

As you know, the site owner performed building demolition from mid-July to early August, 1996. During this time, Bechtel performed personnel, perimeter, and area air monitoring, sampling and analyses of demolition rubble, pre/post equipment surveys and exit dose rate surveys on all vehicles transporting the demolition debris. The building demolition did not include the floor slabs for either building; however, during the course of FUSRAP's remedial action, approximately 40 percent of buildings A and A1 slab were subsequently removed. This was performed in order to remove contaminated soils from beneath the slabs primarily in the areas of the leach tank pit and fan pit in Building A, and in two sub-slab areas in Building A-1. Additionally, as a best management practice, slab areas that exceeded approximately 10 times the surface criteria were scabbled/removed in order to ensure that no waste management problems would be encountered during owner disposition of the slab material.

A total of 48 samples were collected from the building demolition debris. One sample was a grab sample and the remaining 47 samples were composites collected during debris generation for each phase of the owner's demolition effort. The concentrations of uranium-238 ranged from 0.84 pCi/g to 3.7 pCi/g (average 2.35 pCi/g). The concentrations of thorium-232 ranged from 0.23 pCi/g to 1.39 Ci/g (average 0.72 pCi/g). The concentrations of radium-226 ranged from 0.16 pCi/g to 1.2 pCi/g (average 0.60 pCi/g).

Results for perimeter air monitoring conducted during the demolition effort ranged from 1.96 E-15 uCi/ml to 2.19 E-14 uCi/ml (average 9.35 E-15 uCi/ml) which is less than 1 percent of the derived concentration guide for uranium-238.

Radiation exposure rates collected during exit surveys of all trucks transporting the demolition debris for offsite disposal typically ranged from 8 uR/hr to 10 uR/hr, with the highest exposure rate measured at 12 uR/hr for one vehicle measurement. These measurements indicate that the material did not present an external radiation exposure hazard.

It is estimated that approximately 90-94 percent of the total debris volume which would result from the demolition of Buildings A and A-1 has been represented with the sampling efforts previously described. As demonstrated in the original dose calculations (CCN140242), these results further substantiate compliance with applicable DOE requirements and guidance. Based on these considerations, I am requesting that no additional air monitoring be required and that no additional measurements for residual uranium are necessary.

I would appreciate your decision regarding the elimination of requirements and recommendations from the original supplemental standards approval for A/A1 demolition debris by September 30, 1997. If you have any questions, please contact me at (423) 576-9441. Thank you for your help in this matter.

James D. Kopotic

James D. Kopotic, Site Manager
FUSRAP Group

DOE F 1325.8
(8-89)
EFG (07-90)

Williams Reader

United States Government | Department of Energy

# memorandum

127-GOA-GAM-00007

DATE: SEP 29 1997

REPLY TO ATTN OF: EM-42 (A. Williams, 301-903-8149)

SUBJECT: Ratification, Confirmation, and Changes to Supplemental Standards for Residual Radioactive Material at the Ventron Site, Beverly, Massachusetts

TO: William Seay
Oak Ridge Operations Office

This is to approve requested changes in the application of supplemental standards for remediation of the Ventron Site in Beverly, Massachusetts, and to ratify and confirm the supplemental standards previously approved.

Request:

Supplemental standards for remedial action at this site were previously requested and approved with the various conditions and recommendations. One condition required air monitoring for airborne radioactivity during building demolition activities. One recommendation was to perform monitoring on masonry debris during its removal from the site by the property owner.

Your staff requested that the mandatory condition for air monitoring during demolition activities be discontinued based on the observed insignificant levels of airborne uranium observed during demolition activities.

Similarly, your staff requested that recommended monitoring of uranium levels in masonry debris be discontinued because observed values were extremely low and well within the approved guideline for the site.

Discussion:

At the Ventron Site, all field activities related to the remediation of the site are complete, with the exception of the removal of portions of the slabs from buildings A and A1. The prior monitoring of similar demolition activities show insignificant airborne uranium levels. The measured concentrations of uranium in masonry debris is clearly insignificant and well within the variation in the concentrations of natural background. Levels of uranium on the remaining slabs has been measured and are not significantly different in any way from debris and slabs that have already been removed and disposed by the property owner. At the present time, almost all of the demolition work has been completed, and there is no reason to believe that the future demolition and removal of the remaining slabs would be any different than for the past demolition work.

We estimate the cost of providing additional monitoring to exceed $10,000. Based on the previous measurements, there would be no commensurate benefit from this expenditure.

Approval:

The available monitoring data supplies an adequate basis for ratifying and confirming the previously approved supplemental standards. Actual monitoring data establishes that the implementation of supplemental standards has been

accomplished at the Ventron Site well within the applicable dose limits. However, pursuant to DOE Order 5400.5, Chapter IV, a change in the conditions for the removal of the remaining slabs of buildings A and A1 is justified. This change rescinds the required monitoring of air and the recommended monitoring of uranium in demolition waste for the remaining portions of the Buildings A and A1 slabs, based on the experience at the site and lack of commensurate benefit.

These changes do not affect the need for the remaining slabs to be demolished and removed. An effort should be made (in conjunction with the property owner) to confirm and document the removal of the remaining slabs. This record should include both written and photographic documents. A trip report from a Department of Energy or contractor official, with annotated pictures, would be entirely adequate; alternatively, a similar transmittal from the property owner, a municipal or State official, or the independent verification contractor would also be satisfactory.

Please contact me with any questions.

Albert S. Johnson
Team Leader
FUSRAP Team
Office of Eastern Area Programs
Office of Environmental Restoration

cc: J. Kopotic, OR
A. Wallo III, EH-232
J. Beck, ORISE

bcc:
Booz, Allen and Hamilton, Inc.

Distribution:
EM-42 (2)
EM-40 (2)
Williams Reader

EM-42:williams:dlg:903-8149:9/25/97:ventron2.haz

EM-42
Johnson
9/22/97

Fm-42
Morphice
9/25/97

142976 96-293

# Department of Energy

Oak Ridge Operations
P.O. Box 2001
Oak Ridge, Tennessee 37831— 8723

June 3, 1996

Ms. Alicia Raddatz
Ventron Site Coordinator
Morton International
150 Andover Street
Danvers, Massachusetts 01923

Dear Ms. Raddatz:

**VENTRON SITE - DISPOSAL OF BUILDING DEMOLITION DEBRIS**

At your request, the Department of Energy has evaluated the demolition waste that would result from the demolition of Building A/A1 against the radiological criteria provided for Waste Management of New Hampshire, Inc. The material matrix to be generated as a result of Morton International's building demolition project will consist primarily of typical construction debris (e.g., concrete and other masonry material, wood, sheetrock, steel, etc.).

New Hampshire does not currently regulate naturally occurring radioactive material. The landfill site permit prohibits the disposal of source, special nuclear or byproduct material as defined by the Atomic Energy Act of 1954, as amended. The demolition debris does not meet the definition of any of the aforesaid categories, and does not contain technologically enhanced radium-226 or radium-228. Therefore, the material can be disposed of as ordinary demolition debris as long as other permit conditions are met.

The primary radionuclide of concern at this site is uranium-238, with much lesser amounts of radium and thorium, which occur naturally in the environment, with concentrations in soil and rock, typically in the range 1-20 pCi/g for uranium-238. Background concentrations in the area of the Ventron site have been measured at approximately 5-10 pCi/g for uranium-238, and 1-2 pCi/g for radium and thorium. Based upon the DOE's survey results and subsequent calculations, it is anticipated that the material will have an average uranium concentration of approximately less than 10 pCi/g which falls within the range found in typical construction materials (i.e., typically ranges from 2 to 20 pCi/g for naturally occurring uranium in concrete, brick and other masonry materials). All material will be staged, sampled, and analyzed prior to loading for shipment to the disposal facility. The release criteria for the site is 50 pCi/g of uranium-238 and 15 pCi/g of radium and thorium. Under no circumstances will construction debris be released from the site that exceeds these criteria.

Please contact me at (423) 576-9441 at your earliest convenience so that we can develop an agreed upon schedule covering this activity or for any questions you may have regarding this proposed approach.

Sincerely,

James D. Kopotic

James D. Kopotic, Site Manager
Former Sites Restoration Division

ornl

OAK RIDGE NATIONAL LABORATORY

MARTIN MARIETTA

ORNL/TM-10053

# RESULTS OF THE RADIOLOGICAL SURVEY AT THE VENTRON SITE, BEVERLY, MASSACHUSETTS

W. D. Cottrell
R. F. Carrier

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
NTIS price codes—Printed Copy: A06 Microfiche A01

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

ORNL/TM-10053

HEALTH AND SAFETY RESEARCH DIVISION

Nuclear and Chemical Waste Programs
(Activity No. AH 10 05 00 0; ONLWCO1)

# RESULTS OF THE RADIOLOGICAL SURVEY AT THE VENTRON SITE, BEVERLY, MASSACHUSETTS

W. D. Cottrell and R. F. Carrier

Date of Issue — May 1988

B. A. Berven - Environmental Assessments Program Manager
W. D. Cottrell - FUSRAP Project Director

Work performed as part of the
ENVIRONMENTAL ASSESSMENTS PROGRAM

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under Contract No. DE-AC05-84OR21400

# CONTENTS

FIGURES ..... v

TABLES ..... ix

ACKNOWLEDGMENTS ..... xi

ABSTRACT ..... xiii

1. INTRODUCTION ..... 1

2. SURVEY METHODS ..... 6

2.1 OUTDOOR SURVEY METHODS ..... 6
2.2 INDOOR SURVEY METHODS ..... 6

3. SURVEY RESULTS ..... 7

3.1 OUTDOOR SURVEY RESULTS ..... 7

3.1.1 Gamma Exposure Rate Measurements ..... 7
3.1.2 Surface Soil Samples ..... 17
3.1.3 Subsurface Soil Samples and Gamma Logging of Auger Holes ..... 17
3.1.4 Sediment Samples ..... 25

3.2 INDOOR SURVEY RESULTS ..... 25

3.2.1 Building A ..... 28
3.2.2 Building A-1 ..... 44
3.2.3 Buildings B-1, B-2, and B-3 ..... 57
3.2.4 Buildings C-1, C-2, C-3, and C-4 ..... 57
3.2.5 Building D ..... 61
3.2.6 The Alfa Building ..... 61
3.2.7 Storage Building and Warehouse ..... 64

4. SIGNIFICANCE OF FINDINGS ..... 64

REFERENCES ..... 69

APPENDIX: GAMMA PROFILE GRAPHS OF AUGER HOLES AT THE VENTRON SITE, BEVERLY, MASSACHUSETTS ..... 71

# FIGURES


1 Diagram showing general location of the Ventron site . . . . . 2

2 Scaled drawing of the grid system used in the outdoor survey of the Ventron site . . . . . 3

3 View of the Storage Building looking southeast from Building A at the Ventron site . . . . . 4

4 View of Buildings C-2, C-3, and C-4 looking west from Building A at the Ventron site . . . . . 4

5 View of Buildings B-1, B-2, B-3, and B-4 looking southwest from Building A at the Ventron site . . . . . 5

6 Locations of elevated gamma exposure rate measurements outdoors at the Ventron site . . . . . 14

7 Locations of surface soil samples at the Ventron site . . . . . 17

8 Locations of auger holes and subsurface soil samples at the Ventron site . . . 19

9 Contaminated regions outdoors at the Ventron site as indicated by soil sample analyses . . . . . 23

10 Locations of sediment samples taken from storm sewers at the Ventron site . . . . . 26

11 Location of contaminated areas on the first level of Building A at the Ventron site . . . . . 33

12 View of rotary kiln in room 20, Building A, at the Ventron site . . . . . 37

13 View of region above pit in room 20, Building A, at the Ventron site . . . . . 37

14 Location of contaminated areas in room 20, Building A, at the Ventron site . . . . . 38

15 Location of contaminated areas in room 29, Building A, at the Ventron site . . . . . 39

16 View of the exhaust fan in room 29, Building A, at the Ventron site ..... 40

17 View of the fan duct and raised roof above room 29, Building A, at the Ventron site ..... 40

18 View of kilns in room 30, Building A, at the Ventron site ..... 41

19 Location of contaminated areas on the roof of Building A at the Ventron site ..... 42

20 View of the roof with hooded vent, Building A, at the Ventron site ..... 45

21 View of the contaminated region of the roof, Building A, at the Ventron site ..... 45

22 Location of contaminated areas in the basement of Building A at the Ventron site ..... 46

23 Location of contaminated areas in Building A-1 at the Ventron site ..... 47

24 Location of contaminated areas in room 3, Building A-1, at the Ventron site ..... 51

25 Location of contaminated areas in room 4, Building A-1, at the Ventron site ..... 52

26 Location of contaminated areas in room 6, Building A-1, at the Ventron site ..... 53

27 View beneath the balcony in room 6, Building A-1, at the Ventron site ..... 54

28 View showing windows and roof area in room 6, Building A-1, at the Ventron site ..... 54

29 View of the contaminated window ledge above room 6, Building A-1, at the Ventron site ..... 55

30 Location of contaminated areas in room 4A, Building A-1, at the Ventron site ..... 56

31 Location of contaminated areas on the roof of Building A-1 at the Ventron site ..... 58

32 View of the roof of Building A-1 at the Ventron site ..... 59

33 Basements of Buildings B-1, B-2, and B-3 at the Ventron site showing regions of elevated gamma exposure rates and locations of auger holes . . . . . 60

34 Basement of Building C-1 at the Ventron site showing locations of auger holes . . . . . 62

35 Location of contaminated areas in the Alfa Building at the Ventron site . . . . . 63

# TABLES


1 Background radiation levels in the Beverly, Massachusetts, area ..... 8

2 Applicable guidelines for protection against radiation ..... 9

3 Outdoor gamma exposure rate measurements at the Ventron site ..... 10

4 Measurements taken in regions of elevated gamma exposure rates outdoors at the Ventron site ..... 15

5 Concentration of radionuclides in surface soil samples from the Ventron site ..... 18

6 Concentration of radionuclides in subsurface soil samples from the Ventron site ..... 20

7 Extent of subsurface contamination at the Ventron site as indicated by scintillation probe loggings and sample analyses ..... 24

8 Concentration of radionuclides in sediment samples from storm sewers at the Ventron site ..... 27

9 Gamma exposure rate measurements in Building A at the Ventron site .... 29

10 Alpha and beta-gamma measurements in Building A at the Ventron site ... 31

11 Alpha, beta-gamma, and gamma measurements in drain troughs in Building A at the Ventron site ..... 34

12 Alpha, beta-gamma, and gamma measurements in contaminated areas of overhead regions of Building A at the Ventron site ..... 35

13 Alpha, beta-gamma, and gamma measurements in contaminated areas on the roof of Building A at the Ventron site ..... 43

14 Gamma exposure rate measurements in Building A-1 at the Ventron site ..... 48

15 Alpha and beta-gamma measurements in Building A-1 at the Ventron site ..... 49

# ACKNOWLEDGMENTS

This research was sponsored by the Division of Facility and Site Decommissioning Projects, U.S. Department of Energy. The authors wish to acknowledge the support of J. E. Baublitz, Deputy Director, Office of Remedial Action and Waste Technology, J. J. Fiore, Director, Division of Facility and Site Decommissioning Projects, and members of their staff. The authors also appreciate the contributions of C. Clark, Jr., D. Dawley, R. W. Doane, B. S. Ellis, J. A. Kark, E. T. Loy, R. Ray, D. A. Roberts, W. H. Shinpaugh, T. R. Stewart, and D. A. Witt for participation in collection, analyses, and reporting of data for this survey. We are also grateful for the assistance of B. C. Littleton of the IR&A Publications Office.

# ABSTRACT

The results of a radiological survey of the Ventron site (the Ventron Division of Morton Thiokol, Inc.) in Beverly, Massachusetts, are presented in this report. From 1942 through 1948, the site was used for various projects involving the production of uranium metal powder from uranium oxide and the recovery of uranium from scrap metal. After 1948, the Atomic Energy Commission surveyed the facility and performed decontamination and decommissioning activities in accordance with current procedural policies. In 1980 and 1982, a comprehensive radiological survey of the site was conducted by the Oak Ridge National Laboratory. Included were measurements of the following: residual alpha and beta-gamma contamination levels inside the buildings; external gamma radiation levels at 1 m above the surface and at the surface in the buildings and outdoors; and uranium, radium, and thorium concentrations in surface and subsurface soil outdoors and beneath the buildings.

The results show the presence of residual radioactive contamination, largely uranium with lesser amounts of thorium and radium, in outdoor soil and in fill material beneath Buildings B-1, B-2, and C-1. The spotty contamination found in Buildings A and A-1, and the Alfa Building on floors, walls, and overhead surfaces, and equipment included beta-gamma dose rates exceeding the limits set by current guidelines applicable to the release of property for unrestricted use. Surface contamination dose rates on the roof of Building A were comparable to those inside the buildings.

In summary, concentrations of residual radioactive material found in buildings and soils at the site are in excess of concentration guidelines established by the Department of Energy to determine if a site needs to be considered for remedial action. These guildelines are typically derived to ensure that unrestricted use of the facility (including residential use) will not result in above-guideline doses to the general public. An examination of work/occupancy scenarios for this site suggests that the annual radiation exposures to personnel from any credible current use scenario would be well below dose limits which would be applied to protect members of the general public from exposure to radiation.

# 1. INTRODUCTION

The Metal Hydrides Corporation was under contract to the Manhattan Engineer District (MED) and the Atomic Energy Commission (AEC) from 1942 to 1948 to convert uranium oxide to uranium metal powder. This procedure, as well as later operations involving recovering uranium from scrap uranium and turnings from the slug fabrication plant at Hanford, Washington, were conducted at the foundry site located in Beverly, Massachusetts. The city lies on Massachusetts Bay approximately 15 miles northeast of the central Boston area. The property, which comprises approximately three acres, is located at the confluence of the Bass and Danvers rivers and is bounded by Congress Street to the north (Fig. 1). During contract operations three buildings were used for uranium work. Two wooden buildings that housed the foundry facilities were demolished sometime between 1948 and 1950, and two other buildings have since been erected at these locations. The remaining original building contained furnace and leaching facilities, a mixing room, a drying room, and analytical laboratories. The Metal Hydrides Corporation became the Ventron Corporation in 1965, and in late 1976 the Thiokol Corporation acquired control of the company.[1] In 1982 Ventron became a Division of Morton Thiokol, Incorporated.

The AEC conducted a radiation survey of the facility in 1948. The two foundry buildings and various pieces of equipment were found to be contaminated and cleaning was recommended. Painted surfaces were sandblasted, and contaminated concrete floors and platforms were removed. Ocean dumping was the method used for disposing of contaminated equipment and rubble. In 1977, following acquisition of the property by the Thiokol Corporation, the Oak Ridge Operations office of the Department of Energy (DOE) and the Oak Ridge National Laboratory (ORNL) conducted a screening survey of the site in 1977. Based on the results of exploratory measurements, it was determined that a comprehensive radiological survey of the entire site was in order.

A radiological characterization survey of the outdoor portion of the site was conducted by members of the Health and Safety Research Division (HASRD) of ORNL during the period September 19-25, 1980. Buildings and structures on the site were surveyed February 22-28, 1982. A preliminary report, documenting a recommendation for the consideration of remedial action, was presented to DOE in December 1985.[2]

This report describes the results of the radiological survey in detail. A scaled drawing of the property showing the location of buildings and the grid network established for measurements outside the existing buildings is shown in Fig. 2. The locations of the original foundry buildings are also indicated. Photographs showing several of the buildings are presented in Figs. 3-5.

ORNL-DWG 87-12507

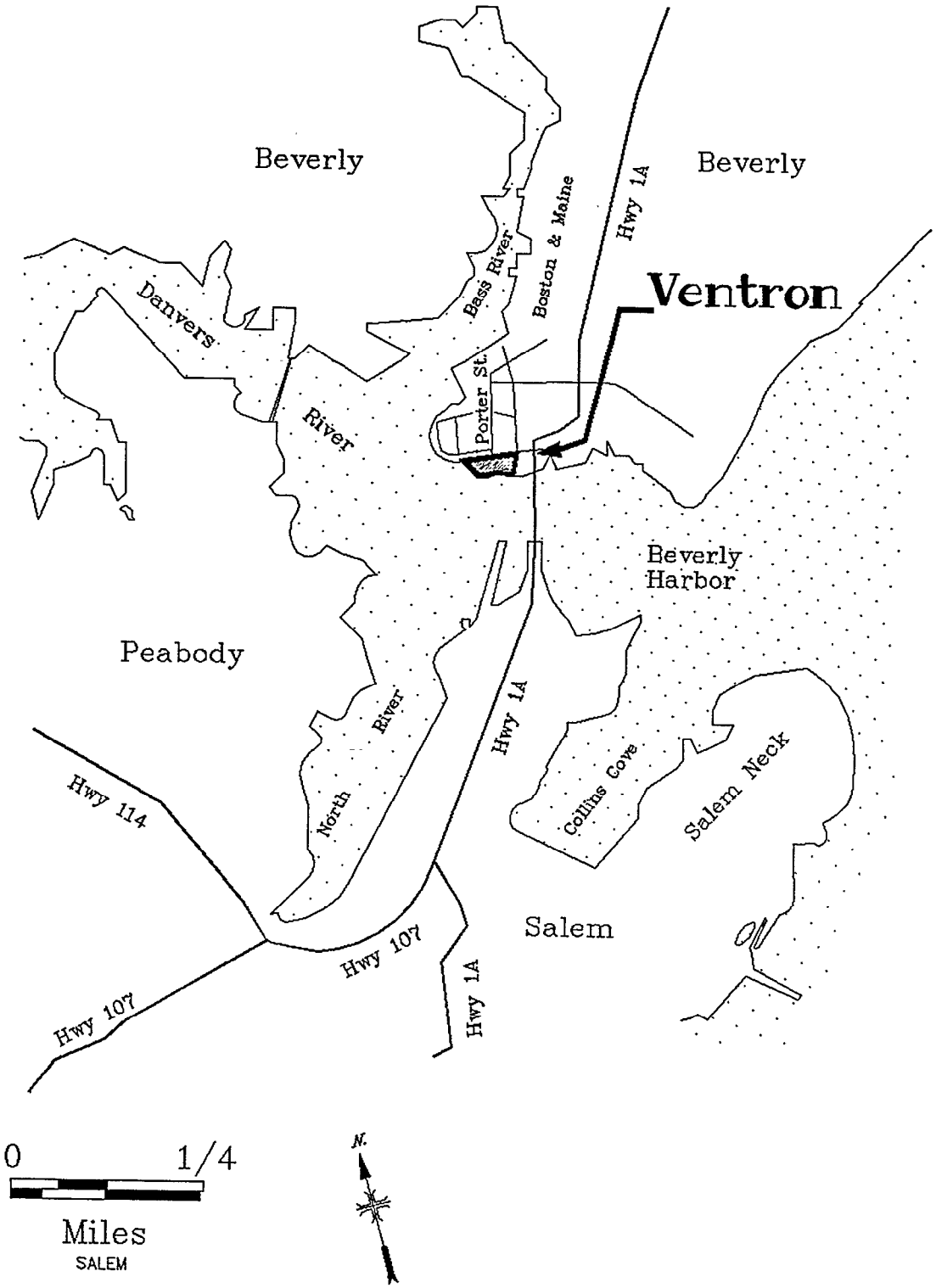



**Fig. 1. Diagram showing general location of the Ventron site.**

ORNL-DWG 86-12862

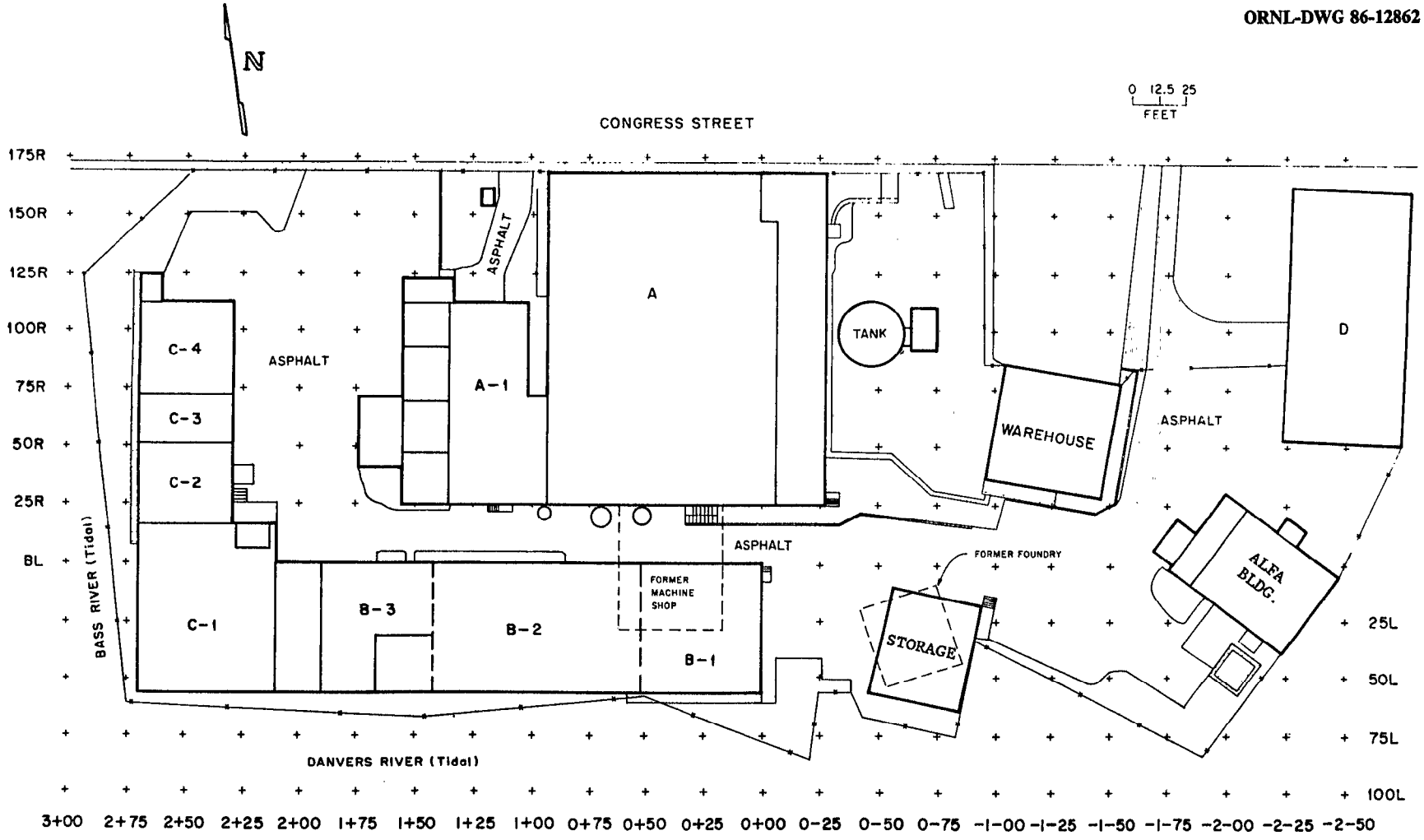



**Fig. 2. Scaled drawing of the grid system used in the outdoor survey of the Ventron site.**

ORNL-PHOTO 3264-86

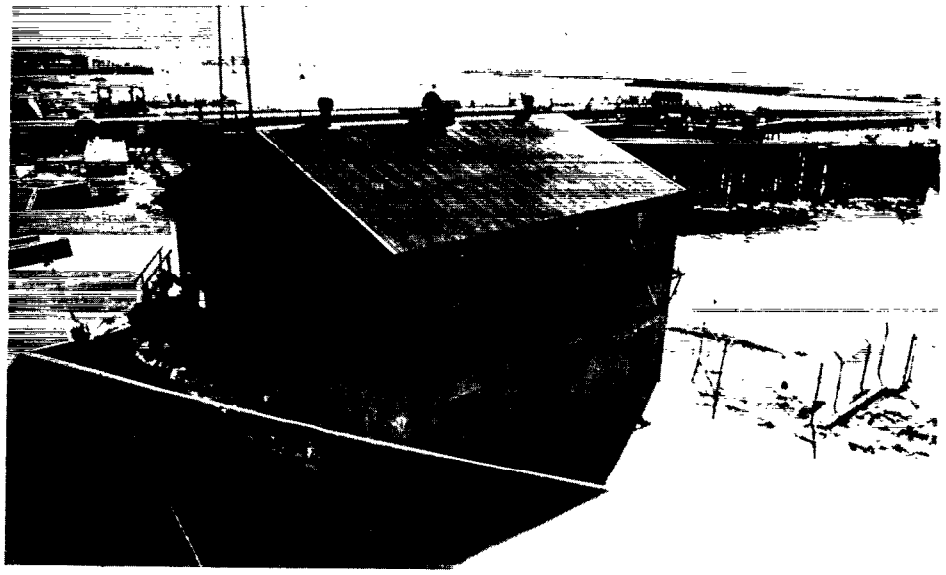


**Fig. 3. View of the Storage Building looking southeast from Building A at the Ventron site.**

ORNL-PHOTO 3265-86

**Fig. 4. View of Buildings C-2, C-3, and C-4 looking west from Building A at the Ventron site.**

ORNL-PHOTO 3266-86

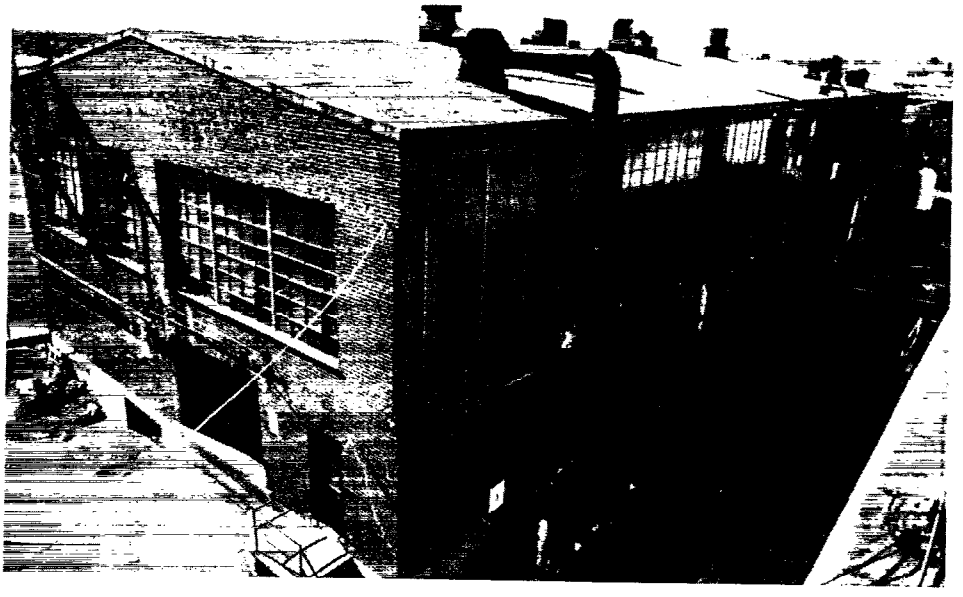


**Fig. 5. View of Buildings B-1, B-2, B-3, and B-4 looking southwest from Building A at the Ventron site.**

# 2. SURVEY METHODS

The radiological survey of this property included: (1) gamma exposure rates at 1 m above the ground surface and at the ground surface at outdoor grid locations; (2) gamma exposure rates at 1 m above the floor surface and at the floor surface at indoor grid locations; (3) gamma scanning of both indoor and outdoor areas; (4) radionuclide analysis of surface and subsurface soil samples; (5) logging of gamma radiation levels at various depths in auger holes; (6) radionuclide analysis of sediment samples from storm sewer manholes; and (7) direct and transferable alpha and beta-gamma activity inside the structures. A comprehensive description of the survey methods and instrumentation has been presented in another report.[3]

Large areas to be surveyed either indoors or outdoors were subdivided into "grid block" subsections for convenience in reporting results.

## 2.1 OUTDOOR SURVEY METHODS

The entire outdoor area was divided into 25-ft grid blocks. Unless otherwise stated in Sect. 2.1, each block was surveyed in the following manner: Accessible areas in each grid block were scanned with the portable gamma scintillation meter, and the area-weighted average found within the block was recorded. Measurements at 1 m above the ground surface and at the ground surface at the center point in each block were then made. Surface soil samples were taken at systematically selected locations and analyzed for $^{238}U$, $^{226}Ra$, and $^{232}Th$ content. At points showing elevated gamma rates, "biased" surface soil samples were taken for similar analyses.

To define the extent of subsurface soil contamination on the site, holes were augered to depths of 2.4 m and more in regions of suspected subsurface contamination. A plastic pipe was placed in each hole, and a NaI scintillation probe was lowered inside the pipe. The probe was encased in a lead shield with a horizontal row of collimating slits on the side. This collimation allows measurement of gamma radiation intensities resulting from contamination within small fractions of the hole depth. When possible, if the gamma readings in the hole were not uniform, a soil sample was scraped from the wall of the auger hole at the point showing the highest gamma radiation level. The auger hole loggings were used to select locations where further soil sampling would be useful. At points as close as practical to several selected auger holes, a split-spoon sampler was used to collect subsurface samples at known depths. Sediment samples were taken from several storm sewers to determine radionuclide concentration. The soil and sediment samples were analyzed for $^{238}U$, $^{226}Ra$, and $^{232}Th$.

## 2.2 INDOOR SURVEY METHODS

Throughout this report, the term "lower walls" refers to wall surfaces up to a height of 6 ft. Whenever practical, floors and lower walls were divided into grid blocks defined by natural boundaries such as building supports. The size of the survey blocks generally

varied with the size of the building and room. Where possible, grid block designations are used in presenting results. However, in some cases, the complexity of the grid system would unnecessarily complicate the reporting of data. To circumvent this difficulty, grid block measurements taken inside the buildings have been averaged on a room-by-room basis when tabulated.

Unless otherwise stated in Sect. 3, each block was surveyed in the following manner: Accessible areas were scanned with a gamma scintillation detector, and the range and average gamma radiation levels were recorded. The gamma radiation levels at 1 m and at the surface were measured near the center of the block. Beta-gamma dose rate measurements were made at the point of maximum gamma radiation level in each block. One or more alpha measurements were taken at the surface near the center of each grid block, and the measurement or the average of the measurements was recorded. Smear samples were taken at systematically chosen locations and/or in areas of elevated beta-gamma dose rates. For the survey of overhead surfaces (including walls above 6 ft), measurements of direct and transferable alpha and beta-gamma contamination levels were made at numerous points as uniformly spaced as practicable. In addition to these measurements, holes were drilled through the floors of Buildings B-1, B-2, B-3, and C-1 to depths of 2.4 m (8 ft) or more, and soil samples were taken at various intervals. The samples were analyzed for $^{238}U$, $^{226}Ra$, and $^{232}Th$.

# 3. SURVEY RESULTS

Typical radiation background levels in the Beverly, Massachusetts, area are presented in Table 1. These data are provided for comparison with the survey results presented in this section. Applicable federal guidelines for radiation exposure to the general public are summarized in Table 2.

With the exception of measurements of transferable activity, which are reported as net disintegration rates, all direct measurements presented in this report are gross readings; background radiation levels have not been subtracted. Similarly, background concentrations have not been subtracted from radionuclide concentrations in soil samples.

## 3.1 OUTDOOR SURVEY RESULTS

### 3.1.1 Gamma Exposure Rate Measurements

Gamma exposure rates taken at 1 m above the ground surface and at the ground surface near the center point in each grid block are listed in Table 3. The average exposure rate found during the scan of grid blocks is also given. These data show an overall average of 8 $\mu$R/h. Elevated measurements ranging from 10 to 450 $\mu$R/h were identified in several regions with the contamination at the south side of the property appearing to extend beyond the sea wall into the rip-rap and tidal areas. The regions of elevated gamma levels are indicated on Fig. 6 and the measurements appear in Table 4.

**Table 1. Background radiation levels in the Beverly, Massachusetts, area**

| Type of radiation measurement or sample | Radiation level or radionuclide concentration | |
|---|---|---|
| | Range | Average |
| Gamma exposure rate at 1 m above floor or ground surface ($\mu$R/h)[a] | 6–8 | 7 |
| Concentration of radionuclides in soil (pCi/g)[a] | | |
| $^{238}$U | 0.92–2.7 | 1.6 |
| $^{226}$Ra | 1.0–1.8 | 1.3 |
| $^{232}$Th | 0.98–1.2 | 1.1 |

[a]Values obtained from three locations in the Beverly area.

**Table 2. Applicable guidelines for protection against radiation[a]**

| Mode of exposure | Exposure conditions | Guideline value |
|---|---|---|
| Gamma radiation | Indoor gamma radiation level (above background) | 20 $\mu$R/h |
| Surface contamination | $^{238}$U, U-natural | |
| | Fixed on surfaces | 5000 dpm/100 cm$^2$ |
| | Removable | 1000 dpm/100 cm$^2$ |
| | $^{232}$Th, Th-natural | |
| | Fixed on surfaces | 1000 dpm/100 cm$^2$ |
| | Removable | 200 dpm/100 cm$^2$ |
| | $^{226}$Ra | |
| | Fixed on surfaces | 100 dpm/100 cm$^2$ |
| | Removable | 20 dpm/100 cm$^2$ |
| Beta-gamma dose rates | Surface dose rate averaged over not more than 1 m$^2$ | 0.20 mrad/h |
| | Maximum dose rate in any 100 cm$^2$ area | 1.0 mrad/h |
| Radionuclide concentrations in soil | Maximum permissible concentration of the following radionuclides in soil above background levels averaged over 100 m$^2$ area | 5 pCi/g averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over 15-cm thick soil layers more than 15 cm below the surface |
| | $^{232}$Th | |
| | $^{230}$Th | |
| | $^{228}$Ra | |
| | $^{226}$Ra | |
| | $^{238}$U | Derived (site specific) |

[a]U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites (Revision 2, March 1987).

[b]Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except $^{90}$Sr, $^{228}$Ra, $^{223}$Ra, $^{227}$Ac, $^{133}$I, $^{131}$I, $^{129}$I, $^{126}$I, and $^{125}$I.

**Table 3. Outdoor gamma exposure rate measurements at the Ventron site**

| Grid location[a] | Center point measurements[b] (μR/h) | | Average gamma exposure rate during scan of grid block[c] (μR/h) |
|---|---|---|---|
| | Gamma exposure rate at the surface | Gamma exposure rate at 1 m | |
| 0−25, BL | 8 | 7 | 8 |
| 0−50, BL | 7 | 7 | 7 |
| 0−75, BL | 7 | 6 | 7 |
| −1−00, BL | 8 | 6 | 8 |
| −1−25, BL | 6 | 6 | 6 |
| −1−50, BL | 6 | 6 | 6 |
| −1−75, BL | 6 | 5 | 6 |
| −2−00, BL | 8 | 7 | 7 |
| −2−25, BL | d | d | 8 |
| −2−50, BL | d | d | 8 |
| −2−75, BL | d | d | 8 |
| 0+00, BL | 8 | 8 | 7 |
| 0+25, BL | 7 | 8 | 7 |
| 0+50, BL | 8 | 7 | 8 |
| 0+75, BL | 7 | 7 | 8 |
| 1+00, BL | 8 | 9 | 8 |
| 1+25, BL | 9 | 8 | 8 |
| 1+50, BL | 7 | 8 | 8 |
| 1+75, BL | 6 | 6 | 8 |
| 2+00, BL | 7 | 8 | 7 |
| 2+25, BL | d | d | 7 |
| 2+50, BL | d | d | 7 |
| 2+75, BL | 8 | 7 | d |
| 0−50, 25R | 9 | 7 | 8 |
| 0−75, 25R | 8 | 7 | 8 |
| −1−00, 25R | 7 | 7 | 7 |
| −1−25, 25R | d | d | 7 |
| −1−50, 25R | d | d | 6 |
| −1−75, 25R | 6 | 5 | 6 |
| 2−00, 25R | 5 | 5 | 6 |
| 2−25, 25R | 6 | 6 | 7 |
| 2−50, 25R | 7 | 5 | 8 |
| 1+50, 25R | 9 | 6 | 7 |
| 1+75, 25R | 6 | 6 | 7 |
| 2+00, 25R | 7 | 7 | 7 |
| 2+25, 25R | d | d | 7 |
| 2+50, 25R | d | d | 6 |
| 0−50, 50R | 8 | 8 | 8 |
| 0−75, 50R | 6 | 6 | 8 |
| −1−00, 50R | 6 | 6 | 7 |
| −1−75, 50R | 5 | 6 | 7 |

**Table 3 (continued)**

| Grid location[a] | Center point measurements[b] (μR/h) | | Average gamma exposure rate during scan of grid block[c] (μR/h) |
|---|---|---|---|
| | Gamma exposure rate at the surface | Gamma exposure rate at 1 m | |
| −2−00, 50R | 5 | 5 | 7 |
| −2−25, 50R | 7 | 5 | 7 |
| 1+50, 50R | d | d | 7 |
| 1+75, 50R | 5 | 6 | 7 |
| 2+00, 50R | 7 | 7 | 7 |
| 2+25, 50R | d | d | 7 |
| 2+50, 50R | d | d | 6 |
| 0−50, 75R | 7 | 6 | 8 |
| 0−75, 75R | 6 | 5 | 7 |
| −1−00, 75R | 6 | 5 | 7 |
| −1−25, 75R | 6 | 6 | 7 |
| −1−50, 75R | 6 | 6 | 5 |
| −1−75, 75R | 6 | 6 | 6 |
| −2−00, 75R | 6 | 6 | 7 |
| −2−25, 75R | 7 | 6 | 6 |
| 0+75, 75R | d | d | 7 |
| 1+50, 75R | 6 | 7 | 7 |
| 1+75, 75R | 6 | 6 | 7 |
| 2+00, 75R | 6 | 6 | 7 |
| 2+25, 75R | d | d | 7 |
| 2+50, 75R | d | d | 6 |
| 0−50, 100R | 7 | 6 | 6 |
| 0−75, 100R | 6 | 6 | 6 |
| −1−00, 100R | 6 | 6 | 6 |
| −1−25, 100R | 6 | 6 | 6 |
| −1−50, 100R | 6 | 5 | 7 |
| −1−75, 100R | 7 | 6 | 7 |
| −2−00, 100R | 6 | 6 | 7 |
| −2−25, 100R | 6 | 6 | 7 |
| 0+75, 100R | d | d | 8 |
| 1+00, 100R | d | d | 8 |
| 1+25, 100R | d | d | 7 |
| 1+50, 100R | 6 | 6 | 7 |
| 1+75, 100R | 6 | 6 | 7 |
| 2+00, 100R | 7 | 6 | 7 |
| 2+25, 100R | d | d | 7 |
| 2+50, 100R | d | d | 6 |
| 2+75, 100R | d | d | 6 |
| 0−50, 125R | d | d | 6 |
| 0−75, 125R | d | d | 6 |
| −1−00, 125R | 7 | 7 | 6 |
| −1−25, 125R | 6 | 6 | 6 |

**Table 3 (continued)**

| Grid location[a] | Center point measurements[b] (μR/h) | | Average gamma exposure rate during scan of grid block[c] (μR/h) |
|---|---|---|---|
| | Gamma exposure rate at the surface | Gamma exposure rate at 1 m | |
| −1−50, 125R | 7 | 6 | 6 |
| −1−75, 125R | 7 | 6 | 6 |
| −2−00, 125R | 7 | 6 | 7 |
| −2−25, 125R | 7 | 6 | 7 |
| 0+75, 125R | d | d | 7 |
| 1+00, 125R | 9 | 7 | 7 |
| 1+25, 125R | 6 | 5 | 7 |
| 1+50, 125R | 5 | 5 | 7 |
| 1+75, 125R | 6 | 6 | 7 |
| 2+00, 125R | 6 | 6 | 7 |
| 2+25, 125R | 6 | 6 | 7 |
| 2+50, 125R | 7 | 7 | 7 |
| 2+75, 125R | d | d | 6 |
| 0−25, 150R | d | d | 7 |
| 0−50, 150R | d | d | 6 |
| 0−75, 150R | d | d | 6 |
| −1−00, 150R | d | d | 6 |
| −1−25, 150R | d | d | 7 |
| −1−50, 150R | d | d | 6 |
| −1−75, 150R | d | d | 6 |
| −2−00, 150R | d | d | 7 |
| −2−25, 150R | d | d | 7 |
| −2−50, 150R | d | d | 7 |
| 0+00, 150R | d | d | 7 |
| 0+25, 150R | d | d | 7 |
| 0+50, 150R | d | d | 7 |
| 0+75, 150R | d | d | 7 |
| 1+00, 150R | d | d | 7 |
| 1+25, 150R | d | d | 7 |
| 1+50, 150R | d | d | 7 |
| 1+75, 150R | d | d | 7 |
| 2+00, 150R | d | d | 7 |
| 2+25, 150R | d | d | 7 |
| 2+50, 150R | d | d | 7 |
| 0−25, 25L | 7 | 7 | 7 |
| 0−50, 25L | 7 | 6 | 7 |
| 0−75, 25L | 8 | 7 | 7 |
| −1−00, 25L | 6 | 6 | 6 |
| −1−25, 25L | 6 | 6 | 6 |
| −1−50, 25L | 6 | 6 | 6 |
| −1−75, 25L | 6 | 6 | 7 |
| −2−00, 25L | 9 | 21 | 21 |

**Table 3 (continued)**

| Grid location[a] | Center point measurements[b] (μR/h) | | Average gamma exposure rate during scan of grid block[c] (μR/h) |
|---|---|---|---|
| | Gamma exposure rate at the surface | Gamma exposure rate at 1 m | |
| 1+75, 25L | 7 | 6 | 7 |
| 2+00, 25L | 7 | 7 | 7 |
| 2+50, 25L | d | d | 21 |
| 0−25, 50L | 7 | 7 | 7 |
| 0−50, 50L | 7 | 6 | 7 |
| 0−75, 50L | d | d | 7 |
| −1−00, 50L | 8 | 6 | 8 |
| −1−25, 50L | 7 | 6 | 6 |
| −1−50, 50L | 10 | 8 | 6 |
| −1−75, 50L | 6 | 6 | 18 |
| −2−00, 50L | 76 | 61 | 61 |
| −2−25, 50L | d | d | 7 |
| 1+75, 50L | 7 | 6 | 7 |
| 2+00, 50L | 8 | 8 | 7 |
| 2+50, 50L | d | d | 24 |
| 0+00, 75L | d | d | 7 |
| 0−25, 75L | d | d | 5 |
| 0−50, 75L | d | d | 7 |
| 0−75, 75L | d | d | 7 |
| −1−50, 75L | d | d | 7 |
| −1−75, 75L | 45 | 47 | 45 |
| −2−00, 75L | 40 | 31 | 40 |
| 2−25, 75L | d | d | 24 |
| 0+25, 75L | d | d | 7 |
| 0+50, 75L | d | d | 7 |
| 0+75, 75L | d | d | 7 |
| 1+00, 75L | d | d | 7 |
| 1+25, 75L | d | d | 7 |
| 1+50, 75L | d | d | 7 |
| 1+75, 75L | d | d | 7 |
| 2+00, 75L | d | d | 8 |
| 2+25, 75L | d | d | 7 |
| 2+50, 75L | d | d | 24 |

[a]Grid location shown on Fig. 2.
[b]Center point measurements are discrete measurements at the center of each grid block.
[c]Grid block measurements are obtained by a gamma scan of the entire block.
[d]Inaccessible.

ORNL-DWG 87-12508

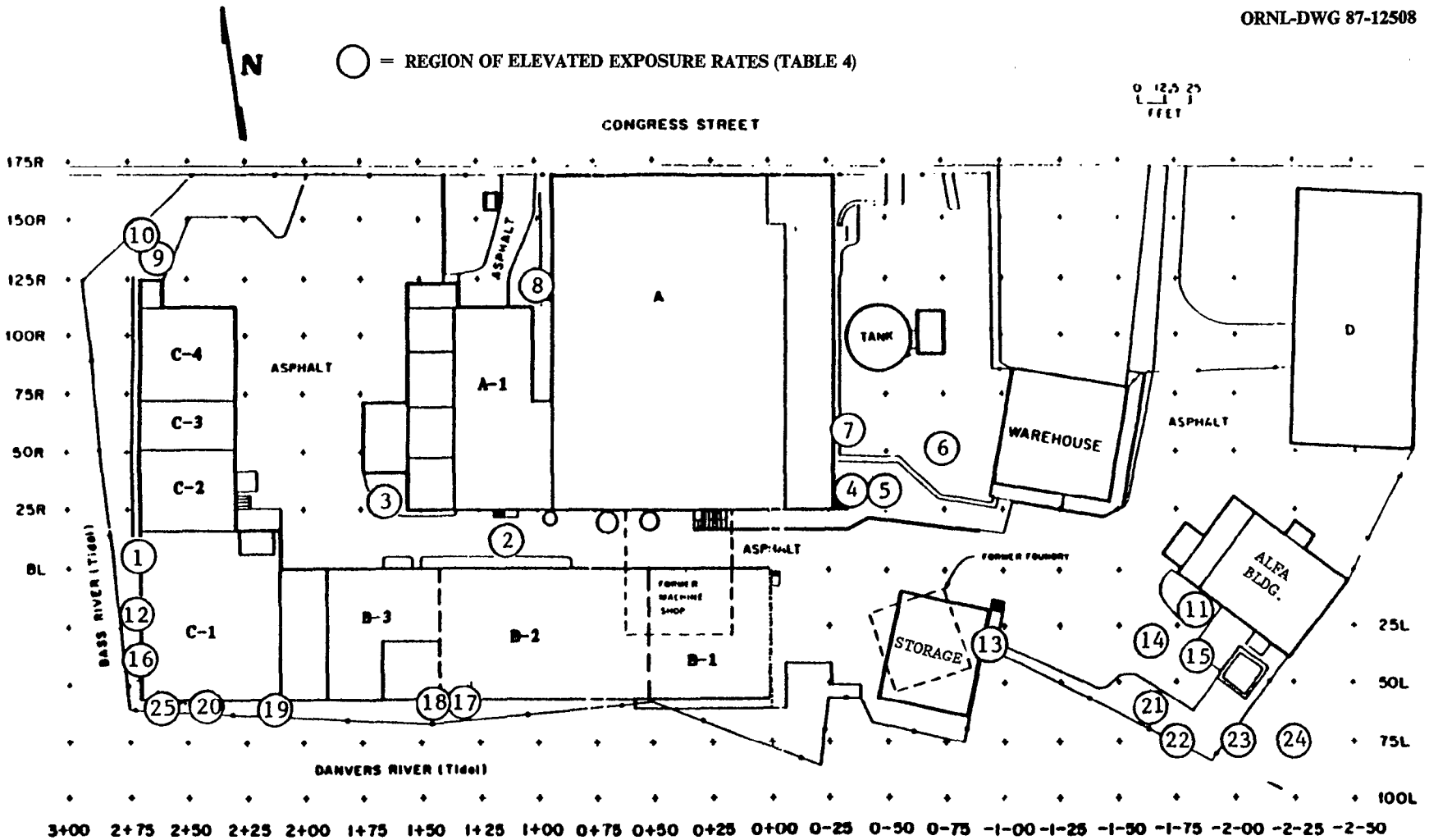



Fig. 6. Locations of elevated gamma exposure rate measurements outdoors at the Ventron site.

**Table 4. Measurements taken in regions of elevated gamma exposure rates outdoors at the Ventron site**

| Location code[a] | Grid location | Maximum gamma exposure rate at surface ($\mu$R/h)[b] | Maximum gamma exposure rate at 1 m ($\mu$R/h)[b] | Beta-gamma dose rate at surface (mrad/hr) | Estimated area ($m^2$) |
|---|---|---|---|---|---|
| 1 | 2+73, 05R | 45 | c | c | <0.1 |
| 2 | 1+10, 12R | 24 | c | c | <0.1 |
| 3 | 1+60, 27R | 24 | c | 0.04 | <0.1 |
| 4 | 0−30, 30R | 10 | c | c | <0.1 |
| 5 | 0−50, 30R | 24 | c | c | <0.1 |
| 6 | 0−75, 50R | 10 | c | c | 0.28 |
| 7 | 0−30, 60R | 20 | c | c | c |
| 8 | 0+98, 120R | 30–55 | 23 | 0.5 | 1.5 |
| 9 | 2+62, 137R | 24 | 6 | 0.06 | <0.1 |
| 10 | 2+60, 145R | 24 | c | c | c |
| 11 | −1−85, 20L | 30–150 | c | c | 1.9 |
| 12 | 2+70, 23L | 45 | c | c | <0.1 |
| 13 | 0−90, 35L | 24 | c | c | 0.28 |
| 14 | −1−65, 35L | 67 | c | c | <0.1 |
| 15[d] | −2−00, 50L | 300 | 61 | 0.35 | 9.3 |
| 16[e] | 2+50, 50L | 120–450 | 45 | 5 | ~1.9 |
| 17 | 1+35, 60L | 45 | c | c | <0.1 |
| 18 | 1+45, 60L | 45 | c | c | <0.1 |
| 19 | 2+10, 60L | 76 | c | c | 0.093 |
| 20 | 2+45, 60L | 61 | c | c | 0.093 |
| 21 | −1−65, 62L | 73 | c | c | <0.1 |
| 22 | −1−75, 75L | 240 | 45 | 0.45 | 2.8 |
| 23[f] | −2−00, 75L | 91 | c | c | 2.8 |
| 24[g] | −2−25, 75L | 24 | c | c | c |
| 25[e] | 2+50, 75L | 61–300 | 30 | 0.6 | 1.6 |

[a]Codes are shown on Fig. 6 in locations approximating grid points where anomalies were measured.

[b]Maximum gamma exposure rate measured during scan of grid block.

[c]No measurement taken.

[d]Maximum levels found in many spots within grid block.

[e]Maximum levels found in spotty regions next to building wall.

[f]Measurement located south of fence.

[g]Average gamma exposure rate during scan of grid block.

### 3.1.2 Surface Soil Samples

Surface (0-15 cm) soil samples were taken at locations S1 through S19 and B1 through B9 as exhibited on Fig. 7. The samples designated "systematic" (S1-S19) were taken at systematically chosen locations; those designated "biased" (B1-B9) were taken in areas showing elevated gamma radiation levels. Concentrations of $^{238}U$, $^{226}Ra$, and $^{232}Th$ in these samples are listed in Table 5.

Concentrations of $^{232}Th$ in systematic soil samples ranged from less than 1 to 370 pCi/g. Of the 20 systematic soil samples analyzed for $^{232}Th$, all but four were at background levels. Concentrations as high as 3900 pCi/g of $^{232}Th$ were observed in biased samples. The maximum concentration of $^{232}Th$ exceeds the DOE guideline of 5 pCi/g above background in any top 15-cm layer of soil by a factor of approximately 800. Concentrations of $^{238}U$ in systematic surface soil ranged from 0.74 to 97 pCi/g and averaged 12 pCi/g. The maximum concentration of $^{238}U$ found in biased soil samples was 44,000 pCi/g. Fourteen of the twenty systematic soil samples contained uranium concentrations in excess of local background. All concentrations of $^{226}Ra$ in surface soil samples were well below the DOE guideline and were at or near background levels for the Beverly area.

### 3.1.3 Subsurface Soil Samples and Gamma Logging of Auger Holes

Holes were augered at the locations outdoors as shown on Fig. 8 and beneath Buildings B-1, B-2, B-3, and C-1 (see Sects. 3.2.3 and 3.2.4). One to several soil samples were taken from each hole at various depths ranging from the surface to 3.5 m. Selected auger holes were then "logged" using a gamma scintillation detector.

The logging technique used here is not radionuclide specific. However, the logging data, in conjunction with the soil analyses data, may be used to estimate the region of contamination in the auger holes. It appears from a comparison of these data that a reading of 1000 cpm or greater using the shielded scintillator indicates the presence of elevated (above background) concentrations of $^{238}U$, $^{226}Ra$, and $^{232}Th$. Graphs of the gamma logging of the holes are provided in the appendix.

Concentrations of $^{238}U$, $^{226}Ra$, and $^{232}Th$ found in subsurface soil on this property are presented in Table 6. Concentrations of $^{238}U$ in soil samples taken from auger holes outside buildings ranged from 1.7 to 62,000 pCi/g. The maximum concentrations of $^{226}Ra$ and $^{232}Th$ found were 30 and 53 pCi/g, respectively. These concentrations exceed the DOE guideline concentration of 15 pCi/g in any 15-cm layer of soil beneath the surface by factors of approximately 2.0 and 3.5, respectively. The contaminated regions outdoors, as determined by the soil sample results, are shown on Fig. 9. Analyses of subsurface strata taken from beneath buildings showed concentrations of $^{238}U$ ranging from 1.8 to 71,000 pCi/g and averaging 1800 pCi/g. The maximum concentrations of $^{238}U$ found beneath Buildings B-1, B-2, B-3, and C-1 were 14,000, 71,000, 17, and 1400 pCi/g, respectively. Concentrations of $^{226}Ra$ and $^{232}Th$ ranged from 0.08 to 37 pCi/g and <0.08 to 3.3 pCi/g, respectively.

ORNL-DWG 86-12863

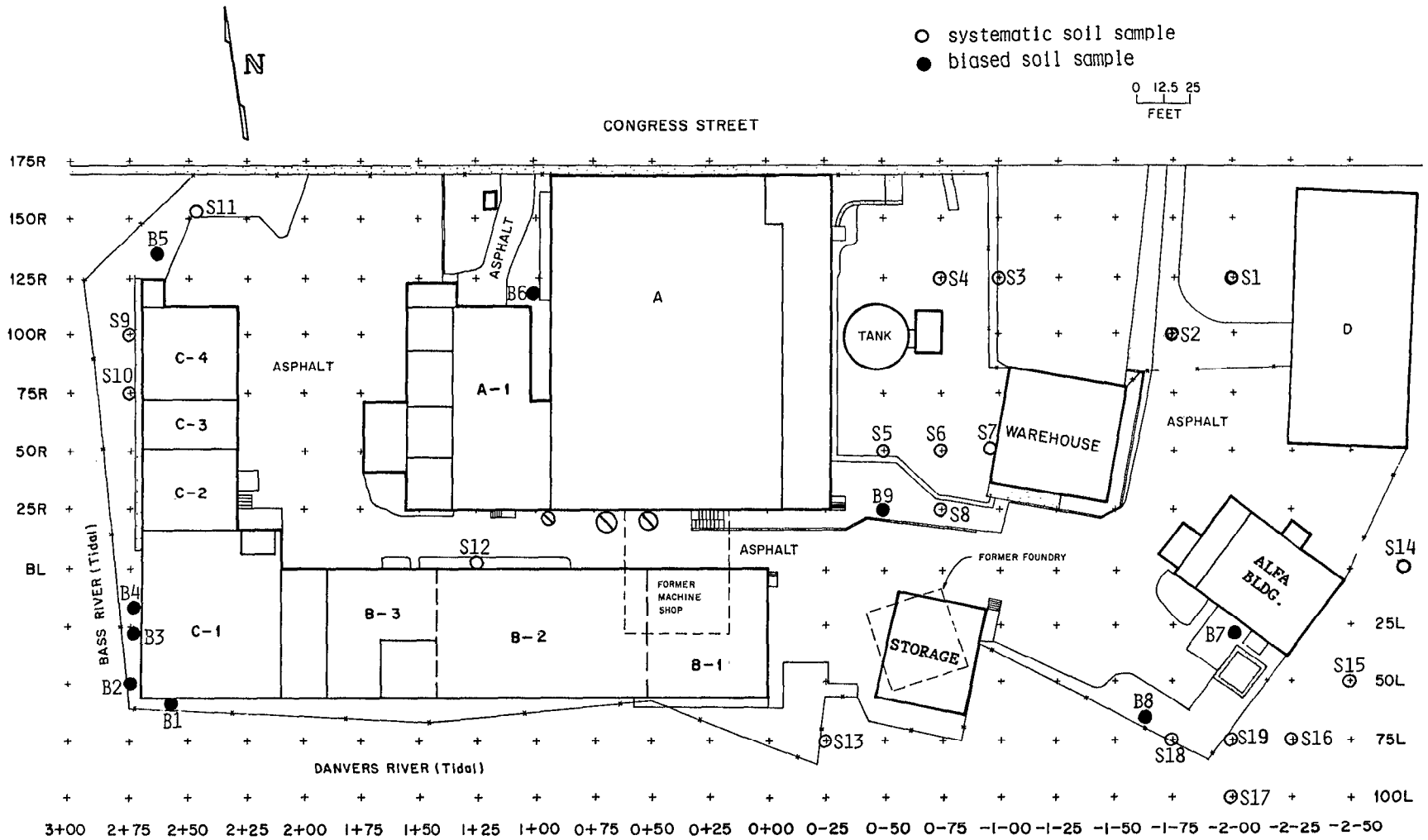



**Fig. 7. Locations of surface soil samples at the Ventron site.**

**Table 5. Concentration of radionuclides in surface soil samples from the Ventron site**

| Sample number | Location[a] | Depth (cm) | Radionuclide concentration (pCi/g) | | |
|---|---|---|---|---|---|
| | | | $^{226}Ra$[b] | $^{232}Th$[c] | $^{238}U$[d] |
| | | *Systematic Samples*[e] | | | |
| 1 | −2−00, 125R | 0−15 | 0.77 ± 0.04 | 0.83 | 0.74 |
| 2 | −1−75, 100R | 0−15 | 0.65 ± 0.04 | 0.65 | 1.0 |
| 3 | −1−00, 125R | 0−15 | 0.58 ± 0.04 | 0.78 | 8.4 |
| 4 | −1−75, 125R | 0−15 | 0.85 ± 0.03 | 0.88 | 0.81 |
| 5 | −1−50, 50R | 0−15 | 0.78 ± 0.1 | 0.81 | 50 |
| 6 | 0−75, 50 R | 0−15 | 0.60 ± 0.04 | 0.69 | 9.9 |
| 7 | −1−00, 50R | 0−15 | 0.69 ± 0.06 | 0.74 | 6.4 |
| 8 | 0−75, 25R | 0−15 | 0.70 ± 0.04 | 0.86 | 97 |
| 9 | 2+75, 100R | 0−15 | 0.84 ± 0.05 | 0.77 | 1.1 |
| 10 | 2+75, 75R | 0−15 | 0.91 ± 0.05 | 1.1 | 1.3 |
| 11 | 2+45, 155R | 0−15 | 0.71 ± 0.1 | 0.70 | 5.0 |
| 12 | 1+25, 02R | 0−15 | 0.76 ± 0.02 | 0.81 | 4.1 |
| 13 | 0−25, 75L | 0−15 | 0.68 ± 0.07 | 0.72 | 1.0 |
| 14 | −2−75, BL | 0−15 | 0.88 ± 0.04 | 1.1 | 17 |
| 15 | −2−50, 50L | 0−15 | 0.68 ± 0.04 | 0.77 | 3.4 |
| 16 | −2−25, 75L | 0−15 | 0.86 ± 0.05 | 1.3 | 9.7 |
| 17 | −2−00, 100L | 0−15 | 1.1 ± 0.05 | 6.1 | 5.4 |
| 18A | −1−75, 75L | 0−15 | 0.88 ± 0.04 | 23 | 2.9 |
| 18B | −1−75, 75L | 35−50 | 3.0 ± 1 | 160 | 6.3 |
| 19 | −2−00, 75L | 0−15 | 2.9 ± 3 | 370 | 17 |
| | | *Biased samples*[f] | | | |
| B1 | South, Bldg. C-1 | 0−15 | 6 ± 5 | 1,300 | 48 |
| B2 | West, Bldg. C-1 | 0−15 | <1 | 340 | 120 |
| B3 | West, Bldg. C-1 | 0−15 | <1 | 240 | 89 |
| B4 | West, Bldg. C-1 | 0−15 | <1 | <1 | 44,000 |
| B5 | 2+63, 132R | 0−15 | 0.91 ± 0.3 | 20 | 7.7 |
| B6 | 1+00, 115R | 0−15 | 1.7 ± 0.3 | 2.1 | 200 |
| B7 | −2−00, 30L | 0−15 | 2.0 ± 0.4 | 390 | 24 |
| B8 | −1−65, 65L | 0−15 | <1 | 3,900 | 93 |
| B9A | −0−50, 25R | 0−15 | 0.73 ± 0.02 | 0.83 | 57 |
| B9B | −0−50, 25R | 45−50 | 0.62 ± 0.02 | 0.74 | 11 |

[a]Locations of soil samples are shown on Fig. 7.
[b]Indicated counting error is at the 95% confidence level (± 2 $\sigma$).
[c]The error of the reported radionuclide concentration is ± 5% (95% confidence level).
[d]Total analytical error of measurement results is less than ± 5% (95% confidence level).
[e]Systematic samples are taken at grid locations irrespective of gamma exposure.
[f]Biased samples are taken from areas shown to have elevated gamma exposure rates.

ORNL-DWG 86-12864

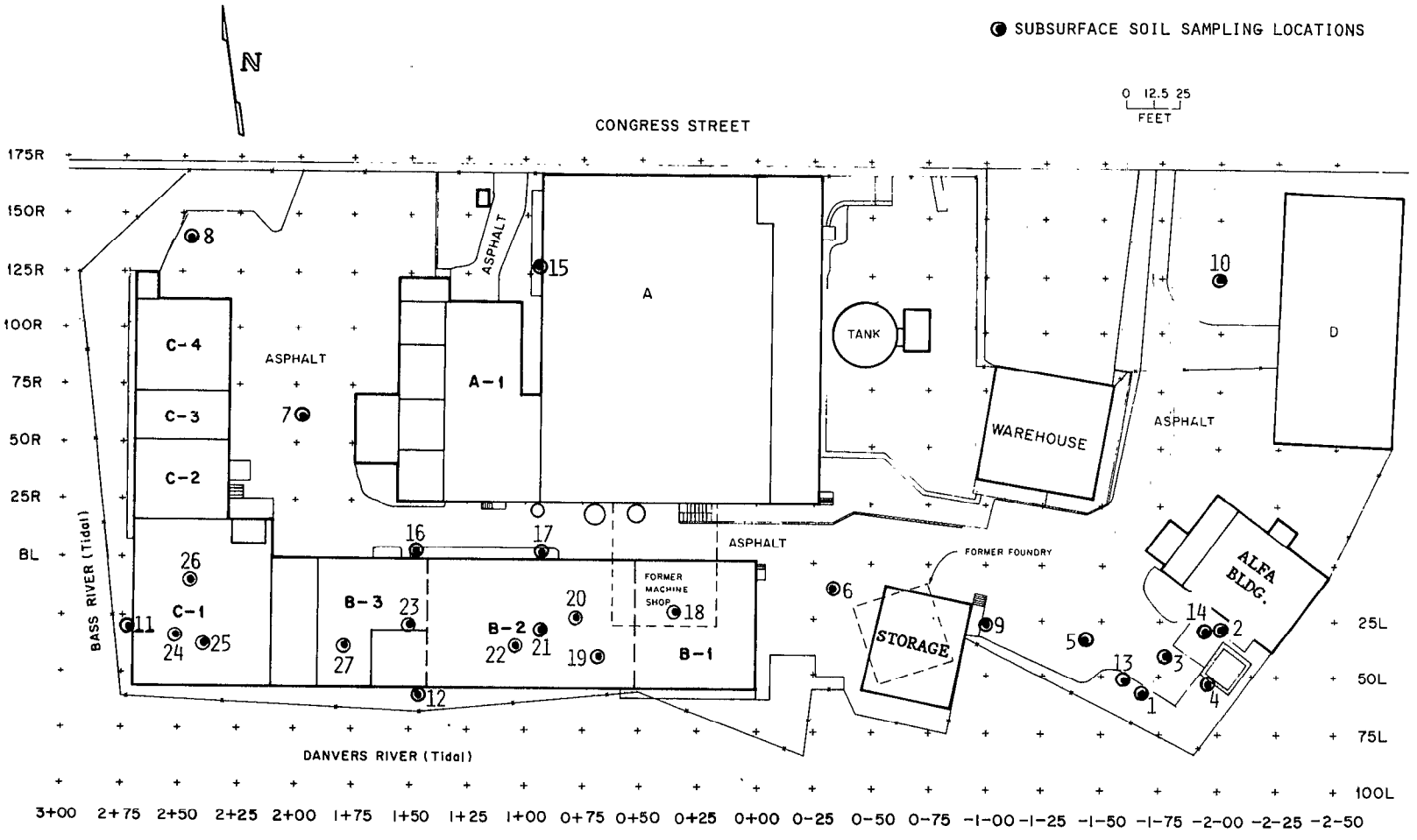



**Fig. 8. Locations of auger holes and subsurface soil samples at the Ventron site.**

**Table 6. Concentration of radionuclides in subsurface soil samples from the Ventron site**

| Hole number | Location[a] | Depth (cm) | Radionuclide concentration (pCi/g) | | |
|---|---|---|---|---|---|
| | | | $^{226}Ra$[b] | $^{232}Th$[c] | $^{238}U$[d] |
| | | *Outdoors* | | | |
| 1 | −1−65, 65L | 0–30 | 0.66 ± 0.07 | 15 | 3.7 |
| 2 | −2−00, 30L | 0–30 | 3.2 ± 0.4 | 12 | 26 |
| 3 | −1−78, 40L | 0–30 | 0.74 ± 0.02 | 1.4 | 6.5 |
| 4 | −1−97, 55L | 0–30 | 3.9 ± 0.1 | 1.2 | 6.3 |
| 5 | −1−40, 33L | 0–30 | 0.84 ± 0.08 | 5.0 | 5.6 |
| 6 | 0+35, 12L | 0–30 | 0.77 ± 0.04 | 0.87 | 1.9 |
| 7 | 1+95, 60R | 0–30 | 0.43 ± 0.06 | 0.42 | 5.4 |
| 8 | 2+42, 137R | 0–30 | 0.87 ± 0.04 | 0.85 | 60 |
| 9 | −1−00, 26L | 0–30 | 0.91 ± 0.3 | 0.74 | 3.1 |
| 10 | −2−00, 125R | 0–30 | 0.77 ± 0.04 | 0.85 | 4.5 |
| 11 | 2+70, 30L | 0–15 | 0.95 ± 0.2 | 1.5 | 88 |
| | | 15–45 | <1 | <0.14 | 590 |
| | | 45–60 | <1 | 46 | 62,000 |
| | | 60–75 | <1 | 6.8 | 5,600 |
| 12 | 1+45, 60L | 0–15 | 30 ± 0.7 | 0.82 | 45 |
| | | 50 | 6.6 ± 1.8 | 2.1 | 12 |
| 13 | −1−60, 55L | 0–20 | 0.92 ± 0.4 | 53 | 7.2 |
| | | 40–80 | 0.72 ± 0.04 | 0.97 | 1.7 |
| | | 80–90 | 0.90 ± 0.2 | 1.9 | 8.1 |
| | | 135–150 | 0.70 ± 0.03 | 0.81 | 4.2 |
| 14 | −1−95, 30L | 0–15 | 1.2 ± 0.05 | 41 | 19 |
| | | 15–45 | 1.6 ± 0.1 | 11 | 34 |
| | | 45–60 | 1.2 ± 0.03 | 7.3 | 12 |
| | | 90–100 | 0.90 ± 0.2 | 2.2 | 9.7 |
| | | 135–165 | 1.1 ± 0.04 | 1.3 | 18 |
| | | 185–195 | 1.0 ± 0.06 | 4.5 | 28 |
| | | 275–305 | 0.87 ± 0.03 | 1.1 | 30 |
| 15 | 0+96, 127R | 0–15 | 1.4 ± 0.1 | 1.2 | 590 |
| | | 15–45 | 1.6 ± 0.08 | 0.90 | 19 |
| | | 45–50 | 0.84 ± 0.07 | 0.89 | 38 |
| 16 | 1+50, 3R | 0–15 | 0.67 ± 0.04 | 0.85 | 3.7 |
| | | 20–25 | 0.74 ± 0.09 | 0.70 | 3.7 |
| 17 | 0+98, 2R | 0–10 | 0.78 ± 0.03 | 0.62 | 3.7 |
| | | 10–20 | 0.64 ± 0.07 | 0.72 | 2.7 |
| | | *Under Buildings* | | | |
| 18 | Bldg. B-1 | 8–18 | <1 | <1 | 460 |
| | | 18–30 | <1 | <1 | 14,000 |
| | | 45–60 | <0.11 | <0.08 | 210 |

**Table 6 (continued)**

| Hole number | Location[a] | Depth (cm) | Radionuclide concentration (pCi/g) | | |
|---|---|---|---|---|---|
| | | | $^{226}Ra$[b] | $^{232}Th$[c] | $^{238}U$[d] |
| | | *Under Buildings* | | | |
| | | 60–85 | <0.08 | <0.05 | 130 |
| | | 85–105 | 0.72 ± 0.05 | 0.90 | 57 |
| | | 105–120 | 0.60 ± 0.07 | 0.72 | 40 |
| | | 120–140 | 0.65 ± 0.07 | 0.70 | 46 |
| | | 140–155 | 0.62 ± 0.06 | 0.73 | 37 |
| 19 | Bldg. B-2 | 10–35 | <1 | <1 | 71,000 |
| | | 35–55 | <1 | <1 | 4,200 |
| | | 55–75 | 4.4 ± 0.4 | 2.0 | 290 |
| | | 75–95 | 3.5 ± 0.1 | 2.2 | 150 |
| | | 95–120 | 5.6 ± 0.2 | 1.8 | 1,500 |
| | | 120–145 | 2.7 ± 0.2 | 1.2 | 72 |
| | | 145–180 | 37 ± 1 | <0.23 | 940 |
| | | 180–215 | 0.37 ± 0 | <0.26 | 850 |
| 20 | Bldg. B-2 | 15–30 | 2.7 ± 0.6 | <1 | 1,900 |
| | | 30–45 | 4.7 ± 0.1 | 1.4 | 170 |
| | | 45–65 | 2.8 ± 0.2 | 1.7 | 39 |
| | | 115–125 | 1.0 ± 0.06 | 0.94 | 35 |
| | | 125–140 | 0.60 ± 0.03 | 0.60 | 16 |
| | | 140–155 | 0.61 ± 0.03 | 0.58 | 13 |
| 21 | Bldg. B-2 | 8–25 | 1.2 ± 20 | 1.2 | 440 |
| | | 25–45 | 0.84 ± 0.1 | 1.8 | 76 |
| 22 | Bldg. B-2 | 8–30 | 1.2 ± 0.08 | 0.97 | 90 |
| 23 | Bldg. B-3 | 45–95 | 1.0 ± 0.7 | 0.40 | 10 |
| | | 95–115 | 0.92 ± 0.04 | 0.80 | 7.1 |
| | | 115–140 | 0.40 ± 0.08 | 0.67 | 1.9 |
| | | 140–170 | 1.3 ± 0.09 | 1.2 | 7.6 |
| 24 | Bldg. C-1 | 8–35 | <1 | <1 | 540 |
| | | 35–65 | 2.0 ± 1 | 2.2 | 1,400 |
| | | 65–85 | 0.66 ± 0.2 | 0.74 | 110 |
| | | 85–110 | 1.5 ± 0.09 | 1.7 | 82 |
| | | 110–135 | 3.0 ± 0.1 | 3.1 | 56 |
| | | 135–155 | 2.1 ± 6 | 2.4 | 29 |
| | | 155–180 | 2.5 ± 0.07 | 2.7 | 48 |
| | | 180–205 | 2.5 ± 0.07 | 3.3 | 35 |
| 25 | Bldg. C-1 | 15–30 | <0.08 | 0.98 | 54 |
| | | 85–110 | 0.70 ± 0.1 | <1 | 460 |
| | | 110–135 | 2.3 ± 0.3 | 2.3 | 150 |
| | | 135–155 | 1.3 ± 0.2 | 1.2 | 130 |
| | | 155–180 | 3.4 ± 1 | 3.1 | 940 |
| | | 180–195 | 0.75 ± 0.05 | 0.64 | 810 |
| | | 195–215 | 0.62 ± 0.19 | 0.79 | 130 |

**Table 6 (continued)**

| Hole number | Location[a] | Depth (cm) | Radionuclide concentration (pCi/g) | | |
|---|---|---|---|---|---|
| | | | $^{226}Ra$[b] | $^{232}Th$[c] | $^{238}U$[d] |
| | | *Under Buildings* | | | |
| 26 | Bldg. C-1 | 10–35 | 0.82 ± 0.06 | 1.0 | 34 |
| | | 35–60 | 0.98 ± 0.06 | 0.88 | 24 |
| | | 60–85 | 0.68 ± 0.06 | 0.88 | 15 |
| | | 85–105 | 2.3 ± 0.06 | 2.5 | 6.6 |
| | | 105–130 | 2.7 ± 0.1 | 2.5 | 22 |
| | | 130–150 | 2.2 ± 0.09 | 2.5 | 72 |
| | | 150–175 | 2.1 ± 0.1 | 2.2 | 65 |
| | | 175–195 | 2.3 ± 0.45 | 2.2 | 49 |
| | | 195–245 | 0.77 ± 0.1 | <1 | 36 |
| 27 | Bldg. B-3 | 8–35 | 0.66 ± 0.03 | 0.69 | 5.3 |
| | | 35–55 | 1.1 ± 0.12 | 0.9 | 17 |
| | | 55–75 | 0.56 ± 0.05 | 0.67 | 16 |
| | | 75–100 | 0.60 ± 0.06 | 0.75 | 1.8 |
| | | 100–145 | 0.54 ± 0.06 | 0.67 | 5.6 |

[a]Locations of soil samples are shown on Fig. 8.

[b]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).

[c]The error of the reported radionuclide concentration is ± 5% (95% confidence level).

[d]Total analytical error of measurement results is less than ± 5% (95% confidence level).

ORNL-DWG 86-12865

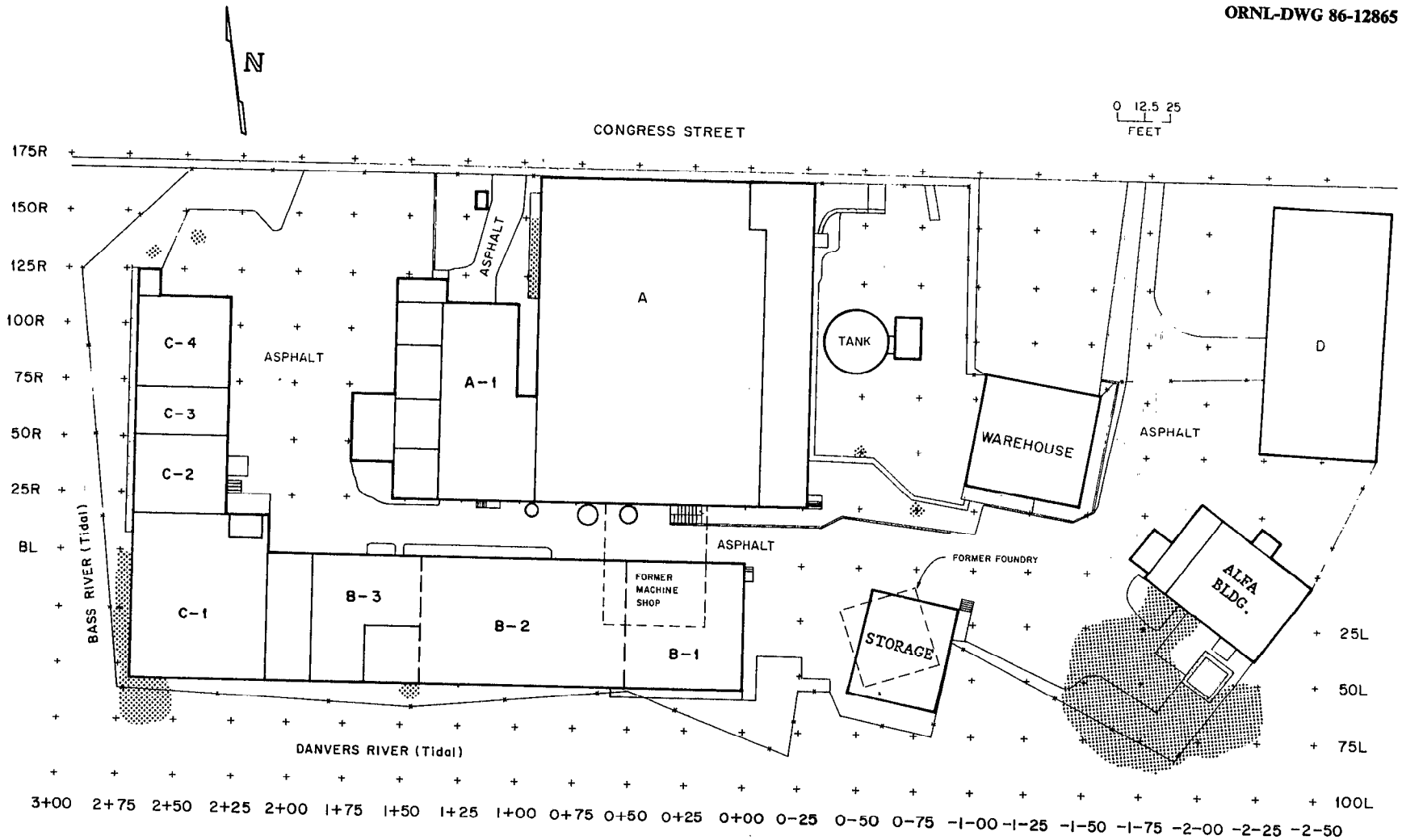



**Fig. 9. Contaminated regions outdoors at the Ventron site as indicated by soil sample analyses.**

**Table 7. Extent of subsurface contamination at the Ventron site as indicated by scintillation probe loggings and soil sample analyses**

| Hole | Location[a] | Depth of hole (m) | Estimated vertical extent of contaminated soil[b] (m) | Region of maximum contamination (m) | Radionuclide concentration in region of maximum contamination (pCi/g) | | |
|---|---|---|---|---|---|---|---|
| | | | | | $^{226}$Ra[c] | $^{232}$Th[d] | $^{238}$U[e] |
| 1 | −1−65, 65L | 2.6 | 0–2.6 | 0–0.3 | 0.66 ± 0.07 | 15 | 3.7 |
| 2 | −2−00, 30L | 3.4 | 0–3.4 | 0–0.15 | 3.2 ± 0.4 | 12 | 26 |
| 3 | −1−78, 40L | 3.4 | f | f | 0.74 ± 0.02 | 1.4 | 6.5 |
| 4 | −1−97, 55L | 3.5 | 0–3.5 | 1.1–1.3 | Not Sampled | | |
| 5 | −1−40, 33L | 2.3 | 0–2.3 | 0–0.3 | 0.84 ± 0.08 | 5 | 5.6 |
| 6 | 0+35, 12L | 2.4 | f | f | 0.77 ± 0.04 | 0.87 | 1.9 |
| 7 | 1+95, 60R | 0.76 | f | f | 0.43 ± 0.06 | 0.42 | 5.4 |
| 8 | 2+42, 137R | 3.2 | 0–3.2 | 0–0.3 | 0.87 ± 0.04 | 0.85 | 60 |
| 9 | −1−00, 26L | 2.6 | f | f | 0.91 ± 0.3 | 0.74 | 3.1 |
| 10 | −2−00, 125R | 1.4 | f | f | 0.77 ± 0.04 | 0.85 | 4.5 |
| 11 | 2+70, 30L | 0.75 | 0–0.75 | 0.45–0.6 | <1 | 46 | 62,000 |
| 12 | 1+45, 60L | 0.51 | 0–0.51 | 0–0.15 | 30 ± 0.7 | 0.82 | 45 |
| 13 | −1−60, 55L | 2.3 | 0–0.3 | 0–0.2 | 0.92 ± 0.4 | 53 | 8.1 |
| 14 | −1−95, 30L | 3.05 | 0–0.3 | 0–0.15 | 1.2 ± 0.05 | 41 | 30 |
| 15 | 0+96, 127R | 0.50 | 0–0.5 | 0.15–0.45 | 1.4 ± 0.1 | 1.2 | 590 |
| 16 | 1+50, 3R | 0.25 | f | f | 0.74 ± 0.09 | 0.70 | 3.7 |
| 17 | 0+98, 2R | 0.20 | f | f | 0.78 ± 0.03 | 0.62 | 3.7 |
| 18 | Bldg. B-1 | 1.6 | 0–0.91 | 0.18–0.3 | <1 | <1 | 14,000 |
| 19 | Bldg. B-2 | 2.2 | 0–2.2 | 0.10–0.35 | <1 | <1 | 71,000 |
| 20 | Bldg. B-2 | 1.6 | 0–0.76 | 0.15–0.3 | 2.7 ± 0.6 | <1 | 1,900 |
| 21 | Bldg. B-2 | 0.61 | 0–0.61 | 0.08–0.25 | 1.2 ± 20 | 1.2 | 440 |
| 22 | Bldg. B-2 | 0.3 | 0–0.3 | 0.08–0.3 | 1.2 ± 0.08 | 0.97 | 90 |
| 23 | Bldg. B-3 | 1.7 | f | f | 1.0 ± 0.07 | 0.40 | 10 |
| 24 | Bldg. C-1 | 2.1 | 0–2.1 | 0.35–0.65 | 2.0 ± 1 | 2.2 | 1,400 |
| 25 | Bldg. C-1 | 2.2 | 0.3–2.2 | 1.6–1.8 | 3.4 ± 1 | 3.1 | 940 |
| 26 | Bldg. C-1 | 2.5 | 0.76–2.5 | 1.3–2.0 | 2.2 ± 0.09 | 2.5 | 72 |
| 27 | Bldg. B-3 | 1.5 | f | f | 1.1 ± 0.12 | 0.9 | 17 |

[a]Location shown on Fig. 8.

[b]Contaminated soil is defined as soil having concentrations of $^{226}$Ra or $^{232}$Th ⩾ than the criteria given in Table 2, or giving rise to 1000 cpm or more on the shielded scintillator.

[c]Indicated counting error is at the 95% confidence level (± 2 $\alpha$).

[d]The error of the reported radionuclide concentration is ± 5% (95% confidence level).

[e]The total analytical error is ± 5% (95% confidence level).

[f]No measurement above criteria given in [b] above.

The gamma logging data and the soil sample analyses results were used to estimate the depth of contamination in the bore holes (Table 7). Contamination beneath the basement floors of Buildings B-1, B-2, and C-1 extends to 2.5 m. In the southeast portion of the site (holes 2 and 4), the depth of contamination appears to be >3 m.

### 3.1.4 Sediment Samples

Sediment samples were taken from three of the four storm sewer manholes located as shown on Fig. 10. Table 8 lists the concentrations of $^{226}$Ra, $^{232}$Th, and $^{238}$U found in those samples. Radionuclide analysis of the sediment samples indicated $^{226}$Ra concentrations exceeded 5 pCi/g in all three samples and $^{232}$Th was as high as 21 pCi/g in one sample (the other two were equal to background).

## 3.2 INDOOR SURVEY RESULTS

Surface contamination levels measured on the site are compared in this report with DOE guidelines for release of property for unrestricted use. The major contaminant on the Beverly site is $^{238}$U. DOE guidelines specify that average and maximum direct alpha measurements of uranium and natural uranium (uranium in equilibrium with its decay products) should not exceed 5000 and 15,000 dpm/100 cm$^2$, respectively, and transferable alpha should not exceed 1000 dpm/100 cm$^2$. Records and survey data also indicate $^{232}$Th was used at this site. Average and maximum surface contamination limits for $^{232}$Th are 1000 and 3000 dpm/100 cm$^2$, respectively, and 200 dpm/100 cm$^2$ for transferable alpha. Furthermore, average and maximum beta-gamma dose rates for all radionuclides should not exceed 0.20 mrad/h and 1.0 mrad/h, respectively. Unless otherwise stated, beta-gamma dose rates between 0.20 mrad/h and 1.0 mrad/h reported in this document are average measurements over an area of not more than 1 m$^2$ and are considered to be above DOE guidelines.

Whenever feasible, data from the indoor survey are displayed in figures rather than tables. Where grid blocks are shown in a figure, it should be assumed that measurements were taken in each survey block as described in Sect. 2.2, unless stated otherwise in the text. The absence of data for a particular type of measurement in a grid block or other defined area on any given figure should be interpreted as meaning that that particular measurement was below guidelines. Blocks which were completely inaccessible are labeled as such. The following notation is used in many of the figures in this report:

$d\alpha$ = direct alpha measurements in dpm/100 cm$^2$,

$d\beta$-$\gamma$ = directly measured beta-gamma dose rates in mrad/h measured at 1 cm distance from surfaces,

$t\alpha$ = transferable alpha contamination level in dpm/100 cm$^2$,

$t\beta$ = transferable contamination level in dpm/100 cm$^2$,

$\gamma$ = gamma radiation level at the surface in $\mu$R/h.

ORNL-DWG 86-12866

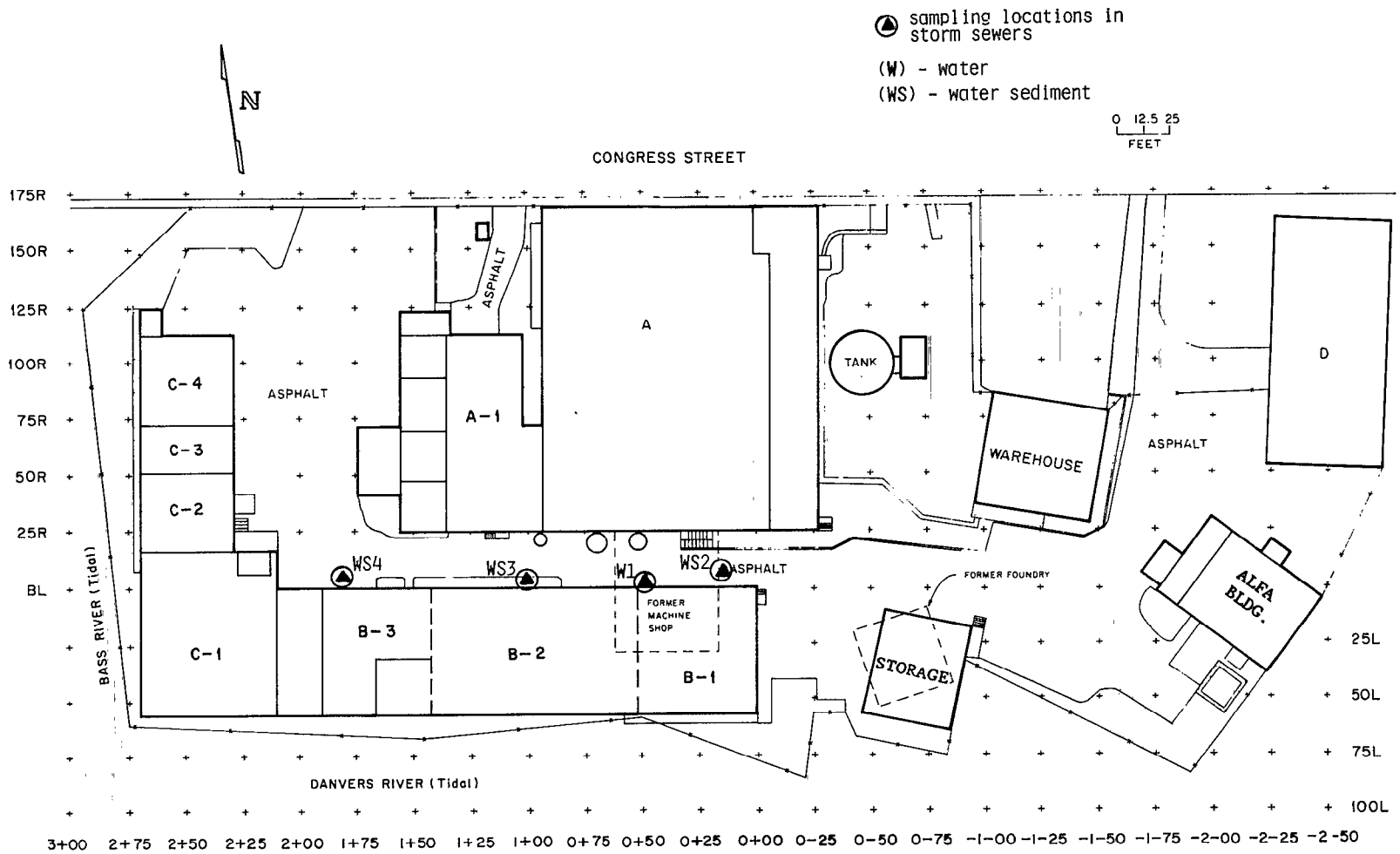



**Fig. 10. Locations of sediment samples taken from storm sewers at the Ventron site.**

**Table 8. Concentration of radionuclides in sediment samples from storm sewers at the Ventron site**

| Sample number | Location[a] | Radionuclide concentration (pCi/g) | | |
|---|---|---|---|---|
| | | $^{226}Ra$[b] | $^{232}Th$[b] | $^{238}U$[c] |
| 1 | No sample taken | | | |
| 2 | 0+10, 10R | 100 ± 3 | <1 | 1.5 |
| 3 | 1+00, 6R | 13 ± 0.31 | 0.9 ± 0.05 | 25 |
| 4 | 1+80, 6R | 7.4 ± 0.28 | 21 ± 0.28 | 1.2 |

[a]Locations of samples are shown on Fig. 10.
[b]Indicated counting error is at the 95% confidence level ($\pm$ 2 $\sigma$).
[c]Total analytical error of measurement results is less than ± 5% (95% confidence level).

Any small oval, circular, or rectangular area shown on the figures and associated with an elevated measurement is intended only as a first approximation of the extent of the contaminated area and is not drawn to scale.

### 3.2.1 Building A

Building A was used for uranium processing activities and contains one main floor and a basement. On the first floor were offices and laboratories on the east side of the building, with shipping and receiving areas in the northwest quadrant. Some of the rooms had been converted from processing areas to office rooms by the addition of dropped ceilings, finished walls, etc. Processing activities were being carried out in the remainder of the first level. Figure 11 shows the layout of the entire building.

Gamma exposure rates measured near the center of grid blocks and during the scan of grid blocks in the building and on the roof are given in Table 9, averaged by room, grid block, or type of structure. Exposure rates in first floor and basement rooms ranged from 7 to 52 $\mu$R/h during the scan of accessible areas and averaged 12 $\mu$R/h both at 1 m above the surface and at the surface near the center points of grid blocks. Gamma levels in overhead regions ranged from 13 to 78 $\mu$R/h and were 7 to 160 $\mu$R/h on the roof.

Alpha and beta-gamma measurements taken inside the building and on the roof are listed by location in Table 10. Numerous regions in which levels were higher than the average for the same survey block were observed in rooms 20 and 29 where processing activities would be expected to result in residual contamination. By comparison, little contamination was detected during the grid block survey of other first floor rooms. However, measurements approaching and exceeding DOE guidelines were noted in several areas, including overhead regions, as indicated in Fig. 11 and associated Tables. The areas designated by lowercase letters (a through e) indicate locations of contamination on floors and/or lower walls. An area under a weighing table in room 19 gave a direct alpha measurement of 2500 dpm/100 cm$^2$. Two areas in room 27, one in the northeast corner and the other at the floor/wall interface at the south wall, had associated beta-gamma dose rates of 0.3 mrad/h. Finally, gamma exposure rates were 26 to 32 $\mu$R/h at the locations indicated in room 28.

Table 11 lists the radiological measurements taken in 13 regions of the floor drain troughs. The locations of the measurements are exhibited on Fig. 11. Surface contamination in the troughs was evidenced by direct alpha activities ranging to 2000 dpm/100 cm$^2$. Furthermore, beta-gamma dose rates were 0.2 mrad/h and higher in four of the trough regions. The maximum beta-gamma dose rate measured was 1.7 mrad/h.

The level of contamination in overhead regions in rooms other than 20 and 29 is indicated by the data given in Table 12. Beta-gamma dose rates of 0.01 to 1 mrad/h were found in association with alpha activities ranging from 40 to 350 dpm/100 cm$^2$. Gamma exposure rates were also elevated in several of the regions, ranging from 13 to 78 $\mu$R/h. Transferable alpha and beta-gamma contamination in one area in room 30 measured 52 and 122 dpm/100 cm$^2$, respectively (below the thorium limit). All other measurements of transferable contamination in overhead regions were lower. Most of the elevated gamma readings found in room 28 were due to contamination on the roof above.

**Table 9. Gamma exposure rate measurements in Building A at the Ventron site**

| Location[a] | Center point measurements[b] (μR/h) | | Range of gamma exposure rates from scan of grid blocks[c] (μR/h) | Average gamma exposure rate from scan of grid blocks[c] (μR/h) |
|---|---|---|---|---|
| | Average gamma exposure rate at 1 m | Average gamma exposure rate at the surface | | |
| *First level* | | | | |
| Room 1 | 10 | 10 | 9–11 | 10 |
| 2 | 12 | 12 | 8–15 | 12 |
| 3 | 14 | 15 | 12–19 | 16 |
| 4 | 12 | 12 | 10–14 | 12 |
| 5 | 9 | 10 | 7–12 | 10 |
| 6 | 8 | 8 | 7–10 | 8 |
| 7 | 15 | 15 | 12–17 | 14 |
| 8 | 15 | 13 | 12–15 | 14 |
| 9 | 11 | 11 | 10–14 | 12 |
| 10 | 12 | 12 | 10–15 | 13 |
| 11 | 11 | 12 | 12–17 | 14 |
| 12 | 15 | 15 | 12–16 | 14 |
| 13 | 11 | 11 | 10–13 | 11 |
| 14 | 9 | 10 | 7–11 | 9 |
| 15 | 10 | 11 | 7–11 | 10 |
| 16 | 12 | 12 | 11–14 | 12 |
| 17 | 12 | 12 | 10–15 | 13 |
| 18 | 13 | 13 | 11–15 | 13 |
| 19 | 12 | 12 | 10–14 | 12 |
| 20 | 12 | 12 | 7–52 | 12 |
| 21 | 10 | 11 | 10–12 | 11 |
| 22 | 10 | 10 | 10–12 | 10 |
| 23 | 11 | 12 | 11–15 | 12 |
| 24 | 11 | 12 | 12–14 | 13 |
| 25 | 17 | 16 | 10–17 | 19 |
| 26 | 17 | 13 | 12–19 | 14 |
| 27 | 16 | 16 | 12–19 | 20 |
| 28 | 21 | 17 | 10–32 | 19 |
| 29 | 14 | 16 | 11–32 | 16 |
| 30 | 10 | 10 | 7–17 | 10 |
| 31 | 13 | 13 | 12–15 | 14 |
| 32 | 10 | 11 | 8–14 | 11 |
| 33 | 11 | 12 | 7–15 | 11 |
| 34 | 8 | 10 | 8–11 | 9 |
| 35 | 11 | 11 | 11–17 | 13 |
| 36 | 10 | 12 | 8–14 | 11 |
| 37 | 12 | 12 | 10–14 | 12 |

**Table 9 (continued)**

| Location[a] | Center point measurements[b] (μR/h) | | Range of gamma exposure rates from scan of grid blocks[c] (μR/h) | Average gamma exposure rate from scan of grid blocks[c] (μR/h) |
|---|---|---|---|---|
| | Average gamma exposure rate at 1 m | Average gamma exposure rate at the surface | | |
| *Overhead* | | | | |
| Room 20 | d | d | 13–52 | 23 |
| 28 | d | d | 13–78 | 52 |
| 30 | d | d | – | 50 |
| *Basement* | | | | |
| Room 1 | 11 | 12 | 7–15 | 11 |
| 2 | 9 | 10 | 7–13 | 10 |
| 3 | 10 | 10 | 7–45 | 10 |
| *Roof* | | | | |
| Grid block A | d | d | 7–160 | 30 |
| B | d | d | 7–130 | 13 |
| C | d | d | 7–13 | 9 |
| D | d | d | 6–12 | 8 |
| E | d | d | 5–17 | 8 |
| Fan duct 37 | d | d | – | 36 |
| Wall vents | d | d | 11–15 | 14 |
| Hooded vent 33 | d | d | – | 36 |

[a]Location shown on Figs. 11, 19, and 22.
[b]Center point measurements are discrete measurements near the center of each grid block.
[c]Grid block measurements are obtained by a scan of the entire block.
[d]No measurement taken.

**Table 10. Alpha and beta-gamma measurements in Building A at the Ventron site**

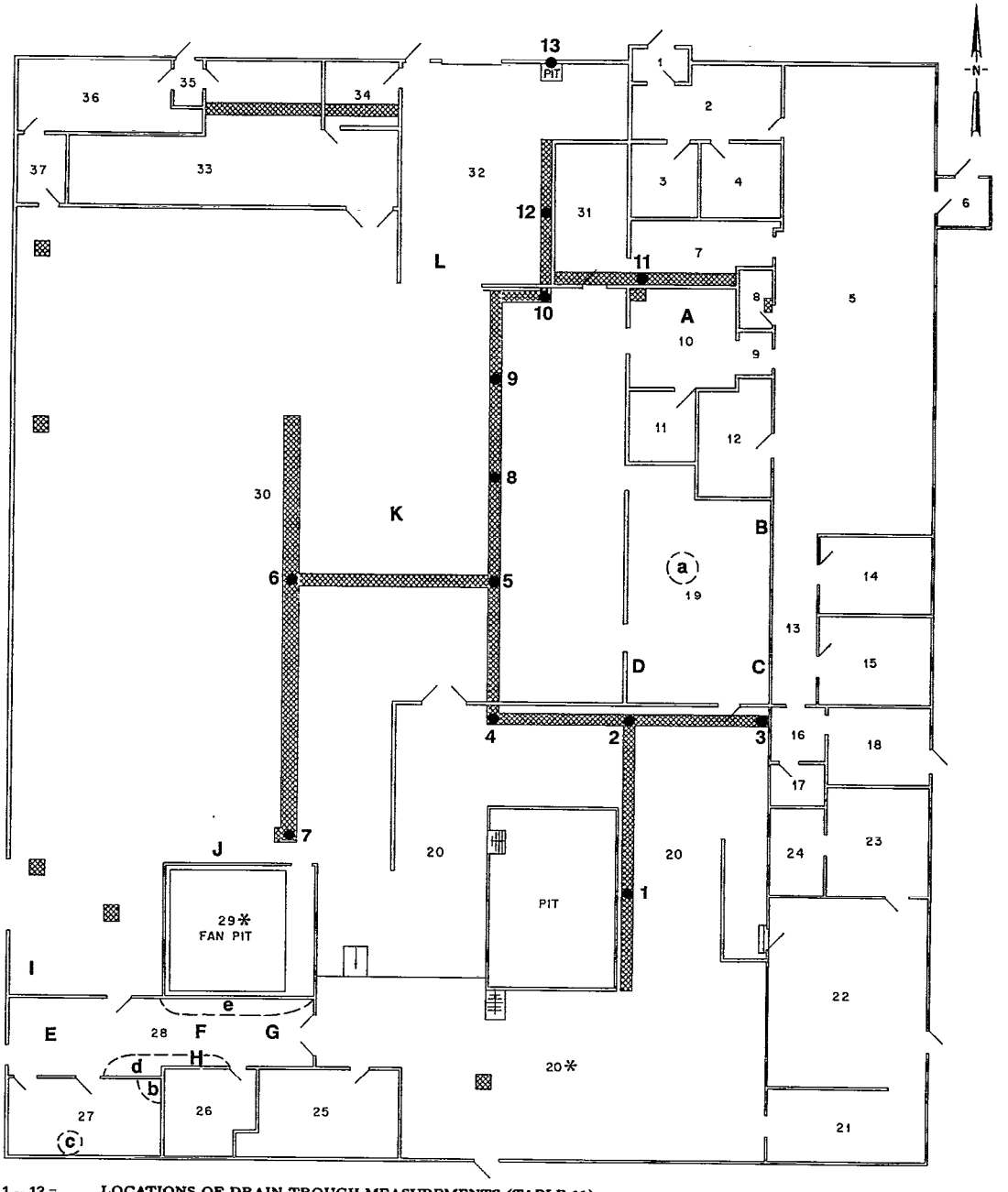
| Location[a] | Directly measured contamination | | | | Transferable contamination | | | |
|---|---|---|---|---|---|---|---|---|
| | Alpha (dpm/100 cm²) | | Beta-gamma dose rate at 1 cm (mrad/h) | | Alpha (dpm/100 cm²) | | Beta-gamma (dpm/100 cm²) | |
| | Average | Range | Average | Range | Average | Range | Average | Range |
| *First level* | | | | | | | | |
| Room 1 | 20 | 0–40 | 0.02 | – | b | b | b | b |
| 2 | 20 | 0–40 | 0.01 | – | c | – | c | – |
| 3 | 20 | 0–40 | 0.01 | – | b | b | b | b |
| 4 | 30 | 0–40 | 0.02 | – | b | b | b | b |
| 5 | 20 | 0–40 | 0.02 | – | b | b | b | b |
| 6 | 20 | 0–40 | 0.02 | – | b | b | b | b |
| 7 | 30 | 20–40 | 0.02 | – | b | b | b | b |
| 8 | 20 | 0–40 | 0.02 | – | b | b | b | b |
| 9 | 10 | 0–20 | 0.02 | – | b | b | b | b |
| 10 | 10 | 0–20 | 0.02 | – | c | – | c | – |
| 11 | 10 | 0–40 | 0.03 | – | c | – | 82 | – |
| 12 | 30 | 20–60 | 0.02 | – | b | b | b | b |
| 13 | 30 | 20–40 | 0.02 | 0.01–0.02 | b | b | b | b |
| 14 | 30 | 20–40 | 0.01 | – | b | b | b | b |
| 15 | 20 | 0–40 | 0.01 | – | b | b | b | b |
| 16 | 20 | 0–40 | 0.01 | – | b | b | b | b |
| 17 | 20 | 0–40 | 0.01 | – | b | b | b | b |
| 18 | 10 | 0–20 | 0.02 | – | c | – | 27 | – |
| 19 | 370 | 0–2,500 | 0.02 | – | 3 | – | c | – |
| 20 | 270 | 0–4,200 | 0.56 | 0.02–3 | c | – | c | – |
| 21 | 30 | 0–40 | 0.02 | – | c | – | c | – |
| 22 | <10 | 0–20 | 0.02 | 0.01–0.02 | c | – | c | – |
| 23 | 10 | 0–20 | 0.02 | – | b | b | b | b |
| 24 | 0 | 0–0 | 0.01 | – | b | b | b | b |
| 25 | 20 | 0–40 | 0.03 | 0.02–0.03 | c | – | 41 | – |
| 26 | 40 | – | 0.03 | – | b | b | b | b |
| 27 | 20 | 0–20 | 0.19 | 0.05–0.3 | b | b | b | b |
| 28 | 40 | 0–80 | 0.03 | 0.20–0.05 | c | – | 41 | 0–82 |
| 29 | 380 | 40–760 | 0.46 | 0.03–1.5 | c | – | c | – |
| 30 | <97 | 0–2,900 | 0.03 | 0.01–0.25 | b | b | b | b |
| 31 | 20 | 0–40 | 0.01 | – | b | b | b | b |
| 32 | 30 | 20–40 | 0.02 | 0.01–0.02 | c | – | 95 | – |
| 33 | 30 | 0–60 | 0.02 | 0.02–0.02 | c | – | 54 | – |
| 34 | 30 | 20–40 | 0.01 | – | b | b | b | b |
| 35 | 30 | 20–40 | 0.02 | – | b | b | b | b |
| 36 | 30 | 20–40 | 0.02 | – | b | b | b | b |
| 37 | 20 | 0–40 | 0.03 | – | b | b | b | b |

**Table 10 (continued)**

| Location[a] | Directly measured contamination | | | | Transferable contamination | | | |
|---|---|---|---|---|---|---|---|---|
| | Alpha (dpm/100 cm$^2$) | | Beta-gamma dose rate at 1 cm (mrad/h) | | Alpha (dpm/100 cm$^2$) | | Beta-gamma (dpm/100 cm$^2$) | |
| | Average | Range | Average | Range | Average | Range | Average | Range |
| *Overhead* | | | | | | | | |
| Room 10 | 300 | – | 0.02 | – | 3 | – | 68 | – |
| 11 | 10 | – | 0.02 | – | b | b | b | b |
| 12 | 10 | – | 0.02 | – | b | b | b | b |
| 19 | 130 | 60–210 | 0.14 | 0.05–0.3 | b | b | b | b |
| 20 | 10 | 0–110 | 0.3 | 0.02–2 | b | b | b | b |
| 28 | 130 | 40–280 | 0.13 | 0.01–0.2 | b | b | b | b |
| 29 | 580 | 100–760 | 0.26 | 0.01–0.85 | b | b | b | b |
| 30 | 70 | 0–350 | 0.19 | 0.01–1.3 | 52 | – | 122 | – |
| 32 | 30 | 0–120 | 0.05 | 0.01–0.15 | c | c | c | c |
| *Basement* | | | | | | | | |
| Room 1 | 50 | 0–200 | 0.21 | 0.02–1.9 | b | b | b | b |
| 2 | 100 | 40–570 | 0.26 | 0.01–1.3 | b | b | b | b |
| 3 | 80 | 0–280 | 0.06 | 0.02–0.3 | b | b | b | b |
| *Roof* | | | | | | | | |
| Grid block A | 350 | 0–700 | 0.17 | 0.05–0.32 | b | b | b | b |
| B | c | c | 0.06 | 0.02–0.22 | c | c | b | b |
| C | c | c | 0.02 | – | b | b | b | b |
| D | b | b | 0.02 | | c | c | b | b |
| Fan duct | 150 | | 5 | – | c | c | c | c |
| Wall vents | 400 | 0–1,600 | 0.13 | 0.01–0.75 | b | b | b | b |
| Hooded vents | 7,500 | 4,900–10,000 | 1.1 | 0.01–2.2 | c | c | c | c |

[a]Location shown on Figs. 11, 19, and 22.
[b]No measurement taken.
[c]Measurement could not be distinguished from background.

ORNL-DWG 86-12765




1 – 13 = LOCATIONS OF DRAIN TROUGH MEASUREMENTS (TABLE 11).
A – L = CONTAMINATED AREAS IN OVERHEAD REGIONS (TABLE 12).
(a) – (e) = CONTAMINATED AREAS DISCUSSED IN TEXT.
* = FIGS. 14 AND 15 SHOW CONTAMINATED REGIONS IN ROOMS 20 AND 29.

BUILDING "A" FIRST FLOOR

0 8
SCALE FT.

TREADPLATE COVERS OVER DRAIN TROUGHS AND CRAWL SPACE ACCESS

**Fig. 11. Location of contaminated areas on the first level of Building A at the Ventron site.**

**Table 11. Alpha, beta-gamma, and gamma measurements in drain troughs in Building A at the Ventron site**

| Room/ Location[a] | Average direct alpha activity on surface (dpm/100 $cm^2$) | Beta-gamma dose rate at 1 cm above surface (mrad/hr) | Average gamma exposure rate ($\mu$R/h) |
|---|---|---|---|
| 20/1 | 2000 | 1.7 | 26 |
| 20/2 | 130 | 0.1 | 45 |
| 20/3 | 600 | 0.2 | 15 |
| 20/4 | [b] | 0.05 | 16 |
| 30/5 | [b] | 0.02 | 10 |
| 30/6 | [b] | 0.01 | 7 |
| 30/7 | [b] | 0.01 | 10 |
| 30/8 | [b] | 0.03 | 10 |
| 30/9 | 1600 | 0.25 | 12 |
| 30/10 | 320 | 0.05 | 14 |
| 7/11 | 800 | 0.06 | 12 |
| 32/12 | 1500 | 0.3 | 14 |
| 32/13 | 500 | 0.05 | 14 |

[a]Location indicated on Fig. 11.
[b]Measurements could not be distinguished from background.

**Table 12. Alpha, beta-gamma, and gamma measurements in contaminated areas of overhead regions of Building A at the Ventron site**

| Room/ location[a] | Directly measured contamination | | Average gamma reading from scan ($\mu$R/h) |
|---|---|---|---|
| | Alpha (dpm/100 cm$^2$) | Beta-gamma dose rate at 1 cm from surface (mrad/h) | |
| 10/A[b] | 300 | 0.02 | c |
| 19/B | 210 | 0.05 | c |
| 19/C | 120 | 0.07 | c |
| 19/D | 60 | 0.3 | c |
| 28/E | 280 | 0.01 | 13 |
| 28/F | 80 | 0.17 | 78 |
| 28/G | 40 | 0.2 | 65 |
| 28/H | c | c | 77 |
| 30/I | 250 | 0.6 | 50 |
| 30/J[d] | 350 | 1 | c |
| 30/K | 100 | 0.01 | c |
| 32/L | 120 | 0.2 | c |

[a]Location shown on Fig. 11.

[b]This area showed transferable alpha and beta-gamma contamination levels of 3 and 68 dpm/100 cm$^2$, respectively.

[c]Measurement could not be distinguished from background.

[d]This area showed transferable alpha and beta-gamma contamination levels of 52 and 120 dpm/100 cm$^2$, respectively.

In room 20, crushing, leaching, and retorting processes were carried out. A view of the base of the rotary kiln above the acid leaching pit is provided in Fig. 12. Another photograph taken from the pit shows the raised wooden roof above (Fig. 13). The regions where radiological measurements exceeded DOE guidelines or where alpha measurements exceeded 100 dpm/100 $cm^2$ (10% of the thorium limit) are identified on Fig. 14. Surface contamination exceeding guidelines was found on walls, floors, and overhead surfaces in this room. Beta-gamma dose rates ranged from 0.02 to 3 mrad/h, with the maximum occurring near a large piece of machinery located in the acid leach pit. Direct alpha measurements in the pit averaged 280 dpm/100 $cm^2$ with a maximum of 380 dpm/100 $cm^2$ in the center of the pit's north wall. Gamma radiation levels ranged from 20 to 31 $\mu$R/h on the walls and floor of the pit.

The maximum level of alpha contamination noted in room 20 was 4200 dpm/100 $cm^2$ and was found in the northwest corner of survey block D4 near the drain trough. At the same point, the beta-gamma dose rate was 1.7 mrad/h. A crack in the floor outside the northeast corner of the pit gave a beta-gamma dose rate of 0.6 mrad/h. Elevated beta-gamma dose rates ranging from 0.2 to 0.75 mrad/h were observed on top of, and inside, a shed located northwest of the pit and housing a rotary crusher. At the rotary kiln and surrounding gear above the pit, beta-gamma dose rates were 1.0 to 2.0 mrad/h. A fan overhead in the southeast corner of the pit gave a beta-gamma dose rate of 0.5 mrad/h. The alpha contamination levels overhead were generally 100 to 110 dpm/100 $cm^2$. Beta-gamma exposure rates overhead ranged to 2.0 mrad/h, and gamma radiation levels were 10 to 52 $\mu$R/h. Elevated gamma radiation levels measured overhead were increased significantly by secondary radiation from roof contamination.

The floor and walls of room 29, the fan pit, were divided into survey blocks as indicated on Fig. 15. Figure 16 is a view of the pit showing the process exhaust fan. A view looking above at the large fan duct and raised roof area is provided in Fig. 17. As indicated on the drawing in Fig. 15, there are a number of contaminated regions with measurements exceeding DOE guidelines. The maximum beta-gamma dose rate was 1.5 mrad/h with six measurements ranging between 0.2 and 1.5 mrad/h. In grid block B4' a variety of "hot spots" and miscellaneous structural cracks displayed beta-gamma contamination levels above guidelines. Gamma exposure rates were also elevated, ranging from 11 to 58 $\mu$R/h. Alpha activities ranging from 100 to 760 dpm/100 $cm^2$ were found by direct reading on the walls, windows, and overhead surfaces of the pit.

In room 30, white powder covering areas of the kilns (Fig. 18) displayed alpha activities ranging from 60 to 2700 dpm/100 $cm^2$. The surrounding surfaces of the bowls in the kilns read an average of 900 dpm/100 $cm^2$ with a maximum of 2900 dpm/100 $cm^2$. The beta-gamma dose rates averaged 0.25 mrad/h. At the time of the survey, the powder was being used in an ongoing commercial process.

Gamma measurements ranged from 5 to 160 $\mu$R/h on the roof of Building A. The locations of the grid blocks are shown on Fig. 19, and Table 13 details the level of contamination. Surface contamination was evident in scattered locations over the roof as well as in association with fan and vent structures as indicated. Residual contamination would be expected on these structures through which fumes and dust from the processing activities would have exited. In general, gamma exposure rates increased from northeast to

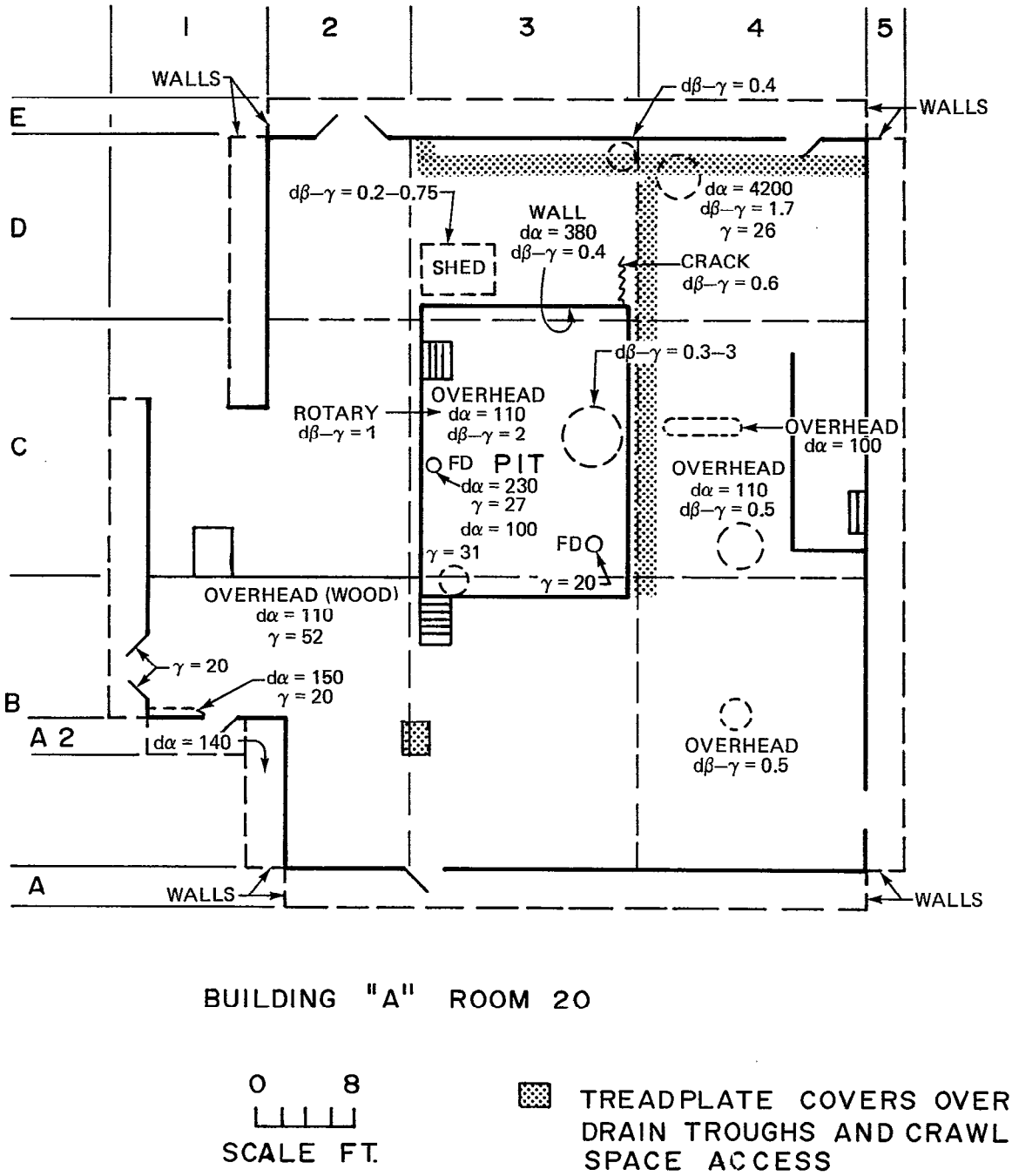
ORNL-PHOTO 3267-86

**Fig. 12. View of rotary kiln in room 20, Building A, at the Ventron site.**

ORNL-PHOTO 3268-86

**Fig. 13. View of region above pit in room 20, Building A, at the Ventron site.**

ORNL-DWG 86-12767




BUILDING "A" ROOM 20

0 8
SCALE FT.

TREADPLATE COVERS OVER DRAIN TROUGHS AND CRAWL SPACE ACCESS

**Fig. 14. Location of contaminated areas in room 20, Building A, at the Ventron site.**

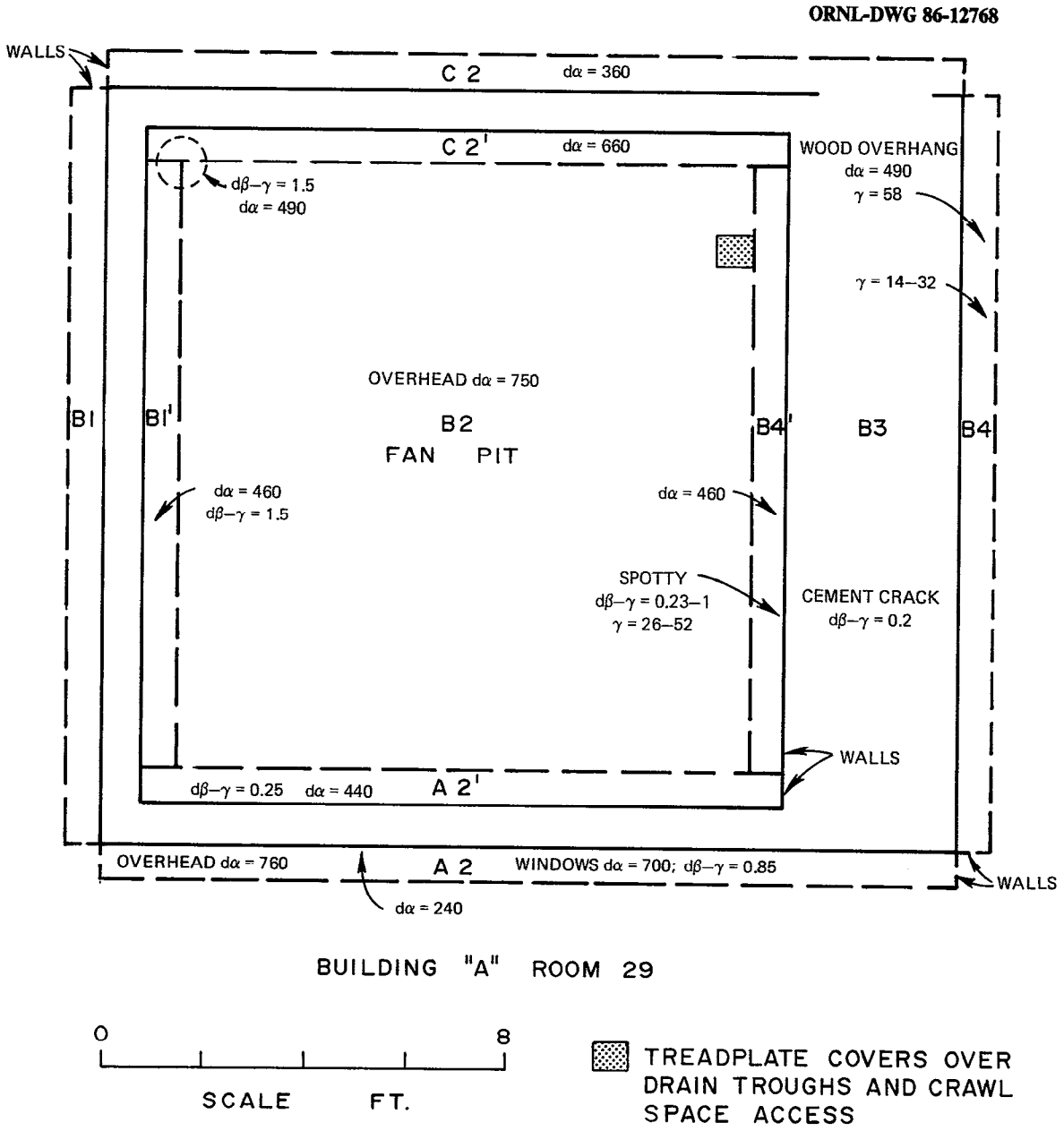



**Fig. 15. Location of contaminated areas in room 29, Building A, at the Ventron site.**

ORNL-PHOTO 3269-86

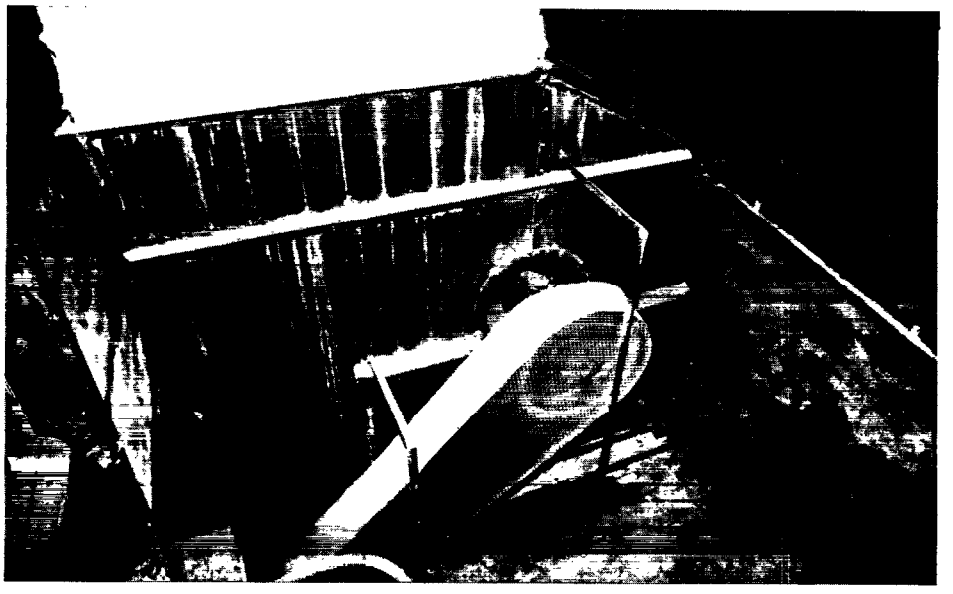


**Fig. 16. View of the exhaust fan in room 29, Building A, at the Ventron site.**

ORNL-PHOTO 3270-86

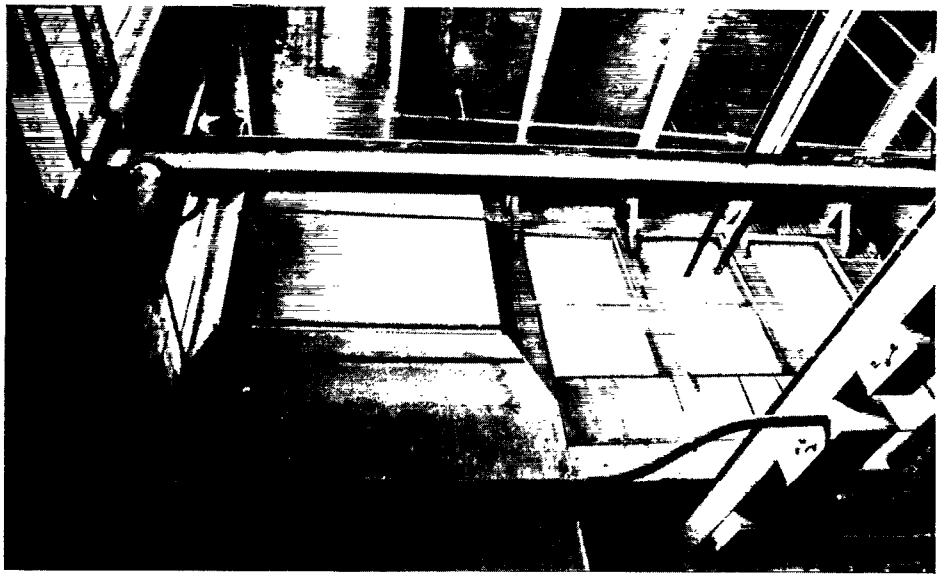
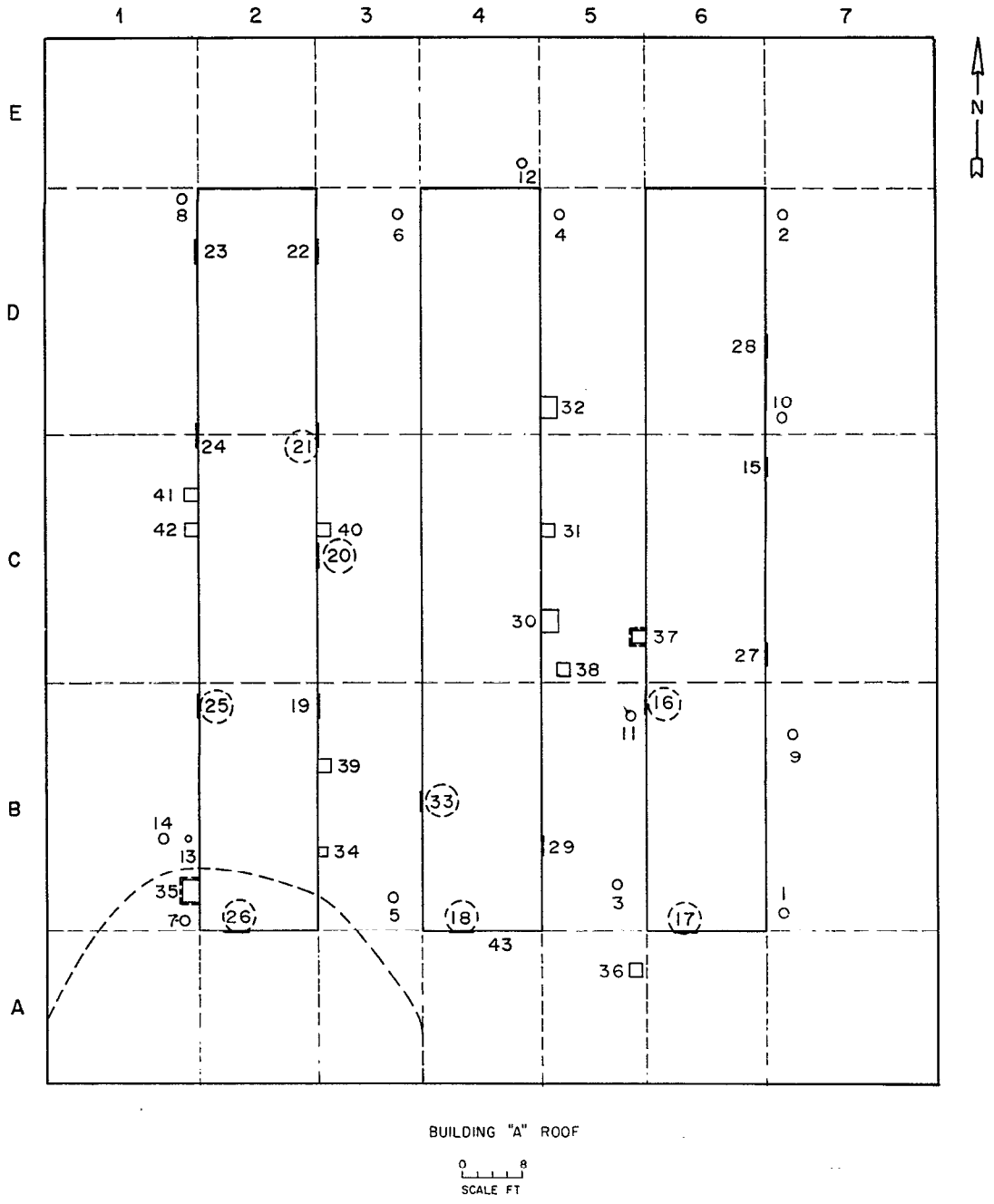


**Fig. 17. View of the fan duct and raised roof above room 29, Building A, at the Ventron site.**

ORNL-PHOTO 3271-86

**Fig. 18. View of kilns in room 30, Building A, at the Ventron site.**

ORNL-DWG 86-12766




NOTE: HATCHED LINES INDICATE AREAS OF ELEVATED MEASUREMENTS.

**Fig. 19. Location of contaminated areas on the roof of Building A at the Ventron site.**

**Table 13. Alpha, beta-gamma, and gamma measurements in contaminated areas on the roof of Building A at the Ventron site**

| Location[a] | Directly measured contamination: Alpha (dpm/100 $cm^2$) | Directly measured contamination: Beta-gamma dose rate at 1 cm above surface (mrad/h) | Average gamma reading from scan ($\mu$R/h) |
|---|---|---|---|
| Grid block | | | |
| A1 | [b] | [b] | 39 |
| A2 | 700 | 0.32 | 78 |
| A3 | [b] | 0.22 | 45 |
| B3 | [b] | 0.22 | 13 |
| Wall vent | | | |
| 16 | 420 | 0.15 | 15 |
| 17 | 150 | 0.30 | 11 |
| 18 | 140 | [b] | [b] |
| 20 | 210 | 0.01 | 14 |
| 21 | 980 | 0.05 | [c] |
| 25 | 490 | 0.05 | [c] |
| 26 | 1,600 | 0.75 | [c] |
| Hooded vent | | | |
| 33 | 10,000 | 2.3 | 36 |
| 35 | 4,900 | [b] | [d] |
| Fan duct | | | |
| 37 | 150 | 5 | 36 |

[a]Location shown on Fig. 19.
[b]No measurement taken.
[c]Measurement could not be distinguished from background.
[d]No measurement possible due to nearby surface contamination.

southwest with the maximum measurement of 160 $\mu$R/h found in grid blocks A2 and A3 where, apparently, residuals were funneled from room 29 below through the hooded vent as shown in Fig. 20. A view of this contaminated region, facing northwest from the hooded vent, is shown in Fig. 21. Fan duct number 37 in survey blocks C5 and C6 is above the rotary leach tank in room 20 below. The level of alpha contamination in that duct was observed to be 150 dpm/100 $cm^2$ with an average beta-gamma dose rate of 5 mrad/h. Overall direct alpha measurements on the roof ranged from 140 to 10,000 dpm/100 $cm^2$ in the contaminated areas with directly measured beta-gamma dose rates ranging to 2.3 mrad/h.

Most radiological measurements taken in rooms 1 and 2 of the basement of Building A did not differ significantly from background. The areas identified as having maximum contamination levels are shown on Fig. 22. Only two of these areas exceed DOE guidelines. Beta-gamma dose rates of 1.3 mrad/h were measured on both sides of doors at the southwest end of room 2. Surface contamination in this area was indicated by alpha activities of 570 dpm/100 $cm^2$. A wall ledge along the east part of the north wall in room 1 disclosed a maximum beta-gamma dose rate of 1.9 mrad/h. The associated alpha activity was 200 dpm/100 $cm^2$. In room 3, survey blocks through which a trough ran east to west displayed an average alpha contamination level of 120 dpm/100 $cm^2$ and a maximum gamma exposure rate of 45 $\mu$R/h. Above floor drain number 2 in room 3, the directly measured beta-gamma dose rate was 0.1 mrad/h. Within the drain, it was 0.3 mrad/h. Additionally, alpha contamination was identified on several wall surfaces, ranging from 100 to 280 dpm/100 $cm^2$.

### 3.2.2 Building A-1

Building A-1 constitutes an addition to Building A and contained facilities for the production of distilled calcium and the drying of uranium oxide powder, a machine shop, and electric furnaces and kilns. A drawing of the interior floor plan is presented in Fig. 23.

Gamma exposure rates measured near the center of grid blocks and during the scan of grid blocks in Building A-1 and on the roof are given in Table 14. Exposure rates in first floor and basement rooms ranged from 7 to 45 $\mu$R/h during the scan of accessible areas, averaging 12 $\mu$R/h at 1 m from the surface and 13 $\mu$R/h at the surface near the center point of grid blocks. Gamma levels in overhead regions and on the roof ranged from 8 to 12 $\mu$R/h and from 7 to 26 $\mu$R/h, respectively.

Alpha and beta-gamma measurements taken within the building and on the roof are provided in Table 15. The location of regions in which measurements exceeded 100 dpm/100 $cm^2$ is shown in Fig. 23. Five of the regions, designated a through e, are located in room 5. The contamination, manifested in every case as alpha activity, showed direct measurements of 110 to 2600 dpm/100 $cm^2$. Two of the measurements in room 5 were found at vents to the ceiling. The maximum level of alpha contamination, 2600 dpm/100 $cm^2$, was measured at one of these vents. The other contaminated areas were located at the juncture of floors and walls. The alpha levels determined in regions f and g (180 and 160 dpm/100 $cm^2$ respectively) were measured during grid block scans of rooms 8 and 9.

ORNL-PHOTO 3272-86

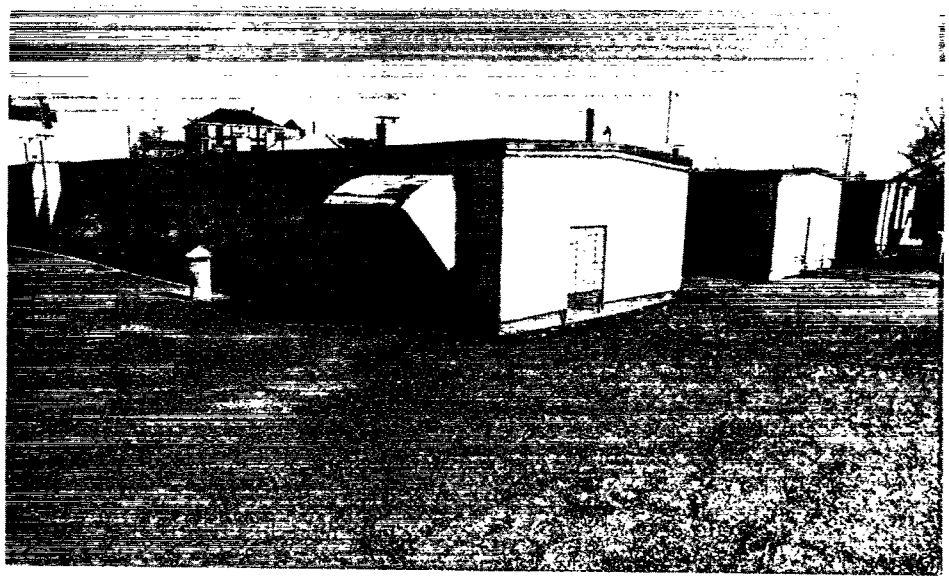


Fig. 20. View of the roof with hooded vent, Building A, at the Ventron site.

ORNL-PHOTO 3273-86

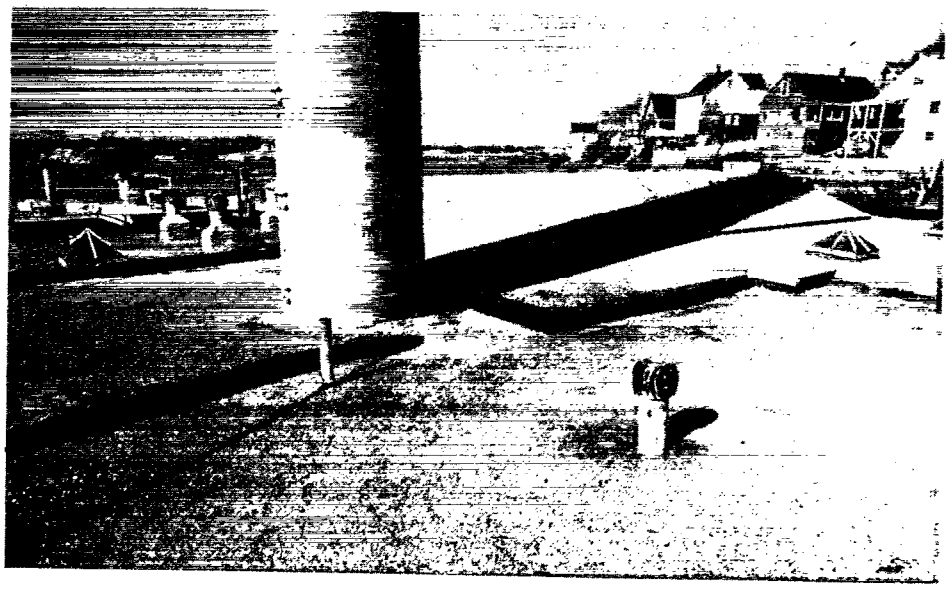


Fig. 21. View of the contaminated region of the roof, Building A, at the Ventron site.

ORNL-DWG 86-12764

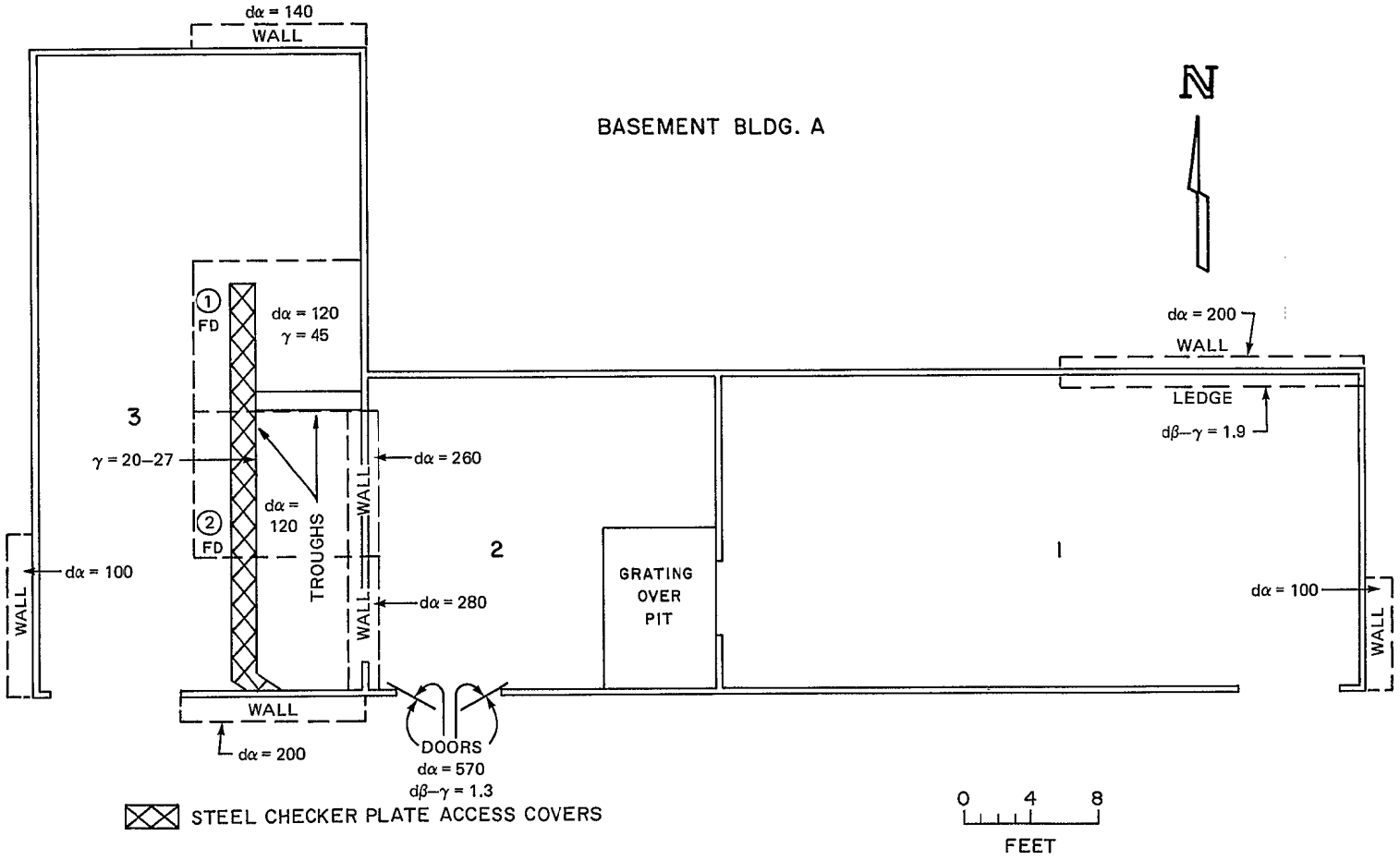
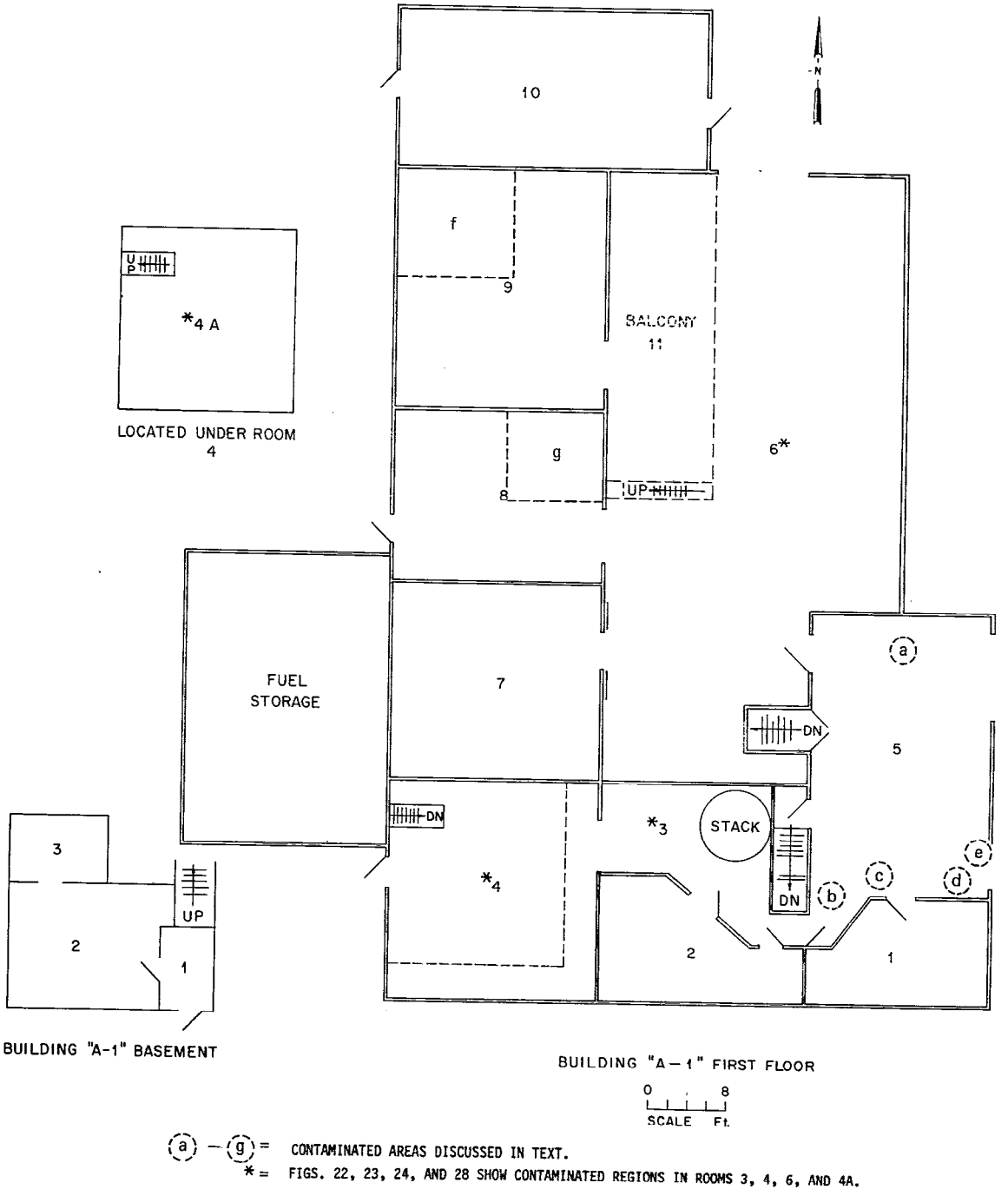



**Fig. 22. Location of contaminated areas in the basement of Building A at the Ventron site.**

ORNL-DWG 86-12769




(a) – (g) = CONTAMINATED AREAS DISCUSSED IN TEXT.
* = FIGS. 22, 23, 24, AND 28 SHOW CONTAMINATED REGIONS IN ROOMS 3, 4, 6, AND 4A.

**Fig. 23. Location of contaminated areas in Building A-1 at the Ventron site.**

**Table 14. Gamma exposure rate measurements in Building A-1 at the Ventron site**

| Location[a] | Center point measurements[b] (μR/h) | | Range of gamma exposure rates from scan of grid blocks[c] (μR/h) | Average gamma exposure rate from scan of grid blocks[c] (μR/h) |
|---|---|---|---|---|
| | Average gamma exposure rate at 1 m | Average gamma exposure rate at the surface | | |
| *First level* | | | | |
| Room 1 | 13 | 14 | 11–17 | 14 |
| 2 | 13 | 13 | 11–17 | 13 |
| 3 | 16 | 16 | 12–29 | 16 |
| 4 | 12 | 13 | 10–19 | 12 |
| 5 | 13 | 13 | 10–19 | 12 |
| 6 | 12 | 12 | 7–45 | 12 |
| 7 | 12 | 13 | 8–16 | 12 |
| 8 | 12 | 12 | 11–19 | 12 |
| 9 | 12 | 12 | 10–17 | 13 |
| 10 | 13 | 13 | 10–19 | 14 |
| *Overhead* | | | | |
| Room 5 | d | d | – | 10 |
| 6 | d | d | 8–12 | 11 |
| *Basement* | | | | |
| Room 1 | 14 | 15 | 10–19 | 15 |
| 2 | 14 | 15 | 11–16 | 14 |
| 3 | 13 | 14 | 11–15 | 13 |
| 4 | 11 | 12 | 10–18 | 12 |
| *Roof* | | | | |
| Grid blocks | d | d | 10–26 | 13 |
| Skylights | d | d | 7–19 | 12 |
| Vents, drains | d | d | 7–21 | 12 |

[a]Location shown on Figs. 23 and 31.

[b]Center point measurements are discrete measurements near the center of each grid block.

[c]Grid block measurements are obtained by a scan of the entire block.

[d]No measurement taken.

**Table 15. Alpha and beta-gamma measurements in Building A-1 at the Ventron site**

| | Directly measured contamination | | | | Transferable contamination | | | |
|---|---|---|---|---|---|---|---|---|
| | Alpha (dpm/100 cm$^2$) | | Beta-gamma dose rate at 1 cm (mrad/h) | | Alpha (dpm/100 cm$^2$) | | Beta-gamma dose rate at 1 cm from surface (dpm/100 cm$^2$) | |
| Location[a] | Average | Range | Average | Range | Average | Range | Average | Range |
| *First level* | | | | | | | | |
| Room 1 | 20 | 0–40 | 0.01 | 0.01–0.01 | b | – | b | – |
| Room 2 | 30 | 0–40 | 0.03 | 0.02–0.03 | b | – | b | – |
| Room 3 | 200 | 20–1,000 | 0.08 | 0.02–0.18 | 2 | 0–3 | b | – |
| Room 4 | 280 | 0–2,100 | 0.13 | 0.02–0.45 | 6 | – | b | – |
| Room 5 | 190 | 0–2,600 | 0.05 | 0.01–0.18 | b | – | b | – |
| Room 6 | 550 | 0–12,500 | 0.27 | 0.01–4 | 100 | 0–590 | 56 | 0–310 |
| Room 7 | 17 | 0–20 | 0.02 | 0.02–0.02 | 6 | – | 41 | – |
| Room 8 | 50 | 0–160 | 0.04 | 0.03–0.05 | 6 | – | 110 | – |
| Room 9 | 60 | 0–180 | 0.03 | 0.02–0.05 | b | – | 14 | – |
| Room 10 | 30 | 0–40 | 0.03 | 0.01–0.1 | c | c | c | c |
| *Overhead* | | | | | | | | |
| Room 1 | 40 | – | 0.01 | – | c | c | c | c |
| Room 2 | c | c | 0.01 | – | c | c | c | c |
| Room 3 | 53 | 40–80 | 0.02 | – | c | c | c | c |
| Room 4 | 3,000 | 40–6,000 | 0.56 | 0.15–1 | c | c | c | c |
| Room 5 | 33 | 0–60 | 0.02 | – | c | c | c | c |
| Room 6 | 86 | 20–100 | 0.12 | 0.01–0.5 | c | c | c | c |
| Room 7 | 42 | 28–56 | 0.06 | 0.01–0.1 | c | c | c | c |
| Room 9 | 53 | 42–56 | 0.02 | 0.01–0.05 | c | c | c | c |
| *Basement* | | | | | | | | |
| Room 1 | b | – | 0.03 | 0.02–0.03 | c | c | c | c |
| Room 2 | b | – | 0.02 | – | c | c | c | c |
| Room 3 | b | – | 0.02 | 0.02–0.02 | c | c | c | c |
| Room 4A | 340 | 70–1,700 | 0.29 | 0.02–1 | 12 | – | b | – |
| *Roof* | | | | | | | | |
| Grid blocks | c | c | 0.34 | 0.1–0.6 | c | c | c | c |
| Skylights | c | c | 0.01 | 0.01–0.02 | c | c | c | c |
| Vents | c | c | 0.02 | 0.01–0.03 | c | c | c | c |
| Drain | c | c | 0.25 | – | c | c | c | c |

[a]Location shown on Figs. 23, 24–26, and 30.
[b]Measurements could not be distinguished from background.
[c]No measurement taken.

In room 3 (Fig. 24), which contained a stack and furnace, gamma exposure rates ranged from 12 to 29 $\mu$R/h. Average direct alpha activities found on floor and wall surfaces ranged from 20 to 120 dpm/100 cm$^2$. Alpha levels were higher on the floor and at the base of the stack, measuring 280 and 660 dpm/100 cm$^2$, respectively. A direct beta-gamma dose rate of 0.18 mrad/h was detected at the base of the stack. The maximum direct alpha measurement of 1000 dpm/100 cm$^2$ was made in grid block B2.

Room 4 served as a drying area for uranium oxide powder and exhibited contamination in several regions as indicated on Fig. 25. The walls (survey blocks A2, A3, B1, and C1) had average alpha contamination levels ranging from 120 to 680 dpm/100 cm$^2$. An isolated alpha measurement of 210 dpm/100 cm$^2$ was detected on the top of a piece of machinery in block C2. One region overhead in C3 gave directly measured alpha and beta-gamma activities of 12,000 dpm/100 cm$^2$ and 1 mrad/h, respectively. Direct alpha activities ranging from 130 to 2100 dpm/100 cm$^2$ were found on, under, and around the furnaces in the south end of the room. Associated direct beta-gamma dose rates ranged from 0.25 to 0.45 mrad/h.

Room 6, in which the production of distilled calcium was carried out, was found to contain surface contamination in many accessible areas. Much of the room was impossible to survey due to the presence of equipment. Figure 26 identifies the locations with elevated levels including several exceeding DOE guidelines. The beta-gamma dose rates in the room ranged from 0.01 to 4 mrad/h. Direct alpha activities averaged 550 dpm/100 cm$^2$ in this room with the maximum found on contact with old wooden beams and braces underneath the balcony (Fig. 27). Measurements on these structures ranged from 2100 to 12,500 dpm/100 cm$^2$. Associated beta-gamma dose rates ranged from 0.15 to 1 mrad/h. Average alpha contamination levels on the balcony ranged from 40 to 140 dpm/100 cm$^2$. Measurements of transferable surface contamination were taken in eight locations on the floor in room 6. Values were indistinguishable from background except in survey blocks E2, F2, and G2 on the wooden portions of the bottom of the balcony. The alpha levels in E2 and G2 read 586 and 116 dpm/100 cm$^2$, respectively. The glazing along the windows and ledge in these survey blocks gave directly measured beta-gamma dose rates of 0.15 to 0.3 mrad/h with spots measuring 0.5 mrad/h. An interior view of some of the windows in room 6 is presented in Fig. 28. The contaminated ledge beneath the windows is shown in Fig. 29. In grid block E4, at the location of the maximum gamma rate measured (45 $\mu$R/h) the beta-gamma dose rate reached 4 mrad/h. The alpha activity measured there was 2200 dpm/100 cm$^2$. Overhead at C3, the average direct alpha activity was 100 dpm/100 cm$^2$. Four power tools (hacksaw, lathe, drill press, and sheet metal roller) located in room 6, which was being used as a machine shop at the time of the survey, showed beta-gamma surface contamination levels of 0.4 to 8.5 mrad/h.

No measurements above guidelines were observed in rooms 1, 2, and 3 of the basement of Building A-1. The lower walls and floor of room 4A were contaminated with levels of alpha activity exceeding 100 dpm/100 cm$^2$ (Fig. 30). The maximum direct alpha measurement, 1700 dpm/100 cm$^2$, was determined to be on a pipe running along the wall at A3. At the base of that wall, in B3, the alpha level was 530 dpm/100 cm$^2$. In C3, a point on the ceiling gave an alpha level of 350 dpm/100 cm$^2$ while the average alpha level measured on the ceiling was 240 dpm/100 cm$^2$. A hole in the ceiling in B2 showed a

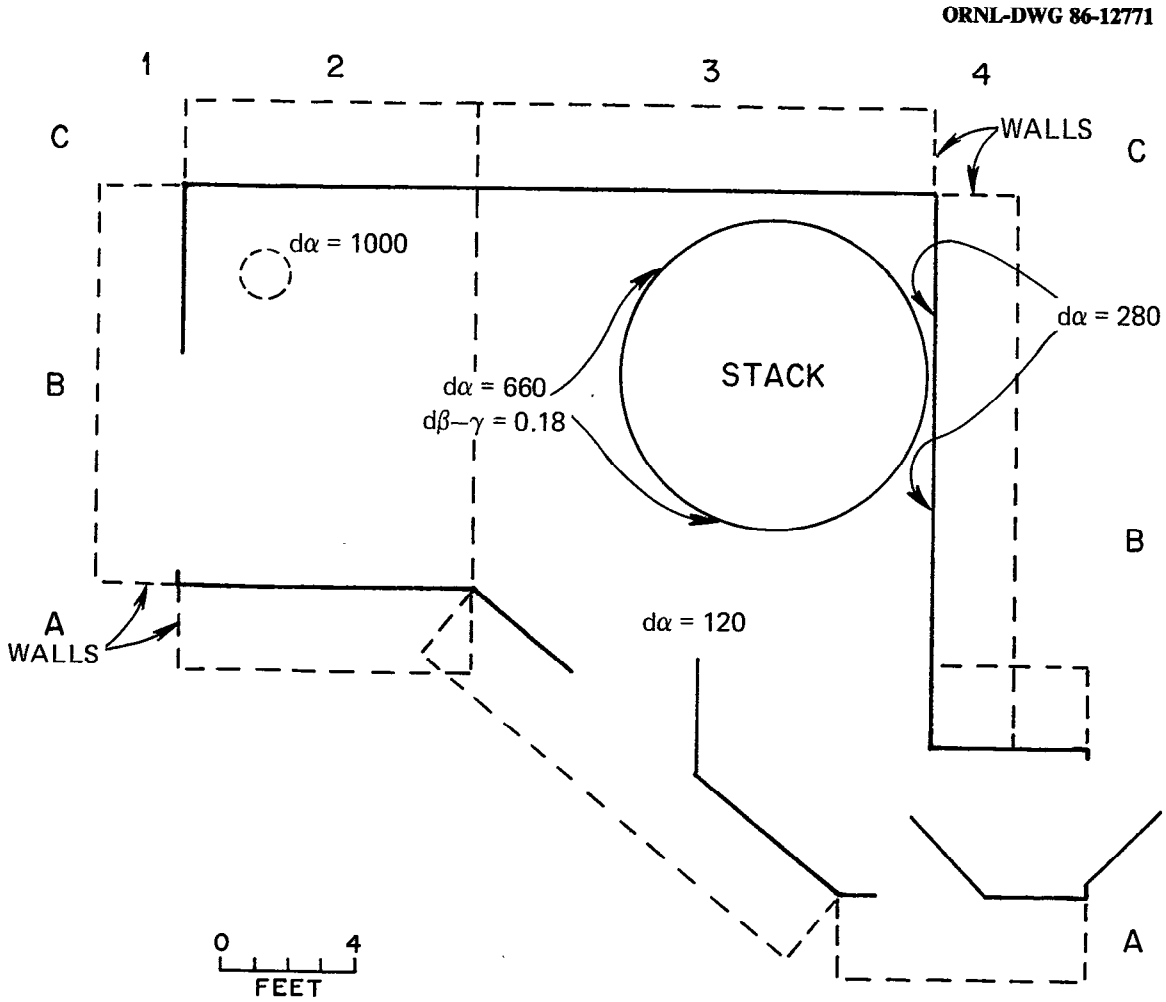



**Fig. 24. Location of contaminated areas in room 3, Building A-1, at the Ventron site.**

ORNL-DWG 86-12770

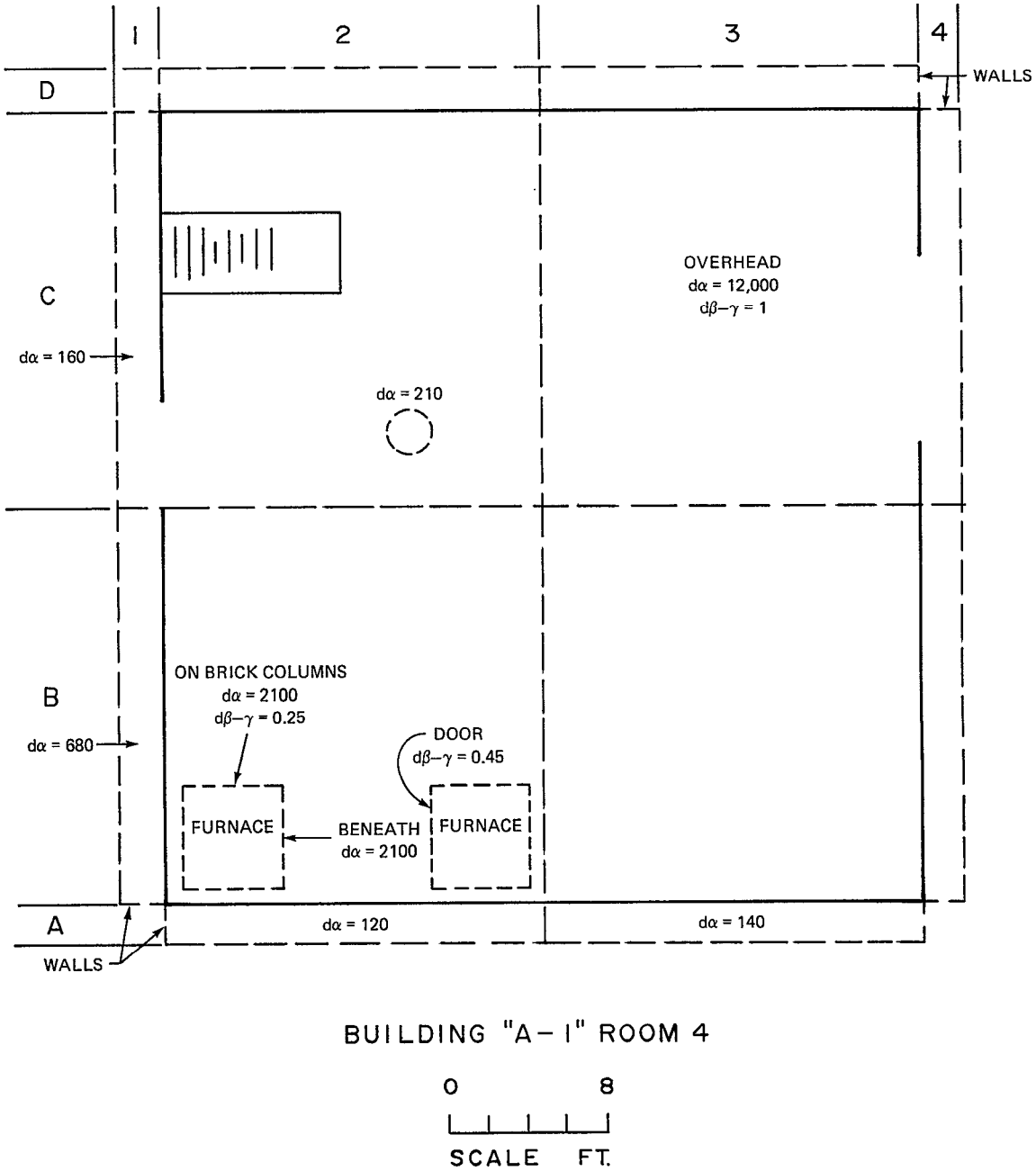



**Fig. 25. Location of contaminated areas in room 4, Building A-1, at the Ventron site.**

ORNL-DWG 86-12772R

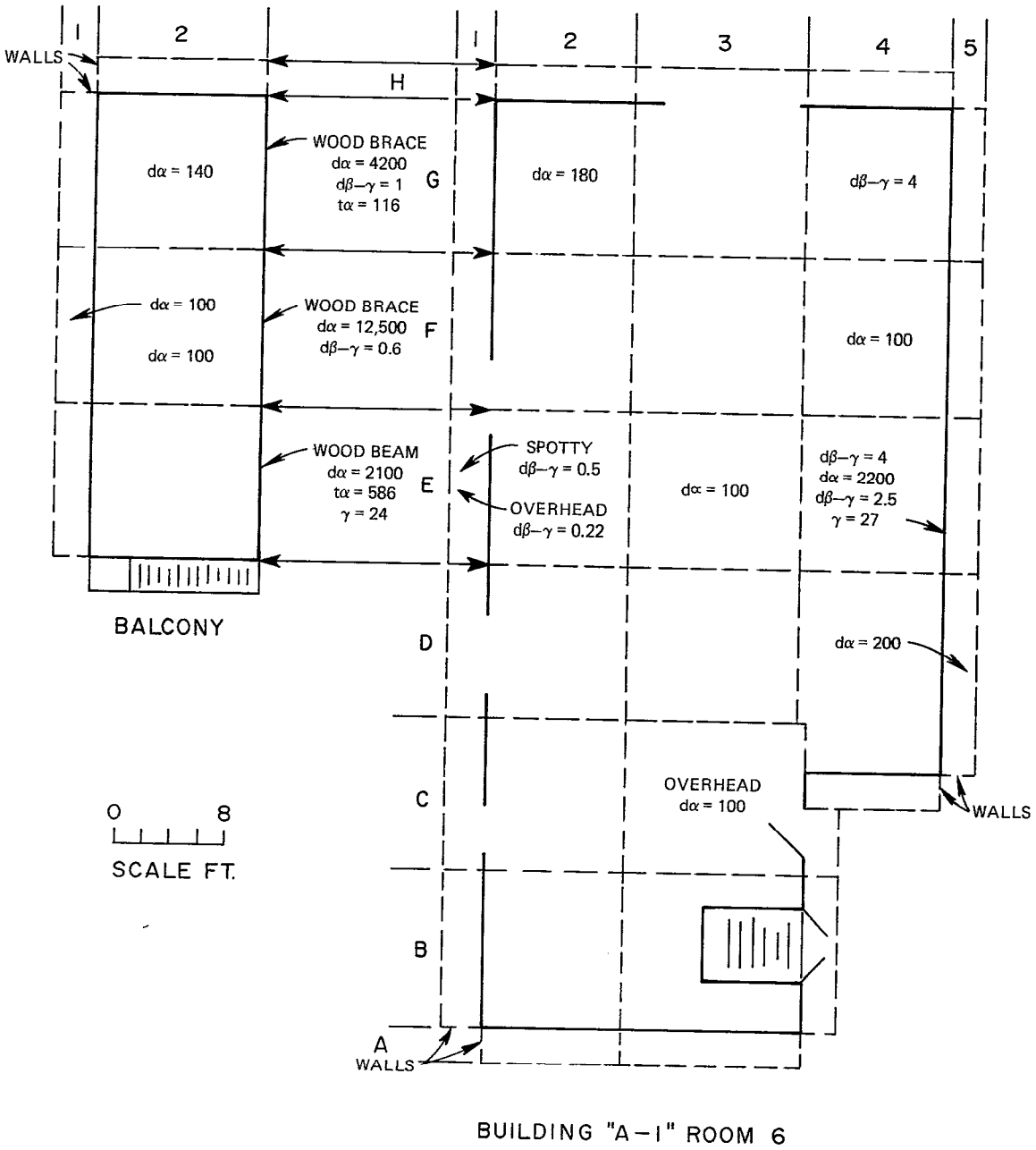



**Fig. 26. Location of contaminated areas in room 6, Building A-1, at the Ventron site.**

ORNL-PHOTO 3274-86

Fig. 27. View beneath the balcony in room 6, Building A-1, at the Ventron site.

ORNL-PHOTO 3275-86

Fig. 28. View showing windows and roof area in room 6, Building A-1, at the Ventron site.

ORNL-PHOTO 3276-86

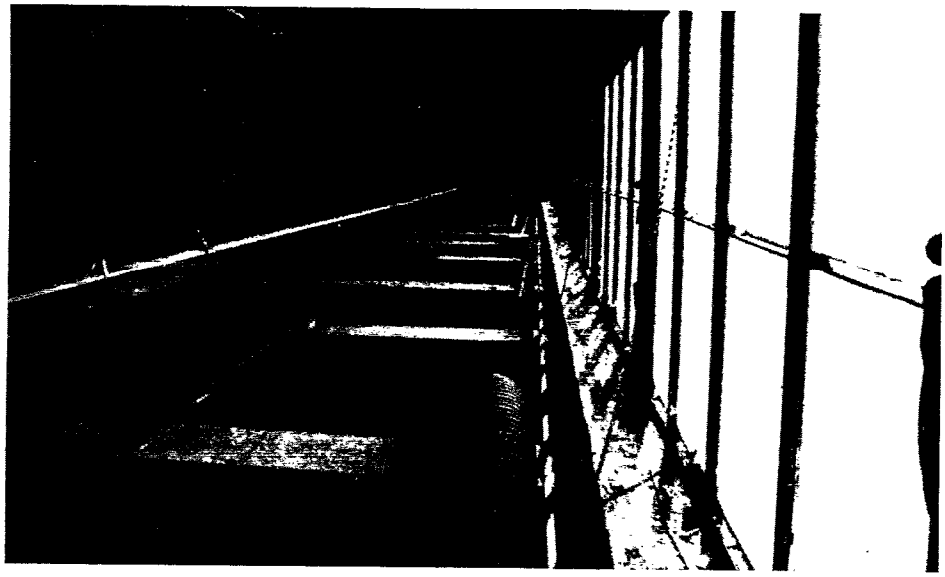


**Fig. 29. View of the contaminated window ledge above room 6, Building A-1, at the Ventron site.**

ORNL-DWG 86-12773

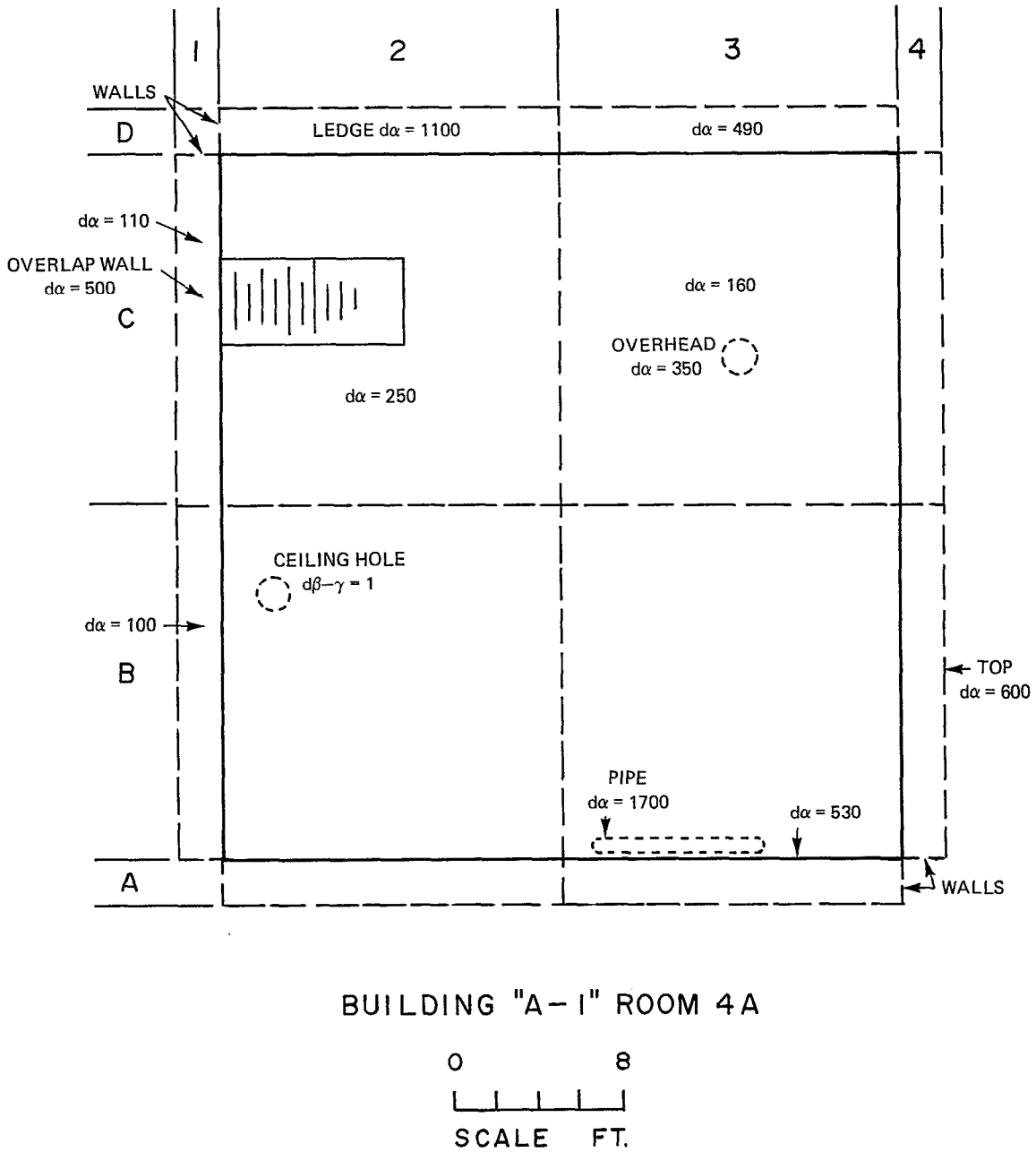



**Fig. 30. Location of contaminated areas in room 4A, Building A-1, at the Ventron site.**

beta-gamma dose rate of 1 mrad/h. An alpha contamination level of more than 1100 dpm/100 $cm^2$ was found on a ledge in block D2. Various wall areas were found to have alpha levels ranging from 100 to 600 dpm/100 $cm^2$ as shown, with the maximum measurement discovered at the top of wall B4.

Gamma measurements made on the roof of Building A-1, including those in survey blocks, skylights, and vents, ranged from 7 to 26 $\mu$R/h. Surface contamination evidenced by beta-gamma dose rates ranging from 0.2 to 0.6 mrad/h were observed in association with loose dirt in scattered regions of the roof. Figure 31 shows the location of some of the measurements exceeding guidelines. The data were typical of other widely dispersed regions not shown. The maximum gamma exposure rates were also associated with the loose dirt. A view of the roof, vent structures, and raised windows is given in Fig. 32.

### 3.2.3 Buildings B-1, B-2, and B-3

Buildings B-1, B-2, and B-3 are relatively new (built in 1950) and were used at the time of the survey for the manufacture of chemical hydrides. No residual radioactive materials would be expected within the buildings. A photograph, reproduced in Fig. 5, presents a view of the three attached buildings. This report is limited to the survey details of the basement areas because a gamma scan of upper levels established no evidence of contamination.

A gamma scan of the survey blocks laid out in the basements of the three buildings revealed a total range of gamma exposure rates from 7 to 32 $\mu$R/h. Because several regions of elevated gamma levels suggesting the presence of subsurface contamination were found in each building, 6-in diameter core holes were drilled with a concrete saw through the floors in the locations indicated on Fig. 33. Radionuclide analysis of soil samples retrieved from these holes (see Sect. 3.1.3) confirmed the presence of contaminated fill material beneath Buildings B-1 and B-2 to a depth of 2.5 m. Exposure rates ranged from 8 to 17 $\mu$R/h in Building B-1 and from 7 to 32 $\mu$R/h in Building B-2. The region of elevated gamma at the west end of Building B-1 extends to Building B-2. Exposure rates of 13 to 16 $\mu$R/h were detected at the sides of barrels stored in various locations within the three buildings at the time of the screening.

None of the surface measurements taken in the three buildings exceeded the appropriate DOE guidelines. Direct beta-gamma dose rates at 1 cm above the floor surface in the basements averaged 0.01 and 0.02 mrad/h in Buildings B-1 and B-3 while results averaged 0.03 mrad/h in Building B-2. The maximum measurement (0.07 mrad/h) was found in Building B-2. Only one direct alpha measurement taken in Building B-1, 30 dpm/100 $cm^2$, was distinguishable from background. Direct alpha activities averaged 25 and 34 dpm/100 $cm^2$ in Buildings B-2 and B-3, respectively. Representative sampling of transferable alpha and beta-gamma activities yielded readings no higher than 1 and 82 dpm/100 $cm^2$, respectively, in the three buildings.

### 3.2.4 Buildings C-1, C-2, C-3, and C-4

Buildings C-1, C-2, C-3, and C-4 (built in 1945) consist of analytical laboratories. The attached buildings are shown in Fig. 4 in a view looking west from the roof of Build-

ORNL-DWG 86-12774

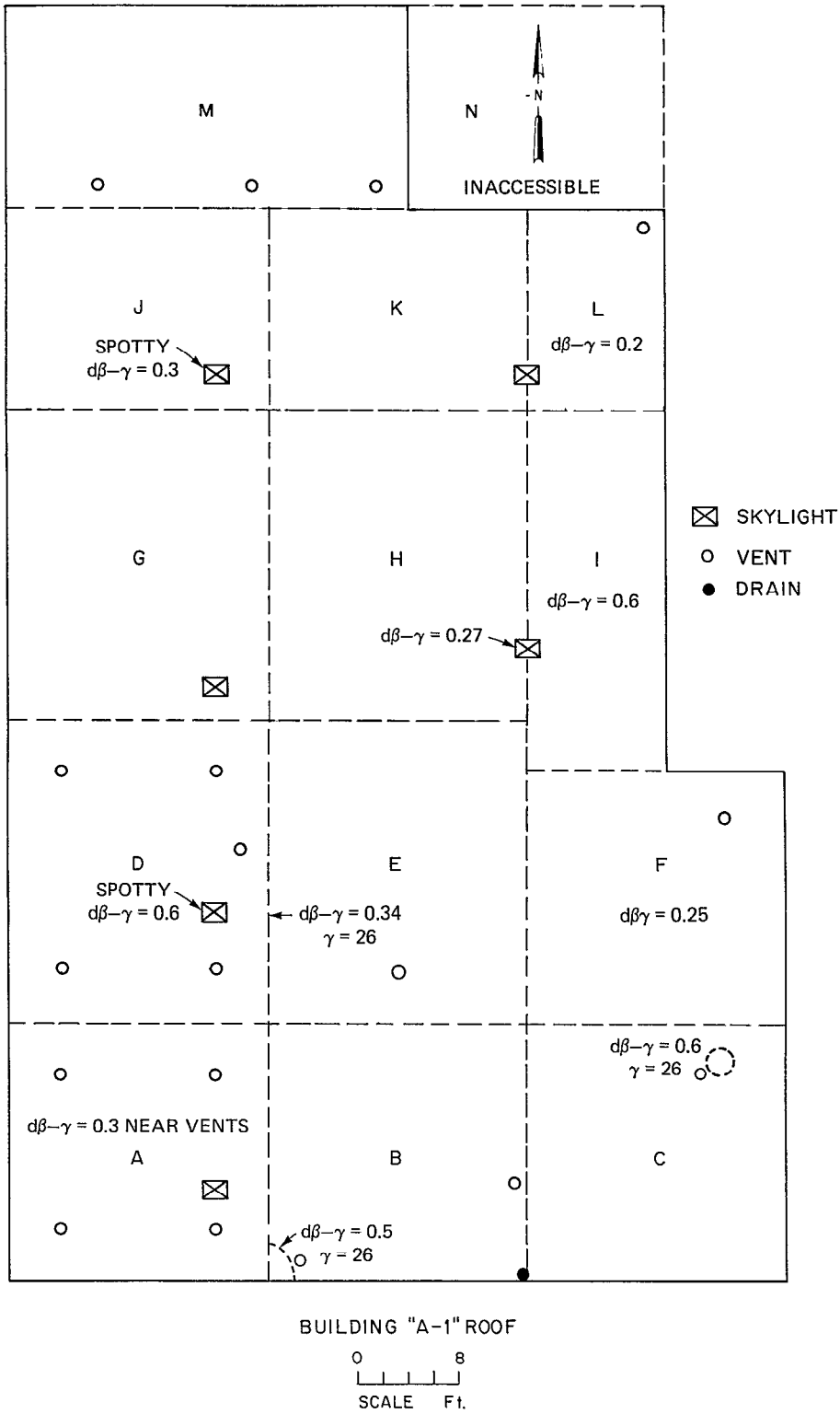



**Fig. 31. Location of contaminated areas on the roof of Building A-1 at the Ventron site.**

ORNL-PHOTO 3277-86

**Fig. 32. View of the roof of Building A-1 at the Ventron site.**

ORNL-DWG 86-12867

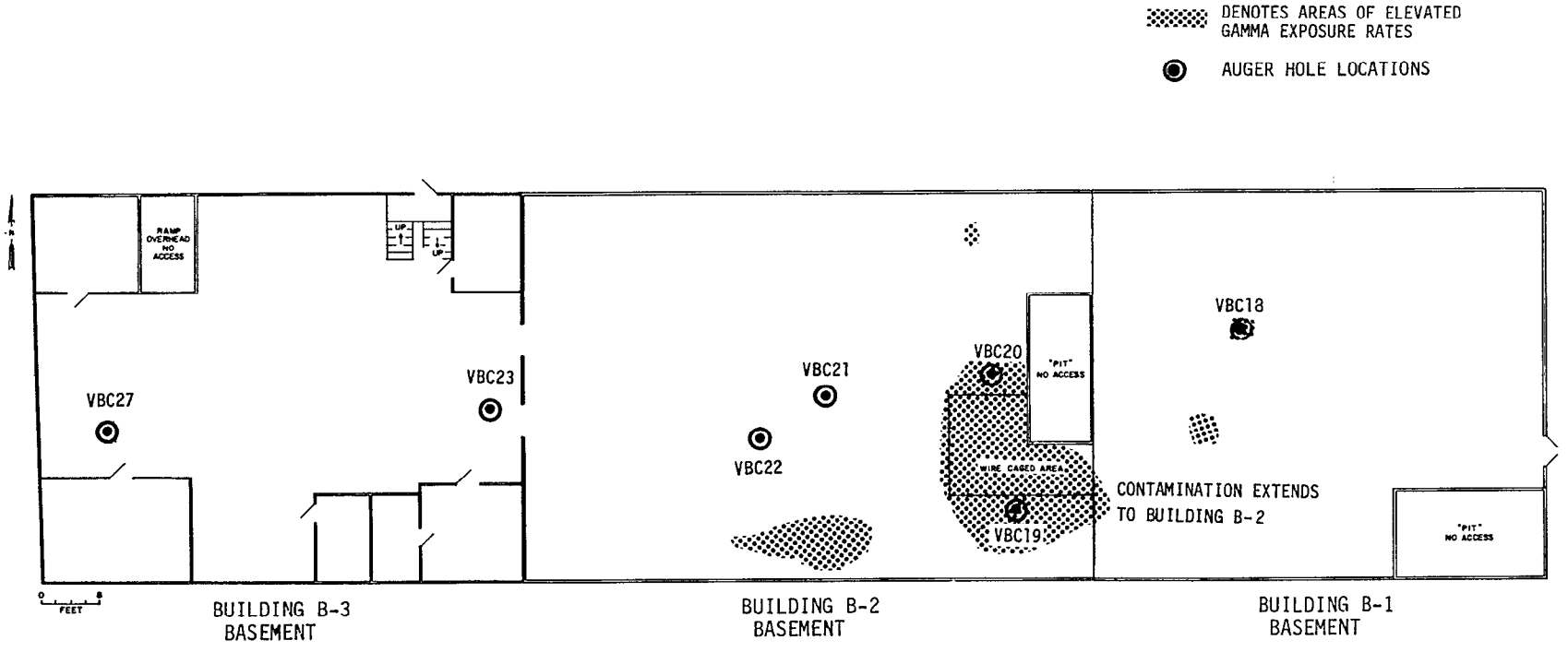



**Fig. 33. Basements of Buildings B-1, B-2, and B-3 at the Ventron site showing regions of elevated gamma exposure rates and locations of auger holes.**

ing A-1. Building C-1 at the time of the survey contained a library, research laboratories, and a basement used for miscellaneous storage. The results that follow are for the first levels of Buildings C-2, C-3, and C-4 and the basement of Building C-1. The first and second levels of Building C-1 and the second-level cafeteria over Building C-2 disclosed no gamma or direct alpha measurements suggesting the presence of residual radioactive materials.

The range of measurements found during the gamma scan of the four attached buildings as described was 5 to 17 $\mu$R/h. Average gamma exposure rates were 9 to 11 $\mu$R/h at 1 m from the floor surface and 10 to 11 $\mu$R/h at the surface. Soil samples were taken underneath the floor in the three regions of maximum gamma levels in the basement of Building C-1 to investigate the possibility of subsurface contamination. The results of radionuclide analysis substantiated the supposition (see Sect. 3.1.3), indicating contaminated fill material beneath the floor at the auger hole locations shown on Fig. 34. The contamination extends to a depth of 2.5 m.

Surface measurements taken in the four buildings were below guidelines. Direct alpha activities averaged 27 dpm/100 $cm^2$ in the basement of Building C-1 and were 20 dpm/100 $cm^2$ throughout Buildings C-2, C-3, and C-4. Direct beta-gamma dose rates for Building C-1 averaged 0.01 mrad/h while transferable alpha and beta-gamma activities on floor and wall surfaces were negligible.

### 3.2.5 Building D

Building D, built in 1967, was used for the research and development of biocides and is situated on the property as shown on Fig. 2.

The range of exposure rates disclosed by the scan of this building was 5 to 10 $\mu$R/h, with average readings of 6 and 7 $\mu$R/h at 1 m from the surface and at the surface, respectively. Elevated gamma levels of 65 $\mu$R/h were determined to be associated with three boxes of carbon arc filaments stored in room 25 at the time of the survey. All other readings were within the range of typical background values. Furthermore, the average beta-gamma dose rate of 0.03 mrad/h at 1 cm above surfaces is well below the DOE guideline of 0.2 mrad/h. No evidence was found of the presence of the contaminated fill material used beneath other buildings.

### 3.2.6 The Alfa Building

The Alfa Building, built in 1953, was used for crystal growing and other research related activities. Its location and interior floor plan may be seen in Figs. 2 and 35, respectively.

Overall gamma exposure rates determined during the scan of this building ranged from 5 to 19 $\mu$R/h, averaging 10 $\mu$R/h. Gamma levels at 1 m from the floor surface also averaged 10 $\mu$R/h, while the average at the floor surface was 11 $\mu$R/h. Areas of elevated exposure rates associated with radioactive process materials were found in rooms 2 and 6 as presented on Fig. 35. No suggestion of the presence of contaminated subsurface soil was detected.

ORNL-DWG 86-12868

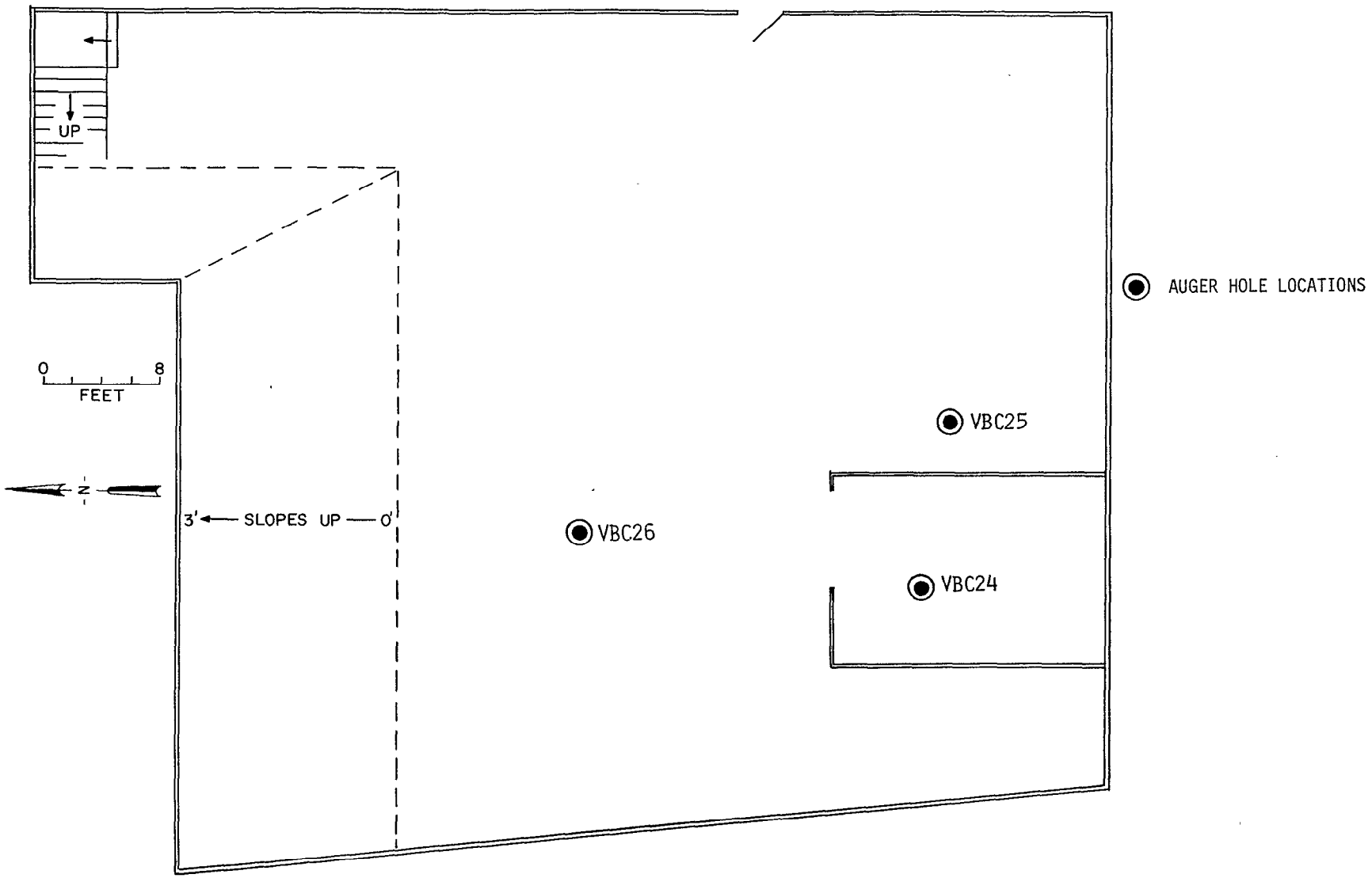



**Fig. 34. Basement of Building C-1 at the Ventron site showing locations of auger holes.**

ORNL-DWG 86-12778

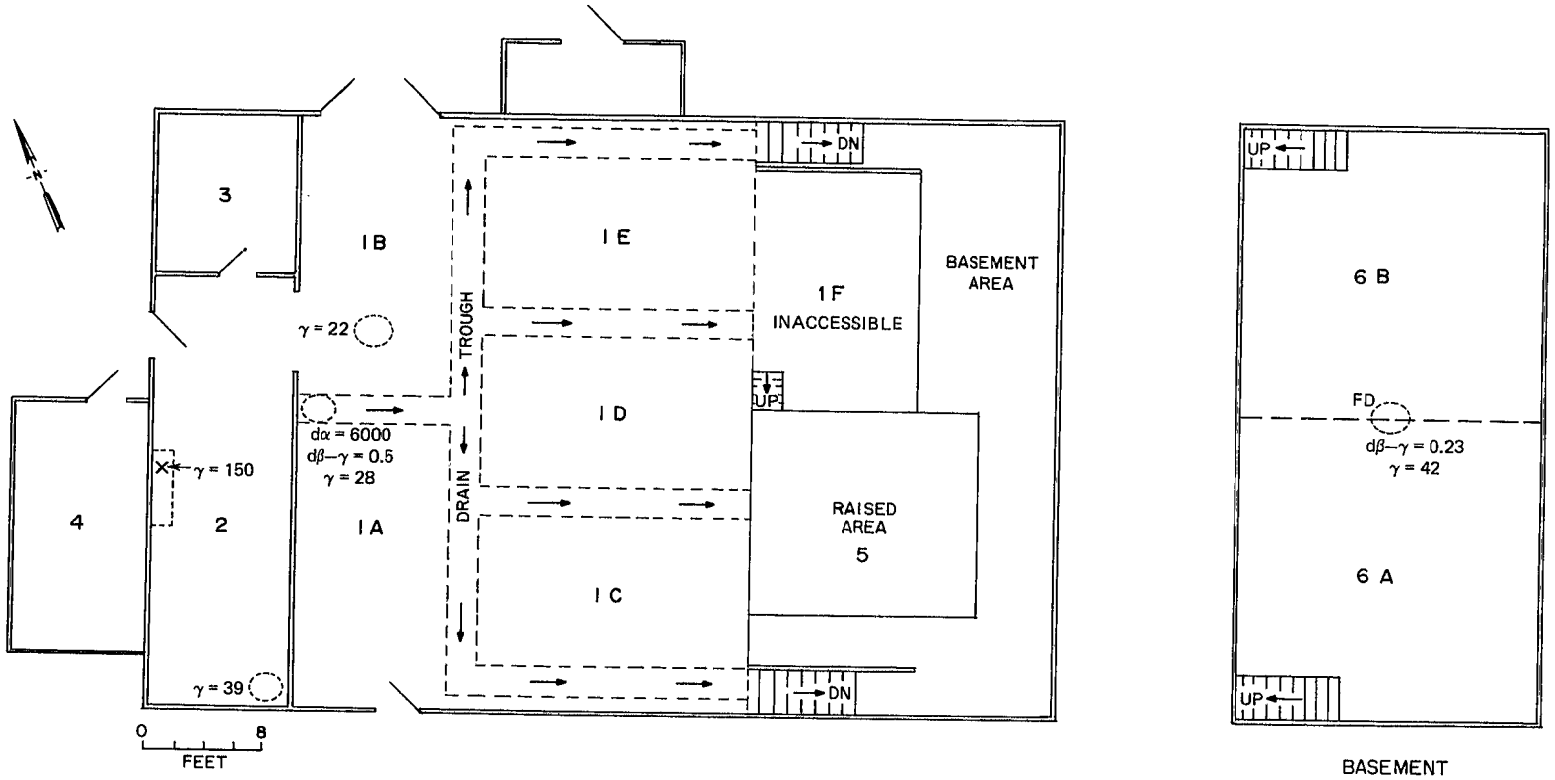



**Fig. 35. Location of contaminated areas in the Alfa Building at the Ventron site.**

Two vessels containing thorium crystals were discovered in the locations shown. One of these vessels rested on a cabinet along the west wall of room 2 as indicated and scanned 150 $\mu$R/h. This cabinet contained thorium-processing materials. The second vessel registered a gamma exposure rate of 39 $\mu$R/h. Additional anomalous regions were found in room 1 where a piece of equipment used in the thorium process and situated northwest of the drain trough registered 22 $\mu$R/h. A small area in the drain trough showed a beta-gamma dose rate of 0.5 mrad/h, which exceeds the DOE guideline of 0.20 mrad/h. Direct alpha activities at that spot were 6000 dpm/100 $cm^2$.

The beta-gamma dose rate (0.23 mrad/h) at the floor drain in the center of the basement level also exceeded 0.20 mrad/h and was accompanied by a gamma exposure rate of 42 $\mu$R/h. The alpha activity, however, at this spot was <1 dpm/100 $cm^2$. There was water present during the time measurements were being obtained.

Because the Alfa Building was built after the MED/AEC contract was terminated, elevated areas in this building would not be associated with MED/AEC operations.

### 3.2.7 Storage Building and Warehouse

Gamma scanning was conducted in accessible areas in the Storage Building and in the Warehouse located as shown on Fig. 2. A view of the Storage Building from the roof of Building A is shown in Fig. 3.

Surveying was prohibited in 75% of the first level of the Storage Building because of the barrels of solvents and other materials in stock. However, exposure rates in the center of the room were 5 and 7 $\mu$R/h at 1 meter and at the surface, respectively. No indication of contamination was found. Similarly, 50% of the basement of this building was unavailable to the team. Exposure rates averaged in the 7 to 14 $\mu$R/h range where scanning was possible. A maximum of 85 $\mu$R/h was measured on contact with a number of 3- to 5-gallon buckets of zinc oxide in storage.

Approximately 50% of the Warehouse was inaccessible to the survey team. However, gamma exposure rates scanned 5 to 10 $\mu$R/h, averaging 7 $\mu$R/h at both 1 m from the surface and at the surface. No contamination due to the presence of radioactive materials was observed in either building.

## 4. SIGNIFICANCE OF FINDINGS

The results of the radiological survey at the Ventron site demonstrate the presence of residual radioactive contamination. The primary contaminant is $^{238}U$ with lesser amounts of $^{232}Th$ and $^{226}Ra$. The contamination occurs outdoors as both surface and subsurface contamination in soil and as contaminated fill material underneath Buildings B-1, B-2, and C-1. Buildings A and A-1 and the Alfa Building contain spotty surface contamination on floors, walls, overhead surfaces, equipment, and roofs.

A cursory gamma scan of the tidal area of the bay adjacent to the plant site revealed elevated levels of gamma radiation indicating the presence of radionuclides along the water line and in the mud of the tidal area. These findings verify historical information which indicates that there were uranium releases to the bay during MED operations and suggests that additional surveys should be completed to determine if there is residual uranium present in this area.

The maximum concentration of $^{238}U$ found on the site was 71,000 pCi/g and was measured in subsurface soil from beneath Building B-2. The maximum concentration of $^{238}U$ found in surface soil on the site was 44,000 pCi/g. The highest concentration of $^{232}Th$ measured in soil onsite was 3900 pCi/g. The DOE guideline concentration for $^{232}Th$ in surface soil is 5 pCi/g above background levels averaged over a 100 $m^2$ area (Table 2). The depth of contamination appeared to be greater than 3 m in the southeast portion of the site outdoors and extended to 2.5 m beneath the buildings.

Inside Building A, the surface contamination found in scattered regions was most evident in the rooms where leaching and retorting processes had been conducted (i.e., rooms 20 and 29) and in room 30 where current activities involved materials containing naturally occurring radionuclides. Directly measured alpha and/or beta-gamma levels exceeded DOE guidelines on floors, walls, overhead surfaces, and equipment. Contamination was also evident in the floor drain troughs. It was apparent that dust and particulates had been funneled through ducts and vents to the outdoors, particularly from room 29, resulting in the deposition of surface contamination over a portion of the roof. The maximum beta-gamma dose rate measured in Building A exceeded the DOE criterion (1.0 mrad/h) by a factor of 3. Levels of directly measured alpha contamination were as high as 4.2 times the thorium limit (Table 2).

DOE guidelines for surface contamination were also exceeded in Building A-1 in numerous regions, especially in rooms 3, 4, 4A, and 6. Again, the elevated measurements were found on floor, wall, overhead, and equipment surfaces. On the roof, the contamination was largely associated with the presence of loose dirt in scattered regions. Maximum direct alpha and beta-gamma count rate measurements exceeded criteria (Table 2) by <13 and <4 times, respectively, on structural surfaces. The beta-gamma dose rates measured on the power equipment (room 6) indicated levels as high as 8.5 mrad/h (more than 8 times the beta-gamma dose rate limit).

In the Alfa Building, elevated gamma exposure rates were found in association with thorium crystals and thorium-processing equipment not related to DOE predecessor activities. Directly measured alpha and beta-gamma levels were elevated in drains and drain troughs in several regions.

Surface measurements taken in Buildings B-1, B-2, B-3, C-1, C-2, C-3, C-4, and D were all below criteria. Elevated gamma levels discovered in areas of the basements of Buildings B-1, B-2, and C-1 suggested the presence of contamination beneath the floors. Radionuclide analysis of soil samples taken from holes drilled into the substrata confirmed that assumption. No evidence of the presence of radioactive residuals was found inside or beneath the Storage Building or the Warehouse.

The residual radioactivity on this site will produce slight radiation exposures to persons frequenting the contaminated areas. These exposures result primarily from beta-gamma and alpha radiations emitted by radionuclides retained in the soil and in some areas of the former process buildings (A and A-1). The present use of the site is industrial and its condition renders the soil unsuitable for growing crops. Consequently, it is highly unlikely that any significant exposure would be received by way of ingestion from eating vegetables or fruit grown on the site. Most of the area outside the buildings is covered by asphalt or concrete and the remaining area is covered by a heavy growth of lawn grass. This grass cover precludes any significant resuspension of particulate contamination from the land surface by wind or air currents; hence, radiation exposures from inhalation of radioparticulates is currently not a problem. If operations which involve considerable scraping or turning of dry soil were performed in areas showing high concentrations of radionuclides, radiation exposures from the inhalation pathway would need to be re-evaluated.

The average gamma exposure rate at one meter from the ground surface outdoors on the site was 8 $\mu$R/h. This level is essentially the same as the background exposure rate in the Beverly area (7 $\mu$R/h). One area in the southeast corner of the site located between the Storage and Alfa Buildings exhibited elevated gamma radiation levels ranging up to 60 $\mu$R/h at one meter from the ground. The maximum level (60 $\mu$R/h) occurred in a relatively small area ($\sim$10 $m^2$), and, at the time of the survey, this area appeared to be unoccupied except for occasional entry. If a worker occupied this area for 1/4 of a typical work year (two hours per shift or 500 h/y), that individual would receive a potential exposure of 30 milliroentgens annually (a dose of less than 30 mrem/y). For comparison, a basic dose limit of 100 mrem/y is used by the Department for limiting the radiation dose received by an individual member of the general public and 5,000 mrem/y is used for a radiation worker. Therefore, the worst case use of this area could result in a dose of less than 1/3 the dose limit for the general public. It is expected that occupancy in this area will continue to be much less than 500 h/y and, as a result, potential doses will be even lower than those projected here.

The maximum gamma radiation level measured at the perimeter of the plant (30 $\mu$R/h) occurred along the fence at the southeast corner of the site (location 22, Fig. 6). The ground outside the fence at this point drops off rather rapidly down a rocky bank to the bay. Therefore, the potential for any significant radiation exposure to members of the general public from this source is extremely low.

The average gamma radiation level measured one meter from floor surfaces in each of the former process buildings (A and A-1) was 12 $\mu$R/h. This level is 1.7 times the background level in the Beverly area and about 44% of the external gamma radiation level of 20 $\mu$R/h above background allowable by DOE in buildings or habitable structures to be released for unrestricted use by the general public. The maximum gamma level detected at one meter in either building was 21 $\mu$R/h in a hallway of Building A (Room 28, Fig. 11). Since this area is used only as a passageway, radiation exposures to personnel from this source would not be significant.

Residual radioactive surface contamination exceeded DOE guidelines in some areas inside Buildings A and A-1, and in the Alfa Building. Potential exposures from surface contamination could be from ingestion, inhalation, or from direct radiation by beta-gamma

emitting radionuclides. Very few measurements of transferable contamination exceeded DOE guidelines; hence, given the use of the building at the time of the survey, the risk of receiving significant exposures from inhalation or ingestion of radioactive material is extremely small. Beta-gamma dose rates from contaminated surfaces exceeded guidelines in some areas of Buildings A and A-1. These contaminated areas occurred in cracks in floors, on beams and ledges, and in floor drains, and do not lend themselves to extended contact with people; hence, potential exposures from these sources is judged to be insignificant. However, because measurements of fixed surface contamination exceeded guidelines in some buildings, if operations involving the generation of dust such as scraping contaminated surfaces were conducted, the potential for radiation exposures would need to be re-evaluated to determine if control measures are needed.

In summary, concentrations of residual radioactive material found in buildings and soils at the site are in excess of concentration guidelines established by the Department of Energy to determine if a site needs to be considered for remedial action. These guidelines are typically derived to ensure that unrestricted use of the facility (including residential use) will not result in above-guideline doses to the general public. An examination of work/occupancy scenarios for this site suggests that annual radiation exposures to personnel from any credible current use scenario would be well below the dose limits which would be applied to protect members of the general public from exposure to radiation.

## REFERENCES

1. *A Background Report for the Formerly Utilized Manhattan Engineer District, Atomic Energy Commission Sites Program,* DOE/EV-0097A (September 1980).
2. W. D. Cottrell, *Preliminary Report of Ventron Site, Beverly, Massachusetts* (December 1985).
3. T. E. Myrick, B. A. Berven, W. D. Cottrell, W. A. Goldsmith, and F. F. Haywood, *Procedures Manual for the ORNL Survey Activities (RASA) Program,* Oak Ridge National Laboratory, ORNL/TM-8600 (April 1987).

# APPENDIX

## GAMMA PROFILE GRAPHS OF AUGER HOLES AT THE VENTRON SITE, BEVERLY, MASSACHUSETTS

ORNL-DWG 86-12784

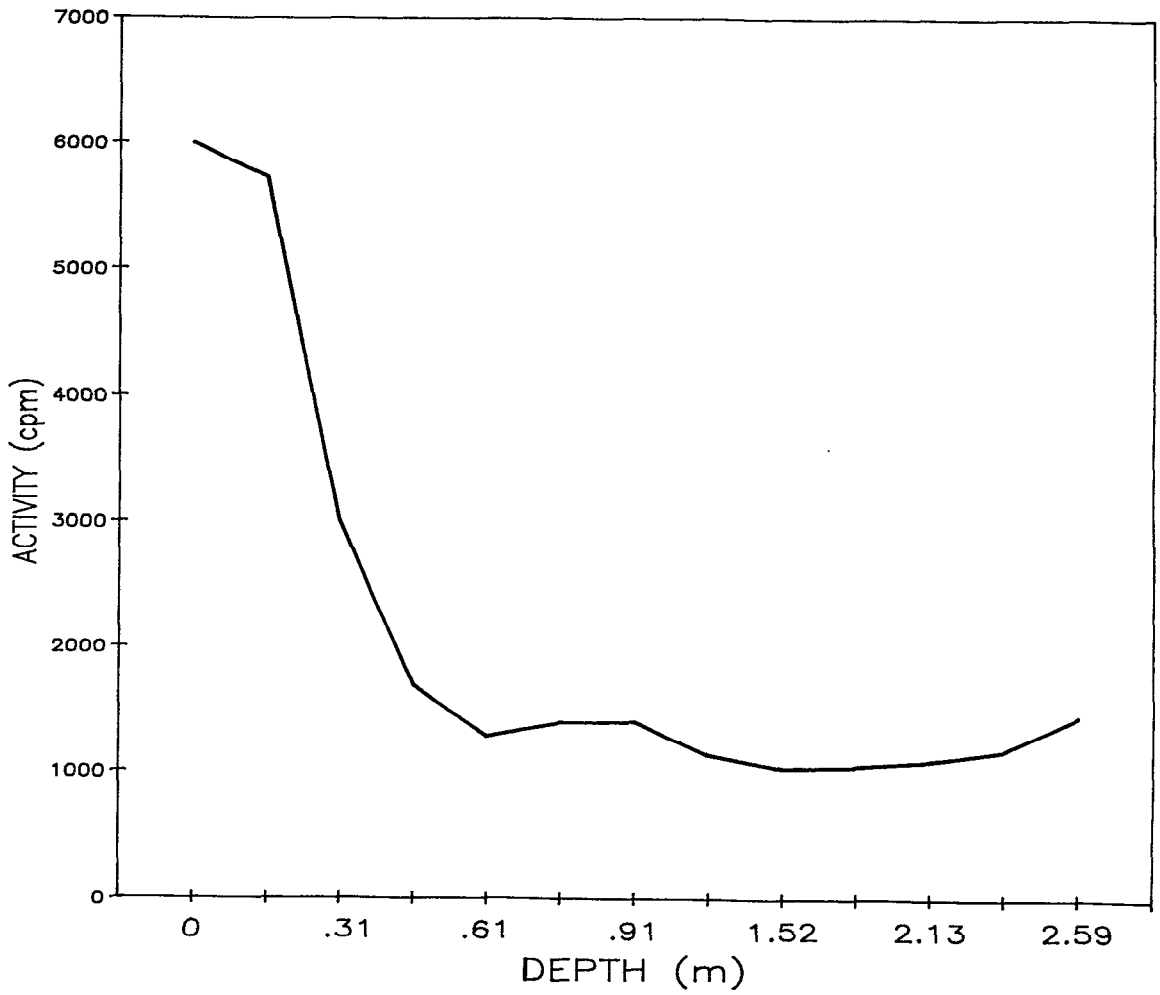



**Fig. A.1. Gamma profile of auger hole 1.**

ORNL-DWG 86-12785

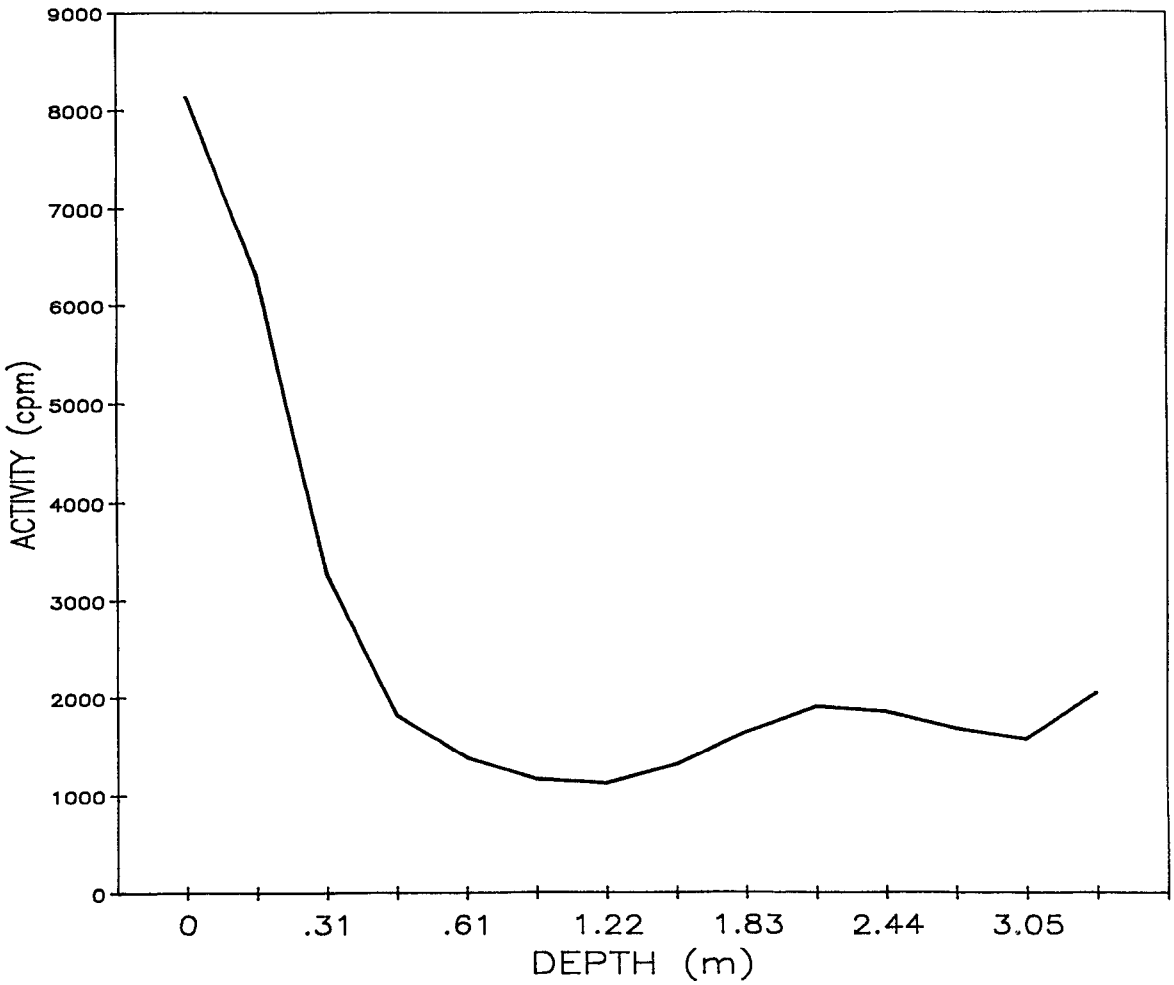



**Fig. A.2. Gamma profile of auger hole 2.**

ORNL-DWG 86-12786

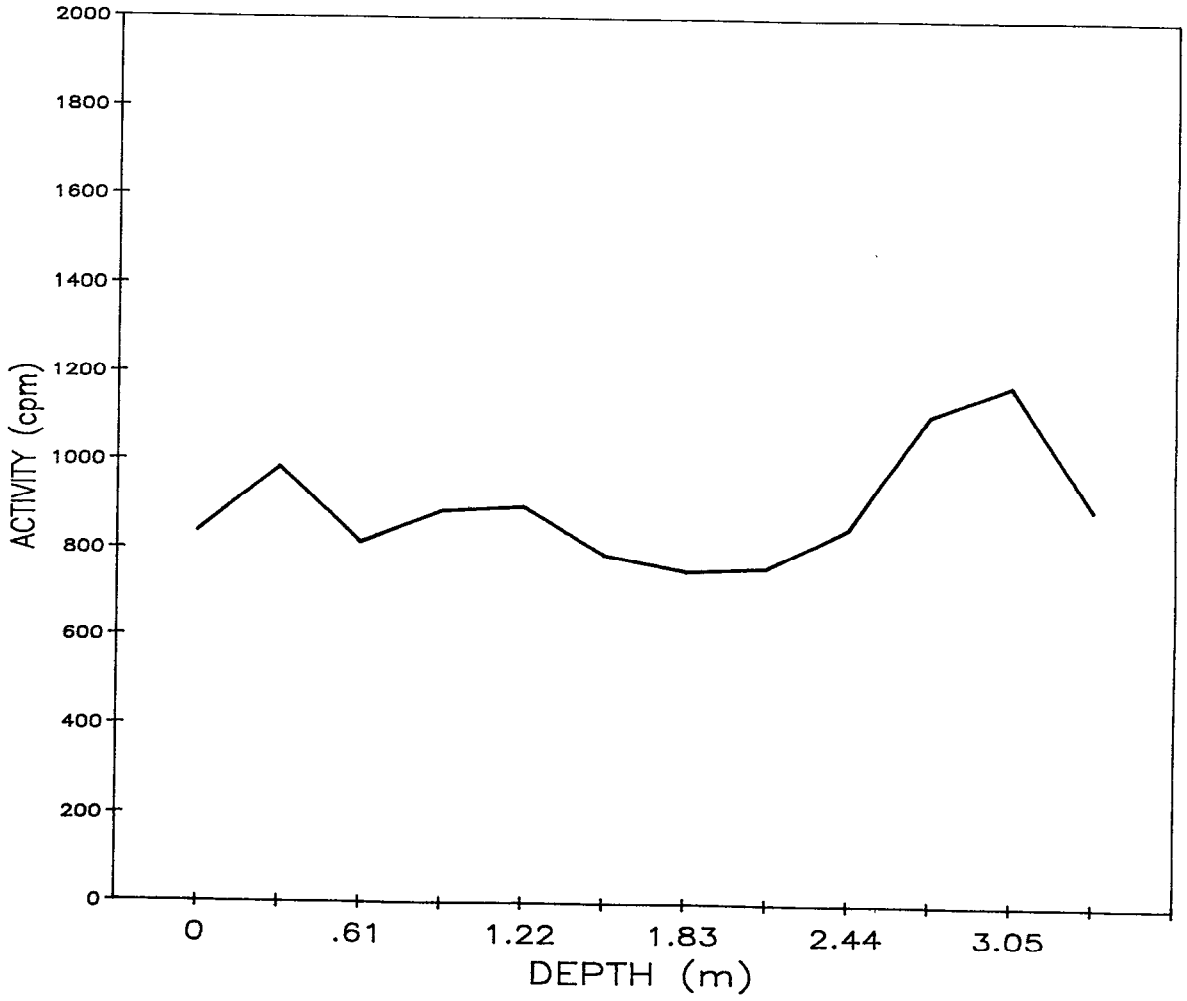



**Fig. A.3. Gamma profile of auger hole 3.**

ORNL-DWG 86-12787

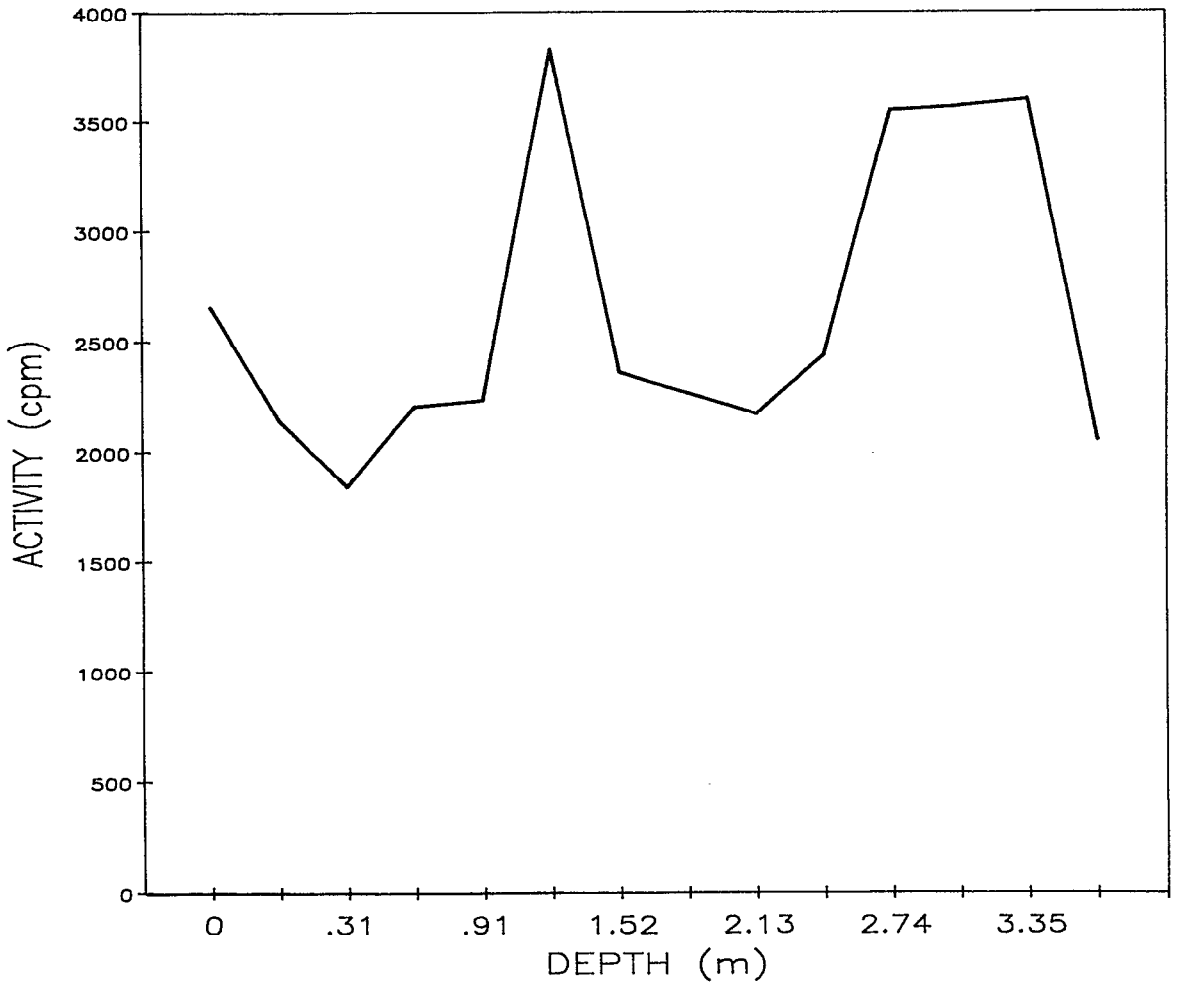



**Fig. A.4. Gamma profile of auger hole 4.**

ORNL-DWG 86-12788

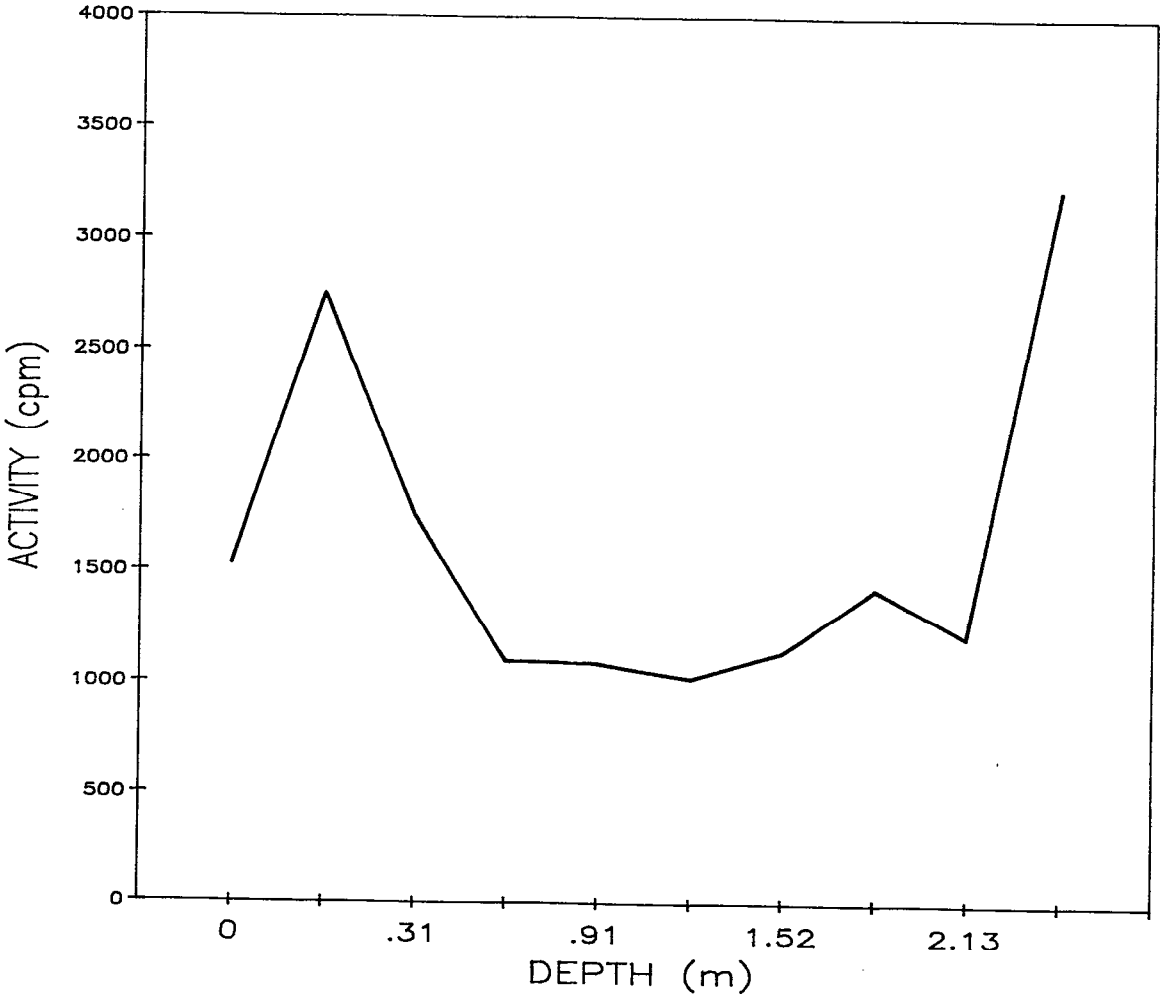



**Fig. A.5. Gamma profile of auger hole 5.**

ORNL-DWG 86-12789

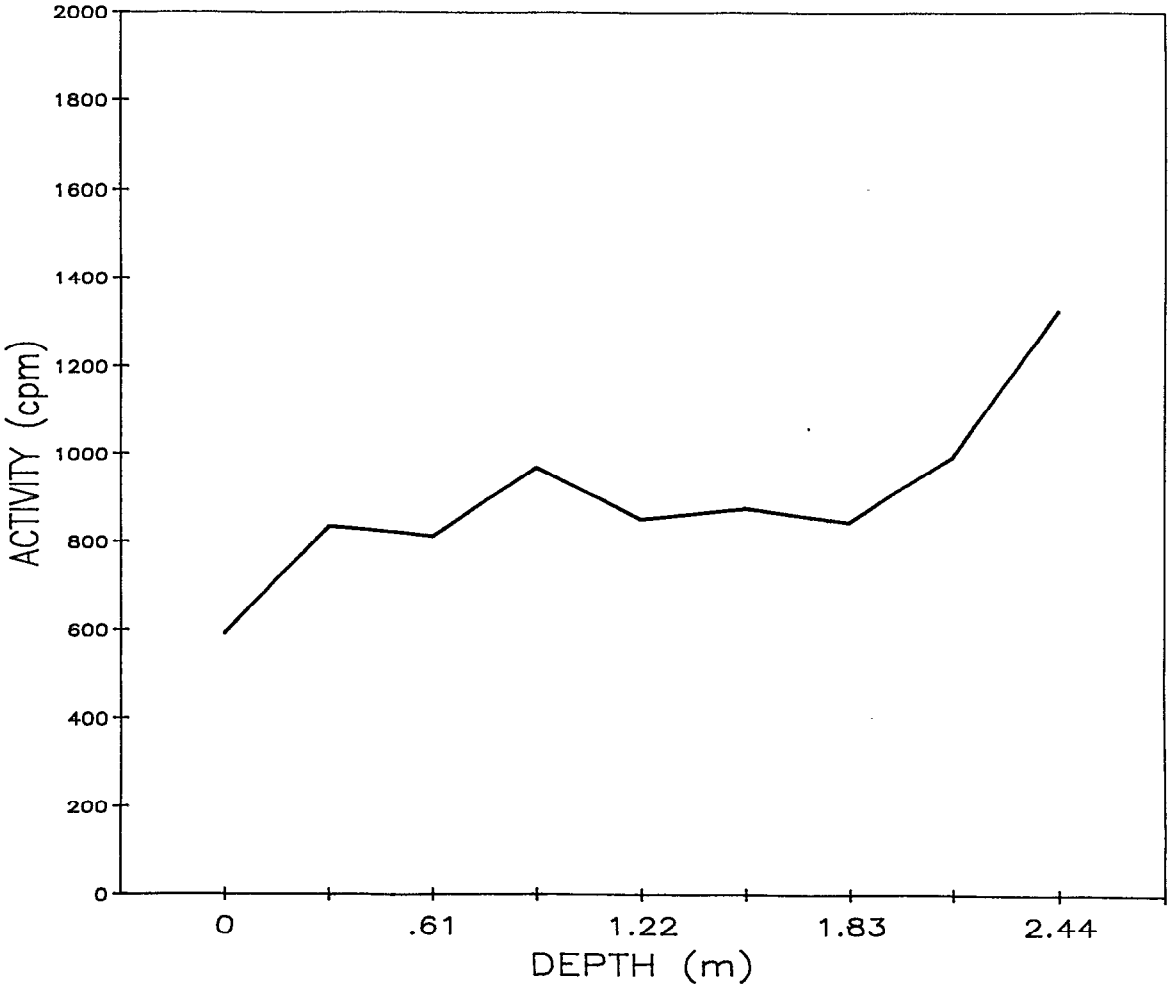



**Fig. A.6. Gamma profile of auger hole 6.**

ORNL-DWG 86-12790

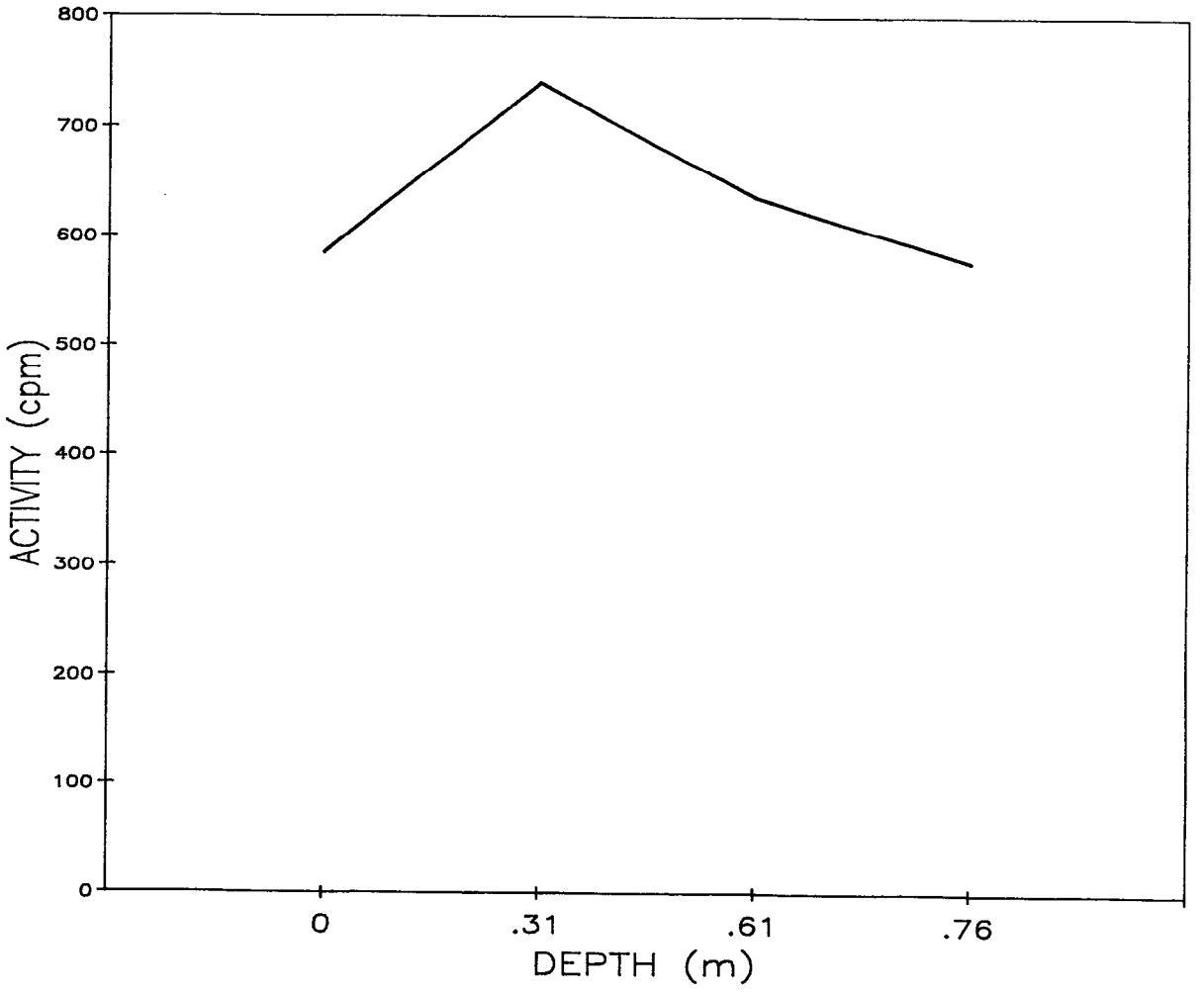



**Fig. A.7. Gamma profile of auger hole 7.**

ORNL-DWG 86-12791

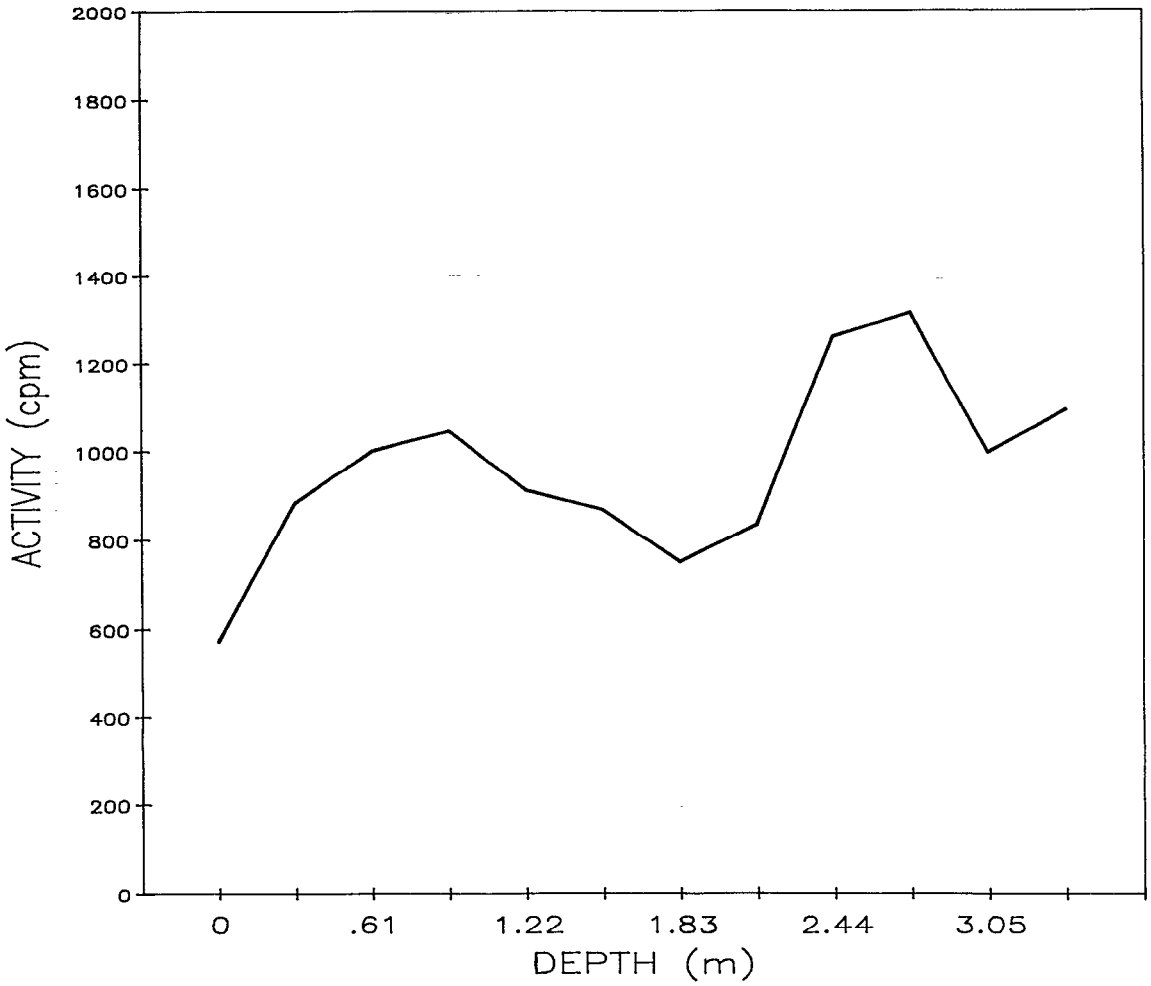



**Fig. A.8. Gamma profile of auger hole 8.**

ORNL-DWG 86-12792

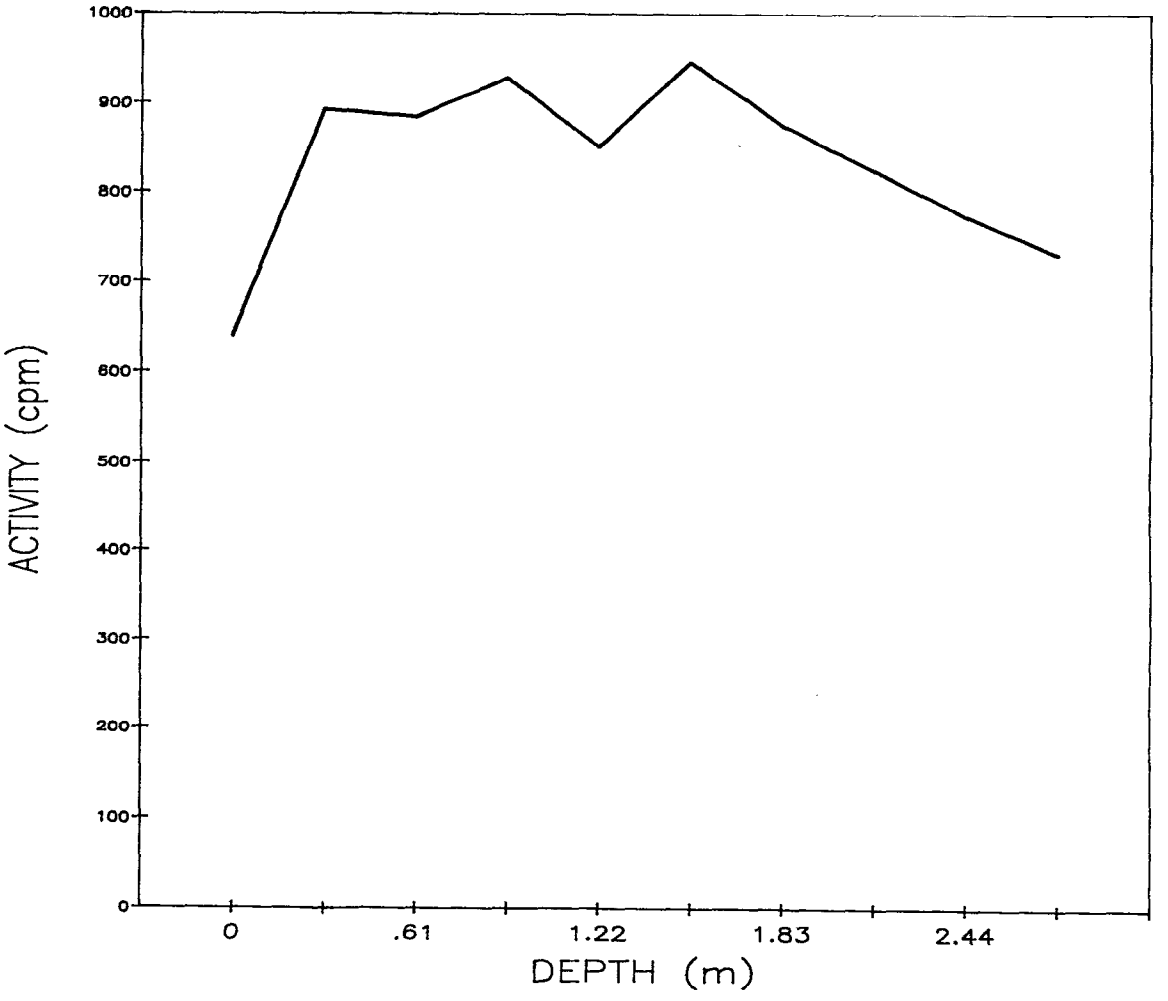



**Fig. A.9. Gamma profile of auger hole 9.**

ORNL-DWG 86-12793

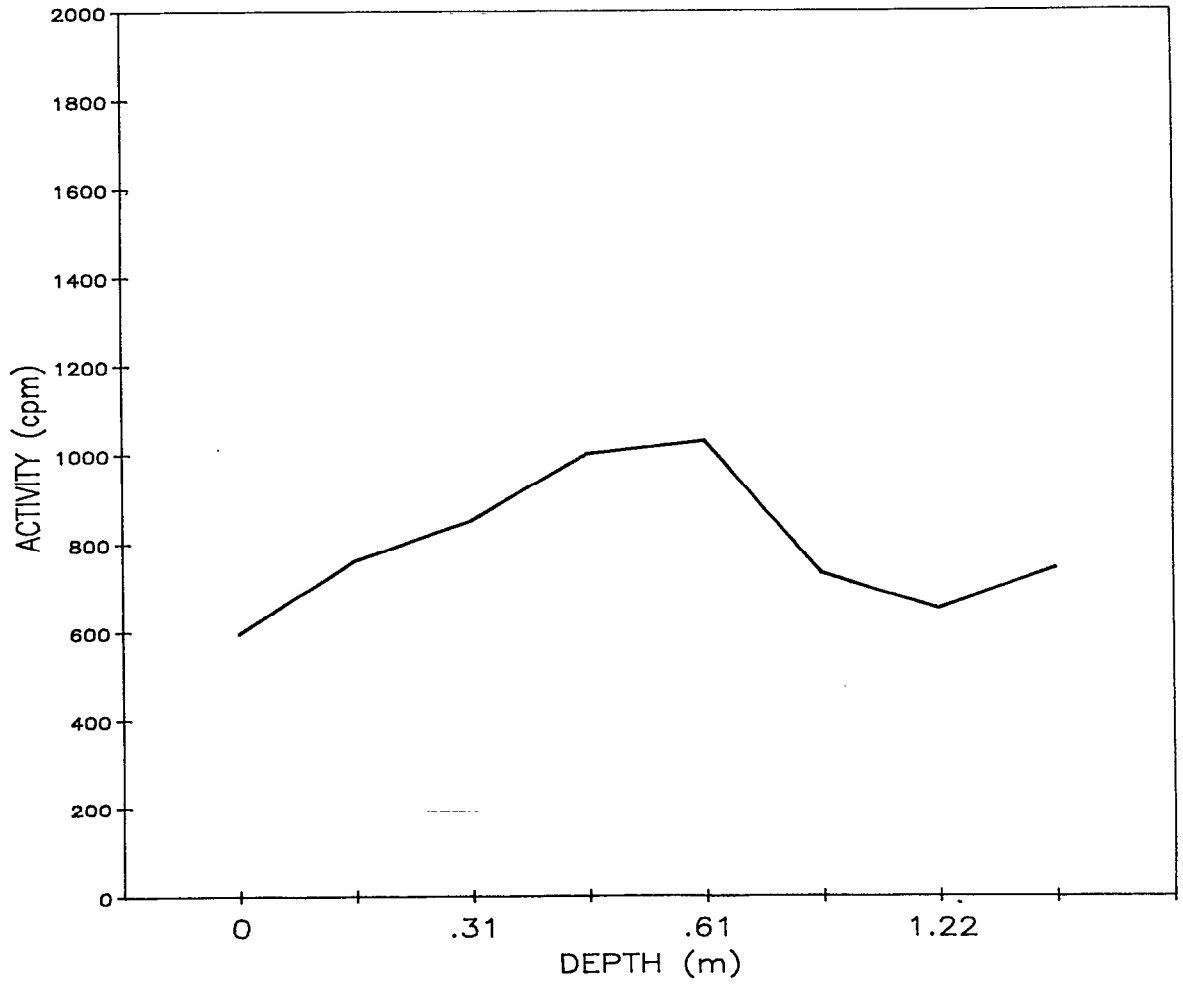



**Fig. A.10. Gamma profile of auger hole 10.**

ORNL-DWG 86-12794

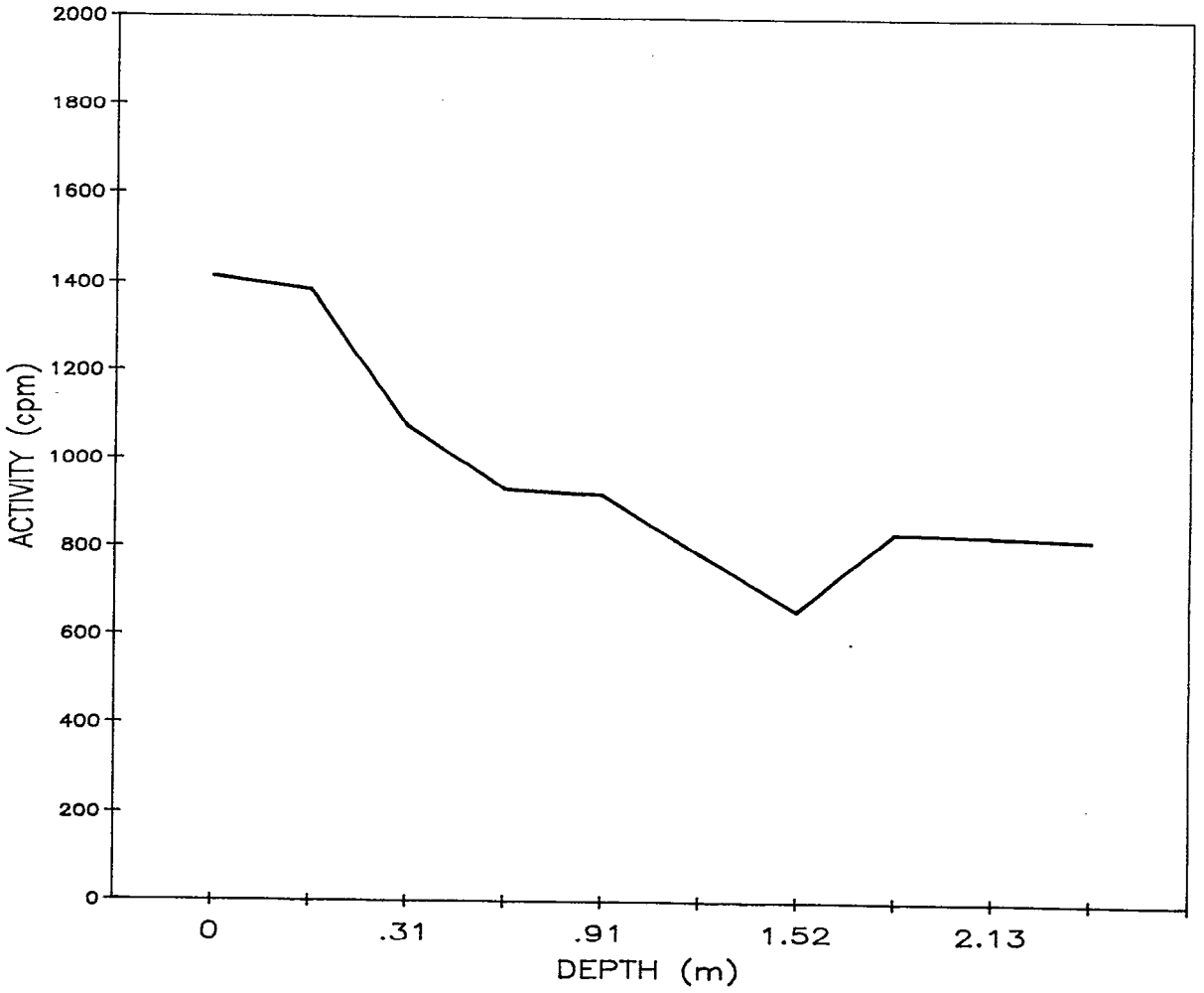



**Fig. A.11. Gamma profile of auger hole 13.**

ORNL-DWG 86-12795

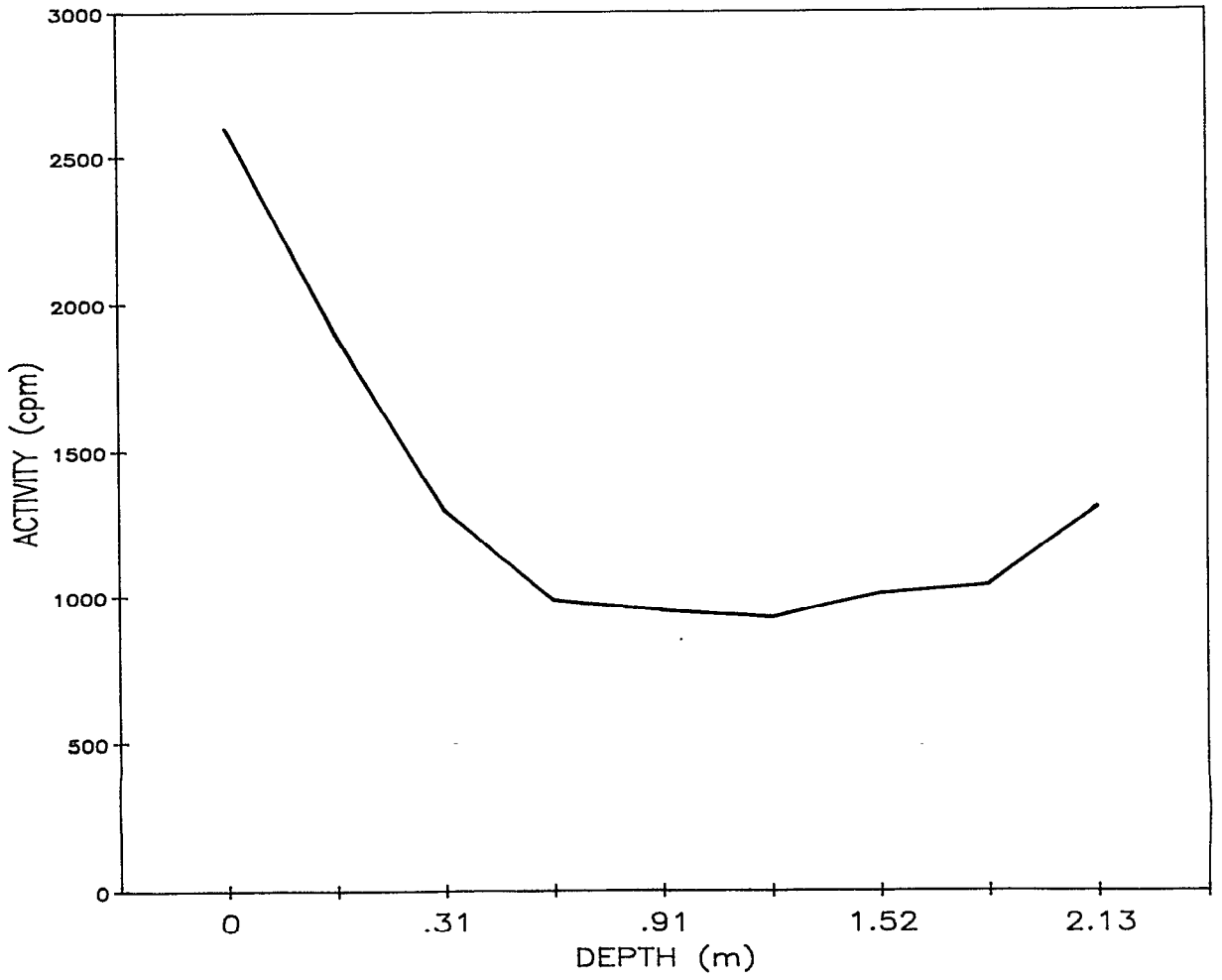



**Fig. A.12. Gamma profile of auger hole 14.**

ORNL-DWG 86-12796

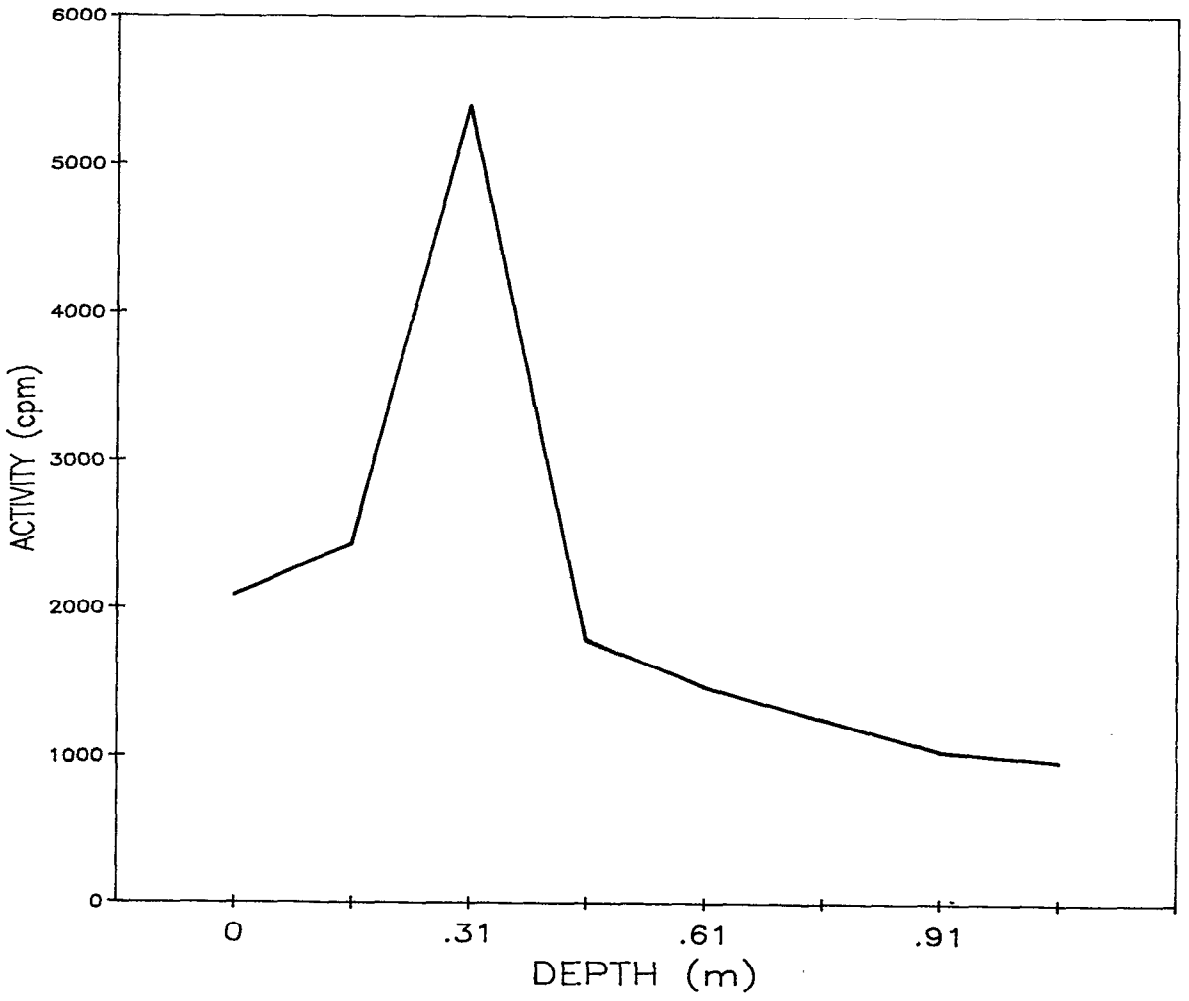



**Fig. A.13. Gamma profile of auger hole 18.**

ORNL-DWG 86-12797

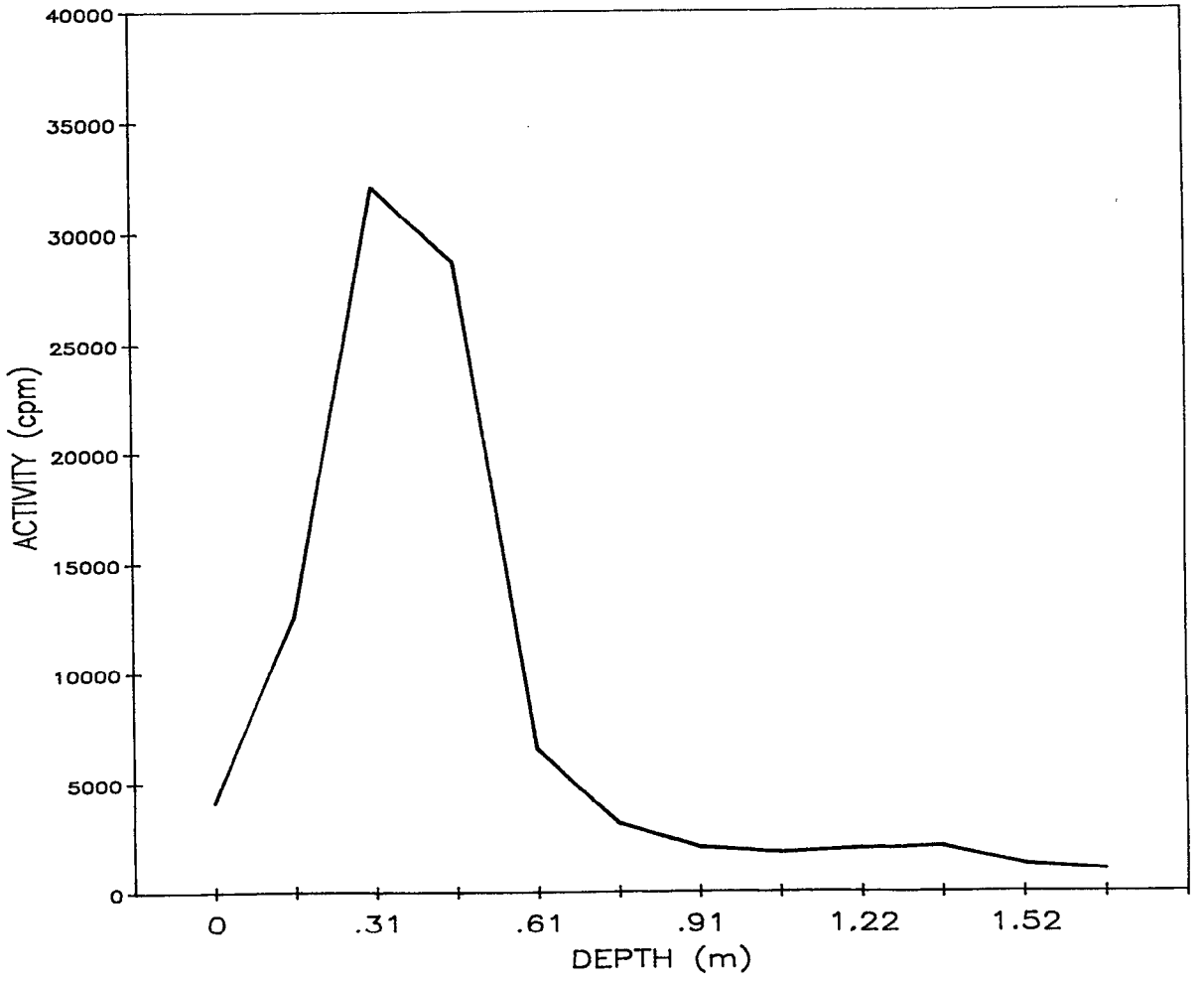



**Fig. A.14. Gamma profile of auger hole 19.**

ORNL-DWG 86-12798

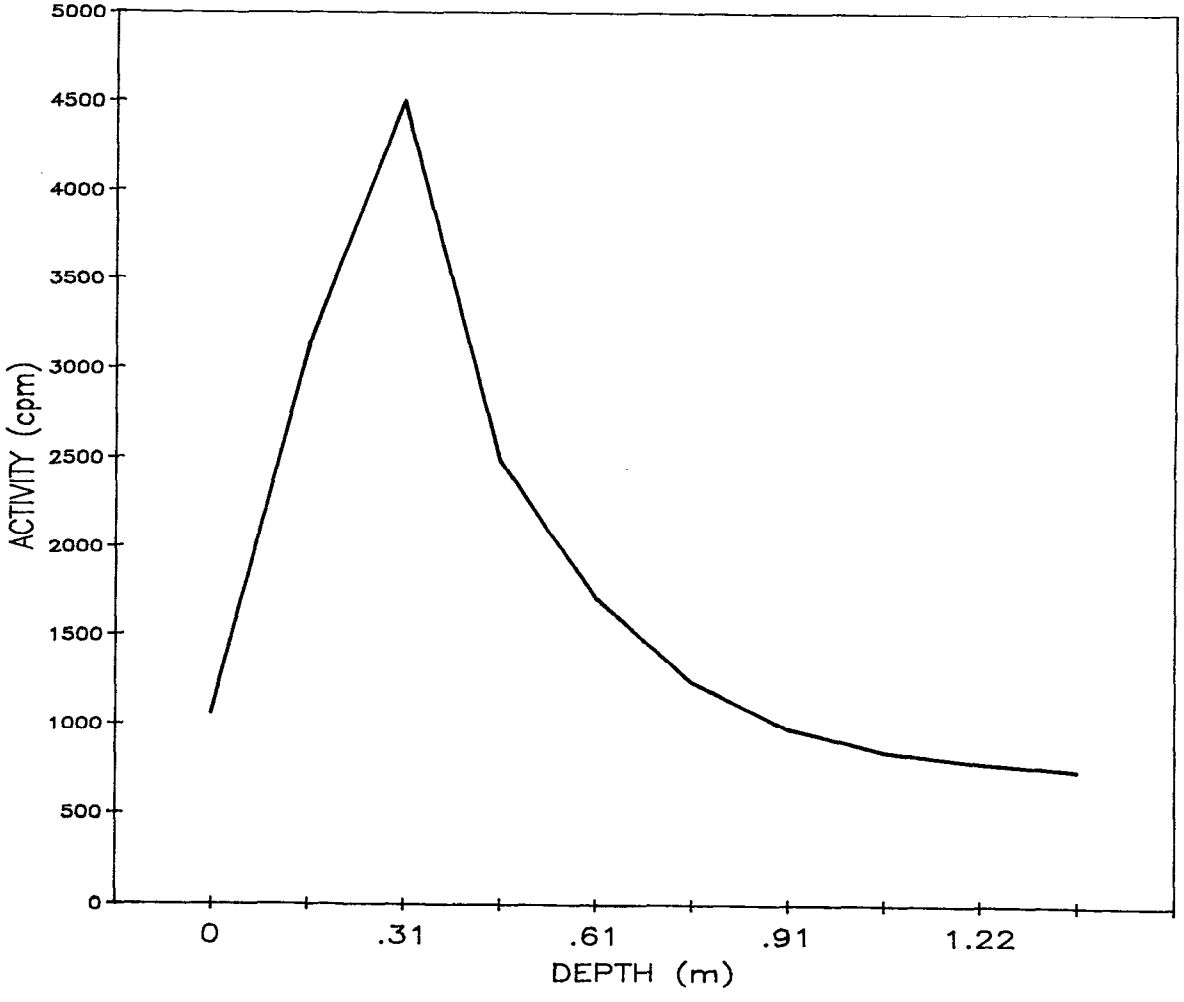



**Fig. A.15. Gamma profile of auger hole 20.**

ORNL-DWG 86-12799

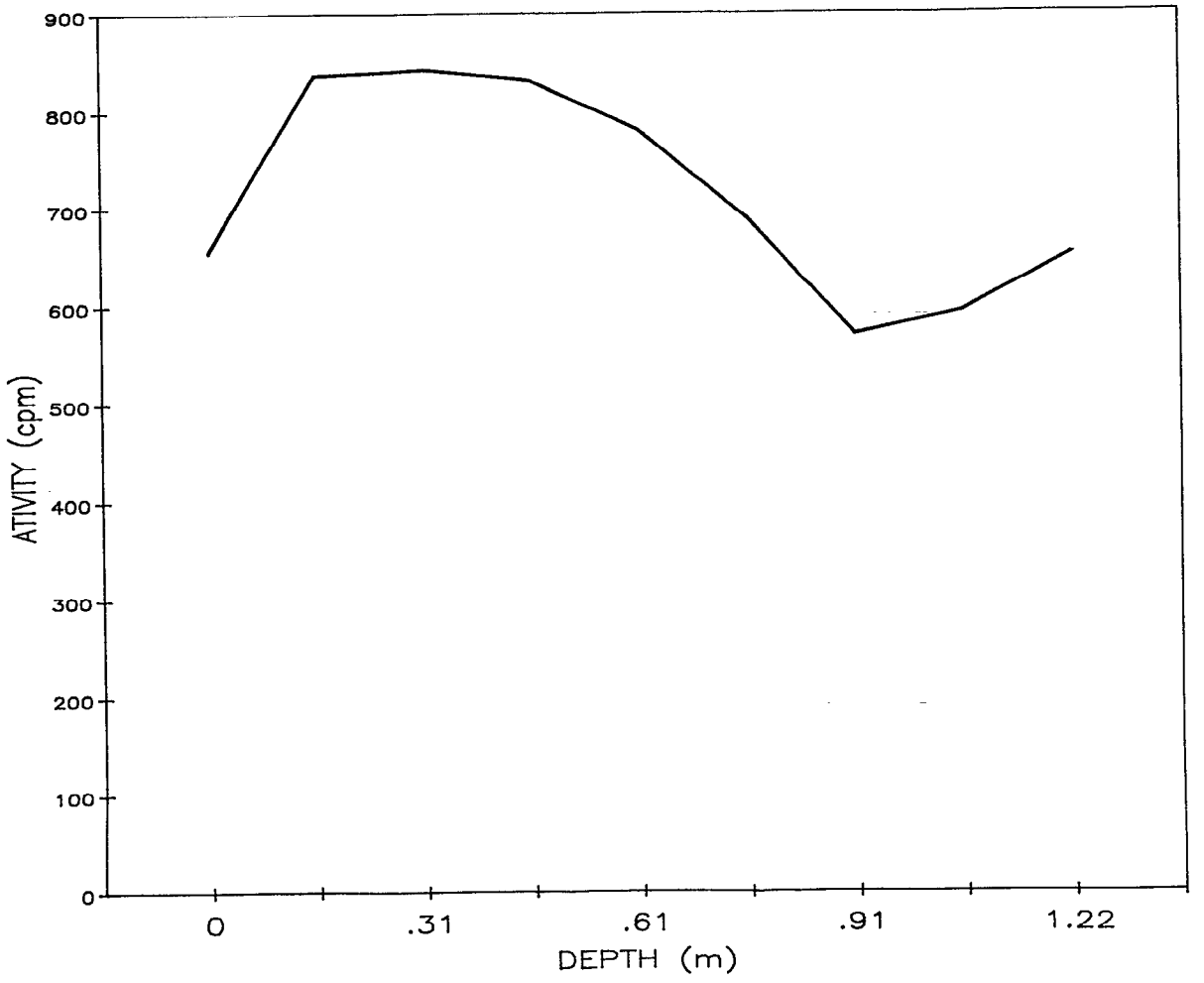



**Fig. A.16. Gamma profile of auger hole 23.**

ORNL-DWG 86-12800

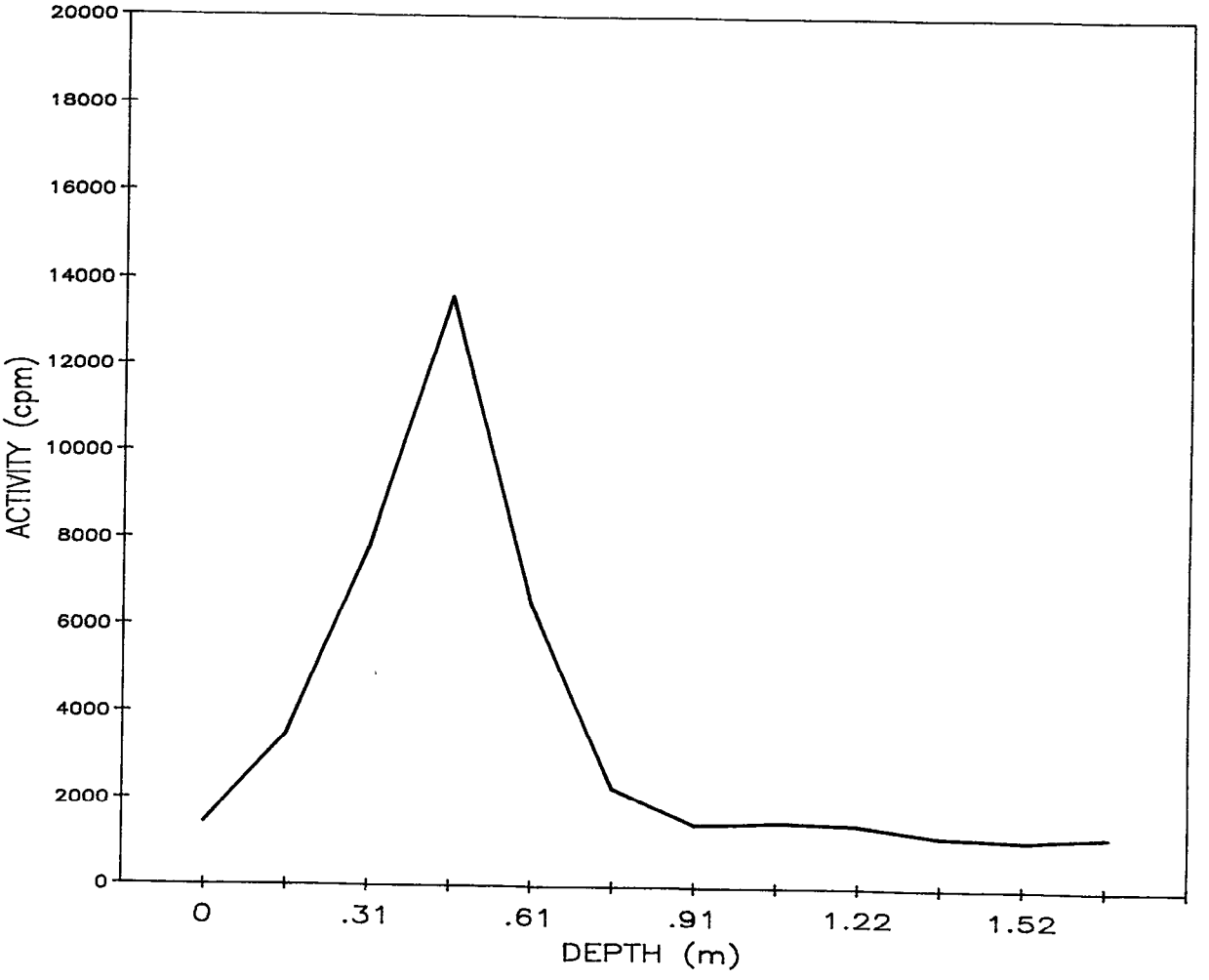



**Fig. A.17. Gamma profile of auger hole 24.**

ORNL-DWG 86-12801

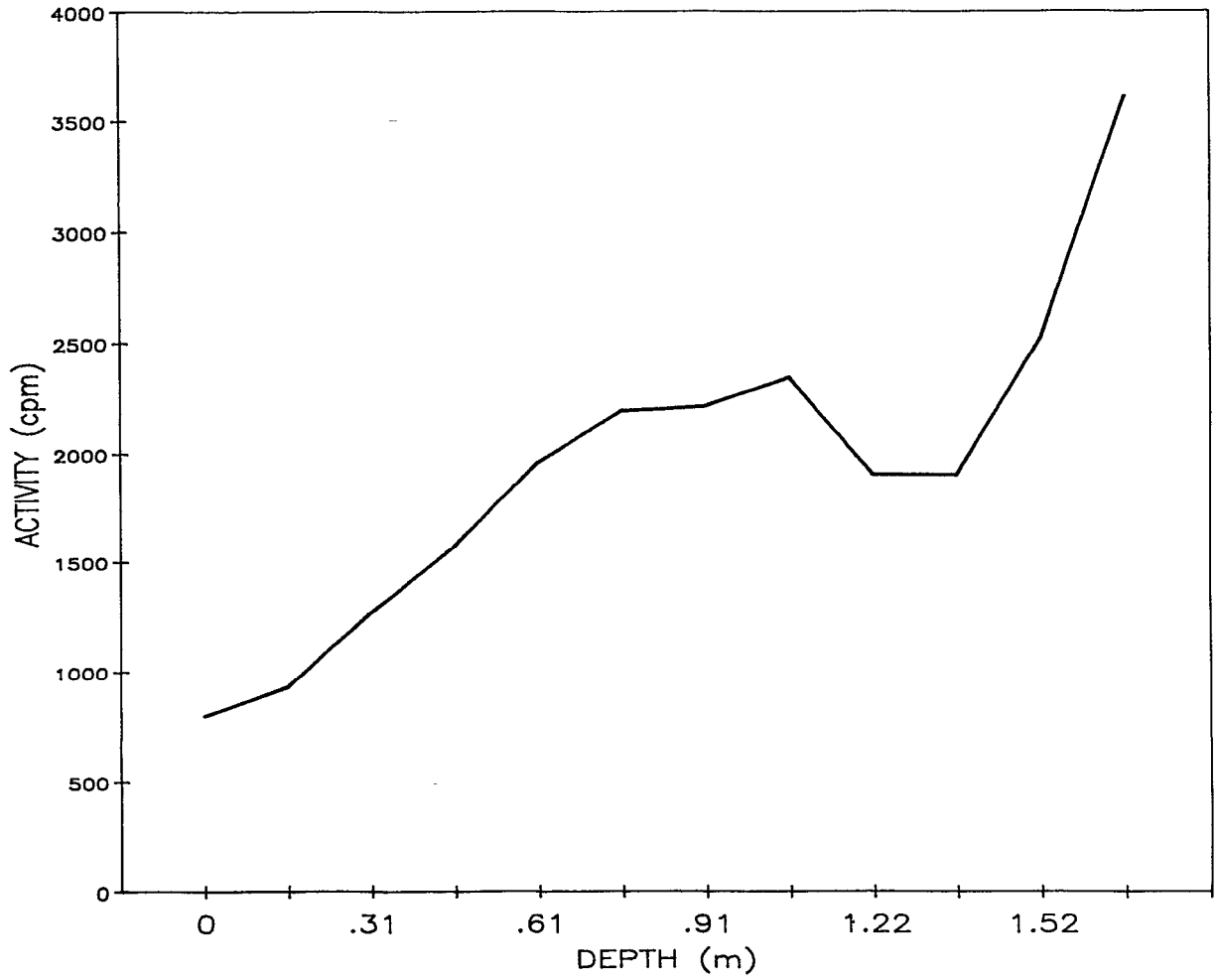



**Fig. A.18. Gamma profile of auger hole 25.**

ORNL-DWG 86-12802

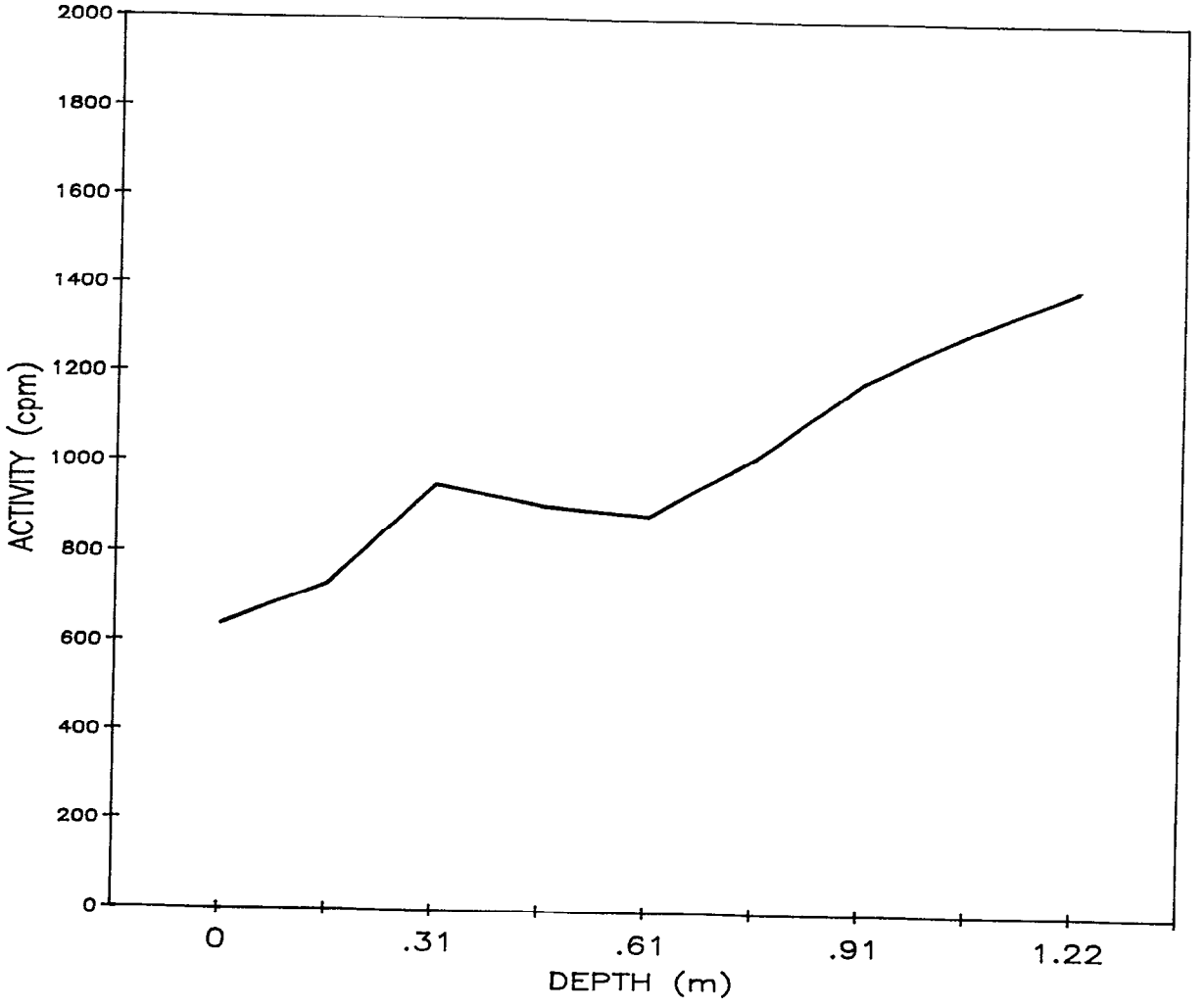



**Fig. A.19. Gamma profile of auger hole 26.**

ORNL-DWG 86-12803

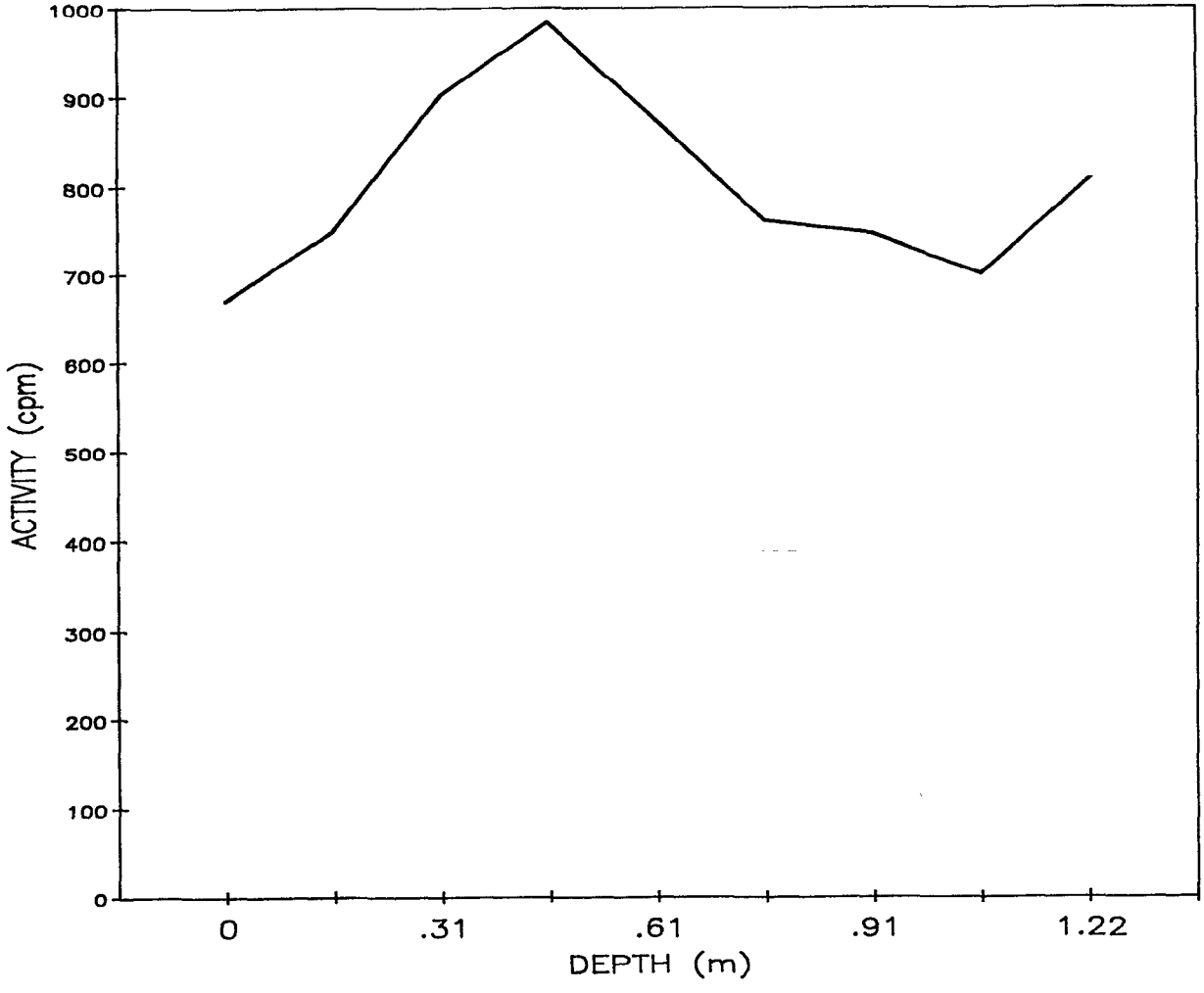



**Fig. A.20. Gamma profile of auger hole 27.**

## INTERNAL DISTRIBUTION

1. B. A. Berven
2–6. R. F. Carrier
7–16. W. D. Cottrell
17. J. T. Ensminger
18. R. D. Foley
19. A. R. Hawthorne
20. S. V. Kaye
21. G. D. Kerr
22. C. A. Little
23. J. L. Marley
24. P. T. Owen
25. H. A. Pfuderer
26. C. R. Richmond
27. T. H. Row
28. R. E. Swaja
29. J. K. Williams
30. J. P. Witherspoon
31. D. A. Witt
32. M. G. Yalcintas
33–34. Central Research Library
35. ORNL Technical Library, Y-12
36. IR&A Publications Office
37–38. Information Analysis Library
39–40. Laboratory Records
41. Laboratory Records – RC
42. ORNL Patent Office

## EXTERNAL DISTRIBUTION

43–47. P. J. Gross, U.S. Department of Energy, Technical Services Division, Oak Ridge Operations Office, Oak Ridge, TN 37831
48. J. D. Berger, Oak Ridge Associated Universities, P.O. Box 117, Oak Ridge, TN 37831
49–51. J. J. Fiore, U.S. Department of Energy, Director, Division of Facilities and Site Decommissioning Projects, Office of Nuclear Energy, 19901 Germantown Road, Germantown, MD 20874
52–55. C. E. Miller, U.S. Department of Energy, Director, Surplus Facilities Management, Richland Operations Office, P.O. Box 550, Richland, WA 99352
56–57. G. K. Hovey, Bechtel National, Inc., 800 Oak Ridge Turnpike, Oak Ridge, TN 37831
58. G. P. Turi, U.S. Department of Energy, Division of Facilities and Site Decommissioning Projects, Office of Nuclear Energy, 19901 Germantown Road, Germantown, MD 20874
59. J. W. Wagoner II, U.S. Department of Energy, Division of Facilities and Site Decommissioning Projects, Office of Nuclear Energy, 19901 Germantown Road, Germantown, MD 20874
60. A. Wallo III, U.S. Department of Energy, Division of Facilities and Site Decommissioning Projects, Office of Nuclear Energy, 19901 Germantown Road, Germantown, MD 20874
61. Office of Assistant Manager, Energy Research and Development, Oak Ridge Operations Office, Oak Ridge, TN 37831
62–71. Office of Scientific and Technical Information, U.S. Department of Energy, Oak Ridge, TN 37831

☆U.S. GOVERNMENT PRINTING OFFICE 1988–548-118/80047

120267

94-529

# Department of Energy

Oak Ridge Operations
P.O. Box 2001
Oak Ridge, Tennessee 37831— 8723

September 8, 1994

Mr. Scott Greene
Massachusetts Department of Environmental Protection
10 Commerce Way
Woburn, Massachusetts 01801

Dear Mr. Greene:

**VENTRON SITE - TRANSMITTAL OF RADIOLOGICAL DATA FROM BEVERLY HARBOR**

Enclosed are the requested radiological data for sediment samples collected during May 1994 from the Beverly Harbor near the Ventron Site. To date, there have been three sampling events at the Ventron site conducted by DOE (1991, 1992, and 1994) which have included sediment samples from the Beverly Harbor. In addition to the enclosed results for the May 1994 sampling event, data for 1991 and 1992 have also been included.

The 1991 sampling effort was conducted by the Oak Ridge National Laboratory to determine if uranium from work performed under government contract at the former Ventron facility had migrated off site. The report for this investigation (ORNL/RASA-91-29) is enclosed.

The 1992 samples were collected by Bechtel to further define existing data from the 1991 ORNL effort. The sampling results and a map showing the sampling locations are enclosed.

The 1994 sediment samples were collected during a joint sampling effort by Bechtel and CH2M Hill, Morton International's contractor. The resulting data is enclosed along with a map prepared by CH2M Hill showing the proposed sampling locations; a figure showing actual sampling locations is not yet available. None of the data for the May 1994 samples exceeded the DOE cleanup guideline of 50 pCi/g for U-238, the primary contaminant at the site. The highest concentration of U-238 detected in any of the samples was 17.40 pCi/g in sample SD-8, located adjacent to Building C-1.

If you need more information, please call me at 615-576-9441.

Sincerely,

James D. Kopotic

James D. Kopotic, Site Manager
Former Sites Restoration Division

Enclosures

cc: A.Raddatz, Morton, Inc.

120267

TMA/Eberline Oak Ridge, FUSRAP Radiological Reports
Sampling Event: 1994 Beverly Harbor Sediment Sampling Results

| Sample ID | Date Collected | Analyte | Result | Error | Units | MDA |
|---|---|---|---|---|---|---|
| 127-SD-1 | 05/24/94 | U-238 | 2.20 | 3.000 | PCI/G | 2.00 |
| 127-SD-1 | 05/24/94 | RA-226 | 0.45 | 0.160 | PCI/G | 0.29 |
| 127-SD-1 | 05/24/94 | TH-232 | 0.59 | 0.320 | PCI/G | 0.47 |
| 127-SD-1 | 05/24/94 | K-40 | 13.70 | 2.600 | PCI/G | 0.23 |
| 127-SD-1 | 05/24/94 | CS-137 | 0.58 | 0.190 | PCI/G | 0.15 |
| 127-SD-1 | 05/24/94 | SN-113 | 0.21 | 0.190 | PCI/G | 0.14 |
| 127-SD-1 | 05/24/94 | BI-214 | 0.36 | 0.250 | PCI/G | 0.29 |
| 127-SD-1 | 05/24/94 | PB-212 | 0.77 | 0.290 | PCI/G | 0.23 |
| 127-SD-1 | 05/24/94 | BI-212 | 2.30 | 0.170 | PCI/G | 2.20 |
| 127-SD-10 | 05/25/94 | K-40 | 13.30 | 2.300 | PCI/G | 1.90 |
| 127-SD-10 | 05/25/94 | RA-226 | 0.45 | 0.100 | PCI/G | 0.20 |
| 127-SD-10 | 05/25/94 | TH-232 | 0.64 | 0.550 | PCI/G | 0.30 |
| 127-SD-10 | 05/25/94 | U-238 | 3.10 | 1.900 | PCI/G | 1.40 |
| 127-SD-10 | 05/25/94 | BI-214 | 0.50 | 0.250 | PCI/G | 0.20 |
| 127-SD-10 | 05/25/94 | PB-214 | 0.87 | 1.500 | PCI/G | 0.17 |
| 127-SD-11 | 05/26/94 | U-238 | 2.20 | 1.400 | PCI/G | 1.50 |
| 127-SD-11 | 05/26/94 | RA-226 | 0.30 | 0.050 | PCI/G | 0.22 |
| 127-SD-11 | 05/26/94 | TH-232 | 0.41 | 0.370 | PCI/G | 0.33 |
| 127-SD-11 | 05/26/94 | K-40 | 13.70 | 1.900 | PCI/G | 2.10 |
| 127-SD-11 | 05/26/94 | CS-137 | 0.96 | 0.150 | PCI/G | 0.11 |
| 127-SD-11 | 05/26/94 | PB-212 | 0.53 | 0.170 | PCI/G | 0.18 |
| 127-SD-11 | 05/26/94 | PB-214 | 0.52 | 0.710 | PCI/G | 0.19 |
| 127-SD-11 | 05/26/94 | BI-211 | 0.94 | 0.530 | PCI/G | 0.54 |
| 127-SD-12 | 05/26/94 | U-238 | 2.90 | 2.200 | PCI/G | 2.60 |
| 127-SD-12 | 05/26/94 | RA-226 | 0.44 | 0.000 | PCI/G | 0.44 |
| 127-SD-12 | 05/26/94 | TH-232 | 0.72 | 0.000 | PCI/G | 0.72 |
| 127-SD-12 | 05/26/94 | K-40 | 21.40 | 2.800 | PCI/G | 3.50 |
| 127-SD-12 | 05/26/94 | CS-137 | 0.10 | 0.130 | PCI/G | 0.19 |
| 127-SD-12 | 05/26/94 | PB-212 | 0.74 | 0.270 | PCI/G | 0.30 |
| 127-SD-12 | 05/26/94 | BI-211 | 1.10 | 0.660 | PCI/G | 2.40 |
| 127-SD-13 | 05/24/94 | U-238 | 2.40 | 2.100 | PCI/G | 1.70 |
| 127-SD-13 | 05/24/94 | RA-226 | 0.49 | 0.270 | PCI/G | 0.24 |
| 127-SD-13 | 05/24/94 | TH-232 | 0.59 | 0.250 | PCI/G | 0.36 |
| 127-SD-13 | 05/24/94 | K-40 | 12.90 | 2.600 | PCI/G | 2.30 |
| 127-SD-13 | 05/24/94 | BI-214 | 0.31 | 0.250 | PCI/G | 0.44 |
| 127-SD-13 | 05/24/94 | PB-214 | 0.96 | 1.300 | PCI/G | 2.10 |
| 127-SD-13 | 05/24/94 | BI-212 | 1.30 | 1.300 | PCI/G | 1.60 |
| 127-SD-13 | 05/24/94 | BI-211 | 1.50 | 0.790 | PCI/G | 0.60 |
| 127-SD-13 | 05/24/94 | BE-7 | 0.99 | 1.700 | PCI/G | 0.90 |
| 127-SD-13 | 05/24/94 | CO-58 | 0.08 | 0.130 | PCI/G | 0.11 |
| 127-SD-13 | 05/24/94 | CS-137 | 0.29 | 0.100 | PCI/G | 0.13 |
| 127-SD-13 | 05/24/94 | RA-228 | 0.63 | 0.210 | PCI/G | 0.52 |
| 127-SD-14 | 05/26/94 | U-238 | 1.80 | 2.700 | PCI/G | 2.60 |
| 127-SD-14 | 05/26/94 | RA-226 | 0.43 | 0.000 | PCI/G | 0.43 |
| 127-SD-14 | 05/26/94 | TH-232 | 0.58 | 0.000 | PCI/G | 0.58 |
| 127-SD-14 | 05/26/94 | K-40 | 14.40 | 2.900 | PCI/G | 0.30 |
| 127-SD-14 | 05/26/94 | CS-137 | 0.20 | 0.100 | PCI/G | 0.20 |

120267

TMA/Eberline Oak Ridge, FUSRAP Radiological Reports
Sampling Event: 1994 Beverly Harbor Sediment Sampling Results

| Sample ID | Date Collected | Analyte | Result | Error | Units | MDA |
|---|---|---|---|---|---|---|
| 127-SD-14 | 05/26/94 | PB-212 | 0.60 | 0.200 | PCI/G | 0.30 |
| 127-SD-15 | 05/26/94 | U-238 | 1.50 | 1.400 | PCI/G | 1.70 |
| 127-SD-15 | 05/26/94 | RA-226 | 0.56 | 0.260 | PCI/G | 0.26 |
| 127-SD-15 | 05/26/94 | TH-232 | 0.45 | 0.340 | PCI/G | 0.41 |
| 127-SD-15 | 05/26/94 | K-40 | 12.20 | 2.000 | PCI/G | 0.20 |
| 127-SD-15 | 05/26/94 | MN-54 | 0.07 | 0.110 | PCI/G | 0.10 |
| 127-SD-15 | 05/26/94 | CS-137 | 0.06 | 0.080 | PCI/G | 0.13 |
| 127-SD-15 | 05/26/94 | PB-212 | 0.55 | 0.190 | PCI/G | 0.20 |
| 127-SD-15 | 05/26/94 | PB-214 | 0.72 | 0.480 | PCI/G | 0.21 |
| 127-SD-15 | 05/26/94 | BI-212 | 1.20 | 0.930 | PCI/G | 1.90 |
| 127-SD-16 | 05/26/94 | U-238 | 4.00 | 2.000 | PCI/G | 2.00 |
| 127-SD-16 | 05/26/94 | RA-226 | 0.37 | 0.000 | PCI/G | 0.37 |
| 127-SD-16 | 05/26/94 | TH-232 | 0.81 | 0.330 | PCI/G | 0.43 |
| 127-SD-16 | 05/26/94 | K-40 | 15.00 | 2.100 | PCI/G | 2.70 |
| 127-SD-16 | 05/26/94 | CO-58 | 0.13 | 0.110 | PCI/G | 0.13 |
| 127-SD-16 | 05/26/94 | RA-228 | 0.96 | 0.160 | PCI/G | 0.61 |
| 127-SD-16 | 05/26/94 | PB-212 | 0.69 | 0.240 | PCI/G | 0.23 |
| 127-SD-17 | 05/25/94 | CS-137 | 0.33 | 0.300 | PCI/G | 0.30 |
| 127-SD-17 | 05/25/94 | K-40 | 15.50 | 4.200 | PCI/G | 5.40 |
| 127-SD-17 | 05/25/94 | TH-232 | 1.10 | 0.000 | PCI/G | 1.10 |
| 127-SD-17 | 05/25/94 | U-238 | 5.70 | 0.000 | PCI/G | 5.70 |
| 127-SD-17 | 05/25/94 | RA-226 | 0.91 | 0.000 | PCI/G | 0.91 |
| 127-SD-18 | 05/24/94 | U-238 | 6.30 | 6.900 | PCI/G | 4.50 |
| 127-SD-18 | 05/24/94 | RA-226 | 0.92 | 0.000 | PCI/G | 0.92 |
| 127-SD-18 | 05/24/94 | TH-232 | 1.20 | 0.000 | PCI/G | 1.20 |
| 127-SD-18 | 05/24/94 | K-40 | 18.40 | 5.200 | PCI/G | 0.53 |
| 127-SD-18 | 05/24/94 | CS-137 | 0.52 | 0.300 | PCI/G | 0.35 |
| 127-SD-18 | 05/24/94 | RU-106 | 1.10 | 2.200 | PCI/G | 3.40 |
| 127-SD-19 | 05/26/94 | U-238 | 3.10 | 0.000 | PCI/G | 3.10 |
| 127-SD-19 | 05/26/94 | RA-226 | 0.42 | 0.150 | PCI/G | 0.30 |
| 127-SD-19 | 05/26/94 | TH-232 | 0.67 | 0.240 | PCI/G | 0.48 |
| 127-SD-19 | 05/26/94 | K-40 | 12.80 | 2.900 | PCI/G | 0.24 |
| 127-SD-19 | 05/26/94 | CR-51 | 1.50 | 2.000 | PCI/G | 0.82 |
| 127-SD-19 | 05/26/94 | CS-137 | 0.13 | 0.130 | PCI/G | 0.16 |
| 127-SD-19 | 05/26/94 | PB-214 | 0.96 | 1.900 | PCI/G | 0.25 |
| 127-SD-19 | 05/26/94 | BI-211 | 0.95 | 0.760 | PCI/G | 0.70 |
| 127-SD-2 | 05/24/94 | U-238 | 11.40 | 2.100 | PCI/G | 1.60 |
| 127-SD-2 | 05/24/94 | RA-226 | 0.37 | 0.200 | PCI/G | 0.24 |
| 127-SD-2 | 05/24/94 | TH-232 | 0.86 | 0.500 | PCI/G | 0.38 |
| 127-SD-2 | 05/24/94 | K-40 | 9.90 | 2.200 | PCI/G | 0.19 |
| 127-SD-2 | 05/24/94 | AM-241 | 0.25 | 0.180 | PCI/G | 0.16 |
| 127-SD-2 | 05/24/94 | CS-137 | 0.54 | 0.160 | PCI/G | 0.12 |
| 127-SD-2 | 05/24/94 | U-235 | 0.70 | 0.180 | PCI/G | 0.73 |
| 127-SD-2 | 05/24/94 | RA-228 | 0.88 | 0.570 | PCI/G | 0.42 |
| 127-SD-2 | 05/24/94 | PB-212 | 0.83 | 0.290 | PCI/G | 0.19 |
| 127-SD-2 | 05/24/94 | PB-214 | 0.76 | 1.200 | PCI/G | 0.19 |
| 127-SD-2 | 05/24/94 | TE-123 | 0.09 | 0.090 | PCI/G | 0.08 |

120267

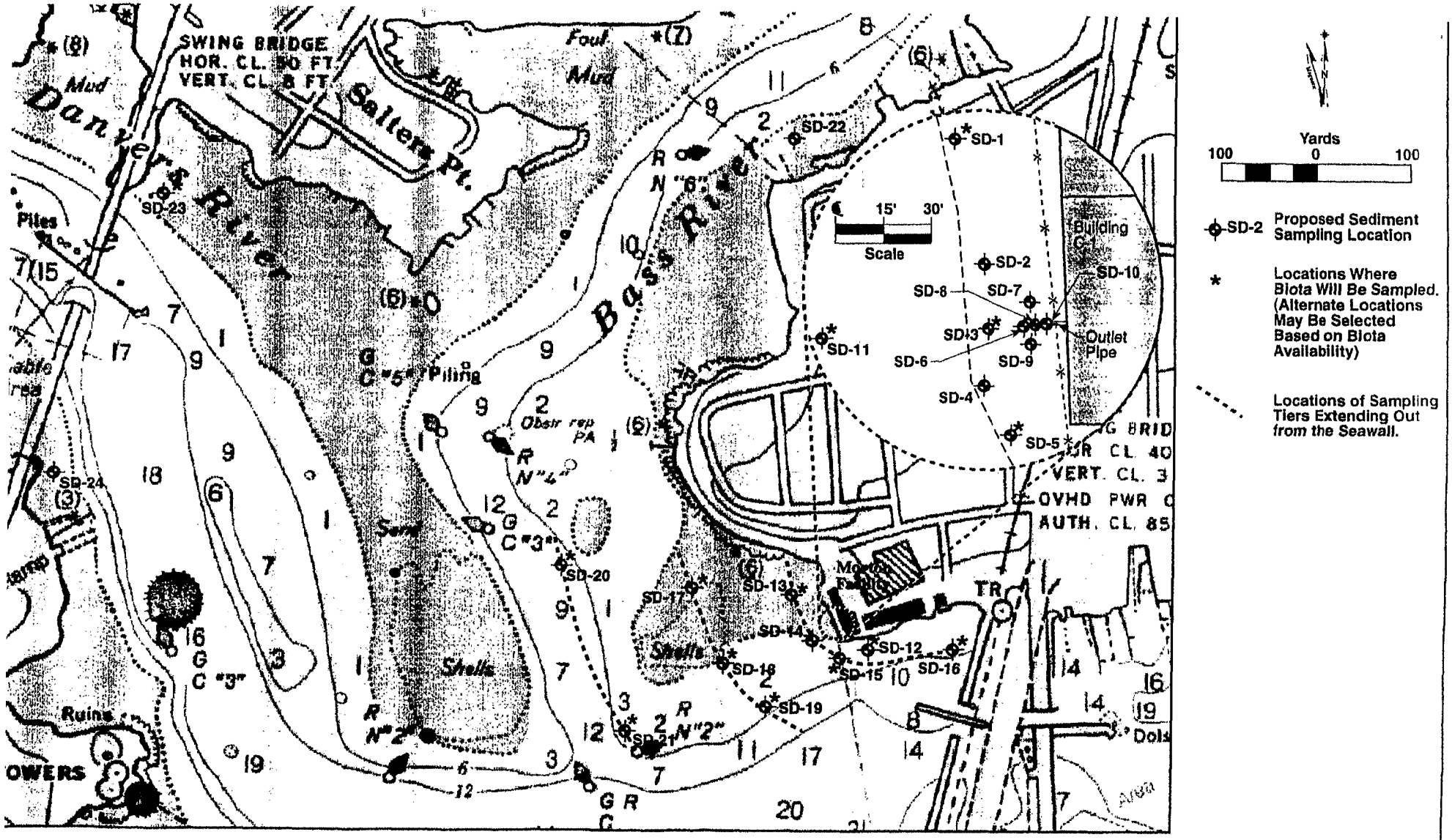
TMA/Eberline Oak Ridge, FUSRAP Radiological Reports
Sampling Event: 1994 Beverly Harbor Sediment Sampling Results

| Sample ID | Date Collected | Analyte | Result | Error | Units | MDA |
|---|---|---|---|---|---|---|
| 127-SD-2 | 05/24/94 | BI-212 | 1.50 | 1.700 | PCI/G | 1.80 |
| 127-SD-20 | 05/25/94 | U-238 | 10.20 | 5.000 | PCI/G | 5.80 |
| 127-SD-20 | 05/25/94 | RA-226 | 0.89 | 0.000 | PCI/G | 0.89 |
| 127-SD-20 | 05/25/94 | TH-232 | 1.30 | 0.000 | PCI/G | 1.30 |
| 127-SD-20 | 05/25/94 | K-40 | 29.10 | 4.800 | PCI/G | 8.00 |
| 127-SD-20 | 05/25/94 | PB-212 | 1.30 | 0.580 | PCI/G | 0.67 |
| 127-SD-20 | 05/25/94 | BI-211 | 2.90 | 1.900 | PCI/G | 2.10 |
| 127-SD-21 | 05/25/94 | U-238 | 1.00 | 1.900 | PCI/G | 2.10 |
| 127-SD-21 | 05/25/94 | RA-226 | 0.44 | 0.010 | PCI/G | 0.31 |
| 127-SD-21 | 05/25/94 | TH-232 | 0.66 | 0.000 | PCI/G | 0.66 |
| 127-SD-21 | 05/25/94 | K-40 | 16.40 | 3.100 | PCI/G | 3.00 |
| 127-SD-21 | 05/25/94 | CD-109 | 1.30 | 2.000 | PCI/G | 2.60 |
| 127-SD-21 | 05/25/94 | BI-214 | 0.44 | 0.220 | PCI/G | 0.31 |
| 127-SD-21 | 05/25/94 | BI-212 | 1.30 | 1.700 | PCI/G | 2.10 |
| 127-SD-21 | 05/25/94 | PB-212 | 0.63 | 0.210 | PCI/G | 0.25 |
| 127-SD-23 | 05/24/94 | U-238 | 3.60 | 3.900 | PCI/G | 3.20 |
| 127-SD-23 | 05/24/94 | RA-226 | 0.99 | 0.480 | PCI/G | 0.48 |
| 127-SD-23 | 05/24/94 | TH-232 | 1.10 | 0.000 | PCI/G | 1.10 |
| 127-SD-23 | 05/24/94 | K-40 | 19.80 | 4.100 | PCI/G | 0.38 |
| 127-SD-23 | 05/24/94 | MN-54 | 0.29 | 0.000 | PCI/G | 0.29 |
| 127-SD-23 | 05/24/94 | CS-137 | 0.60 | 0.270 | PCI/G | 0.25 |
| 127-SD-23 | 05/24/94 | PB-212 | 1.60 | 0.340 | PCI/G | 0.38 |
| 127-SD-23 | 05/24/94 | PB-214 | 2.60 | 4.600 | PCI/G | 0.39 |
| 127-SD-23 | 05/24/94 | BI-214 | 0.77 | 0.560 | PCI/G | 0.48 |
| 127-SD-3 | 05/24/94 | U-238 | 8.40 | 2.800 | PCI/G | 1.80 |
| 127-SD-3 | 05/24/94 | RA-226 | 0.43 | 0.080 | PCI/G | 0.26 |
| 127-SD-3 | 05/24/94 | TH-232 | 0.70 | 0.560 | PCI/G | 0.40 |
| 127-SD-3 | 05/24/94 | K-40 | 11.10 | 2.600 | PCI/G | 2.50 |
| 127-SD-3 | 05/24/94 | CO-58 | 0.03 | 0.100 | PCI/G | 0.12 |
| 127-SD-3 | 05/24/94 | CS-137 | 0.19 | 0.120 | PCI/G | 0.14 |
| 127-SD-3 | 05/24/94 | PB-212 | 0.79 | 0.290 | PCI/G | 0.21 |
| 127-SD-3 | 05/24/94 | PB-214 | 0.93 | 1.800 | PCI/G | 0.23 |
| 127-SD-4 | 05/24/94 | U-238 | 5.20 | 2.400 | PCI/G | 2.20 |
| 127-SD-4 | 05/24/94 | RA-226 | 0.38 | 0.000 | PCI/G | 0.38 |
| 127-SD-4 | 05/24/94 | TH-232 | 0.54 | 0.000 | PCI/G | 0.54 |
| 127-SD-4 | 05/24/94 | K-40 | 10.60 | 2.400 | PCI/G | 0.25 |
| 127-SD-4 | 05/24/94 | CS-137 | 0.06 | 0.070 | PCI/G | 0.17 |
| 127-SD-4 | 05/24/94 | U-235 | 0.42 | 0.190 | PCI/G | 0.98 |
| 127-SD-4 | 05/24/94 | PB-212 | 0.50 | 0.160 | PCI/G | 0.25 |
| 127-SD-4 | 05/24/94 | BI-212 | 1.50 | 1.200 | PCI/G | 2.40 |
| 127-SD-5 | 05/24/94 | U-238 | 13.00 | 3.500 | PCI/G | 1.80 |
| 127-SD-5 | 05/24/94 | RA-226 | 0.39 | 0.000 | PCI/G | 0.39 |
| 127-SD-5 | 05/24/94 | TH-232 | 0.66 | 0.000 | PCI/G | 0.66 |
| 127-SD-5 | 05/24/94 | K-40 | 12.60 | 2.500 | PCI/G | 0.22 |
| 127-SD-5 | 05/24/94 | CS-137 | 0.37 | 0.130 | PCI/G | 0.14 |
| 127-SD-5 | 05/24/94 | U-235 | 0.45 | 0.210 | PCI/G | 0.83 |
| 127-SD-6 | 05/25/94 | K-40 | 15.00 | 2.600 | PCI/G | 2.40 |

120267

TMA/Eberline Oak Ridge, FUSRAP Radiological Reports
Sampling Event: 1994 Beverly Harbor Sediment Sampling Results

| Sample ID | Date Collected | Analyte | Result | Error | Units | MDA |
|---|---|---|---|---|---|---|
| 127-SD-6 | 05/25/94 | RA-226 | 0.72 | 0.170 | PCI/G | 0.24 |
| 127-SD-6 | 05/25/94 | U-235 | 0.81 | 0.190 | PCI/G | 0.81 |
| 127-SD-6 | 05/25/94 | TH-232 | 0.75 | 0.280 | PCI/G | 0.37 |
| 127-SD-6 | 05/25/94 | U-238 | 11.90 | 3.000 | PCI/G | 1.70 |
| 127-SD-6 | 05/25/94 | PB-212 | 0.83 | 0.270 | PCI/G | 0.20 |
| 127-SD-6 | 05/25/94 | PB-214 | 1.10 | 1.200 | PCI/G | 0.21 |
| 127-SD-7 | 05/25/94 | U-238 | 11.60 | 2.500 | PCI/G | 1.50 |
| 127-SD-7 | 05/25/94 | RA-226 | 0.28 | 0.000 | PCI/G | 0.28 |
| 127-SD-7 | 05/25/94 | TH-232 | 0.44 | 0.000 | PCI/G | 0.44 |
| 127-SD-7 | 05/25/94 | K-40 | 8.80 | 1.900 | PCI/G | 2.00 |
| 127-SD-7 | 05/25/94 | U-235 | 0.85 | 0.110 | PCI/G | 0.69 |
| 127-SD-7 | 05/25/94 | PB-212 | 0.83 | 0.210 | PCI/G | 0.17 |
| 127-SD-8 | 05/25/94 | K-40 | 10.10 | 2.200 | PCI/G | 2.10 |
| 127-SD-8 | 05/25/94 | RA-226 | 0.44 | 0.100 | PCI/G | 0.21 |
| 127-SD-8 | 05/25/94 | U-235 | 1.10 | 0.210 | PCI/G | 0.71 |
| 127-SD-8 | 05/25/94 | RA-228 | 0.71 | 0.580 | PCI/G | 0.46 |
| 127-SD-8 | 05/25/94 | TH-232 | 0.78 | 0.570 | PCI/G | 0.32 |
| 127-SD-8 | 05/25/94 | U-238 | 17.40 | 3.300 | PCI/G | 1.50 |
| 127-SD-8 | 05/25/94 | BI-214 | 0.46 | 0.070 | PCI/G | 0.21 |
| 127-SD-8 | 05/25/94 | PB-212 | 0.86 | 0.240 | PCI/G | 0.17 |
| 127-SD-8 | 05/25/94 | PB-214 | 1.00 | 2.100 | PCI/G | 0.19 |
| 127-SD-9 | 05/25/94 | K-40 | 10.10 | 1.900 | PCI/G | 2.30 |
| 127-SD-9 | 05/25/94 | RA-226 | 0.33 | 0.130 | PCI/G | 0.23 |
| 127-SD-9 | 05/25/94 | U-235 | 0.43 | 0.170 | PCI/G | 0.78 |
| 127-SD-9 | 05/25/94 | RA-228 | 0.56 | 0.540 | PCI/G | 0.50 |
| 127-SD-9 | 05/25/94 | TH-232 | 0.61 | 0.440 | PCI/G | 0.35 |
| 127-SD-9 | 05/25/94 | U-238 | 3.90 | 1.900 | PCI/G | 1.60 |
| 127-SD-9 | 05/25/94 | PB-212 | 0.70 | 0.210 | PCI/G | 0.19 |
| 127-SD-9 | 05/25/94 | PB-214 | 0.56 | 0.840 | PCI/G | 0.20 |




Attachment B
**Proposed Sediment and Biological Sampling Locations Associated with Ecological Hazard Assessment Morton, International, Beverly, MA.**

CH2M HILL

BECHTEL - OAK RIDGE
LIBRARY
4575

MA/VC 120261

ORNL/RASA--91/29

DE93 000420

HEALTH AND SAFETY RESEARCH DIVISION

Environmental Restoration and Waste Management Non-Defense Programs
(Activity No. EX 20 20 01 0; ADS3170000)

# Radiological Survey Results at Beverly Harbor, Beverly, Massachusetts (VB025)

R. D. Foley and C. A. Johnson

Date Issued —August 1992

Investigation Team

R. E. Swaja — Measurement Applications and Development Manager
W. D. Cottrell — FUSRAP Project Director
R. D. Foley — Survey Team Leader

Survey Team Members

| | |
|---|---|
| J. F. Allred | M. E. Murray |
| A. C. Butler* | V. P. Patania |
| R. D. Foley | D. E. Rice |
| P. Blom† | D. A. Rose |

W. H. Shinpaugh*

*D. R. Stone and Associates, Inc.
†U.S. Department of Energy

Work performed by the
MEASUREMENT APPLICATIONS AND DEVELOPMENT GROUP

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-6285
managed by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U. S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

120267

# CONTENTS


LIST OF FIGURES ..... v

LIST OF TABLES ..... vii

ACKNOWLEDGMENTS ..... ix

ABSTRACT ..... xi

INTRODUCTION ..... 1

SURVEY METHODS ..... 2

- SURFACE RADIATION MEASUREMENTS ..... 2
- SOIL AND BIOLOGICAL SAMPLING AND ANALYSES ..... 2

SURVEY RESULTS ..... 3

- SURFACE RADIATION MEASUREMENTS ..... 3
- SOIL SAMPLES ..... 3
  - Systematic ..... 3
  - Biased ..... 4
- SHELLFISH SAMPLES ..... 4

SIGNIFICANCE OF FINDINGS ..... 5

REFERENCES ..... 5

120261

# LIST OF FIGURES


1 Diagram showing general location of the former Ventron site and Beverly Harbor, Beverly, Massachusetts ..... 6

2 View of the rear of the Ventron plant looking north from the tidal area of the harbor , Beverly, Massachusetts ..... 7

3 View looking east from the rear of the Ventron plant towards the bridge, Beverly, Massachusetts ..... 7

4 View looking north at the adjacent vicinity properties on the harbor west of the Ventron plant, Beverly, Massachusetts ..... 8

5 Surface gamma exposure rates, and soil and biological sampling locations at Beverly Harbor, Beverly, Massachusetts ..... 9

120261

# LIST OF TABLES


1 Applicable guidelines for protection against radiation ..... 10

2 Background radiation levels and concentrations of selected radionuclides in soil in the Beverly, Massachusetts, area ..... 11

3 Concentrations of radionuclides in soil samples from Beverly Harbor, Beverly, Massachusetts ..... 12

4 Concentrations of radionuclides in lobster samples from Beverly Harbor, Beverly, Massachusetts ..... 16

120267

## ACKNOWLEDGMENTS

Research for this project was sponsored by the Office of Environmental Restoration, U.S. Department of Energy, under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc. The authors wish to acknowledge the contributions of R. F. Carrier, W. D. Cottrell, M. S. Uziel, D. A. Roberts, D. A. Rose, V. P. Patania, J. F. Allred, and T. R. Stewart of the Measurement Applications and Development Group for participation in the sample preparation and analyses, editing, graphics, and reporting of data for this survey.

120267

## ABSTRACT

At the request of the U.S. Department of Energy (DOE), a team from Oak Ridge National Laboratory conducted a radiological survey at Beverly Harbor, Beverly, Massachusetts. The survey was performed in May 1991. The purpose of the survey was to determine if uranium from work performed under government contract at the former Ventron facility had migrated off-site to the harbor and neighboring areas. The survey included a surface gamma scan and the collection of soil and biological samples for radionuclide analyses.

Results of the survey demonstrated isolated and spotty radionuclide concentrations in soil, and radiation measurements in excess of the DOE Formerly Utilized Sites Remedial Action Program guidelines.

120267

# RADIOLOGICAL SURVEY RESULTS AT BEVERLY HARBOR, BEVERLY, MASSACHUSETTS (VB025)*

## INTRODUCTION

The Metal Hydrides Corporation facility in Beverly, Massachusetts (which became the Ventron Corporation in 1965), was one of many companies performing work during the 1940s associated with the development of nuclear energy for defense-related projects under contract to the Manhattan Engineer District (MED) and the Atomic Energy Commission (AEC). Operations conducted under government contract at such sites included the procurement, storage, and processing of uranium oxides, salts, and metals, and the subsequent machining of these products. As a result of activities involving these materials, equipment, buildings, and land at some of the sites became radiologically contaminated with small amounts of the material resulting in low levels of contamination on the properties. At contract termination, release limits and decontamination operations were typically applied in conformance with standards currently deemed adequate for purposes of health and environmental protection. Subsequent to original assessments and the release of these facilities, new research and information have resulted in the development of more stringent guidelines for release of such facilities for unrestricted use. Furthermore, in some instances, documentation is limited or nonexistent, and conditions at a specific site may be unknown. It is the policy of the Department of Energy (DOE) to verify that radiological conditions at such facilities comply with existing guidelines.[1] The Formerly Utilized Sites Remedial Action Program (FUSRAP) was established by DOE in 1974 to assist in assessment and cleanup activities at these sites.

The radiological survey detailed in this report was performed under the FUSRAP program and is one of several conducted in May, 1991, on properties in the vicinity of the former Ventron facility by members of the Oak Ridge National Laboratory (ORNL) at the request of DOE. The city of Beverly lies on Beverly Harbor approximately 15 miles northeast of the central Boston area . The former Ventron facility, now owned by Morton International, Inc., is located at the confluence of the Bass and Danvers rivers on Congress Street near the Beverly-Salem bridge (Fig. 1, p. 6).

From 1942 through 1948, the Metal Hydrides Corporation (later to become the Ventron facility), converted uranium oxide to uranium metal powder at the facility under contract to the MED in support of the war effort. Other operations conducted at the facility included the recovery of uranium from scrap uranium and turnings from the slug fabrication plant at Hanford, Washington. Contracts between Metal Hydrides and the government were completed in 1954.

---

*The survey was performed by members of the Measurement Applications and Development Group of the Health and Safety Research Division of Oak Ridge National Laboratory under DOE contract DE-AC05-84OR21400.

120267



Following a radiological screening survey at the site in 1977, a comprehensive survey was performed in 1982.[2] In 1987, DOE contractors removed the uranium-contaminated roof from a Ventron building, which had begun to leak. Radioactive materials remaining on the site do not pose a health hazard under present use conditions, but could cause radiation exposure to workers if excavation or major renovation took place on the property. DOE plans a complete characterization study of the site in 1992 and the initiation of remedial action soon thereafter.

The survey of the property reported in this document and of other surrounding properties is part of DOE's continuing program to assess the former Ventron site and plan for remedial action. The objective of the surveys was to determine if uranium from plant operations had migrated offsite to neighboring areas including Beverly Harbor, and if so, to what degree. The relative location of the harbor to the former Ventron site is shown in Fig. 1. The radiological surveys consisted of measurements of radiation levels over the ground surface of the properties and analysis of soil, sediment, and other material samples for the presence of radionuclides in concentrations exceeding guidelines.

Photos of Beverly Harbor and the tidal area of the waters adjacent to the former Ventron plant site are shown in Figs. 2 - 4 (pp. 7-8).

## SURVEY METHODS

A comprehensive description of the survey methods and instrumentation used in this survey is given in *Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program*, ORNL/TM-8600 (April 1987).[3]

### SURFACE RADIATION MEASUREMENTS

Gamma radiation levels were determined using a portable NaI gamma scintillation meter. Because NaI gamma scintillators are energy dependent, measurements of gamma radiation levels in counts per minute (cpm) are normalized to pressurized ionization chamber (PIC) measurements to estimate gamma exposure rates in μR/h.

### SOIL AND BIOLOGICAL SAMPLING AND ANALYSES

Surface and subsurface soil samples were systematically collected near the Ventron property in a pattern sufficient to obtain a characterization of the radionuclide content of the soil. Surface and subsurface soil samples were also collected in areas of elevated gamma exposure rates. Such samples are referred to as biased samples and are more likely to contain elevated concentrations of radionuclides than are systematically chosen samples. Lobster samples were collected from the waters south of the Ventron site. All soil and biological samples were analyzed to determine $^{238}U$, $^{232}Th$, $^{226}Ra$, $^{40}K$, and $^{137}Cs$ concentrations.

120267



# SURVEY RESULTS

Current guidelines for sites included within the FUSRAP are summarized in Table 1 (p. 10). Typical background radiation levels for the Beverly, Massachusetts, area are presented in Table 2 (p. 11). These data are provided for comparison with the survey results presented in this section. All direct measurements presented in this report are gross readings; background radiation levels have not been subtracted. Similarly, background concentrations have not been subtracted from radionuclide concentrations in soil, debris, and other samples.

## SURFACE RADIATION MEASUREMENTS

A general gamma scan was conducted of the tidal area of the harbor adjacent to the former Ventron plant site. On the back (south) and side (west) of the plant site are the tidal areas of the Danvers River on the south and the Bass River on the west. Results of gamma measurements taken around the plant site at the seawall and on the mud of the tidal area are shown on Fig. 5 (p. 9). Exposure rates at the ground surface ranged from 24 to 40 μR/h at the southwest corner of the site (building labeled C-1, Fig.5), and 16 to 24 μR/h on the south side of the plant (buildings B-1 and B-2), with a maximum of 60 μR/h measured in one spot near the seawall behind building B-2. These values are higher than the typical background measurements in the Beverly area, and indicate the presence of residual radioactive contamination. Biased soil samples were not taken at all areas with elevated gamma measurements. Exposure rates further out from the buildings, in the tidal mud, ranged from 4 to 9 μR/h. These values are comparable to the background measurements in the Beverly area (Table 2).

## SOIL SAMPLES

### Systematic

Soil sample locations are shown in Fig. 5 and results of analyses are listed in Table 3 (pp. 12-15). Systematic soil samples were taken from the area close to the Ventron plant, and also up to the low tide water line in the harbor area west of the Ventron Plant on the adjacent vicinity properties VB011, VB012, and VB013. All soil samples are included in Table 3. In all the samples, maximum concentrations of $^{226}Ra$ and $^{232}Th$ in surface soil (0-15 cm) were 0.80 and 0.99 pCi/g, respectively. In all subsurface soil samples (15-60 cm), maximum values were 0.81 pCi/g for $^{226}Ra$ and 1.0 pCi/g for $^{232}Th$. These values are comparable to typical background levels in the Beverly area (Table 2), and well below DOE guidelines (Table 1). Uranium-238 concentrations in all surface samples ranged from 0.84 to 12 pCi/g. In subsurface soil, ranges were from 0.81 to 8.1 pCi/g on the Ventron site, and from 2.4 to 7.7 pCi/g on the harbor tidal area of the adjacent properties, with a maximum of 40 pCi/g measured in the 15-30 cm portion of one sample (VB12S9B). With this one exception, all $^{238}U$ concentrations in these systematic samples were near or slightly above typical

120267



background soil concentrations in the Beverly area (Table 2), but still below guidelines of 35 to 40 pCi/g that have been applied at other FUSRAP sites (Table 1).

Biased

Biased samples were taken in the areas of elevated gamma readings that were measured close to the Ventron buildings on the outside of the perimeter fence. (See Fig. 5). These samples, when analyzed for $^{238}U$, contained concentrations ranging from 32 to 4600 pCi/g in surface soil. Sample B3C, also a surface sample taken after monitoring for spot contamination near the B3 sample location (see ** footnote, Table 3, p. 15), measured 22,000 pCi/g. Uranium-238 concentrations in subsurface soil ranged from 11 to 5500 pCi/g. Maximum $^{226}Ra$ and $^{232}Th$ concentrations in the biased samples were 1.2 and 21 pCi/g, respectively, in surface soil, and 1.6 and 27 pCi/g, respectively, in subsurface samples.

Sample B1A was subdivided until a metal fragment was isolated. The sample containing the metal fraction, labeled B1AM, measured 210,000 pCi/g of $^{238}U$. Concentrations of $^{226}Ra$ and $^{232}Th$ in this sample were 27 and 42 pCi/g, respectively. Although neither potassium-40 ( $^{40}K$) nor Cesium-137 ($^{137}Cs$ ) were associated with any MED operations or processing activities at the Ventron site, samples are routinely analyzed for their presence. These analyses showed that the B1AM sample contained 41 pCi/g $^{40}K$ and 15 pCi/g $^{137}Cs$, while all other samples were well below guidelines for $^{40}K$ (Ref. 4) and $^{137}Cs$ (see Table 1). Potassium-40 is naturally occurring; worldwide the concentration of $^{40}K$ in soil ranges from 3.5 to 22 pCi/g, and an individual weighing 70 kg (~188 lb) would normally contain about 140 pCi/g.[4] The concentration of $^{137}Cs$ in the sample is well below the guidelines.

SHELLFISH SAMPLES

Lobster traps were set in three locations in the waters of the harbor behind (to the south of) the former Ventron plant. For background readings, a fourth trap was set 3.25 nautical miles east of the plant at the Eagle Island Buoy (coordinates: 70°49'6" Longitude, 42°31'17" Latitude). Trap locations are indicated in Figs. 1 and 5 and results of analyses are given in Table 4. Each lobster was marked by color-coded bands attached to the claws to designate its location of capture, and shipped live to ORNL for analysis.

Three lobsters from each of the four locations were analyzed to determine $^{238}U$, $^{232}Th$, and $^{226}Ra$ concentrations. In two of the lobsters from each trap, the edible parts (tail and claws) were removed and combined for analysis. In the remaining lobster in each trap, the inedible parts (stomach and its contents, green gland, and carapace) were removed and combined for analysis. In all, eight lobsters were used for edible parts analysis, and four for inedible parts analysis.

120267



Results of the analyses showed that there was no significant difference in $^{238}U$, $^{232}Th$, and $^{226}Ra$ concentrations between the background samples and any of the other samples (see Table 4).

## SIGNIFICANCE OF FINDINGS

The results of the radiological survey at Beverly Harbor, Beverly, Massachusetts, indicated the general elevation of uranium concentrations in soil and the presence of isolated spots of significantly elevated $^{238}U$ concentrations. The contamination occurs as both surface and subsurface contamination in spotty locations in the tidal areas of the harbor, usually within 50 ft of the plant sea wall.

The concentrations of residual radioactive material in the form of $^{238}U$ found in certain areas in the soils of the harbor around the Former Ventron site are in excess of concentration guidelines established by the Department of Energy.

## REFERENCES


1. U.S. Department of Energy, *Radiological Control Manual*, DOE/EH-0256T (DOE N 5480.6), June 1992; U.S. Department of Energy, *A Background Report for the Formerly Utilized Manhattan Engineer District/Atomic Energy Commission Sites Program*, DOE/EV-0097, September 1980.

2. W. D. Cottrell and R. F. Carrier, *Results of the Radiological Survey at the Ventron Site, Beverly, Massachusetts*, ORNL/TM-10053, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., May 1988.

3. T. E. Myrick, B. A. Berven, W. D. Cottrell, W. A. Goldsmith, and F. F. Haywood, *Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program*, ORNL/TM-8600, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., April 1987.

4. National Council on Radiation Protection and Measurements (NCRP) Report No. 50, December 27, 1976.

120267



ORNL-DWG 87-12507R

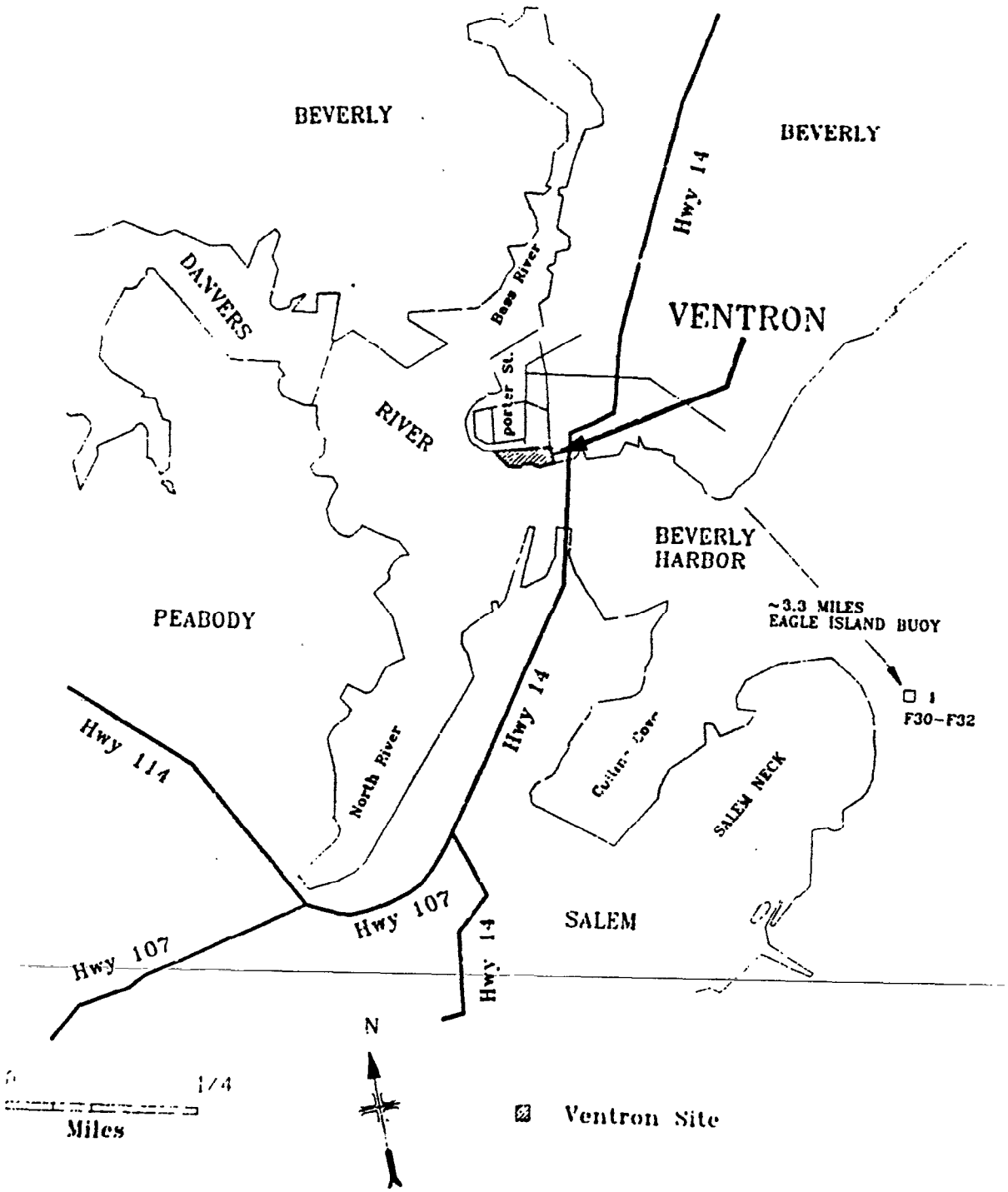



Fig. 1. Diagram showing general location of the former Ventron site and Beverly Harbor, Beverly, Massachusetts.

120261



ORNL-PHOTO 3984-92

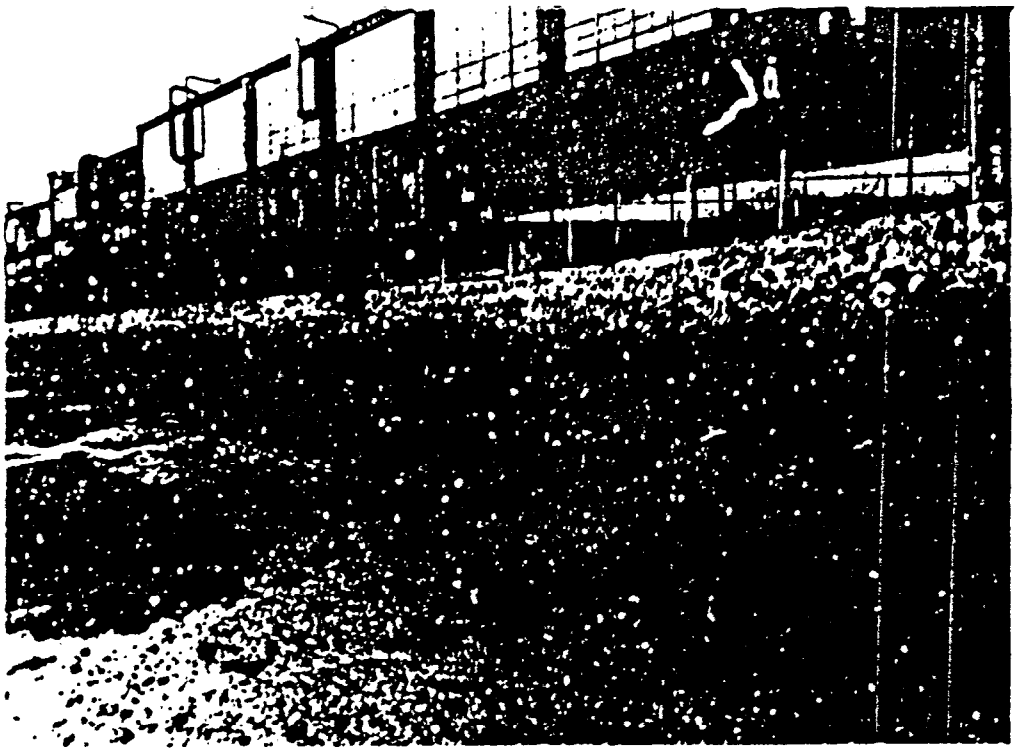


Fig. 2. View of the rear of the Ventron plant looking north from the tidal area of the harbor, Beverly, Massachusetts.

ORNL-PHOTO 3985-92

Fig. 3. View looking east from the rear of the Ventron plant towards the bridge, Beverly, Massachusetts.

120267



ORNL-PHOTO 3986-92

Fig. 4. View looking north at the adjacent vicinity properties on the harbor west of the Ventron plant, Beverly, Massachusetts.

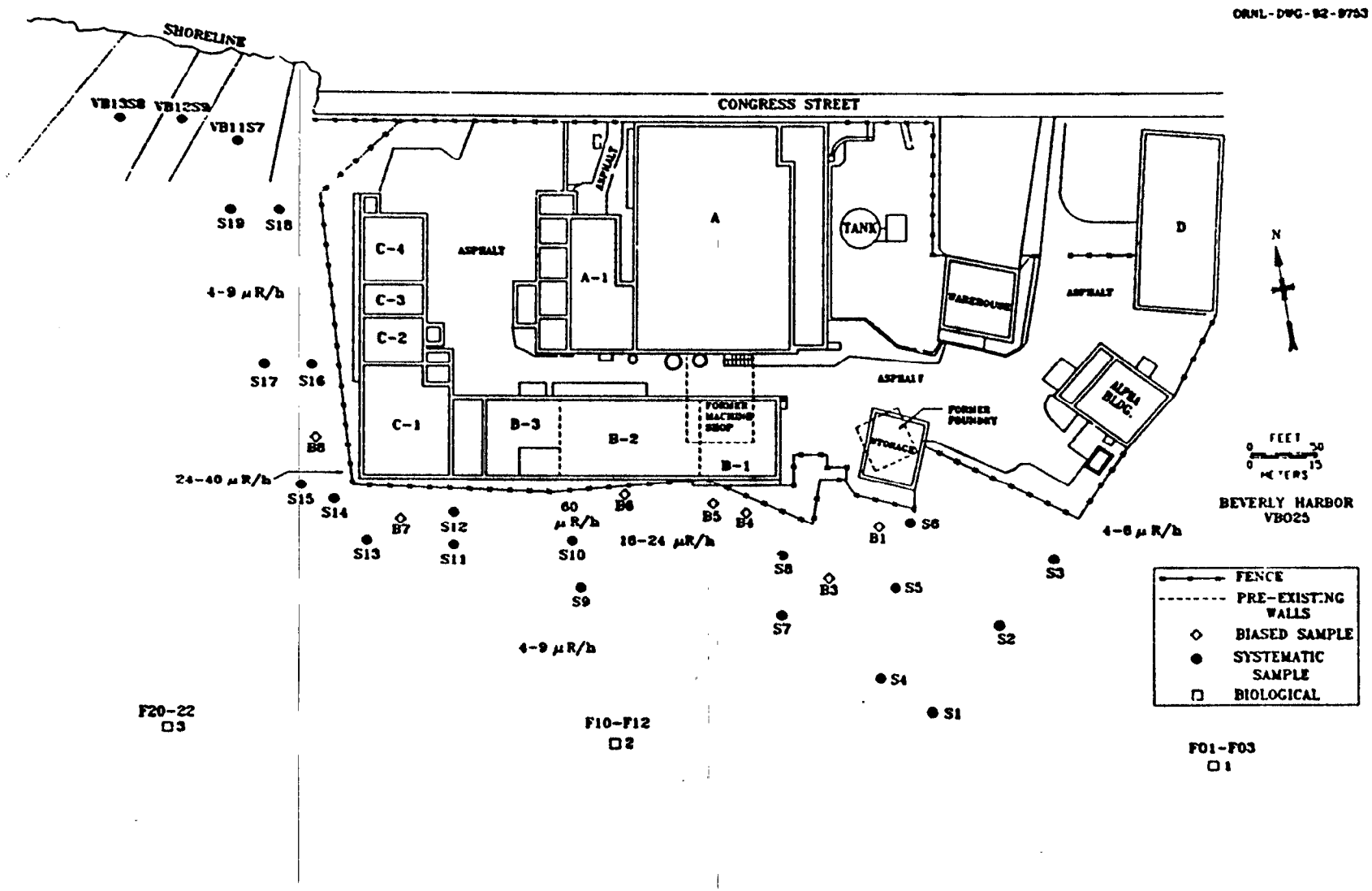



Fig. 5. Surface gamma exposure rates, and soil and biological sampling locations at Beverly Harbor, Beverly, Massachusetts.



120261

120267



Table 1. Applicable guidelines for protection against radiation
(Limits for uncontrolled areas)

| Mode of exposure | Exposure conditions | Guideline value |
|---|---|---|
| Gamma radiation | Indoor gamma radiation level (above background) | 20 μR/h[a] |
| Radionuclide concentrations in soil (generic) | Maximum permissible concentration of the following radionuclides in soil above background levels, averaged over a 100-m² area | 5 pCi/g averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over 15 cm-thick soil layers > 15 cm below the surface |
| | $^{226}Ra$<br>$^{232}Th$<br>$^{230}Th$ | |
| Derived concentrations | $^{238}U$ | Site specific[b] |
| | Concentration limit in surface soil above background levels based on dose estimates from major exposure pathways<br>$^{137}Cs$ | 80 pCi/g over a 100-m² area of contamination[c] |
| Guideline for non-homogeneous contamination (used in addition to the 100-m² guideline)[d] | Applicable to locations with an area ≤25 m², with significantly elevated concentrations of radionuclides ("hot spots") | $G_A = G_i\ (100/A)^{1/2}$<br>where<br>$G_A$= guideline for "hot spot" of area ($A$)<br>$G_i$=guideline averaged over a 100-m² area |

[a]The 20 μR/h shall comply with the basic dose limit (100 mrem/yr) when an appropriate-use scenario is considered.

[b]DOE guidelines for uranium are derived on a site-specific basis. Guidelines of 35-40 pCi/g have been applied at other FUSRAP sites. *Sources*: J. L. Marley and R. F. Carrier, *Results of the Radiological Survey at 4 Elmhurst Avenue, Colonie, New York (AL219)*, ORNL/RASA-87/117, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., February 1988; B. A. Berven et. al., *Radiological Survey of the Former Kellex Research Facility, Jersey City, New Jersey*, DOE/EV-0005/29, ORNL-5734, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., February 1982.

[c]J. W. Healy, J. C. Rodgers, and C. L. Wienke, *Interim Soil Limits for D&D Projects*, LA-UR-79-1865-Rev., Los Alamos Scientific Laboratory, Los Alamos, NM, 1979. Cited in U. S. Department of Energy, *Radiological Guidelines for Application to DOE's Formerly Utilized Sites Remedial Action Program*, ORO-831, March 1983.

[d]DOE guidelines specify that every reasonable effort shall be made to identify and to remove any source which has a concentration exceeding 30 times the guideline value, irrespective of area. (adapted from *Revised Guidelines for Residual Radioactive Material at FUSRAP and Remote SFMP Sites*, April 1987).

*Sources*: Adapted from U.S. Department of Energy, *Radiation Protection of the Public and the Environment*, DOE Order 5400.5, April 1990 and U.S. Department of Energy, *Guidelines for Residual Radioactive Material at FUSRAP and Remote SFMP Sites*, Rev. 2, March 1987.

120267



Table 2. Background radiation levels and concentrations of selected radionuclides in soil in the Beverly, Massachusetts, area

| Type of radiation measurement or sample | Radiation level or radionuclide concentration | |
|---|---|---|
| | Range | Average |
| Gamma exposure rate at ground surface (μR/h)[a] | 6-9 | 7 |
| Concentration of radionuclides in soil (pCi/g)[a] | | |
| $^{226}Ra$ | 0.70-0.94 | 0.84 |
| $^{232}Th$ | 0.76-0.94 | 0.84 |
| $^{238}U$ | 0.69-1.05 | 0.89 |

[a]Values obtained from three locations in the Beverly area.

120267



**Table 3. Concentrations of radionuclides in soil samples from Beverly Harbor, Beverly, Massachusetts**

| Sample number[a] | Depth (cm) | Radionuclide concentration (pCi/g)[b] | | |
|---|---|---|---|---|
| | | $^{226}Ra$ | $^{232}Th$ | $^{238}U$ |
| | | *Systematic samples*[c] | | |
| S1A | 0-15 | 0.45 ± 0.01 | 0.52 ± 0.03 | 2.0 ± 0.4 |
| S1B | 15-25 | 0.46 ± 0.02 | 0.49 ± 0.02 | 1.7 ± 0.7 |
| S2A | 0-15 | 0.48 ± 0.02 | 0.55 ± 0.03 | 2.5 ± 0.8 |
| S2B | 15-30 | 0.56 ± 0.02 | 0.73 ± 0.03 | 4.4 ± 0.8 |
| S2C | 30-40 | 0.51 ± 0.02 | 0.57 ± 0.03 | 3.2 ± 0.4 |
| S3A | 0-15 | 0.51 ± 0.02 | 0.57 ± 0.03 | 3.1 ± 0.5 |
| S3B | 15-30 | 0.56 ± 0.02 | 0.63 ± 0.03 | 2.2 ± 0.5 |
| S3C | 30-40 | 0.61 ± 0.02 | 0.70 ± 0.03 | 5.9 ± 1 |
| S4A | 0-15 | 0.47 ± 0.02 | 0.48 ± 0.03 | 2.5 ± 0.7 |
| S4B | 15-30 | 0.47 ± 0.02 | 0.49 ± 0.02 | 1.6 ± 0.7 |
| S4C | 30-45 | 0.59 ± 0.02 | 0.61 ± 0.03 | 1.6 ± 0.6 |
| S4D | 45-60 | 0.46 ± 0.02 | 0.52 ± 0.03 | 1.5 ± 0.6 |
| S5A | 0-15 | 0.74 ± 0.02 | 0.99 ± 0.04 | 1.6 ± 1 |
| S5B | 15-30 | 0.61 ± 0.02 | 0.82 ± 0.03 | 0.81 ± 0.8 |
| S6A | 0-15 | 0.56 ± 0.03 | 0.74 ± 0.06 | 4.2 ± 0.5 |
| S6B | 15-30 | 0.58 ± 0.02 | 0.72 ± 0.03 | 3.0 ± 0.6 |
| S7A | 0-15 | 0.45 ± 0.02 | 0.50 ± 0.03 | 2.9 ± 0.6 |
| S7B | 15-30 | 0.56 ± 0.03 | 0.68 ± 0.06 | 4.6 ± 0.6 |
| S8A | 0-15 | 0.48 ± 0.02 | 0.59± 0.03 | 7.6 ± 0.6 |
| S8B | 15-30 | 0.73 ± 0.03 | 0.73 ± 0.03 | 8.1 ± 1 |

120267



**Table 3 (continued)**

| Sample number[a] | Depth (cm) | Radionuclide concentration (pCi/g)[b] | | |
|---|---|---|---|---|
| | | $^{226}Ra$ | $^{232}Th$ | $^{238}U$ |
| | | *Systematic samples*[c] | | |
| S9A | 0-15 | 0.80 ± 0.03 | 0.97 ± 0.05 | 3.8 ± 0.5 |
| S9B | 15-30 | 0.52 ± 0.02 | 0.58 ± 0.03 | 6.7 ± 1 |
| S10A | 0-15 | 0.56 ± 0.02 | 0.62 ± 0.03 | 9.2 ± 0.9 |
| S10B | 15-30 | 0.53 ± 0.02 | 0.66 ± 0.03 | 3.4 ± 0.6 |
| S11A | 0-15 | 0.41 ± 0.02 | 0.40 ± 0.04 | 1.3 ± 0.6 |
| S11B | 15-30 | 0.54 ± 0.02 | 0.63 ± 0.03 | 3.2 ± 0.8 |
| S12A | 0-15 | 0.65 ± 0.03 | 0.73 ± 0.05 | 12.0 ± 1 |
| S12B | 15-30 | 0.53 ± 0.01 | 0.55 ± 0.02 | 4.5 ± 0.6 |
| S13A | 0-15 | 0.51 ± 0.02 | 0.60 ± 0.03 | 1.7 ± 1 |
| S13B | 15-30 | 0.55 ± 0.02 | 0.68 ± 0.04 | 4.2 ± 1 |
| S14 | 0-15 | 0.60 ± 0.02 | 0.76 ± 0.03 | 5.5 ± 0.4 |
| S15A | 0-15 | 0.56 ± 0.03 | 0.58 ± 0.04 | 2.4 ± 1 |
| S15B | 15-30 | 0.53 ± 0.02 | 0.67 ± 0.04 | 2.6 ± 0.9 |
| S16 | 0-15 | 0.54 ± 0.02 | 0.73 ± 0.03 | 11 ± 0.8 |
| S17 | 0-15 | 0.55 ± 0.02 | 0.62 ± 0.03 | 1.6 ± 0.9 |
| S18A | 0-15 | 0.58 ± 0.02 | 0.59 ± 0.03 | 1.3 ± 0.5 |
| S18B | 15-30 | 0.61 ± 0.02 | 0.67 ± 0.03 | 2.2 ± 0.6 |

120267



Table 3 (continued)

| Sample number[a] | Depth (cm) | Radionuclide concentration (pCi/g)[b] | | |
|---|---|---|---|---|
| | | $^{226}Ra$ | $^{232}Th$ | $^{238}U$ |
| *Systematic samples*[c] | | | | |
| S19A | 0-15 | 0.58± 0.02 | 0.65 ± 0.04 | 1.5 ± 0.8 |
| S19B | 15-30 | 0.68± 0.02 | 0.72 ± 0.03 | 1.6 ± 0.7 |
| VB11S7A* | 0-15 | 0.52± 0.02 | 0.60 ± 0.04 | 0.84±0.7 |
| S7B | 15-30 | 0.65± 0.02 | 0.80 ± 0.03 | 2.4 ±0.9 |
| VB12S9A* | 0-15 | 0.69± 0.02 | 0.74± 0.03 | 1.9± 0.4 |
| S9B | 15-30 | 0.81± 0.04 | 1.0 ± 0.07 | 40 ± 2 |
| S9C | 30-45 | 0.81± 0.05 | 1.0 ± 0.07 | 7.7 ± 1 |
| VB13S8A* | 0-15 | 0.60± 0.02 | 0.69 ± 0.03 | 2.2 ± 0.5 |
| S8B | 15-20 | 0.65± 0.02 | 0.73 ± 0.03 | 4.1 ± 1 |
| *Biased samples*[d] | | | | |
| B1A | 0-15 | 0.77± 0.3 | 0.67 ± 0.4 | 4600± 90 |
| B1AM | 0-15 | <27 | <42 | 210000±1000 |
| B1B | 15-30 | 0.56± 0.05 | 0.56 ± 0.1 | 45± 3 |
| B3A | 0-15 | 0.71± 0.2 | 1.4 ± 0.4 | 2600± 200 |
| B3B | 15-30 | 0.74± 0.2 | <0.7 | 1400± 30 |
| B3C** | 0-10 | <1.1 | <1.7 | 22000± 100 |
| B4A | 0-15 | 1.2 ± 0.1 | 9.9 ± 0.2 | 3000± 30 |
| B4B | 15-30 | 1.6 ± 0.3 | 27 ± 0.4 | 5500± 300 |

120267



Table 3 (continued)

| Sample number[a] | Depth (cm) | Radionuclide concentration (pCi/g)[b] | | |
|---|---|---|---|---|
| | | $^{226}Ra$ | $^{232}Th$ | $^{238}U$ |
| | | *Biased samples*[d] | | |
| B5A | 0-15 | 1.2 ± 0.1 | 21 ± 0.5 | 230 ± 10 |
| B5B | 15-30 | 0.83± 0.1 | 7.7 ± 0.2 | 130 ± 8 |
| B5C | 30-45 | 0.48± 0.03 | 1.4 ± 0.07 | 25 ± 1 |
| B6A | 0-15 | 1.2 ± 0.2 | 1.8 ± 0.4 | 2000 ± 200 |
| B6B | 15-30 | 0.56± 0.09 | 1.2 ± 0.2 | 160 ± 7 |
| B7A | 0-15 | 0.63± 0.1 | 14 ± 0.5 | 32 ± 3 |
| B7B | 15-30 | 0.61± 0.05 | 4.0 ± 0.1 | 11 ± 2 |
| B8A | 0-15 | 0.46± 0.1 | 0.78± 0.2 | 620± 10 |
| B8B | 15-30 | 0.70± 0.1 | 0.69± 0.2 | 640± 20 |
| B8C | 30-45 | 0.50± 0.07 | 0.71± 0.1 | 160± 7 |

[a]Locations of soil samples are shown on Fig .5

[b]Indicated counting error is at the 95% confidence level (± 2σ).

[c]Systematic samples are taken at locations irrespective of gamma exposure rates.

[d]Biased samples are taken from areas with elevated gamma exposure rates.

*Samples from adjacent private properties VB11, VB12, VB13, taken from adjoining bay area.

**Sample B3C was taken ~1.5 ft east of B3A sample hole. Surface contamination was monitored with the gamma scintillator until primary contaminant was found.

120267



Table 4. Concentration of radionuclides in lobster samples from Beverly Harbor, Beverly, Massachusetts

| Location[a] | Sample number | Radionuclide concentration (pCi/g) | | |
|---|---|---|---|---|
| | | $^{226}Ra$ | $^{232}Th$ | $^{238}U$ |
| | | *Edible parts* | | |
| 1 | F001 | 0.020±0.03 | 0.001 ±0.002 | 0.001±0.003 |
| | F003 | 0.027±0.1 | 0.0004±0.0005 | 0.002±0.003 |
| 2 | F010 | 0.024±0.03 | 0.0002±0.0004 | 0.002±0.002 |
| | F011 | 0.038±0.05 | 0.001 ±0.001 | 0.002±0.003 |
| 3 | F021 | 0.006±0.009 | 0.0003 ±0.001 | 0.003±0.002 |
| | F022 | 0.070±0.1 | 0.00004±0.001 | 0.002±0.003 |
| 4 | F031 | 0.011±0.02 | 0.0003±0.0004 | 0.006±0.004 |
| | F032 | 0.032±0.04 | 0.0005±0.002 | 0.003±0.003 |
| | | *Inedible parts* | | |
| 1 | F002 | 0.032±0.04 | 0.0002 ±0.001 | 0.017±0.006 |
| 2 | F012 | 0.038±0.03 | 0.00005±0.00009 | 0.002±0.002 |
| 3 | F020 | 0.016±0.02 | 0.0003 ±0.001 | 0.004±0.002 |
| 4 | F030 | 0.024±0.05 | 0.001 ±0.001 | 0.004±0.002 |

[a] Trap Locations are shown on Figs. 1 and 5.

120267

TMA/Eberline Oak Ridge, FUSRAP Radiological Reports
Sampling Event: 1992 Beverly Harbor Sediment Sampling Results

| Sample ID | Location | Date Collected | Analyte | Result | Error | Units | MDA |
|---|---|---|---|---|---|---|---|
| 127CV00111 | SD1 | 10/12/92 | U-238 | 2.60 | 0.980 | PCI/G | 5.60 |
| 127CV00111 | | 10/12/92 | RA-226 | 0.69 | 0.000 | PCI/G | 0.69 |
| 127CV00111 | | 10/12/92 | TH-232 | 1.10 | 0.000 | PCI/G | 1.10 |
| 127CV00111 | | 10/12/92 | TH-230 | 0.73 | 0.560 | PCI/G | 0.07 |
| 127CV00211 | SD2 | 10/12/92 | U-238 | 4.30 | 0.000 | PCI/G | 4.30 |
| 127CV00211 | | 10/12/92 | RA-226 | 0.64 | 0.000 | PCI/G | 0.64 |
| 127CV00211 | | 10/12/92 | TH-232 | 0.84 | 0.000 | PCI/G | 0.84 |
| 127CV00211 | | 10/12/92 | TH-230 | 0.44 | 0.510 | PCI/G | 0.07 |
| 127CV00311 | SD3 | 10/13/92 | U-238 | 3.20 | 0.000 | PCI/G | 3.20 |
| 127CV00311 | | 10/13/92 | RA-226 | 0.49 | 0.020 | PCI/G | 0.25 |
| 127CV00311 | | 10/13/92 | TH-232 | 0.63 | 0.040 | PCI/G | 0.44 |
| 127CV00311 | | 10/13/92 | TH-230 | 0.91 | 0.570 | PCI/G | 0.07 |
| 127CV00411 | SD4 | 10/13/92 | U-238 | 4.50 | 0.000 | PCI/G | 4.50 |
| 127CV00411 | | 10/13/92 | RA-226 | 0.59 | 0.000 | PCI/G | 0.59 |
| 127CV00411 | | 10/13/92 | TH-232 | 0.75 | 0.000 | PCI/G | 0.75 |
| 127CV00411 | | 10/13/92 | TH-230 | 0.78 | 0.540 | PCI/G | 0.07 |
| 127CV00511 | SD5 | 10/13/92 | U-238 | 2.30 | 1.400 | PCI/G | 3.60 |
| 127CV00511 | | 10/13/92 | RA-226 | 0.61 | 0.090 | PCI/G | 0.46 |
| 127CV00511 | | 10/13/92 | TH-232 | 0.73 | 0.530 | PCI/G | 0.81 |

SD1 - Background location in the Danvers River upstream from the site.

SD2 - Background location in the Bass River upstream from the site.

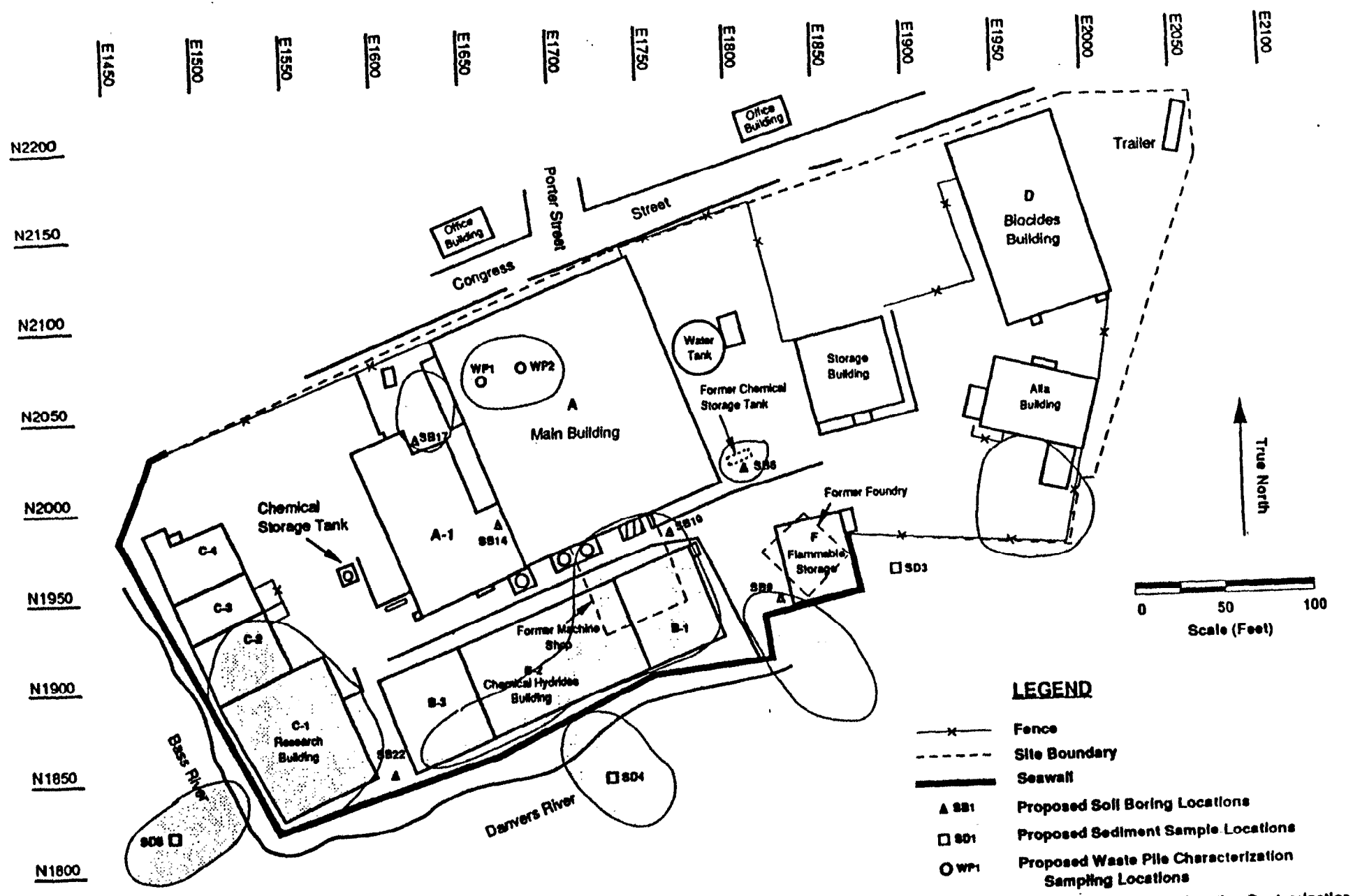



Figure 5-3. Proposed Sampling Locations for Chemical Analysis

120267

126002 95-050

# Department of Energy

Oak Ridge Operations
P.O. Box 2001
Oak Ridge, Tennessee 37831—8723

January 30, 1995

Ms. Debbie Browning
Science Applications International Corporation
P. O. Box 2501
Oak Ridge, Tennessee 37831

Dear Ms. Browning:

**VENTRON CHARACTERIZATION REPORT - APPROVAL FOR PUBLICATION**

This letter provides FSRD approval to publish the Ventron Characterization Report. Following our internal review of the document, I met with FSRD and support staff in early January to discuss comments. Our overall impression is that the Ventron Characterization Report is an acceptable document. I approve publication of the Ventron Characterization Report, subject to resolution of the comments with FSRD which were provided via my e-mail note to you on January 20, 1995.

If you have any questions, please call me at (615) 576-9441.

Sincerely,

James D. Kopotic

James D. Kopotic, Site Manager
Former Sites Restoration Division

cc:
Steve Oldham, EW-93
Bill Seay, EW-93

.1044.960102.001

138005

Science Applications International Corporation
An Employee-Owned Company

January 2, 1996

U.S. Department of Energy
Oak Ridge Field Office
P.O. Box 2001
Oak Ridge, TN 37831-8758

Attention: Mr. James D. Kopotic
Opportunity Sites Manager, FUSRAP

**Subject: Contract DE-AC05-91OR21950**
**VENTRON - CHARACTERIZATION REPORT - FINAL**

Dear Mr. Kopotic:

Enclosed please find the Final Ventron Characterization Report and comment resolution forms for DOE and BNI comments on the second draft. As requested, this document has been revised to clarify DOE's authority at the Ventron site, as well as, incorporate characterization data from the 1991 ORNL offsite property surveys and sampling, and the 1993 and 1994 DOE harbor sampling.

By copy of this letter, three bound and one unbound copy of the report have been provided to BNI for record retention purposes. An electronic copy of the report has been provided to BNI for future distribution requirements.

If you have any questions or comments please feel free to call me at 481-8531.

Sincerely,

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

Debbie S. Browning

Debbie S. Browning, P.E.
Opportunity Sites Manager

DSB:bt

Enclosures

cc: L. Price, FSRD (w/o)
B. Seay, FSRD (w/o)
S. Oldham, FSRD (w/e)
D. Harbert, BNI (w/e)
M. Redmon, BNI (w/2e)
J. Lesch, BNI (w/o)
R. Weber, BNI (w/o)
PDCC, BNI (w/unb encl.)
J. Beck, ORISE (w/e)
G. Toddings, BNI (electronic copy)

No. 1044.960102.001
Internal Distribution

| | Name | Initials | Date |
|---|---|---|---|
| Originator | D. Browning | DB | 1-2-96 |
| Concurrence | N/A | | |
| Approved | J.D.. Waddell | TMP for JDW | 1-2-96 |

J. Waddell
T. Patterson
D. Browning
G. Stephens (w/o)
DRC
CRF
G. Cowart (w/o)
K. Renfro (w/o)
K. Ironside (w/o)
D. Miller (w/o)
H. Cothron (w/o)

301 Laboratory Road, P.O. Box 2501, Oak Ridge, Tennessee 37831 (615) 482-9031
Other SAIC Offices: Albuquerque, Boston, Colorado Springs, Dayton, Huntsville, Las Vegas, Los Angeles, McLean, Orlando, Palo Alto, San Diego, Seattle, Tucson

**Editor's Note:**

**PAGES**

**5-20, 5-22, 5-24, 5-26,**
**B-6, B-42, B-46, B-51, & B-52,**

**IN THE FOLLOWING REPORT**

**ARE BLANK AND HAVE NOT**

**BEEN REPRODUCED**

138005

FINAL
DOE/OR/21950-1011

# CHARACTERIZATION REPORT FOR THE VENTRON SITE

## BEVERLY, MASSACHUSETTS

DECEMBER 1995

*prepared by*
U.S. Department of Energy, Oak Ridge Operations Office, Formerly Utilized Sites Remedial Action Program

*with technical assistance from*
Science Applications International Corporation ESC-FUSRAP
under Contract No. DE-AC05-91OR21950

138005

# TABLE OF CONTENTS


Page

LIST OF FIGURES . . . . . vii
LIST OF TABLES . . . . . ix
ACRONYMS AND ABBREVIATIONS . . . . . xi
EXECUTIVE SUMMARY . . . . . ES-1

1. INTRODUCTION . . . . . 1-1
   1.1 STREAMLINED APPROACH FOR ENVIRONMENTAL RESTORATION (SAFER) . . . . . 1-2

2. REGIONAL SETTING, SITE HISTORY, AND BUILDING HISTORY . . . . . 2-1
   2.1 REGIONAL SETTING . . . . . 2-1
      2.1.1 Regional Geology . . . . . 2-1
      2.1.2 Site Geology . . . . . 2-1
      2.1.3 Soils . . . . . 2-1
      2.1.4 Surface Hydrology . . . . . 2-1
      2.1.5 Hydrogeology . . . . . 2-2
   2.2 SITE HISTORY . . . . . 2-2
   2.3 BUILDING HISTORY . . . . . 2-3
   2.4 CURRENT SITE CONDITIONS . . . . . 2-4

3. REMEDIATION GUIDELINES . . . . . 3-1
   3.1 RADIOLOGICAL CONSTITUENTS . . . . . 3-1
   3.2 HAZARDOUS CONSTITUENTS . . . . . 3-1

4. PREVIOUS STUDIES . . . . . 4-1
   4.1 GAMMA EXPOSURE RATE SCANS OF THE OUTDOOR SITE AREA . 4-1
   4.2 SITE SOIL ANALYSIS . . . . . 4-2
      4.2.1 Surface Site Soils . . . . . 4-2
      4.2.2 Subsurface Site Soils . . . . . 4-2
   4.3 HARBOR SURVEY AND ANALYSES . . . . . 4-3
   4.4 STORM SEWER SEDIMENT ANALYSIS . . . . . 4-4
   4.5 INDOOR SURVEY . . . . . 4-5
   4.6 OFFSITE PROPERTIES . . . . . 4-5

5. 1992 CHARACTERIZATION ACTIVITIES . . . . . 5-1
   5.1 METHODOLOGY . . . . . 5-1
   5.2 PRELIMINARY CHARACTERIZATION ACTIVITIES . . . . . 5-2
      5.2.1 Site Civil Survey . . . . . 5-2
      5.2.2 Radiological and Chemical Background Data Collection . . . . . 5-2
      5.2.3 Previous Gamma Survey Verification . . . . . 5-3

TABLE OF CONTENTS (continued)

Page

5.3 1992 CHARACTERIZATION METHODS . . . . . 5-3
5.3.1 Walkover Gamma Survey . . . . . 5-3
5.3.2 Site Soils . . . . . 5-4
5.3.3 Harbor Surface Water/Sediment and Biological Samples . . . . . 5-5
5.3.4 Sewer Line Sediment . . . . . 5-6
5.3.5 Structures and Equipment . . . . . 5-6
5.3.6 Building A Ash Pile . . . . . 5-8
5.3.7 Offsite Properties . . . . . 5-8
5.4 CHARACTERIZATION RESULTS . . . . . 5-8
5.4.1 Site Soils . . . . . 5-8
5.4.1.1 Surface Soils . . . . . 5-8
5.4.1.2 Subsurface Soils . . . . . 5-9
5.4.2 Harbor Surface Water/Sediment and Biological Samples . . . . . 5-10
5.4.3 Sewer Line Sediment . . . . . 5-10
5.4.4 Structures and Equipment . . . . . 5-10
5.4.5 Building A Ash Pile . . . . . 5-13
5.4.6 Offsite Properties . . . . . 5-13

6. 1993 AND 1994 HARBOR SEDIMENT SAMPLING . . . . . 6-1

7. CHARACTERIZATION EVALUATION . . . . . 7-1
7.1 CHARACTERIZATION DATA SUMMARY . . . . . 7-1
7.1.1 Site Soils . . . . . 7-1
7.1.2 Harbor Surface Water/Sediment and Biological Samples . . . . . 7-2
7.1.3 Sewer Line Sediment . . . . . 7-2
7.1.4 Buildings . . . . . 7-2
7.1.5 Offsite Properties . . . . . 7-2
7.1.6 Building A Ash Piles . . . . . 7-3
7.1.7 New Area . . . . . 7-3
7.2 DATA NEEDS . . . . . 7-3
7.3 CONCEPTUAL MODEL EVALUATION . . . . . 7-3

8. REMEDIAL CONDITIONS AND DECISION RULES . . . . . 8-1
8.1 REMEDIAL CONDITIONS . . . . . 8-1
8.2 STAKEHOLDER DECISIONS . . . . . 8-3
8.3 MONITORING DECISIONS RULES . . . . . 8-3
8.4 REMEDIATION DECISION RULES . . . . . 8-5

9. REFERENCES . . . . . 9-1

## TABLE OF CONTENTS (continued)

Page

APPENDICES:

A URANIUM GUIDELINES FOR THE VENTRON SITE, BEVERLY, MASSACHUSETTS . . . . . A-1

B
B-1 BACKGROUND SOIL SAMPLES . . . . . B-1
B-2 SURFACE WATER SAMPLES . . . . . B-3
B-3 SURFACE SOIL SAMPLES . . . . . B-5
B-4 SOIL BORING SAMPLES . . . . . B-7
B-5 11 AND 15 CONGRESS STREET SAMPLES . . . . . B-41
B-6 BUILDING A-1 THROUGH-THE-FLOOR SAMPLES . . . . . B-44
B-7 HARBOR AND SEWER LINE SEDIMENT SAMPLES . . . . . B-48
B-8 MUSSEL SAMPLES . . . . . B-52
B-9 BUILDING A ASH PILES . . . . . B-53

C SITE MAPS - WALKOVER GAMMA SCAN, FIDLER WALKOVER, AND CONE SHIELDED GAMMA SCAN . . . . . C-1

D
D-1 BOREHOLE GAMMA LOG VALUES . . . . . D-1
D-2 GEOLOGIC DRILL LOGS . . . . . D-5

E WALKOVER GAMMA SCANS AND SURFACE CONTAMINATION SURVEYS OF BUILDINGS . . . . . E-1

138005

## LIST OF FIGURES


| Figure | | Page |
|---|---|---|
| 2-1 | Location of the Ventron Site | 2-5 |
| 2-2 | Plan View of the Ventron Site | 2-6 |
| 4-1 | Locations of Elevated Gamma Exposure Rate Measurements Outdoors at the Ventron Site (1982 ORNL Sampling Event) | 4-6 |
| 4-2 | Locations of Surface Soil Samples (1982 ORNL Sampling Event) | 4-7 |
| 4-3 | Locations of Surface Soil Samples with Concentrations of Ra-226 or Th-232 >5 pCi/g or U-238 >50 pCi/g (1992 Sampling Event) | 4-8 |
| 4-4 | Locations of Subsurface Soil Samples (1982 ORNL Sampling Event) | 4-9 |
| 4-5 | Locations of Subsurface Samples with Concentrations of Ra-226 or Th-232 >15 pCi/g or U-238 >50 pCi/g (1982 ORNL Sampling Event) | 4-10 |
| 4-6 | Locations of Soil, Sediment, and Lobster Samples at Beverly Harbor (1991 ORNL Sampling Event) | 4-11 |
| 4-7 | Locations of Harbor Sediment Samples with Concentrations of Th-232 >5 pCi/g or U-238 >50 pCi/g (1991 ORNL Sampling Event) | 4-12 |
| 4-8 | Locations of Storm Sewer Sediment Samples (1982 ORNL Sampling Event) | 4-13 |
| 5-1 | Approximate Background Sampling Locations | 5-14 |
| 5-2 | Technician Using a Hand Auger to Collect Background Samples | 5-15 |
| 5-3 | Locations of Surface and Subsurface Soil Samples (1992 DOE Sampling Event) | 5-16 |
| 5-4 | Technician Sampling Mussels on the Tidal Flats | 5-17 |
| 5-5 | Locations of Sewer Line Sediment Samples | 5-18 |
| 5-6 | Technician Using a Floor Monitor in Building A | 5-19 |
| 5-7 | Technician Performing a Scan in Building A | 5-21 |
| 5-8 | Surface Soil Samples with Concentrations of Th-230 or Th-232 >5 pCi/g or U-238 >50 pCi/g (1992 DOE Sampling Event) | 5-23 |
| 5-9 | Subsurface Soil Samples with Concentrations of Th-230 >15 pCi/g or U-238 >50 pCi/g (1992 DOE Sampling Event) | 5-25 |
| 5-10 | Building A Floors | 5-27 |
| 5-11 | Building A Walls | 5-28 |
| 5-12 | Building A First Floor Horizontal Equipment Surfaces | 5-29 |
| 5-13 | Building A Overhead Surfaces | 5-30 |
| 5-14 | Building A Basement | 5-31 |
| 5-15 | Building A-1 Floors | 5-32 |
| 5-16 | Building A-1 Horizontal Equipment Surfaces | 5-33 |
| 5-17 | Building A-1 Walls | 5-34 |
| 5-18 | Alfa Building | 5-35 |

138005

## LIST OF FIGURES (continued)


| Figure | | Page |
|---|---|---|
| 6-1 | Ventron 1994 DOE Sampling Event, Beverly, Massachusetts | 6-2 |
| 7-1 | Locations of Surface Soil Samples with Concentrations of Ra-226 or Th-232 >5 pCi/g or U-238 >50 pCi/g (1982 ORNL and 1992 DOE Sampling Events) | 7-4 |
| 7-2 | Locations of Subsurface Soil Samples with Concentrations of Ra-226 or Th-232 >15 pCi/g or U-238 >50 pCi/g (1988 ORNL and 1992 DOE Sampling Events) | 7-5 |
| 7-3 | Conceptual Model | 7-6 |
| 7-4 | Probable Extent of Radiologically Impacted Soils and Sediment Based on Sampling Information to Date | 7-7 |

# LIST OF TABLES


| Table | | Page |
|---|---|---|
| ES-1 | Concentrations of U-238 in Impacted Media | ES-4 |
| 2-1 | Chronology of Events for the Ventron Site | 2-7 |
| 3-1 | Summary of DOE Guidelines for Residual Radioactive Contamination | 3-2 |
| 3-2 | Background Radiation Levels in the Beverly, Massachusetts Area | 3-4 |
| 4-1 | Elevated Gamma Exposure Rates Measurements Outdoors | 4-14 |
| 4-2 | Surface Soil Samples with Concentrations of Ra-226 or Th-232 >5 pCi/g or U-238 >50 pCi/g | 4-15 |
| 4-3 | Subsurface Soil Samples with Concentrations of Ra-226 or Th-232 >15 pCi/g or U-238 >50 pCi/g | 4-16 |
| 4-4 | Harbor Sediment Samples with Concentrations of Th-232 >5 pCi/g or U-238 >50 pCi/g | 4-18 |
| 4-5 | Concentration of Radionuclides in Storm Sewer Sediment Samples | 4-19 |
| 5-1 | Analytical Parameters for the 1992 Characterization | 5-36 |
| 5-2 | Sample Identification, Location, and Analyses | 5-37 |
| 5-3 | Soil Around Building A and Ash Pile | 5-44 |
| 5-4 | Soil Under and Around Building A-1 | 5-45 |
| 5-5 | Soil Around B Buildings | 5-47 |
| 5-6 | Soil Under and Around C Buildings | 5-48 |
| 5-7 | Soil Around Building F | 5-51 |
| 5-8 | Soil Around Alfa Building | 5-52 |
| 5-9 | Samples from the Basements of 11 and 15 Congress Street | 5-54 |
| 5-10 | Surface Soil Samples with Concentrations of Th-230 or Th-232 >5 pCi/g or U-238 >50 pCi/g | 5-55 |
| 5-11 | Subsurface Soil Samples with Concentrations of Th-230 >15 pCi/g or U-238 >50 pCi/g | 5-56 |
| 5-12 | Harbor Sediment Samples | 5-57 |
| 5-13 | Mussel Samples | 5-58 |
| 5-14 | Sewer Line Sediment Samples | 5-59 |
| 5-15 | Gamma Exposure Rate Survey Results | 5-60 |
| 5-16 | Radon-222 Concentrations | 5-61 |
| 5-17 | Ventron Building Survey Results | 5-62 |
| 6-1 | Concentrations of Radionuclides in Composite Sediment Samples from the Harbor Area | 6-3 |
| 6-2 | Concentrations of Radionuclides in Sediment Samples from the Harbor Area | 6-4 |
| 7-1 | 1992 Characterization Data Needs and Results | 7-8 |

# ACRONYMS AND ABBREVIATIONS

138005

| | |
|---|---|
| AEA | Atomic Energy Act |
| AEC | U.S. Atomic Energy Commission |
| ALARA | as low as reasonably achievable |
| ANL | Argonne National Laboratory |
| BLS | below land surface |
| BNI | Bechtel National, Inc. |
| cm | centimeter |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| COC | contaminant of concern |
| COE | Corp of Engineers (Army) |
| cpm | counts per minute |
| CR | Characterization Report |
| Cs | Cesium |
| DOE | U.S. Department of Energy |
| $dpm/cm^2$ | disintegrations per minute per square centimeter |
| DQO | Data Quality Objectives |
| EE/CA | Engineering Evaluation/Cost Analysis |
| EPA | U.S. Environmental Protection Agency |
| ft | foot (feet) |
| FS | Feasibility Study |
| FUSRAP | Formerly Utilized Sites Remedial Action Program |
| g | gram |
| ha | hectare |
| hr | hour |
| in. | inch |
| K | Potassium |
| kg | kilogram |
| km | kilometer |
| l | liter |
| m | meter |
| MED | Manhattan Engineer District |
| MeV | mega electric volts |
| $\mu$R/hr | microRoentgens per hour |
| mg | milligram |
| MGL | Massachusetts General Law |
| mi | mile |
| Morton | Morton International |
| mrad | millirad |
| MSL | mean sea level |
| NaI | sodium iodide |

## ACRONYMS AND ABBREVIATIONS (continued)

| | |
|---|---|
| NRC | Nuclear Regulatory Commission |
| OA | Observational Approach |
| ORNL | Oak Ridge National Laboratory |
| PCB | polychlorinated biphenyl |
| pCi | picoCurie |
| pCi/g | picoCuries per gram |
| PIC | pressurized ionization chamber |
| ppm | parts per million |
| Ra | radium |
| RCRA | Resource Conservation and Recovery Act |
| RD/RA | Remedial Design/Remedial Action |
| RI | Remedial Investigation |
| SAFER | Streamlined Approach For Environmental Restoration |
| TCLP | toxicity characteristic leaching procedure |
| Th | thorium |
| Tl | thallium |
| TMA/E | TMA/Eberline, Inc. |
| TPH | total petroleum hydrocarbon |
| U | uranium |
| U.S. | United States |

# EXECUTIVE SUMMARY

## BACKGROUND

The 1.2-ha (3-acre) Ventron site is located in Beverly, Massachusetts on the Massachusetts Bay, approximately 24 km (15 mi) northeast of Boston, at the confluence of the Bass and Danvers Rivers. The site is bounded by Congress Street to the north, the Boston and Maine Railroad to the east, and the Bass and Danvers Rivers to the west and south, respectively.

Ventron Corporation, formerly Metal Hydrides Corporation, was under contract to the U.S. Army Corps of Engineers (COE) Manhattan Engineer District (MED) from 1942 to 1947 to convert uranium oxide to uranium metal powder. In 1965, the Metal Hydrides Corporation became the Ventron Corporation, which in turn was acquired by the Thiokol Corporation in late 1976. In 1982, Ventron became a division of Morton Thiokol, Inc. (BNI 1988), which was renamed Morton International in 1990. Prior to and subsequent to MED-related activities, Morton performed independent work at the Ventron site with uranium and thorium materials up until 1986. These radiological activities may have resulted in the deposition of residual radioactive material in surface and sub-surface soils, interior and exterior building surfaces, and equipment surfaces.

Established by Congress in 1974, the Formerly Utilized Sites Remedial Action Program (FUSRAP) is managed by the U.S. Department of Energy (DOE) to identify and clean up or otherwise control sites where residual radioactive materials exceed current guidelines. Residual radioactive materials at the Ventron site remain from the early years of the nation's atomic energy program.

A 1977 radiological screening survey and a 1980 radiological characterization survey of the site, both conducted by Oak Ridge National Laboratory (ORNL), confirmed the presence of residual materials, leading DOE to designate Ventron as a FUSRAP site in 1986 (DOE 1986a). Specific isotopes of concern found at the Ventron site are uranium-238 (U-238), radium-226 (Ra-226), and thorium-232 (Th-232). Under FUSRAP, DOE has the authority to remediate MED-related materials (uranium) at the site. Morton, the current owner of the site, is responsible for all non-MED-related materials at the site.

This report documents the results of the 1992 characterization efforts by FUSRAP conducted in accordance with the *Ventron Characterization Plan* (DOE 1992) and subsequent characterization efforts performed by DOE in 1993 and 1994. This report, like the characterization plan, has been developed using DOE's Streamlined Approached For Environmental Restoration (SAFER) method for task definition.

## SUMMARY OF THE CHARACTERIZATION RESULTS

DOE has authority at the Ventron site for remediation of materials containing U-238 greater than 50 pCi/g. Morton has the responsible at the site for the remediation of non-MED materials. For completeness, this report presents the characterization results for uranium, radium, and thorium regardless of the division of responsibility for cleanup.

Table ES-1 shows the U-238 concentration ranges for the media at the site that have been impacted by MED-related materials. A summary of the characterization results for the buildings and various media is presented below.

For the buildings, minimal residual alpha activity was detected above remedial guidelines on surfaces in Buildings A, A-1, and the Alfa Building. No removable radioactive materials above remedial guidelines were detected (i.e., only fixed beta-gamma levels exceed guidelines).

Surface soil samples confirmed the presence of elevated levels of radioactive materials primarily in the southwest and southeast corners of the site. Elevated Th-232 was detected in the surface soil south of the Alfa Building. Elevated U-238 was detected in the surface soil south and southwest of Building C-1. One surface sample near the south end of the C Buildings failed the toxicity characteristic leaching procedure (TCLP) criteria for lead.

Subsurface soils containing concentrations of Th-232, Th-230, Ra-226, or U-238 above remedial guidelines were detected south of the Alfa Building, under the basements of Buildings A-1, B-1, B-2, C-1, and C-2, between the B buildings and the seawall, and between Building C-1 and the seawall.

Analysis of samples from the ash piles in Building A detected Ra-226 above remedial guidelines and high levels of metals (chromium, lead, nickel, and zinc). One composite sample from the ash piles failed the test for ignitability.

Offsite harbor sediment was recognized as containing radioactive materials above remedial guidelines in previous characterization efforts, however, it was uncertain whether migration had occurred. New sediment samples taken in the river, further offshore from the site, found no radioactive materials above remedial guidelines. Therefore, the extent of radioactive materials is anticipated to be bound within 50 ft of the seawall, southwest of the C Buildings, south of the B Buildings, and south of Building F.

Samples taken from the storm sewer system during the 1992 characterization effort showed all parameters to be well below the remedial guidelines for soil.

Mussels collected from beds south of and adjacent to the site showed no significant difference when compared to the background samples.

For the 1992 characterization effort, the area east of Building D, which is not one of the original areas of concern, produced some elevated readings in the gamma walkover survey. No soil samples have been taken from this area to date. The extent of soil that is impacted will be determined during remedial action.

Section 1 of this report provides an introduction and a discussion of the application of the SAFER approach to the 1992 characterization effort. Section 2 discusses the background, history, and regional setting of the site. The remediation guidelines for the site are presented in Section 3. Data gathered from previous characterization efforts are presented in Section 4. The methods and results of the investigation carried out as a result of the characterization plan (DOE 1992) are discussed in Section 5. This section also serves as a foundation from which data needs are identified consistent with the SAFER approach. Additional characterization information collected from the harbor in 1993 and 1994 is presented in Section 6. The characterization plan defined data needs that were important to the understanding of the site and possible remediation alternatives; in Section 7, these data needs are evaluated in relation to the data collected. Section 7 also evaluates the conceptual model in light of the new data as well as the historical data, which is another essential element of SAFER. The probable conditions are refined and the uncertainties are re-evaluated using the new data. Any new or remaining uncertainties including data gaps are also identified. Section 8 describes remedial conditions and presents decision rules for both monitoring and remediation.

## Table ES-1. Concentrations of U-238 in Impacted Media[a]

| Media | Maximum[b] (pCi/g) | Minimum (pCi/g) | Average[c] (pCi/g) |
|---|---|---|---|
| Site soil (surface 0-15 cm) | 44,000 | 0.74 | 829.4 |
| Site soil (subsurface >15 cm) | 71,000 | 1.7 | 1,221.5 |
| Harbor sediment (surface 0-15 cm) | 210,000 | 0.81 | 4,022.3 |
| Harbor sediment (subsurface >15 cm) | 5,500 | 1.5 | 248.3 |

[a] Background concentrations have not been subtracted.
[b] Maximum concentrations were detected at biased sample locations.
[c] Concentrations represent averages for systematic and biased samples combined.

# 1. INTRODUCTION

Characterization of the Ventron site in Beverly, Massachusetts, has been conducted as part of the Formerly Utilized Sites Remedial Action Program (FUSRAP). Established by Congress in 1974, FUSRAP is managed by the United States (U.S.) Department of Energy (DOE) to identify and clean up or otherwise control sites where residual radioactivity exceeds current guidelines. Congress has authorized DOE to remediate residual radioactive material remaining from the early years of the nation's atomic energy program.

Ventron Corporation, formerly Metal Hydrides Corporation, began operations involving uranium material in the early 1940s and continued handling uranium and thorium materials under licenses granted by the Nuclear Regulatory Commission (NRC) until 1986. Ventron was under contract to the U.S. Army Corps of Engineers (COE) Manhattan Engineer District (MED) from 1942 to 1947 to convert uranium oxide to uranium metal powder. These MED-related activities may have resulted in the deposition of residual radioactive material in surface and sub-surface soils, interior and exterior building surfaces, and equipment surfaces. A 1977 radiological screening survey and a 1980 radiological characterization survey of the site, both conducted by Oak Ridge National Laboratory (ORNL), confirmed the presence of residual radioactive materials, leading DOE to designate Ventron as a FUSRAP site in 1986 (DOE 1986a). Under FUSRAP, DOE has the authority to remediate MED-related materials (i.e., uranium) at the site. Morton, the current owner/operator of the site, is responsible for all non-MED-related materials at the site (e.g., chemicals, thorium, etc.). Morton entered into a consent order with the State of Massachusetts to identify, characterize, and remediate these non-MED-related materials (e.g., mineral oil, mercury).

This characterization report presents the results of previous surveys conducted by ORNL, the 1992 field investigation effort carried out by DOE in accordance with the *Ventron Characterization Plan* (DOE 1992), and subsequent characterization efforts conducted by DOE. This report presents detailed information about the site, and fills gaps (or inconsistencies) left by the historical information review conducted during development of the characterization plan.

This report has been developed using the Streamlined Approach For Environmental Restoration (SAFER) method for task definition. The SAFER approach was developed by DOE as a way to proceed quickly and efficiently through the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Remedial Investigation/Feasibility Study (RI/FS) process at DOE facilities.

The objective of this report is to define areas on the Ventron site where environmental remediation by DOE may be required. Specific isotopes of concern found at the Ventron site are uranium-238 (U-238), radium-226 (Ra-226), and thorium-232 (Th-232). DOE has the authority at the Ventron site for materials that contain greater than 50 picoCuries per gram (pCi/g) of U-238. Prior to and subsequent to MED-related activities, Morton performed independent work with radiological constituents up until 1986. Therefore, remediation of

materials that contain concentrations of U-238 that are greater than 50 pCi/g and are commingled with radium, thorium, and/or hazardous constituents, will be negotiated between DOE and Morton.

For completeness, this report presents the characterization results for uranium, radium, and thorium, regardless of the division of responsibility for cleanup.

## 1.1 STREAMLINED APPROACH FOR ENVIRONMENTAL RESTORATION (SAFER)

Traditional engineering approaches have proven to be both very time-consuming and an inefficient use of resources (i.e., money, laboratory capacity, and staff) when applied to environmental remediation. Prior U.S. Environmental Protection Agency (EPA) experience in the Superfund program has identified a strong need for streamlining the remediation process (EPA 1989). To address these needs, DOE developed the SAFER approach (Dailey *et al.* 1992). FUSRAP elected to implement the SAFER approach at the Ventron site.

SAFER has four essential elements: (1) defining and using a conceptual model to provide a foundation for remedial planning and action; (2) planning and conducting assessment, remedy selection, and remedial action on a "learn-as-you-go" basis; (3) recognizing the management of uncertainty as a key to conducting each phase of the remedial process; and (4) recognizing the role and contributions of stakeholders. The application of each element is dynamic during the environmental restoration process.

SAFER is based on the need, from both a scientific and engineering perspective, to make decisions under uncertain conditions while maintaining progress throughout the environmental restoration process. By bringing the knowledge of site conditions to acceptable levels, remaining knowledge gaps can be managed through implementing SAFER processes. SAFER combines elements of two recognized processes developed for managing uncertainty at different points in the environmental restoration process: the Data Quality Objectives (DQO) process developed by the Quality Assurance Management Staff of EPA (Neptune *et al.* 1990), and the Observational Approach (OA) whose roots are in managing uncertainty in traditional geotechnical engineering applications (Peck 1969). The OA provides a framework for flexible action throughout the environmental restoration process, while the DQO process focuses on establishing the quality and quantity of data required to help make decisions at various points in the process.

The SAFER method combines the DQO and OA processes with a focus on achieving the following, all of which can be considered as elements of the SAFER process:

- enhanced emphasis on planning,
- linked data collection and decision-making needs,
- explicit recognition and management of uncertainty,

- direct and efficient application of information gained as planning and remediation proceed,
- development and refinement of a conceptual site model,
- early convergence on a remedy, and
- informing and soliciting input from key stakeholders (regulators and public).

The SAFER process addresses uncertainties in one of two ways: (1) the measurement system is enhanced to bring the level of knowledge to an acceptable level (i.e., additional data collection is performed or better analytical techniques are used), or (2) the uncertainty is acknowledged and expressed as a reasonable deviation to probable conditions.

The key concept of SAFER is the emphasis on quantitatively defining data adequacy by using a *decision rule*. The decision rule provides a quantitative statement defining what quantity of data provides adequate information upon which decisions can be based. Inherent in the idea of the decision rule is the understanding that there will be uncertainty in the decision-making process. The goal is to identify data adequacy that provides *acceptable uncertainty* in making decisions while managing the residual uncertainty. The objective of the decision rule is to establish the linkage between the problem at a site, its remedial objective, and data requirements. This will be done iteratively: first, by basing decisions on preliminary understandings, and second, by modifying decisions as more information is obtained.

The explicit recognition of limitations in understanding the waste site conditions allows the realization that knowledge of the site is not definitive. Therefore, SAFER recognizes that the goal of site characterization is to establish the *probable conditions* (e.g., probable contaminants, pathways, etc.) at a site. The term "probable" is quantitatively defined by the level of certainty specified as acceptable in the decision rule. Other possible (as distinguished from probable) conditions may exist at a site because residual acceptable uncertainty remains in the understanding of site conditions. SAFER recognizes these conditions as possible *deviations* to the probable conditions. The possibility that deviations may occur is recognized explicitly during scoping and throughout the site characterization and remediation process under SAFER.

*Contingency plans* are developed to manage deviations from expectations and their potential impact on the ability of the remediation technology to achieve the identified remediation objectives. Deviations assessed to be reasonably possible have various levels of responses that are necessary to mitigate their impact. Deviations that are judged not reasonably possible are not considered further. Contingency plans are developed for reasonable deviations, to different degrees of detail depending on the relative probability of occurrence, time to respond, and stakeholder concerns.

*Monitoring plans* are developed to detect any of the identified reasonable potential deviations during the site remediation process. The monitoring plan is developed in concept during the FS or Engineering Evaluation/Cost Analysis (EE/CA) phase and in detail during the Remedial Design (RD) phase. The monitoring plan may require modification following implementation of a contingency plan.

*Stakeholders* at the Ventron site have been defined as groups directly involved in or affected by the actions undertaken as part of the FUSRAP remedial activities. The Ventron site is located within the boundaries of the town of Beverly, Massachusetts. The identified stakeholders include DOE, Morton, the State of Massachusetts, and the town of Beverly and its citizens.

Essential elements of SAFER have been applied to the implementation of the characterization plan and the results of this effort and subsequent characterization efforts are presented in this characterization report. Section 2 of this report will discuss the background, history, and regional setting of the site. The remediation guidelines for the site are presented in Section 3. Data gathered from previous characterization efforts is presented in Section 4. The methods and results of the investigation carried out as a result of the characterization plan (DOE 1992) are discussed in Section 5. This section will serve as a foundation from which data needs are identified consistent with the SAFER approach. Additional characterization information collected from the harbor in 1993 and 1994 is presented in Section 6. The characterization plan defined data needs that were important to the understanding of the site and possible remediation alternatives; these data needs are evaluated in relation to the data collected in Section 7. Section 7 also evaluates the conceptual model in light of the new data as well as the historical data, which is another essential element of SAFER. The probable conditions are refined and the uncertainties are re-evaluated using the new data. Any new or remaining uncertainties including data gaps are also identified. Section 8 will describe remedial conditions and present decision rules for both monitoring and remediation based on the types and quality of data collected.

# 2. REGIONAL SETTING, SITE HISTORY, AND BUILDING HISTORY

## 2.1 REGIONAL SETTING

The 1.2 hectare (ha) (3-acre) Ventron site is located in Beverly, Massachusetts, on Massachusetts Bay, approximately 24 kilometers (km) (15 mi) northeast of Boston (Figure 2-1) at the confluence of the Bass and Danvers Rivers. The site is bounded by Congress Street to the north, the Boston and Maine Railroad to the east, and the Bass and Danvers Rivers to the west and south, respectively.

### 2.1.1 Regional Geology

The near-surface geology of the region is dominated by granitic bedrock beneath varying thicknesses of glacial till and glacial outwash sediments deposited during the retreat of extensive Pleistocene glaciers. The topography is generally low rolling hills and plains with some bedrock outcrops forming round to oval hills ranging from about 30 to 85 meters (m) (100 to 280 ft) in elevation.

### 2.1.2 Site Geology

The geology at the Ventron site and neighboring area is consistent with the regional geology, although the land surface and shallow subsurface have been altered by residential and commercial development (including fill used to raise Ventron to its current elevation). Four primary stratigraphic units have been described from drilling conducted by Morton International: fill, native alluvial deposits, glacial till, and bedrock. The depth to bedrock varies between 2 and 20 ft below grade. In general, the bedrock consists of a gray to greenish gray gabbro.

### 2.1.3 Soils

Site soils are classified as udorthents, which are soils that have been altered by human activity such as construction. Site soils are primarily imported coarse gravel and sand fill material that most likely overlie native glacial till. The topsoil consists of fine to medium sand. The glacial till is unstratified and very poorly sorted, with clast sizes ranging from fine sand and silt to variable sized cobbles.

### 2.1.4 Surface Hydrology

Surface water at the Ventron site flows into the Danvers and Bass Rivers or into Congress Street drainage structures via gutters, culverts, storm sewers, or surface sheet runoff. Most of the site is either occupied by building space or covered with asphalt or concrete. Thus, only a small fraction of surface water introduced to the Ventron site currently penetrates the ground.

### 2.1.5 Hydrogeology

Seven monitoring wells were installed by Morton at the Ventron site to assess groundwater quality and groundwater flow direction. Some of the wells were screened in bedrock because no water was found in overburden sediments due to shallow bedrock and/or because tidal influences were likely to cause a drop in the watertable below the top of bedrock.

In general, two hydrostratigraphic units are present at the site: unconsolidated deposits and fractured bedrock. Throughout most of the site, the top of bedrock is above the mean groundwater table. Groundwater generally flows to the south-southwest toward the Danvers River, reflecting the overall topography of the area. Subtle changes in the flow gradient and flow direction are apparent around monitoring wells proximal to the seawall.

Potentiometric levels at the site range from minus 1.34 to 14.63 ft above mean sea level (MSL). Tidal influences are only seen in wells close to the seawall with watertable elevation fluctuating between 4 and 2 ft with the rise and fall in sea level. Based on the few large, transmissive fractures encountered while coring the bedrock wells and the water level responses from wells farther from the seawall, it appears that the bedrock probably has a low conductivity and poor connection with the Danvers River.

## 2.2 SITE HISTORY

From 1942 to 1947, the Metal Hydrides Corporation was under contract to MED and its successor, AEC, to convert uranium oxide to uranium metal powder using calcium hydride at the site. All MED/AEC-related work at the site involved handling natural processed uranium; no depleted or enriched uranium was processed at the site. Other operations performed at the site involved recovery of uranium from scrap uranium materials.

Following the MED/AEC activities, the site was decontaminated to cleanup standards applicable for the time. Two of the three buildings that housed the foundry facilities were demolished sometime between 1948 and 1950 (after completion of AEC surveying and decommissioning), and two other buildings (Buildings B and F) were erected at these locations (Figure 2-2). The remaining original buildings (Buildings A and A-1) contained furnaces, leaching facilities, a mixing room, a drying room, and analytical laboratories (Cottrell and Carrier 1988).

In 1965, Metal Hydrides Corporation became the Ventron Corporation, which in turn was acquired by the Thiokol Corporation in late 1976. In 1982, the Ventron site became a division of Morton Thiokol, Inc. (Cottrell and Carrier 1988), which was renamed Morton International in 1990. Table 2-1 provides a brief chronology for the site.

MED-related activities at the Ventron site conducted between 1942 and 1947 were limited to the use of uranium. Morton was licensed to handle uranium before and after the MED-related activities. However, significantly larger quantities of uranium appear to have been used for the MED-related activities. MED-related activities did not reference thorium material; however, Morton was licensed to handle thorium following the MED-related activities. Neither MED nor Morton licenses/contracts referenced radium as a source material used at the site. Radium residuals at the site may have occurred as a result of radium being (1) a byproduct of ore concentrates used prior to MED-related activities, (2) a byproduct of significant quantities of oxides used during the MED processes, (3) a byproduct of pitchblende ore and oxides used after MED processes, and (4) less significantly, a decay product from any natural uranium used by Morton. Due to the significant differences in quantities of materials used for MED versus non-MED processes, the source of the limited amounts of radium materials on the site is indeterminable.

Based on current knowledge of MED-related processes performed at Ventron, no hazardous constituents resulting from MED-related activities are expected to be present in the soil. However, hazardous constituents from other Morton activities may be commingled with MED-related material.

## 2.3 BUILDING HISTORY

The site has four groups of buildings (Alfa, A, B, and C), one chemical storage tank, two office buildings, and three other buildings (D, E, and F) (see Figure 2-2). Based on existing radiological and chemical data, the buildings and grounds described below were selected for further investigation during the 1992 characterization effort. The results of the 1992 characterization effort are described in Section 5.

*A Buildings: A and A-1*

Building A is one of the two remaining original buildings that were used for MED-related work. It adjoins Building A-1 and together these buildings were used by MED for uranium oxide storage during processing. The building is built directly on bedrock. Some of the original equipment is still in the building, including furnaces, vents, blowers, and piping. Ash from the furnaces has been piled on the floor of the building under each of the furnaces. In previous investigations, elevated levels of radioactivity were detected on the interior building surfaces, on MED-related equipment, and on the roof. The impacted portion of the roof was removed and replaced by DOE in 1987 (see Table 2-1).

A concrete loading pad adjacent to Building A-1 is thought to have been the location of uranium oxide storage and transfer activities.

*B Buildings: B-1, B-2, and B-3*

These adjoining buildings face the harbor to the south. Buildings B-1 and B-2 were erected over the location of the machine shop which had been in use during MED-related activities. The machine shop was demolished some time between 1948 and 1950, after being surveyed and decommissioned in compliance with cleanup standards set at that time. The basements of these buildings hold pipes and other equipment. An impacted sump is located in the basement of Building B-2. The upper floors of these buildings are used for chemical storage and for some processing. Previous investigations detected impacted soils beneath Buildings B-1 and B-2; however, no residual radioactive materials were detected within the B Buildings.

*C Buildings: C-1, C-2, C-3, and C-4*

These buildings are joined and face the harbor to the west. They contained an analytical laboratory and an employee cafeteria. Previous investigations detected radioactivity in the soils adjacent to and beneath the C Buildings. However, no residual radioactive materials were detected within the C Buildings. Two subsurface liquid waste pits in the vicinity of the C Buildings are reported to have been active during MED-related activities.

*Alfa Building*

The Alfa Building was built after the MED/AEC contract was terminated (Cottrell and Carrier 1988). This building was used primarily for storage, although occasionally it was used as a laboratory. The first floor contains hoods, duct work, and other equipment. This building was used by Ventron for thorium processing after MED-related activities had ceased. Th-232 and U-238 have been found in soils adjacent to this building.

*F Building*

Building F was constructed after MED-related activity had ceased. The foundry, which it replaced, was active during MED-related activity. Investigations conducted prior to the characterization plan did not include Building F or the adjacent soils and fill. Building F was used as a solvent storage area.

## 2.4 CURRENT SITE CONDITIONS

Production operations at the Ventron site ceased in November 1994. Morton is in the process of removing all equipment free of radioactive materials from the facility. The Ventron site is being remediated, by Morton, in accordance with Massachusetts General Law (MGL), Chapter 21E (The Massachusetts Contingency Plan 1993). Morton has completed the first phase of the remediation process and is proceeding towards completing the remaining four phases.

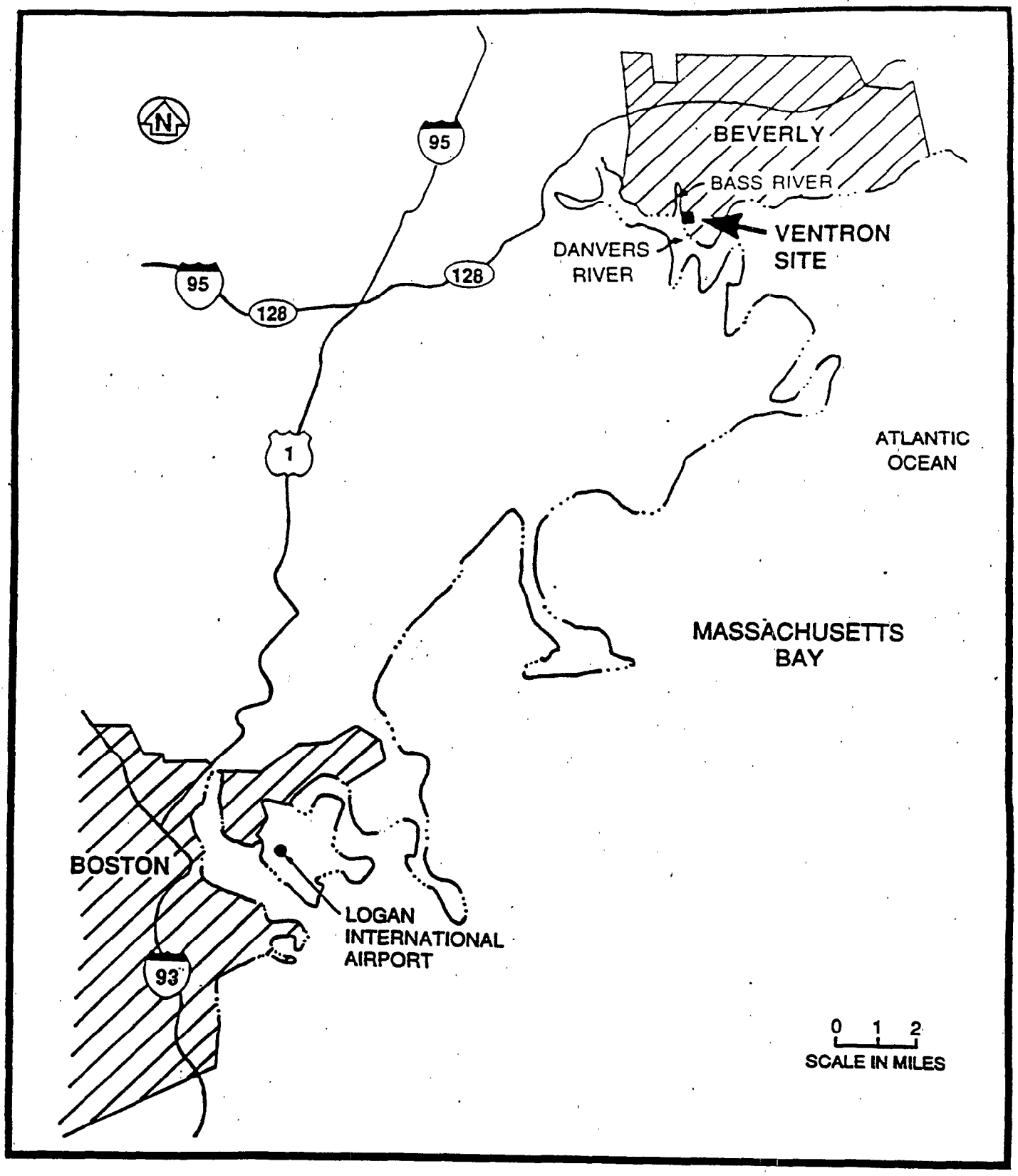
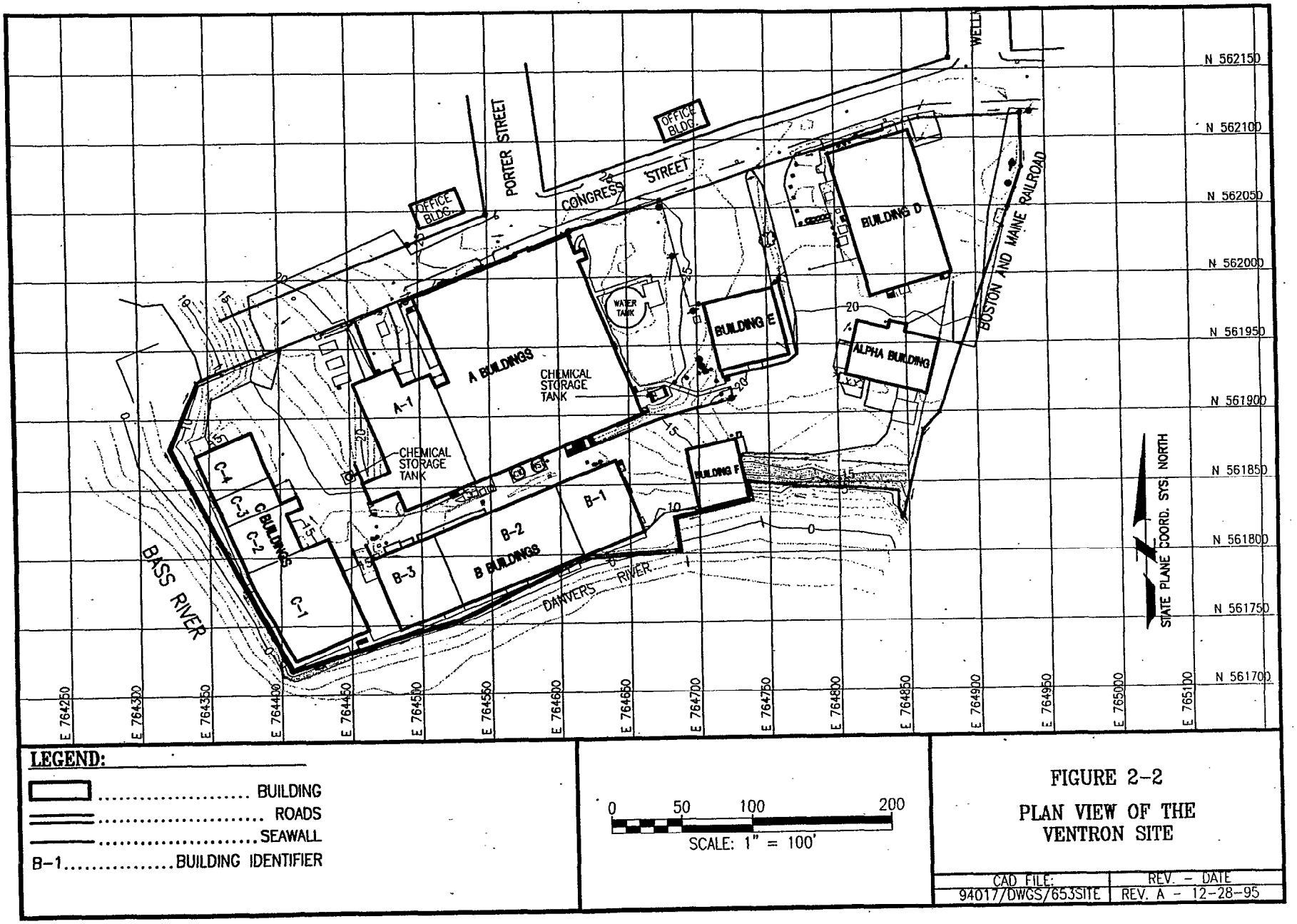



**Figure 2-1. Location of the Ventron Site**




**LEGEND:**

- BUILDING
- ROADS
- SEAWALL
- B-1 ..... BUILDING IDENTIFIER

0 50 100 200
SCALE: 1" = 100'

FIGURE 2-2
PLAN VIEW OF THE VENTRON SITE

| CAD FILE: | REV. - DATE |
|---|---|
| 94017/DWGS/653SITE | REV. A - 12-28-95 |

SOURCE: BNI 1994

**Figure 2-2. Plan View of the Ventron Site**



138005

## Table 2-1. Chronology of Events for the Ventron Site

| | |
|---|---|
| 1942 to 1948 | • Metal Hydrides Corporation operated under contract to the Manhattan Engineer District (MED) to convert uranium oxide to uranium metal powder. |
| 1948 | • Atomic Energy Commission (AEC) conducted a radiological survey of the site.<br>• Decommissioning activities performed by AEC. |
| 1948 to 1950 | • Two of the three buildings that housed foundry facilities were demolished and two new buildings were later constructed in the same locations. |
| 1965 | • Metal Hydrides Corporation became Ventron Corporation. |
| 1976 | • Ventron Corporation acquired by Thiokol Corporation. |
| 1977 | • Radiological survey assessment (included both indoor and outdoor surveys of the Ventron site) performed for DOE by Oak Ridge National Laboratory (ORNL). |
| 1980 | • Ventron became a division of Morton Thiokol, Inc., which was renamed Morton International in 1990. |
| 1980 to 1982 | • More complete surveys of land and buildings at Ventron conducted by ORNL. |
| 1986 | • Ventron designated to FUSRAP.<br>• Based upon the evaluation of the survey results, DOE determined that remedial action at the site was warranted.<br>• Underground tank removed by Morton; DOE provided health physics support to Morton during this activity. |
| 1987 | • Contaminated roof replaced by DOE and material disposed at the DOE Hanford facility. |
| 1987 to 1988 | • Radiological survey of onsite buildings conducted by ORNL. |
| 1987, 1988, 1991 | • DOE provided health physics support to Morton. |
| 1991 | • Offsite Vicinity Property Survey Investigation—Subsequent radiological survey performed by ORNL in May to determine if radiological contamination from plant operations had migrated offsite. |
| 1992 | • Ventron Site Characterization Investigation—To determine the nature and extent of radiological contamination at the Ventron site, further characterization of radioactive and chemical contamination was performed in September and October. Preliminary results reveal elevated levels of radioactivity in a few small, isolated areas of the site, inside two buildings, and beneath three other buildings.<br>• Information session held in Beverly, Massachusetts, in December to explain the results from the offsite vicinity property survey to the residents. |
| 1993 | • In September, health physics support provided to Morton in support of the state's request to sample sediments from Beverly Harbor.<br>• Composite sediment samples collected from Ventron site harbor area. |
| 1994 | • Discrete sediment samples collected from Ventron site harbor area.<br>• Production ceased at the Ventron site in November 1994. |

THIS PAGE INTENTIONALLY LEFT BLANK

# 3. REMEDIATION GUIDELINES

## 3.1 RADIOLOGICAL CONSTITUENTS

Preliminary remediation objectives have been derived from DOE Order 5400.5. Remedial action guidelines for residual concentrations of Ra-226, Th-230, and Th-232, when averaged over any 100 $m^2$ area, are:

- 5 pCi/g above background, averaged over the first 15 centimeters (cm) of soil below the surface; and
- 15 pCi/g above background, averaged over 15 cm-thick layers of soil at greater than 15 cm below the surface (see Table 3-1).

Remedial objectives for uranium are established on a site-specific basis. The remedial objective for U-238 in soils at the Ventron site is 50 pCi/g above background levels; the remedial objective for total uranium is 100 pCi/g above background levels (Appendix A) (ANL 1992).

DOE has authority at the Ventron site for soils which contain greater than 50 pCi/g of U-238. Remediation of soils which contain concentrations of U-238 greater than 50 pCi/g and which are commingled with radium and/or thorium will be negotiated between DOE and Morton.

In general, the screening limit for gamma-radiation walkovers is twice naturally occurring background levels. For the Beverly area near Ventron, background radiation measurements were taken and are presented in Table 3-2.

The guidelines for allowable radioactivity levels on structural surfaces are shown in Table 3-1.

## 3.2 HAZARDOUS CONSTITUENTS

Remediation of soils which contain concentrations of U-238 greater than 50 pCi/g and which are commingled with hazardous constituents will be negotiated between DOE and Morton.

Remedial objectives for hazardous constituents are under negotiation between Morton and the State of Massachusetts as part of Morton's ongoing site investigation.

## Table 3-1. Summary of DOE Guidelines for Residual Radioactive Contamination

**BASIC DOSE LIMITS**

The basic limit for the annual radiation dose (excluding radon) received by an individual member of the general public is 100 mrem/yr. In implementing this limit, DOE applies as low as reasonably achievable (ALARA) principles to set site-specific guidelines.

**SOIL GUIDELINES**

| Radionuclide | Soil Concentration (pCi/g) Above Background[a,b,c] |
|---|---|
| Ra-226, Ra-228, Th-230, and Th-232 | 5 pCi/g when averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over any 15-cm thick soil layer more than 15 cm below the surface. |
| Other radionuclides | Site-specific U-238 guideline of 50 pCi/g and a total-uranium guideline of 100 pCi/g were developed for the Ventron site soils. |

**STRUCTURE GUIDELINES**

**Airborne Radon Decay Products**

"Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for release without restriction; structures that will be demolished or buried are excluded" (DOE 1990). The applicable generic guideline (40 CFR 192.12 (b)1) is: "in any occupied or habitable building, the objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL[d]. In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL." Remedial actions are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive materials are not the cause.

**External Gamma Radiation**

The average level of gamma radiation inside a building or habitable structure on a site that has no radiological restrictions on its use shall not exceed the background level by more than 20 $\mu$R/hr and will comply with the basic dose limits when an appropriate-use scenario is considered.

**Indoor/Outdoor Structure Surface Contamination**

| | Allowable Surface Residual Contamination (dpm/100 cm$^2$)[e] | | |
|---|---|---|---|
| Radionuclide[f] | Average[g,h] | Maximum[h,i] | Removable[h,j] |
| Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129 | 100[k] | 300[k] | 20[k] |
| Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133 | 1,000 | 3,000 | 200 |
| U-Natural, U-235, U-238, and associated decay product alpha emitters | 5,000 $\alpha$ | 15,000 $\alpha$ | 1,000 $\alpha$ |
| Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above[l] | 5,000 $\beta$-$\gamma$ | 15,000 $\beta$-$\gamma$ | 1,000 $\beta$-$\gamma$ |

## Table 3-1. (continued)

[a] These guidelines take into account ingrowth of Ra-226 from Th-230 and of Ra-228 from Th-232 and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that: 1) the dose for the mixtures will not exceed the basic dose limit, or 2) the sum of ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed 1 ("unity").

[b] These guidelines represent allowable residual concentrations above background averaged across any 15 cm-thick layer to any depth and over any contiguous 100 $m^2$ surface area.

[c] If the average concentration in any surface or below-surface area less than or equal to 25 $m^2$ exceeds the authorized limit or guideline by a factor of $(100/A)^{1/2}$, where A is the area of the elevated region in square meters, limits for hotspots shall also be applicable. Procedures for calculating these hotspot limits, which depend on the extent of the elevated local concentrations, are given in the supplement of the FUSRAP Summary Protocol. In addition, every reasonable effort shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit for soil, irrespective of the average concentration in the soil.

[d] A working level (WL) is any combination of the short-lived radon decay products in 1 liter of air that will result in the ultimate emission of $1.3 \times 10^5$ MeV (mega electric volts) of potential alpha energy.

[e] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute (cpm) measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[f] Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

[g] Measurements of average contamination should not be averaged over an area of more than 1 $m^2$. For objects of less surface area, the average should be derived for each such object.

[h] The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr and 1.0 mrad/hr, respectively, at a depth of 1 cm.

[i] The maximum contamination level applies to an area of not more than 100 $cm^2$.

[j] The amount of removable radioactive material per 100 $cm^2$ of surface area should be determined by wiping an area of that size with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 $cm^2$ is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels if direct scan surveys indicate that total residual surface contamination levels are within the limits for removable contamination.

[k] Guidelines for these radionuclides are not given in DOE Order 5400.5; however, these guidelines are considered applicable until guidance is provided.

[l] This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90 which has been separated from the other fission products or mixtures where the Sr-90 has been enriched.

*Sources:* 40 *CFR* 192, DOE 1986b, DOE 1990.

**Table 3-2. Background Radiation Levels in the Beverly, Massachusetts Area[a]**

| Type of Radiation Measurement or Sample | Background Radiation Level or Radionuclide Concentration | |
|---|---|---|
| | Range | Average |
| Gamma exposure rate at 1 m above floor or ground surface ($\mu$R/hr)[b] | 6 - 8 | 7 |
| Background concentration of radionuclides in soil (pCi/g)[b] | | |
| Ra-226 | 1.0 - 1.8 | 1.3 |
| Th-232 | 0.98 - 1.2 | 1.1 |
| U-238 | 0.92 - 2.7 | 1.6 |

[a] Cottrell and Carrier 1988.
[b] Values obtained from three locations in the Beverly area.

# 4. PREVIOUS STUDIES

AEC conducted a radiological survey of the Ventron facility in 1948. Survey results indicated the presence of elevated levels of radioactivity in the two foundry buildings and on various pieces of equipment. Decontamination and decommissioning activities performed by AEC in 1948 included demolishing the foundry buildings, sandblasting painted surfaces on equipment, and removing concrete floors and platforms. These cleanup activities were performed in accordance with guidelines in effect at the time (Cottrell and Carrier 1988).

ORNL conducted a radiological site screening survey in 1977 to determine compliance with current DOE environmental cleanup guidelines. Based upon these results, DOE determined that a comprehensive radiological survey of the entire site was warranted. A comprehensive radiological survey of the outdoor portion of the site was conducted by ORNL in 1980. The outdoor survey included gamma exposure rate scans, analysis of radionuclide concentrations from surface and subsurface soil samples, downhole gamma logging of augered boreholes, and analysis of radionuclide concentrations from sediment samples from storm sewer manholes. The buildings and structures on the site were surveyed by ORNL in 1982 (Cottrell and Carrier 1988).

Subsequent radiological surveys were performed by ORNL in 1991 to determine if uranium materials from work performed at Ventron under MED contracts had migrated offsite. The surveys were performed on the Beverly Harbor and 24 offsite residential/municipal properties. The survey of the harbor included gamma exposure rate scans and analysis of sediment and biological samples. The survey of the offsite properties included surface gamma scans, beta-gamma scans, and analysis of soil samples. Results of these previous studies are discussed below.

## 4.1 GAMMA EXPOSURE RATE SCANS OF THE OUTDOOR SITE AREA

For the ORNL survey (Cottrell and Carrier 1988), the overall average exposure rate at 1 m above the ground surface was 8 microRoentgens per hour ($\mu$R/hr). Although this is only slightly above the average background gamma exposure rate of 7 $\mu$R/hr at 1 m above the ground surface for the Beverly, Massachusetts area (see Table 3-2), elevated gamma exposure rates above background were detected in numerous areas. Table 4-1 lists the gamma exposure rate data collected by ORNL in 1980 for grid blocks that had maximum gamma exposure rates ($\geq$ 10 $\mu$R/hr). Figure 4-1 shows the locations of the elevated gamma exposure rates ($\geq$10 $\mu$R/hr). The highest gamma exposure rate values were reported for the southwest and southeast corners of the site. The maximum gamma exposure rate values of 300 and 450 $\mu$R/hr were measured south of the Alfa Building and adjacent to the southwest corner of Building C-1 (Locations 15, 16, and 25). The close proximity of high gamma measurements to the intertidal zone suggests a high potential for elevated levels of radioactivity in the rip-rap and intertidal sediments. This concern was supported by the detection of elevated gamma radiation during a cursory gamma scan of the tidal area adjacent to the site.

## 4.2 SITE SOIL ANALYSIS

Characterization of site soils was performed by ORNL by collecting surface and subsurface soil samples for radionuclide analyses and logging of gamma radiation levels at various depths in subsurface boreholes.

### 4.2.1 Surface Site Soils

The surface soil sampling included samples taken primarily from 0 to 15 cm (0 to 6 in.) from systematically selected locations and biased locations. The biased samples were taken at points showing elevated gamma radiation levels based on a gamma walkover surface survey. Nineteen systematic samples and 9 biased samples were collected for a total of 28 surface soil samples (see Figure 4-2). All samples were analyzed for Ra-226, Th-232, and U-238.

Figure 4-3 depicts the locations of the surface soil samples taken that had radionuclide concentrations of Ra-226 or Th-232 greater than 5 pCi/g or U-238 greater than 50 pCi/g. The radionuclide concentrations for these surface soil samples are shown in Table 4-2 (Cottrell and Carrier 1988).

Consistent with the gamma scan results, the highest surface soil radionuclide concentrations were reported for samples from the southwest and southeast corners of the site. Concentrations of Th-232 in the systematic samples ranged from less than 1 to 370 pCi/g. Of the 19 systematic soil samples analyzed for Th-232, all but four were at background levels. The maximum concentration of Th-232 found in the biased soil samples was 3,900 pCi/g found in the southeast corner of the site. Concentrations of U-238 in the systematic surface soil ranged from 0.74 to 97 pCi/g and averaged 12 pCi/g. Fourteen of the 19 systematic soil samples contained uranium concentrations in excess of local background concentrations. The maximum concentration of U-238 found in the biased soil samples was 44,000 pCi/g in the southwest corner of the site adjacent to Building C-1. All concentrations of Ra-226 in the surface soil samples were at or near background levels for the Beverly area. The average concentrations of Ra-226, Th-232, and U-238 were 2 pCi/g, 196 pCi/g, and 1,342 pCi/g, respectively.

### 4.2.2 Subsurface Site Soils

Boreholes were augered by ORNL around and beneath Buildings B-1, B-2, B-3, and C-1 and south of the Alfa Building (see Figure 4-4). One or more soil samples were taken from each borehole at various depths ranging from the surface to 3.5 m and analyzed for U-238, Ra-226, and Th-232 concentrations. Selected boreholes were downhole gamma logged using a shielded gamma scintillator.

Table 4-3 provides the radionuclide concentrations for the borehole samples that had concentrations of Ra-226 or Th-232 greater than 15 pCi/g or U-238 greater than 50 pCi/g. The locations of these boreholes are shown in Figure 4-5.

Concentration of U-238 found in the subsurface soil samples taken from boreholes around the buildings ranged from 1.7 to 62,000 pCi/g. The maximum concentrations of Ra-226 and Th-232 around the buildings were 30 and 53 pCi/g, respectively.

Analysis of subsurface soil samples taken from boreholes beneath the buildings showed concentrations of U-238 ranging from 1.8 to 71,000 pCi/g and averaging 1,800 pCi/g. The maximum concentrations of U-238 found beneath Buildings B-1, B-2, B-3 and C-1 were 14,000 pCi/g, 71,000 pCi/g, 17 pCi/g, and 1,400 pCi/g, respectively. Concentrations of Ra-226 and Th-232 beneath the buildings ranged from less than 0.08 to 37 pCi/g, and less than 0.05 to 3.3 pCi/g, respectively.

The average concentrations of Ra-226, Th-232, and U-238 in the subsurface soils were 1.8 pCi/g, 4.7 pCi/g, and 1,945 pCi/g, respectively.

The data suggest that the areas of greatest U-238 concentrations are under Buildings B-1, B-2, and C-1. Areas of elevated Th-232 concentrations are much less extensive and are found mostly in the southeast corner of the site. Only two boreholes had concentrations of Ra-226 greater than 15 pCi/g: one borehole was adjacent to Building B-3 (B12) and the second borehole beneath Building B-2 (B19) (Cottrell and Carrier 1988).

The maximum borehole depth, measured by ORNL, beneath the basement floors of Buildings B-1, B-2, B-3, and C-1 with U-238 concentrations greater than 50 pCi/g was 2.15 m (samples B-19 and B-25). The maximum borehole depth measured around the buildings with U-238 concentrations greater than 50 pCi/g was 0.75 m (sample B-11).

## 4.3 HARBOR SURVEY AND ANALYSES

The 1991 ORNL radiological survey of the Ventron site harbor area consisted of measurements of radiation levels over the ground surface and analyses of soil, sediment, and biological samples. The locations of the soil, sediment, and biological samples are shown in Figure 4-6. The results of the gamma survey, soil, and sediment analyses, and biological analyses are discussed below.

The radiological survey of the tidal flat area adjacent to the facility indicated that gamma exposure rates on the tidal flats adjacent to the seawall ranged from 24 to 40 $\mu$R/hr at the southwest corner of the site (adjacent to Building C-1), and 16 to 24 $\mu$R/hr on the south side of the site (adjacent to Buildings B-1 and B-2), with a maximum of 60 $\mu$R/hr measured in one spot near the seawall behind Building B-2. Exposure rates farther out from the buildings, in the tidal flats, ranged from 4 to 9 $\mu$R/hr. These values are comparable to the background measurements in the Beverly area.

The systematic soil samples were taken from the area close to the Ventron site and also up to the low tide water line in the harbor area west of the Ventron site on adjacent vicinity

properties. The biased samples were taken in the areas of elevated gamma readings that were measured close to the Ventron site buildings on the outside of the perimeter fence.

All systematic samples, both surface (0-15 cm) and subsurface (15-60 cm), contained less than 5 pCi/g of Ra-226 or Th-232 and less than 50 pCi/g of U-238.

The biased surface samples (0-15 cm) contained U-238 concentrations ranging from 32 to 4,600 pCi/g. Sample B3C, a surface sample taken after monitoring for localized elevated radiation readings near the B3 sample location, measured 22,000 pCi/g. U-238 concentrations in the subsurface biased samples ranged from 11 to 5,500 pCi/g. Maximum Ra-226 and Th-232 concentrations in the biased samples were 1.2 and 21 pCi/g, respectively, in the surface sediment, and 1.6 and 27 pCi/g, respectively, in the subsurface sediment.

Biased sample B1A was subdivided until a metal fragment was isolated. The sample containing the metal fraction was labeled B1AM and measured 210,000 pCi/g for U-238. Concentrations of Ra-226 and Th-232 in this sample were less than 27 and less than 42 pCi/g, respectively.

Figure 4-7 and Table 4-4 show the locations and concentrations, respectively, of the surface and subsurface sediment samples that contained concentrations of Th-232 greater than 5 pCi/g for surface samples or 15 pCi/g for subsurface samples or U-238 greater than 50 pCi/g (ORNL 1991).

Lobster traps were set in three locations in the harbor to the south of the site. For background readings, a fourth trap was set 3.25 nautical miles east of the site. Three lobsters from each of the locations were analyzed to determine U-238, Th-232, and Ra-226 concentrations. In two of the lobsters from each trap, the edible parts (tail and claws) were removed and combined for analysis. In the remaining lobster in each trap, the inedible parts (stomach, green gland, and carapace) were removed and combined for analysis. Results of the analyses showed no significant difference in U-238, Th-232, and Ra-226 concentrations between the background samples and any of the other samples (ORNL 1991).

## 4.4 STORM SEWER SEDIMENT ANALYSIS

Sediment samples from three storm sewer manholes on the site were analyzed for Ra-226, Th-232, and U-238 (Cottrell and Carrier 1988). Table 4-5 lists radionuclide concentrations for each of the samples and Figure 4-8 illustrates the storm sewer sediment sample locations.

Concentrations of Ra-226 ranged from 7.4 to 100 pCi/g in the three samples. One elevated Th-232 concentration (21 pCi/g) and one elevated U-238 concentration (25 pCi/g) was also detected.

## 4.5 INDOOR SURVEY

In 1982, ORNL conducted a radiological survey of all building interiors on the Ventron site, and the roofs of Buildings A and A-1 (Cottrell and Carrier 1988). The survey included gamma exposure rates at 1 m above the floor surface, and at the floor surface at indoor grid locations, gamma scanning, and direct and transferable alpha and beta-gamma activity.

Spotty regions of elevated radionuclide measurements were identified on the floors, walls, overhead surfaces, equipment, and roofs of Buildings A and A-1 and the Alfa Building.

Inside Building A, elevated measurements were most evident in Rooms 20, 29 and 30. Directly measured alpha and/or beta-gamma levels were elevated on floors, walls, overhead surfaces, equipment, and in the floor drain troughs. Elevated radionuclide measurements were found on the roof as a result of particulate deposition. In 1987, DOE replaced the roof of Building A. Direct alpha ranged from 140 to 10,000 disintegrations per minute (dpm)/cm$^2$ and direct beta-gamma dose rates were as high as 2.3 millirad (mrad)/hr.

Elevated surface measurements were also found in Building A-1 in numerous regions (especially in Rooms 3, 4, 4A, and 6), on the floors, walls, and overhead and equipment surfaces. Elevated measurements found on the roof were largely associated with the presence of loose dirt in scattered regions.

In the Alfa Building, elevated gamma exposure rates were found in association with thorium crystals and thorium-processing equipment not related to DOE/MED-related activities. Directly measured alpha and beta-gamma levels were elevated in the drains and drain troughs in several regions.

Surface measurements taken in Buildings B-1, B-2, B-3, C-1, C-2, C-3, C-4, and D were not elevated. Elevated gamma levels discovered in areas of the basements of Buildings B-1, B-2, and C-1 suggested the presence of radioactive materials beneath the floors. Radionuclide analysis of soil samples taken from holes drilled into the substrata confirmed that assumption. No evidence of the presence of radioactive residuals was found inside or beneath the storage building or the warehouse.

## 4.6 OFFSITE PROPERTIES

During May 1991, DOE performed a radiological investigation of the residential housing area adjacent to the Ventron site. This radiological investigation included radiological surveys of approximately 24 offsite residential and municipal properties and included surface gamma scans, beta-gamma scans of paved areas, and the collection of soil samples for radionuclide analyses. The objective of the surveys was to determine whether or not radioactive constituents from the Ventron site had migrated offsite to neighboring areas, and, if so, to what extent. Based on the survey data, no detectable radiological constituents had migrated into the vicinity properties and no further investigation was warranted (ORNL 1992a through 1992s).

138005

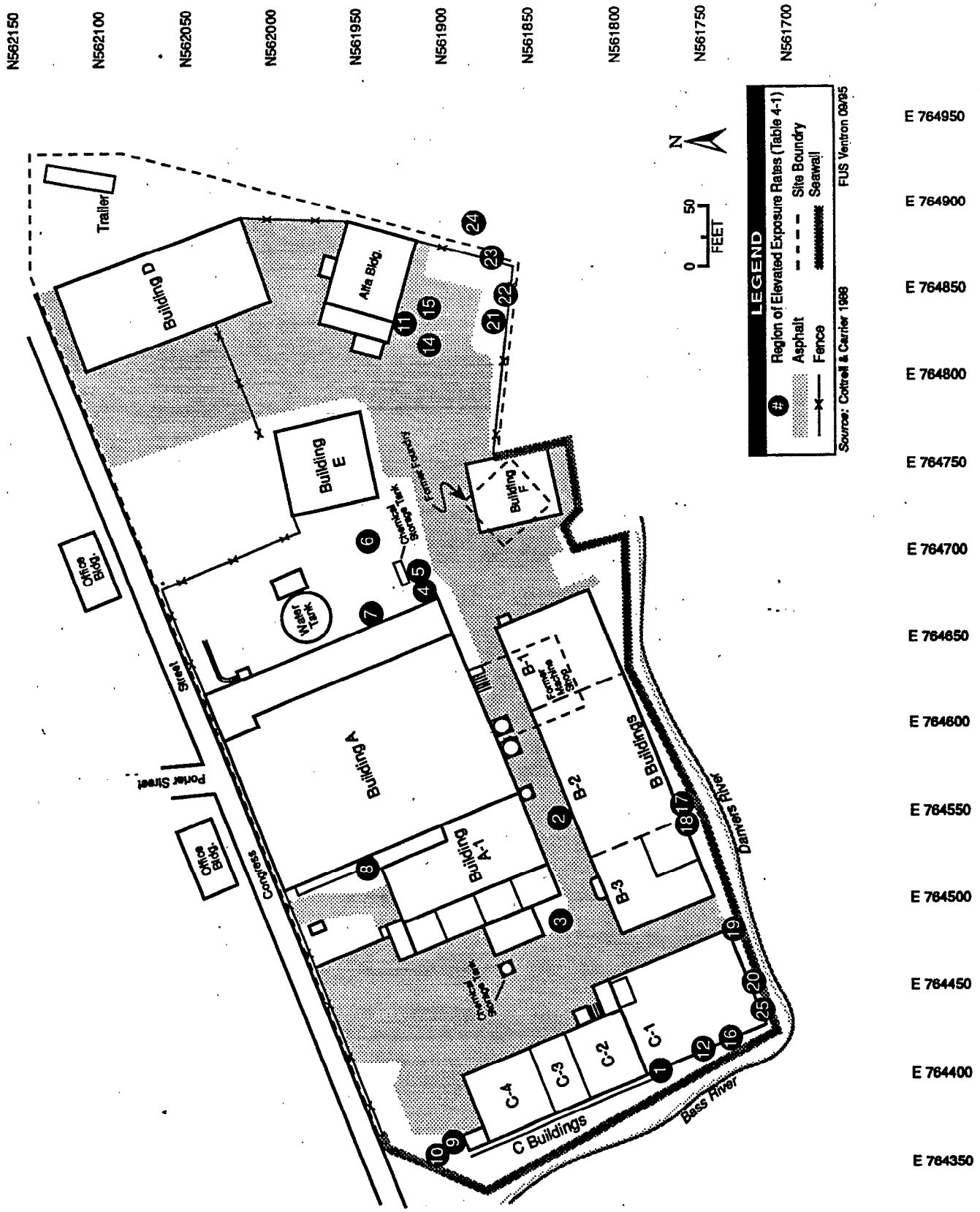



**Figure 4-1. Locations of Elevated Gamma Exposure Rate Measurements Outdoors at the Ventron Site (1982 ORNL Sampling Event)**



FUS092P/110295

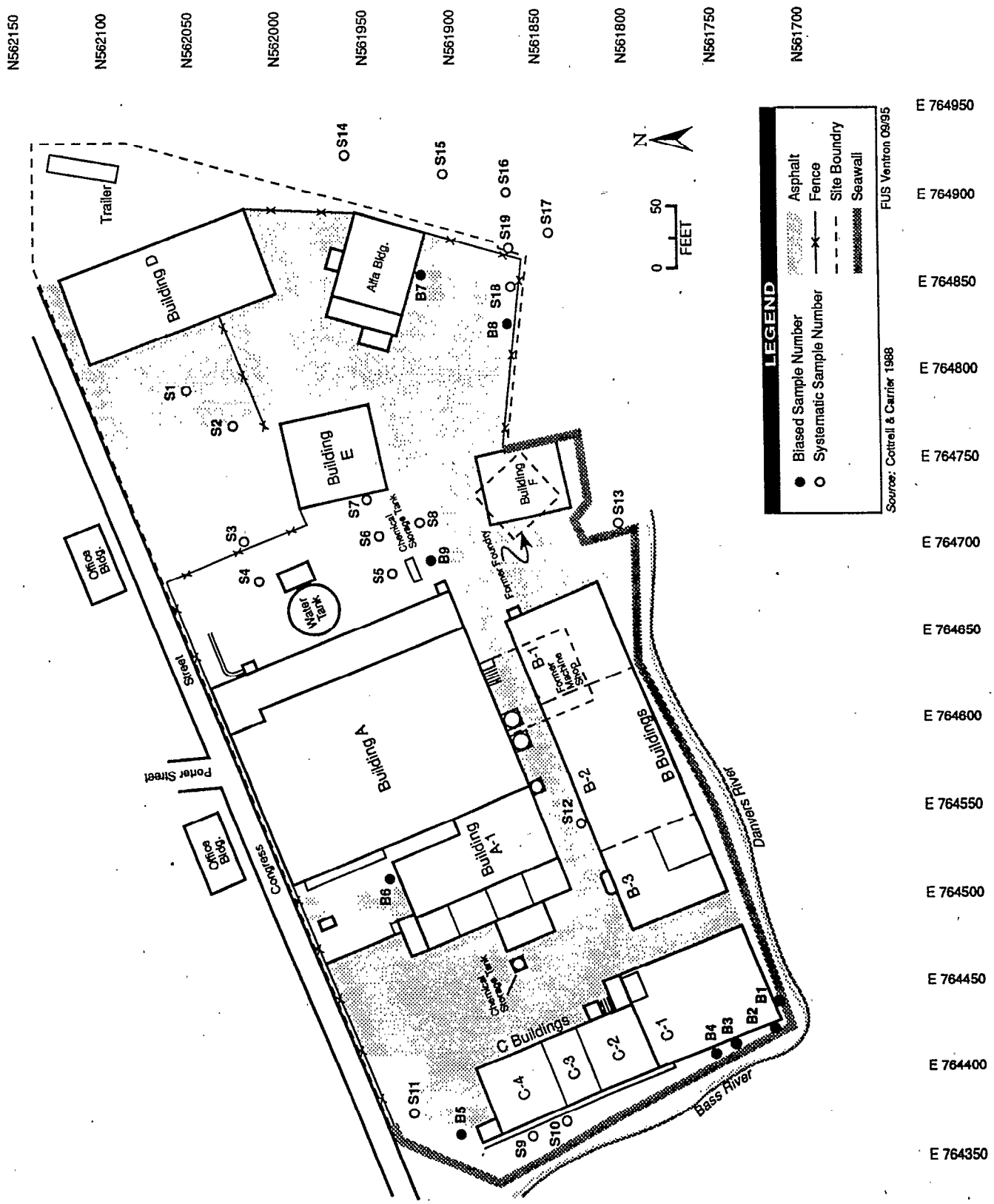



**Figure 4-2. Locations of Surface Soil Samples (1982 ORNL Sampling Event)**

138005

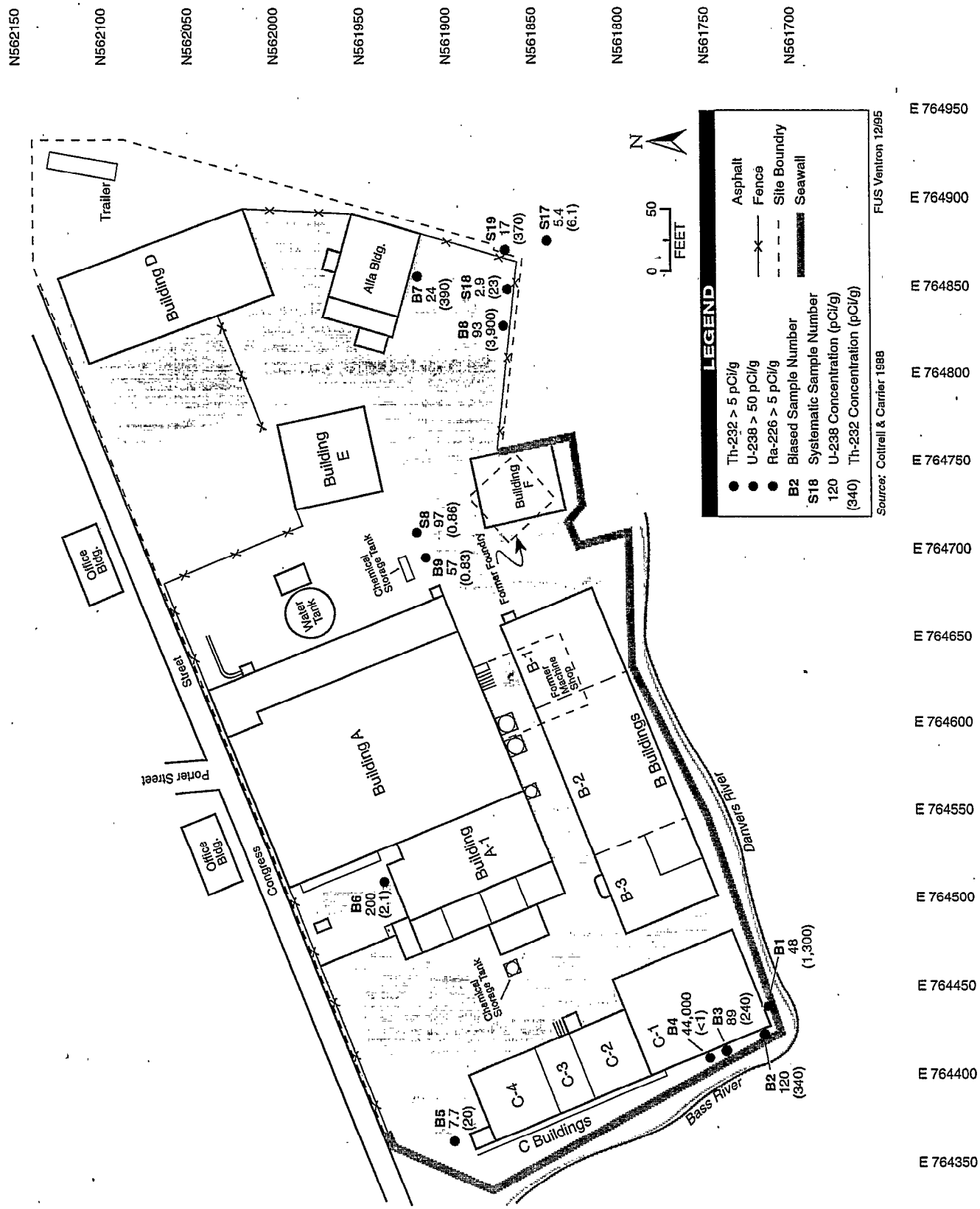



**Figure 4-3. Locations of Surface Soil Samples with Concentrations of Ra-226 or Th-232 >5 pCi/g or U-238 >50 pCi/g (1982 ORNL Sampling Event)**

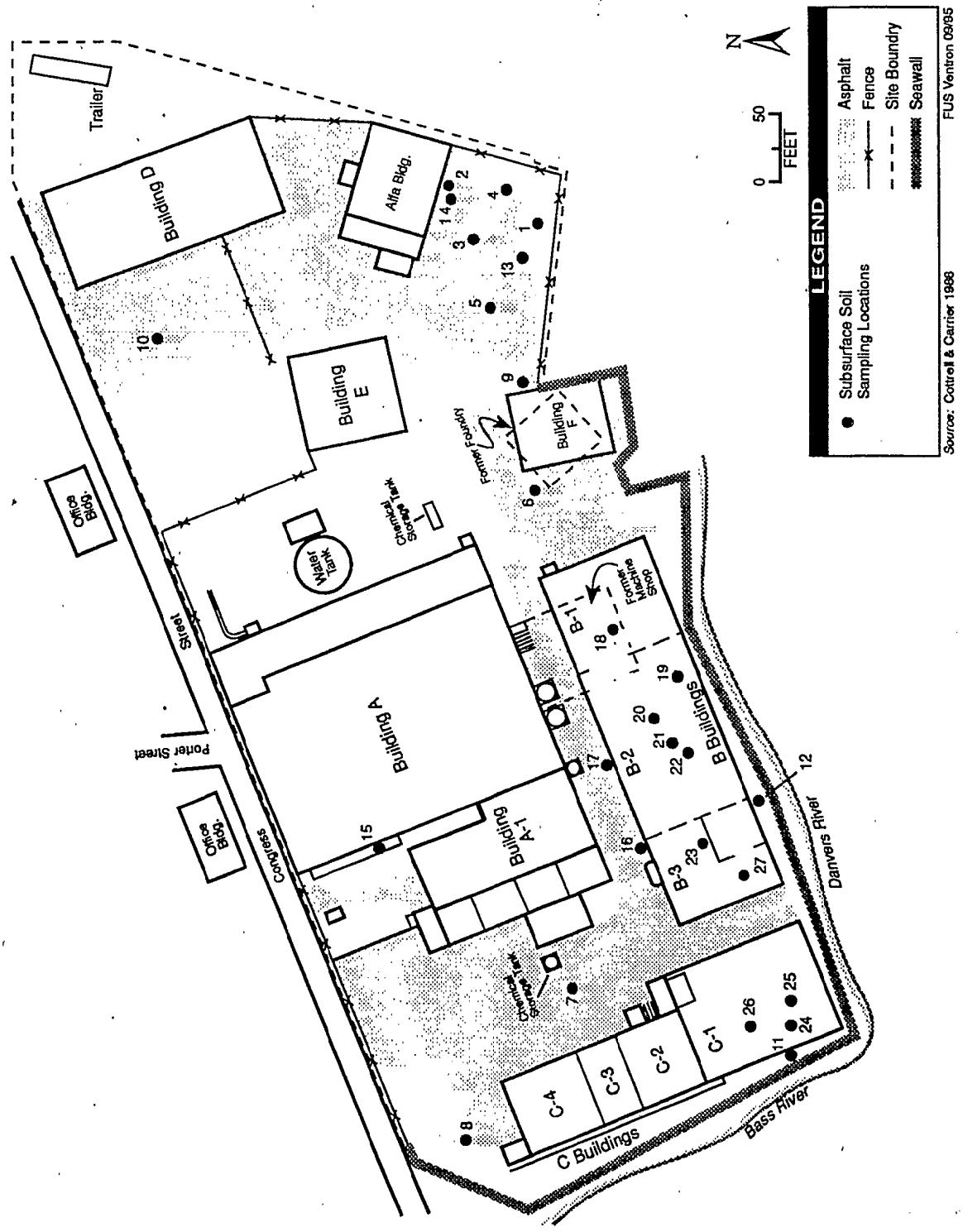



**Figure 4-4. Locations of Subsurface Soil Samples (1982 ORNL Sampling Event)**

138005

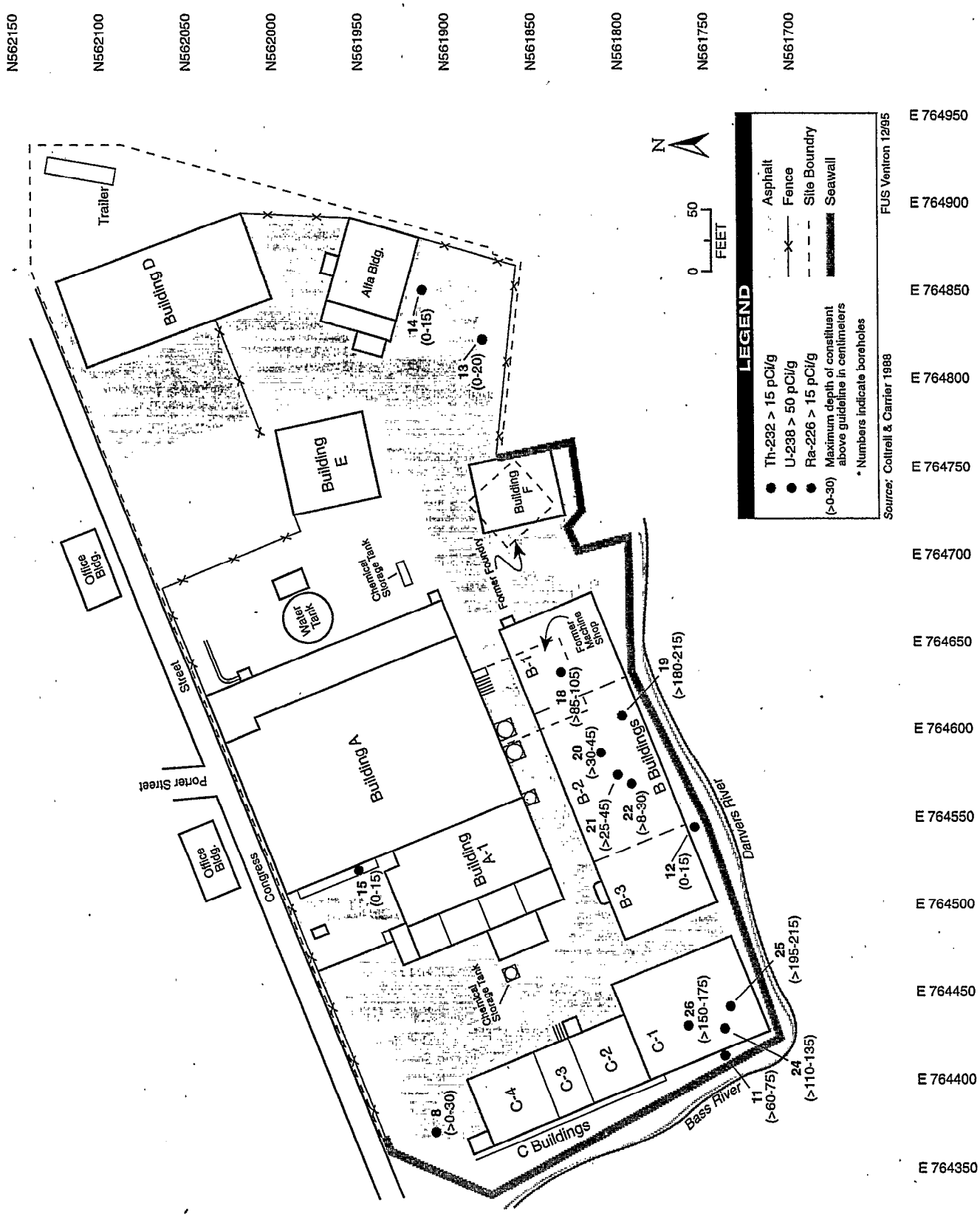



**Figure 4-5. Locations of Subsurface Samples with Concentrations of Ra-226 or Th-232 >15 pCi/g or U-238 >50 pCi/g (1982 ORNL Sampling Event)**

138005

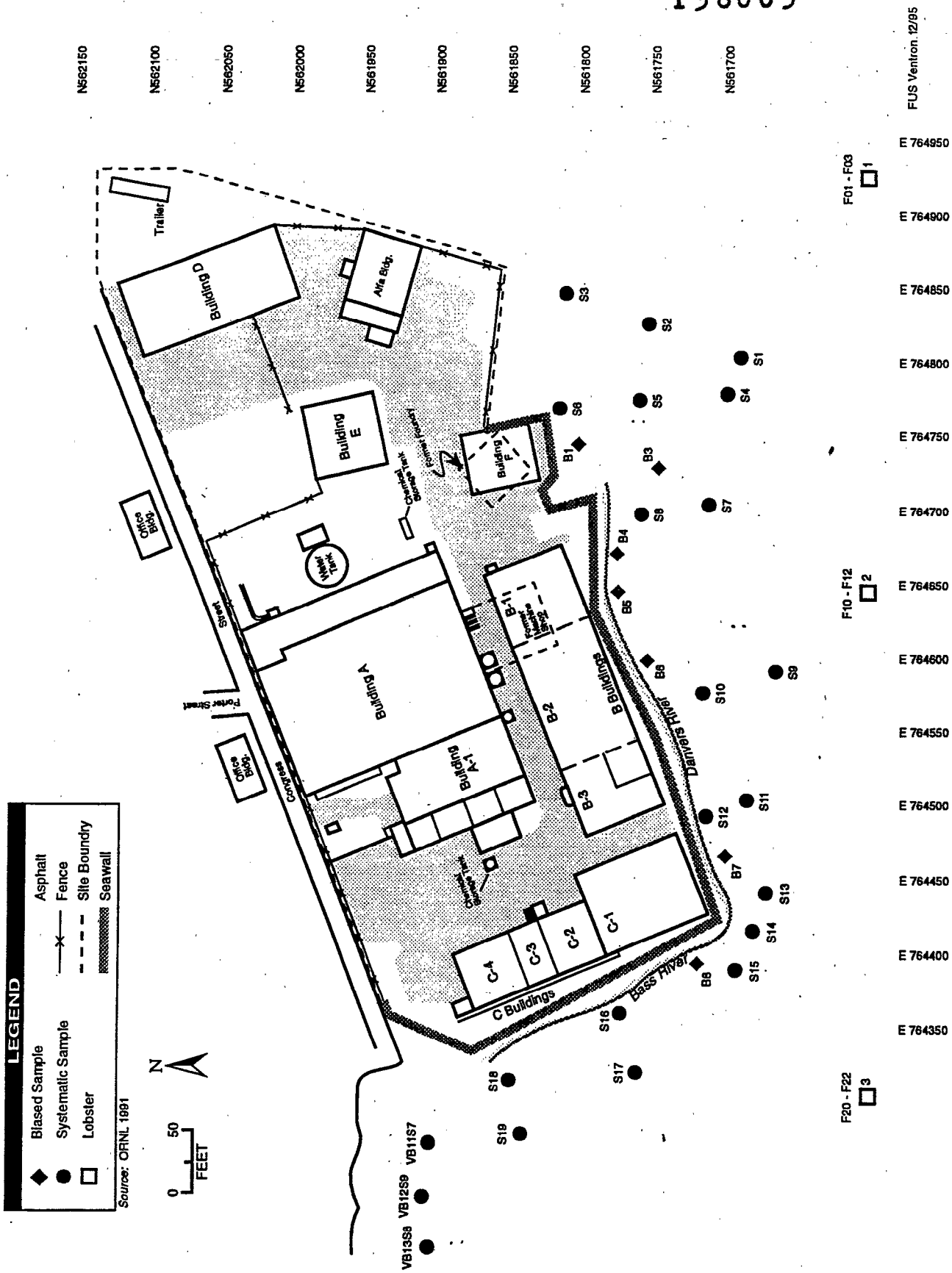



**Figure 4-6. Locations of Soil, Sediment, and Lobster Samples at Beverly Harbor (1991 ORNL Sampling Event)**

138005

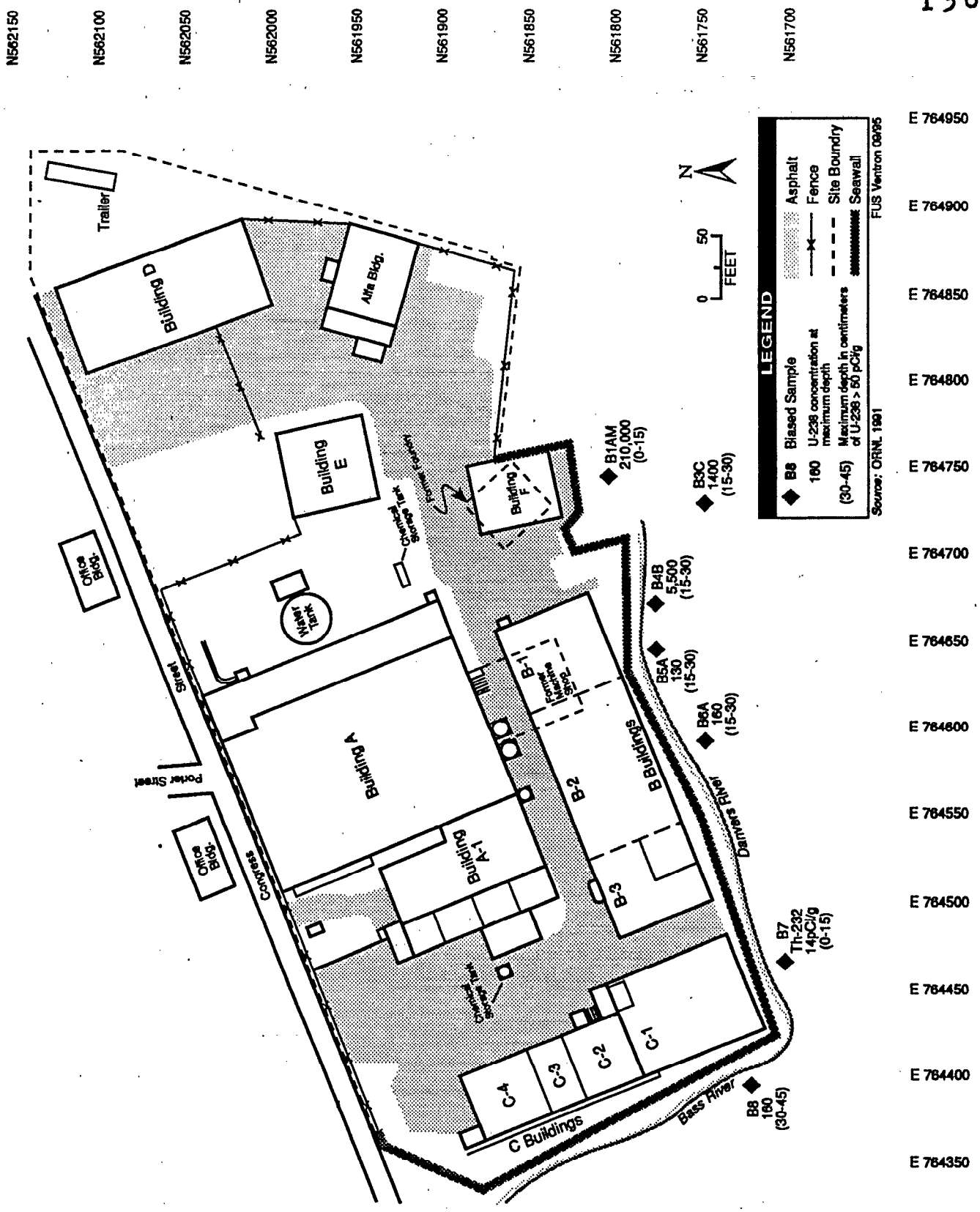



**Figure 4-7. Locations of Harbor Sediment Samples with Concentrations of Th-232 >5 pCi/g or U-238 >50 pCi/g (1991 ORNL Sampling Event)**

138005

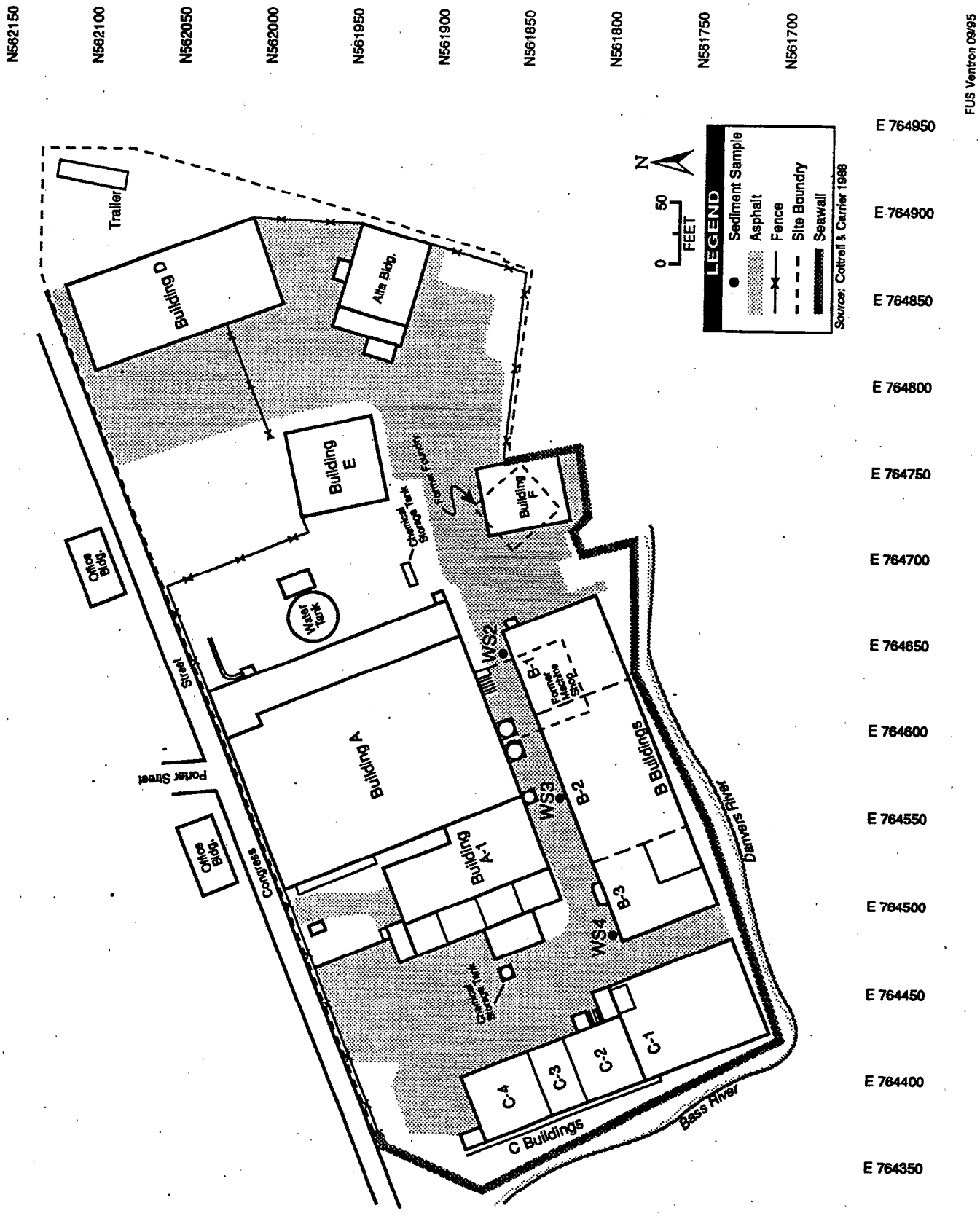



**Figure 4-8. Locations of Storm Sewer Sediment Samples (1982 ORNL Sampling Event)**

## Table 4-1. Elevated Gamma Exposure Rate Measurements Outdoors

| Location Code[a] | Maximum Gamma Exposure Rate at Surface (μR/h)[b] | Maximum Gamma Exposure Rate at 1 m (μR/h)[b] | Beta-Gamma Dose Rate at Surface (mrad/h) | Estimated Area ($m^2$) |
|---|---|---|---|---|
| 1 | 45 | c | c | <0.1 |
| 2 | 24 | c | c | <0.1 |
| 3 | 24 | c | 0.04 | <0.1 |
| 4 | 10 | c | c | <0.1 |
| 5 | 24 | c | c | <0.1 |
| 6 | 10 | c | c | 0.28 |
| 7 | 20 | c | c | c |
| 8 | 30-55 | 23 | 0.5 | 1.5 |
| 9 | 24 | 6 | 0.06 | <0.1 |
| 10 | 24 | c | c | c |
| 11 | 30-150 | c | c | 1.9 |
| 12 | 45 | c | c | <0.1 |
| 13 | 24 | c | c | 0.28 |
| 14 | 67 | c | c | <0.1 |
| 15[d] | 300 | 61 | 0.35 | 9.3 |
| 16[e] | 120-450 | 45 | 5 | ~1.9 |
| 17 | 45 | c | c | <0.1 |
| 18 | 45 | c | c | <0.1 |
| 19 | 76 | c | c | 0.093 |
| 20 | 61 | c | c | 0.093 |
| 21 | 73 | c | c | <0.1 |
| 22 | 240 | 45 | 0.45 | 2.8 |
| 23[f] | 91 | c | c | 2.8 |
| 24[g] | 24 | c | c | c |
| 25[e] | 61-300 | 30 | 0.6 | 1.6 |

[a] Codes are shown on Figure 4-1 in locations approximating grid points where anomalies were measured.
[b] Maximum gamma exposure rate measured during scan of grid block.
[c] No measurement taken.
[d] Maximum levels found in many spots within grid block.
[e] Maximum levels found in spotty regions next to building wall.
[f] Measurement located south of fence.
[g] Average gamma exposure rate during scan of grid block.
*Source:* Cottrell and Carrier 1988.

**Table 4-2. Surface Soil Samples with Concentrations of Ra-226 or Th-232 >5 pCi/g or U-238 >50 pCi/g**

| Sample Number[a] | Depth (cm) | Radionuclide Concentration (pCi/g) | | |
|---|---|---|---|---|
| | | Ra-226[b] | Th-232[c] | U-238[d] |
| **Systematic Samples[e]** | | | | |
| S8 | 0-15 | 0.70 | 0.86 | 97 |
| S17 | 0-15 | 1.1 | 6.1 | 5.4 |
| S18A | 0-15 | 0.88 | 23 | 2.9 |
| S18B | 35-50 | 3.0 | 160 | 6.3 |
| S19 | 0-15 | 2.9 | 370 | 17 |
| **Biased Samples[f]** | | | | |
| B1 | 0-15 | 6 | 1,300 | 48 |
| B2 | 0-15 | <1 | 340 | 120 |
| B3 | 0-15 | <1 | 240 | 89 |
| B4 | 0-15 | <1 | <1 | 44000 |
| B5 | 0-15 | 0.91 | 20 | 7.7 |
| B6 | 0-15 | 1.7 | 2.1 | 200 |
| B7 | 0-15 | 2.0 | 390 | 24 |
| B8 | 0-15 | <1 | 3,900 | 93 |
| B9A | 0-15 | 0.73 | 0.83 | 57 |

[a] Locations of soil samples are shown in Figure 4-3.
[b] Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).
[c] The error of the reported radionuclide concentration is $\pm 5\%$ (95% confidence level).
[d] Total analytical error of measurement results $< \pm 5\%$ (95% confidence level).
[e] Systematic samples are taken at grid locations irrespective of gamma exposure rates.
[f] Biased samples are taken from areas shown to have elevated gamma exposure rates.
*Source:* Cottrell and Carrier 1988.

**Table 4-3. Subsurface Soil Samples with Concentrations of Ra-226 or Th-232 >15 pCi/g or U-238 >50 pCi/g**

| Borehole Number[a] | Depth of Hole (m) | Depth (cm) | Radionuclide Concentration (pCi/g) | | |
|---|---|---|---|---|---|
| | | | Ra-226[b] | Th-232[c] | U-238[d] |
| 8 | 3.2 | 0 - 30 | 0.87 | 0.85 | 60 |
| 11 | 0.75 | 0 - 15 | 0.95 | 1.5 | 88 |
| | | 15-45 | <1 | <0.14 | 590 |
| | | 45-60 | <1 | 46 | 62,000 |
| | | 60-75 | <1 | 6.8 | 5,600 |
| 12 | 0.51 | 0 - 15 | 30 | 0.82 | 45 |
| 13 | 2.3 | 0 - 20 | 0.92 | 53 | 7.2 |
| 14 | 3.05 | 0 - 15 | 1.2 | 41 | 19 |
| 15 | 0.50 | 0 - 15 | 1.4 | 1.2 | 590 |
| 18 | 1.6 | 8 - 18 | <1 | <1 | 460 |
| | | 18 - 30 | <1 | <1 | 14,000 |
| | | 45-60 | <0.11 | <0.08 | 210 |
| | | 60-85 | <0.08 | <0.05 | 130 |
| | | 85-105 | 0.72 | 0.90 | 57 |
| 19 | 2.2 | 10 - 35 | <1 | <1 | 71,000 |
| | | 35-55 | <1 | <1 | 4,200 |
| | | 55-75 | 4.4 | 2.0 | 290 |
| | | 75-95 | 3.5 | 2.2 | 150 |
| | | 95-120 | 5.6 | 1.8 | 1,500 |
| | | 120-145 | 2.7 | 1.2 | 72 |
| | | 145-180 | 37 | <0.23 | 940 |
| | | 180-215 | 0.37 | <0.26 | 850 |
| 20 | 1.6 | 15 - 30 | 2.7 | <1 | 1,900 |
| | | 30-45 | 4.7 | 1.4 | 170 |

Table 4-3 (continued)

| Borehole Number[a] | Depth of Hole (m) | Depth (cm) | Radionuclide Concentration (pCi/g) | | |
|---|---|---|---|---|---|
| | | | Ra-226[b] | Th-232[c] | U-238[d] |
| 21 | 0.61 | 8 - 25 | 1.2 | 1.2 | 440 |
| | | 25-45 | 0.84 | 1.8 | 76 |
| 22 | 0.3 | 8 - 30 | 1.2 | 0.97 | 90 |
| 24 | 2.1 | 8 - 35 | <1 | <1 | 540 |
| | | 35-65 | 2.0 | 2.2 | 1,400 |
| | | 65-85 | 0.66 | 0.74 | 110 |
| | | 85-110 | 1.5 | 1.7 | 82 |
| | | 110-135 | 3.0 | 3.1 | 56 |
| 25 | 2.2 | 15 - 30 | <0.08 | 0.98 | 54 |
| | | 85 - 110 | 0.70 | <1 | 460 |
| | | 110 - 135 | 2.3 | 2.3 | 150 |
| | | 135 - 155 | 1.3 | 1.2 | 130 |
| | | 155 - 180 | 3.4 | 3.1 | 940 |
| | | 180 - 195 | 0.75 | 0.64 | 810 |
| | | 195 - 215 | 0.62 | 0.79 | 130 |
| 26 | 2.5 | 130 - 150 | 2.2 | 2.5 | 72 |
| | | 150 - 175 | 2.1 | 2.2 | 65 |

[a] Locations shown on Figure 4-5.
[b] Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).
[c] The error of the reported radionuclide concentration is $\pm 5\%$ (95% confidence level).
[d] The total analytical error is $< \pm 5\%$ (95% confidence level).
*Source:* Cottrell and Carrier 1988.

## Table 4-4. Harbor Sediment Samples with Concentrations of Th-232 >5 pCi/g or U-238 >50 pCi/g

| Sample Number[a] | Depth (cm) | Radionuclide Concentration (pCi/g)[b] | | |
|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-238 |
| **Biased Samples[c]** | | | | |
| B1A | 0-15 | 0.77 | 0.67 | 4,600 |
| B1AM | 0-15 | <27[d] | <42[d] | 210,000 |
| B3A | 0-15 | 0.71 | 1.4 | 2,600 |
| B3B | 15-30 | 0.74 | <0.7 | 1,400 |
| B3C* | 0-10 | <1.1 | <1.7 | 22,000 |
| B4A | 0-15 | 1.2 | 9.9 | 3,000 |
| B4B | 15-30 | 1.6 | 27 | 5,500 |
| B5A | 0-15 | 1.2 | 21 | 230 |
| B5B | 15-30 | 0.83 | 7.7 | 130 |
| B6A | 0-15 | 1.2 | 1.8 | 2,000 |
| B6B | 15-30 | 0.56 | 1.2 | 160 |
| B7A | 0-15 | 0.63 | 14 | 32 |
| B8A | 0-15 | 0.46 | 0.78 | 620 |
| B8B | 15-30 | 0.70 | 0.69 | 640 |
| B8C | 30-45 | 0.50 | 0.71 | 160 |

[a] Locations of soil samples are shown on Figure 4-7.
[b] Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).
[c] Biased samples are taken from areas with elevated gamma exposure rates.
[d] Higher detection limits for Ra-226 and Th-232 could have been due to a smaller sample size or higher background readings due to the higher levels of U-238.
* Sample B3C was taken ~1.5 ft east of the B3A (0-15 cm) sample hole. Surface contamination was monitored with the gamma scintillator until primary contaminant was found.

## Table 4-5. Concentration of Radionuclides in Storm Sewer Sediment Samples

| Sample Number | Location[a] | Radionuclide Concentration (pCi/g) | | |
|---|---|---|---|---|
| | | Ra-226[b] | Th-232[b] | U-238[c] |
| WS2 | 0 + 10, 10R | 100 | <1 | 1.5 |
| WS3 | 1 + 00, 6R | 13 | 0.9 | 25 |
| WS4 | 1 + 80, 6R | 7.4 | 21 | 1.2 |

[a] Sample locations are shown on Figure 4-8.
[b] Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).
[c] Total analytical error of measurement results is $< \pm 5\%$ (95% confidence level).
*Source:* Cottrell and Carrier 1988.

THIS PAGE INTENTIONALLY LEFT BLANK

# 5. 1992 CHARACTERIZATION ACTIVITIES

## 5.1 METHODOLOGY

This section provides an overview of the sampling methodology used for DOE's 1992 characterization of the Ventron site. The 1992 characterization effort was built upon the data collected during the 1988 and 1991 ORNL sampling and surveys of the Ventron site. The 1992 characterization was performed in accordance with the *Ventron Characterization Plan* (DOE 1992).

The targeted media for sampling and analysis were the site structures and contents, vadose and saturated soil zones, harbor surface water/sediment, sewer line sediment, and mussel beds located in the intertidal zone. Groundwater was not included as part of this investigation. The Ventron site is listed with the state Superfund program and groundwater is being characterized by the site owners under the auspices of those regulations. Currently, DOE has no responsibility to the state regulatory agency regarding this Superfund listing, as the state Superfund listing is a result of non-MED-related activities. Morton is currently remediating the site for non-MED-related constituents (e.g., mineral oil, mercury), in accordance with the MGL, Chapter 21E.

The parameters selected for analyses during the 1992 characterization were based on the known MED-related activities at the Ventron site. The primary MED-related activity consisted of processing uranium. Chemical processes conducted at the facility may have generated metal salts and acid byproducts. Therefore, the soil and sediment samples collected during this characterization were analyzed for selected radionuclides and chemical compounds to reduce or eliminate data and knowledge deficits in a manner consistent with the SAFER approach. The categories of analytical parameters included in the 1992 characterization effort, along with the rationale for their selection, are listed below:

- *Radionuclides (U-238, Th-230, Th-232, and Ra-226).* Uranium oxide was processed at the Ventron site for the MED-related activities. Uranium ore and thorium were processed at the site for non-MED activities. Elevated levels of U-238, Th-232, and Ra-226 were detected at the site during the 1988 and 1991 ORNL sampling efforts.

- *Resource Conservation and Recovery Act (RCRA) characteristics (corrosivity, ignitability, reactivity, and toxicity).* Hazardous chemicals were used at the site for non-MED-related activities and may be commingled with MED-related waste.

- *Total metals.* Current process knowledge indicates the potential for residual metals.

- *Polychlorinated biphenyls (PCBs).* Oils have been used at the site.

- *Total petroleum hydrocarbons (TPHs).* Oils have been used at the site. TPH is a generic screening analysis that can identify the presence of organic constituents that may be associated with the oils.

- *Base/neutral and acid extractable organic compounds (BNAEs).* If organic constituents are identified by the TPH analysis, the BNAE compounds will be analyzed to identify and quantify specific organic constituents.

Table 5-1 presents the individual analytical parameters included in the above categories.

Section 5.2 describes the preliminary activities conducted to support the characterization effort. Sections 5.3 and 5.4 describe the technical approach used to fulfill the data requirements, and the results obtained during the 1992 characterization effort.

## 5.2 PRELIMINARY CHARACTERIZATION ACTIVITIES

### 5.2.1 Site Civil Survey

A subcontracted licensed surveyor established a site grid network using 10-m (33-ft) centers and installed hub markers at node points. Each marker was clearly labeled with grid coordinates that tied into the state coordinate system. In addition, a site map was provided that showed property boundaries, site grids, grid point elevations (mean sea level), buildings, and obstructions that could effect the characterization study. The information generated from the site civil survey is used in the figures throughout this report.

### 5.2.2 Radiological and Chemical Background Data Collection

Background levels were established for radioisotopes and chemical constituents in soil, surface water, and sediment samples. Background/control samples were collected from undisturbed, non-industrialized areas such as parks. Three soil borings (SB-1A, SB-1B, and SB-1C) were installed at the Greenhill Playground, Tuck Point Playground, and the Prospect Hill Athletic Field, which were expected to be uneffected by activities conducted at the Ventron site. Approximate background sampling locations are shown in Figure 5-1. Surface soil samples were collected at each of the three locations, SB-1A, SB-1B, and SB-1C. The samples collected at SB-1A and SB-1B were submitted for radiological and chemical analysis. At SB-1C, a stainless steel hand auger, shown in Figure 5-2, was used to advance the boring to 3 m (10 ft). At SB-1C, samples for radiological analyses were collected at 0 to 15 cm (0 to 0.5 ft), 90 to 120 cm (3 to 4 ft), and 3 m (10 ft) below land surface (bls) and a sample for chemical analysis was composited from 0 to 120 cm (0 to 4 ft). Sample identifications, locations, and analyses performed are shown in Table 5-2. The analytical results for these background samples are shown in Appendix B-1. A walkover gamma scan of the immediate area of soil borings SB-1A, SB-1B, and SB-1C was also performed to establish an average background radiation level for the Beverly area. The scan was performed using a sodium iodide, thallium-[NaI(Tl)-]activated

unshielded gamma scintillation detector. The background determined was 9.0 $\mu$R/hr with a range of 8.9 to 9.2 $\mu$R/hr.

Background surface water samples were obtained from both the Danvers River (location SW-1) and the Bass River (location SW-2). The surface water samples were collected using a bottom filling bailer and analyzed for radiological parameters. Background sediment samples (SD-1 and SD-2) were collected at each surface water sampling location (SW-1 and SW-2) using a Ponar-type sampler. The sampling interval was approximately 0 to 30 cm (0 to 1 ft). Sediment samples were analyzed for both chemical and radiological parameters. In addition, the field sampling team located a mussel bed upstream of the Ventron site and collected one composite background sample for radiological parameters analysis. The analytical results for the harbor surface water, harbor sediment, and mussel samples are shown in Appendix B-2, and Tables 5-10 and 5-12, respectively.

Background samples were collected in accordance with the procedures and methods outlined in *Test Methods for Evaluating Solid Waste*, SW-846 (EPA 1986), *A Compendium of Superfund Field Operations Methods* (EPA 1987), and the *Ventron Characterization Plan* (DOE 1992).

### 5.2.3 Previous Gamma Survey Verification

Gamma exposure-rate measurements were taken indoors and outdoors to determine if measurements obtained during previous surveys were representative. Outdoor measurements were taken at the approximate locations of previous surveys. Up to four gamma exposure rate measurements were taken from the A, B, and C Buildings and Building F where access could be obtained. Interior measurement points were located in the rooms of these buildings which previously exhibited elevated exposure rates (Cottrell and Carrier 1988).

Measurements were taken 1 m (3 ft) above the ground using either a NaI(Tl) gamma scintillation detector (designed to detect gamma radiation only) or a pressurized ionization chamber (PIC). The PIC response to gamma radiation is proportional to exposure in roentgens. All survey procedures were performed in accordance with Thermo Analytical/Eberline (TMA/E) procedures (TMA/E 1988).

Data from outdoor and indoor measurements from the site were compared with data obtained during previous surveys to determine if locations sampled were representative of the property.

## 5.3 1992 CHARACTERIZATION METHODS

### 5.3.1 Walkover Gamma Survey

In order to determine the extent and magnitude of elevated radioactivity, a near-surface walkover gamma survey was performed on all accessible outside areas of the site. The scan was

performed using a NaI(Tl) unshielded gamma scintillation detector and a field instrument for detecting low-energy radiation (FIDLER) that identified areas of elevated gamma-emitting radionuclide activity.

For surface gamma scanning measurements using portable instrumentation (NaI detector/ratemeter combination), twice the background count rate was used as a screening measurement to help focus the radiation survey on areas most likely to contain elevated levels. Twice the background count rate is often used as a field screening level; at this level, there is a high probability that the count rate is due to the presence of radioactivity greater than background levels, and not statistical fluctuations of the instrument. Areas with gamma count rates greater than twice the background level are selected for further sampling and/or more detailed measurements. Areas that show gamma count rates less than twice the background level are considered unlikely to contain radioactivity levels greater than the remediation guidelines shown in Table 3-1, and were not investigated further. The results from the surveys are presented in Appendix C.

Areas where the detector registered levels in excess of twice the established background level for the Beverly area were resurveyed with a cone-shielded gamma scintillation detector (SPA-3) held 30.4 cm (12 in.) above the ground. The cone-shielded detector primarily measures radiation originating from the ground directly beneath the unit.

Results that are greater than twice background should be considered as potentially containing elevated radioactivity, while results that are several times background should be considered as likely areas for remediation.

### 5.3.2 Site Soils

Soil samples for radiological analysis were collected to investigate the impact from potential source areas and other areas suspected of containing elevated levels of radioactivity identified by previous ORNL surveys. Figure 5-3 presents locations where surface and subsurface soil samples were collected. Soils around and beneath Buildings A-1, C-2, C-3, C-4, the Alfa Building, the former machine shop, and Building F (former foundry location) were investigated. Soils around Building C-1 were also investigated. Soils beneath Buildings B-1, B-2, B-3, and C-1 were previously shown to contain elevated levels of radioactivity and it was determined that no further characterization would be conducted in these areas until remedial action is implemented. Loading-areas investigated include one area on the west side and one area on the north side of Building A-1. Another area between the B Buildings and Building F in the vicinity of the former barge pier was also investigated. Other potential source areas sampled included the existing and former above-ground chemical storage tank locations.

Soil samples from all locations were analyzed for U-238, Ra-226, and Th-230. Most were also analyzed for Th-232. Samples for radionuclide analysis were collected at approximately 15-cm (0.5-ft) intervals for surface samples, and at approximately 30-cm (1-ft) intervals for subsurface samples. The soil samples taken for chemical analyses designated in

Figure 5-3 were analyzed for RCRA characteristics, total metals, PCBs, and TPHs. Samples containing TPH greater than 1,000 ppm were also analyzed for BNAE compounds. Because of the large sample volume required for chemical analysis, the samples collected for chemical constituents were composited over 0 to 120 cm (0 to 4 ft) in depth.

Where possible, samples complied with the intervals described in the characterization plan (DOE 1992) and the intervals of highest activity as determined by gamma log were analyzed. Soil sample identification codes, locations, and analyses performed are listed in Table 5-2.

The soil borings for subsurface samples (with the exception of SB-1A, SB-1B, SB-1C, SB-13, SB-14, SB-15, SB-16, SB-18, SB-24, and SB-26) were installed using a hollow stem auger. Each soil boring was continuously sampled using a split-spoon method to bedrock refusal. Subsequently, downhole gamma radiation measurements were recorded by lowering the gamma scintillation detector into the borehole with 60-second equivalent readings being collected at 15-cm (6-in.) intervals.

The soil samples collected from the background locations (SB-1A, SB-1B, and SB-1C) were collected using a stainless steel hand auger.

The soil samples beneath Building A-1 (SB-13, SB-14, SB-15, and SB-16) were collected using a stainless steel hand auger after an access borehole was made in the concrete floor. These samples drilled through the floor of Building A-1 are not shown on Figure 5-3 as no sample coordinates are available for these locations. Soil boring 18 (SB-18), north of Building A-1, was sampled using a tripod drill rig.

The soil borings beneath Buildings C-2 and C-4 (SB-24 and SB-26) required directional drilling techniques. These borings were continuously sampled, however, only three samples were analyzed. A soil sample was collected as close as possible to the bottom of the building floor, and another sample was collected near the bedrock surface (as estimated in the field based on the depth of other soil borings).

Although a few of the boreholes failed to penetrate the fill, most were drilled to granitic diorite or diorite bedrock. Only a few passed through glacial till or silty sands and gravels overlying the diorite.

### 5.3.3 Harbor Surface Water/Sediment and Biological Samples

Harbor sediment samples were collected to further define impacted areas previously identified by the ORNL sediment sampling of Beverly Harbor (ORNL 1991). Three sediment samples were collected in shallow water on the south side of the facility but beyond the 50-ft zone sampled by ORNL in 1991. Sample SD-3 was collected from the Danvers River east of Building F. Sample SD-4 was collected from the Danvers River south of Building B-2, and sample SD-5 was collected from the Bass River west of Building C-1. The sampling interval

was 0 to 30 cm (0 to 1 ft). All sediment samples were analyzed for both radiological and chemical content.

Surface water samples were collected from the same locations as the sediment samples. Harbor surface water samples were analyzed for radiological parameters. Half of each surface water sample was filtered before preservation. Both the filtered and unfiltered samples were analyzed to evaluate particulate and solute transport pathways and solubility of applicable particulate matter.

Harbor surface water was sampled using a bottom filling bailer that provided a vertically representative sample. Harbor sediment samples were collected with a clam shell sediment sampler (Ponar-type).

Composite samples (AS-2 and AS-3) were collected from two of the mussel beds in the intertidal zone near the south side of the site. A background sample (AS-1) was also collected west of the site up the river. Four mussels were collected from each bed and composited in the laboratory. In Figure 5-4, a technician stands at one of the sampling locations. These samples were analyzed for radiological content.

Harbor surface water/sediment and biological sample locations and analytical parameters are presented in Table 5-2. The sample locations are not shown in Figure 5-3 as no sample coordinates are available for these locations.

### 5.3.4 Sewer Line Sediment

Samples of scale, dirt, sludge, and sediment were collected from the four manhole inlets in the sewer line between the A and B Buildings (Figure 5-5). These samples were analyzed for radiological content. In addition, a scale sample (DS1) was collected from a drain in the basement of Alfa Building, which in previous studies showed elevated gamma activity. However, this sample, suspected to have contained sodium metal, reportedly reacted before analysis could be performed. Verbal communication from an onsite person indicated that sodium metal, which reacts violently with water, was evident in the room.

### 5.3.5 Structures and Equipment

In order to determine the general extent of fixed and/or removable MED-related residual radioactive material within site structures, limited radiological surveys were performed. Five building groups, previously identified as containing residual radioactive material, (Figure 2-2) underwent limited radiological surveys. The surveyed areas of the buildings are identified below.

- A Buildings
- B Buildings (Basement surfaces only)

- C Buildings (Basement surfaces only)
- F Building (Basement surfaces only)
- Alfa Building (Rooms 2 and 6 only)

Walkover gamma scans (for beta-gamma radiation) and accessible surface surveys were performed at the offsite Ventron office buildings (see Section 5.3.7). The survey methods discussed below were used in all of the Ventron buildings.

*Floors and Walls*

The accessible floor areas of each building to be surveyed were marked on a 3-m (10-ft) grid. Subsequently, an alpha floor monitor was used to measure detectable alpha radiation levels across the floor. Figures 5-6 and 5-7 show a floor monitor and gamma scan being conducted in Building A. Alpha and beta-gamma measurements were obtained from the lower walls. Measurements were taken at each 3-m (10-ft) grid intersection using hand-held alpha and beta-gamma detectors. Direct alpha measurements were taken using an Eberline model AC-3 detector coupled to an Eberline model PRS-1 scaler (or equivalent). Direct beta-gamma measurements were taken using an Eberline model HP-210 detector coupled to an Eberline model PRS-1 scaler. Access to the upper wall areas was limited mainly by the fact that the manufacturing equipment, ductwork, and HVAC equipment were in place at the time of the survey. All survey work was performed by working on ladders because manlifts and scaffolding could not be used. This limited the areas that could be reached by the technicians in a safe manner. Therefore, lower wall surfaces received a more thorough examination than upper wall surfaces.

Removable residual radioactivity on surfaces was identified by collecting 100-$cm^2$ (15.5-$in.^2$) smear samples from the floor and wall areas exhibiting activity levels that exceeded radiological guidelines. Smear samples were placed in a light-tight smear holder and counted using an Eberline model SAC-4 alpha scintillation detector. Surveying was also conducted on horizontal surfaces, such as window ledges, stairs, and floors where dust and dirt buildup was observed.

Surface areas containing elevated radioactivity levels were marked on a drawing of the building interior rather than on the building itself.

*Overhead Surfaces*

Direct alpha and beta-gamma measurements were obtained at 3-m (10-ft) grid intersections on the ceilings. Measurements were performed using the same procedures and instruments as previously described. Horizontal surfaces and suspect overhead areas were surveyed for fixed and removable residual radioactive material. Smear samples were obtained from those areas exceeding radiological fixed guidelines.

*Equipment*

The results of previous radiological surveys indicated measurable amounts of radioactive material on some equipment within the A Buildings (Cottrell and Carrier 1988). Equipment areas inside these buildings were surveyed for removable and fixed residual radioactive material. Emphasis was placed on surveying horizontal equipment surfaces only; no internal equipment areas were surveyed. Fixed levels were determined with hand-held alpha and beta-gamma detectors as previously described. Removable residual radioactive material on surface areas was identified by collecting 100-$cm^2$ (15.5-$in.^2$) smear samples from those areas of the equipment which exceeded fixed radiological guidelines.

### 5.3.6 Building A Ash Pile

The ash piles beneath the furnaces in Building A were sampled using a stainless steel soil probe. Composite samples (WP-1 and WP-2) were collected to represent the stratified nature of the piles. The composite samples were homogenized in stainless steel mixing bowls prior to containerization. Both samples were analyzed for chemical and radiological content. The approximate sample locations are shown in Figure 5-3.

### 5.3.7 Offsite Properties

Two former houses located at 11 and 15 Congress Street, across the street from the plant, were used as office buildings for past operations. These buildings were surveyed for fixed and removable residual radioactive material using the methods described in Section 5.3.5.

## 5.4 CHARACTERIZATION RESULTS

Results from the DOE 1992 characterization effort are presented below.

### 5.4.1 Site Soils

#### 5.4.1.1 Surface Soils

The analytical and isotopic results for the surface soil samples are shown in Tables 5-3 through 5-9, Appendix B-3, and Appendix B-4.

Of the 21 surface soil samples, eight contained concentrations of Th-230 or Th-232 greater than 5 pCi/g and four contained concentrations of U-238 greater than 50 pCi/g. The locations of these samples are shown on Figure 5-8 and the radionuclide concentrations are shown on Table 5-10. No concentrations of Ra-226 greater than 5 pCi/g were detected in the surface soil samples. The maximum concentrations of Th-232 (399 pCi/g) and U-238 (412 pCi/g) were found in SS-32, south of Building C-1. Surface sample SB-5 with Th-232 of 16.7 pCi/g registered a maximum of 39,300 cpm on the gamma log and was described as silty

loam on the geologic log. The surface sample of SB-28 which contained a concentration of Th-232 of 10.9 pCi/g registered a gamma log value of 65,400 cpm and is described on the geologic log as silty sand fill with a trace of ash and some gravel and brick. Consistent with the 1988 ORNL sampling, the surface soils containing elevated Th-230 or Th-232 and U-238 concentrations are located primarily in the southwest corner of the site, south and southwest of Building C-1, and in the southeast corner of the site, south of the Alfa Building.

Chemical analyses of the surface soil for sample SB-6, which is near the former location of a chemical storage tank, show all elements within the range of the background samples, except nickel which was slightly more than four times background and zinc which was less than twice background. At this location, aroclor-1254 was the only PCB detected, although the concentration was below federal standards. No pesticides were detected and no TCLP criteria were exceeded for any hazardous constituent (see Appendix B-4).

Chemical analyses done on the surface soil sample from SB-17 (see Figure 5-3) in the vicinity of the northwestern loading dock detected no pesticides or PCBs, and no TCLP guidelines were exceeded. The inorganic analyses showed calcium, copper, nickel, and zinc to exceed background by more than a factor of two (Appendix B-4).

A surface sample taken at SB-10 (Appendix B-4) revealed no inorganic results greater than twice background, no pesticides or PCBs detected, and no TCLP parameters above guidelines.

The surface sample of SB-22 (Figure 5-8) failed TCLP limits for lead (6.36 mg/L versus the 5.0 mg/L criteria).

Inorganic analysis of the surface sample from SB-9 (Appendix B-4) indicated all analytical results for selected parameters were within background concentrations. In addition, no pesticides or PCBs were detected, no TCLP guidelines were exceeded, and a very low TPH reading was obtained from the sample (8 mg/kg).

#### 5.4.1.2 Subsurface Soils

The analytical and isotopic results for the subsurface soil samples are shown in Tables 5-3 through 5-9 and in Appendices B-4, B-5, B-6, D-1, and D-2.

Of the 29 borehole locations sampled, one location (SB-14) contained concentrations of Th-230 greater than 15 pCi/g and U-238 greater than 50 pCi/g, and two other locations (SB-22 and SB-24) contained concentrations of U-238 greater than 50 pCi/g. The locations of these samples are shown in Figure 5-9 with the radionuclide concentrations depicted on Table 5-11. Concentrations of Ra-226 or Th-232 greater than 15 pCi/g were not detected in any of the subsurface samples. Th-230 and U-238 were detected in one of the four boreholes through the floor of Building A-1 at a depth of 0.5 ft below the slab with concentrations of 44.5 and 190.0 pCi/g, respectively (SB-14). Borehole SB-24, which was drilled at a 22 degree angle

beneath Building C-2, contained two subsurface intervals with U-238 greater than 50 pCi/g. The intervals with elevated readings were at 8 to 9 ft and 10 to 11 ft measured along the length of the borehole, which corresponds to true vertical depths of 3 to 3.25 and 3.75 to 4.0 ft bls. The geologic log describes the upper interval as coal and ash and the lower interval as silty sand with a trace of gravel and coal. U-238 was also detected at a concentration of 60.9 pCi/g at a depth of 2 ft to the south of Building C-1 (SB-22).

Chemical analyses were done on sample SB-15, which is one of the soil borings through the floor of Building A-1. The results (Appendix B-6) show all parameter concentrations to be below guidelines. Although TPH was high at 1,400 milligrams (mg)/kilogram (kg), only 2-methylnapthalene, naphthalene, and phenanthrene were positively identified among the semi-volatile organic compounds (SVOC). No pesticides or PCBs were identified. TCLP analyses showed no values above guidelines.

### 5.4.2 Harbor Surface Water/Sediment and Biological Samples

Surface water samples were taken at the same locations as the harbor sediment samples. One unfiltered water sample contained 10.6 pCi/liter (L) of Ra-226, which is slightly greater than the drinking water maximum concentration level of 5 pCi/L for Ra-226 and Ra-228 combined (Appendix B-2). The filtered sample contained 0.41 pCi/L of Ra-226.

Harbor sediment samples were taken south of Building B-2, east of Building F, and west of Building C-1. None of the samples showed Ra-226 or Th-232 greater than 5 pCi/g or U-238 greater than 50 pCi/g (Table 5-12 and Appendix B-7).

Three mussel samples were taken from the tidal flat areas adjacent to the site and compared to a background mussel sample. Average activity levels were 1.8 pCi/g for Ra-226, 2.3 pCi/g for Th-232, and 6.2 pCi/g for U-238 (Table 5-13 and Appendix B-8). No samples showed evidence of radionuclide concentrations greater than the background concentrations.

### 5.4.3 Sewer Line Sediment

Sewer line sediment samples were taken from the sewer running between the A and B Buildings. None of these samples showed Ra-226 or Th-232 greater than 5 pCi/g or U-238 greater than 50 pCi/g (Table 5-14 and Appendix B-7).

### 5.4.4 Structures and Equipment

*Radon and Gamma Exposure Rate Surveys*

Gamma exposure rate measurements ranged from 10 to 32.3 $\mu$R/hr (Table 5-15). Only one measurement, 32.3 $\mu$R/hr in the basement of Building B-2, exceeded twice the average site background of 14.5 $\mu$R/hr. Measured radon concentrations for indoor air ranged from 0.01 to 4.34 pCi/L (Table 5-16). Only one measurement, 4.34 pCi/L in the Alfa Building, marginally

exceeded the guideline of 4 pCi/L established by EPA for continuous exposure. No employees are permanently stationed in the Alpha Building; it is used primarily for storage. Since no elevated concentrations of Ra-226 were observed in the soils in the vicinity of the Alfa Building, the indoor radon concentrations cannot be attributed to elevated levels of radioactivity in the soils.

Only two measurements in Building A exceeded the residual alpha guideline of 5,000 dpm/100 $cm^2$. The buildings on site have no removable residual radioactive material above the DOE uranium guidelines, (i.e., only fixed beta-gamma levels exceeded guidelines).

A summary of the measurements taken in the individual buildings is shown in Table 5-17 and discussed below.

*Building A*

Building A contains residual radioactive material on the first floor level on all surfaces: floors, walls, overhead surfaces, and horizontal equipment surfaces. The basement level of Building A also has residual radioactivity on the walls and horizontal equipment surfaces.

Residual radioactive material on the first floor level of Building A has a maximum activity of 36,810 dpm/100 $cm^2$ beta-gamma at the southernmost end of Room 30 west of the fan pit. See Figures 5-10 and 5-11 for applicable floor and wall survey locations.

The walls of the first floor of Building A also contain some localized residual radioactive material. Rooms 9, 13, 19, 20, 27, 28, 29 and 30 show activity ranging from 3,960 $\pm$ 1,100 dpm/100 $cm^2$ to 77,880 $\pm$ 3,600 dpm/100 $cm^2$ beta-gamma. The highest activity outside of the fan pit (Room 29) is 17,310 $\pm$ 1,870 dpm/100 $cm^2$ beta-gamma in Room 19.

Horizontal surfaces on equipment in Rooms 20, 26 through 30, 33, and 34 from 4,070 $\pm$ 1,070 dpm/100 $cm^2$ beta-gamma on a well in Room 30 to 87,810 $\pm$ 3,880 dpm/100 $cm^2$ beta-gamma on a window sill in Room 30. Rooms 1 through 18 have no horizontal equipment surfaces and the remainder of the rooms (21-25, 31, 32, 35-37) have no elevated levels of radioactivity on these surfaces. Figure 5-12 shows applicable survey locations of horizontal equipment surfaces in Building A.

A few of the overhead surfaces in Rooms 19, 20 28, 29, and 30 of the first floor of Building A have surface activity levels that range from 4,400 $\pm$ 790 dpm/100 $cm^2$ beta-gamma on an I-beam in Room 20 to 62,040 $\pm$ 2,540 dpm/100 $cm^2$ beta-gamma on a wooden cross-beam in the same room. Figure 5-13 shows locations of applicable overhead surfaces in Building A.

The basement of Building A also has localized areas of residual radioactive material on the walls and horizontal equipment surfaces. In Room 3 of the basement, there are eight areas on the walls ranging from 4,320 $\pm$ 1,060 dpm/100 $cm^2$ beta-gamma to 27,940 $\pm$ 2,220 dpm/100 $cm^2$ beta-gamma. The other two rooms of the basement had only one wall area each

exceeding radiological guidelines. Room 2 had a reading of 25,930 ± 2,140 dpm/100 $cm^2$ beta-gamma while Room 1 had a lower reading of 9,930 ± 1,410 dpm/100 $cm^2$ beta-gamma. Horizontal equipment surfaces in the three basement rooms had a total of six spots of localized residual radioactivity. Three spots were in Room 1 ranging from 16,960 ± 1,390 dpm/100 $cm^2$ to 69,180 ± 2,700 dpm/100 $cm^2$ beta-gamma. Two surfaces in Room 2 (15,980 ± 1,350 dpm/100 $cm^2$ and 45,850 ± 2,220 dpm/100 $cm^2$) and only one surface (14,770 ± 1,310 dpm/100 $cm^2$) in Room 3 had elevated readings (measurements). Figure 5-14 shows applicable locations of wall and horizontal equipment surfaces in the basement of Building A. Walkover gamma scans for both Building A and its basement are in Appendix E.

*Building A-1*

Building A-1 has elevated levels of radioactivity on floors, walls, overhead surfaces, and horizontal equipment surfaces. Rooms 4, 5, 6, 7, and 10, as well as basement Rooms 1 and 2, have residual radioactivity on the floor ranging from 4,270 ± 780 dpm/100 $cm^2$ beta-gamma in Room 7 to 35,500 ± 1,940 dpm/100 $cm^2$ beta-gamma in Room 4 (Figure 5-15).

The horizontal equipment surfaces in Rooms 4, 6, 7, 10, and basement Rooms 1, 2, and 4 have elevated levels of radioactivity ranging from 7,720 ± 980 dpm/100 $cm^2$ beta-gamma in Room 4 to 78,340 ± 2,850 dpm/100 $cm^2$ beta-gamma in Room 6 (Figure 5-16). A pipe in Room 3 (5,400 ± 990 dpm/100 $cm^2$) and a pressure line in Room 4 (11,080 ± 1,310 dpm/100 $cm^2$) are the only overhead surfaces in Building A-1 with elevated readings.

Walls in rooms 1, 2, 5, 6, 7, 10 and basement Rooms 1 and 4 show elevated levels of residual radioactivity ranging from 3,960 ± 1,100 dpm/100 $cm^2$ to 307,230 ± 7,280 dpm/100 $cm^2$ beta-gamma (Room 7, west wall). All of the levels of radioactivity are less than 15,000 dpm/100 $cm^2$ beta-gamma (Figure 5-17) except for Room 7, one location in Room 10, and one in basement Room 1. Walkover gamma scans for Building A-1 are in Appendix E.

*Buildings B-1, B-2, and B-3*

Radiological surveys for levels of fixed and removable residual radioactive material of the main floors of the B Buildings did not exceed the 5,000 dpm/100 $cm^2$ fixed guideline (1,000 dpm/100 $cm^2$ transferable). However, the basements of the three B Buildings showed walkover scan readings up to 60,000 cpm (7 times background) (see Appendix E). Building B-3 readings did not exceed twice background. Building B-2 showed fairly extensive levels of elevated radioactivity in the east half of the room with readings from 18,000 cpm to 60,000 cpm. Elevated readings found in Building B-2 extend into Building B-1, in addition to several areas near the center of Building B-1. Gamma scan readings in Building B-1 ranged from 17,000 cpm to 40,000 cpm. No hotspots were discovered in the B Buildings by the walkover surface contamination surveys.

*Building C*

The floors of the C Buildings were checked for fixed and removable residual radioactive material and none was discovered.

A walkover scan for the C Buildings (see Appendix E) showed readings for the basement of Building C-3, which were all in the 10,000 to 19,000 cpm range with only a 3 to 4 $m^2$ (3.6 to 4.8 $yd^2$) area near the southwest corner registering above the 17,110 cpm (twice background) limit.

*Building F*

The floors in Building F were surveyed for fixed and removable residual radioactive material. Detectable levels did not exceed current DOE guidelines. A walkover gamma scan performed in Building F indicated that no areas exceed twice background.

*Alfa Building*

The Alfa Building was surveyed for fixed and removable surface contamination. Overhead surfaces, floors, and walls in Rooms 2 and 6 did not exceed current guidelines for uranium. One pump surface in Room 6 (Figure 5-18) had a reading of 12,480 $\pm$ 1,530 cpm beta-gamma radiation. A walkover gamma scan of Alfa Building agreed with previous surface survey information and detected no areas that exceeded twice background.

### 5.4.5 Building A Ash Pile

The samples from the ash piles in Building A were analyzed for radiological parameters and showed Ra-226 concentrations greater than 5 pCi/g (Table 5-3 and Appendix B-9).

Chemical analyses of the ash pile samples showed elevated levels of calcium, magnesium, potassium, and sodium as well as elevated metal concentrations (chromium, lead, nickel, and zinc), with one sample showing elevated levels of TPH and one sample failed the RCRA ignitability test (see Appendix B-9).

### 5.4.6 Offsite Properties

The basement, first floor, and upstairs of 11 Congress Street, and the basement, interior, and outside stairs at 15 Congress Street did not exceed current radiological guidelines.

The soil samples taken in the basement of the buildings located at 11 and 15 Congress Street were near background concentrations (Table 5-9).

138005

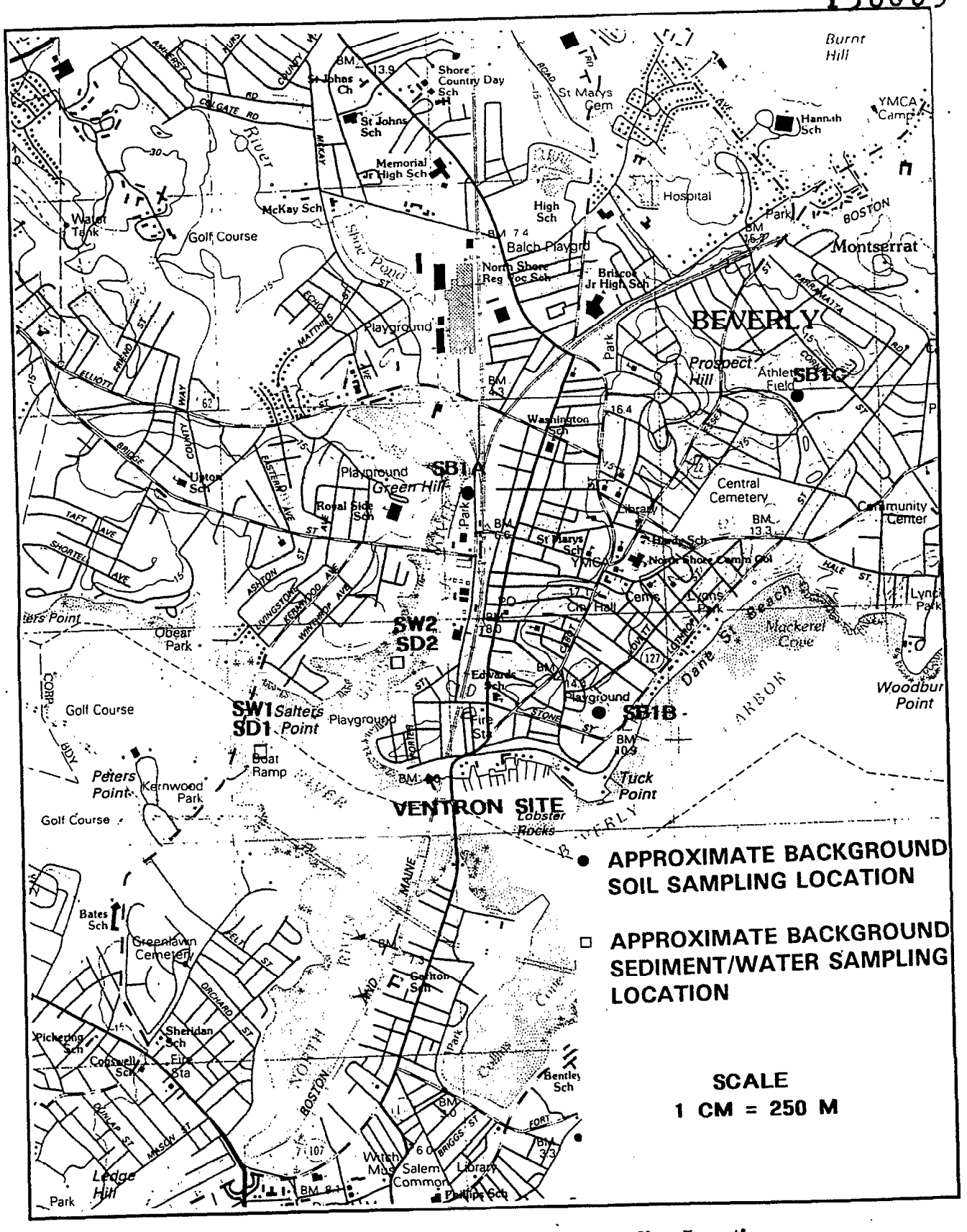



**Figure 5-1. Approximate Background Sampling Locations**

**Figure 5-2. Technicians Using a Hand Auger to Collect Background Samples**

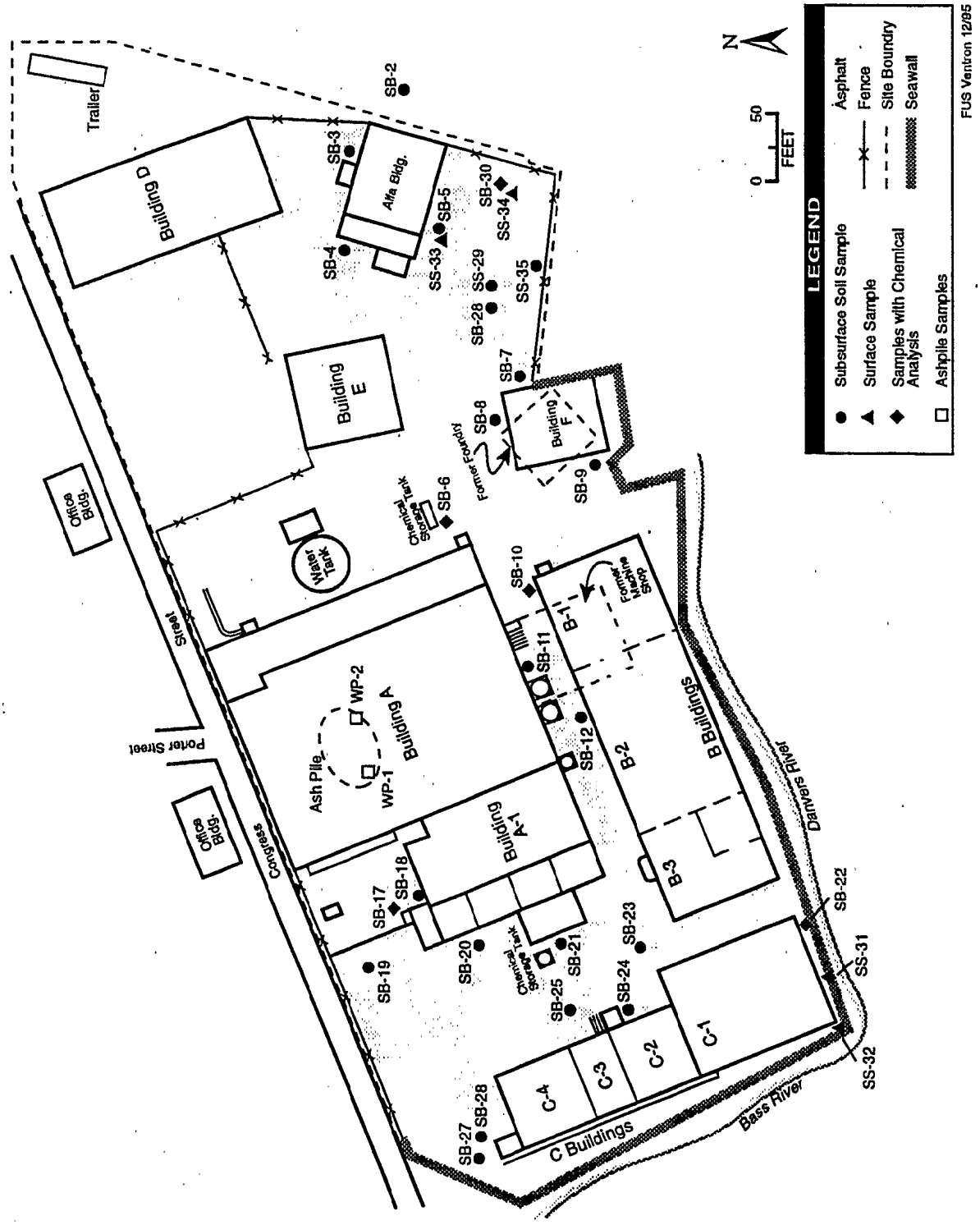



**Figure 5-3. Locations of Surface and Subsurface Soil Samples (1992 DOE Sampling Event)**

**Figure 5-4. Technicians Sampling Mussels on the Tidal Flats (Ventron is on the left)**

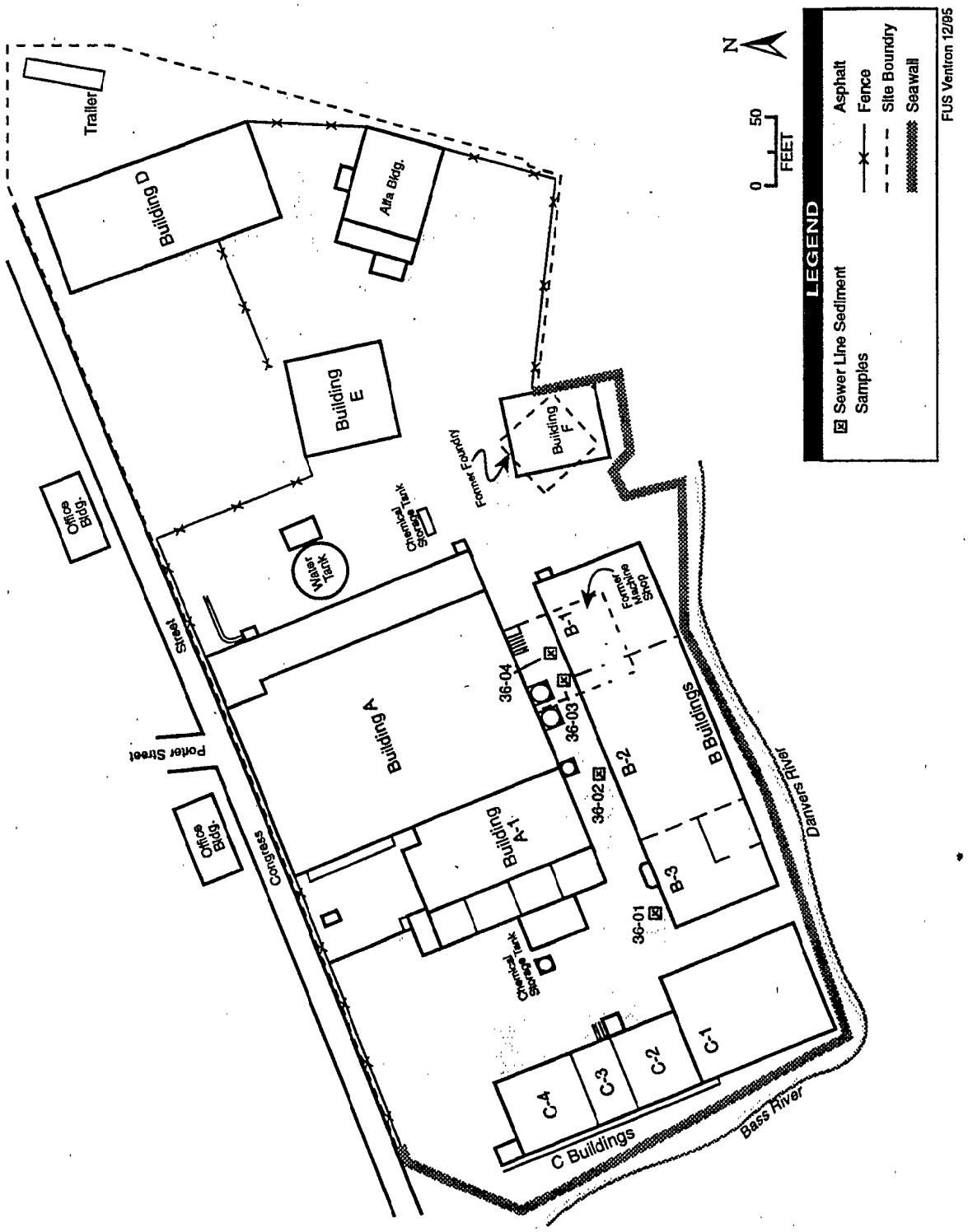



**Figure 5-5. Locations of Sewer Line Sediment Samples**

138005

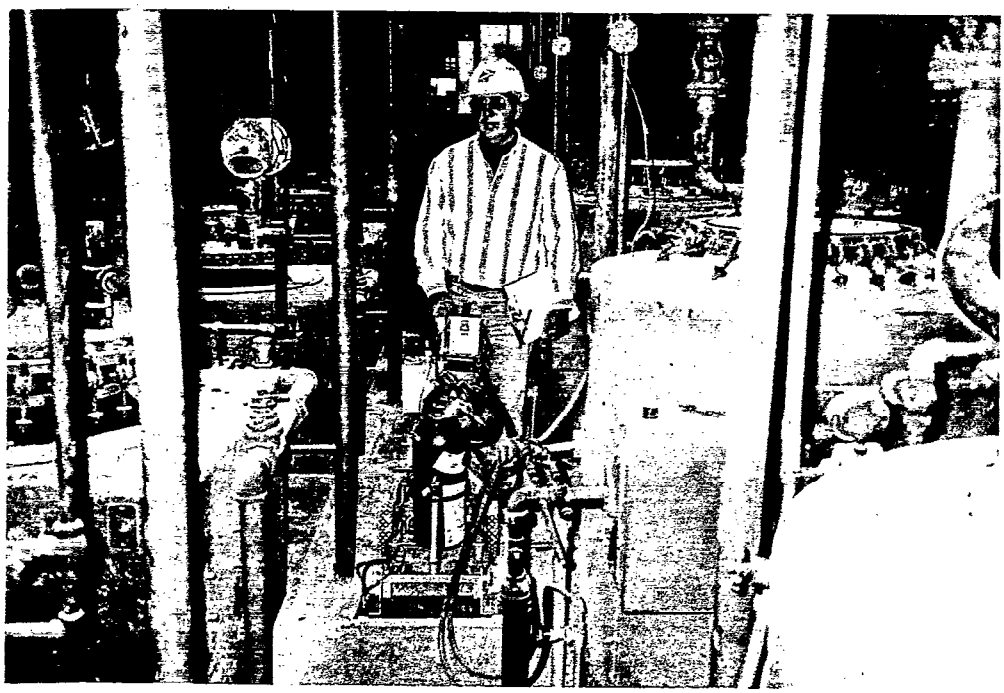


**Figure 5-6. Technician Using a Floor Monitor in Building A**

138005

**Figure 5-7. Technician Performing a Scan in Building A**

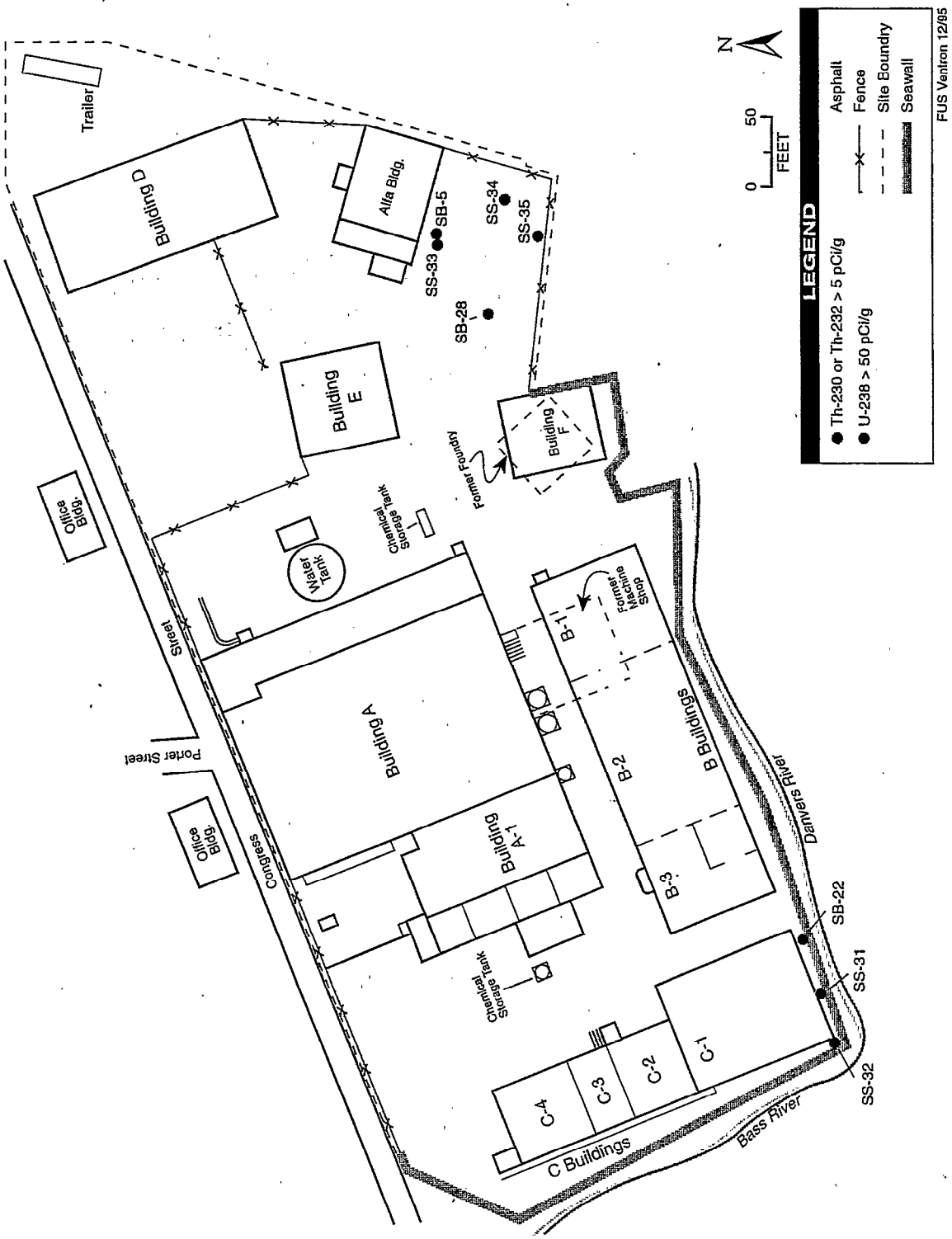



**Figure 5-8. Surface Soil Samples with Concentrations of Th-230 or Th-232 >5 pCi/g or U-238 >50 pCi/g (1992 DOE Sampling Event)**

138005

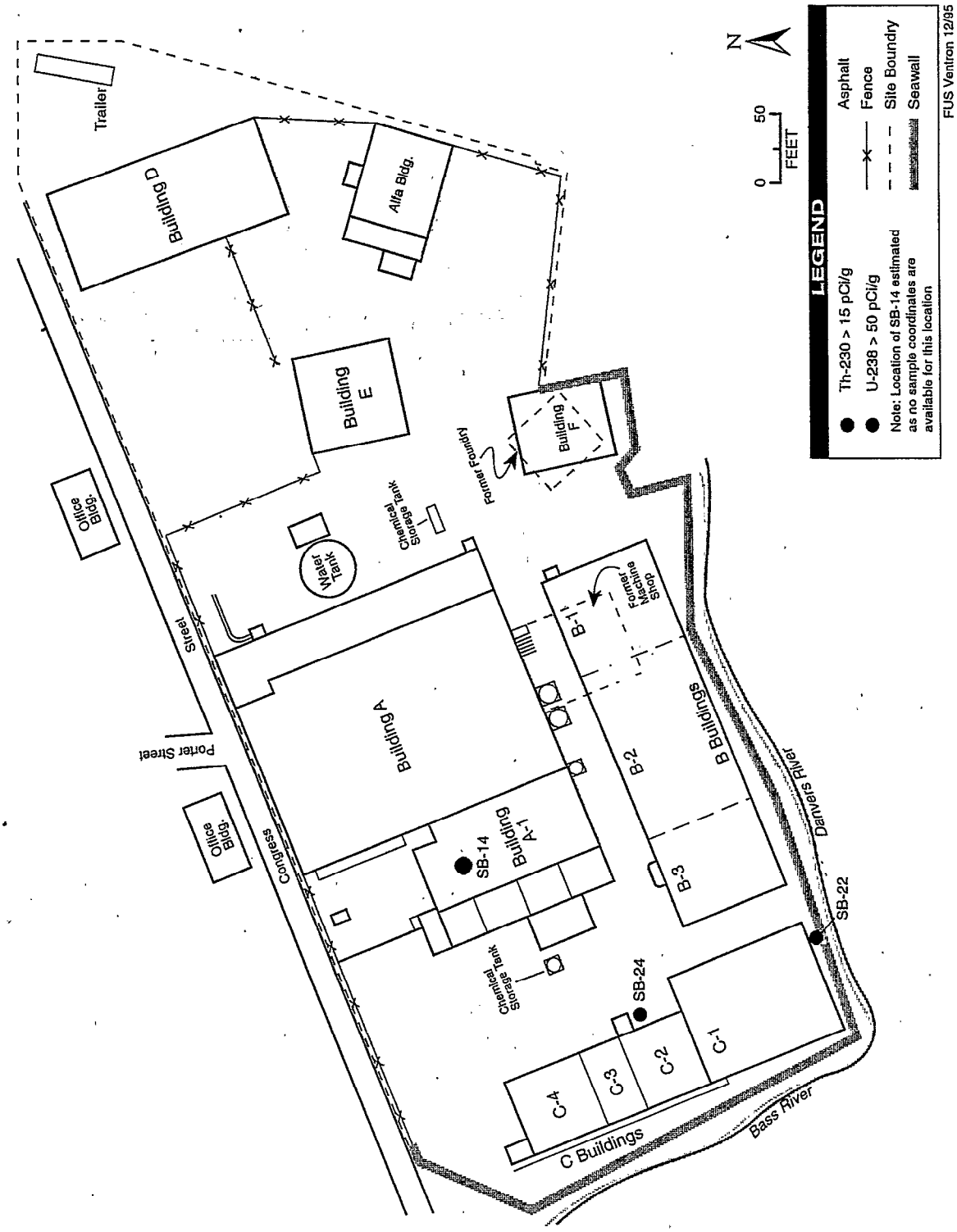
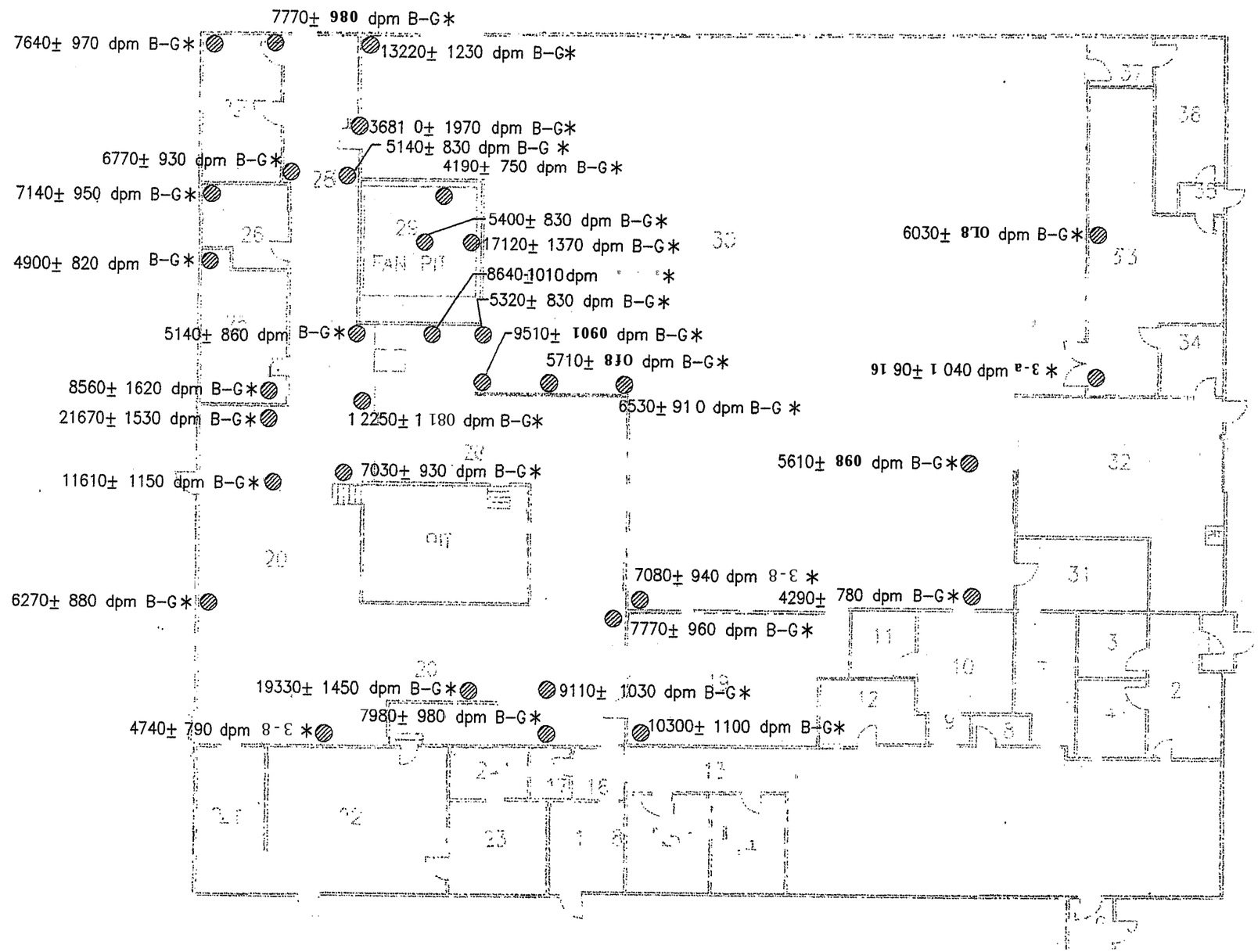



**Figure 5-9. Subsurface Soil Samples with Concentrations of Th-230 >15 pCi/g or U-238 >50 pCi/g (1992 DOE Sampling Event)**




LEGEND:

*.....SMEAR TAKEN

⊘.....CONTAMINATED FLOOR AREAS

NOT TO SCALE

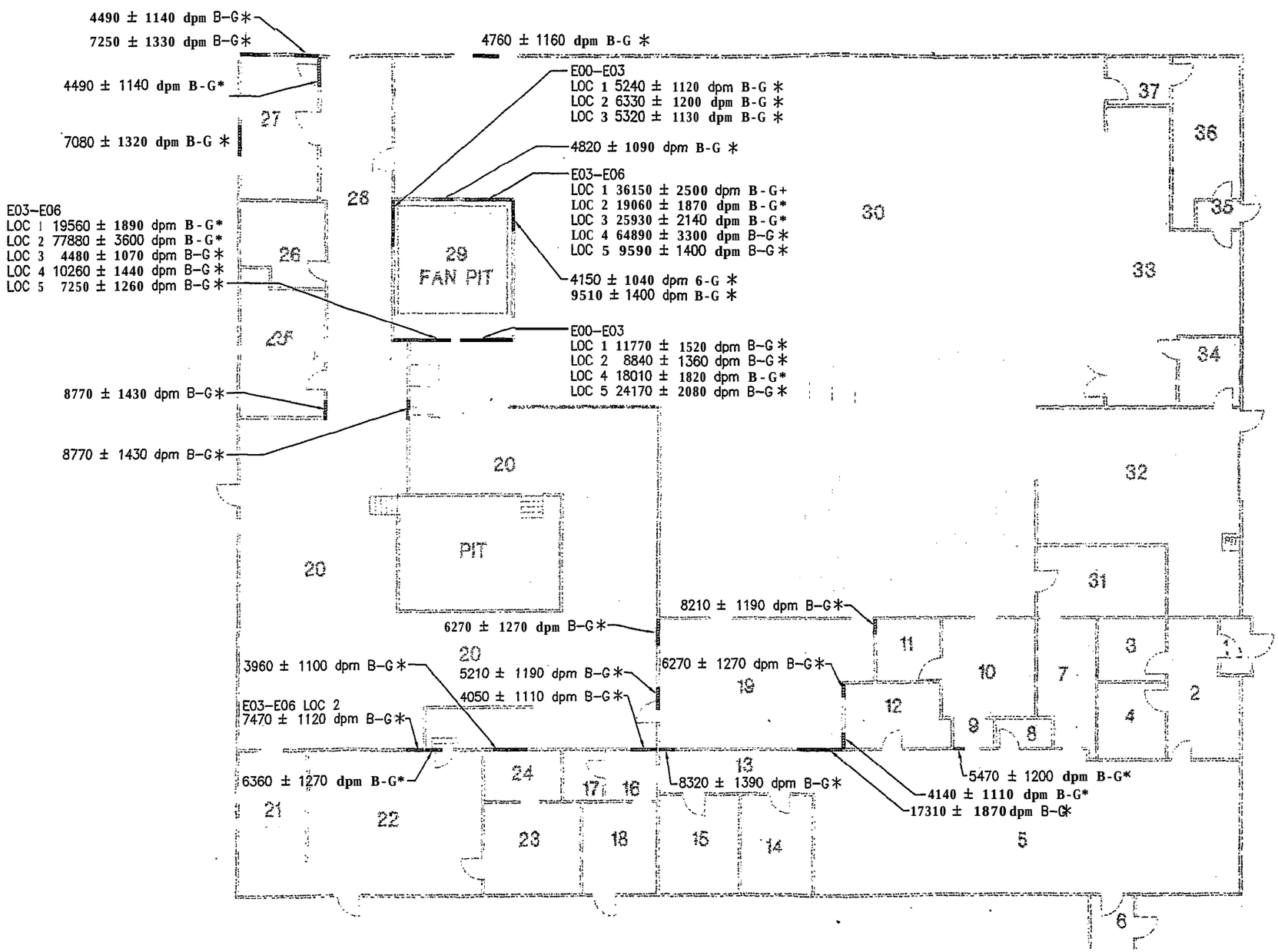
**Figure 5-10**
**Building A Floors**

| REVISION | DRAWN BY: | CHKD. BY: | DATE: |
|---|---|---|---|
| 0 | R. BEELER | P. HOLM | 10-16-95 |

| XREFERENCES | PLOT FILES |
|---|---|
| | |

| SHT. 1 OF 1 | /94017/DWGS/653FLR-A | N/A |
|---|---|---|
| DRAWING # | CAD FILE # | ROT. ANGLE |

138005




LEGEND:

*.....SMEAR TAKEN

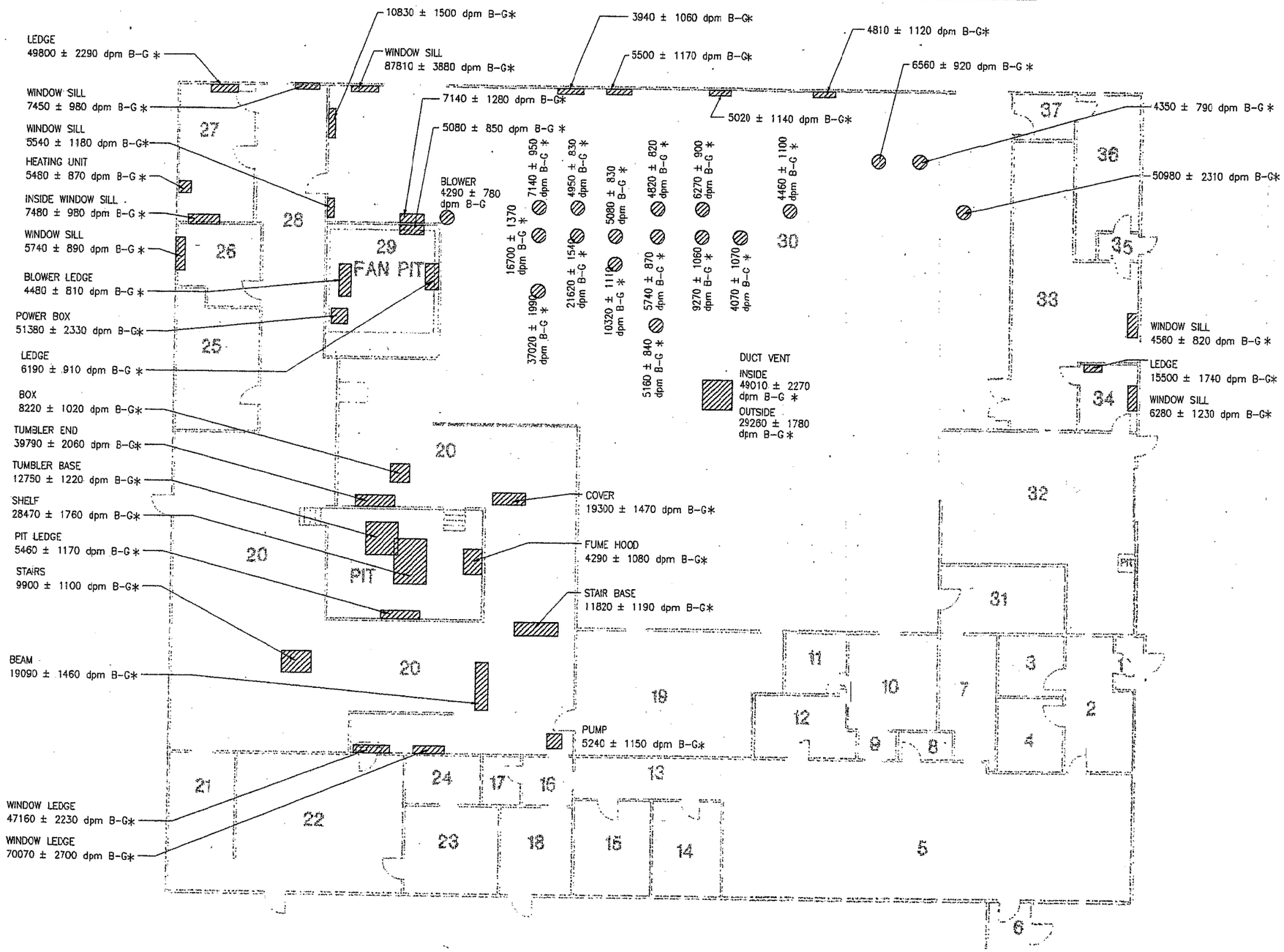
NOT TO SCALE

Figure 5-11.
Building A Walls

| REVISION | DRAWN BY: | CHKD. BY: | DATE: |
|---|---|---|---|
| 0 | R. BEELER | P. HOLM | 10-16-95 |

| XREFERENCES | PLOT FILES |
|---|---|
| | /94017/PLOT/653AWAL |

| SHT. 1 OF 1 | /94017/DWGS/653AWAL | N/A |
|---|---|---|
| DRAWING # | CAD FILE # | ROT. ANGLE |




LEGEND:

* .. .....SMEAR TAKEN

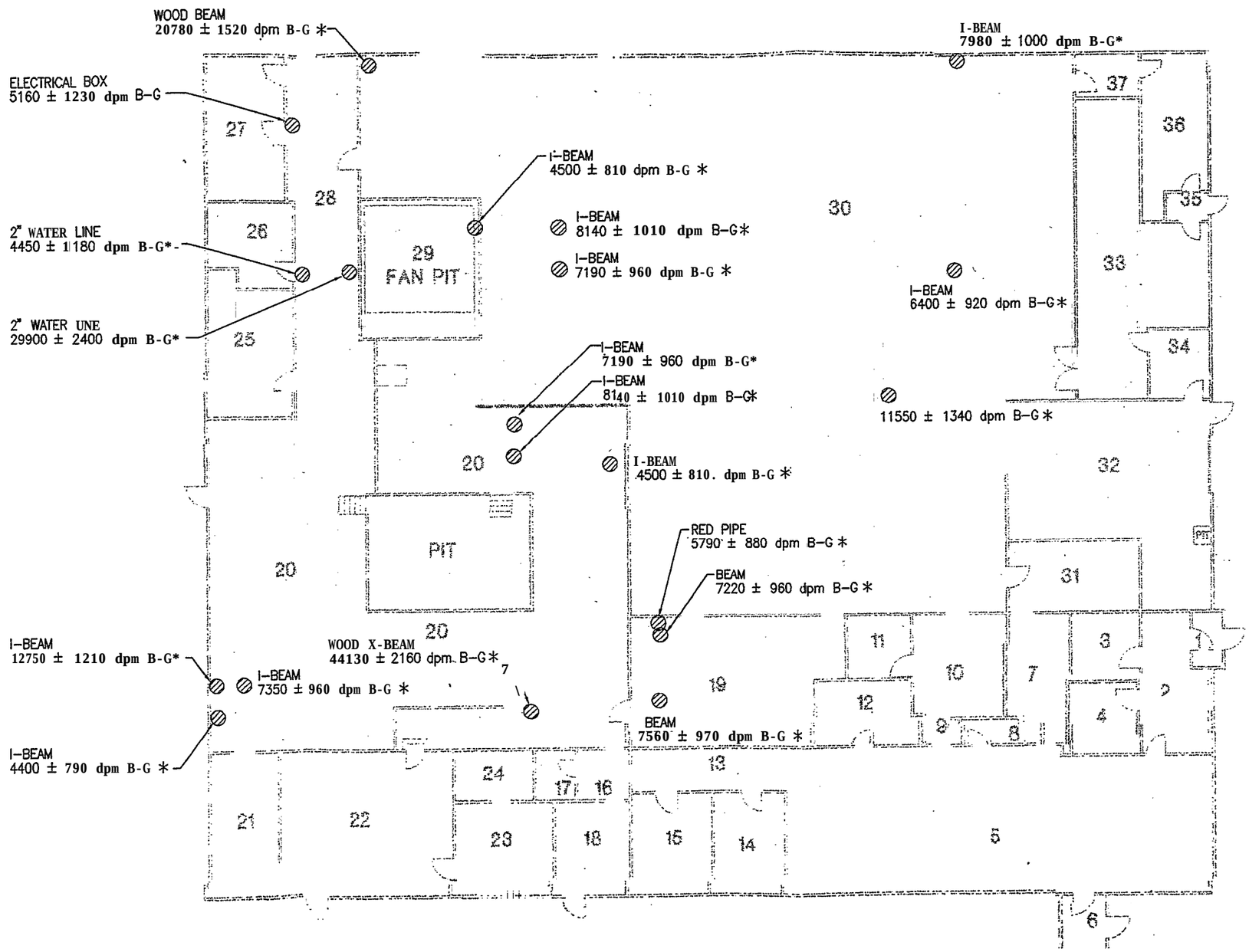
NOT TO SCALE

Figure 5-12.
Building A First Floor
Horiz. Equipment Surfaces

| REVISION | DRAWN BY: | CHKD. BY: | DATE: |
|---|---|---|---|
| 0 | R. BEELER | P. HOLM | 10-16-95 |

| XREFERENCES | PLOT FILES |
|---|---|
| | /94017/PLOT/653AHRZ |

| SHT. 1 OF 1 | /94017/DWGS/653AHRZ | N/A |
|---|---|---|
| DRAWING # | CAD FILE # | ROT. ANGLE |




LEGEND:

*.....SMEAR TAKEN

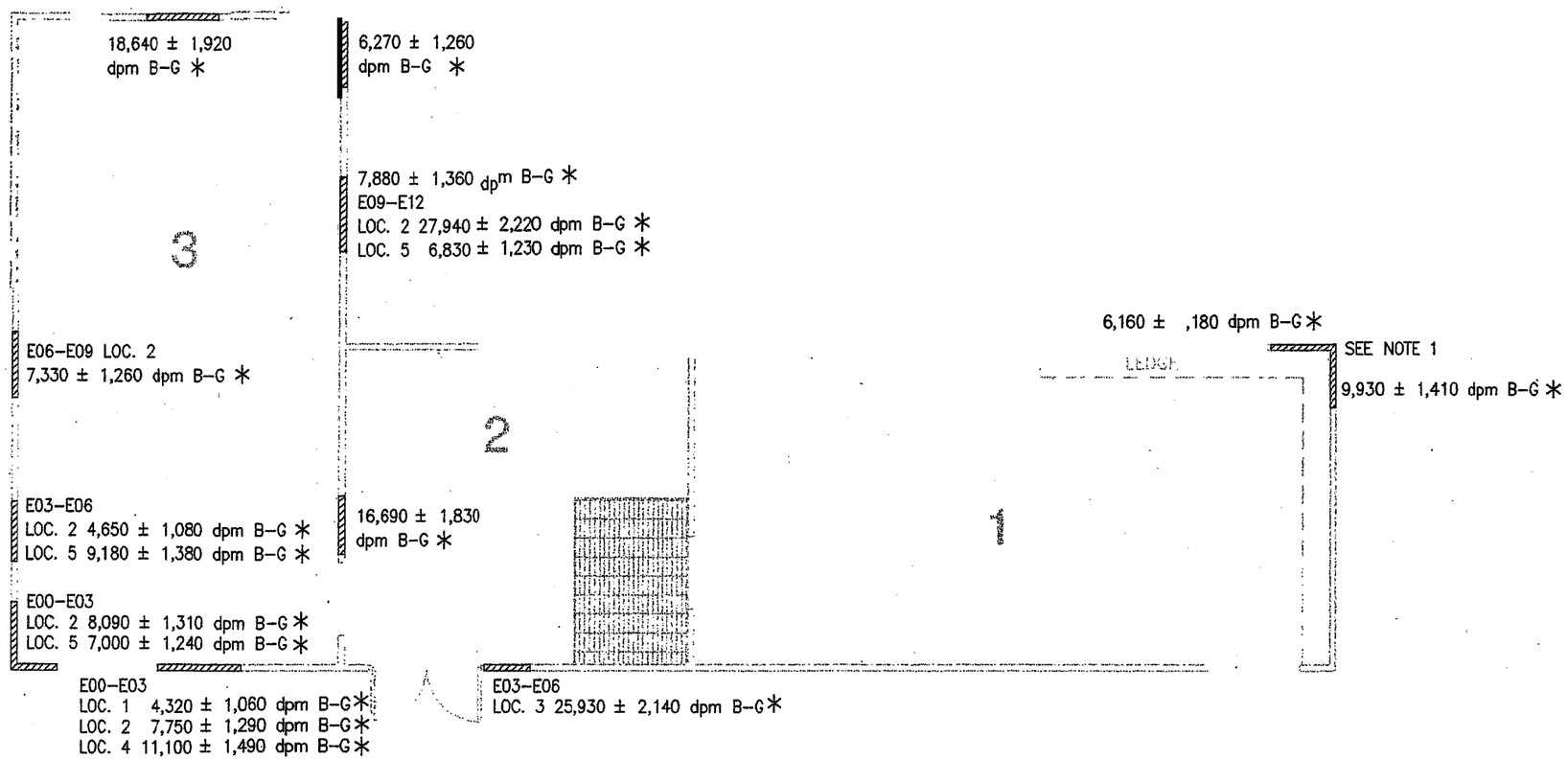
NOT TO SCALE

Figure 5-13.
Building A
Overhead Surfaces

| REVISION | DRAWN BY: | CHKD. BY: | DATE: |
|---|---|---|---|
| 0 | R. BEELER | P. HOLM | 10-16-95 |

| XREFERENCES | PLOT FILES |
|---|---|
| | /94017/PLOT/653AOVHD |

| SHT. 1 OF 1 | /94017/DWGS/653AOVHD | N/A |
|---|---|---|
| DRAWING # | CAD FILE # | ROT. ANGLE |




LEGEND:

...SURFACE CONTAMINATION ON WALLS
*.....SMEAR TAKEN

NOTES:

1.) OVERHEAD SURVEY INDICATED CONTAMINATION AT 5,500 ± 860 dpm B-G ON A WALL EXTENSION.

N

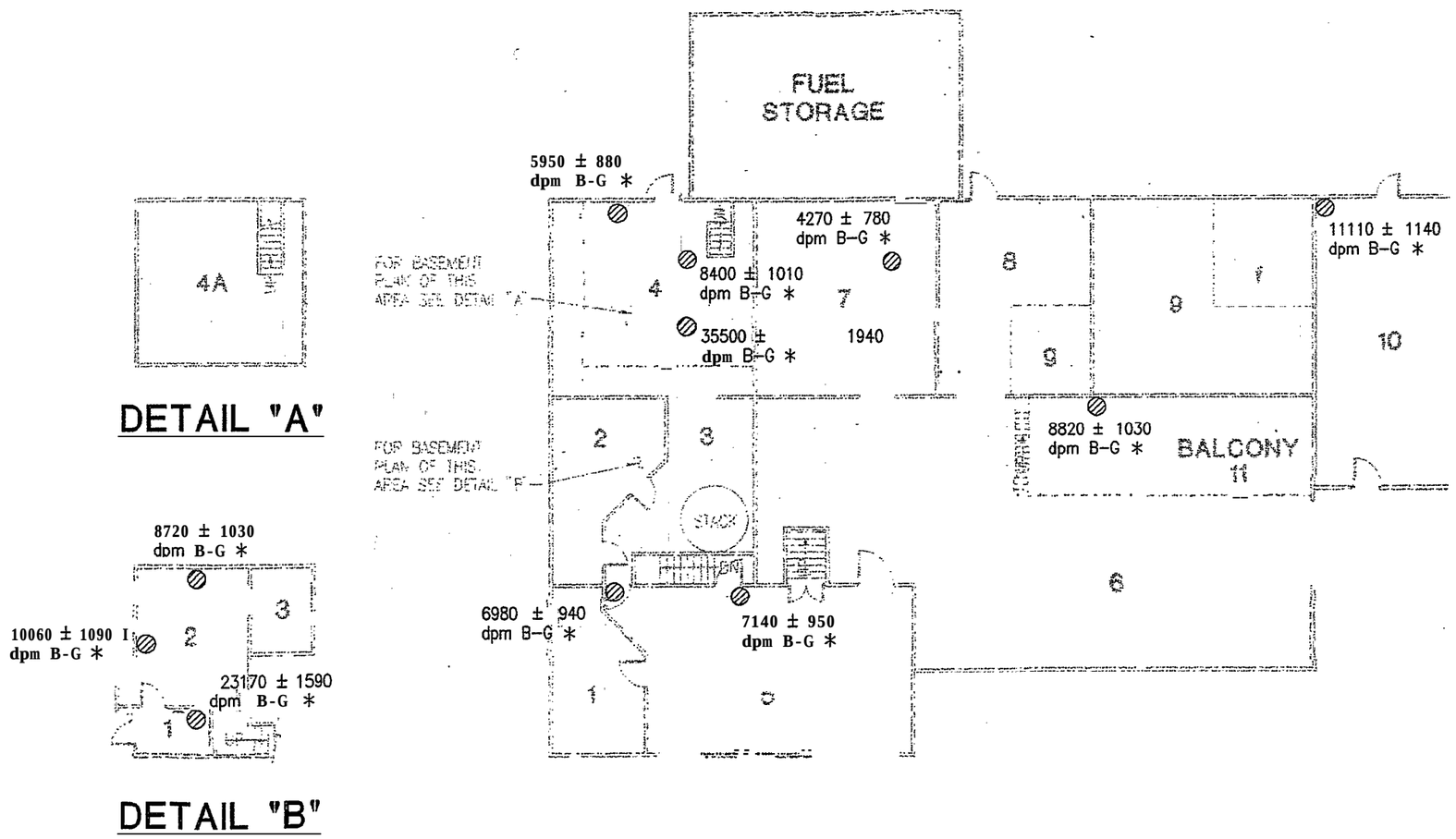
NOT TO SCALE

Figure 5-14.
Building A Basement

| REVISION | DRAWN BY: | CHKD. BY: | DATE: |
|---|---|---|---|
| 0 | R. BEELER | P. HOLM | 10-16-95 |

| XREFERENCES | PLOT FILES |
|---|---|
| | /94017/PLOT/653BAWAL |

| SHT. 1 OF 1 | /94017/DWGS/653BAWAL | N/A |
|---|---|---|
| DRAWING # | CAD FILE # | ROT. ANGLE |




LEGEND:

*.....SMEAR TAKEN

⊘.....CONTAMINATED FLOOR AREAS

NOT TO SCALE

Figure 5-15
Building A-1 Floors

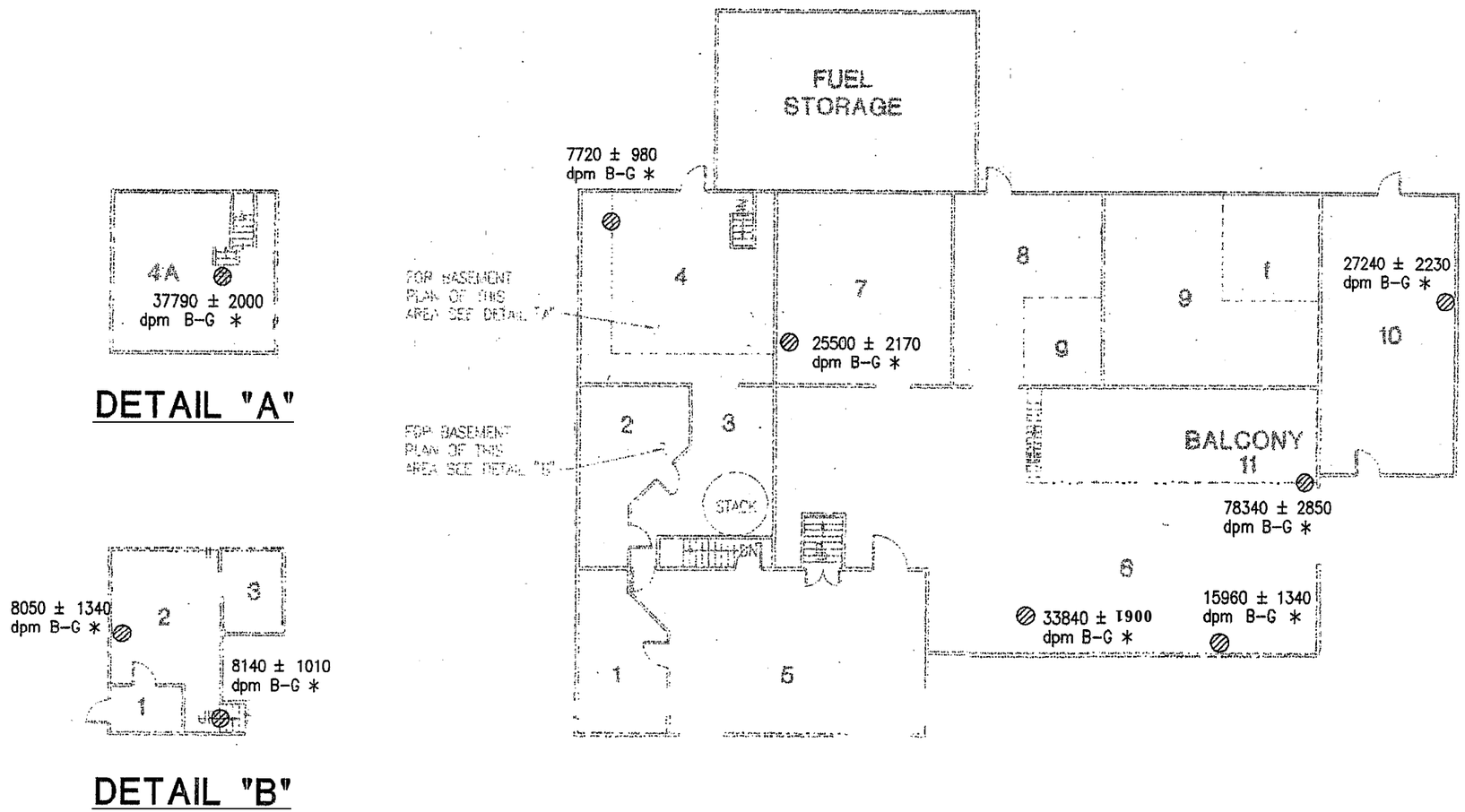
| REVISION | DRAWN BY: | CHKD. BY: | DATE: |
|---|---|---|---|
| 0 | R. BEELER | P. HOLM | 10-16-95 |

| XREFERENCES | PLOT FILES |
|---|---|
| | /94017/PLOT/653A1FLR |

| SHT. 1 OF 1 | /94017/DWGS/653A1FLR | N/A |
|---|---|---|
| DRAWING # | CAD FILE # | ROT. ANGLE |

LEGEND:

*.....SMEAR TAKEN
⊘..CONTAMINATED HORIZONTAL SURFACES



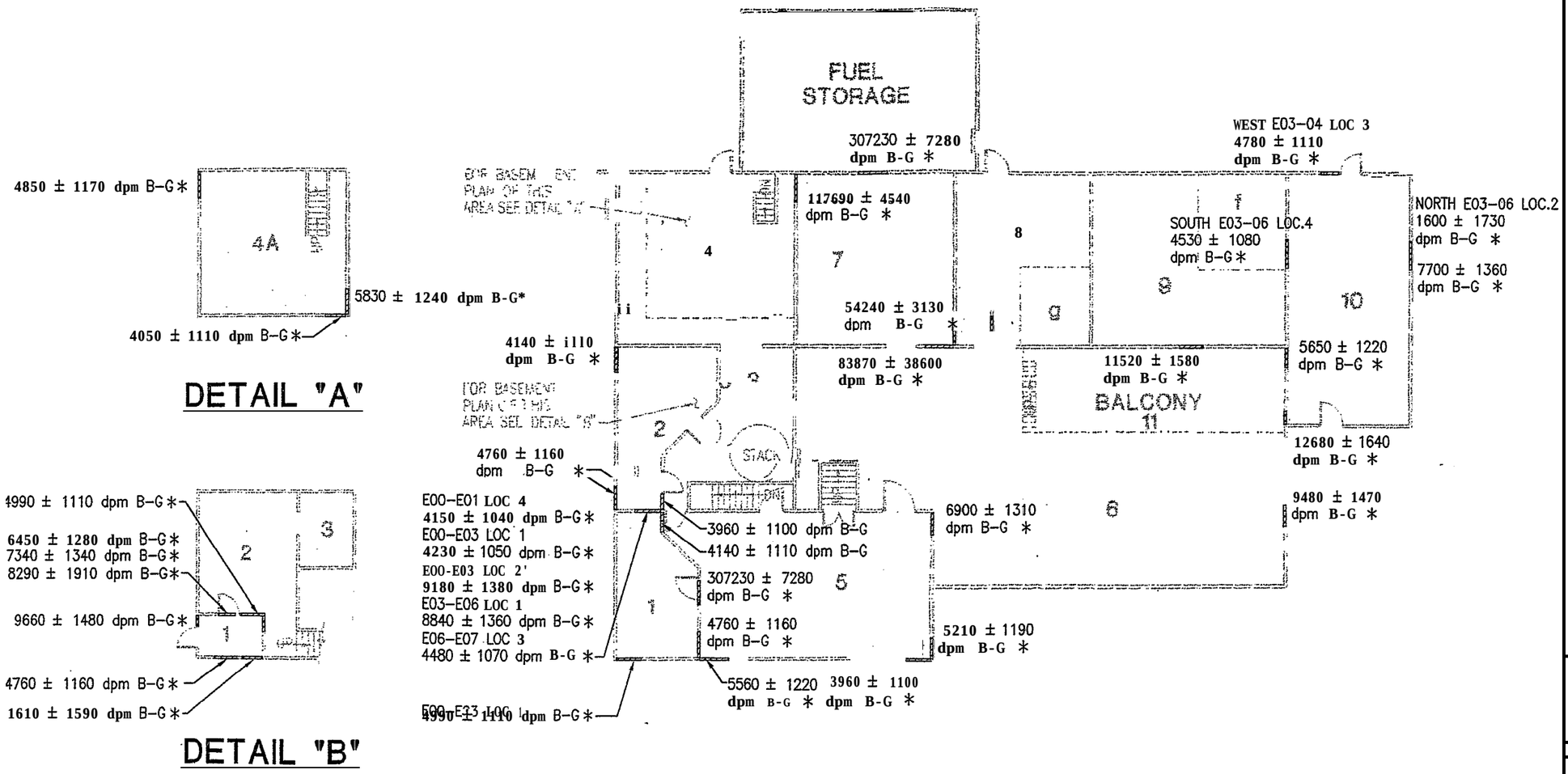

NOT TO SCALE

Figure 5-16
Building A-1 Horizontal Equipment Surfaces

| REVISION | DRAWN BY: | CHKD. BY: | DATE: |
|---|---|---|---|
| 0 | R. BEELER | P. HOLM | 10-16-95 |

| XREFERENCES | PLOT FILES |
|---|---|
| | /94017/PLOT/653A1HRZ |

| SHT. 1 OF 1 | /94017/DWGS/653A1HRZ | N/A |
|---|---|---|
| DRAWING # | CAD FILE # | ROT. ANGLE |




LEGEND:

* ..... SMEAR TAKEN
▨ ..... CONTAMINATED WALL AREAS

NOT TO SCALE

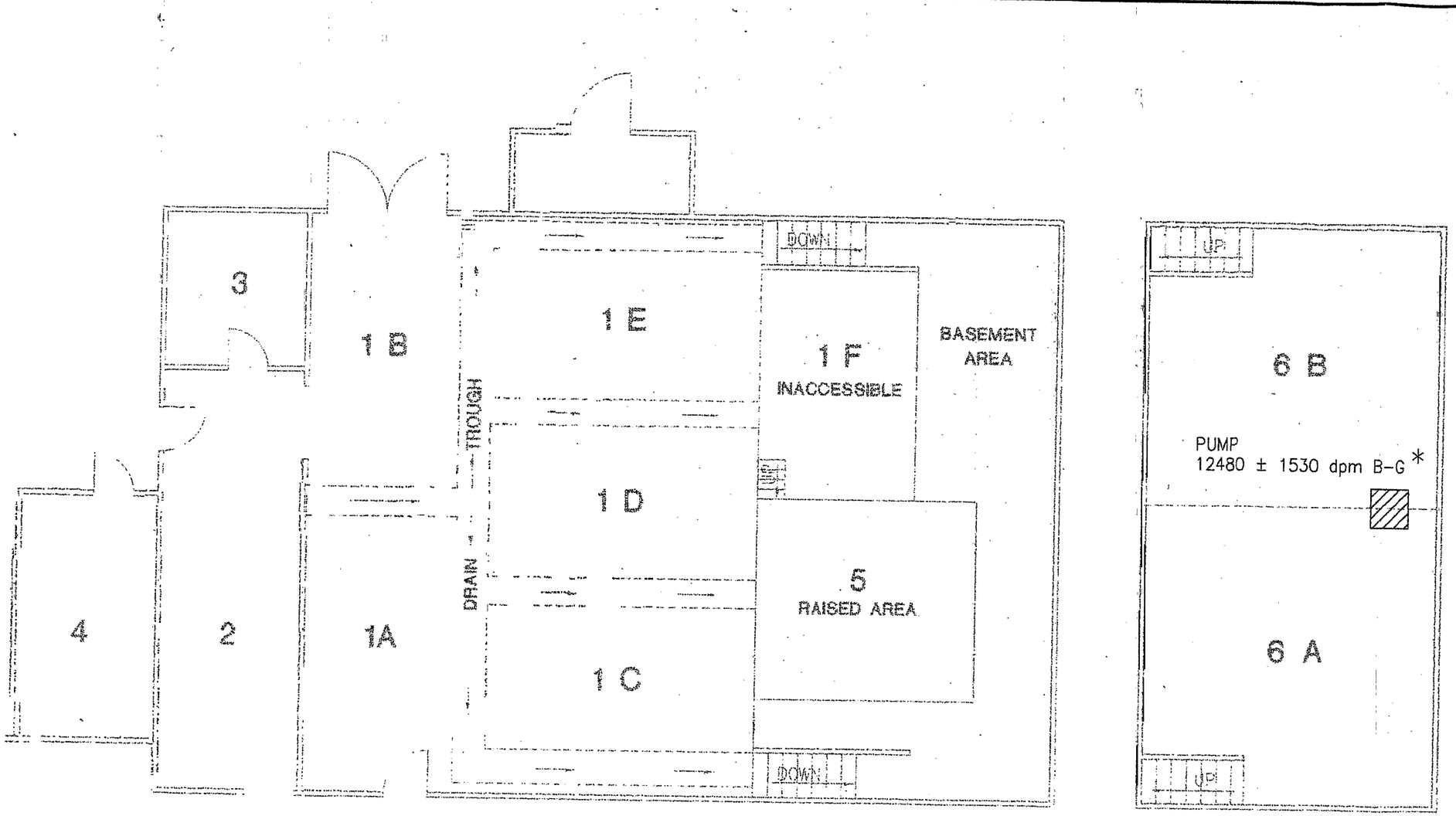
Figure 5-17
Building A-1 Walls

| REVISION | DRAWN BY: | CHKD. BY: | DATE: |
|---|---|---|---|
| 0 | R. BEELER | P. HOLM | 10-16-95 |

| XREFERENCES | PLOT FILES |
|---|---|
| | /94017/PLOT/653A1WAL |

| SHT. 1 OF 1 | /94017/DWGS/653A1WAL | N/A |
|---|---|---|
| DRAWING # | CAD FILE # | ROT. ANGLE |

T38005




LEGEND:

*.....SMEAR TAKEN

▨....CONTAMINATED HORIZ. SURFACE

NOT TO SCALE

FIGURE 5-18
ALFA BUILDING

| REVISION | DRAWN BY: | CHKD. BY: | DATE: |
|---|---|---|---|
| 0 | R. BEELER | P. HOLM | 12-28-95 |

| XREFERENCES | PLOT FILES |
|---|---|
| | |

| SHT. 1 OF 1 | /94017/DWGS/653ALF | N/A |
|---|---|---|
| DRAWING # | CAD FILE # | ROT. ANGLE |

## Table 5-1. Analytical Parameters for the 1992 Characterization

| Radionuclides | | |
|---|---|---|
| Ra-226<br>Th-230 | Th-232<br>U-238 | |
| **RCRA Characteristics** | | |
| Corrosivity by pH<br>Ignitability by flashpoint | Reactivity<br>Cyanide<br>Sulfide | Toxicity by TCLP<br>Arsenic<br>Barium<br>Cadmium<br>Chromium<br>Lead<br>Mercury<br>Selenium<br>Silver |
| **Total Metals** | | |
| Aluminum<br>Antimony<br>Arsenic<br>Barium<br>Beryllium<br>Boron<br>Cadmium<br>Calcium | Chromium<br>Cobalt<br>Copper<br>Iron<br>Lead<br>Magnesium<br>Manganese<br>Molybdenum | Nickel<br>Potassium<br>Selenium<br>Silver<br>Sodium<br>Thallium<br>Vanadium<br>Zinc |
| **PCBs** | | |
| Aroclor-1016<br>Aroclor-1221<br>Aroclor-1232 | Aroclor-1242<br>Aroclor-1248 | Aroclor-1254<br>Aroclor-1260 |
| **BNAEs** | | |
| Acenaphthene<br>Acenaphthylene<br>Anthracene<br>Benzidine<br>Benzo(a)anthracene<br>Benzo(a)pyrene<br>Benzo(b)fluoranthene<br>Benzo(g,h,i)perylene<br>Benzo(k)fluoranthene<br>Benzoic Acid<br>Benzyl Alcohol<br>bis(2-Chloroethoxy)methane<br>bis(2-Chloroethyl)ether<br>bis(2-Ethylhexyl)phthalate<br>4-Bromophenyl-phenylether<br>Butylbenzylphthalate<br>4-Chloro-3-methylphenol<br>4-Chloroaniline<br>2-Chloronaphthalene<br>2-Chlorophenol<br>4-Chlorophenyl-phenylether<br>Chrysene<br>Di-n-butylphthalate | Di-n-octylphthalate<br>Dibenzo(a,h)anthracene<br>Dibenzofuran<br>1,2-Dichlorobenzene<br>1,3-Dichlorobenzene<br>1,4-Dichlorobenzene<br>3,3-Dichlorobenzidine<br>2,4-Dichlorophenol<br>Diethylphthalate<br>2,4-Dimethylphenol<br>Dimentylphthalate<br>4,6-Dinitro-2-methylphenol<br>2,4-Dinitrophenol<br>2,4-Dinitrotoluene<br>2,6-Dinitrotoluene<br>1,2-Diphenylhydrazine<br>Fluoranthene<br>Fluorene<br>Hexachlorobenzene<br>Hexachlorobutadiene<br>Hexachlorocyclopentadiene<br>Hexachloroethane<br>Indeno(1,2,3-c,d)pyrene | Isophorone<br>2-Methylnaphthalene<br>2-Methylphenol<br>4-Methylphenol<br>N-Nitroso-di-n-propylamine<br>N-Nitroso-dimethylamine<br>N-Nitroso-diphenylamine<br>Naphthalene<br>2-Nitroaniline<br>3-Nitroaniline<br>4-Nitroaniline<br>Nitrobenzene<br>2-Nitrophenol<br>4-Nitrophenol<br>2,2-oxybis(1-Chloropropane)<br>Pentachlorophenol<br>Phenanthrene<br>Phenol<br>Pyrene<br>1,2,4-Trichlorobenzene<br>2,4,5-Trichlorobenzene<br>2,4,6-Trichlorobenzene |

## Table 5-2. Sample Identification, Location, and Analyses

| Sample Number | Sample Point | Sample Type | Sample Location | Sample Instrument | Analyses Performed |
|---|---|---|---|---|---|
| 127 CV A01 01 | SB-1A | Background | Greenhill Playground | Hand Auger | 1,2,3,5,6 |
| 127 CV B01 01 | SB-1B | Background | Tuck Point Playground | Hand Auger | 1,2,3,5,6 |
| 127 CV C01 01 | SB-1C | Background | Prospect Hill Ath. Field | Hand Auger | 1,2,3,5,6 |
| 127 RV C01 02 | SB-1C | Background | Prospect Hill Ath. Field | Hand Auger | 1,2 |
| 127 RV C01 03 | SB-1C | Background | Prospect Hill Ath. Field | Hand Auger | 1,2 |
| 127 RV 002 01 | SB-2 | Surface Soil | Alfa Building | Split Spoon | 1 |
| 127 RV 002 02 | SB-2 | Subsurface Soil | Alfa Building | Split Spoon | 1,2 |
| 127 RV 002 03 | SB-2 | Subsurface Soil | Alfa Building | Split Spoon | 1 |
| 127 RV 003 01 | SB-3 | Surface Soil | Alfa Building | Split Spoon | 1,2 |
| 127 RV 003 02 | SB-3 | Subsurface Soil | Alfa Building | Split Spoon | 1 |
| 127 RV 003 03 | SB-3 | Subsurface Soil | Alfa Building | Split Spoon | 1 |
| 127 RV 004 01 | SB-4 | Surface Soil | Alfa Building | Split Spoon | 1 |
| 127 RV 004 02 | SB-4 | Subsurface Soil | Alfa Building | Split Spoon | 1,2 |
| 127 RV 004 03 | SB-4 | Subsurface Soil | Alfa Building | Split Spoon | 1 |
| 127 RV 005 01 | SB-5 | Surface Soil | Alfa Building | Split Spoon | 1 |

Analyses Codes:
1 = Uranium-238, Radium-226, and Thorium-230
2 = Thorium-232
3 = Total Metals (arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium)
4 = RCRA characteristics (ignitability, corrosivity, reactivity, and toxicity)
5 = Pesticides/PCBs
6 = Total Petroleum Hydrocarbons (TPH)
7 = Semivolatile organic compounds (if TPH >1,000 ppm)



138005

## Table 5-2 (continued)

| Sample Number | Sample Point | Sample Type | Sample Location | Sample Instrument | Analyses Performed |
|---|---|---|---|---|---|
| 127 RV 005 02 | SB-5 | Subsurface Soil | Alfa Building | Split Spoon | 1,2 |
| 127 RV 005 03 | SB-5 | Subsurface Soil | Alfa Building | Split Spoon | 1,2 |
| 127 CV 006 01 | SB-6 | Surface Soil | Building A | Split Spoon | 1,2,3,4,5,6 |
| 127 RV 006 03 | SB-6 | Subsurface Soil | Building A | Split Spoon | 1 |
| 127 RV 007 01 | SB-7 | Surface Soil | Building F | Split Spoon | 1 |
| 127 RV 007 02 | SB-7 | Subsurface Soil | Building F | Split Spoon | 1,2 |
| 127 RV 007 03 | SB-7 | Subsurface Soil | Building F | Split Spoon | 1,2 |
| 127 RV 008 01 | SB-8 | Subsurface Soil | Building F | Split Spoon | 1,2 |
| 127 RV 008 02 | SB-8 | Subsurface Soil | Building F | Split Spoon | 1 |
| 127 RV 008 03 | SB-8 | Subsurface Soil | Building F | Split Spoon | 1 |
| 127 CV 009 01 | SB-9 | Composite | Building F | Split Spoon | 1,3,4,5,6 |
| 127 RV 009 03 | SB-9 | Subsurface Soil | Building F | Split Spoon | 1,2 |
| 127 CV 010 01 | SB-10 | Surface Soil | Building B | Split Spoon | 1,3,4,5,6 |
| 127 RV 010 03 | SB-10 | Subsurface Soil | Building B | Split Spoon | 1 |
| 127 RV 011 02 | SB-11 | Subsurface Soil | Building B | Split Spoon | 1,2 |
| 127 RV 012 02 | SB-12 | Subsurface Soil | Building B | Split Spoon | 1 |

Analyses Codes:
1 = Uranium-238, Radium-226, and Thorium-230
2 = Thorium-232
3 = Total Metals (arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium)
4 = RCRA characteristics (ignitability, corrosivity, reactivity, and toxicity)
5 = Pesticides/PCBs
6 = Total Petroleum Hydrocarbons (TPH)
7 = Semivolatile organic compounds (if TPH >1,000 ppm)

## Table 5-2 (continued)

| Sample Number | Sample Point | Sample Type | Sample Location | Sample Instrument | Analyses Performed |
|---|---|---|---|---|---|
| 127 RV 012 03 | SB-12 | Subsurface Soil | Building B | Split Spoon | 1,2 |
| 127 RV 013 01 | SB-13 | Subsurface Soil | Building A-1 Room 4 | Hand Auger | 1 |
| 127 RV 014 01 | SB-14 | Subsurface Soil | Building A-1 Room 5 | Hand Auger | 1,2 |
| 127 CV 015 01 | SB-15 | Subsurface Soil | Building A-1 Room 6 | Split Spoon | 1,2,3,4,5,6,7 |
| 127 RV 016 01 | SB-16 | Subsurface Soil | Building A-1 Room 6 | Split Spoon | 1 |
| 127 CV 017 01 | SB-17 | Surface Soil | North Loading Area | Split Spoon | 1,3,4,5,6 |
| 127 RV 017 02 | SB-17 | Subsurface Soil | North Loading Area | Split Spoon | 1,2 |
| 127 RV 017 03 | SB-17 | Subsurface Soil | North Loading Area | Split Spoon | 1 |
| 127 RV 018 01 | SB-18 | Subsurface Soil | North Loading Area | Split Spoon | 1 |
| 127 RV 019 01 | SB-19 | Subsurface Soil | North Loading Area | Split Spoon | 1 |
| 127 RV 019 04 | SB-19 | Duplicate | North Loading Area | Split Spoon | 1 |
| 127 RV 020 01 | SB-20 | Surface Soil | West Loading Area | Split Spoon | 1,2 |
| 127 RV 020 02 | SB-20 | Subsurface Soil | West Loading Area | Split Spoon | 1 |
| 127 RV 020 03 | SB-20 | Subsurface Soil | West Loading Area | Split Spoon | 1 |
| 127 RV 021 01 | SB-21 | Subsurface Soil | West of A-1 | Split Spoon | 1,2 |
| 127 RV 021 02 | SB-21 | Subsurface Soil | West of A-1 | Split Spoon | 1,2 |

Analyses Codes:
1 = Uranium-238, Radium-226, and Thorium-230
2 = Thorium-232
3 = Total Metals (arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium)
4 = RCRA characteristics (ignitability, corrosivity, reactivity, and toxicity)
5 = Pesticides/PCBs
6 = Total Petroleum Hydrocarbons (TPH)
7 = Semivolatile organic compounds (if TPH >1,000 ppm)



138005

## Table 5-2 (continued)

| Sample Number | Sample Point | Sample Type | Sample Location | Sample Instrument | Analyses Performed |
|---|---|---|---|---|---|
| 127 CV 022 01 | SB-22 | Surface Soil | South of C-1 | Split Spoon | 1,2,3,4,5,6 |
| 127 RV 022 02 | SB-22 | Subsurface Soil | South of C-1 | Split Spoon | 1,2 |
| 127 RV 022 04 | SB-22 | Duplicate | South of C-1 | Split Spoon | 1,2 |
| 127 RV 023 01 | SB-23 | Surface Soil | Outside C-1 | Split Spoon | 1,2 |
| 127 RV 023 02 | SB-23 | Subsurface Soil | Outside C-1 | Split Spoon | 1 |
| 127 RV 023 03 | SB-23 | Subsurface Soil | Outside C-1 | Split Spoon | 1 |
| 127 RV 024 01 | SB-24 | Subsurface Soil | Under C-2 | Directional Drill | 1 |
| 127 RV 024 02 | SB-24 | Subsurface Soil | Under C-2 | Directional Drill | 1 |
| 127 RV 024 03 | SB-24 | Subsurface Soil | Under C-2 | Directional Drill | 1 |
| 127 RV 025 01 | SB-25 | Surface Soil | Outside C-3 | Split Spoon | 1,2 |
| 127 RV 025 02 | SB-25 | Subsurface Soil | Outside C-3 | Split Spoon | 1,2 |
| 127 RV 025 03 | SB-25 | Subsurface Soil | Outside C-3 | Split Spoon | 1 |
| 127 RV 026 01 | SB-26 | Subsurface Soil | Under C-4 | Directional Drill | 1 |
| 127 RV 026 02 | SB-26 | Subsurface Soil | Under C-4 | Directional Drill | 1 |
| 127 RV 026 03 | SB-26 | Subsurface Soil | Under C-4 | Directional Drill | 1 |
| 127 RV 027 01 | SB-27 | Surface Soil | North of C-4 | Split Spoon | 1 |

Analyses Codes:
1 = Uranium-238, Radium-226, and Thorium-230
2 = Thorium-232
3 = Total Metals (arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium)
4 = RCRA characteristics (ignitability, corrosivity, reactivity, and toxicity)
5 = Pesticides/PCBs
6 = Total Petroleum Hydrocarbons (TPH)
7 = Semivolatile organic compounds (if TPH >1,000 ppm)



138005

## Table 5-2 (continued)

| Sample Number | Sample Point | Sample Type | Sample Location | Sample Instrument | Analyses Performed |
|---|---|---|---|---|---|
| 127 RV 027 02 | SB-27 | Subsurface Soil | North of C-4 | Split Spoon | 1,2 |
| 127 RV 027 03 | SB-27 | Subsurface Soil | North of C-4 | Split Spoon | 1 |
| 127 RV 027 04 | SB-27 | Duplicate | North of C-4 | Split Spoon | 1 |
| 127 RV 027 05 | SB-27 | Subsurface Soil | North of C-4 | Split Spoon | 1 |
| 127 RV 027 06 | SB-27 | Subsurface Soil | North of C-4 | Split Spoon | 1 |
| 127 RV 028 01 | SB-28 | Surface Soil | Between Alfa & F | Split Spoon | 1,2 |
| 127 RV 028 02 | SB-28 | Subsurface Soil | Between Alfa & F | Split Spoon | 1 |
| 127 RV 028 03 | SB-28 | Subsurface Soil | Between Alfa & F | Split Spoon | 1 |
| 127 RV 029 01 | SB-29 | Surface Soil | Between Alfa & F | Split Spoon | 1,2 |
| 127 RV 029 02 | SB-29 | Subsurface Soil | Between Alfa & F | Split Spoon | 1 |
| 127 CV 030 01 | SB-30 | Surface Soil | South of Alfa Building | Split Spoon | 1,2,3,4,5,6 |
| 127 RV 030 02 | SB-30 | Subsurface Soil | South of Alfa Building | Split Spoon | 1,2 |
| 127 RV 030 03 | SB-30 | Subsurface Soil | South of Alfa Building | Split Spoon | 1 |
| 127 RV 030 04 | SB-30 | Duplicate | South of Alfa Building | Split Spoon | 3,4,5,6 |
| 127 RV 031 01 | SS-31 | Surface Soil | South of Building C | St. Steel Garden Trowel | 1 |
| 127 RV 032 01 | SS-32 | Surface Soil | South of Building C | St. Steel Garden Trowel | 1 |

Analyses Codes:
1 = Uranium-238, Radium-226, and Thorium-230
2 = Thorium-232
3 = Total Metals (arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium)
4 = RCRA characteristics (ignitability, corrosivity, reactivity, and toxicity)
5 = Pesticides/PCBs
6 = Total Petroleum Hydrocarbons (TPH)
7 = Semivolatile organic compounds (if TPH >1,000 ppm)



138005

## Table 5-2 (continued)

| Sample Number | Sample Point | Sample Type | Sample Location | Sample Instrument | Analyses Performed |
|---|---|---|---|---|---|
| 127 RV 033 01 | SS-33 | Surface Soil | South of Alfa Building | St. Steel Garden Trowel | 1 |
| 127 RV 034 01 | SS-34 | Surface Soil | South of Alfa Building | St. Steel Garden Trowel | 1 |
| 127 RV 035 01 | SS-35 | Surface Soil | Decon Pad | St. Steel Spatula | 1 |
| 127 RV 036 01 | 036 | Sewer Sediment | Between A-1 and B | St. Rod w/Nalgene Btl. | 1,2 |
| 127 RV 036 02 | 036 | Sewer Sediment | Between A-1 and B | St. Rod w/Nalgene Btl. | 1,2 |
| 127 RV 036 03 | 036 | Sewer Sediment | Between A and B | St. Rod w/Nalgene Btl. | 1,2 |
| 127 RV 036 04 | 036 | Sewer Sediment | Between A and B | St. Rod w/Nalgene Btl. | 1,2 |
| 127 RV 037 01 | | Soil | 11 Congress St. Bsmt. | St. Steel Spoon | 1,2 |
| 127 RV 038 01 | | Soil | 11 Congress St. Bsmt. | St. Steel Spoon | 1,2 |
| 127 RV 039 01 | | Soil | 15 Congress St. Bsmt. | St. Steel Spoon | 1,2 |
| 127 RV 040 01 | | Soil | 15 Congress St. Bsmt. | St. Steel Spoon | 1,2 |
| 127 RV 041 01 | | Soil | 15 Congress St. Bsmt. | St. Steel Spoon | 1,2 |
| 127 RV 042 01 | | Soil | 15 Congress St. Bsmt. | St. Steel Spoon | 1,2 |
| 127 RV 001 51 | SW-1 | Background | Danvers River | Bottom Filling Bailer | 1,2 |
| 127 RV 002 51 | SW-2 | Background | Bass River | Bottom Filling Bailer | 1,2 |
| 127 RV 003 51 | SW-3 | Surface Water | East of Foundry | Bottom Filling Bailer | 1,2 |

Analyses Codes:
1 = Uranium-238, Radium-226, and Thorium-230
2 = Thorium-232
3 = Total Metals (arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium)
4 = RCRA characteristics (ignitability, corrosivity, reactivity, and toxicity)
5 = Pesticides/PCBs
6 = Total Petroleum Hydrocarbons (TPH)
7 = Semivolatile organic compounds (if TPH >1,000 ppm)



138005

## Table 5-2 (continued)

| Sample Number | Sample Point | Sample Type | Sample Location | Sample Instrument | Analyses Performed |
|---|---|---|---|---|---|
| 127 RV 004 51 | SW-4 | Surface Water | South of B-2 | Bottom Filling Bailer | 1,2 |
| 127 RV 004 52 | SW-4 | Duplicate | South of B-2 | Bottom Filling Bailer | 1,2 |
| 127 RV 005 51 | SW-5 | Surface Water | West of C-1 | Bottom Filling Bailer | 1,2 |
| 127 CV 001 11 | SD-1 | Background | Danvers River | Ponar Type Sampler | 1,2,3,5,6 |
| 127 CV 002 11 | SD-2 | Background | Bass River | Ponar Type Sampler | 1,2,3,5,6 |
| 127 CV 003 11 | SD-3 | Sediment | East of Foundry | Ponar Type Sampler | 1,2,3,5,6 |
| 127 CV 004 11 | SD-4 | Sediment | South of B-2 | Ponar Type Sampler | 1,2,3,5,6 |
| 127 CV 004 12 | SD-4 | Duplicate | South of B-2 | Ponar Type Sampler | 1,2,3,5,6 |
| 127 CV 005 11 | SD-5 | Sediment | West of C-1 | Ponar Type Sampler | 1,2,3,5,6 |
| 127 CV P01 01 | WP-1 | Ash Pile | Inside Building A | Soil Probe | 1,2,3,4,5,6 |
| 127 CV P02 01 | WP-2 | Ash Pile | Inside Building A | Soil Probe | 1,2,3,4,5,6 |
| 127 RV 001 31 | AS-1 | Mussel | Background | Rake | 1,2 |
| 127 RV 002 31 | AS-2 | Mussel | Tidal Flat | Rake | 1,2 |
| 127 RV 002 32 | AS-2 | Duplicate | Tidal Flat | Rake | 1,2 |
| 127 RV 003 31 | AS-3 | Mussel | Tidal Flat | Rake | 1 |
| 127 CV 500 00 | | Decon Water | Drums | | |

Analyses Codes:
1 = Uranium-238, Radium-226, and Thorium-230
2 = Thorium-232
3 = Total Metals (arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium)
4 = RCRA characteristics (ignitability, corrosivity, reactivity, and toxicity)
5 = Pesticides/PCBs
6 = Total Petroleum Hydrocarbons (TPH)
7 = Semivolatile organic compounds (if TPH >1,000 ppm)



138005

# Table 5-3. Soil Around Building A and Ash Pile

**VENTRON - SOIL BORING - 06**

| Sample | Number | 127CV00601 | | | 127RV00603 | | |
|---|---|---|---|---|---|---|---|
| | | Collected: 09/10/92 0.0 - 1.0 FT | | | Collected: 09/10/92 4.0 - 5.0 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | |
| Ra-226 | pCi/g | 0.740 | 0.09 | | 0.84 | | J |
| Th-230 | pCi/g | 0.920 | 0.49 | | | | |
| Th-232 | pCi/g | 1.400 | 0.44 | | 1.2 | | J |
| U-238 | pCi/g | 4.7 | | J | 7.7 | 0.32 | |

**VENTRON - SOIL BORING - 11**

| Sample | Number | 127RV01102 | | | |
|---|---|---|---|---|---|
| | | Collected: 09/10/92 2.0 - 3.0 FT | | | |
| | | Result | Error Range | Data Qualifer | |
| Radiological | Units | | | | |
| Ra-226 | pCi/g | 0.45 | | J | |
| Th-230 | pCi/g | 0.580 | 0.45 | | |
| Th-232 | pCi/g | 0.59 | | J | |
| U-238 | pCi/g | 5.800 | 0.66 | | |

**BUILDING A - ASH PILES**

| Sample | Number | 127CVP0101 | | | 127CVP0201 | | |
|---|---|---|---|---|---|---|---|
| | | Collected: 10/19/92 0.0 - 0.0 FT Station: P01 | | | Collected: 10/19/92 0.0 - 0.0 FT Station: P02 | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | |
| Ra-226 | pCi/g | 26.000 | 0.62 | | 42.800 | 1.7 | |
| Th-230 | pCi/g | 0.220 | 0.22 | | 0.650 | 0.4 | |
| Th-232 | pCi/g | 2.1 | | J | 2.4 | | J |
| U-238 | pCi/g | 10.3 | | J | 12.7 | | J |

J Indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

# Table 5-4. Soil Under and Around Building A-1

| VENTRON - SOIL BORING - 17 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample | Number | 127CV01701 | | | 127RV01702 | | | 127RV01703 | | | |
| | | Collected: 09/03/92 0.0 - 1.0 FT | | | Collected: 09/03/92 2.0 - 3.0 FT | | | Collected: 09/03/92 4.0 - 5.0 FT | | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | |
| Radiological | Units | | | | | | | | | | |
| Ra-226 | pCi/g | 0.960 | 0.23 | | 1.100 | 0.21 | | 1.200 | 0.22 | | |
| Th-230 | pCi/g | | | | 1.600 | 0.64 | | | | | |
| Th-232 | pCi/g | 1.400 | 0.55 | | 1.300 | 0.39 | | 1.300 | 0.54 | | |
| U-238 | pCi/g | 10.500 | 0.97 | | 9.000 | 0.88 | | 6.000 | 1.9 | | |

| VENTRON - SOIL BORING - 18 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sample | Number | 127RV01801 | | | | | |
| | | Collected: 09/21/92 2.0 - 3.0 FT | | | | | |
| | | Result | Error Range | Data Qualifer | | | |
| Radiological | Units | | | | | | |
| Ra-226 | pCi/g | 0.550 | 0.19 | | | | |
| Th-232 | pCi/g | 0.590 | 0.26 | | | | |
| U-238 | pCi/g | 2.6 | | J | | | |

| VENTRON - SOIL BORING - 19 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sample | Number | 127RV01901 | | | 127RV01904 | | | | |
| | | Collected: 09/21/92 4.0 - 5.0 FT | | | Collected: 09/21/92 4.0 - 5.0 FT | | | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | | |
| Radiological | Units | | | | | | | | |
| Ra-226 | pCi/g | 0.68 | | J | 1.000 | 0.11 | | | |
| Th-232 | pCi/g | 0.92 | | J | 0.91 | | J | | |
| U-238 | pCi/g | 4 | | J | 2.500 | 0.57 | | | |

# Table 5-4 (continued)

**VENTRON - SOIL BORING - 20**

| Sample Number | | 127RV02001 | | | 127RV02002 | | | 127RV02003 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/03/92 0.0 - 1.0 FT | | | Collected: 09/03/92 2.0 - 3.0 FT | | | Collected: 09/03/92 4.0 - 5.0 FT | | |
| Radiological | Units | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Ra-226 | pCi/g | 1.500 | 0.14 | | 0.460 | 0.13 | | 0.560 | 0.13 | |
| Th-230 | pCi/g | 1.000 | 0.51 | | | | | | | |
| Th-232 | pCi/g | 1.800 | 0.05 | | 0.71 | | J | 0.630 | 0.15 | |
| U-238 | pCi/g | 25.400 | 4.9 | | 5 | | J | 8.200 | 1.8 | |

**VENTRON - SOIL BORING - 21**

| Sample Number | | 127RV02101 | | | 127RV02102 | | |
|---|---|---|---|---|---|---|---|
| | | Collected: 09/04/92 2.0 - 3.0 FT | | | Collected: 09/04/92 3.0 - 4.0 FT | | |
| Radiological | Units | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Ra-226 | pCi/g | 1.300 | 0.73 | | 2.300 | 0.32 | |
| Th-230 | pCi/g | 1.400 | 0.58 | | 1.300 | 0.56 | |
| Th-232 | pCi/g | 2.300 | 0.78 | | 3.300 | 0.22 | |
| U-238 | pCi/g | 8.900 | 1.4 | | 3.700 | 3.2 | |

**BUILDING A-1 Basement (Soil Borings SB 13, 14, 15 and 16)**

| Sample Number | | 127RV01301 | | | 127RV01401 | | | 127CV01501 | | | 127RV01601 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/22/92 0.0- 0.5 FT Station: 013 | | | Collected: 10/20/92 0.0- 0.5 FT Station: 014 | | | Collected: 09/17/92 0.0- 0.5 FT Station: 015 | | | Collected: 09/17/92 0.0- 0.5 FT Station: 016 | | |
| Radiological | Units | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Ra-226 | pCi/g | 0.930 | 0.14 | | 0.940 | 0.33 | | 1.500 | 0.2 | | 1.100 | 0.05 | |
| Th-230 | pCi/g | | | | 44.500 | 3.3 | | 1.100 | 0.6 | | | | |
| Th-232 | pCi/g | 1.200 | 0.11 | | 1.100 | 0.22 | | 1.800 | 0.39 | | 1.300 | 0.26 | |
| U-238 | pCi/g | 3.5 | | J | 190.000 | 22.9 | | 9.1 | | J | 1.900 | 0.83 | J |

J Indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

# Table 5-5. Soil Around B Buildings

| VENTRON - SOIL BORING - 10 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sample | Number | 127CV01001 | | | 127RV01003 | | |
| | | Collected: 09/09/92 0.0 - 1.0 FT | | | Collected: 09/09/92 4.0 - 5.0 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | |
| Ra-226 | pCi/g | 2.200 | 0.15 | | 1.300 | 0.45 | |
| Th-232 | pCi/g | 3.600 | 0.92 | | 1.900 | 0.41 | |
| U-238 | pCi/g | 6.300 | 2.2 | | 11.8 | | J |

| VENTRON - SOIL BORING - 12 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sample | Number | 127RV01203 | | | 127RV01202 | | |
| | | Collected: 09/10/92 2.0 - 3.0 FT | | | Collected: 09/10/92 3.0 - 4.0 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | |
| Ra-226 | pCi/g | 0.930 | 0.12 | | 0.690 | 0.22 | |
| Th-230 | pCi/g | 0.420 | 0.39 | | | | |
| Th-232 | pCi/g | 0.76 | | J | 0.880 | 0.46 | |
| U-238 | pCi/g | 25.900 | 2.5 | | 16.300 | 1.9 | |

J Indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

# Table 5-6. Soil Under and Around C Buildings

VENTRON - SOIL BORING - 22

| Sample | Number | 127CV02201 | | | 127RV02204 | | | 127RV02202 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/24/92 0.0 - 1.0 FT | | | Collected: 09/24/92 0.0 - 2.0 FT | | | Collected: 09/24/92 2.0 - 3.0 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | | | | |
| Ra-226 | pCi/g | 1.400 | 0.07 | | 1.500 | 0.12 | | 0.980 | 0.22 | |
| Th-230 | pCi/g | 8.500 | 1.3 | | 5.900 | 1.2 | | 2.900 | 0.84 | |
| Th-232 | pCi/g | 12.500 | 0.85 | | 13.500 | 0.8 | | 2.900 | 0.37 | |
| U-238 | pCi/g | 69.400 | 11.1 | | 60.900 | 5.4 | | 46.800 | 6.4 | |

VENTRON - SOIL BORING - 23

| Sample | Number | 127RV02301 | | | 127RV02302 | | | 127RV02303 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/09/92 0.0 - 1.0 FT | | | Collected: 09/09/92 2.0 - 3.0 FT | | | Collected: 09/09/92 6.0 - 7.0 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | | | | |
| Ra-226 | pCi/g | 0.860 | 0.24 | | 0.850 | 0.2 | | 0.640 | 0.06 | |
| Th-230 | pCi/g | 0.980 | 0.59 | | | | | | | |
| Th-232 | pCi/g | 0.65 | | J | 0.960 | 0.18 | | 1.200 | 0.34 | |
| U-238 | pCi/g | 11.800 | 2.7 | | 8.300 | 2.6 | | 8.9 | | J |

VENTRON - SOIL BORING - 24

| Sample | Number | 127RV02401 | | | 127RV02402 | | | 127RV02403 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/23/92 8.0 - 9.0 FT | | | Collected: 09/23/92 10.0 - 11.0 FT | | | Collected: 09/23/92 30.0 - 31.0 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | | | | |
| Ra-226 | pCi/g | 0.880 | 0.04 | | 0.850 | 0.19 | | 0.470 | 0.1 | |
| Th-232 | pCi/g | 1.200 | 0.33 | | 1.200 | 0.19 | | 1.000 | 0.16 | |
| U-238 | pCi/g | 119.000 | 4.4 | | 186.000 | 14.4 | | 5.200 | 0.56 | |

# Table 5-6 (continued)

**VENTRON - SOIL BORING - 25**

| Sample | Number | 127RV02501 | | | 127RV02502 | | | 127RV02503 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/09/92 0.0 - 1.0 FT | | | Collected: 09/09/92 2.0 - 3.0 FT | | | Collected: 09/09/92 4.0 - 5.0 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | | | | |
| Ra-226 | pCi/g | 0.670 | 0.21 | | 0.600 | 0.03 | | 0.450 | 0.18 | |
| Th-230 | pCi/g | 1.100 | 0.55 | | 0.690 | 0.45 | | | | |
| Th-232 | pCi/g | 1.000 | 0.41 | | 0.510 | 0.01 | | 0.470 | 0.28 | |
| U-238 | pCi/g | 4.300 | 2.4 | | 1.900 | 1.2 | UJ | 0.970 | 0.36 | UJ |

**VENTRON - SOIL BORING - 26**

| Sample | Number | 127RV02601 | | | 127RV02603 | | | 127RV02602 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/15/92 3.0 - 4.0 FT | | | Collected: 09/15/92 11.0 - 12.0 FT | | | Collected: 09/15/92 31.0 - 32.0 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | | | | |
| Ra-226 | pCi/g | 2.300 | 0.22 | | 1.300 | 0.02 | | 0.730 | 0.19 | |
| Th-232 | pCi/g | 3.300 | 0.64 | | 1.900 | 0.44 | | 1.000 | 0.08 | |
| U-238 | pCi/g | 8.000 | 3.4 | | 14.800 | 0.11 | | 6.900 | 1.8 | |

**VENTRON - SOIL BORING - 27**

| Sample | Number | 127RV02701 | | | 127RV02704 | | | 127RV02702 | | | 127RV02705 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/02/92 0.0 - 1.0 FT | | | Collected: 09/02/92 0.0 - 1.0 FT | | | Collected: 09/02/92 2.0 - 3.0 FT | | | Collected: 09/02/92 6.0 - 7.0 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | | | | | | | |
| Ra-226 | pCi/g | 1.300 | 0.15 | | 1.100 | 0.24 | | 0.640 | 0.21 | | 0.51 | | J |
| Th-230 | pCi/g | | | | | | | 1.600 | 0.61 | | | | |
| Th-232 | pCi/g | 2.000 | 0.21 | | 2.900 | 0.39 | | 1.100 | 0.04 | | 0.720 | 0.2 | |
| U-238 | pCi/g | 26.300 | 5.7 | | 24.300 | 3.8 | | 11.100 | 0.09 | | 5.400 | 0.91 | |



138005

# Table 5-6 (continued)

| VENTRON - SOIL BORING - 27 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sample | Number | 127RV02706 | | | 127RV02703 | | |
| | | Collected: 09/02/92 8.0 - 9.0 FT | | | Collected: 09/02/92 10.0 - 11.0 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | |
| Ra-226 | pCi/g | 1.800 | 0.01 | | 0.7 | | J |
| Th-230 | pCi/g | | | | | | |
| Th-232 | pCi/g | 1.700 | 0.36 | | 1.600 | 0.76 | |
| U-238 | pCi/g | 7.400 | 0.91 | | 37.400 | 2.4 | |

| SURFACE SOIL SAMPLES 31 AND 32 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sample | Number | 127RV03101 | | | 127RV03201 | | |
| | | Collected: 09/22/92 0.0 - 0.5 FT | | | Collected: 09/22/92 0.0 - 0.5 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | |
| Ra-226 | pCi/g | 1.8 | | J | 1.800 | 0.08 | |
| Th-232 | pCi/g | 107.000 | 4.6 | | 399.000 | 11.7 | |
| U-238 | pCi/g | 70.300 | 36.7 | | 412.000 | 194 | |

J Indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

U Indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.



138005

# Table 5-7. Soil Around Building F

**VENTRON - SOIL BORING - 07**

| Sample Number | | 127RV00701 | | | 127RV00702 | | | 127RV00703 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/11/92 0.0 - 1.0 FT | | | Collected: 09/11/92 2.0 - 3.0 FT | | | Collected: 09/11/92 10.0 - 11.0 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | | | | |
| Ra-226 | pCi/g | 0.630 | 0.07 | | 0.950 | 0.33 | | 0.66 | | J |
| Th-230 | pCi/g | | | | 0.720 | 0.47 | | 0.980 | 0.56 | |
| Th-232 | pCi/g | 0.69 | | J | 1.600 | 0.41 | | 1.500 | 0.92 | |
| U-238 | pCi/g | 3.300 | 0.72 | | 3.600 | 0.91 | UJ | 3.9 | | J |

**VENTRON - SOIL BORING - 08**

| Sample Number | | 127RV00801 | | | 127RV00802 | | | 127RV00803 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/11/92 2.0 - 3.0 FT | | | Collected: 09/11/92 8.0 - 9.0 FT | | | Collected: 09/11/92 10.0 - 11.0 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | | | | |
| Ra-226 | pCi/g | 0.800 | 0.12 | | 0.55 | | J | 0.390 | 0.16 | |
| Th-230 | pCi/g | 0.890 | 0.56 | | | | | | | |
| Th-232 | pCi/g | 1.000 | 0.21 | | 0.800 | 0.17 | | 0.690 | 0.13 | |
| U-238 | pCi/g | 1.800 | 0.96 | UJ | 2.600 | 0.16 | | 1.400 | 0.13 | UJ |

**VENTRON - SOIL BORING - 09**

| Sample Number | | 127CV00901 | | | 127RV00902 | | | 127RV00903 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/08/92 0.0 - 1.0 FT | | | Collected: 09/08/92 8.0 - 9.0 FT | | | Collected: 09/08/92 10.0 - 11.0 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | | | | |
| Ra-226 | pCi/g | | | | 0.750 | 0.24 | | 0.51 | | J |
| Th-230 | pCi/g | | | | | | | 1.200 | 0.53 | |
| Th-232 | pCi/g | | | | 1.000 | 0.19 | | 0.830 | 0.05 | |
| U-238 | pCi/g | | | | 15.900 | 4.8 | | 33.600 | 0.58 | |

J Indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

U Indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

# Table 5-8. Soil Around Alfa Building

**VENTRON - SOIL BORING - 02**

| Sample Numbers | | 127RV00201 | | | 127RV00202 | | | 127RV00203 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/11/92 0.0 - 1.0 FT | | | Collected: 09/11/92 2.0 - 3.0 FT | | | Collected: 09/11/92 22.0 - 23.0 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | | | | |
| Ra-226 | pCi/g | 1.200 | 0.25 | | 0.920 | 0.11 | | 1.200 | 0.19 | |
| Th-230 | pCi/g | | | | 1.800 | 0.63 | | | | |
| Th-232 | pCi/g | 2.000 | 0.52 | | 1.000 | 0.03 | | 1.700 | 0.1 | |
| U-238 | pCi/g | 5.500 | 0.98 | | 11.500 | 0.75 | | 3.7 | | J |

**VENTRON - SOIL BORING - 03**

| Sample Numbers | | 127RV00301 | | | 127RV00302 | | | 127RV00303 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/08/92 0.0 - 1.0 FT | | | Collected: 09/08/92 4.0 - 5.0 FT | | | Collected: 09/08/92 12.0 - 13.0 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | | | | |
| Ra-226 | pCi/g | 0.820 | 0.05 | | 1.500 | 0.13 | | 0.790 | 0.07 | |
| Th-230 | pCi/g | 1.600 | 0.6 | | | | | | | |
| Th-232 | pCi/g | 0.890 | 0.14 | | 1.500 | 0.39 | | 0.940 | 0.25 | |
| U-238 | pCi/g | 14.300 | 0.13 | | 41.400 | 4.2 | | 2.200 | 1.6 | UJ |

**VENTRON - SOIL BORING - 04**

| Sample Numbers | | 127RV00401 | | | 127RV00402 | | | 127RV00403 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/08/92 0.0 - 1.0 FT | | | Collected: 09/08/92 2.0 - 3.0 FT | | | Collected: 09/08/92 11.0 - 12.0 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | | | | |
| Ra-226 | pCi/g | 0.670 | 0.19 | | 0.820 | 0.19 | | 0.720 | 0.23 | |
| Th-230 | pCi/g | | | | 1.600 | 0.62 | | | | |
| Th-232 | pCi/g | 1.300 | 0.27 | | 0.910 | 0.17 | | 0.740 | 0.43 | |
| U-238 | pCi/g | 3.200 | 1.1 | | 10.900 | 2.3 | | 4.700 | 1.4 | |



138005

# Table 5-8 (continued)

**VENTRON - SOIL BORING - 05**

| Sample Numbers | | 127RV00501 | | | 127RV00502 | | | 127RV00503 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/14/92 0.0 - 1.0 FT | | | Collected: 09/14/92 7.0 - 8.0 FT | | | Collected: 09/14/92 12.0 - 13.0 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | | | | |
| Ra-226 | pCi/g | 2.100 | 0.58 | | 1.100 | 0.06 | | 1.000 | 0.03 | |
| Th-230 | pCi/g | | | | 1.500 | 0.64 | | 2.500 | 0.79 | |
| Th-232 | pCi/g | 16.700 | 1 | | 1.300 | 0.16 | | 1.600 | 0.37 | |
| U-238 | pCi/g | 26.200 | 0.9 | | 27.700 | 1.1 | | 27.200 | 0.97 | |

**VENTRON - SOIL BORING - 30**

| Sample Numbers | | 127CV03001 | | | 127CV03004 | | | 127RV03002 | | | 127RV03003 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/21/92 0.0 - 1.0 FT | | | Collected: 09/21/92 0.0 - 1.0 FT | | | Collected: 09/21/92 2.0 - 4.0 FT | | | Collected: 09/21/92 8.0 - 9.5 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | | | | | | | |
| Ra-226 | pCi/g | 1.200 | 0.08 | | | | | 0.73 | | J | 1.200 | 0.11 | |
| Th-230 | pCi/g | 1.800 | 0.63 | | | | | 0.610 | 0.42 | | | | |
| Th-232 | pCi/g | 2.300 | 0.44 | | | | | 1.400 | 0.12 | | 1.500 | 0.13 | |
| U-238 | pCi/g | 7.800 | 1.5 | | | | | 10.100 | 0.15 | | 18.300 | 1.1 | |

**Surface Soil Samples 33, 34 and 35**

| Sample Numbers | | 127RV03301 | | | 127RV03401 | | | 127RV03501 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/22/92 0.0 - 0.5 FT | | | Collected: 9/22/92 0.0 - 0.5 FT | | | Collected 10/14/92 0.0 - 0.5 FT | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | | | | |
| Ra-226 | pCi/g | 1.9 | | J | 1.1 | | J | 1.300 | 0.29 | |
| Th-232 | pCi/g | 84.900 | 8.2 | | 22.000 | 0.76 | | 22.700 | 1.5 | |
| U-238 | pCi/g | 54.800 | 24.5 | | 11 | | J | 11.200 | 3.1 | |

J Indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.
U Indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.



138005

## Table 5-9. Samples from the Basements of 11 and 15 Congress Street

**SOIL BORINGS - 37 and 38**

| Sample Number | | 127RV03701 | | | 127RV03801 | | |
|---|---|---|---|---|---|---|---|
| | | Collected: 10/20/92<br>0.0 - 0.5 FT<br>Station: 037 | | | Collected: 10/20/92<br>0.0 - 0.5 FT<br>Station: 038 | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| **Radiological** | **Units** | | | | | | |
| Ra-226 | pCi/g | 0.860 | | | 1.1 | | J |
| Th-230 | pCi/g | 1.500 | 0.11 | | 0.760 | 0.47 | |
| Th-232 | pCi/g | 0.85 | 0.62 | J | 1.300 | 0.22 | |
| U-238 | pCi/g | 3.9 | | J | 7.2 | | J |

**SOIL BORINGS 39, 40, 41 and 42**

| Sample Number | | 127RV03901 | | | 127RV04001 | | | 127RV04101 | | | 127RV04201 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 10/20/92<br>0.0 - 0.5 FT<br>Station: 039 | | | Collected: 10/20/92<br>0.0 - 0.5 FT<br>Station: 040 | | | Collected: 10/20/92<br>0.0 - 0.5 FT<br>Station: 041 | | | Collected: 10/20/92<br>0.0- 0.5 FT<br>Station: 042 | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| **Radiological** | **Units** | | | | | | | | | | | | |
| Ra-226 | pCi/g | 0.640 | 0.01 | | 0.69 | | J | 0.580 | 0.11 | | 0.990 | 0.16 | |
| Th-230 | pCi/g | 0.570 | 0.39 | | 2.400 | 0.79 | | 0.970 | 0.5 | | 0.910 | 0.47 | |
| Th-232 | pCi/g | 0.910 | 0.08 | | 1.200 | 0.37 | | 0.82 | | J | 1.200 | 0.3 | |
| U-238 | pCi/g | 7.0 | | J | 2.400 | 0.17 | UJ | 4.2 | | J | 8.8 | | J |

J Indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.
U Indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

**Table 5-10. Surface Soil Samples with Concentrations of Th-230 or Th-232 >5 pCi/g or U-238 >50 pCi/g**

| Sample Point | Ra-226 | Th-230 | Th-232 | U-238 |
|---|---|---|---|---|
| SS-31 | 1.8 | NA | 107.0 | 70.3 |
| SS-32 | 1.8 | NA | 399.0 | 412.0 |
| SS-33 | 1.9 | NA | 84.9 | 54.8 |
| SS-34 | 1.1 | NA | 22.0 | 11.0 |
| SS-35 | 1.3 | NA | 22.7 | 11.2 |
| SB-5 | 2.1 | NA | 16.7 | 26.2 |
| SB-22 | 1.40 | 8.50 | 12.5 | 69.4 |
| SB-28 | 0.76 | 1.6 | 10.9 | 5.4 |

NA = Not analyzed

## Table 5-11. Subsurface Soil Samples with Concentrations of Th-230 >15 pCi/g or U-238 >50 pCi/g

| Sample Point | Depth of Concentration (ft) | Ra-226 | Th-230 | Th-232 | U-238 |
|---|---|---|---|---|---|
| SB-24 | 3 - 3.25[a] | 0.880 | | 1.2 | 119.0 |
| | 3.75 - 4[a] | 0.850 | | 1.2 | 186.0 |
| SB-22 | 0 - 2 | 1.5 | 5.9 | 13.5 | 60.9 |
| SB-14 | 0 - 0.5[b] | 0.940 | 44.5 | 1.10 | 190.0 |

[a] Depth below basement of Building C-2.
[b] Depth below basement of Building A-1.

# Table 5-12. Harbor Sediment Samples

| SEDIMENT SAMPLES | | SD-1 | | | SD-2 | | | SD-3 | | | SD-4 | | | SD-4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample | Number | 127CV00111 | | | 127CV00211 | | | 127CV00311 | | | 127CV00411 | | | 127CV00412 | | |
| | | Collected: 10/12/92 0.0 - 0.0 Station: 001 | | | Collected: 10/12/92 0.0 - 0.0 Station: 002 | | | Collected: 10/13/92 0.0 - 1.0 FT Station: 003 | | | Collected: 10/13/92 0.0 - 1.0 FT Station: 004 | | | Collected: 10/13/92 0.0 - 1.0 FT Station: 004 | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | | | | | | | | | | |
| Ra-226 | pCi/g | 0.69 | | J | 0.64 | | J | 0.490 | 0.02 | | 0.59 | | J | 0.840 | 0.24 | |
| Th-230 | pCi/g | 0.730 | 0.56 | | 0.440 | 0.51 | UJ | 0.910 | 0.57 | | 0.780 | 0.54 | | 0.250 | 0.43 | UJ |
| Thorium | pCi/g | 1.1 | | J | 0.84 | | J | 0.630 | 0.04 | | 0.75 | | J | 0.9 | | J |
| U-238 | pCi/g | 2.600 | 0.98 | J | 4.3 | | J | 3.2 | | J | 4.5 | | J | 4.8 | | J |

| SEDIMENT SAMPLES | | SD-5 | | |
|---|---|---|---|---|
| Sample | Number | 127CV00511 | | |
| | | Collected: 10/13/92 0.0 - 1.0 FT Station: 005 | | |
| | | Result | Error Range | Data Qualifer |
| Radiological | Units | | | |
| Ra-226 | pCi/g | 0.610 | 0.09 | |
| Th-230 | pCi/g | | | |
| Thorium | pCi/g | 0.730 | 0.53 | UJ |
| U-238 | pCi/g | 2.300 | 1.4 | UJ |

J Indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

U Indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.



138005

# Table 5-13. Mussel Samples

VENTRON - MUSSEL SAMPLES

| Sample | Number | 127RV00131 | | | 127RV00231 | | | 127RV00232 | | | 127RV00331 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 09/29/92 Background | | | Collected: 09/29/92 STATION:2 | | | Collected: 09/29/92 STATION:2(Dupl) | | | Collected: 09/29/92 STATION:3 | | |
| | | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| Radiological | Units | | | | | | | | | | | | |
| Ra-226 | pCi/g | 2.2 | | J | 1.500 | 0.7 | UJ | 2.1 | | J | 1.7 | | J |
| Th-230 | pCi/g | 0.110 | 0.1 | | 0.070 | 0.1 | | 0.050 | 0.1 | UJ | | | |
| Thorium | pCi/g | 2.4 | | J | 2.5 | | J | 2.3 | | J | 2 | | J |
| U-238 | pCi/g | 6.300 | 0.6 | J | 6 | | J | 6.4 | | J | 6.3 | | J |

J . Indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.
U Indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.



138005

# Table 5-14. Sewer Line Sediment Samples

| SEWER SEDIMENT SAMPLES | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 036 | | | 036 | | | 036 | | | 036 | | |
| 127RV03601 | | | 127RV03602 | | | 127RV03603 | | | 127RV03604 | | |
| Collected: 10/14/92<br>0.0 - 0.5 FT<br>Station: 036 | | | Collected: 10/14/92<br>0.0 - 0.5 FT<br>Station: 036 | | | Collected: 10/14/92<br>0.0 - 0.5 FT<br>Station: 036 | | | Collected: 10/14/92<br>0.0 - 0.5 FT<br>Station: 036 | | |
| Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer | Result | Error Range | Data Qualifer |
| 0.640 | 0.2 | | 0.550 | 0.05 | | 0.540 | 0.11 | | 0.530 | 0.04 | |
| 1.500 | 0.17 | | 0.490 | 0.23 | | 0.720 | 0.17 | | 0.56 | | J |
| 6.8 | | J | 5.5 | | J | 3.900 | 0.53 | UJ | 1.400 | 0.81 | UJ |

J Indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

U Indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.



138005

## Table 5-15. Gamma Exposure Rate Survey Results[a]

| Building | Location/Room | Gamma Exposure Rate ($\mu$R/hr) |
|---|---|---|
| Building A-1 | 3 | 20.70 |
| | 4 | 14.10 |
| | 6 | 13.70 |
| | 8 | 13.00 |
| Building A | 20 | 12.10 |
| | 20 | 14.20 |
| | 29 | 15.90 |
| | 30 | 10.00 |
| Alfa Building | 2 | 15.00 |
| | 2 | 12.50 |
| | 6 | 11.90 |
| | 6 | 12.80 |
| | LSA West | 12.40 |
| | LSA North | 10.20 |
| | LSA East | 10.50 |
| | LSA South | 16.90 |
| Building B-1 | Basement | 15.80 |
| Building B-2 | Basement | 15.40 |
| | Basement | 32.30 |
| Building C-1 | Basement | 15.30 |
| Building F | West Wall | 11.80 |
| | East Wall | 16.40 |
| | South Wall | 12.60 |
| | North Wall | 12.30 |

[a] Background measurements have not been subtracted.

138005

## Table 5-16. Radon-222 Concentrations

| Location | Canister Number | Radon Concentration (pCi/L) |
|---|---|---|
| Building F Basement | 3810 | 0.78 |
| Alfa Building Room 2 | 3799 | 0.19 |
| Building A boiler Room | 3816 | 0.01 |
| Alfa Building Basement | 3825 | 4.34 |
| Building B-2 Basement | 3904 | 1.00 |
| Building C Basement | 3910 | 0.90 |
| Building A Packing Room | 4121 | 0.15 |
| Building A Drying Room | 4151 | 0.35 |
| Building A Fan Pit | 4202 | 0.58 |
| Building A Library | 4233 | 0.50 |

## Table 5-17. Ventron Building Survey Results

| Location | Surface | Number of Measurements Direct | | Number Above Criteria 5000 dpm/100 cm² | | Number of Measurements Transferable | | Number Above Criteria 1000 dpm/100 cm² | |
|---|---|---|---|---|---|---|---|---|---|
| | | Alpha | Beta-Gamma | Alpha | Beta-Gamma | Alpha | Beta-Gamma | Alpha | Beta-Gamma |
| Building A | Walls | 307 | 307 | 0 | 53 | 56 | 56 | 0 | 0 |
| | Ceiling (rooms 20, 30) | 25 | 25 | 0 | 0 | — | — | — | — |
| | Overhead | 106 | 106 | 0 | 27 | 27 | 27 | 0 | 0 |
| | Floor (37 rooms, basement) | 323 | 323 | 1 | 68 | 77 | 77 | 0 | 0 |
| | Horizontal surfaces | 349 | 349 | 1 | 189 | 188 | 188 | 0 | 0 |
| Building A-1 | Walls | 173 | 173 | 0 | 26 | 33 | 33 | 0 | 0 |
| | Ceiling (rooms 6, 7, 10) | 15 | 15 | 0 | 0 | — | — | — | — |
| | Overhead | 43 | 43 | 0 | 4 | 5 | 5 | 0 | 0 |
| | Floor (10 rooms, basement) | 86 | 86 | 0 | 74 | 75 | 75 | 0 | 0 |
| | Horizontal surfaces | 59 | 59 | 0 | 11 | 11 | 11 | 0 | 0 |
| Alfa Building | Walls | 38 | 38 | 0 | 0 | — | — | — | — |
| | Overhead | 15 | 15 | 0 | 0 | — | — | — | — |
| | Floor (rooms 2,6) | 18 | 18 | 0 | 0 | — | — | — | — |
| | Horizontal surfaces | 14 | 14 | 0 | 1 | 1 | 1 | 0 | 0 |
| Building F | Floor (basement) | 17 | 17 | 0 | 0 | — | — | — | — |
| Building C | Floor (basement) | 13 | 13 | 0 | 0 | — | — | — | — |
| Building C-1 | Floor (basement) | 26 | 26 | 0 | 0 | — | — | — | — |
| Building B-1 | Floor (basement) | 33 | 33 | 0 | 0 | 1 | 1 | 0 | 0 |
| B-2 | Floor (basement) | 52 | 52 | 0 | 0 | — | — | — | — |
| B-3 | Floor (basement) | 44 | 44 | 0 | 0 | — | — | — | — |
| Summary: Total Measurements | | 1756 | 1756 | 2 | 453 | 474 | 474 | 0 | 0 |

*Source:* BNI 1993



138005

# 6. 1993 AND 1994 HARBOR SEDIMENT SAMPLING

Additional sampling of the harbor area was conducted by DOE in 1993 and 1994. In September 1993, Morton collected numerous samples in the harbor area for hazardous constituent analysis. DOE split samples with Morton and prepared two composite samples. The samples were collected west of Building C-1. The first composite also consisted of five samples (SS-1 through SS-5) collected at low tide at a depth of 0 to 2.2 ft. The second composite consisted of five samples (SS-6 through SS-10) collected at a depth of 0 to 1.5 ft next to the seawall. The results of the two composites are shown in Table 6-1. All results are below 50 pCi/g of U-238 (DOE 1993b).

In 1994, 22 sediment samples were collected from the harbor during a joint sampling effort by DOE and Morton. Sampling locations are shown in Figure 6-1. The samples were all collected manually, half of them with a hand auger and the rest with a trowel, at a depth of 0 to 1 ft below the surface. The first four samples (127-SD-1 to 127-SD-4) were collected from a distance ranging from 30 ft to 60 ft southwest and northwest of the outlet pipe in the seawall. Sample 127-SD-5 was collected directly below the seawall. The next five samples (127-SD-6 to 127-SD-10) were collected right next to the seawall from 2 ft to 10 ft north and south of the outlet pipe. The next set of samples (127-SD-11 to 127-SD-15) was collected further out at distances ranging from 60 ft to 300 ft from the seawall. Sample 127-SD-16 was collected about 50 yards from the bridge to Salem. Samples 127-SD-17 and 127-SD-18 were taken from sandbars, adjacent to the beach and 100 yards from the seawall, respectively. The rest of the samples (127-SD-19 to 127-SD-21 and 127-SD-23) were collected in the main channels of the Bass and Danvers Rivers. The results of the sediment samples are shown in Table 6-2. All results are below 50 pCi/g of U-238 (DOE 1994).

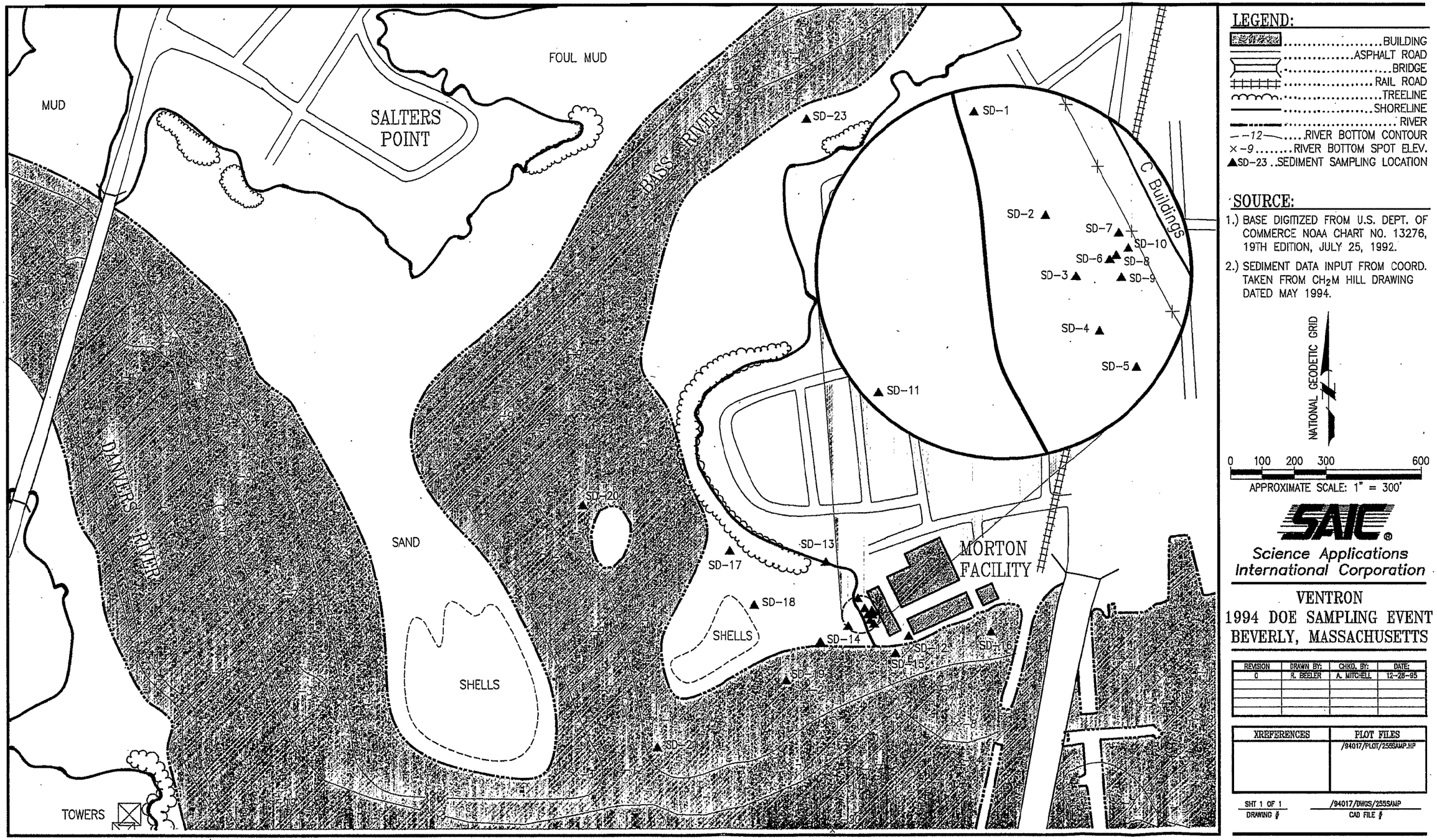



**Figure 6-1. Ventron 1994 DOE Sampling Event, Beverly, Massachusetts**

**Table 6-1. Concentrations of Radionuclides in Composite Sediment Samples from the Harbor Area**

| Sample Number | Ra-226 (pCi/g) | Th-232 (pCi/g) | U-238 (pCi/g) |
|---|---|---|---|
| 127-HG-001 | 0.46 ± 0.1 | 0.62 ± 0.18 | 18.66 ± 2.61 |
| 127-HG-002 | 0.59 ± 0.11 | 0.66 ± 0.22 | 24.01 ± 2.84 |

*Source:* DOE 1993b

**Table 6-2. Concentrations of Radionuclides in Sediment Samples from the Harbor Area**

| Sample Number | Ra-226 (pCi/g) | Th-232 (pCi/g) | U-238 (pCi/g) |
|---|---|---|---|
| 127-SD-1 | 0.45 ± 0.160 | 0.59 ± 0.32 | 2.2 ± 3.0 |
| 127-SD-2 | 0.37 ± 0.2 | 0.86 ± 0.5 | 11.4 ± 2.1 |
| 127-SD-3 | 0.43 ± 0.08 | 0.70 ± 0.56 | 8.4 ± 2.8 |
| 127-SD-4 | 0.38 ± 0.0 | 0.54 ± 0.0 | 5.20 ± 2.4 |
| 127-SD-5 | 0.39 ± 0.0 | 0.66 ± 0.0 | 13.0 ± 3.5 |
| 127-SD-6 | 0.72 ± 0.17 | 0.75 ± O.28 | 11.90 ± 3.0 |
| 127-SD-7 | 0.28 ± 0.0 | 0.44 ± 0.0 | 11.60 ± 2.50 |
| 127-SD-8 | 0.44 ± 0.10 | 0.78 ± 0.57 | 17.40 ± 3.3 |
| 127-SD-9 | 0.33 ± 0.13 | 0.61 ± 0.44 | 3.90 ± 1.90 |
| 127-SD-10 | 0.45 ± 0.1 | 0.64 ± 0.550 | 3.10 ± 1.90 |
| 127-SD-11 | 0.30 ± 0.05 | 0.41 ± 0.37 | 2.20 ± 1.40 |
| 127-SD-12 | 0.44 ± 0.0 | 0.72 ± 0.0 | 2.90 ± 2.20 |
| 127-SD-13 | 0.49 ± 0.27 | 0.59 ± 0.25 | 2.4 ± 2.10 |
| 127-SD-14 | 0.43 ± 0.0 | 0.58 ± 0.0 | 1.8 ± 2.7 |
| 127-SD-15 | 0.56 ± 0.26 | 0.45 ± 0.34 | 1.5 ± 1.40 |
| 127-SD-16 | 0.37 ± 0.0 | 0.81 ± 0.33 | 4.0 ± 2.0 |
| 127-SD-17 | 0.91 ± 0.0 | 1.10 ± 0.0 | 5.70 ± 0.0 |
| 127-SD-18 | 0.92 ± 0.0 | 1.20 ± 0.0 | 6.3 ± 6.9 |
| 127-SD-19 | 0.42 ± 0.150 | 0.67 ± 0.24 | 3.10 ± 0.0 |
| 127-SD-20 | 0.89 ± 0.0 | 1.30 ± 0.0 | 10.2 ± 5.0 |
| 127-SD-21 | 0.44 ± 0.01 | 0.66 ± 0.00 | 1.0 ± 1.9 |
| 127-SD-23 | 0.99 ± 0.48 | 1.10 ± 0.0 | 3.6 ± 3.9 |

*Source:* DOE 1994

# 7. CHARACTERIZATION EVALUATION

In this section, the data collected during the DOE 1992 sampling event is summarized and evaluated to determine if it meets the data needs set out in the characterization plan (DOE 1992). The entire data set is then evaluated with respect to the following essential elements of SAFER: the conceptual model of the site; the knowledge gained by the most recent rounds of sampling (incorporation of new knowledge to eliminate data deficits); and the uncertainties still in existence or those which have arisen because of the most recent sampling.

## 7.1 CHARACTERIZATION DATA SUMMARY

### 7.1.1 Site Soils

The surface and subsurface site soils were sampled by ORNL in 1988 and DOE in 1992. The characterization data for these two sampling efforts are comparable.

Locations of surface soil samples collected during the 1988 and 1992 sampling events that contain Ra-226 or Th-232 greater than 5 pCi/g and U-238 greater than 50 pCi/g are shown in Figure 7-1. The highest surface soil radionuclide concentrations were reported for samples from the southwest and southeast corners of the site. The majority of the elevated Th-232 in the surface soil is located south of the Alfa Building. The majority of the elevated U-238 in the surface soil is located south and southwest of Building C-1. The ORNL 1988 sampling detected concentrations of Th-232 greater than 5 pCi/g northwest of Building C-4 (B5). This elevated Th-232 was not confirmed by the DOE 1992 sampling (SB-27 collected in the same general area contained Th-232 of 2.0 pCi/g). The ORNL 1988 sampling also detected concentrations of U-238 greater than 50 pCi/g north of Building A-1 (B6) and east of Building A in the area of the former chemical storage tank (B9 and S8). Samples collected by DOE in 1992 did not detect concentrations of U-238 greater than 50 pCi/g in these regions (U-238 of 10.5 pCi/g for SB-17 and 4.7 pCi/g for SB-6).

Locations of subsurface soil samples collected during the 1988 and 1992 sampling events with Th-230, Th-232, or Ra-226 greater than 15 pCi/g and U-238 greater than 50 pCi/g are shown in Figure 7-2. Subsurface soils containing concentrations of Th-230, Th-232, or Ra-226 greater than 15 pCi/g or U-238 greater than 50 pCi/g were detected south of the Alfa Building, under Buildings A-1, B-1, B-2, C-1, C-2, between the B Buildings and the seawall, and between Building C-1 and the seawall. The maximum depth of elevated radionuclides measured under the basements of Buildings A-1, B-1, B-2, C-1, and C-2 are approximated below:

- Building A-1 → 15 cm (0.5 ft)
- Building B-1 → 105 cm (3.4 ft)
- Building B-2 → greater than 215 cm (7 ft)
- Building C-1 → greater than 215 cm (7 ft)
- Building C-2 → 122 cm (4 ft)

### 7.1.2 Harbor Surface Water/Sediment and Biological Samples

The radionuclides in the surface water samples from the harbor are comparable to background concentrations except for one unfiltered sample collected by DOE in 1992 which contained 10.6 pCi/L of Ra-226 (the filtered sample contained 0.41 pCi/L of Ra-226).

To date, there have been four sampling events at the Ventron site that have included sediment samples from the Beverly Harbor. The 1991 ORNL sampling was conducted to determine if uranium from work performed under MED contracts at the Ventron facility had migrated offsite. Samples were collected by DOE in 1992 to bound the extent of sediment with elevated levels of radioactivity. The composite and discrete samples collected by DOE in 1993 and 1994 during Morton's sampling activities were to determine if Morton's sampling activities would be impacted by elevated levels of radioactivity in the harbor sediments. Of these four sampling events, only the samples collected by ORNL in 1988 showed concentrations of U-238 greater than 50 pCi/g. The impacted areas identified by ORNL are south of Building F, south of Buildings B-1 and B-2, and south and southwest of Building C-1 (see Figure 4-7).

Radionuclide levels in biological samples collected from the harbor in 1988 and 1992 are comparable to background.

### 7.1.3 Sewer Line Sediment

Sediment samples from manhole inlets in the site's storm water collection system, located between Buildings A and B, were collected by DOE in 1992 and analyzed for radionuclides. All results were comparable to background. The 1988 ORNL sampling detected elevated levels of Ra-226 and Th-232.

### 7.1.4 Buildings

Buildings on the site have minimal residual alpha activity (on surfaces) above DOE guidelines and have no removable residual radioactive material above the DOE uranium guidelines (i.e., only fixed beta-gamma levels exceeded guidelines).

Areas of surface radioactivity levels in excess of the remedial objectives were detected in Buildings A, A-1 and one location in the Alfa Building.

### 7.1.5 Offsite Properties

All surveys and sampling of the offsite properties have shown radioactivity levels below guidelines.

### 7.1.6 Building A Ash Piles

The samples from the ash piles showed Ra-226 concentrations greater than 5 pCi/g. Elevated levels of calcium, magnesium, potassium, and sodium were detected as well as elevated metals. One sample showed elevated levels of TPH and one sample failed the RCRA ignitability test.

### 7.1.7 New Area

For the 1992 DOE characterization, the area east of Building D, which was not one of the original areas of concern, produced some elevated readings in the gamma walkover survey. Since no soil samples have been taken from the area, this area will require additional investigation. This new data need is considered a reasonable uncertainty and will be met at the time of remedial action.

## 7.2 DATA NEEDS

The data needs identified in the DOE characterization plan along with the data obtained during the 1992 characterization report are presented in Table 7-1.

Based on evaluation of the information presented in Table 7-1, all of the data needs identified in the *Ventron Characterization Plan* (DOE 1992) have been met.

## 7.3 CONCEPTUAL MODEL EVALUATION

With the data needs as defined in the *Ventron Characterization Plan* (DOE 1992) met, the conceptual model of the site and each of the buildings can be updated. The knowledge gained has filled in data gaps identified in the characterization plan. Refinement of the conceptual model through application of new information and elimination of data gaps is the key to the SAFER process.

Figure 7-3 presents the revised conceptual model which incorporates all information gained from all characterization data to date. The conceptual model shows the relationship between the primary sources, release mechanism, and the potential pathways to human and ecological receptors. The above ground chemical tanks and the storm and sanitary sewers have been removed as potential sources since they were found to be unlikely contributors, given the current knowledge of the site. The area east of Building D has been added as a potential source as a result of the elevated scans described above. All of the potential pathways for human and ecological exposure remain. The soils and sediment areas that are potentially contaminated, based on sampling conducted to date, are shown in Figure 7-4 and are similar to those identified by the ORNL 1988 sampling.

**Figure 7-1. Locations of Surface Soil Samples with Concentrations of Ra-226 or Th-232 >5 pCi/g or U-238 >50 pCi/g (1982 ORNL and 1992 DOE Sampling Events**

**Figure 7-2. Locations of Subsurface Soil Samples with Concentrations of Ra-226 or Th-232 >15 pCi/g or U-238 >50 pCi/g (1988 ORNL and 1992 DOE Sampling Events**

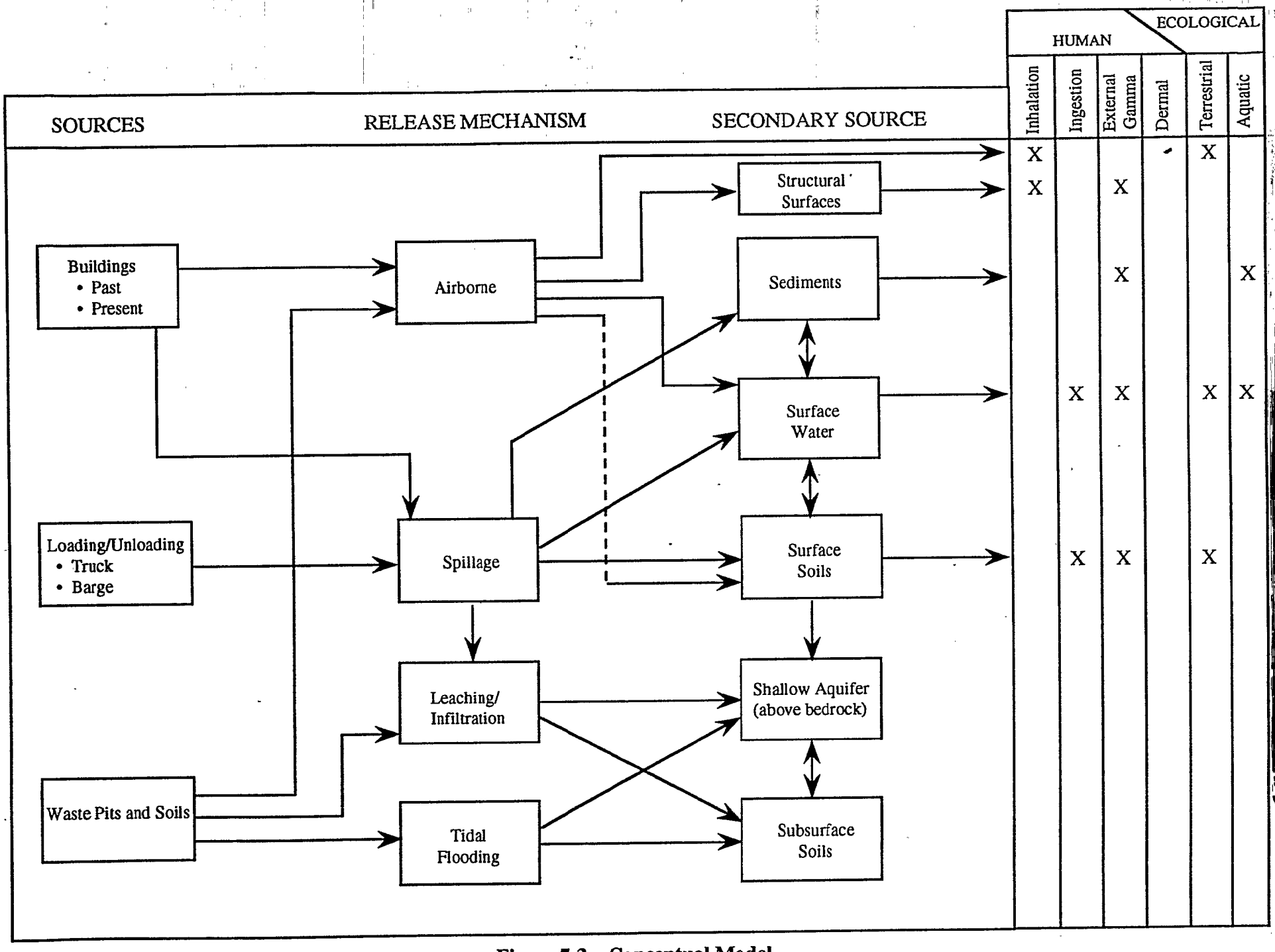



**Figure 7-3. Conceptual Model**

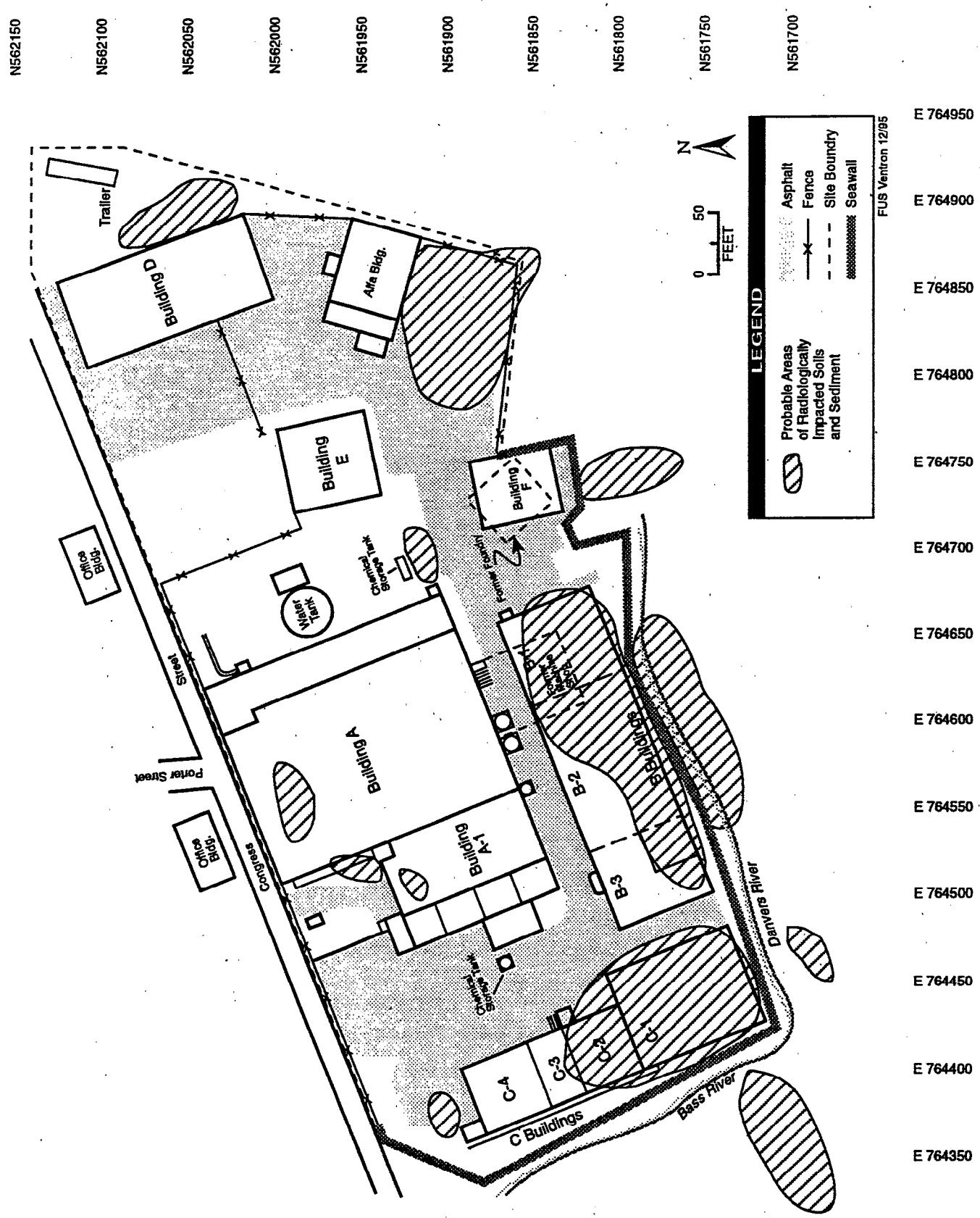



**Figure 7-4. Probable Extent of Radiologically Impacted Soils and Sediment Based on Sampling Information to Date**

## Table 7-1. 1992 Characterization Data Needs and Results

| Area of Concern | Data Needs | Data Obtained |
|---|---|---|
| Buildings A and A-1 | Characterization of ash piles in basement of Building A | Ash piles:<br>• Ra-226 >5 pCi/g<br>• one sample failed RCRA ignitability test<br>• elevated levels of magnesium, potassium, and sodium<br>• elevated metal concentrations (chromium, lead, nickel, zinc) |
| | Makeup of basement floor of Building A (concrete, soil, etc.) | Ash piles lie directly on soil/bedrock. |
| | Extent of residual radioactive material in Buildings A and A-1 | Building A has elevated levels of radioactivity on first floor surfaces, floors, walls and overhead surfaces. The basement level of Building A has elevated levels of radioactivity on walls. Building A-1 has elevated levels of radioactivity on floors, walls, and overhead surfaces. |
| | Extent of residual radioactive material on equipment | Elevated levels of radioactivity detected on horizontal equipment surfaces in Buildings A and A-1. |
| Buildings B-1, B-2, and B-3 | Extent of residual radioactive material in basement | Extensive areas of elevated readings shown in east half of Building B-2 basement extending into Building B-1 basement. Building B-1 basement also showed elevated reading near center of room. No reading over twice background detected in Building B-3 basement. |
| | Presence of hazardous and/or mixed waste in fill/soils beneath basement floor | Soils directly under basement floor of Buildings B-1, B-2, and B-3 were not sampled during DOE 1992 sampling event. Soils northeast of the B Buildings showed no hazardous or mixed waste. |



138005

## Table 7-1 (continued)

| Area of Concern | Data Needs | Data Obtained |
|---|---|---|
| Buildings C-1, C-2, C-3, and C-4 | Extent of residual radioactive material in basement of Building C-1 | A 3- to 4-$m^2$ area containing elevated radioactive levels was detected near the southwest corner of the basement of Building C-1. |
| | Extent of subsurface fill/soil contamination beneath Buildings C-2, C-3, and C-4 | Elevated levels of radioactivity detected beneath Buildings C-2 and C-3. |
| | Presence of hazardous and/or mixed waste in fill/soils beneath basement floor | Soils directly under the basement floor of the C Buildings were not analyzed for hazardous waste constituents. Soils to the south of Building C-1 failed the TCLP limit for lead. |
| Alfa Building | Presence of U-238, Th-230, Ra-226, and hazardous waste | One pump in Room 6 contained elevated beta-gamma radiation. Surface soils to the south of the Alfa Building contained Th-232 >5 pCi/g and U-238 >50 pCi/g. No Th-230 >5 pCi/g or hazardous waste constituents over RCRA criteria were identified. |
| Building F (former Foundry) | Extent of residual radioactive material in surface and subsurface soil beneath and around building | No Ra-226 or Th-232 >5 pCi/g or U-238 >50 pCi/g detected in surface or subsurface soils beneath or around the F Building. |
| Loading/Storage Pad and chemical storage tank adjacent to Building A-1 | Extent of elevated levels radioactive and hazardous waste constituents in surface and subsurface soils | No Ra-226 or Th-232 >5 pCi/g or hazardous waste constituents exceeding RCRA criteria in surface or subsurface soils. One surface sample containing U-238 >50 pCi/g detected north of Building A-1. |
| Former Chemical Storage Tank location adjacent to Building A | Extent of elevated levels of radioactive and hazardous waste constituents in surface and subsurface soils | All chemical analysis parameters for surface soils within the range of background except for nickel, zinc, and aroclor-1254. No hazardous waste criteria exceeded for surface or subsurface soils. No Ra-226 or Th-232 >5 pCi/g or U-238 >50 pCi/g detected in surface or subsurface soils. |



138005

## Table 7-1 (continued)

| Area of Concern | Data Needs | Data Obtained |
|---|---|---|
| Loading/Storage Area between Buildings B and F | Extent of elevated levels of radioactive and hazardous waste constituents in surface and subsurface soils | No Ra-226 or Th-232 >5 pCi/g, U-238 >50 pCi/g or hazardous constituents greater than RCRA criteria detected in surface or subsurface soils. |
| Storm Water Sewer System | Extent of residual radioactive materials (specifically from Building A and A-1) | No Ra-226 or Th-232 >5 pCi/g or U-238 >50 pCi/g. |
| Tidal Flat (Harbor) Sediments | Extent of residual radioactive materials and hazardous waste constituents | Levels of U-238 >50 pCi/g in the harbor sediments is bounded within 50 ft of the seawall to the south of the B Buildings, and west of the C Buildings. |
| Mussel Beds/Surface Water | Presence or absence of radionuclides above guidelines | Mussel beds shown to be at background levels. One of 5 unfiltered harbor surface water samples contained Ra-226 concentrations greater than the MCL. |

*Source:* DOE 1992



138005

# 8. REMEDIAL CONDITIONS AND DECISION RULES

## 8.1 REMEDIAL CONDITIONS

Preliminary remedial conditions based on the characterization data to date are presented in this section. The exact remedial alternatives will be developed, evaluated, and selected in the EE/CA and coordinated with Morton. DOE has authority at the Ventron site for the remediation of materials containing greater than 50 pCi/g U-238. The remediation of materials containing elevated levels of Ra-226, Th-230, or Th-232 will be negotiated with Morton.

*Harbor Sediment*

Sediment samples from the tidal flats and river adjacent to the site have produced evidence of elevated levels of radioactivity attributable to MED-related activities. The ORNL sampling in 1991 showed three areas of impacted sediments. The DOE 1992 characterization effort bounded the impacted areas to be within 50 ft of the seawall and confirmed that the mussel population was not impacted. The exact area to be remediated will be determined during remedial activities.

*Sewer Line*

The stormwater sewer system exhibits no sediments with radionuclide concentrations above DOE remediation guidelines; therefore, no remediation is anticipated.

*A Buildings: A and A-1*

It is anticipated that remediation of Buildings A and A-1 structural surfaces will be required. Remediation may range from decontamination to removal and appropriate disposal.

It is anticipated that the soils and bedrock surface beneath the ash piles have been impacted. Remediation of these soils, and the soils to the northwest side of Building A will be required. The extent of removal of these soils will be determined through monitoring during remedial activities.

The extent of soils containing elevated levels of U-238 and/or Th-230 under the floor of Building A-1 is currently unknown. In the event of demolition of the building and floor of Building A-1, underlying soils exhibiting U-238 concentrations greater than 50 pCi/g will be removed and appropriately disposed. As described above, the extent of removal will be determined through monitoring during remedial activities. If the floor of Building A-1 is left intact and the site remains industrial, it is anticipated that the underlying soils will be left in place.

*B Buildings: B-1, B-2, and B-3*

It is anticipated that the B Buildings will need to be demolished to allow access to the soils beneath the basement floors that contain elevated levels of radioactivity. If demolition is the preferred remedial action, it is anticipated that the majority of the construction rubble can be disposed as nonradioactive rubble or left onsite as backfill.

The soils beneath the B Buildings containing elevated levels of U-238 will be removed and appropriately disposed. As described above, the extent of removal will be determined during remedial activities. Since these soils may also contain hazardous constituents, they should be sampled and analyzed to identify appropriate disposal alternatives.

*C Buildings: C-1, C-2, C-3, and C-4*

It is anticipated that the C Buildings will need to be demolished to allow access to the soils beneath the basement floor that contain elevated levels of radioactivity. If demolition is the preferred remedial action, it is anticipated that the majority of the construction rubble can be disposed as nonradioactive rubble or left onsite as backfill.

The soils beneath the C Buildings that contain elevated levels of U-238 will be removed and appropriately disposed. In addition, some remediation of soils around the southern and southwestern end of the building along the seawall will be necessary. As described above, the extent of removal will be determined during remedial activities.

*Building F*

It is anticipated that no remedial action will be necessary around or within Building F.

*Alfa Building*

The surface of one pump in the Alfa Building will require either decontamination or removal and appropriate disposal.

Remediation of surface soils containing U-238 greater than 50 pCi/g south of the Alfa Building will be necessary.

*Other Area*

The area of impacted soil identified east of Building D is anticipated to require remediation. As described above, the extent of removal will be determined during remedial activities.

## 8.2 STAKEHOLDER DECISIONS

After defining remedial conditions, the stakeholders must come to a consensus on actual site problems and how to proceed with remedial actions. The remedy selection process begins after the adequacy of the probable conditions of the site is defined. Deviations from probable conditions represent uncertainty that must be addressed during the Remedial Design/Remedial Action (RD/RA). Decision rules summarize how uncertainty will be reduced by the data management system. Data collection to reduce uncertainty must always be balanced against the ability to manage uncertainty (via the contingency plan) during the RD/RA.

Contingency plans are the mechanism for managing uncertainty during the remedial action. Contingency plans are technology-specific and based on the definition of reasonable deviations. They are defined in detail during the RD/RA. Monitoring plans are part of the ability to manage uncertainty during the RD/RA by detecting deviations. Monitoring plans identify the deviation that is occurring and define which contingency plan is necessary to modify the remedy. Once these situations and plans are agreed upon by the stakeholders, the remedial action phase can proceed.

## 8.3 MONITORING DECISION RULES

Monitoring decision rules are developed by using the results of the characterization and applying these results to the characterization decision rules presented in the characterization plan. These monitoring decision rules will be used during remedial action to finalize the extent of material requiring remediation. Monitoring plans may require modification following implementation of a contingency plan.

*General*

- If radioactively impacted structural or equipment surfaces are decontaminated instead of removed and disposed of, then samples will be collected to confirm the success of the decontamination effort.

- If decontaminated structural or equipment surfaces meet DOE guidelines for fixed and removable radiological contamination, then no further decontamination is necessary. If DOE guidelines are exceeded after decontamination, then consideration must be given to alternate remedial options (e.g., removal and disposal). Economic factors will also be evaluated throughout the process.

- If analytical results of confirmatory samples indicate radionuclide concentrations exceeding DOE guidelines, then excavation and monitoring will continue until activity levels are at or below DOE guidelines. If confirmatory samples indicate radionuclide concentrations are below DOE guidelines, and the full extent of impacted material has been determined, then no further remediation will be necessary.

*Buildings A and A-1*

- If soils underlying ash piles (in the basement of Building A, underlying the floor of Building A-1, and adjacent to the northwest side of Building A) exhibit radiation levels at or below DOE guidelines, then excavation will stop and confirmatory soil samples will be collected and analyzed for constituents of concerns (COCs).

- If soils in and beneath the ash piles in the basement of Building A and underlying the floor of Building A-1 exhibit analytical results that indicate they are hazardous as well as impacted with MED-related radionuclides above guidelines, then they will be treated as mixed waste.

- If soils to be excavated from along the west side of Building A north of the loading area are analyzed and contain PCB concentrations above 50 parts per million (ppm) as well as MED-related radioisotopes above guidelines, they will be appropriately disposed.

*Buildings B-1, B-2, and B-3*

- If soils underlying the basement of Building B exhibit MED-related radionuclide concentrations below DOE guidelines, then excavation will stop and confirmatory soil samples will be collected and analyzed.

*Building C*

- If fill or soils around or beneath the building exhibit MED-related radionuclide concentrations above DOE guidelines, then the material will be selectively removed and sent for appropriate disposal.

*Building F*

- Building F and the soils around it show no MED-related impacted materials above DOE guidelines; therefore, no remedial action is necessary.

*Alfa Building*

- If soils south of the building exhibit MED-related radionuclide concentrations below DOE guidelines, then excavation will stop and confirmatory soil samples will be collected and analyzed.

- If fill or soils east of the building exhibit MED-related radionuclide concentrations above DOE guidelines, then the material will be selectively removed and sent for appropriate disposal.

*Sediments*

- If sediments in the tidal flats offshore from Buildings C, B, and F exhibit MED-related radionuclide concentrations below DOE guidelines, then removal will stop and confirmatory sediment samples will be collected and analyzed for radioactive COCs.

## 8.4 REMEDIATION DECISION RULES

The following remediation rules have been developed based on current knowledge of the Ventron site.

*General*

- If contaminated MED-related structures are removed for disposal, materials will be staged onsite as low-level radioactive waste or commingled waste for subsequent disposal at a licensed facility.

- If clean construction debris is removed by DOE, the debris will be staged onsite for subsequent disposal at an appropriate landfill.

- Contaminated MED-related soils or fill will be staged appropriately onsite. If analytical results show the material to meet the acceptance criteria for low-level waste, then it will be shipped to the selected licensed facility for disposal. If determined to be present during remedial action, mixed waste will be segregated and managed until it can be appropriately disposed.

THIS PAGE INTENTIONALLY LEFT BLANK.

# 9. REFERENCES


40 *CFR* 192 (b)1. "Uranium Mill Tailings Remediation Control Act."

ANL (Argonne National Laboratory) 1992. *Derivation of Uranium Residual Radioactive Material Guidelines for the Ventron Site*, for DOE Field Office, Former Sites Restoration Division, Oak Ridge, Tennessee, March.

BNI (Bechtel National, Inc.) 1988. *Site Plan for Ventron Division of Morton Thiokol, Inc.*, Beverly, Massachusetts, DOE/OR/20722-117, Revision 1, Oak Ridge, Tennessee, July.

BNI 1993. *Ventron Characterization Technical Bulletin*, TB-127-93-001, CCN 105283, June 17.

Cottrell, W.D. and R.F. Carrier 1988. *Results of the Radiological Survey at the Ventron Site*, Beverly, Massachusetts, Oak Ridge National Laboratory, Oak Ridge, Tennessee, May.

Dailey, R.C., D. Smith, and D. Lillian 1992. *Streamlined Approach for Environmental Restoration (SAFER): An Overview*, 1992 Waste Management and Environmental Sciences Conference, San Juan, Puerto Rico, (In Press).

DOE (U.S. Department of Energy) 1986a. Letter from E.L. Keller to J.F. Nemic (Bechtel National, Inc.) concerning Designation of Four (4) Additional Sites for Remedial Action Under FUSRAP, CCN E-02144, Oak Ridge, Tennessee, January 7.

DOE 1986b. *FUSRAP Management Requirements and Policies Manual*, Appendix D-1, FUSRAP Summary Protocol, March 26.

DOE 1990. DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, Washington, D.C., February.

DOE 1992. *Ventron Characterization Plan*, DOE/OR/21950-123, Final, August.

DOE 1993a. Letter from J. Kopotic, DOE-FSRD, Oak Ridge, TN (Ventron site - Response to Inquiry Regarding Property at 3 Agate Street) to P. Rallo, Ralph Leonard Associates, Inc., Beverly, Massachusetts, December 3.

DOE 1993b. Letter from J. Kopotic, DOE-FSRD, Oak Ridge, TN (Ventron - Response for Results for RAD Analyses) to A. Raddatz, Morton International, Danvers, Massachusetts, CCN 111392, December 8.

DOE 1994. Letter from J. Kopotic, DOE-FSRD, Oak Ridge, TN (Ventron - Transmittal of Radiological Data from Beverly Harbor) to S. Green, Massachusetts Department of Environmental Protection, Woburn, Massachusetts, CCN 120267, September 8.

EPA (U.S. Environmental Protection Agency) 1986. *Test Methods for Evaluating Solid Waste, SW-846, Volumes IA, IB, IC*, 3rd Edition, Washington, D.C., November.

EPA 1987. *A Compendium of Superfund Field Operations Methods: Volumes 1 and 2*, EPA/540/P-87/00/b, Washington, D.C., August.

EPA 1989. *RI/FS Streamlining*, OSWER Directive No. 9355.3-06, Washington, D.C.

Massachusetts Contingency Plan 1993, as amended November 19.

Morton International Inc., 1992. *Phase I, Limited Site Investigation Report, Volume I, Beverly, Massachusetts*. DEP Case No. 3-2887. Prepared by CH2M Hill, Boston, Massachusetts, December.

Neptune, D., E.P. Brantly, M. Messner, D.I. Michael 1990. "Quantitative Decision Making In Superfund: A Data Quality Objectives Case Study," Hazardous Materials Control, May/June.

ORNL (Oak Ridge National Laboratory) 1991. *Radiological Survey Results at Beverly Harbor, Beverly, Massachusetts, (VB025)*, Oak Ridge National Laboratory, RASA-91/29.

ORNL 1992a. *Radiological Survey Results at 9 and 11 Congress Street, Beverly, Massachusetts, (VB002)*, CCN 0097264, ORNL/RASA-91/13, Oak Ridge, Tennessee, May.

ORNL 1992b. *Radiological Survey Results at 2 Cliff Street, Beverly, Massachusetts (VB007)*, CCN 0097280, ORNL/RASA-91/23, Oak Ridge, Tennessee, August.

ORNL 1992c. *Radiological Survey Results at 5 Cliff Street, Beverly, Massachusetts (VB018)*, CCN 097270, ORNL/RASA-91-17, Oak Ridge, Tennessee, August.

ORNL 1992d. *Radiological Survey Results at 6 Cliff Street, Beverly, Massachusetts (VB008)*, CCN 0097274, ORNL/RASA-92/2, Oak Ridge, Tennessee, August.

ORNL 1992e. *Radiological Survey Results at 8 Cliff Street, Beverly, Massachusetts (VB009)*, CCN 0097279, ORNL/RASA-92/3, Oak Ridge, Tennessee, August.

ORNL 1992f. *Radiological Survey Results at 9 Cliff Street, Beverly, Massachusetts (VB017)*, CCN 0097271, ORNL/RASA-91/18, Oak Ridge, Tennessee, July.

ORNL 1992g. *Radiological Survey Results at 10 Cliff Street, Beverly, Massachusetts (VB021)*, CCN 0097268, ORNL/RASA-91/14, Oak Ridge, Tennessee, July.

ORNL 1992h. *Radiological Survey Results at 12 Cliff Street, Beverly, Massachusetts (VB010)*, CCN 0097278, ORNL/RASA-91/24, Oak Ridge, Tennessee, August.

ORNL 1992i. *Radiological Survey Results at 13 Cliff Street, Beverly, Massachusetts (VB015)*, CCN 0097272, ORNL/RASA-91/19, Oak Ridge, Tennessee, July.

ORNL 1992j. *Radiological Survey Results at 14 Cliff Street, Beverly, Massachusetts (VB011)*, CCN 009727, ORNL/RASA-91/25, Oak Ridge, Tennessee, August.

ORNL 1992k. *Radiological Survey Results at 15 Cliff Street, Beverly, Massachusetts (VB014)*, CCN 0097273, ORNL/RASA-91/28, Oak Ridge, Tennessee, August.

ORNL 1992*l*. *Radiological Survey Results at 18 Cliff Street, Beverly, Massachusetts (VB012)*, CCN 0097277, ORNL/RASA-91/26, Oak Ridge, Tennessee, August.

ORNL 1992m. *Radiological Survey Results at 20 Cliff Street, Beverly, Massachusetts (VB013)*, CCN 0097275, ORNL/RASA-91/27, Oak Ridge, Tennessee, August.

ORNL 1992n. *Radiological Survey Results at 30 Cliff Street, Beverly, Massachusetts (VB022)*, CCN 094977, ORNL/RASA-91/11, Oak Ridge, Tennessee, July.

ORNL 1992o. *Radiological Survey Results at 2 Porter Street, Beverly, Massachusetts (VB005)*, CCN 0097281, ORNL/RASA-91/22, Oak Ridge, Tennessee, August.

ORNL 1992p. *Radiological Survey Results at 5 Porter Street, Beverly, Massachusetts (VB019)*, CCN 0097269, ORNL/RASA-91/16, Oak Ridge, Tennessee, July.

ORNL 1992q. *Radiological Survey Results at Porter Street City Park, Beverly, Massachusetts (VB026)*, CCN 0097282, ORNL/RASA-91/12, Oak Ridge, Tennessee, August.

ORNL 1992r. *Radiological Survey Results at 19 Wellman Street, Beverly, Massachusetts (VB024)*, CCN 0097265, ORNL/RASA-91/10, Oak Ridge, Tennessee, August.

ORNL 1992s. *Radiological Survey Results at 34 School Street, Beverly, Massachusetts (VB023)*, CCN 0097266, ORNL/RASA-91/9, Oak Ridge, Tennessee, July.

Peck, R.B. 1969. "Advantages and Limitations of the Observational Method in Applied Soil Mechanics," North Rankine Lecture, Geotechnique 19, No. 2, pp. 171-187.

TMA/E (Thermal Analytical/Eberline, Inc.) 1988. *TMA/Eberline Health Physics Operational Procedures Manual for the FUSRAP and SFMP Programs*, Oak Ridge, Tennessee.

138005

# APPENDIX A

# URANIUM GUIDELINES FOR THE VENTRON SITE, BEVERLY, MASSACHUSETTS

United States Government

108174

Department of Energy

# memorandum

138005

DATE: SEP 1 1993

1993 SEP -3 PM 1:50

REPLY TO ATTN OF: EM-421 (W. A. Williams, 903-8149)

SUBJECT: Uranium Guidelines for the Ventron Site, Beverly, Massachusetts

TO: L. Price, OR

This is in response to the request for approval of uranium guidelines for the Ventron Site of the Formerly Utilized Sites Remedial Action Program (FUSRAP), pursuant to DOE Order 5400.5. This site is located in Beverly, Massachusetts, and was used by the Department of Energy's (DOE) predecessor for producing uranium metal. Oak Ridge requested approval of a residual uranium guideline of 100 picoCuries per gram of total uranium for the site. These recommendations were made based on a supporting analysis by Argonne National Laboratory (ANL) and estimates of the waste volume which would result from different uranium guidelines.

Basic Dose Requirement:

The Ventron Site is located directly on a tidal estuary of the Atlantic Ocean and is presently used for industrial research and metal production. The ANL analysis calculated a maximum residual concentration of total uranium in soil of 480 picoCuries per gram (pCi/g) to 3100 pCi/g, depending on future land use. These concentrations are equivalent to 100 millirem per year for various land uses. The recommended 100 pCi/g is equivalent to 6 millirem per year for an industrial worker (Scenario A in the ANL Report). For recreational use, the exposure is less than 4 millirem per year (Scenario B). For residential farming use, the recommended guideline is 21 millirem per year, assuming that off-site water is used for drinking water purposes (Scenario C).

In the ANL analysis, the use of an on-site well for drinking water purposes was not considered because this assumption is not plausible. The site is immediately adjacent to a tidal estuary and the water is saline. For this reason, any water from an on-site well would be saline and not potable.

Based on the ANL analysis, the recommended value of 100 pCi/g of total uranium is within DOE's dose guideline of 100 millirem per year, which must be met under all worst case, plausible scenarios, including the assumed residential and recreational use.

ALARA Analysis:

In addition to meeting the basic radiation protection guideline, any remediation guideline must be analyzed to keep exposures as low as reasonably achievable (ALARA). In the application of ALARA, practical considerations, costs, and benefits are also taken into account. For practical considerations, it is likely that the contaminated areas will be remediated to a level below whatever guideline is established. This is

likely for two reasons. First, in order to remove all material above the guideline, some soil contaminated below the guideline will be removed. This will have the practical effect of lowering the guideline as it is applied during remediation operations. Second, during remediation operations, it is difficult to precisely delineate the point at which contamination above the guideline ends. As a result, remediation personnel will remove all suspect materials to avoid repeated remediation operations on the same property. For these reasons, it is likely that remediation will be accomplished at some level lower than the approved remediation guideline.

A final practical consideration is the use of clean fill material to replace excavated materials. This will cause a shielding and covering effect on the remaining soils, reducing gamma ray, dust, and radon exposures. If the site were to be used for residential or agricultural use in the future, the clean fill would also reduce the projected doses by diluting the residual contamination. The ANL analysis does not assume that there is any clean fill or cover placed over the site after remediation. For this reason, the doses calculated in the ANL report are clearly a worst case scenario. In the actual application of a remediation guideline, it is very likely that a remediation level substantially below the established guideline will be achieved.

A further ALARA consideration is that of costs and benefits. A review of the contaminated soil volume as a function of the remediation guideline indicates an increasing volume of contaminated soil as the guideline becomes smaller.

Between the remediation guidelines of 460 and 200 pCi/g of total uranium, the volume of contaminated soil increases by 1,700 cubic yards. For the current industrial use of the site, this increase in waste volume and cost is equivalent to a reduction in the calculated dose from 26 millirem per year to 11. A reduction from 200 to the recommended 100 pCi/g decreases the dose for the current industrial use from 11 millirem per year to less than 6. This same reduction increases waste volume by another 1,080 cubic yards. Reducing the guideline to 70 pCi/g will reduce the dose for industrial use to less than 4 millirem per year and increase waste volume by 1,550 cubic yards. Further reductions to 40 and 20 pCi/g increase waste volume by an additional 4,100 and 3,000 cubic yards, respectively.

If the costs of excavating, packaging, transporting, and disposing the soil are estimated to be more than $500 per cubic yard, the reduction in the guideline from the recommended 100 pCi/g to 70 pCi/g would cost more than $540,000 with little benefit. Further reductions to 40 and 20 pCi/g will increase costs further with even less benefit.

The possible residential and agricultural use of the site in the future must be also considered. Scenario C examines this possible use and assumes a resident farmer will:

(1) reside at the site after remediation;
(2) drink water from an uncontaminated, off-site source;

(3) eat plant foods grown in the decontaminated area;
(4) drink milk and eat meat from cattle grown on the site; and
(5) ingest 100 milligrams of soil at the site.

These assumptions are very unlikely but may be plausible in the distant future. The recommended guideline of 100 pCi/g is equivalent to an annual exposure of 36 millirem per year under these assumptions. A review of the ANL report indicates that the significant pathway for this scenario is via inhalation of contaminated dust. The mass loading factor used for airborne dust in the calculations (200 micrograms per cubic meter) is much higher than would be expected at the site under ambient conditions and reflects the level of dust loading expected from plowing or digging in the soil. Such a high dust load is unlikely on a continual basis.

Summary and Approval:

Based on the above considerations, a guideline of 100 pCi/g for total uranium above background levels is approved for use in the remediation of the Ventron Site, pursuant to DOE Order 5400.5, Chapter IV, Section 5a. Please provide ANL with post-remedial action data to permit the preparation of another dose estimate report to reflect the actual doses after completion of the remediation.

We also recommend that your staff discuss the site characterization data and the approved guidelines with the State and EPA staff at an appropriate time.

James W. Wagoner II
Director
Division of Off-Site Programs
Office of Eastern Area Programs
Office of Environmental Restoration

cc:
T. Perry, OR
C. Yu, ANL
J. Berger, ORISE

# APPENDIX B

# APPENDIX B-1

# BACKGROUND SOIL SAMPLES

## Ventron Site Characterization Background
## Soil Samples

138005

| Background | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 127CVA0101 | | | 127CVB0101 | | | 127CVC0101 | | | 127RVC0102 | | | 127RVC0103 | | |
| | | Collected: 09/30/92 | | | Collected: 09/30/92 | | | Collected: 10/01/92 | | | Collected: 10/01/92 | | | Collected: 10/01/92 | | |
| | | 0.0- 0.0 | | | 0.0- 0.0 | | | 0.0- 0.1 FT | | | 3.0- 4.0 FT | | | 0.0-10.0 FT | | |
| | | Station: A01 | | | Station: B01 | | | Station: C01 | | | Station: C01 | | | Station: C01 | | |
| | | Result | Lab* | Val* | Result | Lab* | Val* | Result | Lab* | Val* | Result | Lab | Val | Result | Lab | Val |
| | | | | | | | | | | | | | | | | |
| Inorganics | UNITS | | | | | | | | | | | | | | | |
| Aluminum | MG/KG | 8710 | = | | 14400 | = | | 5760 | = | | | | | | | |
| Antimony | MG/KG | 14.2 | U | | 14 | U | | 13.4 | U | | | | | | | |
| Arsenic | MG/KG | 10 | = | | 14.5 | = | | 5.2 | = | | | | | | | |
| Barium | MG/KG | 47.4 | U | | 54.9 | = | | 44.7 | U | | | | | | | |
| Beryllium | MG/KG | 1.2 | U | | 1.2 | = | | 1.1 | U | | | | | | | |
| Boron | MG/KG | 23.7 | U | | 23.4 | U | | 22.4 | U | | | | | | | |
| Cadmium | MG/KG | 1.2 | U | | 1.2 | U | | 1.1 | U | | | | | | | |
| Calcium | MG/KG | 1180 | U | | 2440 | = | | 2050 | = | | | | | | | |
| Chromium | MG/KG | 11.9 | = | | 30 | = | | 10.9 | = | | | | | | | |
| Cobalt | MG/KG | 11.8 | U | | 11.7 | U | | 11.2 | U | | | | | | | |
| Copper | MG/KG | 22.3 | = | | 25.3 | = | | 12 | = | | | | | | | |
| Iron | MG/KG | 13400 | = | | 13700 | = | | 9580 | = | | | | | | | |
| Lead | MG/KG | 128 | = | | 28.7 | = | | 14.1 | = | | | | | | | |
| Magnesium | MG/KG | 1430 | = | | 3190 | = | | 1730 | = | | | | | | | |
| Manganese | MG/KG | 258 | = | | 251 | = | | 143 | = | J | | | | | | |
| Molybdenum | MG/KG | 23.7 | U | | 23.4 | U | | 22.4 | U | | | | | | | |
| Nickel | MG/KG | 9.5 | U | | 21.4 | = | | 8.9 | U | | | | | | | |
| Potassium | MG/KG | 1180 | U | | 1170 | U | | 1120 | U | | | | | | | |
| Selenium | MG/KG | 1.2 | U | | 1.2 | U | | 1.2 | U | | | | | | | |
| Silver | MG/KG | 5 | = | | 3.5 | = | | 2.5 | = | | | | | | | |
| Sodium | MG/KG | 1180 | U | | 1170 | U | | 1120 | U | | | | | | | |
| Thallium | MG/KG | 2.4 | U | | 2.3 | U | | 2.4 | U | UJ | | | | | | |
| Vanadium | MG/KG | 16.8 | = | | 81.3 | = | | 13.5 | = | | | | | | | |
| Zinc | MG/KG | 71.3 | = | | 58.4 | = | | 38 | = | | | | | | | |
| | | | | | | | | | | | | | | | | |
| Organic Petroleum Hydrocarbons | UNITS | | | | | | | | | | | | | | | |
| Total Petroleum Hydrocarbons | MG/KG | 110 | = | | 110 | = | | 5.9 | = | | | | | | | |
| | | | | | | | | | | | | | | | | |
| Pesticides and PCBs | UNITS | | | | | | | | | | | | | | | |
| Aldrin | UG/KG | 47 | U | | 9.4 | U | | 9.6 | U | | | | | | | |
| alpha-BHC | UG/KG | 47 | U | | 9.4 | U | | 9.6 | U | | | | | | | |
| alpha-Chlordane | UG/KG | 470 | U | | 94 | U | | 96 | U | | | | | | | |
| Aroclor-1016 | UG/KG | 470 | U | | 94 | U | | 96 | U | | | | | | | |
| Aroclor-1221 | UG/KG | 470 | U | | 94 | U | | 96 | U | | | | | | | |
| Aroclor-1232 | UG/KG | 470 | U | | 94 | U | | 96 | U | | | | | | | |
| Aroclor-1242 | UG/KG | 470 | U | | 94 | U | | 96 | U | | | | | | | |
| Aroclor-1248 | UG/KG | 470 | U | | 94 | U | | 96 | U | | | | | | | |
| Aroclor-1254 | UG/KG | 950 | U | | 190 | U | | 190 | U | | | | | | | |
| Aroclor-1260 | UG/KG | 950 | U | | 190 | U | | 190 | U | | | | | | | |
| beta-BHC | UG/KG | 47 | U | | 9.4 | U | | 9.6 | U | | | | | | | |
| 4,4'-DDD | UG/KG | 95 | U | | 5.5 | J | | 19 | U | | | | | | | |
| 4,4'-DDE | UG/KG | 95 | U | | 17 | J | | 19 | U | | | | | | | |
| 4,4'-DDT | UG/KG | 95 | U | | 19 | U | | 19 | U | | | | | | | |
| delta-BHC | UG/KG | 47 | U | | 9.4 | U | | 9.6 | U | | | | | | | |
| Dieldrin | UG/KG | 95 | U | | 19 | U | | 19 | U | | | | | | | |
| Endosulfan I | UG/KG | 47 | U | | 9.4 | U | | 9.6 | U | | | | | | | |
| Endosulfan II | UG/KG | 95 | U | | 19 | U | | 19 | U | | | | | | | |
| Endosulfan Sulfate | UG/KG | 95 | U | | 19 | U | | 19 | U | | | | | | | |
| Endrin | UG/KG | 95 | U | | 19 | U | | 19 | U | | | | | | | |
| Endrin Aldehyde | UG/KG | 95 | U | | 19 | U | | 19 | U | | | | | | | |
| Endrin Ketone | UG/KG | 95 | U | | 19 | U | | 19 | U | | | | | | | |
| gamma-BHC (Lindane) | UG/KG | 47 | U | | 9.4 | U | | 9.6 | U | | | | | | | |

## Ventron Site Characterization Background
## Soil Samples

138005

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| gamma-Chlordane | UG/KG | 470 | U | | 94 | U | | 96 | U | | | | | | | |
| Heptachlor | UG/KG | 47 | U | | 9.4 | U | | 9.6 | U | | | | | | | |
| Heptachlor Epoxide | UG/KG | 47 | U | | 9.4 | U | | 9.6 | U | | | | | | | |
| p,p'-Methoxychlor | UG/KG | 470 | U | | 94 | U | | 96 | U | | | | | | | |
| Toxaphene | UG/KG | 950 | U | | 190 | U | | 190 | U | | | | | | | |
| | | | | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | | | | |
| Ra-226 | PCI/G | 0.960+/- | 0.2 | | 0.76 | | J | 0.85 | | J | 1.400+/- | 0.44 | | 1.600+/- | 0.36 | |
| Th-230 | PCI/G | 0.680+/- | 0.5 | | 1.600+/- | 0.7 | | 0.740+/- | 0.54 | | 1.300+/- | 0.66 | | 1.000+/- | 0.6 | |
| Thorium | PCI/G | 1.200+/- | 0.54 | | 1.100+/- | 0.25 | | 0.96 | | J | 1.900+/- | 0.41 | | 1.500+/- | 0.29 | |
| U-238 | PCI/G | 10.5 | | J | 5.1 | | J | 6 | | J | 9.1 | | J | 8.7 | | J |
| | | | | | | | | | | | | | | | | |
| * Note: LAB is the laboratory data qualifier, VAL is the data validation qualifer. | | | | | | | | | | | | | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

= indicates that no data qualifier is required; the results are considered reliable.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

# APPENDIX B-2

# SURFACE WATER SAMPLES

# Ventron Site Characterization
## Surface Water Samples

| VENTRON | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 127RV00151 | | | 127RV00251 | | | 127RV00351 | | | 127RV00451 | | | 127RV00452 | | |
| | | Collected: 10/12/92 | | | Collected: 10/12/92 | | | Collected: 10/13/92 | | | Collected: 10/13/92 | | | Collected: 10/13/92 | | |
| | | 0.0- 1.0 FT | | | 0.0- 1.0 FT | | | 0.0- 1.0 FT | | | 0.0- 1.0 FT | | | 0.0- 1.0 FT | | |
| | | Station: 001 | | | Station: 002 | | | Station: 003 | | | Station: 004 | | | Station: 004 | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val |
| **Radiological** | **UNITS** | | | | | | | | | | | | | | | |
| Ra-226 | PCI/L | 0.750+/- | 0.49 | | 0.210+/- | 0.18 | UJ | 0.470+/- | 0.3 | | 0.280+/- | 0.21 | | 0.130+/- | 0.16 | UJ |
| Th-230 | PCI/L | 0.100+/- | 0.2 | UJ | 0.300+/- | 0.3 | | 0.000+/- | 0.3 | UJ | | | | | | |
| Thorium | PCI/L | 0 | | J | 0.200+/- | 0.3 | J | 0.200+/- | 0.4 | J | -0.100+/- | 0.2 | J | -0.100+/- | 0.2 | J |
| U-238 | PCI/L | 1.400+/- | 0.7 | | 1.300+/- | 0.6 | | 1.000+/- | 0.53 | J | 1.100+/- | 0.51 | J | 0.710+/- | 0.39 | J |
| **Dissolved Radiological** | **UNITS** | | | | | | | | | | | | | | | |
| Ra-226 | PCI/L | 0.420+/- | 0.38 | UJ | 0.150+/- | 0.16 | UJ | 0.260+/- | 0.34 | UJ | 0.130+/- | 0.17 | UJ | 0.180+/- | 0.19 | UJ |
| Th-230 | PCI/L | 0 | | UJ | 0 | | UJ | 0.300+/- | 0.4 | UJ | | | | | | |
| Thorium | PCI/L | 0 | | J | 0.100+/- | 0.2 | J | 0.000+/- | 0.3 | J | 0.000+/- | 0.3 | J | 0.200+/- | 0.4 | J |
| U-238 | PCI/L | 1.100+/- | 0.77 | | 1.100+/- | 0.5 | | 0.990+/- | 0.67 | J | 0.910+/- | 0.45 | J | 1.400+/- | 0.69 | J |

| VENTRON | | | | |
|---|---|---|---|---|
| | | 127RV00551 | | |
| | | Collected: 10/13/92 | | |
| | | 0.0- 1.0 FT | | |
| | | Station: 005 | | |
| | | Result | Lab | Val |
| **Radiological** | **UNITS** | | | |
| Ra-226 | PCI/L | 10.600+/- | 1.5 | |
| Th-230 | PCI/L | | | |
| Thorium | PCI/L | 0.000+/- | 0.3 | J |
| U-238 | PCI/L | 1.400+/- | 0.66 | J |
| **Dissolved Radiological** | **UNITS** | | | |
| Ra-226 | PCI/L | 0.410+/- | 0.26 | |
| Th-230 | PCI/L | | | |
| Thorium | PCI/L | -0.100+/- | 0.2 | J |
| U-238 | PCI/L | 1.600+/- | 0.72 | J |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

138005

# APPENDIX B-3

# SURFACE SOIL SAMPLES

138005

## Ventron Site Characterization
## Soil Samples

| VENTRON | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 127RV03101 | | | 127RV03201 | | | 127RV03301 | | | 127RV03401 | | | 127RV03501 | | |
| | | Collected: 09/22/92 | | | Collected: 09/22/92 | | | Collected: 09/22/92 | | | Collected: 09/22/92 | | | Collected: 10/14/92 | | |
| | | 0.0- 0.5 FT | | | 0.0- 0.5 FT | | | 0.0- 0.5 FT | | | 0.0- 0.5 FT | | | 0.0- 0.5 FT | | |
| | | Station: 031 | | | Station: 032 | | | Station: 033 | | | Station: 034 | | | Station: 035 | | |
| | | Result | Lab* | Val* | Result | Lab* | Val* | Result | Lab* | Val* | Result | Lab* | Val* | Result | Lab* | Val* |
| | | | | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | | | | |
| Ra-226 | PCI/G | 1.8 | | J | 1.800+/- | 0.08 | | 1.9 | | J | 1.1 | | J | 1.300+/- | 0.3 | |
| Thorium | PCI/G | 107.000+/- | 4.6 | | 399.000+/- | 11.7 | | 84.900+/- | 8.2 | | 22.000+/- | 0.8 | | 22.700+/- | 1.5 | |
| U-238 | PCI/G | 70.300+/- | 36.7 | | 412.000+/- | 194 | | 54.800+/- | 25 | | 11 | | J | 11.200+/- | 3.1 | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| * Note: LAB is the laboratory data qualifier, VAL is the data validation qualifer. | | | | | | | | | | | | | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

# APPENDIX B-4

# SOIL BORING SAMPLES

138005

**Ventron Site Characterization**
**Borehole Summary**

| VENTRON - SOIL BORING - 02 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/11/92 | | | | | | | | | | | | | |
| | | 127RV00201 | | | 127RV00202 | | | 127RV00203 | | | | | |
| | | | | | | | | | | | | | |
| | | 0.0- 1.0 FT | | | 2.0- 3.0 FT | | | 22.0-23.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 1.200+/- | 0.25 | | 0.920+/- | 0.11 | | 1.200+/- | 0.19 | | | | |
| Th-230 | PCI/G | | | | 1.800+/- | 0.63 | | | | | | | |
| Thorium | PCI/G | 2.000+/- | 0.52 | | 1.000+/- | 0.03 | | 1.700+/- | 0.1 | | | | |
| U-238 | PCI/G | 5.500+/- | 0.98 | | 11.500+/- | 0.75 | | 3.7 | | J | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

**Ventron Site Characterizatio**
**Borehole Summary**

| VENTRON - SOIL BORING - 03 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/08/92 | | | | | | | | | | | | | |
| | | 127RV00301 | | | 127RV00302 | | | 127RV00303 | | | | | |
| | | | | | | | | | | | | | |
| | | 0.0- 1.0 FT | | | 4.0- 5.0 FT | | | 12.0-13.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 0.820+/- | 0.05 | | 1.500+/- | 0.13 | | 0.790+/- | 0.07 | | | | |
| Th-230 | PCI/G | 1.600+/- | 0.6 | | | | | | | | | | |
| Thorium | PCI/G | 0.890+/- | 0.14 | | 1.500+/- | 0.39 | | 0.940+/- | 0.25 | | | | |
| U-238 | PCI/G | 14.300+/- | 0.13 | | 41.400+/- | 4.2 | | 2.200+/- | 1.6 | UJ | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

**Ventron Site Characterization**
**Borehole Summary**

138005

| VENTRON - SOIL BORING - 04 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/08/92 | | | | | | | | | | | | | |
| | | 127RV00401 | | | 127RV00402 | | | 127RV00403 | | | | | |
| | | | | | | | | | | | | | |
| | | 0.0- 1.0 FT | | | 2.0- 3.0 FT | | | 11.0-12.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 0.670+/- | 0.19 | | 0.820+/- | 0.19 | | 0.720+/- | 0.23 | | | | |
| Th-230 | PCI/G | | | | 1.600+/- | 0.62 | | | | | | | |
| Thorium | PCI/G | 1.300+/- | 0.27 | | 0.910+/- | 0.17 | | 0.740+/- | 0.43 | | | | |
| U-238 | PCI/G | 3.200+/- | 1.1 | | 10.900+/- | 2.3 | | 4.700+/- | 1.4 | | | | |

138005

| VENTRON - SOIL BORING - 05 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/14/92 | | | | | | | | | | | | | |
| | | 127RV00501 | | | 127RV00502 | | | 127RV00503 | | | | | |
| | | | | | | | | | | | | | |
| | | 0.0- 1.0 FT | | | 7.0- 8.0 FT | | | 12.0-13.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 2.100+/- | 0.58 | | 1.100+/- | 0.06 | | 1.000+/- | 0.03 | | | | |
| Th-230 | PCI/G | | | | 1.500+/- | 0.64 | | 2.500+/- | 0.79 | | | | |
| Thorium | PCI/G | 16.700+/- | 1 | | 1.300+/- | 0.16 | | 1.600+/- | 0.37 | | | | |
| U-238 | PCI/G | 26.200+/- | 0.9 | | 27.700+/- | 1.1 | | 27.200+/- | 0.97 | | | | |

# Ventron Site Characterization
## Borehole Summary

| VENTRON - SOIL BORING - 06 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Collected: 09/10/92 | | | | | | | |
| | | 127CV00601 | | | 127RV00603 | | |
| | | 0.0- 1.0 FT | | | 4.0- 5.0 FT | | |
| | | Result | Lab | Val | Result | Lab | Val |
| **Inorganics** | UNITS | | | | | | |
| Aluminum | MG/KG | 7800 | = | | | | |
| Antimony | MG/KG | 13.7 | U | UJ | | | |
| Arsenic | MG/KG | 6 | = | | | | |
| Barium | MG/KG | 46.5 | = | J | | | |
| Beryllium | MG/KG | 1.1 | U | UJ | | | |
| Boron | MG/KG | 22.8 | U | | | | |
| Cadmium | MG/KG | 1.1 | U | UJ | | | |
| Calcium | MG/KG | 2910 | = | J | | | |
| Chromium | MG/KG | 26.2 | = | J | | | |
| Cobalt | MG/KG | 11.4 | U | UJ | | | |
| Copper | MG/KG | 17.6 | = | J | | | |
| Iron | MG/KG | 13500 | = | | | | |
| Lead | MG/KG | 99.2 | = | | | | |
| Magnesium | MG/KG | 2270 | = | | | | |
| Manganese | MG/KG | 208 | = | J | | | |
| Molybdenum | MG/KG | 22.8 | U | UJ | | | |
| Nickel | MG/KG | 91.6 | = | J | | | |
| Potassium | MG/KG | 1140 | U | | | | |
| Selenium | MG/KG | 1.1 | U | UJ | | | |
| Silver | MG/KG | 2 | = | J | | | |
| Sodium | MG/KG | 1140 | U | | | | |
| Thallium | MG/KG | 2.3 | U | | | | |
| Vanadium | MG/KG | 17.4 | = | J | | | |
| Zinc | MG/KG | 120 | = | J | | | |
| | | | | | | | |
| **Pesticides and PCBs** | UNITS | | | | | | |
| Aldrin | UG/KG | 9.1 | U | | | | |
| alpha-BHC | UG/KG | 9.1 | U | | | | |
| alpha-Chlordane | UG/KG | 91 | U | | | | |
| Aroclor-1016 | UG/KG | 91 | U | | | | |
| Aroclor-1221 | UG/KG | 91 | U | | | | |
| Aroclor-1232 | UG/KG | 91 | U | | | | |
| Aroclor-1242 | UG/KG | 91 | U | | | | |
| Aroclor-1248 | UG/KG | 91 | U | | | | |
| Aroclor-1254 | UG/KG | 210 | = | | | | |
| Aroclor-1260 | UG/KG | 180 | U | | | | |
| beta-BHC | UG/KG | 9.1 | U | | | | |
| 4,4'-DDD | UG/KG | 18 | U | | | | |
| 4,4'-DDE | UG/KG | 18 | U | | | | |
| 4,4'-DDT | UG/KG | 18 | U | | | | |
| delta-BHC | UG/KG | 9.1 | U | | | | |
| Dieldrin | UG/KG | 18 | U | | | | |
| Endosulfan I | UG/KG | 9.1 | U | | | | |
| Endosulfan II | UG/KG | 18 | U | | | | |
| Endosulfan Sulfate | UG/KG | 18 | U | | | | |
| Endrin | UG/KG | 18 | U | | | | |
| Endrin Aldehyde | UG/KG | 18 | U | | | | |
| Endrin Ketone | UG/KG | 18 | U | | | | |
| gamma-BHC (Lindane) | UG/KG | 9.1 | U | | | | |

| VENTRON - SOIL BORING - 06 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Collected: 09/10/92 | | | | | | | |
| | | 127CV00601 | | | 127RV00603 | | |
| | | | | | | | |
| | | 0.0- 1.0 FT | | | 4.0- 5.0 FT | | |
| | | Result | Lab | Val | Result | Lab | Val |
| gamma-Chlordane | UG/KG | 91 | U | | | | |
| Heptachlor | UG/KG | 9.1 | U | | | | |
| Heptachlor Epoxide | UG/KG | 9.1 | U | | | | |
| p,p'-Methoxychlor | UG/KG | 91 | U | | | | |
| Toxaphene | UG/KG | 180 | U | | | | |
| | | | | | | | |
| Radiological | UNITS | | | | | | |
| Ra-226 | PCI/G | 0.740+/- | 0.09 | | 0.84 | | J |
| Th-230 | PCI/G | 0.920+/- | 0.49 | | | | |
| Thorium | PCI/G | 1.400+/- | 0.44 | | 1.2 | | J |
| U-238 | PCI/G | 4.7 | | J | 7.700+/- | 0.32 | |
| | | | | | | | |
| TCLP | UNITS | | | | | | |
| Arsenic | UG/L | 100 | U | | | | |
| Barium | UG/L | 325 | = | | | | |
| Cadmium | UG/L | 5 | U | | | | |
| Chromium | UG/L | 13.2 | = | | | | |
| Lead | UG/L | 90 | U | | | | |
| Mercury | UG/L | 0.2 | U | UJ | | | |
| Selenium | UG/L | 100 | U | | | | |
| Silver | UG/L | 10 | U | UJ | | | |
| Corrosivity by pH | PH UNIT | 6.3 | = | | | | |
| Cyanide, Reactive | MG/KG | 0.25 | U | UJ | | | |
| Sulfide, Reactive | MG/KG | 0.5 | U | UJ | | | |
| | | | | | | | |
| Organic Petroleum Hydrocarbons | UNITS | | | | | | |
| Total Petroleum Hydrocarbons | MG/KG | 37 | = | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

= indicates that no data qualifier is required; the results are considered reliable.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

138005

| VENTRON - SOIL BORING - 07 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/11/92 | | | | | | | | | | | | | |
| | | 127RV00701 | | | 127RV00702 | | | 127RV00703 | | | | | |
| | | | | | | | | | | | | | |
| | | 0.0- 1.0 FT | | | 2.0- 3.0 FT | | | 10.0-11.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 0.630+/- | 0.07 | | 0.950+/- | 0.33 | | 0.66 | | J | | | |
| Th-230 | PCI/G | | | | 0.720+/- | 0.47 | | 0.980+/- | 0.56 | | | | |
| Thorium | PCI/G | 0.69 | | J | 1.600+/- | 0.41 | | 1.500+/- | 0.92 | | | | |
| U-238 | PCI/G | 3.300+/- | 0.72 | | 3.600+/- | 0.91 | UJ | 3.9 | | J | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

138005

**Ventron Site Characterization**
**Borehole Summary**

| VENTRON - SOIL BORING - 08 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/11/92 | | | | | | | | | | | | | |
| | | 127RV00801 | | | 127RV00802 | | | 127RV00803 | | | | | |
| | | | | | | | | | | | | | |
| | | 2.0- 3.0 FT | | | 8.0- 9.0 FT | | | 10.0-11.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 0.800+/- | 0.12 | | 0.55 | | J | 0.390+/- | 0.16 | | | | |
| Th-230 | PCI/G | 0.890+/- | 0.56 | | | | | | | | | | |
| Thorium | PCI/G | 1.000+/- | 0.21 | | 0.800+/- | 0.17 | | 0.690+/- | 0.13 | | | | |
| U-238 | PCI/G | 1.800+/- | 0.96 | UJ | 2.600+/- | 0.16 | | 1.400+/- | 0.13 | UJ | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

| VENTRON - SOIL BORING - 09 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/08/92 | | | | | | | | | | | | | |
| | | 127CV00901 | | | 127RV00902 | | | 127RV00903 | | | | | |
| | | 0.0- 1.0 FT | | | 8.0- 9.0 FT | | | 10.0-11.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| **Inorganics** | UNITS | | | | | | | | | | | | |
| Aluminum | MG/KG | 6110 | = | | | | | | | | | | |
| Antimony | MG/KG | 13.8 | U | UJ | | | | | | | | | |
| Arsenic | MG/KG | 6.2 | = | | | | | | | | | | |
| Barium | MG/KG | 46.2 | U | | | | | | | | | | |
| Beryllium | MG/KG | 1.2 | U | | | | | | | | | | |
| Boron | MG/KG | 26.5 | = | | | | | | | | | | |
| Cadmium | MG/KG | 1.2 | U | | | | | | | | | | |
| Calcium | MG/KG | 2360 | = | | | | | | | | | | |
| Chromium | MG/KG | 19 | = | | | | | | | | | | |
| Cobalt | MG/KG | 11.5 | U | | | | | | | | | | |
| Copper | MG/KG | 12.4 | = | | | | | | | | | | |
| Iron | MG/KG | 14900 | = | | | | | | | | | | |
| Lead | MG/KG | 42.2 | = | | | | | | | | | | |
| Magnesium | MG/KG | 2890 | = | | | | | | | | | | |
| Manganese | MG/KG | 324 | = | UJ | | | | | | | | | |
| Molybdenum | MG/KG | 23.1 | U | | | | | | | | | | |
| Nickel | MG/KG | 12.5 | = | | | | | | | | | | |
| Potassium | MG/KG | 1150 | U | | | | | | | | | | |
| Selenium | MG/KG | 1.2 | U | | | | | | | | | | |
| Silver | MG/KG | 2.3 | U | UJ | | | | | | | | | |
| Sodium | MG/KG | 1150 | U | | | | | | | | | | |
| Thallium | MG/KG | 2.3 | U | | | | | | | | | | |
| Vanadium | MG/KG | 16.4 | = | | | | | | | | | | |
| Zinc | MG/KG | 52.7 | = | | | | | | | | | | |
| | | | | | | | | | | | | | |
| **Pesticides and PCBs** | UNITS | | | | | | | | | | | | |
| Aldrin | UG/KG | 9 | U | UJ | | | | | | | | | |
| alpha-BHC | UG/KG | 9 | U | UJ | | | | | | | | | |
| alpha-Chlordane | UG/KG | 90 | U | UJ | | | | | | | | | |
| Aroclor-1016 | UG/KG | 90 | U | UJ | | | | | | | | | |
| Aroclor-1221 | UG/KG | 90 | U | UJ | | | | | | | | | |
| Aroclor-1232 | UG/KG | 90 | U | UJ | | | | | | | | | |
| Aroclor-1242 | UG/KG | 90 | U | UJ | | | | | | | | | |
| Aroclor-1248 | UG/KG | 90 | U | UJ | | | | | | | | | |
| Aroclor-1254 | UG/KG | 180 | U | UJ | | | | | | | | | |
| Aroclor-1260 | UG/KG | 180 | U | UJ | | | | | | | | | |
| beta-BHC | UG/KG | 9 | U | UJ | | | | | | | | | |
| 4,4'-DDD | UG/KG | 18 | U | UJ | | | | | | | | | |
| 4,4'-DDE | UG/KG | 18 | U | UJ | | | | | | | | | |
| 4,4'-DDT | UG/KG | 18 | U | UJ | | | | | | | | | |
| delta-BHC | UG/KG | 9 | U | UJ | | | | | | | | | |
| Dieldrin | UG/KG | 18 | U | UJ | | | | | | | | | |
| Endosulfan I | UG/KG | 9 | U | UJ | | | | | | | | | |
| Endosulfan II | UG/KG | 18 | U | UJ | | | | | | | | | |
| Endosulfan Sulfate | UG/KG | 18 | U | UJ | | | | | | | | | |
| Endrin | UG/KG | 18 | U | UJ | | | | | | | | | |
| Endrin Aldehyde | UG/KG | 18 | U | UJ | | | | | | | | | |
| Endrin Ketone | UG/KG | 18 | U | UJ | | | | | | | | | |
| gamma-BHC (Lindane) | UG/KG | 9 | U | UJ | | | | | | | | | |

| VENTRON - SOIL BORING - 09 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/08/92 | | | | | | | | | | | | | |
| | | 127CV00901 | | | 127RV00902 | | | 127RV00903 | | | | | |
| | | | | | | | | | | | | | |
| | | 0.0- 1.0 FT | | | 8.0- 9.0 FT | | | 10.0-11.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| gamma-Chlordane | UG/KG | 90 | U | UJ | | | | | | | | | |
| Heptachlor | UG/KG | 9 | U | UJ | | | | | | | | | |
| Heptachlor Epoxide | UG/KG | 9 | U | UJ | | | | | | | | | |
| p,p'-Methoxychlor | UG/KG | 90 | U | UJ | | | | | | | | | |
| Toxaphene | UG/KG | 180 | U | UJ | | | | | | | | | |
| | | | | | | | | | | | | | |
| **Radiological** | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | | | | 0.750+/- | 0.24 | | 0.51 | | J | | | |
| Th-230 | PCI/G | | | | | | | 1.200+/- | 0.53 | | | | |
| Thorium | PCI/G | | | | 1.000+/- | 0.19 | | 0.830+/- | 0.05 | | | | |
| U-238 | PCI/G | | | | 15.900+/- | 4.8 | | 33.600+/- | 0.58 | | | | |
| | | | | | | | | | | | | | |
| **TCLP** | UNITS | | | | | | | | | | | | |
| Arsenic | UG/L | 100 | U | | | | | | | | | | |
| Barium | UG/L | 217 | = | | | | | | | | | | |
| Cadmium | UG/L | 5 | U | | | | | | | | | | |
| Chromium | UG/L | 10 | U | | | | | | | | | | |
| Lead | UG/L | 90 | U | | | | | | | | | | |
| Mercury | UG/L | 0.2 | U | | | | | | | | | | |
| Selenium | UG/L | 100 | U | | | | | | | | | | |
| Silver | UG/L | 10 | U | UJ | | | | | | | | | |
| Corrosivity by pH | PH UNIT | 7.3 | = | | | | | | | | | | |
| Cyanide, Reactive | MG/KG | 0.25 | U | UJ | | | | | | | | | |
| Sulfide, Reactive | MG/KG | 0.5 | U | UJ | | | | | | | | | |
| | | | | | | | | | | | | | |
| **Organic Petroleum Hydrocarbons** | UNITS | | | | | | | | | | | | |
| Total Petroleum Hydrocarbons | MG/KG | 8 | = | | | | | | | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

= indicates that no data qualifier is required; the results are considered reliable.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

138005

| VENTRON - SOIL BORING - 10 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Collected: 09/09/92 | | | | | | | |
| | | 127CV01001 | | | 127RV01003 | | |
| | | 0.0- 1.0 FT | | | 4.0- 5.0 FT | | |
| | | Result | Lab | Val | Result | Lab | Val |
| **Inorganics** | **UNITS** | | | | | | |
| Aluminum | MG/KG | 3500 | = | | | | |
| Antimony | MG/KG | 12.7 | U | | | | |
| Arsenic | MG/KG | 7.6 | = | J | | | |
| Barium | MG/KG | 42.3 | U | UJ | | | |
| Beryllium | MG/KG | 1.1 | U | UJ | | | |
| Boron | MG/KG | 21.5 | = | J | | | |
| Cadmium | MG/KG | 1.1 | U | UJ | | | |
| Calcium | MG/KG | 2350 | = | | | | |
| Chromium | MG/KG | 20.8 | = | J | | | |
| Cobalt | MG/KG | 10.6 | U | UJ | | | |
| Copper | MG/KG | 32.7 | = | J | | | |
| Iron | MG/KG | 15700 | = | | | | |
| Lead | MG/KG | 39.4 | = | | | | |
| Magnesium | MG/KG | 1470 | = | | | | |
| Manganese | MG/KG | 338 | = | J | | | |
| Molybdenum | MG/KG | 21.2 | U | UJ | | | |
| Nickel | MG/KG | 26.2 | = | J | | | |
| Potassium | MG/KG | 1060 | U | | | | |
| Selenium | MG/KG | 1.1 | U | UJ | | | |
| Silver | MG/KG | 3.8 | = | J | | | |
| Sodium | MG/KG | 1060 | U | | | | |
| Thallium | MG/KG | 2.1 | U | | | | |
| Vanadium | MG/KG | 10.6 | U | UJ | | | |
| Zinc | MG/KG | 107 | = | J | | | |
| | | | | | | | |
| **Pesticides and PCBs** | **UNITS** | | | | | | |
| Aldrin | UG/KG | 17 | U | | | | |
| alpha-BHC | UG/KG | 17 | U | | | | |
| alpha-Chlordane | UG/KG | 170 | U | | | | |
| Aroclor-1016 | UG/KG | 170 | U | | | | |
| Aroclor-1221 | UG/KG | 170 | U | | | | |
| Aroclor-1232 | UG/KG | 170 | U | | | | |
| Aroclor-1242 | UG/KG | 170 | U | | | | |
| Aroclor-1248 | UG/KG | 170 | U | | | | |
| Aroclor-1254 | UG/KG | 340 | U | | | | |
| Aroclor-1260 | UG/KG | 340 | U | | | | |
| beta-BHC | UG/KG | 17 | U | | | | |
| 4,4'-DDD | UG/KG | 34 | U | | | | |
| 4,4'-DDE | UG/KG | 34 | U | | | | |
| 4,4'-DDT | UG/KG | 34 | U | | | | |
| delta-BHC | UG/KG | 17 | U | | | | |
| Dieldrin | UG/KG | 34 | U | | | | |
| Endosulfan I | UG/KG | 17 | U | | | | |
| Endosulfan II | UG/KG | 34 | U | | | | |
| Endosulfan Sulfate | UG/KG | 34 | U | | | | |
| Endrin | UG/KG | 34 | U | | | | |
| Endrin Aldehyde | UG/KG | 34 | U | | | | |
| Endrin Ketone | UG/KG | 34 | U | | | | |
| gamma-BHC (Lindane) | UG/KG | 17 | U | | | | |

138005

| VENTRON - SOIL BORING - 17 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/03/92 | | | | | | | | | | | | | |
| | | 127CV01701 | | | 127RV01702 | | | 127RV01703 | | | | | |
| | | | | | | | | | | | | | |
| | | 0.0- 1.0 FT | | | 2.0- 3.0 FT | | | 4.0- 5.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| | | | | | | | | | | | | | |
| Inorganics | UNITS | | | | | | | | | | | | |
| Aluminum | MG/KG | 7800 | = | | | | | | | | | | |
| Antimony | MG/KG | 14 | U | | | | | | | | | | |
| Arsenic | MG/KG | 5.1 | = | J | | | | | | | | | |
| Barium | MG/KG | 46.5 | U | | | | | | | | | | |
| Beryllium | MG/KG | 1.2 | U | | | | | | | | | | |
| Boron | MG/KG | 23.3 | U | | | | | | | | | | |
| Cadmium | MG/KG | 1.2 | U | | | | | | | | | | |
| Calcium | MG/KG | 7090 | = | | | | | | | | | | |
| Chromium | MG/KG | 30.5 | = | | | | | | | | | | |
| Cobalt | MG/KG | 11.6 | U | | | | | | | | | | |
| Copper | MG/KG | 153 | = | J | | | | | | | | | |
| Iron | MG/KG | 19000 | = | | | | | | | | | | |
| Lead | MG/KG | 69.3 | = | | | | | | | | | | |
| Magnesium | MG/KG | 3770 | = | | | | | | | | | | |
| Manganese | MG/KG | 207 | = | | | | | | | | | | |
| Molybdenum | MG/KG | 23.3 | U | | | | | | | | | | |
| Nickel | MG/KG | 126 | = | | | | | | | | | | |
| Potassium | MG/KG | 1160 | U | | | | | | | | | | |
| Selenium | MG/KG | 1.2 | U | UJ | | | | | | | | | |
| Silver | MG/KG | 2.3 | U | UJ | | | | | | | | | |
| Sodium | MG/KG | 1160 | U | | | | | | | | | | |
| Thallium | MG/KG | 2.3 | U | | | | | | | | | | |
| Vanadium | MG/KG | 29.4 | = | | | | | | | | | | |
| Zinc | MG/KG | 160 | = | J | | | | | | | | | |
| | | | | | | | | | | | | | |
| Pesticides and PCBs | UNITS | | | | | | | | | | | | |
| Aldrin | UG/KG | 460 | U | | | | | | | | | | |
| alpha-BHC | UG/KG | 460 | U | | | | | | | | | | |
| alpha-Chlordane | UG/KG | 4600 | U | | | | | | | | | | |
| Aroclor-1016 | UG/KG | 4600 | U | | | | | | | | | | |
| Aroclor-1221 | UG/KG | 4600 | U | | | | | | | | | | |
| Aroclor-1232 | UG/KG | 4600 | U | | | | | | | | | | |
| Aroclor-1242 | UG/KG | 4600 | U | | | | | | | | | | |
| Aroclor-1248 | UG/KG | 4600 | U | | | | | | | | | | |
| Aroclor-1254 | UG/KG | 9200 | U | | | | | | | | | | |
| Aroclor-1260 | UG/KG | 2300 | J | | | | | | | | | | |
| beta-BHC | UG/KG | 460 | U | | | | | | | | | | |
| 4,4'-DDD | UG/KG | 920 | U | | | | | | | | | | |
| 4,4'-DDE | UG/KG | 920 | U | | | | | | | | | | |
| 4,4'-DDT | UG/KG | 920 | U | | | | | | | | | | |
| delta-BHC | UG/KG | 460 | U | | | | | | | | | | |
| Dieldrin | UG/KG | 920 | U | | | | | | | | | | |
| Endosulfan I | UG/KG | 460 | U | | | | | | | | | | |
| Endosulfan II | UG/KG | 920 | U | | | | | | | | | | |
| Endosulfan Sulfate | UG/KG | 920 | U | | | | | | | | | | |
| Endrin | UG/KG | 920 | U | | | | | | | | | | |
| Endrin Aldehyde | UG/KG | 920 | U | | | | | | | | | | |
| Endrin Ketone | UG/KG | 920 | U | | | | | | | | | | |
| gamma-BHC (Lindane) | UG/KG | 460 | U | | | | | | | | | | |

**Ventron Site Characterization**
**Borehole Summary**

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VENTRON - SOIL BORING - 18 | | | | | | | | | | | | | |
| Collected: 09/21/92 | | | | | | | | | | | | | |
| | | 127RV01801 | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | 2.0- 3.0 FT | | | | | | | | | | | |
| | | Result | Lab | Val | | | | | | | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 0.550+/- | 0.19 | | | | | | | | | | |
| Thorium | PCI/G | 0.590+/- | 0.26 | | | | | | | | | | |
| U-238 | PCI/G | 2.6 | | J | | | | | | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

= indicates that no data qualifier is required; the results are considered reliable.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

**Ventron Site Characterization**
**Borehole Summary**

| VENTRON - SOIL BORING - 19 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/21/92 | | | | | | | | | | | | | |
| | | 127RV01901 | | | 127RV01904 | | | | | | | | |
| | | | | | OT | | | | | | | | |
| | | 4.0- 5.0 FT | | | 4.0- 5.0 FT | | | | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | | | | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 0.68 | | J | 1.000+/- | 0.11 | | | | | | | |
| Thorium | PCI/G | 0.92 | | J | 0.91 | | J | | | | | | |
| U-238 | PCI/G | 4 | | J | 2.500+/- | 0.57 | | | | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

**Ventron Site Characterization**
**Borehole Summary**

| VENTRON - SOIL BORING - 20 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/03/92 | | | | | | | | | | | | | |
| | | 127RV02001 | | | 127RV02002 | | | 127RV02003 | | | | | |
| | | | | | | | | | | | | | |
| | | 0.0- 1.0 FT | | | 2.0- 3.0 FT | | | 4.0- 5.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 1.500+/- | 0.14 | | 0.460+/- | 0.13 | | 0.560+/- | 0.13 | | | | |
| Th-230 | PCI/G | 1.000+/- | 0.51 | | | | | | | | | | |
| Thorium | PCI/G | 1.800+/- | 0.05 | | 0.71 | | J | 0.630+/- | 0.15 | | | | |
| U-238 | PCI/G | 25.400+/- | 4.9 | | 5 | | J | 8.200+/- | 1.8 | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

**Ventron Site Characterization**
**Borehole Summary**

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VENTRON - SOIL BORING - 21 | | | | | | | | | | | | | |
| Collected: 09/04/92 | | | | | | | | | | | | | |
| | | 127RV02101 | | | 127RV02102 | | | | | | | | |
| | | | | | | | | | | | | | |
| | | 2.0- 3.0 FT | | | 3.0- 4.0 FT | | | | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | | | | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 1.300+/- | 0.73 | | 2.300+/- | 0.32 | | | | | | | |
| Th-230 | PCI/G | 1.400+/- | 0.58 | | 1.300+/- | 0.56 | | | | | | | |
| Thorium | PCI/G | 2.300+/- | 0.78 | | 3.300+/- | 0.22 | | | | | | | |
| U-238 | PCI/G | 8.900+/- | 1.4 | | 3.700+/- | 3.2 | | | | | | | |

**Ventron Site Characterization**
**Borehole Summary**

138005

| VENTRON - SOIL BORING - 22 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/24/92 | | | | | | | | | | | | | |
| | | 127CV02201 | | | 127RV02204 | | | 127RV02202 | | | | | |
| | | 0.0- 1.0 FT | | | 0.0- 2.0 FT | | | 2.0- 3.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| **Inorganics** | **UNITS** | | | | | | | | | | | | |
| Aluminum | MG/KG | 6290 | = | | | | | | | | | | |
| Antimony | MG/KG | 13.4 | U | UJ | | | | | | | | | |
| Arsenic | MG/KG | 7.6 | = | | | | | | | | | | |
| Barium | MG/KG | 179 | = | J | | | | | | | | | |
| Beryllium | MG/KG | 1.1 | U | | | | | | | | | | |
| Boron | MG/KG | 52.2 | = | J | | | | | | | | | |
| Cadmium | MG/KG | 1.7 | = | | | | | | | | | | |
| Calcium | MG/KG | 12000 | = | J | | | | | | | | | |
| Chromium | MG/KG | 19.2 | = | | | | | | | | | | |
| Cobalt | MG/KG | 12.9 | = | | | | | | | | | | |
| Copper | MG/KG | 351 | = | | | | | | | | | | |
| Iron | MG/KG | 34900 | = | | | | | | | | | | |
| Lead | MG/KG | 199 | = | | | | | | | | | | |
| Magnesium | MG/KG | 4410 | = | | | | | | | | | | |
| Manganese | MG/KG | 344 | = | | | | | | | | | | |
| Molybdenum | MG/KG | 22.4 | U | | | | | | | | | | |
| Nickel | MG/KG | 49 | = | | | | | | | | | | |
| Potassium | MG/KG | 1730 | = | | | | | | | | | | |
| Selenium | MG/KG | 1.1 | U | UJ | | | | | | | | | |
| Silver | MG/KG | 2.2 | U | R | | | | | | | | | |
| Sodium | MG/KG | 1120 | U | | | | | | | | | | |
| Thallium | MG/KG | 3.9 | = | | | | | | | | | | |
| Vanadium | MG/KG | 21.9 | = | | | | | | | | | | |
| Zinc | MG/KG | 1220 | = | J | | | | | | | | | |
| | | | | | | | | | | | | | |
| **Pesticides and PCBs** | **UNITS** | | | | | | | | | | | | |
| Aldrin | UG/KG | 89 | U | | | | | | | | | | |
| alpha-BHC | UG/KG | 89 | U | | | | | | | | | | |
| alpha-Chlordane | UG/KG | 890 | U | | | | | | | | | | |
| Aroclor-1016 | UG/KG | 890 | U | | | | | | | | | | |
| Aroclor-1221 | UG/KG | 890 | U | | | | | | | | | | |
| Aroclor-1232 | UG/KG | 890 | U | | | | | | | | | | |
| Aroclor-1242 | UG/KG | 890 | U | | | | | | | | | | |
| Aroclor-1248 | UG/KG | 890 | U | | | | | | | | | | |
| Aroclor-1254 | UG/KG | 1800 | U | | | | | | | | | | |
| Aroclor-1260 | UG/KG | 1800 | U | | | | | | | | | | |
| beta-BHC | UG/KG | 89 | U | | | | | | | | | | |
| 4,4'-DDD | UG/KG | 180 | U | | | | | | | | | | |
| 4,4'-DDE | UG/KG | 180 | U | | | | | | | | | | |
| 4,4'-DDT | UG/KG | 180 | U | | | | | | | | | | |
| delta-BHC | UG/KG | 89 | U | | | | | | | | | | |
| Dieldrin | UG/KG | 180 | U | | | | | | | | | | |
| Endosulfan I | UG/KG | 89 | U | | | | | | | | | | |
| Endosulfan II | UG/KG | 180 | U | | | | | | | | | | |
| Endosulfan Sulfate | UG/KG | 180 | U | | | | | | | | | | |
| Endrin | UG/KG | 180 | U | | | | | | | | | | |
| Endrin Aldehyde | UG/KG | 180 | U | | | | | | | | | | |
| Endrin Ketone | UG/KG | 180 | U | | | | | | | | | | |
| gamma-BHC (Lindane) | UG/KG | 89 | U | | | | | | | | | | |

138005

| VENTRON - SOIL BORING - 22 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/24/92 | | | | | | | | | | | | | |
| | | 127CV02201 | | | 127RV02204 | | | 127RV02202 | | | | | |
| | | | | | | | | | | | | | |
| | | 0.0- 1.0 FT | | | 0.0- 2.0 FT | | | 2.0- 3.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| gamma-Chlordane | UG/KG | 890 | U | | | | | | | | | | |
| Heptachlor | UG/KG | 89 | U | | | | | | | | | | |
| Heptachlor Epoxide | UG/KG | 89 | U | | | | | | | | | | |
| p,p'-Methoxychlor | UG/KG | 890 | U | | | | | | | | | | |
| Toxaphene | UG/KG | 1800 | U | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 1.400+/- | 0.07 | | 1.500+/- | 0.12 | | 0.980+/- | 0.22 | | | | |
| Th-230 | PCI/G | 8.500+/- | 1.3 | | 5.900+/- | 1.2 | | 2.900+/- | 0.84 | | | | |
| Thorium | PCI/G | 12.500+/- | 0.85 | | 13.500+/- | 0.8 | | 2.900+/- | 0.37 | | | | |
| U-238 | PCI/G | 69.400+/- | 11.1 | | 60.900+/- | 5.4 | | 46.800+/- | 6.4 | | | | |
| | | | | | | | | | | | | | |
| TCLP | UNITS | | | | | | | | | | | | |
| Arsenic | UG/L | 100 | U | | | | | | | | | | |
| Barium | UG/L | 1160 | = | | | | | | | | | | |
| Cadmium | UG/L | 75 | = | | | | | | | | | | |
| Chromium | UG/L | 50.6 | = | | | | | | | | | | |
| Lead | UG/L | 6360 | = | | | | | | | | | | |
| Mercury | UG/L | 0.2 | U | | | | | | | | | | |
| Selenium | UG/L | 149 | = | | | | | | | | | | |
| Silver | UG/L | 10 | U | | | | | | | | | | |
| Corrosivity by pH | PH UNIT | 8.8 | = | | | | | | | | | | |
| Cyanide, Reactive | MG/KG | 0.25 | U | UJ | | | | | | | | | |
| Sulfide, Reactive | MG/KG | 2 | U | UJ | | | | | | | | | |
| | | | | | | | | | | | | | |
| Organic Petroleum Hydrocarbons | UNITS | | | | | | | | | | | | |
| Total Petroleum Hydrocarbons | MG/KG | 370 | = | | | | | | | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

= indicates that no data qualifier is required; the results are considered reliable.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

138005

| VENTRON - SOIL BORING - 23 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/09/92 | | | | | | | | | | | | | |
| | | 127RV02301 | | | 127RV02302 | | | 127RV02303 | | | | | |
| | | | | | | | | | | | | | |
| | | 0.0- 1.0 FT | | | 2.0- 3.0 FT | | | 6.0- 7.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 0.860+/- | 0.24 | | 0.850+/- | 0.2 | | 0.640+/- | 0.06 | | | | |
| Th-230 | PCI/G | 0.980+/- | 0.59 | | | | | | | | | | |
| Thorium | PCI/G | 0.65 | | J | 0.960+/- | 0.18 | | 1.200+/- | 0.34 | | | | |
| U-238 | PCI/G | 11.800+/- | 2.7 | | 8.300+/- | 2.6 | | 8.9 | | J | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

**Ventron Site Characterization**
**Borehole Summary**

| VENTRON - SOIL BORING - 24 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/23/92 | | | | | | | | | | | | | |
| | | 127RV02401 | | | 127RV02402 | | | 127RV02403 | | | | | |
| | | | | | | | | | | | | | |
| | | 8.0- 9.0 FT | | | 10.0-11.0 FT | | | 30.0-31.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 0.880+/- | 0.04 | | 0.850+/- | 0.19 | | 0.470+/- | 0.1 | | | | |
| Thorium | PCI/G | 1.200+/- | 0.33 | | 1.200+/- | 0.19 | | 1.000+/- | 0.16 | | | | |
| U-238 | PCI/G | 119.000+/- | 4.4 | | 186.000+/- | 14.4 | | 5.200+/- | 0.56 | | | | |

**Ventron Site Characterization**
**Borehole Summary**

| VENTRON - SOIL BORING - 25 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/09/92 | | | | | | | | | | | | | |
| | | 127RV02501 | | | 127RV02502 | | | 127RV02503 | | | | | |
| | | | | | | | | | | | | | |
| | | 0.0- 1.0 FT | | | 2.0- 3.0 FT | | | 4.0- 5.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 0.670+/- | 0.21 | | 0.600+/- | 0.03 | | 0.450+/- | 0.18 | | | | |
| Th-230 | PCI/G | 1.100+/- | 0.55 | | 0.690+/- | 0.45 | | | | | | | |
| Thorium | PCI/G | 1.000+/- | 0.41 | | 0.510+/- | 0.01 | | 0.470+/- | 0.28 | | | | |
| U-238 | PCI/G | 4.300+/- | 2.4 | | 1.900+/- | 1.2 | UJ | 0.970+/- | 0.36 | UJ | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

138005

**Ventron Site Characterization**
**Borehole Summary**

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VENTRON - SOIL BORING - 26 | | | | | | | | | | | | | |
| Collected: 09/15/92 | | | | | | | | | | | | | |
| | | 127RV02601 | | | 127RV02603 | | | 127RV02602 | | | | | |
| | | | | | | | | | | | | | |
| | | 3.0- 4.0 FT | | | 11.0-12.0 FT | | | 31.0-32.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 2.300+/- | 0.22 | | 1.300+/- | 0.02 | | 0.730+/- | 0.19 | | | | |
| Thorium | PCI/G | 3.300+/- | 0.64 | | 1.900+/- | 0.44 | | 1.000+/- | 0.08 | | | | |
| U-238 | PCI/G | 8.000+/- | 3.4 | | 14.800+/- | 0.11 | | 6.900+/- | 1.8 | | | | |

**Ventron Site Characterization**
**Borehole Summary**

138005

| VENTRON - SOIL BORING - 27 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/02/92 | | | | | | | | | | | | | |
| | | 127RV02701 | | | 127RV02704 | | | 127RV02702 | | | 127RV02705 | | |
| | | | | | OT | | | | | | | | |
| | | 0.0- 1.0 FT | | | 0.0- 1.0 FT | | | 2.0- 3.0 FT | | | 6.0- 7.0 FT | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 1.300+/- | 0.15 | | 1.100+/- | 0.24 | | 0.640+/- | 0.21 | | 0.51 | | J |
| Th-230 | PCI/G | | | | | | | 1.600+/- | 0.61 | | | | |
| Thorium | PCI/G | 2.000+/- | 0.21 | | 2.900+/- | 0.39 | | 1.100+/- | 0.04 | | 0.720+/- | 0.2 | |
| U-238 | PCI/G | 26.300+/- | 5.7 | | 24.300+/- | 3.8 | | 11.100+/- | 0.09 | | 5.400+/- | 0.91 | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

| VENTRON - SOIL BORING - 27 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Collected: 09/02/92 | | | | | | | |
| | | 127RV02706 | | | 127RV02703 | | |
| | | | | | | | |
| | | 8.0- 9.0 FT | | | 10.0-11.0 FT | | |
| | | Result | Lab | Val | Result | Lab | Val |
| | | | | | | | |
| Radiological | UNITS | | | | | | |
| Ra-226 | PCI/G | 1.800+/- | 0.01 | | 0.7 | | J |
| Th-230 | PCI/G | . | | | | | |
| Thorium | PCI/G | 1.700+/- | 0.36 | | 1.600+/- | 0.76 | |
| U-238 | PCI/G | 7.400+/- | 0.91 | | 37.400+/- | 2.4 | |
| | | | | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

**Ventron Site Characterization**
**Borehole Summary**

138005

| VENTRON - SOIL BORING - 28 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/17/92 | | | | | | | | | | | | | |
| | | 127RV02801 | | | 127RV02802 | | | 127RV02803 | | | | | |
| | | | | | | | | | | | | | |
| | | 0.0- 1.0 FT | | | 4.0- 5.0 FT | | | 8.0- 9.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 0.76 | | J | 1.100+/- | 0.08 | | 0.800+/- | 0.21 | | | | |
| Th-230 | PCI/G | 1.600+/- | 0.68 | | | | | | | | | | |
| Thorium | PCI/G | 10.900+/- | 2.2 | | 1.400+/- | 0.6 | | 1.900+/- | 0.73 | | | | |
| U-238 | PCI/G | 5.400+/- | 0.93 | J | 6.000+/- | 1.7 | J | 7.800+/- | 0.8 | J | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

**Ventron Site Characterization**
**Borehole Summary**

| VENTRON - SOIL BORING - 29 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Collected: 09/17/92 | | | | | | | |
| | | 127RV02901 | | | 127RV02902 | | |
| | | | | | | | |
| | | 0.0- 1.0 FT | | | 2.0- 3.0 FT | | |
| | | Result | Lab | Val | Result | Lab | Val |
| | | | | | | | |
| Radiological | UNITS | | | | | | |
| Ra-226 | PCI/G | 1.600+/- | 0.14 | | 1.200+/- | 0.23 | |
| Th-230 | PCI/G | 2.200+/- | 0.78 | | | | |
| Thorium | PCI/G | 1.700+/- | 0.65 | | 8.900+/- | 0.49 | |
| U-238 | PCI/G | 10.000+/- | 2.8 | J | 23.900+/- | 7.1 | J |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

**Ventron Site Characterization**
**Borehole Summary**

138005

| VENTRON - SOIL BORING - 30 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/21/92 | | | | | | | | | | | | | |
| | | 127CV03001 | | | 127CV03004 | | | 127RV03002 | | | 127RV03003 | | |
| | | | | | OT | | | | | | | | |
| | | 0.0- 1.0 FT | | | 0.0- 1.0 FT | | | 2.0- 4.0 FT | | | 8.0- 9.5 FT | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val |
| | | | | | | | | | | | | | |
| **Inorganics** | **UNITS** | | | | | | | | | | | | |
| Aluminum | MG/KG | 6970 | = | J | 7050 | = | | | | | | | |
| Antimony | MG/KG | 13.5 | U | UJ | 13.5 | U | | | | | | | |
| Arsenic | MG/KG | 7.7 | = | J | 8.4 | = | | | | | | | |
| Barium | MG/KG | 126 | = | J | 131 | = | | | | | | | |
| Beryllium | MG/KG | 1.2 | = | J | 1.2 | = | | | | | | | |
| Boron | MG/KG | 31.2 | = | J | 23 | = | | | | | | | |
| Cadmium | MG/KG | 1.1 | U | UJ | 1.1 | U | | | | | | | |
| Calcium | MG/KG | 5090 | = | J | 6190 | = | | | | | | | |
| Chromium | MG/KG | 22 | = | J | 21.5 | = | | | | | | | |
| Cobalt | MG/KG | 16.1 | = | J | 15.3 | = | | | | | | | |
| Copper | MG/KG | 48.4 | = | J | 9180 | = | | | | | | | |
| Iron | MG/KG | 17400 | = | J | 17500 | = | | | | | | | |
| Lead | MG/KG | 142 | = | J | 139 | = | | | | | | | |
| Magnesium | MG/KG | 3150 | = | J | 3320 | = | | | | | | | |
| Manganese | MG/KG | 320 | = | J | 296 | = | | | | | | | |
| Molybdenum | MG/KG | 22.4 | U | UJ | 22.5 | U | | | | | | | |
| Nickel | MG/KG | 125 | = | J | 109 | = | | | | | | | |
| Potassium | MG/KG | 1560 | = | J | 1670 | = | | | | | | | |
| Selenium | MG/KG | 1.1 | U | UJ | 1.1 | U | | | | | | | |
| Silver | MG/KG | 2.6 | = | J | 3.6 | = | | | | | | | |
| Sodium | MG/KG | 1120 | U | UJ | 1120 | U | | | | | | | |
| Thallium | MG/KG | 2.2 | U | UJ | 2.2 | U | UJ | | | | | | |
| Vanadium | MG/KG | 37.7 | = | J | 36.5 | = | | | | | | | |
| Zinc | MG/KG | 208 | = | J | 238 | = | J | | | | | | |
| | | | | | | | | | | | | | |
| **Pesticides and PCBs** | **UNITS** | | | | | | | | | | | | |
| Aldrin | UG/KG | 36 | U | | 36 | U | | | | | | | |
| alpha-BHC | UG/KG | 36 | U | | 36 | U | | | | | | | |
| alpha-Chlordane | UG/KG | 360 | U | | 360 | U | | | | | | | |
| Aroclor-1016 | UG/KG | 360 | U | | 360 | U | | | | | | | |
| Aroclor-1221 | UG/KG | 360 | U | | 360 | U | | | | | | | |
| Aroclor-1232 | UG/KG | 360 | U | | 360 | U | | | | | | | |
| Aroclor-1242 | UG/KG | 360 | U | | 360 | U | | | | | | | |
| Aroclor-1248 | UG/KG | 360 | U | | 360 | U | | | | | | | |
| Aroclor-1254 | UG/KG | 720 | U | | 720 | U | | | | | | | |
| Aroclor-1260 | UG/KG | 720 | U | | 720 | U | | | | | | | |
| beta-BHC | UG/KG | 36 | U | | 36 | U | | | | | | | |
| 4,4'-DDD | UG/KG | 72 | U | | 72 | U | | | | | | | |
| 4,4'-DDE | UG/KG | 72 | U | | 72 | U | | | | | | | |
| 4,4'-DDT | UG/KG | 72 | U | | 72 | U | | | | | | | |
| delta-BHC | UG/KG | 36 | U | | 36 | U | | | | | | | |
| Dieldrin | UG/KG | 72 | U | | 72 | U | | | | | | | |
| Endosulfan I | UG/KG | 36 | U | | 36 | U | | | | | | | |
| Endosulfan II | UG/KG | 72 | U | | 72 | U | | | | | | | |
| Endosulfan Sulfate | UG/KG | 72 | U | | 72 | U | | | | | | | |
| Endrin | UG/KG | 72 | U | | 72 | U | | | | | | | |
| Endrin Aldehyde | UG/KG | 72 | U | | 72 | U | | | | | | | |
| Endrin Ketone | UG/KG | 72 | U | | 72 | U | | | | | | | |
| gamma-BHC (Lindane) | UG/KG | 36 | U | | 36 | U | | | | | | | |

138005

**Ventron Site Characterization**
**Borehole Summary**

| VENTRON - SOIL BORING - 30 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/21/92 | | | | | | | | | | | | | |
| | | 127CV03001 | | | 127CV03004 | | | 127RV03002 | | | 127RV03003 | | |
| | | | | | OT | | | | | | | | |
| | | 0.0- 1.0 FT | | | 0.0- 1.0 FT | | | 2.0- 4.0 FT | | | 8.0- 9.5 FT | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val |
| gamma-Chlordane | UG/KG | 360 | U | | 360 | U | | | | | | | |
| Heptachlor | UG/KG | 36 | U | | 36 | U | | | | | | | |
| Heptachlor Epoxide | UG/KG | 36 | U | | 36 | U | | | | | | | |
| p,p'-Methoxychlor | UG/KG | 360 | U | | 360 | U | | | | | | | |
| Toxaphene | UG/KG | 720 | U | | 720 | U | | | | | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 1.200+/- | 0.08 | | | | | 0.73 | | J | 1.200+/- | 0.11 | |
| Th-230 | PCI/G | 1.800+/- | 0.63 | | | | | 0.610+/- | 0.42 | | | | |
| Thorium | PCI/G | 2.300+/- | 0.44 | | | | | 1.400+/- | 0.12 | | 1.500+/- | 0.13 | |
| U-238 | PCI/G | 7.800+/- | 1.5 | | | | | 10.100+/- | 0.15 | | 18.300+/- | 1.1 | |
| | | | | | | | | | | | | | |
| TCLP | UNITS | | | | | | | | | | | | |
| Arsenic | UG/L | 100 | U | | 100 | U | | | | | | | |
| Barium | UG/L | 1830 | = | | 1320 | = | | | | | | | |
| Cadmium | UG/L | 14.7 | = | | 13.5 | = | | | | | | | |
| Chromium | UG/L | 15.5 | = | | 13.8 | = | | | | | | | |
| Lead | UG/L | 3370 | = | | 307 | = | | | | | | | |
| Mercury | UG/L | 0.2 | U | | 0.2 | U | | | | | | | |
| Selenium | UG/L | 100 | U | | 100 | U | | | | | | | |
| Silver | UG/L | 10 | U | | 10 | U | | | | | | | |
| Corrosivity by pH | PH UNIT | 8.2 | = | | 8.1 | = | | | | | | | |
| Cyanide, Reactive | MG/KG | 0.25 | U | | 0.25 | U | | | | | | | |
| Sulfide, Reactive | MG/KG | 0.5 | U | | 0.5 | U | | | | | | | |
| | | | | | | | | | | | | | |
| Organic Petroleum Hydrocarbons | UNITS | | | | | | | | | | | | |
| Total Petroleum Hydrocarbons | MG/KG | 48 | = | | 62 | = | | | | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

= indicates that no data qualifier is required; the results are considered reliable.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

138005

# DRUM SAMPLE

138005

# Ventron Site Characterization
## Equipment Rinsates and Drummed Materials

| Sealed Drum | | | | |
|---|---|---|---|---|
| | | 127CV50000 | | |
| | | Collected: 10/13/92 | | |
| | | 0.0- 0.0 | | |
| | | Station: | | |
| | | Result | Lab | Val |
| **Inorganics** | UNITS | | | |
| Aluminum | UG/L | 1080 | = | |
| Antimony | UG/L | 60 | U | |
| Arsenic | UG/L | 10 | U | UJ |
| Barium | UG/L | 200 | U | |
| Beryllium | UG/L | 5 | U | |
| Boron | UG/L | 144 | = | |
| Cadmium | UG/L | 5 | U | |
| Calcium | UG/L | 63400 | = | |
| Chromium | UG/L | 11.1 | = | |
| Cobalt | UG/L | 50 | U | |
| Copper | UG/L | 25 | U | |
| Iron | UG/L | 8100 | = | |
| Lead | UG/L | 16.6 | = | J |
| Magnesium | UG/L | 5000 | U | |
| Manganese | UG/L | 366 | = | |
| Molybdenum | UG/L | 100 | U | |
| Nickel | UG/L | 40 | U | |
| Potassium | UG/L | 12900 | = | |
| Selenium | UG/L | 5 | U | |
| Silver | UG/L | 10 | U | |
| Sodium | UG/L | 44200 | = | |
| Thallium | UG/L | 10 | U | |
| Vanadium | UG/L | 50 | U | |
| Zinc | UG/L | 178 | = | J |
| | | | | |
| **Organic Petroleum Hydrocarbons** | UNITS | | | |
| Total Petroleum Hydrocarbons | MG/L | 19 | = | |
| | | | | |
| **Radiological** | UNITS | | | |
| Gross Alpha, Dissolved | PCI/L | 3.700+/- | 3.3 | |
| Gross Beta, Dissolved | PCI/L | 10.700+/- | 4 | |
| Gross Alpha, Total | PCI/L | 6.100+/- | 7.2 | UJ |
| Gross Beta, Total | PCI/L | 12.400+/- | 6.2 | |
| Uranium, Total | UG/L | 7.700+/- | 0.79 | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

= indicates that no data qualifier is required; the results are considered reliable.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

138005

| VENTRON - SOIL BORING - 10 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Collected: 09/09/92 | | | | | | | |
| | | 127CV01001 | | | 127RV01003 | | |
| | | | | | | | |
| | | 0.0- 1.0 FT | | | 4.0- 5.0 FT | | |
| | | Result | Lab | Val | Result | Lab | Val |
| gamma-Chlordane | UG/KG | 170 | U | | | | |
| Heptachlor | UG/KG | 17 | U | | | | |
| Heptachlor Epoxide | UG/KG | 17 | U | | | | |
| p,p'-Methoxychlor | UG/KG | 170 | U | | | | |
| Toxaphene | UG/KG | 340 | U | | | | |
| | | | | | | | |
| Radiological | UNITS | | | | | | |
| Ra-226 | PCI/G | 2.200+/- | 0.15 | | 1.300+/- | 0.45 | |
| Thorium | PCI/G | 3.600+/- | 0.92 | | 1.900+/- | 0.41 | |
| U-238 | PCI/G | 6.300+/- | 2.2 | | 11.8 | | J |
| | | | | | | | |
| TCLP | UNITS | | | | | | |
| Arsenic | UG/L | 100 | U | | | | |
| Barium | UG/L | 454 | = | | | | |
| Cadmium | UG/L | 5 | U | | | | |
| Chromium | UG/L | 10 | U | | | | |
| Lead | UG/L | 139 | = | | | | |
| Mercury | UG/L | 0.2 | U | | | | |
| Selenium | UG/L | 100 | U | | | | |
| Silver | UG/L | 10 | U | | | | |
| Corrosivity by pH | PH UNIT | 8.7 | = | | | | |
| Cyanide, Reactive | MG/KG | 0.25 | U | UJ | | | |
| Sulfide, Reactive | MG/KG | 0.5 | U | UJ | | | |
| | | | | | | | |
| Organic Petroleum Hydrocarbons | UNITS | | | | | | |
| Total Petroleum Hydrocarbons | MG/KG | 870 | = | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

= indicates that no data qualifier is required; the results are considered reliable.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

138005

| | | | | |
|---|---|---|---|---|
| VENTRON - SOIL BORING - 11 | | | | |
| Collected: 09/10/92 | | | | |
| | | 127RV01102 | | |
| | | | | |
| | | 2.0- 3.0 FT | | |
| | | Result | Lab | Val |
| | | | | |
| Radiological | UNITS | | | |
| Ra-226 | PCI/G | 0.45 | | J |
| Th-230 | PCI/G | 0.580+/- | 0.45 | |
| Thorium | PCI/G | 0.59 | | J |
| U-238 | PCI/G | 5.800+/- | 0.66 | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

**Ventron Site Characterization**
**Borehole Summary**

| VENTRON - SOIL BORING - 12 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/10/92 | | | | | | | | | | | | | |
| | | 127RV01203 | | | 127RV01202 | | | | | | | | |
| | | | | | | | | | | | | | |
| | | 2.0- 3.0 FT | | | 3.0- 4.0 FT | | | | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | | | | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 0.930+/- | 0.12 | | 0.690+/- | 0.22 | | | | | | | |
| Th-230 | PCI/G | 0.420+/- | 0.39 | | | | | | | | | | |
| Thorium | PCI/G | 0.76 | | J | 0.880+/- | 0.46 | | | | | | | |
| U-238 | PCI/G | 25.900+/- | 2.5 | | 16.300+/- | 1.9 | | | | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

# APPENDIX B-5

# 11 AND 15 CONGRESS STREET SAMPLES

## Ventron Site Characterization
## Borehole Summary

138005

| VENTRON - SOIL BORING - 17 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collected: 09/03/92 | | | | | | | | | | | | | |
| | | 127CV01701 | | | 127RV01702 | | | 127RV01703 | | | | | |
| | | | | | | | | | | | | | |
| | | 0.0- 1.0 FT | | | 2.0- 3.0 FT | | | 4.0- 5.0 FT | | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | | |
| gamma-Chlordane | UG/KG | 4600 | U | | | | | | | | | | |
| Heptachlor | UG/KG | 460 | U | | | | | | | | | | |
| Heptachlor Epoxide | UG/KG | 460 | U | | | | | | | | | | |
| p,p'-Methoxychlor | UG/KG | 4600 | U | | | | | | | | | | |
| Toxaphene | UG/KG | 9200 | U | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | |
| Ra-226 | PCI/G | 0.960+/- | 0.23 | | 1.100+/- | 0.21 | | 1.200+/- | 0.22 | | | | |
| Th-230 | PCI/G | | | | 1.600+/- | 0.64 | | | | | | | |
| Thorium | PCI/G | 1.400+/- | 0.55 | | 1.300+/- | 0.39 | | 1.300+/- | 0.54 | | | | |
| U-238 | PCI/G | 10.500+/- | 0.97 | | 9.000+/- | 0.88 | | 6.000+/- | 1.9 | | | | |
| | | | | | | | | | | | | | |
| TCLP | UNITS | | | | | | | | | | | | |
| Arsenic | UG/L | 100 | U | | | | | | | | | | |
| Barium | UG/L | 488 | = | | | | | | | | | | |
| Cadmium | UG/L | 5.3 | = | | | | | | | | | | |
| Chromium | UG/L | 10 | U | | | | | | | | | | |
| Lead | UG/L | 90 | U | | | | | | | | | | |
| Mercury | UG/L | 0.2 | U | | | | | | | | | | |
| Selenium | UG/L | 100 | U | UJ | | | | | | | | | |
| Silver | UG/L | 10 | U | | | | | | | | | | |
| Corrosivity by pH | PH UNIT | 8.1 | = | | | | | | | | | | |
| Cyanide, Reactive | MG/KG | 0.25 | U | UJ | | | | | | | | | |
| Sulfide, Reactive | MG/KG | 0.5 | U | UJ | | | | | | | | | |
| | | | | | | | | | | | | | |
| Organic Petroleum Hydrocarbons | UNITS | | | | | | | | | | | | |
| Total Petroleum Hydrocarbons | MG/KG | 95 | = | | | | | | | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

= indicates that no data qualifier is required; the results are considered reliable.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

**Ventron Site Characterization**
**Soil Samples**

138005

| BASEMENT 11 CONGRESS ST. | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 127RV03701 | | | 127RV03801 | | | | | | | | | | | |
| | | Collected: 10/20/92 | | | Collected: 10/20/92 | | | | | | | | | | | |
| | | 0.0- 0.5 FT | | | 0.0- 0.5 FT | | | | | | | | | | | |
| | | Station: 037 | | | Station: 038 | | | | | | | | | | | |
| | | Result | Lab* | Val* | Result | Lab* | Val* | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | | | | |
| Ra-226 | PCI/G | 0.860+/- | 0.11 | | 1.1 | | J | | | | | | | | | |
| Th-230 | PCI/G | 1.500+/- | 0.62 | | 0.760+/- | 0.47 | | | | | | | | | | |
| Thorium | PCI/G | 0.85 | | J | 1.300+/- | 0.22 | | | | | | | | | | |
| U-238 | PCI/G | 3.9 | | J | 7.2 | | J | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| BASEMENT 15 CONGRESS ST. | | | | | | | | | | | | | | | | |
| | | 127RV03901 | | | 127RV04001 | | | 127RV04101 | | | 127RV04201 | | | | | |
| | | Collected: 10/20/92 | | | Collected: 10/20/92 | | | Collected: 10/20/92 | | | Collected: 10/20/92 | | | | | |
| | | 0.0- 0.5 FT | | | 0.0- 0.5 FT | | | 0.0- 0.5 FT | | | 0.0- 0.5 FT | | | | | |
| | | Station: 039 | | | Station: 040 | | | Station: 041 | | | Station: 042 | | | | | |
| | | Result | Lab* | Val* | Result | Lab* | Val* | Result | Lab* | Val* | Result | Lab* | Val* | | | |
| | | | | | | | | | | | | | | | | |
| Radiological | UNITS | | | | | | | | | | | | | | | |
| Ra-226 | PCI/G | 0.640+/- | 0.01 | | 0.69 | | J | 0.580+/- | 0.11 | | 0.990+/- | 0.16 | | | | |
| Th-232 | PCI/G | 0.570+/- | 0.39 | | 2.400+/- | 0.79 | | 0.970+/- | 0.5 | | 0.910+/- | 0.47 | | | | |
| Thorium | PCI/G | 0.910+/- | 0.08 | | 1.200+/- | 0.37 | | 0.82 | | J | 1.200+/- | 0.3 | | | | |
| U-238 | PCI/G | 7 | | J | 2.400+/- | 0.17 | UJ | 4.2 | | J | 8.8 | | J | | | |
| | | | | | | | | | | | | | | | | |
| * Note: LAB is the laboratory data qualifier, VAL is the data validation qualifer. | | | | | | | | | | | | | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

138005

# APPENDIX B-6

# BUILDING A-1
# THROUGH-THE-FLOOR SAMPLES

Ventron Site Characterization
Soil Samples

138005

| BUILDING A-1 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 127CV01501 | | | 127RV01301 | | | 127RV01401 | | | 127RV01601 | | |
| | | Collected: 09/17/92 | | | Collected: 09/22/92 | | | Collected: 10/20/92 | | | Collected: 09/17/92 | | |
| | | 0.0- 0.5 FT | | | 0.0- 0.5 FT | | | 0.0- 0.5 FT | | | 0.0- 0.5 FT | | |
| | | Station: 015 | | | Station: 013 | | | Station: 014 | | | Station: 016 | | |
| | | Result | Lab* | Val* | Result | Lab* | Val* | Result | Lab* | Val* | Result | Lab* | Val* |
| **Inorganics** | **UNITS** | | | | | | | | | | | | |
| Aluminum | MG/KG | 4260 | = | | | | | | | | | | |
| Antimony | MG/KG | 12 | U | UJ | | | | | | | | | |
| Arsenic | MG/KG | 5.1 | = | J | | | | | | | | | |
| Barium | MG/KG | 89.3 | = | J | | | | | | | | | |
| Beryllium | MG/KG | 1 | U | UJ | | | | | | | | | |
| Boron | MG/KG | 20 | U | UJ | | | | | | | | | |
| Cadmium | MG/KG | 1 | U | UJ | | | | | | | | | |
| Calcium | MG/KG | 5420 | = | J | | | | | | | | | |
| Chromium | MG/KG | 5.9 | = | J | | | | | | | | | |
| Cobalt | MG/KG | 13.8 | = | J | | | | | | | | | |
| Copper | MG/KG | 19 | = | J | | | | | | | | | |
| Iron | MG/KG | 11500 | = | | | | | | | | | | |
| Lead | MG/KG | 34.6 | = | | | | | | | | | | |
| Magnesium | MG/KG | 2320 | = | | | | | | | | | | |
| Manganese | MG/KG | 120 | = | J | | | | | | | | | |
| Molybdenum | MG/KG | 20 | U | UJ | | | | | | | | | |
| Nickel | MG/KG | 12.1 | = | J | | | | | | | | | |
| Potassium | MG/KG | 1380 | = | | | | | | | | | | |
| Selenium | MG/KG | 1 | U | | | | | | | | | | |
| Silver | MG/KG | 2 | U | UJ | | | | | | | | | |
| Sodium | MG/KG | 1000 | U | | | | | | | | | | |
| Thallium | MG/KG | 2 | U | UJ | | | | | | | | | |
| Vanadium | MG/KG | 13.7 | = | J | | | | | | | | | |
| Zinc | MG/KG | 48.7 | = | J | | | | | | | | | |
| **Organic Petroleum Hydrocarbons** | **UNITS** | | | | | | | | | | | | |
| Total Petroleum Hydrocarbons | MG/KG | 1400 | = | | | | | | | | | | |
| **Pesticides and PCBs** | **UNITS** | | | | | | | | | | | | |
| Aldrin | UG/KG | 800 | U | | | | | | | | | | |
| alpha-BHC | UG/KG | 800 | U | | | | | | | | | | |
| alpha-Chlordane | UG/KG | 8000 | U | | | | | | | | | | |
| Aroclor-1016 | UG/KG | 8000 | U | | | | | | | | | | |
| Aroclor-1221 | UG/KG | 8000 | U | | | | | | | | | | |
| Aroclor-1232 | UG/KG | 8000 | U | | | | | | | | | | |
| Aroclor-1242 | UG/KG | 8000 | U | | | | | | | | | | |
| Aroclor-1248 | UG/KG | 8000 | U | | | | | | | | | | |
| Aroclor-1254 | UG/KG | 16000 | U | | | | | | | | | | |
| Aroclor-1260 | UG/KG | 16000 | U | | | | | | | | | | |
| beta-BHC | UG/KG | 800 | U | | | | | | | | | | |
| 4,4'-DDD | UG/KG | 1600 | U | | | | | | | | | | |
| 4,4'-DDE | UG/KG | 1600 | U | | | | | | | | | | |
| 4,4'-DDT | UG/KG | 1600 | U | | | | | | | | | | |
| delta-BHC | UG/KG | 800 | U | | | | | | | | | | |
| Dieldrin | UG/KG | 1600 | U | | | | | | | | | | |
| Endosulfan I | UG/KG | 800 | U | | | | | | | | | | |
| Endosulfan II | UG/KG | 1600 | U | | | | | | | | | | |
| Endosulfan Sulfate | UG/KG | 1600 | U | | | | | | | | | | |
| Endrin | UG/KG | 1600 | U | | | | | | | | | | |
| Endrin Aldehyde | UG/KG | 1600 | U | | | | | | | | | | |
| Endrin Ketone | UG/KG | 1600 | U | | | | | | | | | | |
| gamma-BHC (Lindane) | UG/KG | 800 | U | | | | | | | | | | |
| gamma-Chlordane | UG/KG | 8000 | U | | | | | | | | | | |
| Heptachlor | UG/KG | 800 | U | | | | | | | | | | |
| Heptachlor Epoxide | UG/KG | 800 | U | | | | | | | | | | |
| p,p'-Methoxychlor | UG/KG | 8000 | U | | | | | | | | | | |
| Toxaphene | UG/KG | 16000 | U | | | | | | | | | | |

| Semi-volatile Organics | UNITS | | |
|---|---|---|---|
| Acenaphthene | UG/KG | 320 | U |
| Acenaphthylene | UG/KG | 320 | U |
| Anthracene | UG/KG | 320 | U |
| Benzidine | UG/KG | 1600 | U |
| Benzo(a)anthracene | UG/KG | 37 | J |
| Benzo(a)pyrene | UG/KG | 320 | U |
| Benzo(b)fluoranthene | UG/KG | 71 | J |
| Benzo(g,h,i)perylene | UG/KG | 320 | U |
| Benzo(k)fluoranthene | UG/KG | 49 | J |
| Benzoic Acid | UG/KG | 1600 | U |
| Benzyl Alcohol | UG/KG | 320 | U |
| bis(2-Chloroethoxy)methane | UG/KG | 320 | U |
| bis(2-Chloroethyl)ether | UG/KG | 320 | U |
| bis(2-Ethylhexyl)phthalate | UG/KG | 320 | U |
| 4-Bromophenyl-phenylether | UG/KG | 320 | U |
| Butylbenzylphthalate | UG/KG | 320 | U |
| 4-Chloro-3-methylphenol | UG/KG | 320 | U |
| 4-Chloroaniline | UG/KG | 320 | U |
| 2-Chloronaphthalene | UG/KG | 320 | U |
| 2-Chlorophenol | UG/KG | 320 | U |
| 4-Chlorophenyl-phenylether | UG/KG | 320 | U |
| Chrysene | UG/KG | 140 | J |
| Di-n-butylphthalate | UG/KG | 320 | U |
| Di-n-octylphthalate | UG/KG | 320 | U |
| Dibenzo(a,h)anthracene | UG/KG | 320 | U |
| Dibenzofuran | UG/KG | 320 | U |
| 1,2-Dichlorobenzene | UG/KG | 320 | U |
| 1,3-Dichlorobenzene | UG/KG | 320 | U |
| 1,4-Dichlorobenzene | UG/KG | 320 | U |
| 3,3'-Dichlorobenzidine | UG/KG | 650 | U |
| 2,4-Dichlorophenol | UG/KG | 320 | U |
| Diethylphthalate | UG/KG | 320 | U |
| 2,4-Dimethylphenol | UG/KG | 320 | U |
| Dimethylphthalate | UG/KG | 320 | U |
| 4,6-Dinitro-2-methylphenol | UG/KG | 1600 | U |
| 2,4-Dinitrophenol | UG/KG | 1600 | U |
| 2,4-Dinitrotoluene | UG/KG | 320 | U |
| 2,6-Dinitrotoluene | UG/KG | 320 | U |
| 1,2-Diphenylhydrazine | UG/KG | 320 | U |
| Fluoranthene | UG/KG | 280 | J |
| Fluorene | UG/KG | 320 | U |
| Hexachlorobenzene | UG/KG | 320 | U |
| Hexachlorobutadiene | UG/KG | 320 | U |
| Hexachlorocyclopentadiene | UG/KG | 320 | U |
| Hexachloroethane | UG/KG | 320 | U |
| Indeno(1,2,3-c,d)pyrene | UG/KG | 320 | U |
| Isophorone | UG/KG | 320 | U |
| 2-Methylnaphthalene | UG/KG | 1900 | = |
| 2-Methylphenol | UG/KG | 320 | U |
| 4-Methylphenol | UG/KG | 320 | U |
| N-Nitroso-di-n-propylamine | UG/KG | 320 | U |
| N-Nitroso-dimethylamine | UG/KG | 320 | U |
| N-Nitrosodiphenylamine | UG/KG | 320 | U |
| Naphthalene | UG/KG | 690 | = |
| 2-Nitroaniline | UG/KG | 1600 | U |
| 3-Nitroaniline | UG/KG | 1600 | U |
| 4-Nitroaniline | UG/KG | 1600 | U |
| Nitrobenzene | UG/KG | 320 | U |
| 2-Nitrophenol | UG/KG | 320 | U |
| 4-Nitrophenol | UG/KG | 1600 | U |
| 2,2'-oxybis(1-Chloropropane) | UG/KG | 320 | U |
| Pentachlorophenol | UG/KG | 1600 | U |
| Phenanthrene | UG/KG | 2400 | = |
| Phenol | UG/KG | 320 | U |
| Pyrene | UG/KG | 270 | J |
| 1,2,4-Trichlorobenzene | UG/KG | 320 | U |

138005

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2,4,5-Trichlorophenol | UG/KG | 1600 | U | | | | | | | | | | | | | |
| 2,4,6-Trichlorophenol | UG/KG | 320 | U | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| **Radiological** | **UNITS** | | | | | | | | | | | | | | | |
| Ra-226 | PCI/G | 1.500+/- | 0.2 | | 0.930+/- | 0.14 | | 0.940+/- | 0.33 | | 1.100+/- | 0.05 | | | | |
| Th-230 | PCI/G | 1.100+/- | 0.6 | | | | | 44.500+/- | 3.3 | | | | | | | |
| Thorium | PCI/G | 1.800+/- | 0.39 | | 1.200+/- | 0.11 | | 1.100+/- | 0.22 | | 1.300+/- | 0.26 | | | | |
| U-238 | PCI/G | 9.1 | | J | 3.5 | | J | 190.000+/- | 22.9 | | 1.900+/- | 0.83 | J | | | |
| | | | | | | | | | | | | | | | | |
| **TCLP** | **UNITS** | | | | | | | | | | | | | | | |
| Arsenic | UG/L | 100 | U | | | | | | | | | | | | | |
| Barium | UG/L | 393 | = | | | | | | | | | | | | | |
| Cadmium | UG/L | 5 | U | | | | | | | | | | | | | |
| Chromium | UG/L | 10 | U | | | | | | | | | | | | | |
| Corrosivity by pH | PH | 8.1 | = | | | | | | | | | | | | | |
| Cyanide, Reactive | MG/KG | 0.25 | U | UJ | | | | | | | | | | | | |
| Lead | UG/L | 90 | U | | | | | | | | | | | | | |
| Mercury | UG/L | 0.4 | U | | | | | | | | | | | | | |
| Selenium | UG/L | 100 | U | UJ | | | | | | | | | | | | |
| Silver | UG/L | 10 | U | UJ | | | | | | | | | | | | |
| Sulfide, Reactive | MG/KG | 0.5 | U | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| * Note: LAB is the laboratory data qualifier, VAL is the data validation qualifer. | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

= indicates that no data qualifier is required; the results are considered reliable.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

138005

# APPENDIX B-7

# HARBOR AND SEWER LINE SEDIMENT SAMPLES

# Ventron Site Characterization
## Sediment Samples

| VENTRON | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 127CV00111 | | | 127CV00211 | | | 127CV00311 | | | 127CV00411 | | | 127CV00412 | | | | |
| | | Collected: 10/12/92 | | | Collected: 10/12/92 | | | Collected: 10/13/92 | | | Collected: 10/13/92 | | | Collected: 10/13/92 | | | | |
| | | 0.0- 0.0 | | | 0.0- 0.0 | | | 0.0- 1.0 FT | | | 0.0- 1.0 FT | | | 0.0- 1.0 FT | | | | |
| | | Station: 001 | | | Station: 002 | | | Station: 003 | | | Station: 004 | | | Station: 004 | | | | |
| | | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | Result | Lab | Val | | |
| **Inorganics** | **UNITS** | | | | | | | | | | | | | | | | | |
| Aluminum | MG/KG | 4830 | = | | 6080 | = | | 3580 | = | | 3440 | = | | 2630 | = | | | |
| Antimony | MG/KG | 21.8 | U | | 31.6 | U | | 17.4 | U | | 17.3 | U | | 16.5 | U | | | |
| Arsenic | MG/KG | 6.8 | = | | 6.6 | = | | 6.5 | = | J | 4.8 | = | J | 4 | = | J | | |
| Barium | MG/KG | 72.5 | U | | 105 | U | | 58.1 | U | | 57.8 | U | | 54.9 | U | | | |
| Beryllium | MG/KG | 1.8 | U | | 2.6 | U | | 1.5 | U | | 1.4 | U | | 1.4 | U | | | |
| Boron | MG/KG | 36.3 | U | | 52.7 | U | | 38.3 | = | | 30 | = | | 27.5 | U | | | |
| Cadmium | MG/KG | 1.8 | U | | 4.2 | = | U | 2.2 | = | U | 3.3 | = | U | 3.4 | = | U | | |
| Calcium | MG/KG | 4620 | = | | 24200 | = | | 37600 | = | J | 13300 | = | J | 19400 | = | J | | |
| Chromium | MG/KG | 418 | = | | 668 | = | | 148 | = | | 205 | = | | 136 | = | | | |
| Cobalt | MG/KG | 18.1 | U | | 26.3 | U | | 14.5 | U | | 14.4 | U | | 13.7 | U | | | |
| Copper | MG/KG | 32.2 | = | | 63.8 | = | | 27.4 | = | | 24.2 | = | | 20.7 | = | | | |
| Iron | MG/KG | 10800 | = | | 15400 | = | | 10900 | = | | 7420 | = | | 5780 | = | | | |
| Lead | MG/KG | 75.7 | = | | 102 | = | | 57.3 | = | | 32.5 | = | | 23 | = | | | |
| Magnesium | MG/KG | 3840 | = | | 5100 | = | | 4400 | = | | 2920 | = | | 2290 | = | | | |
| Manganese | MG/KG | 110 | = | J | 151 | = | J | 76.9 | = | J | 60.8 | = | J | 48.5 | = | J | | |
| Molybdenum | MG/KG | 36.3 | U | | 52.7 | U | | 29.1 | U | | 28.9 | U | | 27.5 | U | | | |
| Nickel | MG/KG | 14.5 | U | | 21.1 | U | | 245 | = | J | 28.8 | = | J | 18.2 | = | J | | |
| Potassium | MG/KG | 1900 | = | | 2630 | U | | 1450 | U | | 1440 | U | | 1370 | U | | | |
| Selenium | MG/KG | 1.9 | U | | 2.6 | U | | 1.5 | U | | 1.6 | U | | 1.4 | U | | | |
| Silver | MG/KG | 9.4 | = | | 9.7 | = | | 2.9 | U | | 2.9 | U | | 2.7 | U | | | |
| Sodium | MG/KG | 10700 | = | | 17700 | = | | 5510 | = | J | 6540 | = | J | 5160 | = | J | | |
| Thallium | MG/KG | 3.8 | U | UJ | 5.3 | U | UJ | 2.9 | U | UJ | 2.8 | U | UJ | 2.5 | U | UJ | | |
| Vanadium | MG/KG | 22.2 | = | | 36 | = | | 17.6 | = | | 14.5 | = | | 13.7 | U | | | |
| Zinc | MG/KG | 99.4 | = | | 143 | = | | 114 | = | | 66.8 | = | | 80 | = | | | |
| | | | | | | | | | | | | | | | | | | |
| **Organic Petroleum Hydrocarbons** | **UNITS** | | | | | | | | | | | | | | | | | |
| Total Petroleum Hydrocarbons | MG/KG | 39 | = | | 23 | = | | 140 | = | | 60 | = | | 49 | = | | | |
| | | | | | | | | | | | | | | | | | | |
| **Pesticides and PCBs** | **UNITS** | | | | | | | | | | | | | | | | | |
| Aldrin | UG/KG | 62 | U | | 87 | U | | 47 | U | | 51 | U | | 47 | U | | | |
| alpha-BHC | UG/KG | 62 | U | | 87 | U | | 47 | U | | 51 | U | | 47 | U | | | |
| alpha-Chlordane | UG/KG | 620 | U | | 870 | U | | 470 | U | | 510 | U | | 470 | U | | | |
| Aroclor-1016 | UG/KG | 620 | U | | 870 | U | | 470 | U | | 510 | U | | 470 | U | | | |
| Aroclor-1221 | UG/KG | 620 | U | | 870 | U | | 470 | U | | 510 | U | | 470 | U | | | |
| Aroclor-1232 | UG/KG | 620 | U | | 870 | U | | 470 | U | | 510 | U | | 470 | U | | | |
| Aroclor-1242 | UG/KG | 620 | U | | 870 | U | | 470 | U | | 510 | U | | 470 | U | | | |
| Aroclor-1248 | UG/KG | 620 | U | | 870 | U | | 470 | U | | 510 | U | | 470 | U | | | |
| Aroclor-1254 | UG/KG | 1200 | U | | 1700 | U | | 930 | U | | 1000 | U | | 1300 | = | | | |
| Aroclor-1260 | UG/KG | 1200 | U | | 1700 | U | | 930 | U | | 1000 | U | | 930 | U | | | |
| beta-BHC | UG/KG | 62 | U | | 87 | U | | 47 | U | | 51 | U | | 47 | U | | | |
| 4,4'-DDD | UG/KG | 120 | U | | 170 | U | | 93 | U | | 100 | U | | 93 | U | | | |
| 4,4'-DDE | UG/KG | 120 | U | | 170 | U | | 93 | U | | 100 | U | | 93 | U | | | |
| 4,4'-DDT | UG/KG | 120 | U | | 170 | U | | 93 | U | | 100 | U | | 93 | U | | | |
| delta-BHC | UG/KG | 62 | U | | 87 | U | | 47 | U | | 51 | U | | 47 | U | | | |
| Dieldrin | UG/KG | 120 | U | | 170 | U | | 93 | U | | 100 | U | | 93 | U | | | |
| Endosulfan I | UG/KG | 62 | U | | 87 | U | | 47 | U | | 51 | U | | 47 | U | | | |
| Endosulfan II | UG/KG | 120 | U | | 170 | U | | 93 | U | | 100 | U | | 93 | U | | | |
| Endosulfan Sulfate | UG/KG | 120 | U | | 170 | U | | 93 | U | | 100 | U | | 93 | U | | | |
| Endrin | UG/KG | 120 | U | | 170 | U | | 93 | U | | 100 | U | | 93 | U | | | |
| Endrin Aldehyde | UG/KG | 120 | U | | 170 | U | | 93 | U | | 100 | U | | 93 | U | | | |
| Endrin Ketone | UG/KG | 120 | U | | 170 | U | | 93 | U | | 100 | U | | 93 | U | | | |
| gamma-BHC (Lindane) | UG/KG | 62 | U | | 87 | U | | 47 | U | | 51 | U | | 47 | U | | | |
| gamma-Chlordane | UG/KG | 620 | U | | 870 | U | | 470 | U | | 510 | U | | 470 | U | | | |
| Heptachlor | UG/KG | 62 | U | | 87 | U | | 47 | U | | 51 | U | | 47 | U | | | |

**Ventron Site Characterization**
**Sediment Samples**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heptachlor Epoxide | UG/KG | 62 | U | | 87 | U | | 47 | U | | 51 | U | | 47 | U | | | | |
| p,p'-Methoxychlor | UG/KG | 620 | U | | 870 | U | | 470 | U | | 510 | U | | 470 | U | | | | |
| Toxaphene | UG/KG | 1200 | U | | 1700 | U | | 930 | U | | 1000 | U | | 930 | U | | | | |
| | | | | | | | | | | | | | | | | | | | |
| **Radiological** | **UNITS** | | | | | | | | | | | | | | | | | | |
| Ra-226 | PCI/G | 0.69 | | J | 0.64 | | J | 0.490+/- | 0.02 | | 0.59 | | J | 0.840+/- | 0.24 | | | | |
| Th-230 | PCI/G | 0.730+/- | 0.56 | | 0.440+/- | 0.51 | UJ | 0.910+/- | 0.57 | | 0.780+/- | 0.54 | | 0.250+/- | 0.43 | UJ | | | |
| Thorium | PCI/G | 1.1 | | J | 0.84 | | J | 0.630+/- | 0.04 | | 0.75 | | J | 0.9 | | J | | | |
| U-238 | PCI/G | 2.600+/- | 0.98 | J | 4.3 | | J | 3.2 | | J | 4.5 | | J | 4.8 | | J | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

= indicates that no data qualifier is required; the results are considered reliable.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

# Ventron Site Characterization
## Sediment Samples

| VENTRON | | 127CV00511 | | | 127RV03601 | | | 127RV03602 | | | 127RV03603 | | | 127RV03604 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Collected: 10/13/92 | | | Collected: 10/14/92 | | | Collected: 10/14/92 | | | Collected: 10/14/92 | | | Collected: 10/14/92 | | |
| | | 0.0- 1.0 FT | | | 0.0- 0.5 FT | | | 0.0- 0.5 FT | | | 0.0- 0.5 FT | | | 0.0- 0.5 FT | | |
| | | Station: 005 | | | Station: 036 | | | Station: 036 | | | Station: 036 | | | Station: 036 | | |
| | | Result | Lab* | Val* | Result | Lab* | Val* | Result | Lab* | Val* | Result | Lab* | Val* | Result | Lab* | Val* |
| **Inorganics** | UNITS | | | | | | | | | | | | | | | |
| Aluminum | MG/KG | 2340 | = | | | | | | | | | | | | | |
| Antimony | MG/KG | 16.9 | U | | | | | | | | | | | | | |
| Arsenic | MG/KG | 6 | = | J | | | | | | | | | | | | |
| Barium | MG/KG | 56.3 | U | | | | | | | | | | | | | |
| Beryllium | MG/KG | 1.4 | U | | | | | | | | | | | | | |
| Boron | MG/KG | 28.2 | U | | | | | | | | | | | | | |
| Cadmium | MG/KG | 1.4 | U | | | | | | | | | | | | | |
| Calcium | MG/KG | 9420 | = | J | | | | | | | | | | | | |
| Chromium | MG/KG | 100 | = | | | | | | | | | | | | | |
| Cobalt | MG/KG | 14.1 | U | | | | | | | | | | | | | |
| Copper | MG/KG | 13.5 | = | | | | | | | | | | | | | |
| Iron | MG/KG | 5930 | = | | | | | | | | | | | | | |
| Lead | MG/KG | 27.3 | = | | | | | | | | | | | | | |
| Magnesium | MG/KG | 2060 | = | | | | | | | | | | | | | |
| Manganese | MG/KG | 49.6 | = | J | | | | | | | | | | | | |
| Molybdenum | MG/KG | 28.2 | U | | | | | | | | | | | | | |
| Nickel | MG/KG | 17.1 | = | J | | | | | | | | | | | | |
| Potassium | MG/KG | 1410 | U | | | | | | | | | | | | | |
| Selenium | MG/KG | 1.3 | U | | | | | | | | | | | | | |
| Silver | MG/KG | 2.8 | U | | | | | | | | | | | | | |
| Sodium | MG/KG | 5340 | = | J | | | | | | | | | | | | |
| Thallium | MG/KG | 2.4 | U | UJ | | | | | | | | | | | | |
| Vanadium | MG/KG | 14.1 | U | | | | | | | | | | | | | |
| Zinc | MG/KG | 40.8 | = | | | | | | | | | | | | | |
| **Organic Petroleum Hydrocarbons** | UNITS | | | | | | | | | | | | | | | |
| Total Petroleum Hydrocarbons | MG/KG | 56 | = | | | | | | | | | | | | | |
| **Pesticides and PCBs** | UNITS | | | | | | | | | | | | | | | |
| Aldrin | UG/KG | 46 | U | | | | | | | | | | | | | |
| alpha-BHC | UG/KG | 46 | U | | | | | | | | | | | | | |
| alpha-Chlordane | UG/KG | 460 | U | | | | | | | | | | | | | |
| Aroclor-1016 | UG/KG | 460 | U | | | | | | | | | | | | | |
| Aroclor-1221 | UG/KG | 460 | U | | | | | | | | | | | | | |
| Aroclor-1232 | UG/KG | 460 | U | | | | | | | | | | | | | |
| Aroclor-1242 | UG/KG | 460 | U | | | | | | | | | | | | | |
| Aroclor-1248 | UG/KG | 460 | U | | | | | | | | | | | | | |
| Aroclor-1254 | UG/KG | 910 | U | | | | | | | | | | | | | |
| Aroclor-1260 | UG/KG | 910 | U | | | | | | | | | | | | | |
| beta-BHC | UG/KG | 46 | U | | | | | | | | | | | | | |
| 4,4'-DDD | UG/KG | 91 | U | | | | | | | | | | | | | |
| 4,4'-DDE | UG/KG | 91 | U | | | | | | | | | | | | | |
| 4,4'-DDT | UG/KG | 91 | U | | | | | | | | | | | | | |
| delta-BHC | UG/KG | 46 | U | | | | | | | | | | | | | |
| Dieldrin | UG/KG | 91 | U | | | | | | | | | | | | | |
| Endosulfan I | UG/KG | 46 | U | | | | | | | | | | | | | |
| Endosulfan II | UG/KG | 91 | U | | | | | | | | | | | | | |
| Endosulfan Sulfate | UG/KG | 91 | U | | | | | | | | | | | | | |
| Endrin | UG/KG | 91 | U | | | | | | | | | | | | | |
| Endrin Aldehyde | UG/KG | 91 | U | | | | | | | | | | | | | |
| Endrin Ketone | UG/KG | 91 | U | | | | | | | | | | | | | |
| gamma-BHC (Lindane) | UG/KG | 46 | U | | | | | | | | | | | | | |
| gamma-Chlordane | UG/KG | 460 | U | | | | | | | | | | | | | |
| Heptachlor | UG/KG | 46 | U | | | | | | | | | | | | | |
| Heptachlor Epoxide | UG/KG | 46 | U | | | | | | | | | | | | | |
| p,p'-Methoxychlor | UG/KG | 460 | U | | | | | | | | | | | | | |
| Toxaphene | UG/KG | 910 | U | | | | | | | | | | | | | |
| **Radiological** | UNITS | | | | | | | | | | | | | | | |
| Ra-226 | PCI/G | 0.610+/- | 0.09 | | 0.640+/- | 0.2 | | 0.550+/- | 0.05 | | 0.540+/- | 0.11 | | 0.530+/- | 0.04 | |
| Th-230 | PCI/G | | | | | | | | | | | | | | | |
| Thorium | PCI/G | 0.730+/- | 0.53 | UJ | 1.500+/- | 0.17 | | 0.490+/- | 0.23 | | 0.720+/- | 0.17 | | 0.56 | | J |

138005

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-238 | PCI/G | 2.300+/- | 1.4 | UJ | 6.8 | | J | 5.5 | | J | 3.900+/- | 0.53 | UJ | 1.400+/- | 0.81 | UJ | | |
| | | | | | | | | | | | | | | | | | | |
| * Note: Except for Radiological data LAB is the laboratory data qualifier , VAL is the data validation qualifer. | | | | | | | | | | | | | | | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

= indicates that no data qualifier is required; the results are considered reliable.

U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

# APPENDIX B-9

# BUILDING A
# ASH PILE SAMPLES

# Ventron Site Characterization
## Soil Samples

| BUILDING A - ASH PILES | | WP-1 | | | WP-2 | | |
|---|---|---|---|---|---|---|---|
| | | 127CVP0101 | | | 127CVP0201 | | |
| | | Collected: 10/19/92 | | | Collected: 10/19/92 | | |
| | | 0.0- 0.0 | | | 0.0- 0.0 | | |
| | | Station: P01 | | | Station: P02 | | |
| | | Result | Lab* | Val* | Result | Lab* | Val* |
| **Inorganics** | **UNITS** | | | | | | |
| Aluminum | MG/KG | 1000 | = | J | 171 | = | J |
| Antimony | MG/KG | 12.3 | U | UJ | 12.3 | U | |
| Arsenic | MG/KG | 4.6 | = | | 2.1 | U | |
| Barium | MG/KG | 64.4 | = | | 41.1 | U | |
| Beryllium | MG/KG | 1 | U | R | 1 | U | |
| Boron | MG/KG | 20.8 | = | | 20.5 | U | |
| Cadmium | MG/KG | 2 | = | | 1 | U | |
| Calcium | MG/KG | 122000 | = | | 37800 | = | |
| Chromium | MG/KG | 62.4 | = | | 749 | = | |
| Cobalt | MG/KG | 10.3 | U | | 10.3 | U | |
| Copper | MG/KG | 42.2 | = | | 22.3 | = | |
| Iron | MG/KG | 2390 | = | | 4900 | = | |
| Lead | MG/KG | 263 | = | | 358 | = | |
| Magnesium | MG/KG | 229000 | = | | 282000 | = | |
| Manganese | MG/KG | 40 | = | | 361 | = | |
| Molybdenum | MG/KG | 20.6 | U | | 20.5 | U | |
| Nickel | MG/KG | 2550 | = | | 14800 | = | |
| Potassium | MG/KG | 11600 | = | | 42700 | = | |
| Selenium | MG/KG | 1 | U | UJ | 1 | U | |
| Silver | MG/KG | 16.2 | = | J | 7.8 | = | J |
| Sodium | MG/KG | 15200 | = | | 11500 | = | |
| Thallium | MG/KG | 2.1 | U | | 2.1 | U | |
| Vanadium | MG/KG | 10.3 | U | | 10.3 | U | |
| Zinc | MG/KG | 5880 | = | | 5210 | = | |
| **Organic Petroleum Hydrocarbons** | **UNITS** | | | | | | |
| Total Petroleum Hydrocarbons | MG/KG | 540 | = | | 900 | = | |
| **Pesticides and PCBs** | **UNITS** | | | | | | |
| Aldrin | UG/KG | 11 | U | UJ | 11 | U | UJ |
| alpha-BHC | UG/KG | 11 | U | UJ | 11 | U | UJ |
| alpha-Chlordane | UG/KG | 110 | U | UJ | 110 | U | UJ |
| Aroclor-1016 | UG/KG | 110 | U | UJ | 110 | U | UJ |
| Aroclor-1221 | UG/KG | 110 | U | UJ | 110 | U | UJ |
| Aroclor-1232 | UG/KG | 110 | U | UJ | 110 | U | UJ |
| Aroclor-1242 | UG/KG | 110 | U | UJ | 110 | U | UJ |
| Aroclor-1248 | UG/KG | 110 | U | UJ | 110 | U | UJ |
| Aroclor-1254 | UG/KG | 210 | U | UJ | 220 | U | UJ |
| Aroclor-1260 | UG/KG | 210 | U | UJ | 220 | U | UJ |
| beta-BHC | UG/KG | 11 | U | UJ | 11 | U | UJ |
| 4,4'-DDD | UG/KG | 21 | U | UJ | 22 | U | UJ |
| 4,4'-DDE | UG/KG | 21 | U | UJ | 22 | U | UJ |
| 4,4'-DDT | UG/KG | 21 | U | UJ | 22 | U | UJ |
| delta-BHC | UG/KG | 11 | U | UJ | 11 | U | UJ |
| Dieldrin | UG/KG | 21 | U | UJ | 22 | U | UJ |
| Endosulfan I | UG/KG | 11 | U | UJ | 11 | U | UJ |
| Endosulfan II | UG/KG | 21 | U | UJ | 22 | U | UJ |
| Endosulfan Sulfate | UG/KG | 21 | U | UJ | 22 | U | UJ |
| Endrin | UG/KG | 21 | U | UJ | 22 | U | UJ |
| Endrin Aldehyde | UG/KG | 21 | U | UJ | 22 | U | UJ |
| Endrin Ketone | UG/KG | 21 | U | UJ | 22 | U | UJ |
| gamma-BHC (Lindane) | UG/KG | 11 | U | UJ | 11 | U | UJ |
| gamma-Chlordane | UG/KG | 110 | U | UJ | 110 | U | UJ |
| Heptachlor | UG/KG | 11 | U | UJ | 11 | U | UJ |
| Heptachlor Epoxide | UG/KG | 11 | U | UJ | 11 | U | UJ |
| p,p'-Methoxychlor | UG/KG | 110 | U | UJ | 110 | U | UJ |
| Toxaphene | UG/KG | 210 | U | UJ | 220 | U | UJ |
| **Radiological** | **UNITS** | | | | | | |

**Ventron Site Characterization**
**Soil Samples**

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ra-226 | PCI/G | 26.000+/- | 0.62 | | 42.800+/- | 1.7 | | | | | | | | | | | |
| Th-230 | PCI/G | 0.220+/- | 0.22 | | 0.650+/- | 0.4 | | | | | | | | | | | |
| Thorium | PCI/G | 2.1 | | J | 2.4 | | J | | | | | | | | | | |
| U-238 | PCI/G | 10.3 | | J | 12.7 | | J | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| TCLP | UNITS | | | | | | | | | | | | | | | | |
| Arsenic | UG/L | 100 | U | | 100 | U | | | | | | | | | | | |
| Barium | UG/L | 200 | U | | 200 | U | | | | | | | | | | | |
| Cadmium | UG/L | 5 | U | | 5 | U | | | | | | | | | | | |
| Chromium | UG/L | 15.7 | = | | 11.3 | = | | | | | | | | | | | |
| Corrosivity by pH | PH | 11.2 | = | | 11 | = | | | | | | | | | | | |
| Cyanide, Reactive | MG/KG | 0.25 | U | | 0.25 | U | | | | | | | | | | | |
| Flash Point | DEG/F | 79 | = | | | | | | | | | | | | | | |
| Lead | UG/L | 90 | U | | 90 | U | | | | | | | | | | | |
| Mercury | UG/L | 0.2 | U | | 0.2 | U | | | | | | | | | | | |
| Selenium | UG/L | 100 | U | | 100 | U | | | | | | | | | | | |
| Silver | UG/L | 10 | U | | 10 | U | | | | | | | | | | | |
| Sulfide, Reactive | MG/KG | 0.5 | U | | 0.5 | U | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| * Note: LAB is the laboratory data qualifier, VAL is the data validation qualifer. | | | | | | | | | | | | | | | | | |

J indicates an estimated value. This flag is used when a target analyte is detected at a level less than the lower limit of quantification.

= indicates that no data qualifier is required; the results are considered reliable.

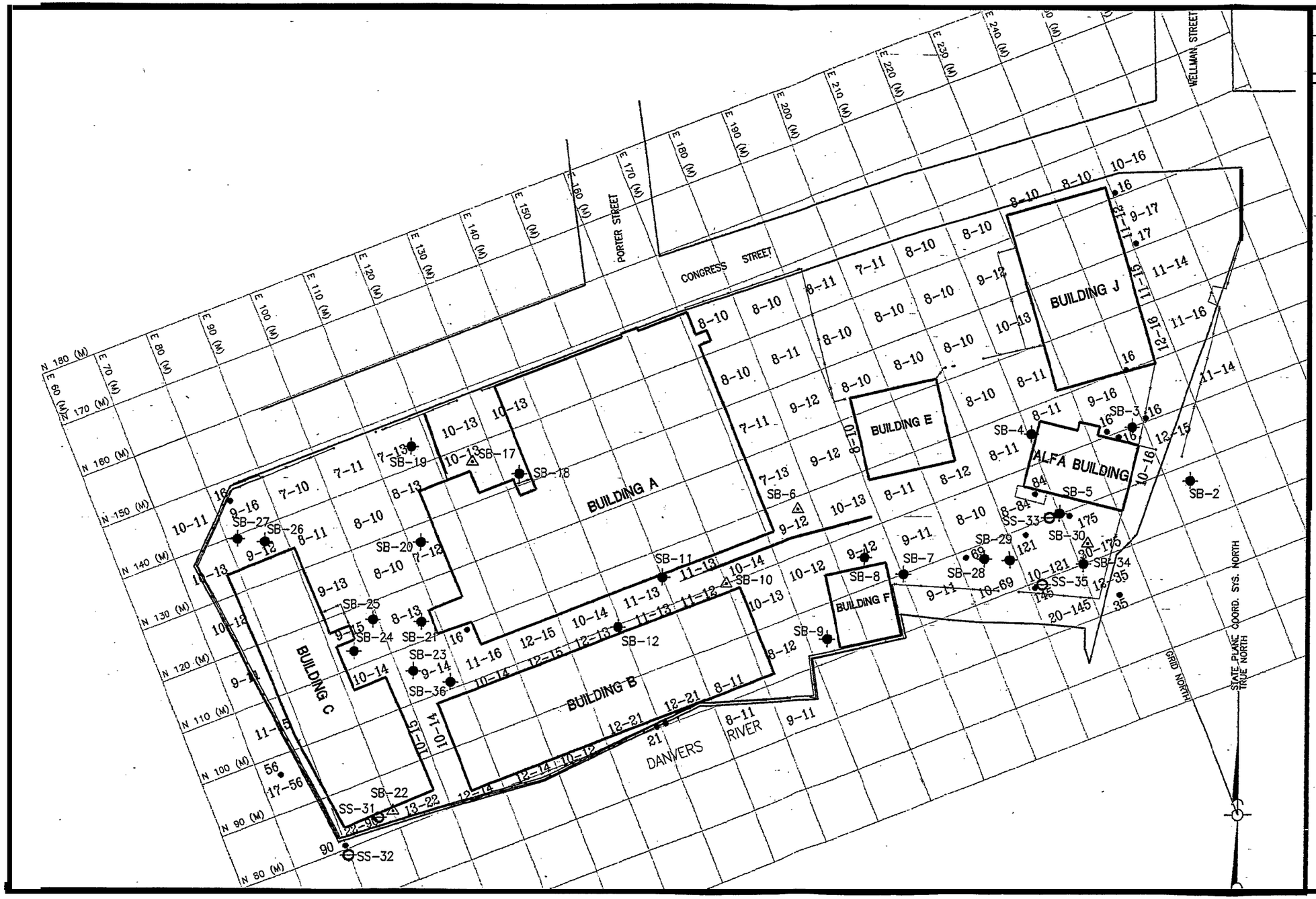
U indicates that the analysis was performed but the analyte was not detected. The minimum detection limit for the sample (not the method detection limit) is reported.

R rejected

138005

# APPENDIX C

# SITE MAPS - WALKOVER GAMMA SCAN, FIDLER WALKOVER, AND CONE SHIELDED GAMMA SCAN




LEGEND:

- BUILDING
- ROADS
- SB-1 SOIL BORING
- SS-31 SURFACE SOIL
- SB-6 CHEMICAL ANALYSIS
- 12 COUNTS PER MINUTE (x 1000)

0 10 20 40
SCALE: 1" = 18.28 meters

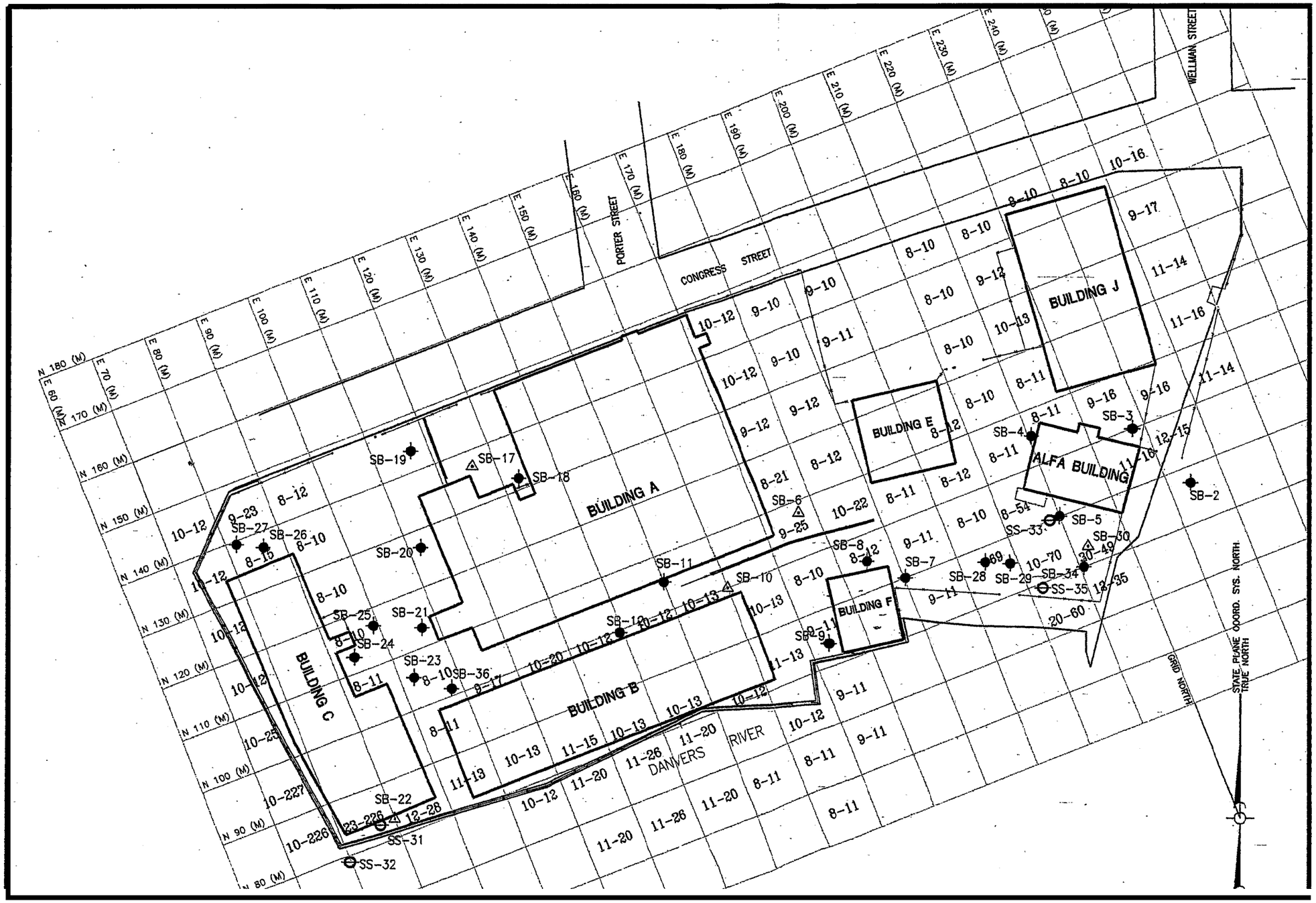
0 30 60 120
SCALE: 1" = 60'

**WALKOVER GAMMA SCAN CHARACTERIZATION REPORT VENTRON, MASS.**

| REVISION | DRAWN BY: | CHKD. BY: | DATE: |
|---|---|---|---|
| 0 | P. HOLM | B. TUCKER | 5/13/94 |

| XREFERENCES | PLOT FILES |
|---|---|
| | |

| 94017 | DWGS/853WGS | N/A |
|---|---|---|
| DRAWING # | CAD FILE # | ROT. ANGLE |




LEGEND:

- BUILDING
- ROADS
- SB-1 SOIL BORING
- SS-3 SURFACE SOIL
- SB-6 CHEMICAL ANALYSIS
- 12 COUNTS PER MINUTE (x 1000)

0 10 20 40
SCALE: 1" = 18.28 meters

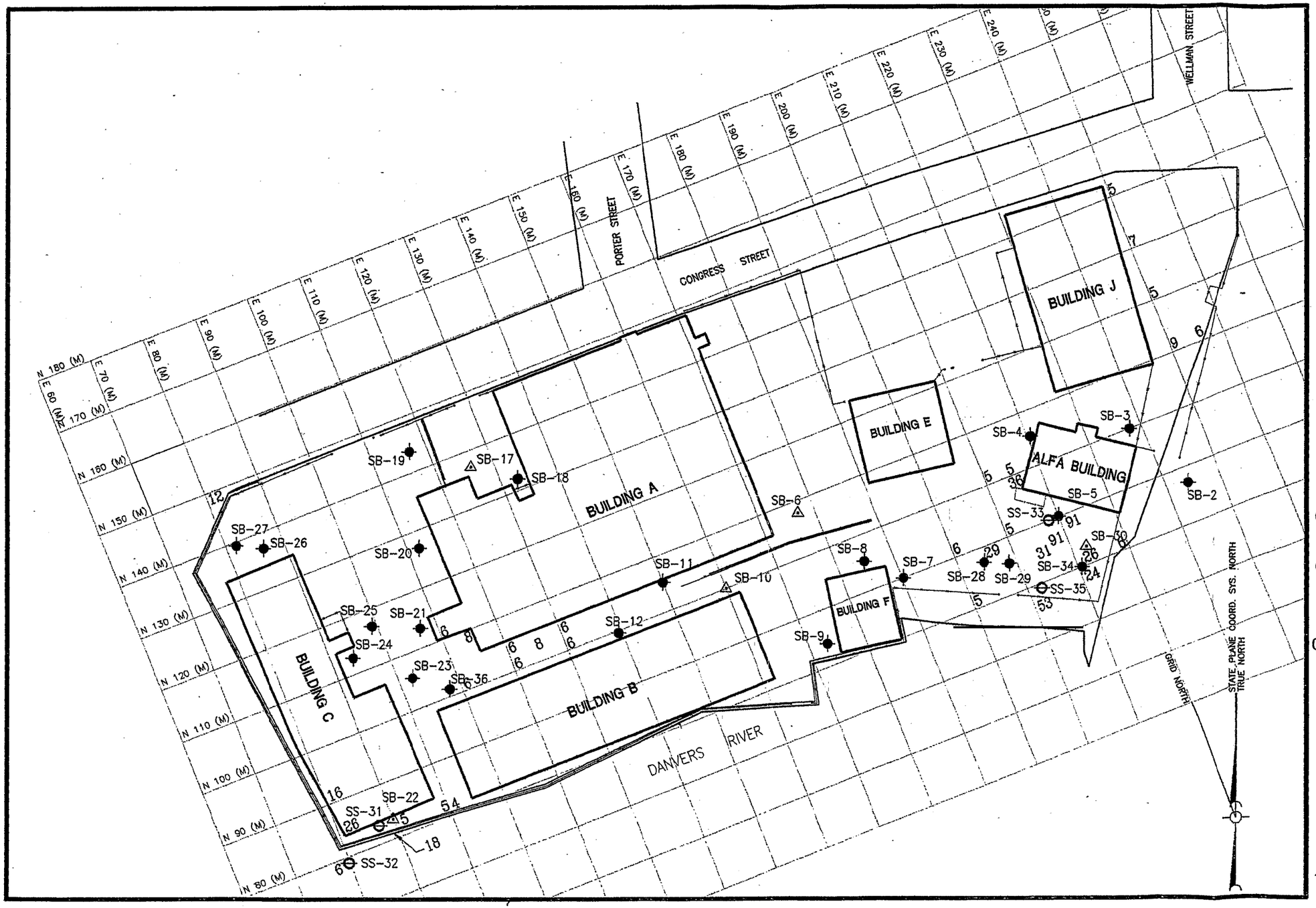
0 30 60 120
SCALE: 1" = 60'

**FIDLER WALKOVER CHARACTERIZATION REPORT VENTRON, MASS.**

| REVISION | DRAWN BY: | CHKD. BY: | DATE: |
|---|---|---|---|
| 0 | P. HOLM | B. TUCKER | 5/13/94 |

| XREFERENCES | PLOT FILES |
|---|---|
| | |

| 94017 | DWGS/653FDL | N/A |
|---|---|---|
| DRAWING # | CAD FILE # | ROT. ANGLE |




LEGEND:

- BUILDING
- ROADS
- SB-1 ..... SOIL BORING
- SS-3 ..... SURFACE SOIL
- SB-6 ..... CHEMICAL ANALYSIS
- 12.. ..... COUNTS PER MINUTE (x 1000)

0 10 20 40
SCALE: 1" = 18.28 meters

0 30 60 120
SCALE: 1" = 60'

**CONE SHIELDED GAMMA SURVEY CHARACTERIZATION REPORT VENTRON, MASS.**

| REVISION | DRAWN BY: | CHKD. BY: | DATE: |
|---|---|---|---|
| 0 | P. HOLM | B. TUCKER | 5/13/94 |

| XREFERENCES | PLOT FILES |
|---|---|
| | |

| 94017 | DWGS/653GNA | N/A |
|---|---|---|
| DRAWING # | CAD FILE # | ROT. ANGLE |

138005

# APPENDIX D

# GEOLOGIC DRILL LOGS
# BOREHOLE GAMMA LOG VALUES

138005

# APPENDIX D-1

# BOREHOLE GAMMA LOG VALUES

## TABLE D-1 Borehole Gamma Log values

138005

| Borehole | SB-2 | SB-3 | SB-4 | SB-5 | SB-6 | SB-7 | SB-8 | SB-9 | SB-10 |
|---|---|---|---|---|---|---|---|---|---|
| Depth | Gamma | Gamma | Gamma | Gamma | Gamma | Gamma | Gamma | Gamma | Gamma |
| 0 | 9955 | 11806 | 8706 | 37729 | 13370 | 8535 | 14981 | 9719 | 13668 |
| 0.5 | 12921 | 20331 | 10117 | 39289 | 16781 | 13520 | 15575 | 11153 | 15152 |
| 1 | 16653 | 35258 | 14518 | 30308 | 16836 | 14620 | 16090 | 11410 | 20869 |
| 1.5 | 20211 | 30498 | 16738 | 24722 | 17302 | 14137 | 16823 | 14189 | 23433 |
| 2 | 18479 | 21959 | 18353 | 20785 | 18049 | 14647 | 17628 | 15261 | 26901 |
| 2.5 | 16408 | 22215 | 17746 | 18669 | 18018 | 16805 | 17759 | 18152 | 28085 |
| 3 | 16151 | 21466 | 17513 | 18154 | 17381 | 16043 | 17596 | 18196 | 32799 |
| 3.5 | 15858 | 23535 | 16446 | 17253 | 16271 | 14412 | 17415 | 15310 | 37355 |
| 4 | 16052 | 24449 | 15336 | 17434 | 16420 | 14102 | 17422 | 16193 | 35884 |
| 4.5 | 16528 | 25005 | 15479 | 18092 | PVC 4 | 14128 | 17526 | 16642 | 34123 |
| 5 | 16079 | 23948 | 16253 | 18678 | | 15030 | 17392 | 16193 | 32780 |
| 5.5 | 16709 | 21435 | 16297 | 19871 | | 15227 | 18248 | 17143 | 35081 |
| 6 | 18964 | 20075 | 14375 | 20382 | | 15509 | 18751 | 18751 | 41033 |
| 6.5 | 19693 | 21493 | 13197 | 21442 | | 15496 | 17544 | 19093 | PVC 6 |
| 7 | 19141 | 18279 | 14499 | 22853 | | 15657 | 17392 | 17549 | |
| 7.5 | 18530 | 16939 | 14263 | 25565 | | 15369 | 18182 | 20516 | |
| 8 | 18543 | 16258 | 14352 | 21936 | | 15566 | PVC 7.5 | 20888 | |
| 8.5 | 19113 | 16330 | 14457 | 18502 | | 14897 | | 23387 | |
| 9 | 18970 | 16373 | 14249 | 17543 | | 14405 | | 25377 | |
| 9.5 | 18836 | 16960 | 13250 | 17432 | | 14068 | | 27157 | |
| 10 | 18780 | 17468 | 12620 | 18083 | | 14475 | | 29459 | |
| 10.5 | 19253 | 19989 | 12438 | 18945 | | 16391 | | 29469 | |
| 11 | 17948 | 20918 | 11189 | 18527 | | 10.8 Bdrck | | 37507 | |
| 11.5 | 14831 | 20551 | 10755 | 19771 | | | | | |
| 12 | 12982 | | | PVC 11.5 | | | | | |
| 12.5 | 12885 | | | | | | | | |
| 13 | 14022 | | | | | | | | |
| 13.5 | 15341 | | | | | | | | |
| 14 | 17086 | | | | | | | | |
| 14.5 | 15952 | | | | | | | | |
| 15 | 14024 | | | | | | | | |
| 15.5 | 13569 | | | | | | | | |
| 16 | 12751 | | | | | | | | |
| 16.5 | 11950 | | | | | | | | |
| 17 | 12210 | | | | | | | | |
| 17.5 | 12860 | | | | | | | | |
| 18 | 13550 | | | | | | | | |
| 18.5 | 14173 | | | | | | | | |
| 19 | 13853 | | | | | | | | |
| 19.5 | 14472 | | | | | | | | |
| 20 | 16031 | | | | | | | | |
| 20.5 | 16213 | | | | | | | | |
| 21 | 16830 | | | | | | | | |
| 21.5 | 18063 | | | | | | | | |
| 22 | 18452 | | | | | | | | |
| | PVC 22 | | | | | | | | |

## TABLE D-1 Borehole Gamma Log values

138005

| Borehole Depth | SB-11 Gamma | SB-12 Gamma | SB-17 Gamma | SB-18 Gamma | SB-19 Gamma | SB-20 Gamma | SB-21 Gamma | SB-23 Gamma | |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 10163 | 12395 | 8741 | 10223 | 9522 | 8958 | 8903 | 15951 | |
| 0.5 | 12609 | 14539 | 11869 | 10770 | 11324 | 10064 | 11918 | 17988 | |
| 1 | 14819 | 15728 | 14242 | 14481 | 14134 | 12572 | 14319 | 21114 | |
| 1.5 | 15180 | 16639 | 14731 | 11920 | 14898 | 14201 | 16262 | 23288 | |
| 2 | 11373 | 17539 | 15196 | 8733 | 15353 | 11831 | 18592 | 23449 | |
| 2.5 | 20385 | 19179 | 14045 | 8183 | 15412 | 13131 | 19132 | 24581 | |
| 3 | Bdrock | 21629 | 13954 | 8669 | 15638 | 11681 | bdrock | 22563 | |
| 3.5 | | 22422 | 16955 | refusal | 15273 | 11569 | | 23352 | |
| 4 | | pvc 3.5 | 14069 | | 15540 | | | 24973 | |
| 4.5 | | | 14122 | | 15410 | | | 24200 | |
| 5 | | | 14288 | | 15333 | | | 24084 | |
| 5.5 | | | 13244 | | 15106 | | | 23879 | |
| 6 | | | | | 15125 | | | 24391 | |
| 6.5 | | | | | pvc 6.0 | | | 24072 | |
| 7 | | | | | | | | 23954 | |
| 7.5 | | | | | | | | pvc 7.0 | |

## TABLE D-1 Borehole Gamma Log values

138005

| Borehole | SB-24 | | SB-24 cont | | SB-25 | SB-26 | | SB-26cont | |
|---|---|---|---|---|---|---|---|---|---|
| Depth | Gamma | depth | | Depth | Gamma | | depth | | |
| 0 | 10344 | 22.5 | 14255 | 0 | 12222 | 12925 | 22.5 | 11962 | |
| 0.5 | 10974 | 23 | 16548 | 0.5 | 11956 | 11043 | 23 | 11163 | |
| 1 | 11033 | 23.5 | 18792 | 1 | 15832 | 13246 | 23.5 | 10782 | |
| 1.5 | 10990 | 24 | 20562 | 1.5 | 17195 | 16110 | 24 | 10915 | |
| 2 | 11098 | 24.5 | 22682 | 2 | 18134 | 19525 | 24.5 | 11858 | |
| 2.5 | 12511 | 25 | 24409 | 2.5 | 17306 | 16133 | 25 | 11881 | |
| 3 | 13224 | 25.5 | 23929 | 3 | 14414 | 28754 | 25.5 | 11410 | |
| 3.5 | 14491 | 26 | 24778 | 3.5 | 12961 | 30440 | 26 | 10614 | |
| 4 | 15200 | 26.5 | 24746 | 4 | 11731 | 31290 | 26.5 | 10258 | |
| 4.5 | 17687 | 27 | 23889 | 4.5 | 12019 | 30722 | 27 | 10578 | |
| 5 | 19814 | 27.5 | 22699 | 5 | 11999 | 25535 | 27.5 | 11695 | |
| 5.5 | 22186 | 28 | 20861 | 5.5 | pvc 5.0 | 24446 | 28 | 11272 | |
| 6 | 23645 | 28.5 | 19496 | 6 | | 23209 | 28.5 | 11214 | |
| 6.5 | 23851 | 29 | 18711 | 6.5 | | 20932 | 29 | 12921 | |
| 7 | 24263 | 29.5 | 18082 | 7 | | 18850 | 29.5 | 13570 | |
| 7.5 | 26445 | 30 | 17309 | 7.5 | | 17244 | 30 | 13131 | |
| 8 | 34168 | 30.5 | 16199 | 8 | | 16112 | 30.5 | 13064 | |
| 8.5 | 41384 | 31 | 15360 | 8.5 | | 15919 | 31 | pvc 30.5 | |
| 9 | 57334 | 31.5 | 15114 | 9 | | 16504 | | | |
| 9.5 | 50232 | 32 | 15649 | 9.5 | | 16176 | | | |
| 10 | 35579 | 32.5 | 15348 | 10 | | 16081 | | | |
| 10.5 | 39806 | 33 | 14913 | 10.5 | | 16028 | | | |
| 11 | 43095 | 33.5 | 15100 | 11 | | 14538 | | | |
| 11.5 | 48026 | 34 | 15141 | 11.5 | | 13968 | | | |
| 12 | 41231 | 34.5 | 14448 | 12 | | 15098 | | | |
| 12.5 | 27365 | 35 | 13556 | 12.5 | | 13873 | | | |
| 13 | 21206 | | | 13 | | 13298 | | | |
| 13.5 | 16698 | | | 13.5 | | 14465 | | | |
| 14 | 14581 | | | 14 | | 16788 | | | |
| 14.5 | 12443 | | | 14.5 | | 21738 | | | |
| 15 | 11659 | | | 15 | | 23770 | | | |
| 15.5 | 11038 | | | 15.5 | | 25275 | | | |
| 16 | 10840 | | | 16 | | 26224 | | | |
| 16.5 | 10764 | | | 16.5 | | 26049 | | | |
| 17 | 10448 | | | 17 | | 25548 | | | |
| 17.5 | 10391 | | | 17.5 | | 26130 | | | |
| 18 | 10402 | | | 18 | | 25010 | | | |
| 18.5 | 10491 | | | 18.5 | | 24380 | | | |
| 19 | 10409 | | | 19 | | 28570 | | | |
| 19.5 | 10724 | | | 19.5 | | 26559 | | | |
| 20 | 10503 | | | 20 | | 23630 | | | |
| 20.5 | 10635 | | | 20.5 | | 19064 | | | |
| 21 | 10602 | | | 21 | | 16348 | | | |
| 21.5 | 10870 | | | 21.5 | | 14296 | | | |
| 22 | 11680 | | | 22 | | 13390 | | | |

## TABLE D-1 Borehole Gamma Log values

138005

| Borehole Depth | SB-27 Gamma | SB-28 Gamma | SB-29 Gamma | SB-30 Gamma | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 2041 | 61288 | 72682 | 24528 | | | | | |
| 0.5 | 3198 | 65439 | 51623 | 40806 | | | | | |
| 1 | 3140 | 53712 | 33981 | 25991 | | | | | |
| 1.5 | 3111 | 38518 | 26596 | 18394 | | | | | |
| 2 | 3002 | 35582 | 22430 | 17625 | | | | | |
| 2.5 | 2970 | 28756 | 23152 | 18699 | | | | | |
| 3 | 3106 | 24192 | | 17524 | | | | | |
| 3.5 | 3256 | 30726 | | 16716 | | | | | |
| 4 | 3409 | 32336 | | 17513 | | | | | |
| 4.5 | 3411 | 31791 | | 18455 | | | | | |
| 5 | 3354 | 42598 | | 18271 | | | | | |
| 5.5 | 3223 | 48782 | | 18020 | | | | | |
| 6 | 2863 | 36179 | | 17384 | | | | | |
| 6.5 | 2744 | 32054 | | 17931 | | | | | |
| 7 | 2682 | 29659 | | 18994 | | | | | |
| 7.5 | 2928 | 25885 | | 22201 | | | | | |
| 8 | 2844 | pvc 7.5 | | 14191 | | | | | |
| 8.5 | 2914 | | | 24153 | | | | | |
| 9 | 2820 | | | 22703 | | | | | |
| 9.5 | 2550 | | | | | | | | |
| 10 | 2406 | | | | | | | | |
| 10.5 | 2558 | | | | | | | | |
| 11 | 2774 | | | | | | | | |
| 11.5 | | | | | | | | | |

Note: Shaded values have analyses above DOE soil guidelines.

138005

# APPENDIX D-2

# GEOLOGIC DRILL LOGS

**Editor's Note:**

**PAGES MARKED AS DRAFT**

**IN ORIGINAL FILE COPY**

THIS PAGE INTENTIONALLY LEFT BLANK.

3560

# DRAFT

138005

BECHTEL

## GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| FUSRAP | 14501 | 1 OF 1 | SB-2 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 87.0 E 244.0 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-11-92 | 9-11-92 | Hydro Group, Inc. | Soil Sentry | 8" | 22.8 | 0.2 | 23.0 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 13.9/60 | | 12 | | NA | / / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G.Pais |

(Template: BCHTLLS)

| SAMP TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | BLOWS 6" / % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME IN MIN. | ELEV. (NA) | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS | 2.0 | 1.5 | 7 18 17 19 | | | | | | | | 0.0 - 0.3 ft: ROADBASE MATERIAL. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 1.3 | 14 5 10 8 | | | | | | | | 0.3 - 9.6 ft: FILL; Gravelly Sand and Silty Sand, Dusky yellowish brown (10 YR 2/2), fine to coarse grained sand, some silt, sub-angular grains, dry, friable, brick fragments, glass shards, cinder, ash, trace metal pieces, and trace organics. | |
| SS | 2.0 | 1.0 | 8 7 7 6 | | | | | 5 | | | | 4" PVC casing inserted to 22.0 ft. for gamma-logging. |
| SS | 2.0 | 0.7 | 5 4 5 5 | | | | | | | | | |
| SS | 2.0 | 0.9 | 14 6 4 3 | | | | | | | | | |
| SS | 2.0 | 1.6 | 4 7 14 8 | | | | | 10 | | | 9.6 - 11.0 ft: SILTY SAND TO SANDY SILT (SM); Olive gray (5 Y 3/2), (5 Y 4/1), fine to medium grained, sub-angular to sub-rounded grains, medium well-sorted, moist, slight plasticity. | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| SS | 2.0 | 0.6 | 8 9 11 11 | | | | | | | | 11.0 - 17.2 ft: GRAVELLY SAND (SG); Olive gray (5 y 4/1), fine to coarse grained sand, su-angular grains, medium well to poorly-sorted, sub-rounded gravel clasts, slighlty moist to moist. | |
| SS | 2.0 | 0.5 | 9 3 3 10 | | | | | 15 | | | | Description and classification by visual examination of sample. |
| SS | 2.0 | 0.9 | 12 3 8 13 | | | | | | | | | |
| SS | 2.0 | 2.0 | 20 20 13 39 | | | | | | | | 17.2 - 18.0 ft: GRAVEL (GS); Dusky yellowish brown (10 YR 2/2), sub-rounded to rounded gravel clasts, sub-angular to sub-rounded sand grains, 10% sand, medium well-sorted, saturated. | |
| SS | 2.0 | 2.0 | 8 12 26 35 | | | | | 20 | | | 18.0 - 22.8 ft: SILTY SAND (SM); Moderate yellowish brown (10 YR 5/4), very fine to medium grained, sub-angular grains, medium well-sorted, saturated.<br>19.0 - 21.0 ft: Silty Sand, Olive gray (5 Y 4/1), very fine to medium grained, 20% silt, saturated, very slight plasticity.<br>21.0 - 22.8 ft: Silty Sand, Moderate yellowish brown (10 YR 5/4), very fine to medium grained, sub-angular to sub-rounded grains,medium well-sorted, saturated. | |
| SS | 1.0 | 0.9 | 14 50/5" | | | | | | | | 22.8 -23.0 ft: DIORITE.<br>TOTAL DEPTH = 23.0 FT. | Colors from "Rock-Color Chart" (GSA, 1948). |

SS = 2" O.D. SPLIT SPOON; CN = CNE | SITE

113560

# DRAFT

138005

| GEOLOGIC DRILL LOG | PROJECT: FUSRAP | JOB NO.: 14501 | SHEET NO.: 1 OF 1 | HOLE NO.: SB-3 |
|---|---|---|---|---|

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 100.0 E 238.0 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-8-92 | 9-8-92 | Hydro Group, Inc. | Soil Sentry | 8" | 12.0 | 0.2 | 12.2 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 6.8/56 | | 7 | | NA | / / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G. Pais |

(Template: BCHTLLS)

| SAMP. TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | BLOWS 6" SAMPLE % CORE RECOVERY | WATER PRESSURE TESTS: LOSS G.P.M | PRESS. P.S.I. | TIME MIN. | ELEV. | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | NA | | | | | |
| SS | 2.0 | 1.2 | 4 7 8 12 | | | | | | | | 0.0 - 9.0 ft: FILL. 0.0 - 4.2 ft: Sandy Loam, Dusky yellowish brown (10 YR 2/2), dry, trace gravel, cinder, ash, and organics. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 1.2 | 9 7 7 6 | | | | | | | | | |
| SS | 2.0 | 1.6 | 8 6 5 4 | | | | | 5 | | | 4.2 - 9.0 ft: Silty Sand, Dark yellowish brown (10 YR 4/2), dry, friable, trace clay, slightly dense, no plasticity, trace concrete and gravel pebbles and cobbles. | 4" PVC casing inserted to 11.5 ft. for gamma-logging. |
| SS | 2.0 | 1.2 | 4 4 4 8 | | | | | | | | | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| SS | 2.0 | 1.2 | 9 9 6 6 | | | | | | | | | |
| SS | 2.0 | 0.2 | 14 15 10 28 | | | | | 10 | | | 9.0 - 12.0 ft: SILTY SAND (SM); Moderate yellowish brown (10 YR 5/4), dry, friable, no plasticity, trace gravel cobbles, fine to medium grained slightly moist, possible natural material. | Description and classification by visual examination of sample. |
| SS | 0.2 | 0.2 | 50/2" | | | | | | | | 12.0 - 12.2 ft: DIORITE. | |
| | | | | | | | | | | | TOTAL DEPTH = 12.2 FT. | |
| | | | | | | | | | | | | Colors from "Rock-Color Chart" (GSA, 1948). |

SS = 2" O.D. SPLIT SPOON; CM = CME

BECHTEL

DRAFT

113560
138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| FUSRAP | 14501 | 1 OF 1 | SB-4 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 104.5 E 222.5 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-8-92 | 9-8-92 | Hydro Group, Inc. | Soil Sentry | 8" | 12.5 | 0 | 12.6 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 7.3/66 | | 7 | | NA | / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G.Pais |

(Template: BCHTLLS)

| SAMP. TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | BLOWS PER 6" % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME IN MIN. | ELEV. NA | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 0.0 - 0.5 ft: ASPHALT. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 0.6 | 6 7 14 7 | | | | | | | | 0.5 - 5.0 ft: FILL; 0.0 - 5.0 ft: Gravelly Sand, Olive gray (5 Y 3/2), Dark yellowish brown (10 YR 4/2), dry, friable, trace granite pebbles and cobble, fine to coarse grained sand, sub-angular to sub-rounded grains. | |
| SS | 2.0 | 0.7 | 4 6 3 9 | | | | | | | | | |
| SS | 2.0 | 1.3 | 30 32 74 74 | | | | | 5 | | | 5.0 - 5.8 ft: Gravelly Sand, Moderate yellowish brown (10 YR 5/4), to Dark yellowish brown (10 YR 6/1), dry, friable, poorly sorted, granite pebbles and cobbles, fine to coarse grained, sub-angular to sub-rounded grains. | 4" PVC casing inserted to 11.5 ft. for gamma-logging. |
| SS | 1.2 | 1.2 | 30 74 50/2" | | | | | | | | 5.8 - 8.5 ft: GRAVELLY SAND (SG); Dusky brown (5 YR 2/2), fine to coarse grained, sub-angular to sub-rounded grains, poorly sorted, trace silt and clay, slightly moist. | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| SS | 1.8 | 1.6 | 33 68 72 100/3" | | | | | 10 | | | 8.5 - 12.5 ft: GLACIAL TILL; Light olive gray (5 Y 5/6), dense, firm, no plasticity, gravel to clay size range, slightly moist to moist. | Description and classification by visual examination of sample. |
| SS | 1.8 | 1.8 | 40 40 94 100/3" | | | | | | | | | |
| SS | 0.1 | 0.1 | 50/1" | | | | | | | | TOTAL DEPTH = 12.5 FT. | Colors from "Rock-Color Chart" (GSA, 1948). |

SS = 2" O.D. SPLIT SPOON; CN = CME | SITE | Last Updated: | HOLE NO.

113560

138005

DRAFT

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| FUSRAP | 14501 | 1 OF 1 | SB-5 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 90.0 E 220.0 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-14-92 | 9-14-92 | Hydro Group, Inc. | Soil Sentry | 8" | 12.8 | 0.0 | 12.8 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 5.6/44 | | 7 | | NA | / / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G.Pais |

(Template: BCHTLLS)

| SAMP. TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | BLOWS "N" % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME MIN. | ELEV. | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS | 2.0 | 1.3 | 6 14 29 7 | | | | NA | | | | 0.0 -0.3 ft: SILTY LOAM (OL); Moderate yellowish brown (10 YR 5/4), dry, friable, 10% sand, rootlets. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| | | | | | | | | | | | 0.3 -12.5 ft: FILL. 0.3 -10.2 ft: Gravelly Sand, Dusky brown (5 YR 2/2), fine to coarse grained, sub-angular to sub-rounded grains, dry, friable, no plasticity, glass shards, wood, porcelin, trace plastic, coal and organics. | |
| SS | 2.0 | 0.8 | 17 7 10 25 | | | | | | | | | |
| SS | 2.0 | 0.9 | 5 5 22 8 | | | | | 5 | | | | 4" PVC casing inserted to 11.5 ft. for gamma-logging. |
| SS | 2.0 | 1.3 | 4 4 5 10 | | | | | | | | | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| SS | 2.0 | 0.2 | 18 7 9 9 | | | | | | | | | |
| SS | 2.0 | 0.5 | 5 6 5 4 | | | | | 10 | | | 10.2 - 12.5 ft: Silty Sand, Moderate yellowish brown (10 YR 5/4), very fine to medium grained, sub-angular grains, slightly moist, no plasticity, porcelin shards, trace coal. | Description and classification by visual examination of sample. |
| SS | 0.8 | 0.6 | 5 100/3" | | | | | | | | 12.5 - 12.8 ft: DIORITE. | |
| | | | | | | | | | | | TOTAL DEPTH = 12.8 FT. | Colors from "Rock-Color Chart" (GSA, 1948). |

SS = 2" O.D. SPLIT SPOON; CN = CME

DRAFT

113560

138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| *FUSRAP* | 14501 | 1 OF 1 | SB-6 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 108.0 E 177.0 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-10-92 | 9-10-92 | Hydro Group, Inc. | Soil Sentry | 8" | 4.5 | 0.5 | 5.0 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 3.3/66 | | 3 | | NA | / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G.Pais |

(Template: BCHTLLS)

| SAMP. TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | SAMPLE BLOWS 6" / % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME IN MIN. | ELEV. | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS | 2.0 | 1.2 | 1<br>1<br>4<br>5 | | | | NA | | | | 0.0 - 4.5 FT: FILL.<br>0.0 - 0.4 ft: Organic Loam, Dusky yellowish brown (10 YR 2/2), sandy silt with roots, dry, friable.<br>0.4 - 4.5 ft: Silty Sand, Moderate yellowish brown (10 YR 5/4), fine to medium grained, sub-angular to sub-rounded grains, dry, friable, rootlets, increase gravel percentage at 2.2 ft. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 1.3 | 7<br>30<br>11/5" | | | | | | | | | |
| SS | 1.0 | 0.8 | 40<br>100/2" | | | | | | | | | 4" PVC casing inserted to 4.0 ft. for gamma-logging. |
| | | | | | | | | | | | 4.5 - 5.0 ft: DIORITIC GRANITE BEDROCK. | |
| | | | | | | | | 5 | | | TOTAL DEPTH = 5.0 FT. | |
| | | | | | | | | | | | | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| | | | | | | | | | | | | Description and classification by visual examination of sample. |
| | | | | | | | | | | | | Colors from "Rock-Color Chart" (GSA, 1948). |

SS = 2" O.D. SPLIT SPOON; CN = CME | SITE

DRAFT 138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| FUSRAP | 14501 | 1 OF 1 | SB-7 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 90.0 E 190.0 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-11-92 | 9-11-92 | Hydro Group, Inc. | Soil Sentry | 8" | 10.8 | 0.45 | 11.5 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 5.7/50 | | 6 | | NA | / / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G. Pais |

(Template: BCHTLLS)

| SAMP TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | SAMPLE BLOWS 4" % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME IN MIN. | ELEV. | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS | 2.0 | 0.9 | 9 8 20 18 | | | | NA | | | | 0.0 - 0.3 ASPHALT. 0.3 - 10.8 ft: FILL. 0.3 - 4.0 ft: Gravelly Sand, Dusky yellowish brown (10 YR 2/2) to moderate yellowish brown (10 YR 5/4), fine to coarse grained, sub-angular to sub-rounded grains, granitic gravel clasts, dry to slightly moist, friable. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 0.2 | 8 8 8 7 | | | | | | | | | |
| SS | 2.0 | 1.6 | 4 3 3 4 | | | | | 5 | | | 4.0 - 5.1 ft: Clayey Sand with Gravel, moderate yellowish brown (10 YR 5/4), slightly moist, dense, slightly plastic. 5.1 - 10.8 ft: Sand, Dusky brown (5 YR 2/2), coarse grained, slightly moist, no plasticity, rootlets, brick fragments, coal, wood pieces. | 4" PVC casing inserted to 10.5 ft. for gamma-logging. |
| SS | 2.0 | 1.1 | 1 2 3 5 | | | | | | | | | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| SS | 2.0 | 0.9 | 21 12 7 7 | | | | | | | | | |
| SS | 1.5 | 1.0 | 8 44 100/3" | | | | | 10 | | | 10.8 - 11.25 ft: DIORITE BEDROCK. TOTAL DEPTH = 11.25 FT. | Description and classification by visual examination of sample. |

Colors from "Rock-Color Chart" (GSA, 1948).

DRAFT

138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| FUSRAP | 14501 | 1 OF 1 | SB-8 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 95.0 E 184.0 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-10-92 | 9-10-92 | Hydro Group, Inc. | Soil Sentry | 8" | 12.0 | 0.5 | 12.5 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 4.7/39 | | 6 | | NA | / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G.Pais |

(Template: BCHTLLS)

| SAMP. TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | SAMPLE "N" BLOWS % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME IN MIN. | ELEV. NA | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 0.0 - 0.5 ft: ASPHALT. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 1.2 | 4 16 16 13 | | | | | | | | 0.5 - 12.0 ft: FILL; Gravelly Sand, Dusky yellowish brown (10 YR 2/2) to moderate yellowish brown (10 YR 5/4), fine to coarse grained, sub-angular to sub-rounded grains, medium well sorted, slightly moist, no plasticity, trace brick and concrete, glass shards in places. | |
| SS | 2.0 | 0.4 | 10 8 6 8 | | | | | | | | | |
| SS | 2.0 | 0.0 | 8 8 11 8 | | | | | 5 | | | | 4" PVC casing inserted to 7.5 ft. for gamma-logging. |
| SS | 2.0 | 0.2 | 12 10 8 11 | | | | | | | | | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| SS | 2.0 | 1.5 | 12 12 28 66 | | | | | 10 | | | | |
| SS | 2.0 | 1.4 | 40 40 90 80/2" | | | | | | | | | Description and classification by visual examination of sample. |
| | | | | | | | | | | | 12.0 - 12.5 ft: DIORITIC GRANITE BEDROCK. | |
| | | | | | | | | | | | TOTAL DEPTH = 12.5 FT. | |
| | | | | | | | | | | | | Colors from "Rock-Color Chart" (GSA, 1948). |

SS = 2" O.D. SPLIT SPOON; CN = CME CONTINUOUS SAMPLER

SITE VENTRON

Last Update:

HOLE NO.

DRAFT 138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| FUSRAP | 14501 | 1 OF 1 | SB-9 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 84.0 E 173.5 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-8-92 | 9-8-92 | Hydro Group, Inc. | Soil Sentry | 8" | 12.5 | | 12.5 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 3.7/31 | | 6 | | NA | / / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G. Pais |

(Template: BCHTLLS)

| SAMP. TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | SAMPLE "N" BLOWS % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME IN MIN. | ELEV. NA | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 0.0 - 0.5 ASPHALT. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 0.7 | 12 20 45 35 | | | | | | | | 0.5 - 12.0 ft: FILL. 0.5 - 4.5 ft: Sandy Gravel, Olive gray (5 Y 4/1), slightly moist, friable, poorly sorted, man-made constiuents. | |
| SS | 2.0 | 0.7 | 21 34 24 25 | | | | | | | | | |
| SS | 2.0 | 0.0 | 12 16 12 11 | | | | | 5 | | | 4.5 - 12.0 ft: Sandy Gravel, Dark yelowish brown (10 YR 4/2), moist to saturated, fine to coarse grained sand, medium well sorted, trace brick and wood fragments. | 4" PVC casing inserted to 11.0 ft. for gamma-logging. |
| SS | 2.0 | 0.4 | 7 8 5 3 | | | | | | | | | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| SS | 2.0 | 0.9 | 7 10 25 11 | | | | | 10 | | | | |
| SS | 2.0 | 1.0 | 30 35 30 90 | | | | | | | | | Description and classification by visual examination of sample. |
| | | | | | | | | | | | 12.0 -12.5 ft: SAND (SM); Moderate olive brown (5 Y 4/4), to light olive brown (5 Y 5/6), trace gravel and silt, dense, moist, wood fragments. | |
| | | | | | | | | | | | TOTAL DEPTH = 12.5 FT. | |
| | | | | | | | | | | | | Colors from "Rock-Color Chart" (GSA, 1948). |

SS = 2" O.D. SPLIT SPOON; CM = CME

DRAFT 138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| *FUSRAP* | 14501 | 1 OF 1 | SB-10 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 100.0 E 160.0 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-9-92 | 9-9-92 | Hydro Group, Inc. | Soil Sentry | 8" | 5.5 | 1.0 | 6.5 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 2.1/35 | | 4 | | NA | / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G. Pais |

(Template: BCHTLLS)

| SAMP. TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | BLOWS PER 6" % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME IN MIN. | ELEV. | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | NA | | | | 0.0 - 0.5 ft: ASPHALT. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 0.2 | 9 9 6 8 | | | | | | | SS | 0.5 - 5.5 ft: FILL. 0.5 - 3.5 ft: Gravelly Sand, Dusky yellowish brown (10 YR 2/2), medium to coarse grained, sub-rounded to rounded pebbles and grains, no plasicity, very slightly moist. | |
| SS | 2.0 | 0.8 | 12 17 18 45 | | | | | | | | 3.5 - 4.0 ft: Gravel, Moderate brown (5 YR 3/4), pebble to cobble sized, drilling induced fractures on cobbles, 10% sand and 10% silt, dry and friable. | |
| SS | 1.5 | 1.1 | 44 44 100/6" | | | | | 5 | | | 4.0 - 5.5 ft: Gravelly Sand, Dusky yellowish brown (10 YR 2/2), fine to coarse grained, sub=-angular to sub-rounded grains, medium well-sorted, no plasticity, slightly moist. | 4" PVC casing inserted to 6.0 ft. for gamma-logging. |
| SS | 0.5 | 0.0 | 100/5" | | | | | | | | 5.5 - 6.5 ft: GRANITE; Pale red (10 R 6/1), highly fractured and weathered, K-feldspar, quarts, biotite, fresh angular breaks, dense. | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| | | | | | | | | | | | TOTAL DEPTH = 6.5 FT. | |

Description and classification by visual examination of sample.

Colors from "Rock-Color Chart" (GSA, 1948).

SS = 2" O.D. SPLIT SPOON; CN = CME CONTINUOUS SAMPLER

DRAFT

138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| *FUSRAP* | 14501 | 1 OF 1 | SB-11 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 105.0 E 150.0 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-9-92 | 9-9-92 | Hydro Group, Inc. | Soil Sentry | 8" | 3.0 | | 3.5 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 2.4/80 | | 2 | | NA | / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G. Pais |

(Template: BCHTLLS)

| SAMP TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | SAMPLE BLOWS 6" / % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME IN MIN. | ELEV. | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | NA | | | | 0.0 - 0.5 ft: ASPHALT. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 1.6 | 4 7 11 20 | | | | | | | | 0.5 - 3.5 ft: FILL; Gravelly Sand, Olive gray (5 Y 4/1) to Dark yellowish brown (10 YR 4/2), fine to coarse grained, sub-angular to sub-rounded grains, medium well-sorted, moist. | |
| SS | 1.0 | 0.8 | 30 20 100/2" | | | | | | | | | |
| | | | | | | | | | | | TOTAL DEPTH = 3.5 FT. | 4" PVC casing inserted to 2.5 ft. for gamma-logging. |
| | | | | | | | | | | | | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| | | | | | | | | | | | | Description and classification by visual examination of sample. |
| | | | | | | | | | | | | Colors from "Rock-Color Chart" (GSA, 1948). |

DRAFT 138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| *FUSRAP* | 14501 | 1 OF 1 | SB-12 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 99.5 E 139.5 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-10-92 | 9-10-92 | Hydro Group, Inc. | Soil Sentry | 8" | 5.5 | | 5.5 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 3.5/76 | | 3 | | NA | / / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G. Pais |

(Template: BCHTLLS)

| SAMP. TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | SAMPLE BLOWS "N" % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME MIN. | ELEV. NA | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 0.0 - 0.5 ft: ASPHALT. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 1.4 | 12 30 24 20 | | | | | | | | 0.5 - 2.8 ft: FILL; Gravelly Sand to Sandy Gravel Dusky yellowish brown (10 YR 2/2), fine to coarse grained, angular to sub-rounded grains, slightly moist, 5% silt, trace mica, slag, and coal. | |
| SS | 1.1 | 0.9 | 18 18 100/2" | | | | | | | | 2.8 - 5.5 ft: SILTY SAND; Moerate yellowish brown (10 YR 5/4), fine to medium grained, sub-angular to sub-rounded grains, firm, no plasicity, well compacted, trace granitic pebbles and cobbles. | |
| SS | 1.5 | 1.2 | 22 20 100/5" | | | | | 5 | | | | 4" PVC casing inserted to 3.5 ft. for gamma-logging. |
| | | | | | | | | | | | TOTAL DEPTH = 5.5 FT. | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| | | | | | | | | | | | | Description and classification by visual examination of sample. |
| | | | | | | | | | | | | Colors from "Rock-Color Chart" (GSA, 1948). |

SS = 2" O.D. SPLIT SPOON; CN = CME CONTINUOUS SAMPLER

SITE VENTRON DRUMLIN AREA

Last Update:

HOLE NO.

DRAFT

138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| *FUSRAP* | 14501 | 1 OF 1 | SB-17 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 137.5 E 126.0 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-3-92 | 9-3-92 | Hydro Group, Inc. | Soil Sentry | 8" | 6.0 | 0.2 | 6.2 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 3.7/60 | | 4 | | NA | / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G. Pais |

(Template: BCHTLLS)

| SAMP TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | SAMPLE BLOWS "N" % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME IN MIN. | ELEV. | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | NA | | | | | |
| SS | 2.0 | 1.3 | 6<br>12<br>9<br>9 | | | | | | | | 0.0 - 6.0 ft: FILL;<br>0.0 - 4.0 ft: Silty Sand, Moderate yellowish brown (10 YR 5/4), Dusky yellowish brown (10 YR 2/2), dry, very friable, trace brick fragments, trace gravel cobbles, 5% cinder throughout. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 1.3 | 9<br>9<br>10<br>12 | | | | | | | | | |
| SS | 2.0 | 0.9 | 31<br>12<br>14<br>35 | | | | | 5 | | | 4.0 - 6.0 ft: Silty Sand, Moderate yellowish brown (10 YR 5/4), Dark yellowish brown (10 YR 4/2), dry, friable, trace man-made constiuents. | 4" PVC casing inserted to 5.5 ft. for gamma-logging. |
| SS | 0.2 | 0.2 | 50/2" | | | | | | | | 6.0 - 6.2 ft: DIORITE; Weathered and fractured.<br>TOTAL DEPTH = 6.2 FT. | PVC casing removed after logging and hole was backfilled with grout by tremie method. |

Description and classification by visual examination of sample.

Colors from "Rock-Color Chart" (GSA, 1948).

DRAFT

138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| *FUSRAP* | 14501 | 1 OF 1 | SB-18 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 132.2 E 133.5 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-21-92 | 9-21-92 | Hydro Group, Inc. | Tri-Pod | 8" | 3.5 | | 3.5 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 2.0/67 | | 2 | | NA | / / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G. Pais |

(Template: BCHTLLS)

| SAMP. TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | SAMPLE BLOWS "N" % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME MIN. | ELEV. | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | NA | | | | 0.0 - 0.5 ft: CONCRETE. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 1.3 | 30<br>20<br>35<br>40 | | | | | | | | 0.5 - 3.5 ft: FILL; Gravelly Sand, Dusky yellowish brown (10 YR 2/2), Dark yellowish brown (01 YR 6/6), mottled, poorly sorted, 10% gravel, some brick and concrete fragments. | |
| SS | 1.0 | 0.7 | 20<br>100/5" | | | | | | | | | |
| | | | | | | | | | | | TOTAL DEPTH = 3.5 FT. | 3" PVC casing inserted to 3.0 ft. for gamma-logging. |
| | | | | | | | | | | | | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| | | | | | | | | | | | | Description and classification by visual examination of sample. |
| | | | | | | | | | | | | Colors from "Rock-Color Chart" (GSA, 1948). |

SS = 2" O.D. SPLIT SPOON; CN = CME

SITE | Last Update: | HOLE NO.

DRAFT 138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| FUSRAP | 14501 | 1 OF 1 | SB-19 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 143.7 E 117.8 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-21-92 | 9-21-92 | Hydro Group, Inc. | Soil Sentry | 8" | 8.0 | | 8.1 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 3.7/48 | | 4 | | NA | / / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G. Pais |

(Template: BCHTLLS)

| SAMP. TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | SAMPLE BLOWS 6" % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME MIN. | ELEV. NA | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 0.0 - 0.3 ft: ASPHALT; | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 0.9 | | | | | | | | | 0.3 - 6.2 ft: FILL. 0.3 - 4.0 ft: Gravelly Sand, Dusky yellowish brown (10 YR 2/2), fine to coarse grained, sub-angular grains, poorly sorted, 10% gravel pebbles and cobbles. | |
| SS | 2.0 | 0.4 | 39 21 20 19 | | | | | | | | | |
| SS | 2.0 | 1.3 | 22 22 20 20 | | | | | 5 | | | 4.0 - 5.0 ft: Sand, Moderate yellowish brown (10 YR 5/4), fine to medium grained, well-sorted, slightly moist, trace amounts of brick. 5.0 - 6.2 ft: Sand, Dusky yellowish brown (10 YR 2/2), fine to medium grained, 5% gravel, slighlty moist. | 4" PVC casing inserted to 6.0 ft. for gamma-logging. |
| SS | 1.7 | 1.1 | 19 74 54 100/3" | | | | | | | | 6.2 - 8.0 ft: SILTY SAND (SM); Moderate yellowish brown (10 YR 5/4), 0.1 ft. silt stringers throughout, fine to coarse grained, medium well sorted, sub-angular to sub-rounded grains, granite cobble at 8.0 ft. | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| | | | | | | | | | | | TOTAL DEPTH = 8.0 FT. | Description and classification by visual examination of sample. |
| | | | | | | | | | | | | Colors from "Rock-Color Chart" (GSA, 1948). |

SS = 2H O.D. SPLIT SPOON; CH = CHS

DRAFT 138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| FUSRAP | 14501 | 1 OF 1 | SB-20 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 127.0 E 112.0 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-3-92 | 9-3-92 | Hydro Group, Inc. | Soil Sentry | 8" | 5.0 | 0.25 | 5.3 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 2.1/44 | | 3 | | NA | / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G. Pais |

(Template: BCHTLLS)

| SAMP. TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | BLOWS/6" % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME MIN. | ELEV. | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | NA | | | | 0.0 - 0.5 ft: ASPHALT | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 1.0 | 12 19 14 12 | | | | | | | | 0.5 - 5.0 ft: FILL; Gravelly Sand Moderate yellowish brown (10 YR 5/4), dry, friable, no plasticity, trace amounts cinder and ash. | |
| SS | 2.0 | 0.7 | 9 10 10 18 | | | | | | | | 2.5 - 5.0 ft: Sandy Gravel, Pale yellowish brown (10 YR 6/2), Dark yellowish brown (10 YR 4/2), Dusky yellowish brown (10 YR 2/2), mottled, brick, rubble, trace clayey silt, slightly moist, no plasticity. | 4" PVC casing inserted to 3.5 ft. for gamma-logging. |
| SS | 0.8 | 0.4 | 10 100/3" | | | | | 5 | | | DIORITE: Weathered and fractured granite. | |
| | | | | | | | | | | | TOTAL DEPTH = 5.25 FT. | PVC casing removed after logging and hole was backfilled with grout by tremie method. |

Description and classification by visual examination of sample.

Colors from "Rock-Color Chart" (GSA, 1948).

DRAFT 138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| *FUSRAP* | 14501 | 1 OF 1 | SB-21 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 113.0 E 107.0 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-4-92 | 9-4-92 | Hydro Group, Inc. | Soil Sentry | 8" | 3.5 | 0.5 | 4.0 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 2.6/76 | | 4 | | NA | / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G. Pais |

(Template: BCHTLLS)

| SAMP. TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | BLOWS 6" SAMPLE % CORE RECOVERY | WATER PRESSURE TESTS: LOSS TIN G.P.M | PRESS. P.S.I. | TIME MIN. | ELEV. NA | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 0.0 - 0.5 ft: ASPHALT. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 1.0 | 0.8 | 19<br>100 | | | | | | | | 0.5 - 3.5 ft: FILL;<br>0.5 - 1.5 ft: Gravelly Sand, Moderate brown (5 YR 4/4), to Olive gray (5 Y 4/1), dry, friable, trace silt, trace brick fragments.<br>1.5 - 3.5 ft: Gravelly Sand, Grayish orange pink (5 Y 7/2), Moderate yellowish brown (10 YR 5/4), dry, friable, 5% mica, granite pebbles, trace man-made materials. | |
| SS | 0.5 | 0.3 | 25 | | | | | | | | | |
| SS | 1.7 | 1.3 | 18<br>29<br>65<br>66/2" | | | | | | | | | |
| SS | 0.2 | 0.2 | 70/2" | | | | | | | | 3.5 - 4.0 ft: WEATHERED DIORITIC GRANITE. | |
| | | | | | | | | | | | TOTAL DEPTH = 4.0 FT. | 4" PVC casing inserted to 2.5 ft. for gamma-logging. |
| | | | | | | | | | | | | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| | | | | | | | | | | | | Description and classification by visual examination of sample. |
| | | | | | | | | | | | | Colors from "Rock-Color Chart" (GSA, 1948). |

SS = 2" O.D. SPLIT SPOON; CN = CME CONTINUOUS SAMPLER

SITE: VENTRON - BEVERLY, MASSACHUSETTS

Last Update:

HOLE NO.

DRAFT 138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| FUSRAP | 14501 | 1 OF 1 | SB-23 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 105.5 E 102.5 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-9-92 | 9-9-92 | Hydro Group, Inc. | Soil Sentry | 8" | 8.5 | | 8.5 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 5.1/64 | | 4 | | NA | / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G. Pais |

(Template: BCHTLLS)

| SAMP TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | SAMPLE BLOWS 6" % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME IN MIN. | ELEV. NA | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 0.0 - 0.5 ft: ASPHALT. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 1.2 | 18 16 24 50 | | | | | | | | 0.5 - 6.0 ft: FILL. 0.5 - 4.6 ft: Gravelly Sand, Dusky yellowish brown (10 YR 2/2), Moderate yellowish brown (10 YR 5/4), fine to coarse grianed, sub-angular to sub-rounded grains, sub-rounded gravels clasts, dry, friable, medium well-sorted, 15% gravel, trace amounts silt and clay. | |
| SS | 2.0 | 1.6 | 18 12 18 18 | | | | | | | | | 4" PVC casing inserted to 7.0 ft. for gamma-logging. |
| SS | 2.0 | 1.3 | 48 43 43 32 | | | | | 5 | | | 4.6 - 5.0 ft: Silty Sand, Moderate yellowish brown (10 YR 5/4), fine to medium grained, sub-angular to sub-rounded grains, dry, friable, no to very slight plasticity. 5.0 - 6.0 ft: Gravelly Sand, Dusky yellowish brown (10 YR 2/2), poorly sorted, dry, friable, sub-rounded gravel clasts, tace brick fragments. | |
| SS | 1.5 | 1.0 | 32 45 53 70/1" | | | | | | | | 6.0 - 8.5 ft: SILTY SAND (SM) with Gravelly Sand; Moderate yellowish brown (10 YR 5/4), fine to medium grained, sub-angular to sub-rounded grains, medium well-sorted, dense and firm in places, slightly moist, trace weathered granite. | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| | | | | | | | | | | | TOTAL DEPTH = 8.5 FT. | |
| | | | | | | | | | | | | Description and classification by visual examination of sample. |
| | | | | | | | | | | | | Colors from "Rock-Color Chart" (GSA, 1948). |

DRAFT 138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| FUSRAP | 14501 | 1 OF 1 | SB-24 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 112.8 E 94.0 | -22.0 | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-23-92 | 9-23-92 | Hydro Group, Inc. | Krupp | 8" | 35.0 | | 35.0 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 15.3/49 | | 16 | | NA | / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| NA | none | G. Pais |

(Template: BCHTLLS)

| SAMP. TYPE AND DIAM. | SAMP. ADV. LEN. CORE | SAMPLE REC. CORE REC. | SAMPLE "N" BLOWS % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M. | PRESS. P.S.I. | TIME IN MIN. | ELEV. NA | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS | 2.0 | 1.2 | | | | | | | | | 0.0 - 35.0 ft: FILL.<br>0.0 - 4.7 ft: Gravelly Sand, fine to coarse grained, sub-angular to sub-rounded grains, 15% gravel, trace amounts of wood, glass, concrete, and brick, trace coal and ash, dry, friable. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 1.0 | | | | | | | | | | |
| SS | 2.0 | 1.8 | | | | | | 5 | | | 4.7 - 8.6 ft: Coal and Ash, Dusky brown (5 YR 2/1), Olive black (5 Y 2/1), Very pale orange (10 YR 8/2), Yellowish gray (5 Y 8/1), chalky texture, blocky structure, mica, trace glass and brick. | Borehole drilled using the ODEX system and drilled at a 22 degree angle from horizontal. |
| SS | 2.0 | 0.5 | | | | | | | | | | |
| SS | 2.0 | 1.0 | | | | | | | | | 8.6 - 14.5 ft: Silty Sand, Olive gray (5 Y 4/1), trace gravel, trace coal, slightly moist, mica. | |
| SS | 2.0 | 0.9 | | | | | | 10 | | | | 4" PVC casing inserted to 35.0 ft. for gamma-logging. |
| SS | 2.0 | 0.0 | | | | | | | | | | |
| SS | 2.0 | 0.3 | | | | | | 15 | | | 14.5 - 19.0 ft: Silty Sand, Moderate yellowish brown (10 YR 5/4), fine to medium grained, sub-angular to sub-rounded grains, well-sorted, slightly moist, trace mica. | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| SS | 2.0 | 1.0 | | | | | | | | | | |
| SS | 2.0 | 1.0 | | | | | | | | | | |
| SS | 2.0 | 1.8 | | | | | | 20 | | | 19.0 - 21.7 ft: Ash and Fill: Grayish black (N 2), medium light gray (N 6), Yellowish gray (5 Y 8/1), chalky texture, platey structure, moist, glass shards, brick fragments. | |
| SS | 2.0 | 1.8 | | | | | | | | | 21.7 - 35.0 ft: Silty to Gravelly Sand, Medium gray (N 5) to Grayish black (N 2), trace organics, saturated, soft to slightly firm and plastic. | |
| SS | 2.0 | 0.6 | | | | | | 25 | | | | |
| SS | 2.0 | 1.2 | | | | | | | | | | |
| SS | 2.0 | 0.2 | | | | | | | | | | |
| SS | 1.0 | 1.0 | | | | | | 30 | | | | Description and classification by visual examination of sample. |
| | | | | | | | | | | | | Colors from "Rock-Color Chart" (GSA, 1948). |
| | | | | | | | | 35 | | | TOTAL DEPTH = 35.0 FT. | |

SS = 2" O.D. SPLIT SPOON; CN = CME CONTINUOUS SAMPLER

SITE: VENTRON - BEVERLY, MASSACHUSETTS

Last Update:

HOLE NO. SB-24

DRAFT

138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| *FUSRAP* | 14501 | 1 OF 1 | SB-25 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 117.0 E 99.0 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-9-92 | 9-9-92 | Hydro Group, Inc. | Soil Sentry | 8" | 4.5 | 1.5 | 6.0 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 3.8/69 | | 3 | | NA | / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G. Pais |

(Template: BCHTLLS)

| SAMP. TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | SAMPLE BLOWS "N" % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME IN MIN. | ELEV. NA | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 0.0 - 0.5 ft: ASPHALT. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 1.5 | 20 38 40 42 | | | | | | | | 0.5 - 4.5 ft: FILL; Gravelly Sand, Dusky yellowish brown (10 YR 2/2), fine to coarse grained, sub-angular to sub-rounded grains, sub-rounded to rounded gravel clasts, poorly sorted, dry, friable, trace metal fragments. | |
| SS | 2.0 | 1.3 | 50 47 90 50/4" | | | | | | | | | 4" PVC casing inserted to 5.0 ft. for gamma-logging. |
| SS | 1.5 | 1.0 | 70 80 100/6" | | | | | 5 | | | 4.5 - 6.0 ft: DIORITIC GRANITE; Dark Gray, fresh drilling induced fractures and FeOx stained fractures, very dense and hard. | |
| | | | | | | | | | | | TOTAL DEPTH = 6.0 FT. | PVC casing removed after logging and hole was backfilled with grout by tremie method. |

Description and classification by visual examination of sample.

Colors from "Rock-Color Chart" (GSA, 1948).

DRAFT 138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| FUSRAP | 14501 | 1 OF 1 | SB-26 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 90.0 E 220.0 | -22.0 | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-15-92 | 9-15-92 | Hydro Group, Inc. | Krupp | 8" | 31.5 | 0.5 | 32.0 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 21.9/68 | | 16 | | NA | / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| NA | none | G. Pais |

(Template: BCHTLLS)

| SAMP TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | BLOWS 6" / % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME IN MIN. | ELEV. NA | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS | 2.0 | 1.5 | | | | | | | | | 0.0 - 21.3 ft: FILL.<br>0.0 -2.2 ft: Gravelly Sand to Sandy Gravel, medium to coarse grained, sub-rounded grains, trace very fined grained sand and silt, poor to medium well-sorted, slightly moist, friable, glass shards, coal, brick fragments. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 1.4 | | | | | | | | | | |
| SS | 2.0 | 0.3 | | | | | | 5 | | | 2.2 - 8.3 ft: Sludge, mottled grays, blacks and beiges, sandy texture, trace gravel, chalky structure, blocky structure, some platey structure throughout, slightly moist. | Borehole drilled using the ODEX system and drilled at a 22 degree angle from horizontal. |
| SS | 2.0 | 0.3 | | | | | | | | | | |
| SS | 2.0 | 1.8 | | | | | | | | | 8.3 - 10.9 ft: Silty Sand, Moderate yellowish brown (10 YR 5/4), very fine to medium grained, sub-angular grained, slightly moist, glass shards, brick fragments, coal. | |
| SS | 2.0 | 2.0 | | | | | | 10 | | | 10.9 - 11.5 ft: Sludge, dusky yellowish brown to beige, gravelly in places, silty to chalky texture, man-made inclusions, moist, sticky. | 4" PVC casing inserted to 30.5 ft. for gamma-logging. |
| SS | 2.0 | 0.3 | | | | | | | | | 11.5 - 16.2 ft: Silty Sand, Moderate yellowish brown (10 YR 5/4), very fine to medium grained, sub-angular grained, medium well-sorted, trace gravel and coal. | |
| SS | 2.0 | 2.0 | | | | | | | | | | |
| | | | | | | | | 15 | | | 15.0 ft: Increase Gravel to 15-20%. | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| SS | 2.0 | 2.0 | | | | | | | | | 16.2 - 21.3 ft: Sludge, Black to shades of white, grayish, purple, orange, chalky texture, slightly moist, stringers of coal, trace slag. | |
| SS | 2.0 | 2.0 | | | | | | | | | | |
| SS | 2.0 | 2.0 | | | | | | 20 | | | | |
| SS | 2.0 | 2.0 | | | | | | | | | 21.3 - 24.0 ft: SILTY SAND (SM); Moderate yellowish brown (10 YR 5/4), 10% gravel, very fine to coarse grained, sub-angular grains, dense, firm, moist.<br>23.0 ft: Increase Gravel to 15%. | |
| SS | 2.0 | 2.0 | | | | | | | | | | |
| SS | 2.0 | 1.0 | | | | | | 25 | | | 24.0 - 31.5 ft: SANDY GRAVEL (SG); Grayish Olive (10 Y 4/2), trace silt, poorly-sorted, fine to coarse grained, saturated at 26.0 ft., dense, firm. | Description and classification by visual examination of sample. |
| SS | 2.0 | 1.2 | | | | | | | | | | |
| SS | 2.0 | 0.3 | | | | | | | | | | |
| SS | 2.0 | 1.8 | | | | | | 30 | | | | |
| | | | | | | | | | | | 31.5 - 32.0 ft: DIORITE. | |
| | | | | | | | | | | | TOTAL DEPTH = 32.0 FT. | Colors from "Rock-Color Chart" (GSA, 1948). |

SS = 2" O.D. SPLIT SPOON; CN = CME CONTINUOUS SAMPLER

SITE: VENTRON - BEVERLY, MASSACHUSETTS

Last Update:

HOLE NO. SB-26

DRAFT

138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| FUSRAP | 14501 | 1 of 1 | SB-27 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 139.0 E 82.0 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-2-92 | 9-2-92 | Hydro Group, Inc. | Soil Sentry | 8" | 11.3 | 0.2 | 11.5 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 3.4/30 | | 6 | | NA | / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G. Pais |

(Template: BCHTLLS)

| SAMP TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | BLOWS 6" SAMPLE % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME MIN. | ELEV. | DEPTH | GRAPHICS | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SS | 2.0 | 1.2 | 3 6 10 11 | | | | NA | | | 0.0 - 11.3 ft: FILL. 0.0 -2.4 ft: Sandy Loam, Dark yellowish brown (10 YR 4/2), silty and gravelly in places, dry, friable, trace organics, no plasicity, trace sinder and ash. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 0.4 | 8 7 5 5 | | | | | | | 2.4 - 6.0 ft: Silty Sand, Moderate yellowish brown (10 YR 5/4), fine to medium grained, trace coarse grains, sub-angular to sub-rounded grains, tr ace gravel pebbles. | |
| SS | 2.0 | 0.0 | 6 6 6 4 | | | | | 5 | | | 4" PVC casing inserted to 11.0 ft. for gamma-logging. |
| SS | 2.0 | 0.7 | 5 7 6 4 | | | | | | | 6.0 -8.0 ft: Clean to Silty Sand, Grayish brown (5 YR /32), fine to medium grained, trace coarse grains, sub-angular grains, well-sorted, micaceous, pyritic, slightly moist. | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| SS | 2.0 | 0.8 | 5 3 4 3 | | | | | | | 8.0 - 11.3 ft: Sandy Gravel to Gravelly Sand, Light gray (N 7), Dark yellowish Orange (10 YR 6/6), Grayish Orange (10 YR 7/4), mottled, medium to coarse grained, sub-angular to sub-rounded grains, FeOx staining, poorly sorted, slightly moist. | |
| SS | 1.5 | 0.3 | 3 2 50/6" | | | | | 10 | | | Description and classification by visual examination of sample. |
| | | | | | | | | | | 11.3 - 11.5 ft: DIORITE BEDROCK. TOTAL DEPTH = 11.5 FT. | |

Colors from "Rock-Color Chart" (GSA, 1948).

BECHTEL

# DRAFT

138005

| GEOLOGIC DRILL LOG | PROJECT: FUSRAP | JOB NO.: 14501 | SHEET NO.: 1 OF 1 | HOLE NO.: SB-28 |
|---|---|---|---|---|

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 87.5 E 124.3 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-17-92 | 9-17-92 | Hydro Group, Inc. | Soil Sentry | 8" | 8.5 | 0.5 | 9.0 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 3.3/39 | | 5 | | NA | / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G. Pais |

(Template: BCHTLLS)

| SAMP. TYPE AND DIAM. | SAMP. ADV. LEN CORE | SAMPLE REC. CORE REC. | SAMPLE BLOWS 6" % CORE RECOVERY | WATER PRESSURE TESTS: LOSS G.P.M | PRESS. P.S.I. | TIME MIN. | ELEV. | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS | 2.0 | 1.0 | 12 12 8 4 | | | | NA | | | | 0.0 - 0.3 ft: ASPHALT. 0.3 - 8.5 ft: FILL. 0.3 - 5.0 ft: Silty Sand, Dusky yellowish brown (10 YR 2/2), very fine to medium grained sub-angular grains, 5-10% gravel, dry, friable, brick fragments, trace ash. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 0.7 | 4 4 6 6 | | | | | | | | | |
| SS | 2.0 | 0.8 | 5 4 4 8 | | | | | | | | | 4" PVC casing inserted to 7.5 ft. for gamma-logging. |
| | | | | | | | | 5 | | | 5.0 - 7.0 ft: Silty Sand with increase clay content, moist, dense, firm, trace man-made constiuents. | |
| SS | 2.0 | 0.5 | 19 29 30 10 | | | | | | | | | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| | | | | | | | | | | | 7.0 - 8.5 ft: Silty Sand, Dusky brown (5 yr 2/2), trace gravel, very fine to medium grained, moist, slight plasicity, brick fragments, glass shards. | |
| SS | 1.0 | 0.3 | 100/6" | | | | | | | | | |
| | | | | | | | | | | | 8.5 - 9.0 ft: DIORITE. | |
| | | | | | | | | | | | TOTAL DEPTH = 9.0 FT. | |
| | | | | | | | | | | | | Description and classification by visual examination of sample. |
| | | | | | | | | | | | | Colors from "Rock-Color Chart" (GSA, 1948). |

SS = 2" O.D. SPLIT SPOON; CN = CME CONTINUOUS SAMPLER | SITE: VENTRON, BEVERLY, MASSACHUSETTS | Last Update: | HOLE NO.

DRAFT

138005

# GEOLOGIC DRILL LOG

| PROJECT | JOB NO. | SHEET NO. | HOLE NO. |
|---|---|---|---|
| *FUSRAP* | 14501 | 1 OF 1 | SB-30 |

| SITE | COORDINATES and/or STATIONINGS | ANGLE FROM HORIZ | BEARING |
|---|---|---|---|
| Ventron | N 83.5 E 222.5 | Vertical | N0E |

| BEGUN | COMPLETED | DRILLER | DRILL MAKE AND MODEL | SIZE | OVERBURDEN | ROCK (FT.) | TOTAL DEPTH |
|---|---|---|---|---|---|---|---|
| 9-21-92 | 9-21-92 | Hydro Group, Inc. | Soil Sentry | 8" | 8.7 | 0.8 | 9.5 |

| CORE RECOVERY (FT./%) | CORE BOXES | SAMPLES | EL. TOP CASING | GROUND EL. | DEPTH/EL. GROUND WATER | DEPTH/EL. TOP OF ROCK |
|---|---|---|---|---|---|---|
| 5.0/53 | | 5 | | NA | / | / |

| SAMPLE HAMMER WEIGHT/FALL | CASING LEFT IN HOLE: DIA./LENGTH | LOGGED BY: |
|---|---|---|
| 140 lbs/30 in | none | G. Pais |

(Template: BCHTLLS)

| SAMP. TYPE AND DIAM. | SAMP. ADV. LEN. CORE | SAMPLE REC. CORE REC. | BLOWS 6" / % CORE RECOVERY | WATER PRESSURE TESTS: LOSS IN G.P.M | PRESS. P.S.I. | TIME IN MIN. | ELEV. | DEPTH | GRAPHICS | SAMPLE | DESCRIPTION AND CLASSIFICATION | NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | NA | | | | | |
| SS | 2.0 | 1.5 | 9<br>15<br>23<br>21 | | | | | | | | 0.0 - 8.7 ft: FILL.<br>0.0 - 4.3 ft: Gravelly Sand, Dusky yellowish brown (10 YR 2/2), slightly moist, very slight plasticity in places, slag, ash, brick, cinder, trace organic matter. | Borehole sampled and gamma-logged by TMA/Eberline Corp |
| SS | 2.0 | 1.0 | 12<br>16<br>14<br>12 | | | | | | | | 2.0 - 2.3 ft: Silty Sand, Moderate yellowish brown (10 YR 5/4), dry, friable. | |
| SS | 2.0 | 1.0 | 15<br>7<br>6<br>7 | | | | | 5 | | | 4.3 - 5.2 ft: Silty Sand, Moderate yellowish brown (10 YR 5/4), slightly moist, very slight plasticity.<br>5.2 - 8.7 ft: Gravelly Sand, Moderate yellowish brown (10 YR 5/4), medium to coarse grained, sub-angular grains, medium well sorted, very slightly moist, trace brick and cinder. | 4" PVC casing inserted to 9.0 ft. for gamma-logging. |
| SS | 2.0 | 0.8 | 7<br>6<br>5<br>6 | | | | | | | | | PVC casing removed after logging and hole was backfilled with grout by tremie method. |
| SS | 1.5 | 0.7 | 6<br>5<br>12<br>50/1" | | | | | | | | 8.0 ft: Saturated Silty Sand. | |
| | | | | | | | | | | | 8.7 - 9.5 ft: DIORITIC GRANITE; Weathered and fresh surfaces, drilling induced angular fractures. | |
| | | | | | | | | | | | TOTAL DEPTH = 9.5 FT. | |

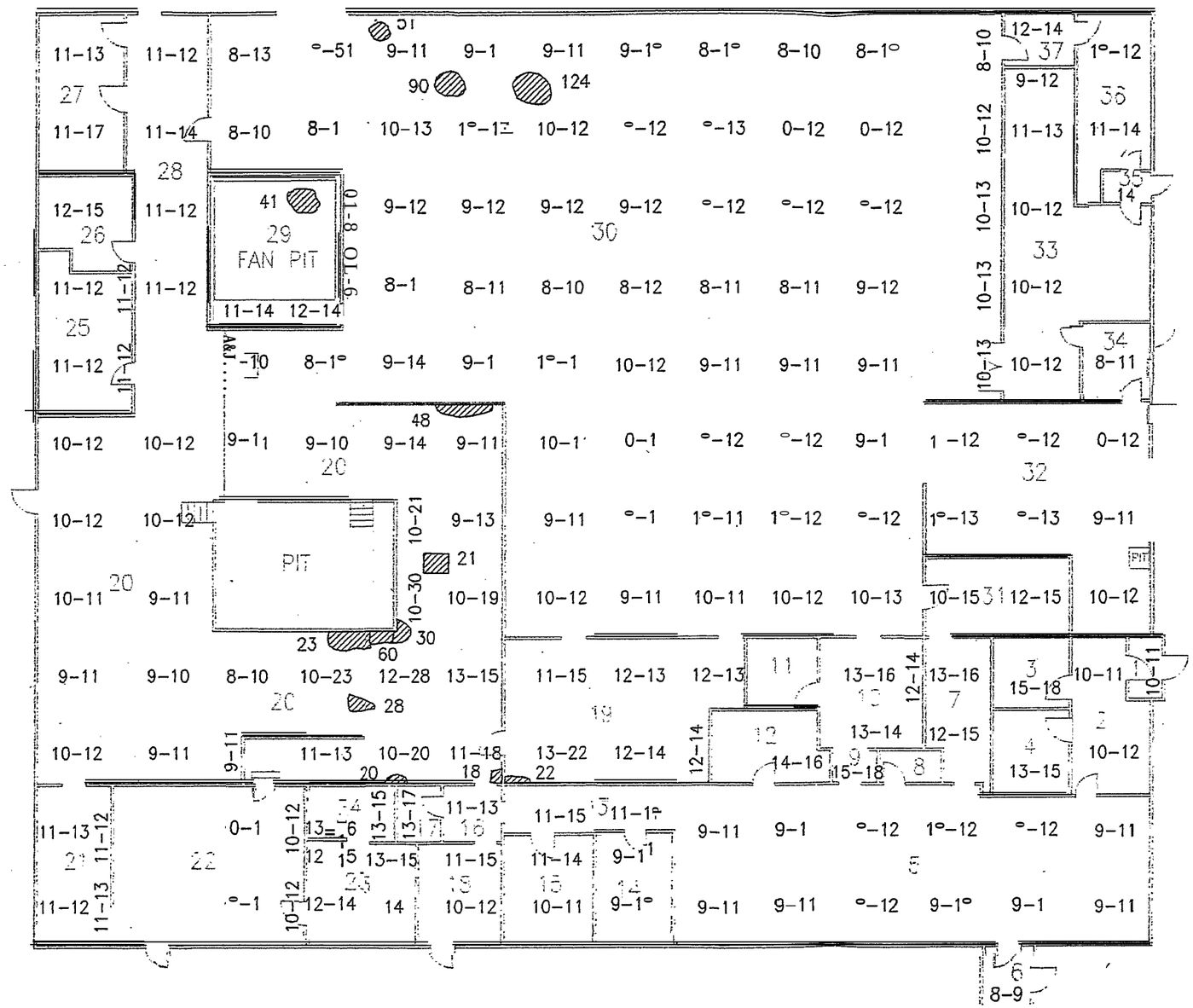
Description and classification by visual examination of sample.

Colors from "Rock-Color Chart" (GSA, 1948).

138005

# APPENDIX E

# WALKOVER GAMMA SCANS AND SURFACE CONTAMINATION SURVEYS OF BUILDINGS




LEGEND:

CONTAMINATED HORIZONTAL SURFACE

COUNTS PER MINUTE
11-14 . . . . . (x 1000)

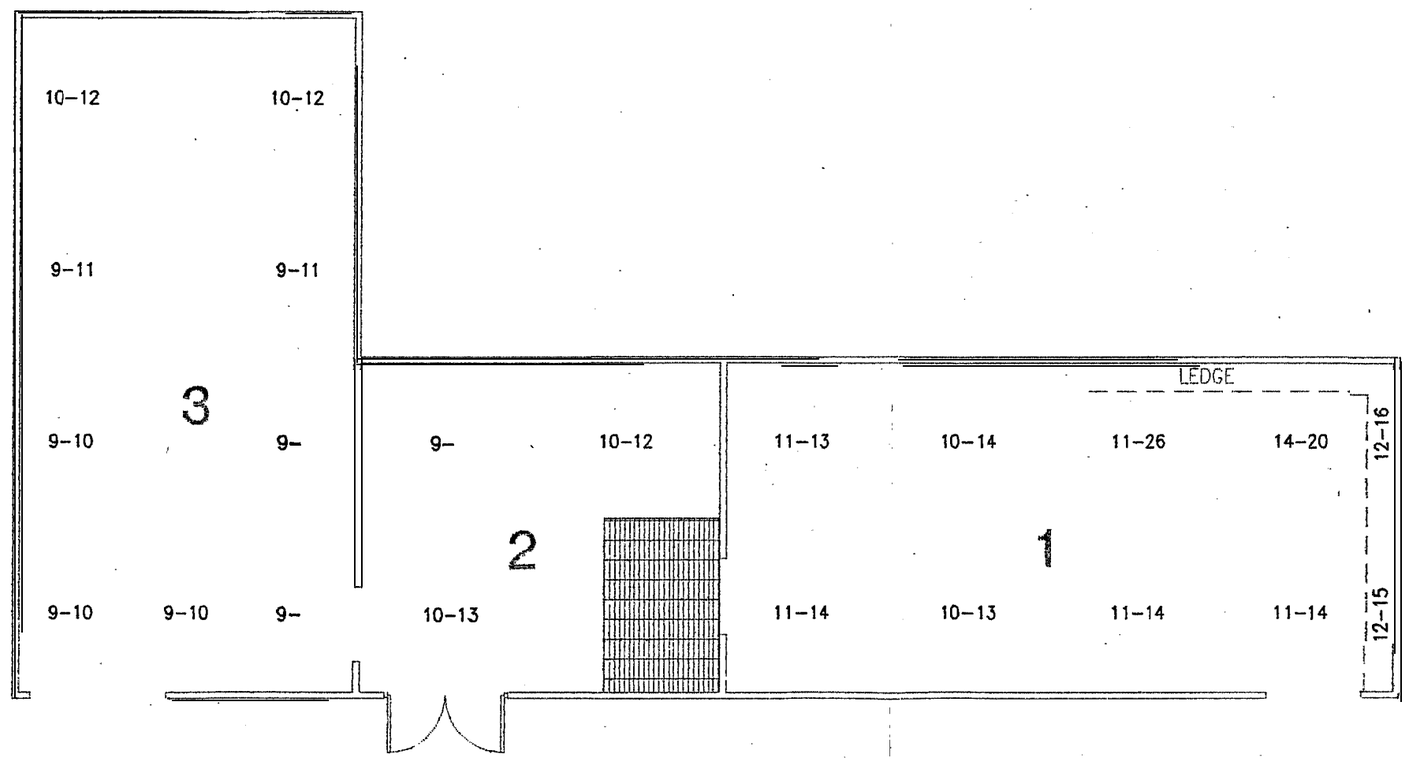
NOT TO SCALE

BUILDING A

| REVISION | DRAWN BY: | CHKD. BY: | DATE: |
|---|---|---|---|
| 0 | R. BEELER | P. HOLM | 05-12-94 |

| XREFERENCES | PLOT FILES |
|---|---|
| | |

| SHT. 1 OF 1 | /94017/DWGS/653PLNA | N/A |
|---|---|---|
| DRAWING # | CAD FILE # | ROT. ANGLE |




BASEMENT BUILDING A

LEGEND:

COUNTS PER MINUTE
11–26 . . . . . (x 1000)

NOT TO SCALE

BUILDING A BASEMENT
GAMMA WALKOVER SURVEY

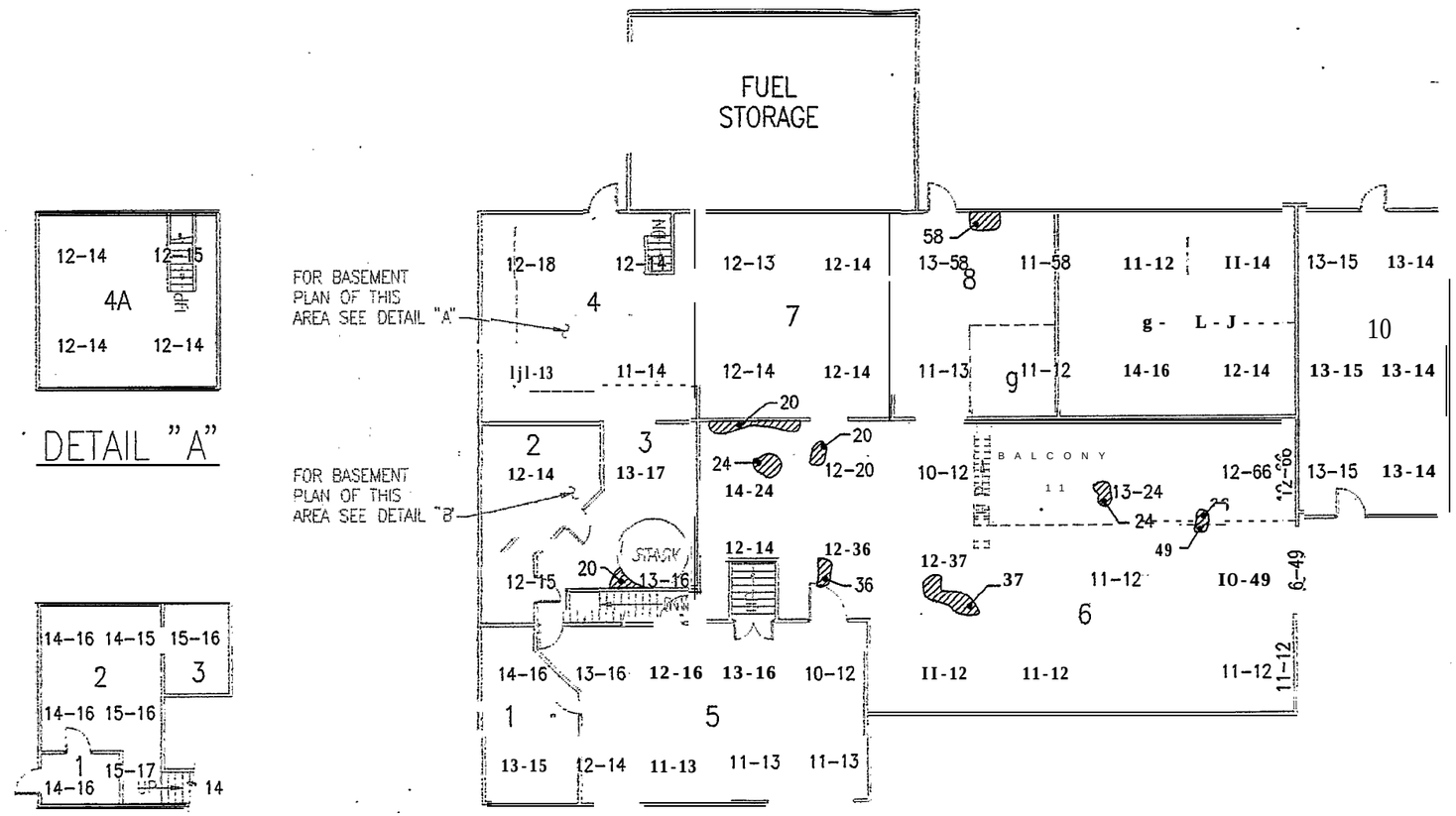
| REVISION | DRAWN BY: | CHKD. BY: | DATE: |
|---|---|---|---|
| 0 | R. BEELER | P. HOLM | 05-10-94 |

| XREFERENCES | PLOT FILES |
|---|---|
| | /94017/PLOT/653BSMTA |

SHT. 1 OF 1 — DRAWING #
/94017/DWGS/653BSMTA — CAD FILE #
N/A — ROT. ANGLE

LEGEND:

≥ TWICE BACKGROUND W/SPA-3




NOT TO SCALE

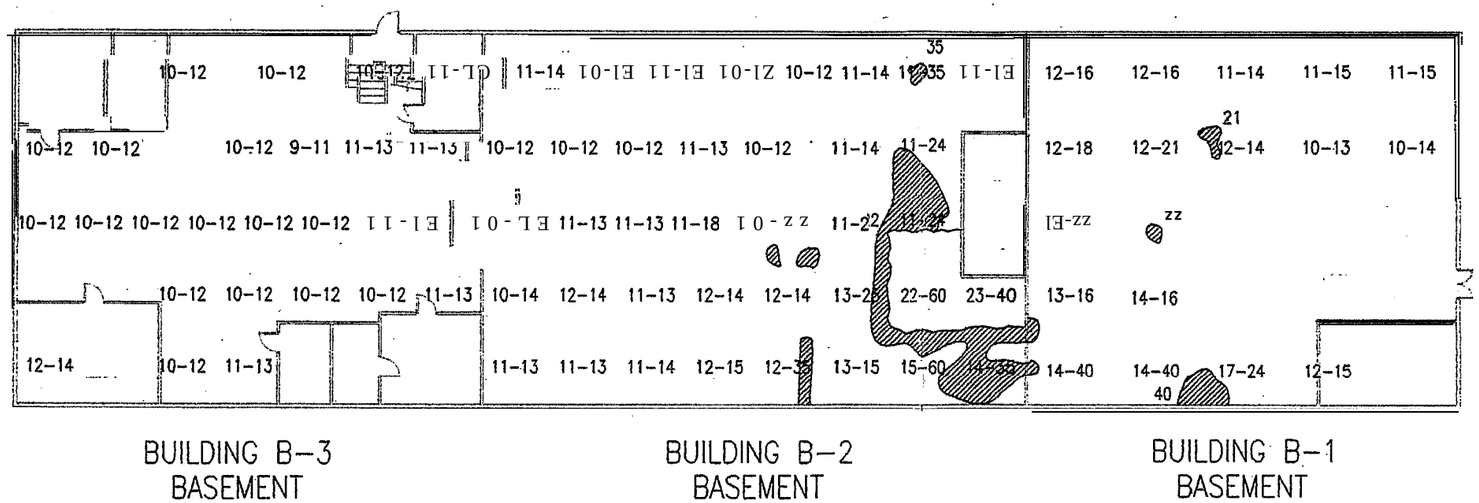
BUILDING A-1 FLOOR SURFACE

| REVISION | DRAWN BY: | CHKD. BY: | DATE: |
|---|---|---|---|
| 0 | R. BEELER | P. HOLM | 05-10-94 |

| XREFERENCES | PLOT FILES |
|---|---|
| | /94017/PLOT/653PLNA1 |

SHT. 1 OF 1 (DRAWING #) | /94017/DWGS/653PLNA1 (CAD FILE #) | N/A (ROT. ANGLE)

138005




LEGEND:

▨... ≥ TWICE BACKGROUND W/SPA-3

COUNTS PER MINUTE

12-16 ..... (x 1000)

NOT TO SCALE

BUILDINGS B-1, B-2, B-3
GAMMA WALKOVER SURVEY

| REVISION | DRAWN BY: | CHKD. BY: | DATE: |
|---|---|---|---|
| 0 | R. BEELER | P. HOLM | 05-10-94 |
| | | | |
| | | | |
| | | | |
| | | | |

| XREFERENCES | PLOT FILES |
|---|---|
| | /94017/PLOT/653BASMT |

| SHT. 1 OF 1 | /94017/DWGS/653BASMT | N/A |
|---|---|---|
| DRAWING # | CAD FILE # | ROT. ANGLE |

139115

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue, Argonne, Illinois 60439

# ACTION DESCRIPTION MEMORANDUM

# REMOVAL OF CONTAMINATED ROOFING MATERIAL FROM BUILDINGS A AND A1 AT THE VENTRON SITE, BEVERLY, MASSACHUSETTS

by

Energy and Environmental Systems Division

November 1987

work supported by

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations
Technical Services Division
Oak Ridge, Tennessee

139115

## CONTENTS


1 SUMMARY ..... 1

2 HISTORY AND NEED FOR ACTION ..... 2

3 CHARACTERISTICS OF THE CONTAMINATED ROOFING ..... 4

4 DESCRIPTION OF THE PROPOSED ACTION ..... 10

5 SUMMARY OF IMPACTS ..... 12
5.1 Radiological Impacts at the Ventron Site ..... 12
5.2 Transportation Impacts ..... 13

6 REFERENCES ..... 14

7 LIST OF CONTRIBUTORS ..... 15

APPENDIX A: DOE Guidelines for Residual Radioactive Material ..... 16


## FIGURES


1 Layout of the Ventron Site ..... 3

2 Details of the Roof of Building A ..... 5

3 Details of the Roof of Building A1 ..... 6

4 Proposed Transportation Route to the Hanford Site ..... 11


## TABLES


1 Isotopic Uranium in Roofing of Buildings A and A1 ..... 7

2 Estimated Radium and Thorium Concentrations in Roofing of Buildings A and A1 ..... 8

139115

# ACTION DESCRIPTION MEMORANDUM

## REMOVAL OF CONTAMINATED ROOFING MATERIAL FROM BUILDINGS A AND A1 AT THE VENTRON SITE, BEVERLY, MASSACHUSETTS

by

Energy and Environmental Systems Division

## 1 SUMMARY

As part of its Formerly Utilized Sites Remedial Action Program (FUSRAP), the U.S. Department of Energy (DOE), Oak Ridge Operations, proposes to perform remedial action activities at the Ventron site in Beverly, Massachusetts. Portions of the site are radioactively contaminated as a result of programs previously conducted by the Manhattan Engineer District (MED) and the U.S. Atomic Energy Commission (AEC). The proposed remedial action consists of the following activities:

- Removal of radioactively contaminated roofing material from Buildings A and A1,
- Packaging of this material in strong, tight containers suitable for transport of low-specific-activity radioactive material,
- Transporting the containers to the Hanford site near Richland, Washington, for disposal, and
- Replacing the roofing with material of comparable quality.

It is estimated that about 150 $m^3$ (200 $yd^3$) of packaged radioactive waste will be generated by these activities and will be transported to the Hanford site in seven truckloads. This action will be carried out in compliance with all applicable health, safety, and environmental regulations. Mitigative measures will be used to reduce environmental impacts to low levels and to minimize the potential for off-site release of contaminated material. Analysis of potential environmental impacts and potential hazards to workers associated with this proposed interim remedial action indicates that the action will not have a significant impact on either the environment or the health of workers.

## 2 HISTORY AND NEED FOR ACTION

The Ventron site is a 1.2-ha (3-acre) parcel of land located at the confluence of the Bass and Danvers rivers in Beverly, Massachusetts. Beverly is a town of about 38,000 inhabitants located on the Atlantic coast, about 24 km (15 mi) northeast of Boston. Economic activities in the area include light manufacturing activities and some fishing and tourism. The area provides good employment for a heterogeneous and stable community. More affluent communities with large residences and vacation homes are located nearby.

The Ventron facility is owned by the Ventron Division of Morton Thiokol. Uranium processing was previously carried out in three buildings at the site under contract to the MED and the AEC (Fig. 1). From 1942 to 1948, uranium oxide was converted to uranium metal powder. Subsequently, uranium was recovered from scrap materials (Bechtel Natl. 1986). Two wooden buildings containing the foundry operations were demolished between 1948 and 1950, and two new buildings were built as replacements. The third original building, which still stands, contained furnace and leaching facilities, mixing and drying rooms, and an analytical laboratory. The total amount of uranium processed at the Ventron site is unknown.

Radiological surveys of the Ventron site were carried out in 1948, 1977, 1980, and 1982. The 1948 survey showed that the two original foundry buildings and pieces of equipment were contaminated. The 1977 survey was exploratory in nature and indicated that a survey of the entire site was needed. A 1980 survey of the outdoor portion of the site indicated that the soil was contaminated with uranium, as well as smaller amounts of thorium-230 and radium-226, to estimated depths of 2 to 3.5 m (6.6 to 12 ft) in some areas.

The 1982 survey covered buildings and structures on the site. Spotty surface contamination was detected on the surfaces of floors, walls, overhead areas, and crawl spaces. Some beta-gamma dose rates were in excess of the current guidelines applicable for release of the property for unrestricted use (App. A). Similar contamination levels were detected on the roof of Building A (Fig. 1).

The Ventron Division would like to replace the roofing on Buildings A and A1 as a maintenance activity. Because the roofing on these buildings is contaminated as a result of previous MED/AEC activities, DOE has agreed to perform this maintenance activity at this time. Remedial activities at the remainder of the site will be performed later.

This document is limited to the proposed removal of contaminated roofing material from Buildings A and A1, transport of this material to Hanford, Washington, for disposal, and replacement of the roofing with material of comparable quality. Documentation of additional remedial actions at the Ventron site will be prepared in the future.

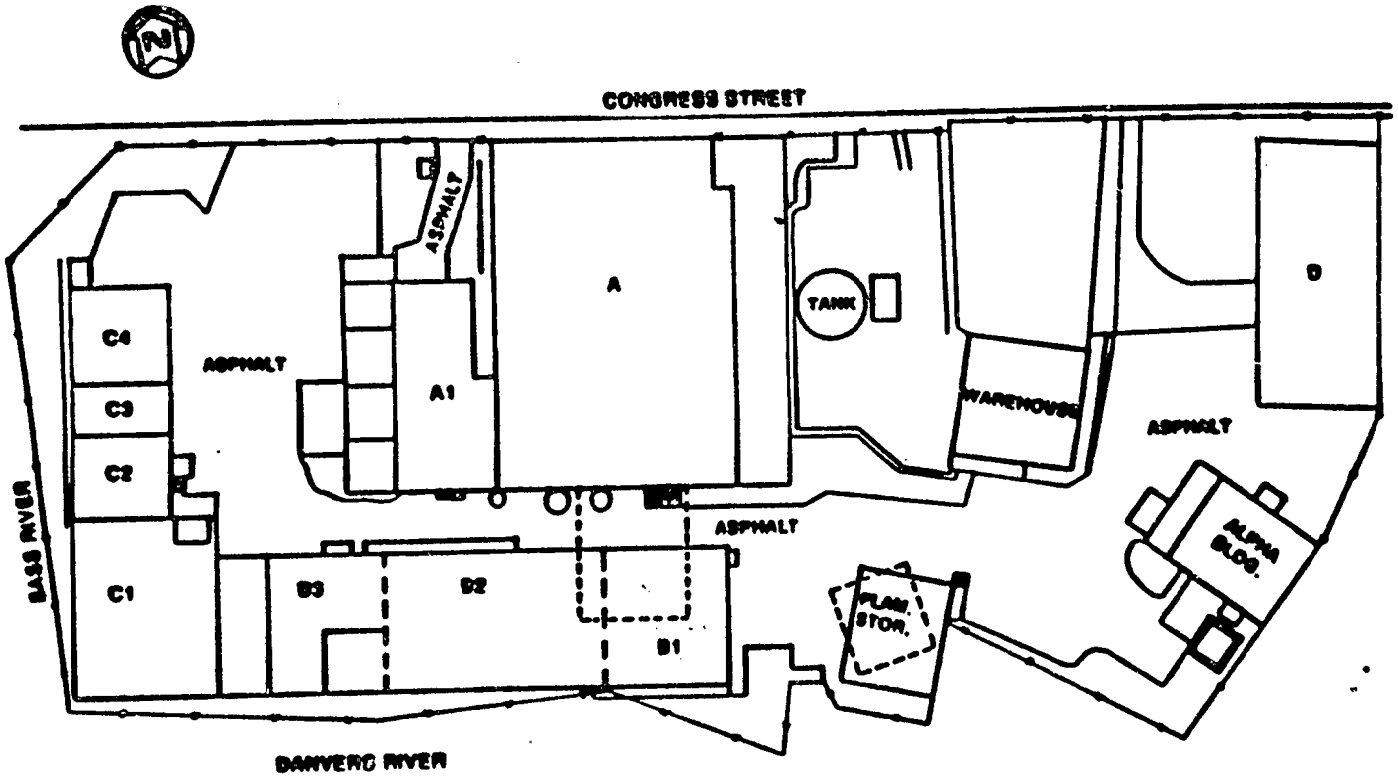



**FIGURE 1 Layout of the Ventron Site (Source: Bechtel Natl. 1986)**

139115

## 3 CHARACTERISTICS OF THE CONTAMINATED ROOFING* 139115

The roof of Building A consists of a layer of thin tar paper covered by a second layer of thicker two-ply tar paper with tar and then gravel on top. The lower roofing is contaminated and is covered by the relatively uncontaminated upper roofing. Small amounts of tar and gravel that formed the top layer of the lower roofing (which was mostly removed) are still present between the first and second layers. The average thickness of the complete roofing is 2 to 2.5 cm (0.8 to 1 in.); this is a rough estimate because the thickness varies appreciably at different places on the roof (Lester 1987). Details of the Building A roof are given in Fig. 2.

The roof of Building A includes three penthouses or skylights. The penthouses have roofs covered with the same material as other parts of the roof. Each penthouse roof has a 5-cm (2-in.) overhang on all sides. Roofing also extends 20 cm (8 in.) up the sides of each penthouse.

The roofing of Building A1 consists of a layer of tar paper covered by tar and gravel. The average thickness of the roofing is about 1 cm (0.4 in.) (Lester 1987). Building A1 has one skylight or penthouse on the roof. The aluminum roof of the penthouse will not be removed because it can be decontaminated in place. Roofing extends 20 cm (8 in.) up the sides of the penthouse. Details of the Building A1 roof are given in Fig. 3.

The thicknesses and dimensions of the roofs can be used to estimate the total volume of roofing to be removed during this remedial action. The estimated volumes are 41 $m^3$ (54 $yd^3$) for Building A and 4.1 $m^3$ (5.4 $yd^3$) for Building A1 for a total of about 45 $m^3$ (60 $yd^3$).

The concentrations of uranium isotopes measured in samples taken from several locations on the roofs of the two buildings are given in Table 1. The concentrations of uranium are much lower in the Building A roofing than in Building A1 roofing. One explanation is that the samples may have been taken at shallow depths in the roofing and that only the relatively uncontaminated upper layer in the roof of Building A was analyzed. Measured beta-gamma activity levels of the lower (subsurface) roofing were higher by a factor of about 10 than those of the upper (surface) roofing (Leichtweis 1987).

The values given in Table 1 for the Building A1 roofing can be used to determine average concentrations of 870 pCi/g uranium-238, 37 pCi/g uranium-235, and 910 pCi/g uranium-234. The average concentrations of uranium isotopes given in Table 1 for Building A roofing — 20 pCi/g uranium-238, 0.91 pCi/g uranium-235, and 20 pCi/g uranium-234 — are assumed to apply to the upper or second roofing of Building A.

---

*Roofing refers to tar paper, tar, and sand/gravel; roofing material includes roofing and the underlying roof decking. The following description applies to roofing only on Buildings A and A1 because no data are available regarding the extent of contamination in the roof decking.

139115

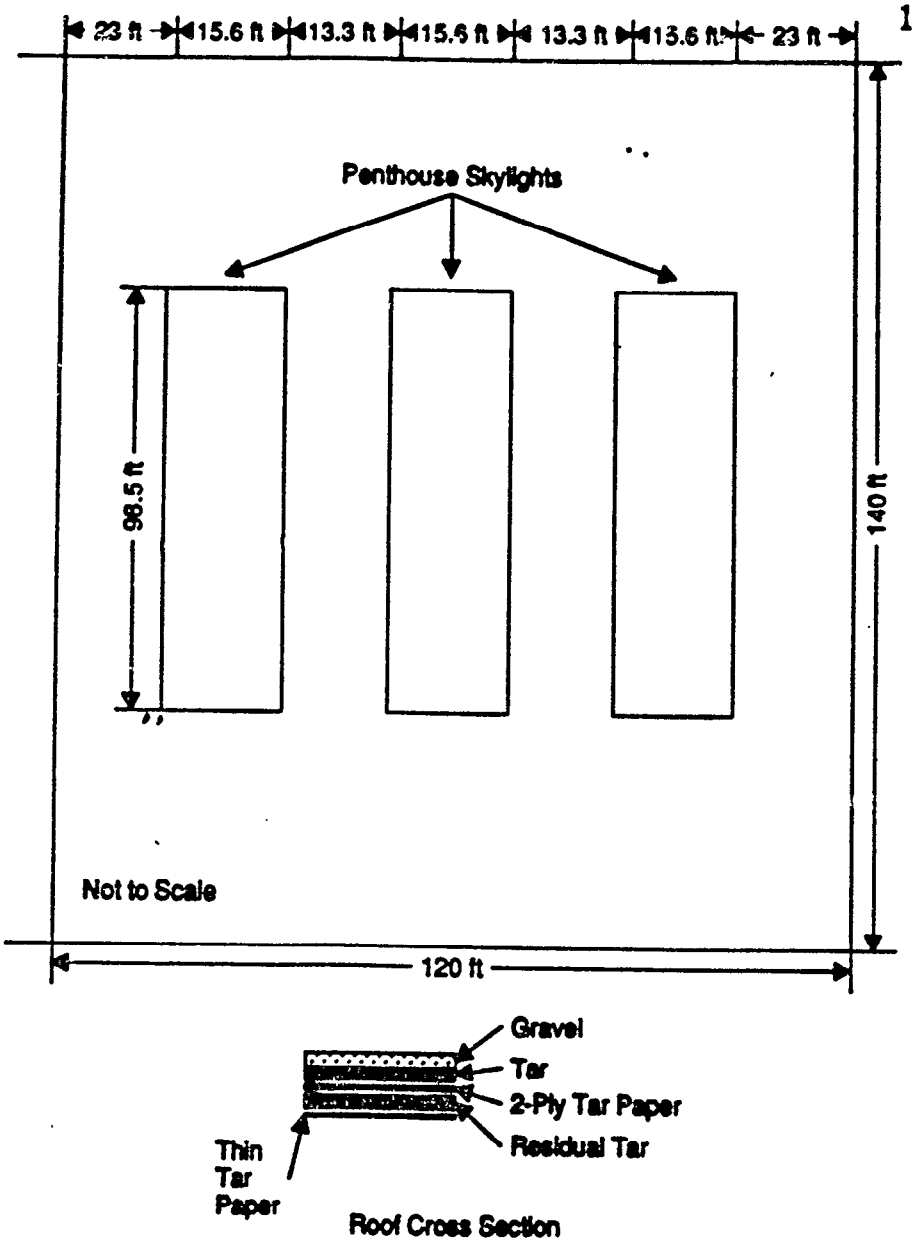



**FIGURE 2 Details of the Roof of Building A**

139115

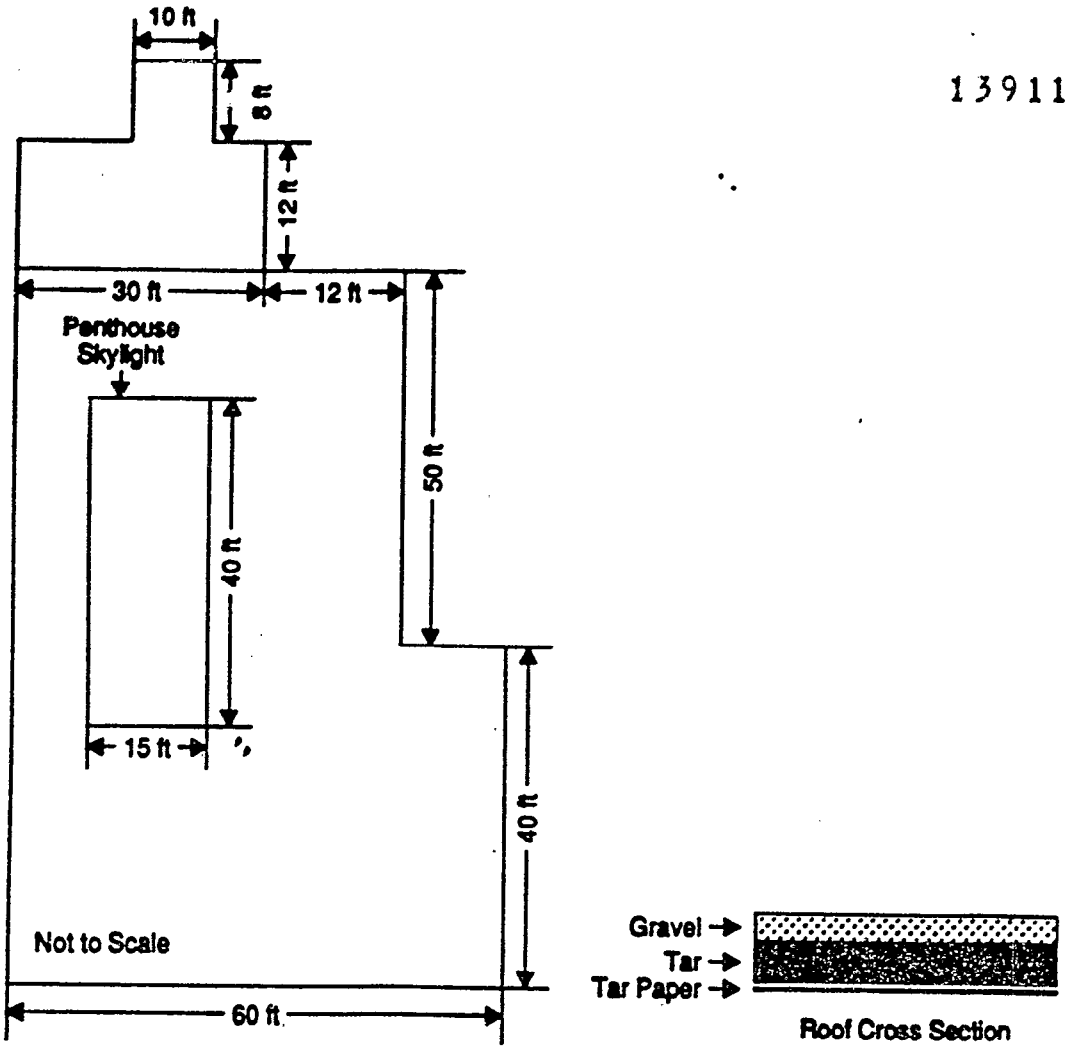



**FIGURE 3 Details of the Roof of Building A1**

139115

TABLE 1 Isotopic Uranium in Roofing of Buildings A and A1

| Building | Depth (cm) | Date Collected | Type of Analysis | Total Weight g (wet/dry) | Total Weight pCi/g (dry) |
|---|---|---|---|---|---|
| A | 0-2 | 6/5/87 | Uranium-234 | 665/616 | 3.5 ± 0.4 |
| | | | Uranium-235 | | 0.2 ± 0.1 |
| | | | Uranium-238 | | 3.8 ± 0.4 |
| A | 0-2 | 6/5/87 | Uranium-234 | 779/710 | 56 ± 1 |
| | | | Uranium-235 | | 2.6 ± 0.3 |
| | | | Uranium-238 | | 55 ± 1 |
| A | 0-2 | 6/5/87 | Uranium-234 | 773/646 | 12 ± 1 |
| | | | Uranium-235 | | 0.5 ± 0.1 |
| | | | Uranium-238 | | 12 ± 1 |
| Dupl.[a] | 0-2 | 6/5/87 | Uranium-234 | 773/646 | 10 ± 1 |
| | | | Uranium-235 | | 0.4 ± 0.1 |
| | | | Uranium-238 | | 10 ± 1 |
| A | 0-2 | 6/5/87 | Uranium-234 | 710/618 | 11 ± 1 |
| | | | Uranium-235 | | 0.4 ± 0.1 |
| | | | Uranium-238 | | 11 ± 1 |
| A1 | 0-1 | 6/5/87 | Uranium-234 | 602/548 | 1000 ± 100 |
| | | | Uranium-235 | | 40 ± 20 |
| | | | Uranium-238 | | 900 ± 100 |
| A1 | 0-4 | 6/5/87 | Uranium-234 | 728/654 | 1170 ± 60 |
| | | | Uranium-235 | | 50 ± 10 |
| | | | Uranium-238 | | 1140 ± 60 |
| Dupl.[a] | 0-4 | 6/5/87 | Uranium-234 | 728/654 | 1140 ± 50 |
| | | | Uranium-235 | | 30 ± 10 |
| | | | Uranium-238 | | 1050 ± 50 |
| A1 | 0-4 | 6/5/87 | Uranium-234 | 450/380 | 560 ± 40 |
| | | | Uranium-235 | | 30 ± 10 |
| | | | Uranium-238 | | 620 ± 40 |

[a]Duplicate sample; duplicate samples were averaged together before computing the average concentrations reported in the text.

Source: Data from Leichtweis (1987).

139115

Average uranium concentrations in the lower roofing of Building A can be estimated from the results of the beta-gamma surveys of the roofs (Leichtweis 1987). Surface and subsurface activities were measured at nine locations on Building A, including two of the penthouse roofs. The average values from the nine locations are 110 cpm (surface) and 53,000 cpm (subsurface). For Building A1, the average of surface values measured at 24 locations is 2,000 cpm. For the Building A1 roof, 2,000 cpm beta-gamma activity corresponds to about 1,800 pCi/g total uranium. Assuming this same ratio for the Building A roof, the total estimated uranium concentration of the lower roofing of Building A is about 5,300 pCi/g total uranium. This assumption appears to be reasonable because applying it to the upper roofing results in an estimate of about 99 pCi/g total uranium whereas the measured value is about 41 pCi/g. The factor of 2.5 difference between the values is reasonable considering the many assumptions involved.

These estimates refer to uranium concentrations only and do not include other radionuclides in the uranium decay chain, such as thorium-230, radium-226, and associated decay products. No data are available on the concentrations of these isotopes in the roofing. However, concentrations can be roughly estimated from the measured concentrations of uranium-238, thorium-230, and radium-226 in soil at 27 locations in the Ventron site (Bechtel National 1986). The average concentrations measured in the soil (with no corrections for background) were 2.4 pCi/g radium-226, 7.2 pCi/g thorium-230, and 5,700 pCi/g uranium-238. The estimates summarized in Table 2 are based on the assumptions that (1) the activity ratios in the roofing are similar to those in this contaminated soil and (2) uranium-234, uranium-235, and uranium-238 are present in the roofing in their natural activity ratios. These assumptions are reasonable given that natural uranium was processed at the site.

TABLE 2 Estimated Radium and Thorium Concentrations in Roofing of Buildings A and A1

| | Concentration (pCi/g) | | | |
|---|---|---|---|---|
| Building | Total Uranium | Thorium-230[a] | Radium-226[a] | Total Specific Activity[b] |
| A surface | 41 | 0.025 | 0.0084 | 81 |
| A subsurface | 5,300 | 3.3 | 1.1 | 11,000 |
| A1 | 1,800 | 1.1 | 0.38 | 3,600 |

[a]Values do not include background concentrations.

[b]Includes the contributions of intermediate decay products between uranium-238 and uranium-234 (i.e., thorium-234 and protactinium-234). Values are reported to two significant figures.

The total curie content and average specific activity of the roofing were determined as follows. The total masses of the components of the roofing were determined using the estimated volumes of 41 $m^3$ (54 $yd^3$) for Building A and 4.1 $m^3$ (5.4 $yd^3$) for Building A1 and assuming a density of 1.7 $g/cm^3$ for the roofing. It was assumed that the first or subsurface roofing on Building A (the first tar paper layer and residual tar below the second layer — see Fig. 1) has a thickness of about 0.6 cm (0.25 in.), which is one-fourth of the total thickness. Using the total specific activities given in Table 2, the upper roofing on Building A is estimated to contain 4.2 mCi total activity; the lower roofing of Building A, 190 mCi; and the roofing on Building A1, 25 mCi. The total amount of activity associated with all the roofing is estimated to be 220 mCi, and the average activity is estimated to be 2,900 pCi/g. Because the average activity level is greater than 2,000 pCi/g, the roofing must be considered as low-specific-activity radioactive material for transportation purposes, as defined by the U.S. Department of Transportation (DOT) in 49 CFR Part 173.403(y).

These estimates of total activity and specific activity do not include any roof decking. If appreciable amounts of roof decking are determined to be contaminated, the total activity of the roofing material would have to be increased to include the contaminated roof decking.

## 4 DESCRIPTION OF THE PROPOSED ACTION

Contaminated roofing will be removed using methods that minimize the amount of dust produced and the possible spread of contamination. In addition, some roof decking may have to be removed if it cannot be decontaminated in place. Contaminated surfaces will be decontaminated by cleaning, scraping, and wire brushing activities, as needed. Decontamination will continue until the levels of residual radioactivity meet the criteria developed by DOE for release for unrestricted use (App. A). The removed roofing material will be brought down to the ground and packaged in strong, tight containers that meet or exceed DOT requirements for shipment. Use of 2.3 $m^3$ (3 $yd^3$) steel boxes is currently planned.

The volume of packaged waste was estimated as follows. The volume of contaminated roofing is estimated to be about 45 $m^3$ (60 $yd^3$). This volume was doubled to 90 $m^3$ (120 $yd^3$) to account for contaminated roof decking that may have to be removed, contaminated protective clothing used by workers, and any other miscellaneous waste generated by these activities. The specific activity of this additional material is assumed to be the same as that of the contaminated roofing. The waste will be compacted into containers to the extent practicable. Because of the nature of the waste (i.e., roofing and construction debris), a significant amount of voids will remain after the waste is packaged. Therefore, the packaged waste volume is estimated to be about 150 $m^3$ (200 $yd^3$), which requires a total of about 65 boxes.

The boxes will be placed on flat-bed trailers for shipment to the Hanford site. The boxes will be secured to the trailer and then covered with a tarp. Prior to leaving the site, each truck will be radiologically surveyed to ensure that no radioactive contamination is present on the exterior of the truck (in particular, on the tires). If needed, the trucks will be decontaminated prior to leaving the site.

The weight restriction for legal weight shipments is 36,000 kg (80,000 lb) per shipment, including the weight of the tractor. Assuming that the trailer weighs approximately 15,000 kg (32,000 lb), the allowable payload per shipment is limited to 21,000 kg (48,000 lb). Because the weight of the package alone is about 10% of the weight of the filled package, about 10 boxes can be transported per shipment. Thus, a total of seven truckloads will be required to transport the wastes from the Ventron site to the Hanford site.

The proposed route to Hanford is shown in Fig. 4. The trucks will exit the Ventron site and proceed north on Highway 1-A until it intersects Massachusetts Route 62. The trucks will travel west on Route 62 to Interstate 95, proceed south on Interstate 95 until it intersects Interstate 90, and then travel west on Interstate 90 to Gary, Indiana. At Gary, Indiana, the trucks will travel west on Interstate 80 to Salt Lake City, Utah. The trucks will then proceed north on Interstate 84 to the Umatilla exit and then north on Oregon Route 395 to the Oregon/Washington border. From the border, the trucks will proceed north on Washington Route 14 to Washington Route 12, and then travel north on Route 12 toward Richland, Washington, until intersecting with Interstate 182. The trucks will travel along Interstate 182 until reaching Washington Route 240 and then take Route 240 to the 200-West Area on the Hanford site where the

139115

disposal facility for the wastes is located. The total length of the route is about 4,800 km (3,000 mi).

After the contaminated material is removed, the remaining roof decking will be inspected for the presence of any residual contamination and for any structural problems. If necessary, subsequent work will be done to correct any structural problems and reduce contamination to levels that meet DOE criteria for release for unrestricted use (App. A).

After the roof decking has passed inspection, new roof decking will be installed in any areas from which contaminated roof decking was removed. New roofing will then be installed over the decking. The quality of the new material will be similar to that of the removed roofing material. After installation is complete, the new roof will be inspected to ensure that its quality is satisfactory. Any problems found during the inspection will be corrected.

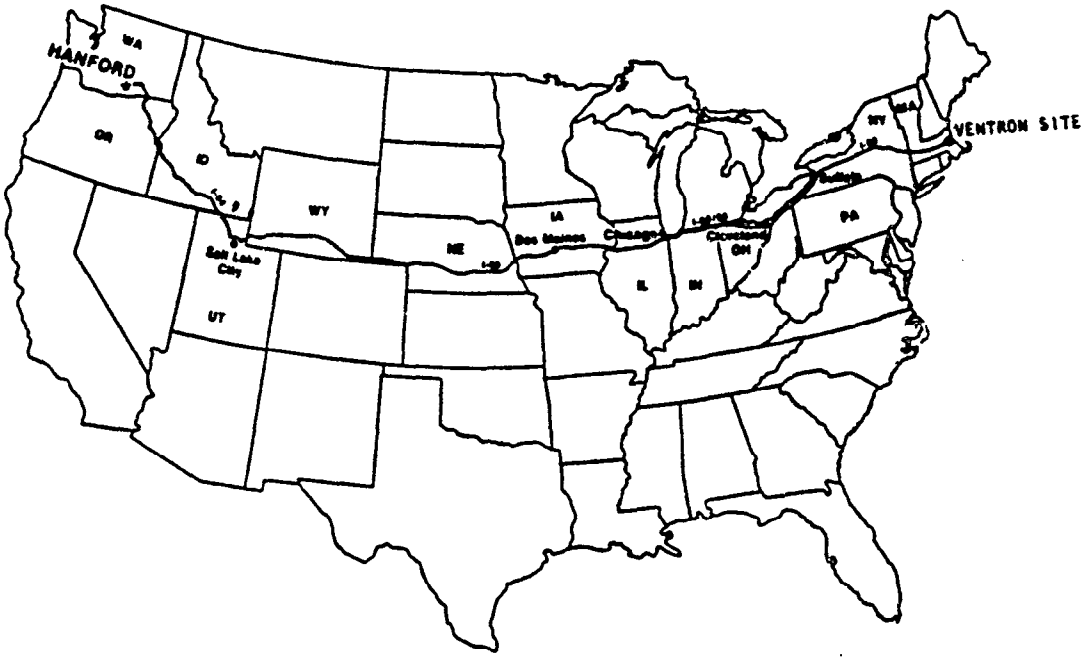



FIGURE 4 Proposed Transportation Route to the Hanford Site

159115

# 5 SUMMARY OF IMPACTS

## 5.1 RADIOLOGICAL IMPACTS AT THE VENTRON SITE

The incremental radiation doses to the general public from decontamination of the contaminated roofs at the Ventron site are expected to be very low compared with doses received from background sources of radiation. The work environment will be monitored for airborne radioactivity during remedial action activities, and corrective actions will be implemented if measurable concentrations of radioactivity are detected. This will ensure that radiation doses to the general public will be kept immeasurably small.

The potential radiation doses to workers performing the remedial action will be kept as low as reasonably achievable (ALARA) by standard health-physics practices and strict compliance with DOE environmental protection, safety, and health protection guidelines given in DOE Order 5480.1A.* The predominant pathways by which workers could incur radiation doses in excess of background exposure are direct external radiation and inhalation of airborne radioactive contaminants generated during the decontamination and waste-packaging activities. Radioactive waste-handling activities will not result in any significant radiation exposure.

Work practices and procedures will be developed to ensure that occupational doses to workers are controlled and limited to doses that are only a small fraction of those specified by DOE regulations for occupational doses. Workers will be trained with regard to radiation risks and proper health-physics procedures. The potential doses to workers will be kept low by minimizing the amount of airborne contamination through practices such as wetting surfaces to minimize dust generation. In addition, workers will wear respiratory protection equipment, as necessary, to reduce the likelihood of inhaling radioactively contaminated particulates. To monitor the environment, air samples will be collected during the entire remedial action period. Procedures to minimize radiation doses will also serve to minimize exposure to any hazardous chemicals, such as asbestos, that may be present.

The occupational dose commitment was estimated by conservatively assuming that an average concentration of 1,000 pCi/g of uranium-238 (with uranium-235 and uranium-234 present in their naturally occurring concentrations) is present in the roofing material. A mass loading factor of 5 mg/m$^3$ of respirable dust is assumed. This value, which is conservative, is the maximum value for respirable dust in the workplace as given by the Occupational Health and Safety Administration (29 CFR Part 1910). The total length of time associated with the proposed decontamination activities is estimated to be 240 work hours over a 10-week period. During all activities that have the potential for generating airborne radioactivity, it is assumed that workers will wear respiratory protection equipment providing a protection factor of 10 (the same factor that is provided by half-masks — see 10 CFR Part 20). An inhalation dose factor of

*Chapter XI of Order 5480.1A has been amended — see Vaughan (1985) and U.S. Department of Energy (1986).

139115

0.25 mrem/pCi inhaled and an external dose factor of 0.13 (mrem/yr)/(pCi/cm$^2$) are used (Gilbert et al. 1985). A worker is estimated to incur an inhalation dose of about 36 mrem during decontamination activities, assuming a breathing rate of 1.2 m$^3$/h and a lung clearance class of Y.* The external dose to a worker is estimated to be 23 mrem.

The combination of the estimated inhalation and external doses gives a resulting total dose to a worker of 59 mrem. The entire occupational dose commitment to a crew of 10 workers is estimated to be 0.59 person-rem. The same work force would incur a dose of about 0.48 person-rem from background sources of radioactivity over the same time period.

## 5.2 TRANSPORTATION IMPACTS

The doses to the general public along the transportation route and near the Hanford site would be very low due to (1) the low external dose rate associated with these wastes (estimated to be less than 0.05 mrem/h at the surface of the vehicle), (2) the distance from these wastes of individuals along the transportation route and near the Hanford site (i.e., the external dose rate decreases rapidly with distance), and (3) the minimal amount of particulate releases associated with transportation of these wastes because the wastes will have been packaged prior to transport. The primary mechanism by which truck drivers would incur a radiation dose while transporting the wastes to the Hanford site is external radiation exposure. The external dose rate in the truck cab is estimated to be about 0.01 mrem/h above background. Based on a distance to the Hanford site of about 4,800 km (3,000 mi), a driver would be exposed to the wastes for about 60 hours and the dose to the truck driver would be about 0.6 mrem per trip. For the estimated seven trips required to transport the wastes to the Hanford site, the collective occupational dose commitment for transportation is estimated to be about 8.4 person-mrem, assuming that each truck has two drivers.

Transportation of the wastes to the Hanford site would increase the potential for traffic accidents to occur, with resultant injuries and possible fatalities. For this assessment, it was assumed that seven round-trips would be required to transport the wastes to the Hanford site, a total round-trip distance of about 67,000 vehicle-km (42,000 vehicle-mi). The number of injuries and fatalities associated with transportation accidents was estimated using the unit-risk factors of $5.1 \times 10^{-7}$ injuries and $3.0 \times 10^{-8}$ fatalities per vehicle-km for truck transportation (Wolff 1984). A total of 0.034 injuries and 0.0020 fatalities are estimated to result from transportation accidents. It is very unlikely that any transportation-related injuries or accidents would occur as a result of the planned remedial action activities.

---

*Internal doses are given as the 50-year committed effective dose equivalent as recommended by the International Commission on Radiological Protection (1979).

## 8 REFERENCES

139115

Bechtel National, Inc. 1986, *Site Plan for Ventron Division of Morton Thiokol, Inc. Beverly, Massachusetts*, prepared for U.S. Department of Energy, Oak Ridge Operations Office (Sept.).

Gilbert, T.L., et al., 1985, *A Manual for Implementing Residual Radioactivity Guidelines: A Supplement to U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites*, prepared by Argonne National Laboratory, Oak Ridge National Laboratory, Los Alamos National Laboratory, and Battelle Pacific Northwest Laboratory for U.S. Department of Energy (Sept.).

International Commission on Radiological Protection, 1979, *Limits for Intakes of Radionuclides by Workers*, ICRP Publ. 30, Pergamon Press, Elmsford, N.Y.

Leichtweis, C., 1987, unpublished data provided by C. Leichtweis (Bechtel National, Inc., Oak Ridge, Tenn.) to N. Beskid (Argonne National Laboratory, Argonne, Ill.) (Sept. 23.).

Lester, B., 1987, personal communication from B. Lester (Bechtel National, Inc., Oak Ridge, Tenn.) to P. Benioff (Argonne National Laboratory, Argonne, Ill.), (Oct. 6 to Oct. 9).

U.S. Department of Energy, 1986, *DOE-Derived Concentration Guides for Drinking Water and Breathing Air Contaminated with Radionuclides by Members of the Public*, attachment to memorandum from R.J. Stern (Director, Office of Environmental Guidance) to Distribution (Feb. 28).

Vaughan, W.A., 1985, memorandum from W.A. Vaughan (U.S. Department of Energy, Assistant Secretary for Environmental, Safety and Health) to Distribution — Subject: Radiation Standards for Protection of the Public in the Vicinity of DOE Facilities (Aug. 5).

Wolff, T.A., 1984, *The Transportation of Nuclear Materials*, SAND-0062; TTC-0461, Transportation Technology Center Department, Sandia National Laboratories, Albuquerque, N.M. (Dec.).

# 7 LIST OF CONTRIBUTORS

139115

| Name | Education/Expertise | Contribution |
|---|---|---|
| Paul B. Benioff | Ph.D., Chemistry<br>27 yr experience in chemistry, including 9 yr in environmental assessment | History of site activities, description of site, radiological characterization, and description of proposed action |
| John M. Peterson | M.S., P.E. Nuclear Engineering<br>12 yr experience in nuclear programs, including 9 yr in environmental assessment | Radiological impacts, transportation analysis |
| John H.-C. Wang | Ph.D. Health Physics<br>6 yr experience in health physics | Radiological impacts |
| Dimis J. Wyman | M.S. Botany; M.A. Library Science<br>12 yr experience in technical editing | Overall editorial responsibility |

139115

# APPENDIX A

## DOE GUIDELINES FOR RESIDUAL RADIOACTIVE MATERIAL

U.S. DEPARTMENT OF ENERGY GUIDELINES
FOR RESIDUAL RADIOACTIVE MATERIAL AT
FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM
AND
REMOTE SURPLUS FACILITIES MANAGEMENT PROGRAM SITES

(Revision 2, March 1987)

### A. INTRODUCTION

This document presents U.S. Department of Energy (DOE) radiological protection guidelines for cleanup of residual radioactive material and management of the resulting wastes and residues. It is applicable to sites identified by the Formerly Utilized Sites Remedial Action Program (FUSRAP) and remote sites identified by the Surplus Facilities Management Program (SFMP).* The topics covered are basic dose limits, guidelines and authorized limits for allowable levels of residual radioactive material, and requirements for control of the radioactive wastes and residues.

Protocols for identification, characterization, and designation of FUSRAP sites for remedial action; for implementation of the remedial action; and for certification of a FUSRAP site for release for unrestricted use are given in a separate document (U.S. Department of Energy 198[illegible]) and subsequent guidance. More detailed information on applications of the guidelines presented herein, including procedures for deriving site-specific guidelines for allowable levels of residual radioactive material from basic dose limits, is contained in "A Manual for Implementing Residual Radioactive Material Guidelines" (U.S. Department of Energy 1987), referred to herein as the "supplement".

"Residual radioactive material" is used in these guidelines to describe radioactive material derived from operations or sites over which DOE has authority. Guidelines or guidance to limit the levels of radioactive material and to protect the public and the environment are provided for (1) residual concentrations of radionuclides in soil,** (2) concentrations of airborne

*A remote SFMP site is one that is excess to DOE programmatic needs and is located outside a major operating DOE research and development or production area.

**"Soil" is defined herein as unconsolidated earth material, including rubble and debris that may be present in earth material.

139115

radon decay products, (3) external gamma radiation levels, (4) surface contamination levels, and (5) radionuclide concentrations in air or water resulting from or associated with any of the above.

A "basic dose limit" is a prescribed standard from which limits for quantities that can be monitored and controlled are derived; it is specified in terms of the effective dose equivalent as defined by the International Commission on Radiological Protection (ICRP 1977, 1978). The basic dose limits are used for deriving guidelines for residual concentrations of radionuclides in soil. Guidelines for residual concentrations of thorium and radium in soil, concentrations of airborne radon decay products, allowable indoor external gamma radiation levels, and residual surface contamination concentrations are based on existing radiological protection standards (U.S. Environmental Protection Agency 1983; U.S. Nuclear Regulatory Commission 1982; and DOE Departmental Orders). Derived guidelines or limits based on the basic dose limits for those quantities are used only when the guidelines provided in the existing standards cited above are shown to be inappropriate.

A "guideline" for residual radioactive material is a level of radioactivity or radioactive material that is acceptable if use of the site is to be unrestricted. Guidelines for residual radioactive material presented herein are of two kinds: (1) generic, site-independent guidelines taken from existing radiation protection standards and (2) site-specific guidelines derived from basic dose limits using site-specific models and data. Generic guideline values are presented in this document. Procedures and data for deriving site-specific guideline values are given in the supplement. The basis for the guidelines is generally a presumed worst-case plausible-use scenario for the site.

An "authorized limit" is a level of residual radioactive material or radioactivity that must not be exceeded if the remedial action is to be considered completed and the site is to be released for unrestricted use. The authorized limits for a site will include (1) limits for each radionuclide or group of radionuclides, as appropriate, associated with residual radioactive material in soil or in surface contamination of structures and equipment, (2) limits for each radionuclide or group of radionuclides, as appropriate, in air or water, and, (3) where appropriate, a limit on external gamma radiation resulting from the residual material. Under normal circumstances, expected to occur at most sites, authorized limits for residual radioactive material or radioactivity are set equal to guideline values. Exceptional conditions for which authorized limits might differ from guideline values are specified in Sections D and F of this document. A site may be released for unrestricted use only if site conditions do not exceed the authorized limits or approved supplemental limits, as defined in Section F.1, at the time remedial action is completed. Restrictions and controls on use of the site must be established and enforced if site conditions exceed the approved limits, or if there is potential to exceed the basic dose limit if use of the site is not restricted (Section F.2). The applicable controls and restrictions are specified in Section E.

139115

DOE policy requires that all exposures to radiation be limited to levels that are as low as reasonably achievable (ALARA). For sites to be released for unrestricted use, the intent is to reduce residual radioactive material to levels that are as far below authorized limits as reasonable considering technical, economic, and social factors. At sites where the residual material is not reduced to levels that permit release for unrestricted use, ALARA policy is implemented by establishing controls to reduce exposure to levels that are as low as reasonably achievable. Procedures for implementing ALARA policy are discussed in the supplement. ALARA policies, procedures, and actions shall be documented and filed as a permanent record upon completion of remedial action at a site.

## B. BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 100 mrem/yr. The internal committed effective dose equivalent, as defined in ICRP Publication 26 (ICRP 1977) and calculated by dosimetry models described in ICRP Publication 30 (ICRP 1978), plus the dose from penetrating radiation sources external to the body, shall be used for determining the dose. This dose shall be described as the "effective dose equivalent". Every effort shall be made to ensure that actual doses to the public are as far below the basic dose limit as is reasonably achievable.

Under unusual circumstances, it will be permissible to allow potential doses to exceed 100 mrem/yr where such exposures are based upon scenarios that do not persist for long periods and where the annual lifetime exposure to an individual from the subject residual radioactive material would be expected to be less than 100 mrem/yr. Examples of such situations include conditions that might exist at a site scheduled for remediation in the near future or a possible, but improbable, one-time scenario that might occur following remedial action. These levels should represent doses that are as low as reasonably achievable for the site. Further, no annual exposure should exceed 500 mrem.

## C. GUIDELINES FOR RESIDUAL RADIOACTIVE MATERIAL

### C.1 Residual Radionuclides in Soil

Residual concentrations of radionuclides in soil shall be specified as above-background concentrations averaged over an area of 100 $m^2$. Generic guidelines for thorium and radium are specified below. Guidelines for residual concentrations of other radionuclides shall be derived from the basic dose limits by means of an environmental pathway analysis using site-specific data where available. Procedures for these derivations are given in the supplement.

If the average concentration in any surface or below-surface area less than or equal to 25 $m^2$ exceeds the authorized limit or guideline by a factor of $(100/A)^{1/2}$, where A is the area of the elevated region in square meters,

139115

limits for "hot spots" shall also be applicable. Procedures for calculating these hot spot limits, which depend on the extent of the elevated local concentrations, are given in the supplement. In addition, every reasonable effort shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit for soil, irrespective of the average concentration in the soil.

Two types of guidelines are provided, generic and derived. The generic guidelines for residual concentrations of Ra-226, Ra-228, Th-230, and Th-232 are:

- 5 pCi/g, averaged over the first 15 cm of soil below the surface
- 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface

These guidelines take into account ingrowth of Ra-226 from Th-230 and of Ra-228 from Th-232, and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the appropriate guideline is applied as a limit to the radionuclide with the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that (1) the dose for the mixtures will not exceed the basic dose limit or (2) the sum of the ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed 1 ("unity"). Explicit formulas for calculating residual concentration guidelines for mixtures are given in the supplement.

## C.2 Airborne Radon Decay Products

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for unrestricted use; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR Part 192) is: In any occupied or habitable building, the objective of remedial action shall be, and a reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.* In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions by DOE are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive material is not the cause.

---

*A working level (WL) is any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of $1.3 \times 10^5$ MeV of potential alpha energy.

139115

C.3 External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site to be released for unrestricted use shall not exceed the background level by more than 20 μR/h and shall comply with the basic dose limit when an appropriate-use scenario is considered. This requirement shall not necessarily apply to structures scheduled for demolition or to buried foundations. External gamma radiation levels on open lands shall also comply with the basic dose limit, considering an appropriate-use scenario for the area.

C.4 Surface Contamination

The generic surface contamination guidelines provided in Table 1 are applicable to existing structures and equipment. These guidelines are adapted from standards of the U.S. Nuclear Regulatory Commission (NRC 1982)* and will be applied in a manner that provides a level of protection consistent with the Commission's guidance. These limits apply to both interior and exterior surfaces. They are not directly intended for use on structures to be demolished or buried, but should be applied to equipment or building components that are potentially salvageable or recoverable scrap. If a building is demolished, the guidelines in Section C.1 are applicable to the resulting contamination in the ground.

C.5 Residual Radionuclides in Air and Water

Residual concentrations of radionuclides in air and water shall be controlled to levels required by DOE Environmental Protection Guidance and Orders, specifically DOE Order 5480.1A and subsequent guidance. Other Federal and/or state standards shall apply when they are determined to be appropriate.

D. AUTHORIZED LIMITS FOR RESIDUAL RADIOACTIVE MATERIAL

Authorized limits shall be established to (1) ensure that, as a minimum, the basic dose limits specified in Section B will not be exceeded under the worst-case plausible-use scenario consistent with the procedures and guidance provided or (2) be consistent with applicable generic guidelines, where such guidelines are provided. The authorized limits for each site and its vicinity properties shall be set equal to the generic or derived guidelines except where it can be clearly established on the basis of site-specific data -- including health, safety, and socioeconomic considerations -- that the guidelines are not appropriate for use at the specific site. Consideration should also be given to ensure that the limits comply with or provide a level of protection equivalent to other appropriate limits and guidelines (i.e., state or

*These guidelines are functionally equivalent to Section 4 -- Decontamination for Release for Unrestricted Use -- of NRC Regulatory Guide 1.86 (U.S. Atomic Energy Commission 1974), but they are applicable to non-reactor facilities.

139115

TABLE 1 SURFACE CONTAMINATION GUIDELINES

| Radionuclides[b] | Allowable Total Residual Surface Contamination (dpm/100 $cm^2$)[a] | | |
|---|---|---|---|
| | Average[c,d] | Maximum[d,e] | Removable[d,f] |
| Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129 | 100 | 300 | 20 |
| Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133 | 1,000 | 3,000 | 200 |
| U-Natural, U-235, U-238, and associated decay products | 5,000 α | 15,000 α | 1,000 α |
| Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above | 5,000 β-γ | 15,000 β-γ | 1,000 β-γ |

[a] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[b] Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

[c] Measurements of average contamination should not be averaged over an area of more than 1 $m^2$. For objects of less surface area, the average should be derived for each such object.

[d] The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

[e] The maximum contamination level applies to an area of not more than 100 $cm^2$.

[f] The amount of removable radioactive material per 100 $cm^2$ of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 $cm^2$ is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

139115

other Federal). Documentation supporting such a decision should be similar to that required for supplemental limits and exceptions (Section F), but should be generally more detailed because the documentation covers the entire site.

Remedial action shall not be considered complete unless the residual radioactive material levels comply with the authorized limits. The only exception to this requirement will be for those special situations where the supplemental limits or exceptions are applicable and approved as specified in Section F. However, the use of supplemental limits and exceptions should be considered only if it is clearly demonstrated that it is not reasonable to decontaminate the area to the authorized limit or guideline value. The authorized limits are developed through the project offices in the field and are approved by the headquarters program office.

E. CONTROL OF RESIDUAL RADIOACTIVE MATERIAL AT FUSRAP AND REMOTE SFMP SITES

Residual radioactive material above the guidelines at FUSRAP and remote SFMP sites must be managed in accordance with applicable DOE Orders. The DOE Order 5480.1A and subsequent guidance or superceding Orders require compliance with applicable Federal and state environmental protection standards.

The operational and control requirements specified in the following DOE Orders shall apply to interim storage, interim management, and long-term management.

a. 5000.3, Unusual Occurrence Reporting System

b. 5440.1C, Implementation of the National Environmental Policy Act

c. 5480.1A, Environmental Protection, Safety, and Health Protection Program for DOE Operations, as revised by DOE 5480.1 change orders and the 5 August 1985 memorandum from Vaughan to Distribution

d. 5480.2, Hazardous and Radioactive Mixed Waste Management

e. 5480.4, Environmental Protection, Safety, and Health Protection Standards

f. 5482.1A, Environmental, Safety, and Health Appraisal Program

g. 5483.1A, Occupational Safety and Health Program for Government-Owned Contractor-Operated Facilities

h. 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements

i. 5820.2, Radioactive Waste Management

139115

E.1 Interim Storage

a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 50 years and, in any case, at least 25 years.

b. Above-background Rn-222 concentrations in the atmosphere above facility surfaces or openings shall not exceed (1) 100 pCi/L at any given point, (2) an annual average concentration of 30 pCi/L over the facility site, and (3) an annual average concentration of 3 pCi/L at or above any location outside the facility site (DOE Order 5480.1A, Attachment XI-1).

c. Concentrations of radionuclides in the groundwater or quantities of residual radioactive material shall not exceed existing Federal or state standards.

d. Access to a site shall be controlled and misuse of on-site material contaminated by residual radioactive material shall be prevented through appropriate administrative controls and physical barriers -- active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These control features should be designed to ensure, to the extent reasonable, an effective life of at least 25 years. The Federal government shall have title to the property or shall have a long-term lease for exclusive use.

E.2 Interim Management

a. A site may be released under interim management when the residual radioactive material exceeds guideline values if the residual radioactive material is in inaccessible locations and would be unreasonably costly to remove, provided that administrative controls are established to ensure that no member of the public shall receive a radiation dose exceeding the basic dose limit.

b. The administrative controls, as approved by DOE, shall include but not be limited to periodic monitoring as appropriate, appropriate shielding, physical barriers to prevent access, and appropriate radiological safety measures during maintenance, renovation, demolition, or other activities that might disturb the residual radioactive material or cause it to migrate.

c. The owner of the site or appropriate Federal, state, or local authorities shall be responsible for enforcing the administrative controls.

E.3 Long-Term Management

139115

Uranium, Thorium, and Their Decay Products

a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 1,000 years and, in any case, at least 200 years.

b. Control and stabilization features shall be designed to ensure that Rn-222 emanation to the atmosphere from the wastes shall not (1) exceed an annual average release rate of 20 $pCi/m^2/s$ and (2) increase the annual average Rn-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L. Field verification of emanation rates is not required.

c. Prior to placement of any potentially biodegradable contaminated wastes in a long-term management facility, such wastes shall be properly conditioned to ensure that (1) the generation and escape of biogenic gases will not cause the requirement in paragraph b. of this section (E.3) to be exceeded and (2) biodegradation within the facility will not result in premature structural failure in violation of the requirements in paragraph a. of this section (E.3).

d. Groundwater shall be protected in accordance with appropriate Departmental Orders and Federal and state standards, as applicable to FUSRAP and remote SFMP sites.

e. Access to a site should be controlled and misuse of on-site material contaminated by residual radioactivity should be prevented through appropriate administrative controls and physical barriers -- active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These controls should be designed to be effective to the extent reasonable for at least 200 years. The Federal government shall have title to the property.

Other Radionuclides

f. Long-term management of other radionuclides shall be in accordance with Chapters 2, 3, and 5 of DOE Order 5820.2, as applicable.

F. SUPPLEMENTAL LIMITS AND EXCEPTIONS

If special site-specific circumstances indicate that the guidelines or authorized limits established for a given site are not appropriate for a portion of that site or for a vicinity property, then the field office may request that supplemental limits or an exception be applied. In either case, the field office must justify that the subject guidelines or authorized limits are not appropriate and that the alternative action will provide adequate

139115

protection, giving due consideration to health and safety, the environment, and costs. The field office shall obtain approval for specific supplemental limits or exceptions from headquarters as specified in Section D of these guidelines and shall provide to headquarters those materials required for the justification as specified in this section (F) and in the FUSRAP and SFMP protocols and subsequent guidance documents. The field office shall also be responsible for coordination with the state or local government of the limits or exceptions and associated restrictions as appropriate. In the case of exceptions, the field office shall also work with the state and/or local governments to ensure that restrictions or conditions of release are adequate and mechanisms are in place for their enforcement.

F.1 Supplemental Limits

The supplemental limits must achieve the basic dose limits set forth in this guideline document for both current and potential unrestricted uses of a site and/or vicinity property. Supplemental limits may be applied to a vicinity property or a portion of a site if, on the basis of a site-specific analysis, it is determined that (1) certain aspects of the vicinity property or portion of the site were not considered in the development of the established authorized limits and associated guidelines for that vicinity property or site and, (2) as a result of these unique characteristics, the established limits or guidelines either do not provide adequate protection or are unnecessarily restrictive and costly.

F.2 Exceptions

Exceptions to the authorized limits defined for unrestricted use of a site or vicinity property may be applied to a vicinity property or a portion of a site when it is established that the authorized limits cannot be achieved and restrictions on use of the vicinity property or portion of the site are necessary to provide adequate protection of the public and the environment. The field office must clearly demonstrate that the exception is necessary and that the restrictions will provide the necessary degree of protection and will comply with the requirements for control of residual radioactive material as set forth in Section E of these guidelines.

F.3 Justification for Supplemental Limits and Exceptions

Supplemental limits and exceptions must be justified by the field office on a case-by-case basis using site-specific data. Every effort should be made to minimize use of the supplemental limits and exceptions. Examples of specific situations that warrant use of the supplemental standards and exceptions are:

a. Where remedial action would pose a clear and present risk of injury to workers or members of the general public, notwithstanding reasonable measures to avoid or reduce risk.

139115

b. Where remedial action -- even after all reasonable mitigative measures have been taken -- would produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near affected sites, now or in the future. A clear excess of environmental harm is harm that is long-term, manifest, and grossly disproportionate to health benefits that may reasonably be anticipated.

c. Where it is clear that the scenarios or assumptions used to establish the authorized limits do not, under plausible current or future conditions, apply to the property or portion of the site identified and where more appropriate scenarios or assumptions indicate that other limits are applicable or necessary for protection of the public and the environment.

d. Where the cost of remedial action for contaminated soil is unreasonably high relative to long-term benefits and where the residual radioactive material does not pose a clear present or future risk after taking necessary control measures. The likelihood that buildings will be erected or that people will spend long periods of time at such a site should be considered in evaluating this risk. Remedial action will generally not be necessary where only minor quantities of residual radioactive material are involved or where residual radioactive material occurs in an inaccessible location at which site-specific factors limit their hazard and from which they are costly or difficult to remove. Examples include residual radioactive material under hard-surface public roads and sidewalks, around public sewer lines, or in fence-post foundations. A site-specific analysis must be provided to establish that it would not cause an individual to receive a radiation dose in excess of the basic dose limits stated in Section B, and a statement specifying the level of residual radioactive material must be included in the appropriate state and local records.

e. Where there is no feasible remedial action.

C. SOURCES

139115

| Limit or Guideline | Source |
|---|---|
| **Basic Dose Limits** | |
| Dosimetry model and dose limits | International Commission on Radiological Protection (1977, 1978) |
| **Generic Guidelines for Residual Radioactivity** | |
| Residual concentrations of radium and thorium in soil | 40 CFR Part 192 |
| Airborne radon decay products | 40 CFR Part 192 |
| External gamma radiation | 40 CFR Part 192 |
| Surface contamination | Adapted from U.S. Nuclear Regulatory Commission (1982) |
| **Control of Radioactive Wastes and Residues** | |
| Interim storage | DOE Order 5480.1A and subsequent guidance |
| Long-term management | DOE Order 5480.1A and subsequent guidance; 40 CFR Part 192; DOE Order 5820.2 |

139115

## M. REFERENCES

International Commission on Radiological Protection, 1977. Recommendations of the International Commission on Radiological Protection (Adopted January 17, 1977). ICRP Publication 26. Pergamon Press, Oxford. [As modified by "Statement from the 1978 Stockholm Meeting of the ICRP." Annals of the ICRP, Vol. 2, No. 1, 1978.]

International Commission on Radiological Protection, 1978. Limits for Intakes of Radionuclides by Workers. A Report of Committee 2 of the International Commission on Radiological Protection. Adopted by the Commission in July 1978. ICRP Publication 30. Part 1 (and Supplement), Part 2 (and Supplement), Part 3 (and Supplements A and B), and Index. Pergamon Press, Oxford.

U.S. Atomic Energy Commission, 1974. Regulatory Guide 1.86, Termination of Operating Licenses for Nuclear Reactors. June 1974.

U.S. Department of Energy, 1986. Formerly Utilized Sites Remedial Action Program. Summary Protocol: Identification - Characterization - Designation - Remedial Action - Certification. Office of Nuclear Energy, Office of Terminal Waste Disposal and Remedial Action, Division of Remedial Action Projects. January 1986.

U.S. Department of Energy, 1987. Supplement to U.S. Department of Energy Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites. A Manual for Implementing Residual Radioactive Material Guidelines. Prepared by Argonne National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, and Pacific Northwest Laboratory for the U.S. Department of Energy. [In press.]

U.S. Environmental Protection Agency, 1983. Standards for Remedial Actions at Inactive Uranium Processing Sites; Final Rule (40 CFR Part 192). Federal Register 48(3):590-604 (January 5, 1983).

U.S. Nuclear Regulatory Commission, 1982. Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material. Division of Fuel Cycle and Material Safety, Washington, D.C. July 1982.

141533

FINAL
DOE/OR/21950-1014

# VENTRON ENGINEERING EVALUATION/COST ANALYSIS (EE/CA)

## BEVERLY, MASSACHUSETTS

APRIL 1996

*prepared by*
U.S. Department of Energy, Oak Ridge Operations Office, Formerly Utilized Sites Remedial Action Program

*with technical assistance from*
Science Applications International Corporation ESC-FUSRAP
under Contract No. DE-AC05-91OR21950

## ACRONYMS AND ABBREVIATIONS

141533

| | |
|---|---|
| AEC | U. S. Atomic Energy Commission |
| ALARA | as low as reasonably achievable |
| ARAR | applicable or relevant and appropriate requirement |
| BNI | Bechtel National, Inc. |
| BNAE | base/neutral and acid extractable |
| CAA | Clean Air Act |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| $cm^2$ | square centimeter |
| CMR | Code of Massachusetts Regulations |
| COE | Corps of Engineers |
| cpm | counts per minute |
| CWA | Clean Water Act |
| CZMA | Coastal Zone Management Act |
| DEP | Department of Environmental Protection |
| DOE | U. S. Department of Energy |
| dpm | disintegrations per minute |
| DWPC | Division of Water Pollution Control |
| DWWR | Division of Wetlands and Waterways Regulations |
| EDE | effective dose equivalent |
| EE/CA | Engineering Evaluation/Cost Analysis |
| EIR | Environmental Impact Report |
| EOEA | Executive Office of Environmental Affairs |
| ENF | Environmental Notification Form |
| EPA | U. S. Environmental Protection Agency |
| ES&H | Environmental Safety and Health |
| FEMA | Federal Emergency Management Agency |
| FFA | Federal Facilities Agreement |
| $ft^2$ | square foot/feet |
| FUSRAP | Formerly Utilized Sites Remedial Action Program |
| ha | hectare |
| ICRP | International Commission on Radiological Protection |
| km | kilometer |
| L | liter |
| LSA | low specific activity |
| $m^2$ | square meters |
| MCZM | Massachusetts Coastal Zone Management |
| MED | Manhattan Engineer District |
| MEPA | Massachusetts Environmental Policy Act |
| MeV | mega electric volts |
| mi | mile |
| MGL | Massachusetts General Law |

141533

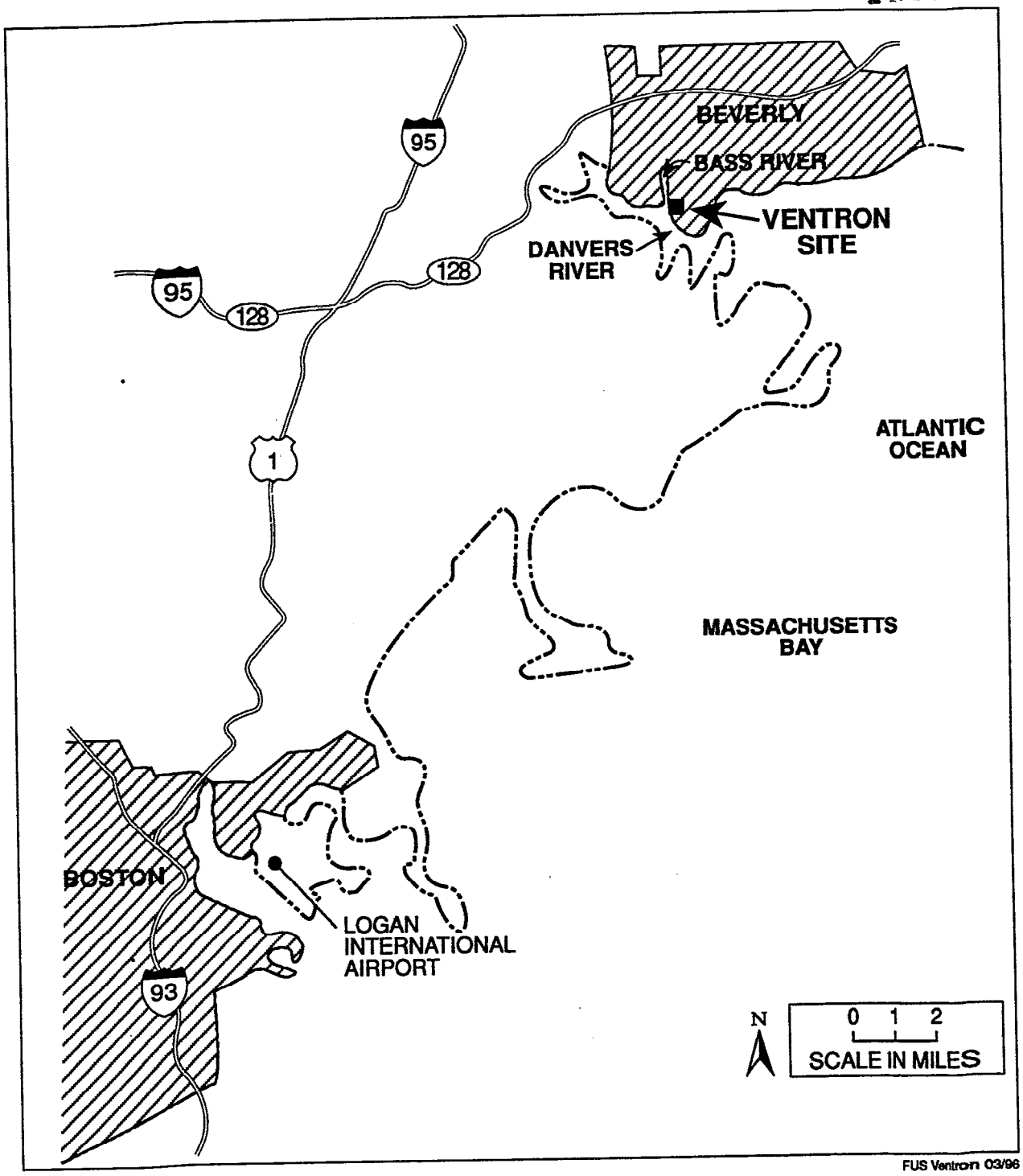



**Figure 1-1. Location of the Ventron Site**

### 6.2.1 Community Background

141533

6.2.1.1 Government Entities and Community Profile

The city of Beverly is located in an urban, industrialized area of Essex County, approximately 24 km (15 miles) northeast of Boston. The populations of Essex County and the city of Beverly, respectively, are approximately 692,859 and 41,266.

The city is governed by an elected mayor and a nine-member council and includes a public health director. Essex County is governed by a three-member county commission.

The Ventron site is in the 6th U.S. Congressional District, Massachusetts Senate District 2 (Essex) and Massachusetts House of Representatives District 6 (Essex).

6.2.1.2 Community Involvement

DOE has established an administrative record file and information repository for the Ventron site at the Beverly Public Library. Documents included in the record are intended to provide information about the site and insight into how site-related decisions are made. The repository contains information of more general interest to the public, such as fact sheets, newspaper articles, and other information materials pertaining to the site. (For locations, hours of operation, and phone numbers, see Section 6.1.)

6.2.1.3 Summary of Community Concerns

DOE's presence in the Beverly community to date has been limited, because only minimal on-site work has yet been performed by the agency and its contractors. During the time since responsibility for radiological cleanup at the Ventron site was assigned to FUSRAP in 1986, DOE representatives have met with local officials, local representatives of Morton, and community members to discuss work plans and progress, such as characterization activities, maintenance issues, environmental compliance, cleanup scenarios, and other site-specific issues.

Because DOE has had limited on-site activity, there has not been an abundant display of community concern regarding the radiological materials located there. There have occasionally been media reports regarding the site's role in MED activities. Such reports typically result in increased community interest and basic curiosity about the DOE connection to site. But the interactions that have taken place generally have been positive and rooted in cooperation. Residents of the neighborhood adjacent to the site were understandably concerned and engaging when, in 1991, radiological surveys were performed on 24 residential properties to determine whether any radiological material from the site had spread off site. No radioactive materials were found off site. A very positive, post-survey, public information session was held to cover the details of the work with affected property owners and other interested parties. Close cooperation between DOE and Morton, and timely, informative contact with community members, were key to the effort's success and helped foster trust between the neighborhood and DOE.

Community interest in DOE's stake at the site also increased in conjunction with state plans to construct a bridge nearby. Some area residents expressed concern that the work may

141533

# ATTACHMENT FOR

# APPENDIX B

# APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

1.3.2 MEPA . . . . . B-7
1.3.3 DEP . . . . . B-7
1.3.4 The Bureau of Waste Site Cleanup . . . . . B-8
1.3.5 Division of Hazardous Waste . . . . . B-8
1.3.6 Division of Wetlands and Waterways Regulations . . . . . B-8
1.3.7 Radiation Control Program . . . . . B-9
1.4 LOCAL PERMITS . . . . . B-9

## LIST OF TABLES

Table Page

B-1. Potential ARARs for the Remediation of the Ventron Site . . . . . B-10
B-2. Potential Chemical-Specific and Action-Specific ARARs for the Remediation of Ventron Department of Energy Orders . . . . . B-14
B-3. Potential ARARs for the Remediation of Ventron State of Massachusetts Executive Office of Environmental Affairs . . . . . B-17
B-4. Potential ARARs for the Remediation of Ventron Local Requirements . . . . . B-19

### 1.3.4 The Bureau of Waste Site Cleanup

141533

The Division of Air Quality Control covers the Ambient Air Quality Standards for the Commonwealth of Massachusetts under *310 CMR 6.00 Air Pollution Control*. This regulation contains the primary ambient air quality standards that the DEP judges are necessary, with an adequate margin of safety to protect the public health. Secondary ambient air quality standards define levels of air quality which the DEP judges necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. *310 CMR 7.0 Air Pollution Control* regulates preventing the occurrence of conditions of air pollution where such do not exist and facilitates the abatement of conditions of air pollution where and when such occur. They are designed to attain, preserve, and conserve the highest possible quality of the ambient air compatible with the needs of society.

### 1.3.5 Division of Hazardous Waste

The Division of Hazardous Waste regulations *310 CMR 30.00* are intended to protect public health, safety, welfare, and the environment by comprehensively regulating the generation, storage, collection, transport, treatment, disposal, use, reuse, and recycling of hazardous waste in Massachusetts. These regulations should be read together with *MGL c. 21C* and *MGL c. 215 § 6* and by *St. 1987, c. 584, § 47*, each of which has many important substantative requirements not repeated in these regulations.

### 1.3.6 Division of Wetlands and Waterways Regulations

The Division of Wetlands and Waterways Regulations (DWWR) is responsible for administering the Wetlands Protection Program through the Wetlands Protection Act (which includes any land underwater, any land subject to tidal action and/or flooding, or any wetlands as defined in the Act). The regulatory authority for these actions is covered under *310 CMR 10.00*. The areas of interest for this agency include flood control, storm damage prevention, prevention of pollution, and protection of water supply, groundwater, fisheries, shellfish areas, and wildlife habitat. The DWWR also administers the Waterways Regulation Program. The Chapter 91 Regulations (*310 CMR 9.00*) protect and promote tidelands for water-dependent uses. There are four basic areas of geographical jurisdiction pursuant to Chapter 91. Any activity taking place (both new and existing) in one of the areas listed requires the issuance of some form of Chapter 91 authorization:

- Flowed tidelands
- Filled tidelands
  - -outside designated port areas (the first public way or 250 feet from mean high water, whichever is farther landward)
  - -in designated port areas (the historic mean high water shoreline i.e., all filled areas)
- Great Ponds
- Non-Tidal Rivers and Streams

This agency concerns itself with the protection of water-dependent uses, promotion of public access, navigation safety, structural soundness, natural resources, littoral property rights, and public facilities.

### 1.3.7 Radiation Control Program

The Radiation Control Program, Executive Office of Health and Human Services—Department of Public Health, requires under 105 *CMR* 120.291 that the Commonwealth of Massachusetts must be notified 30 days prior to vacating any premises which may have been contaminated with radioactive material. The Commonwealth of Massachusetts has the authority to require decontamination of the premises in such a manner that the annual effective dose equivalent (EDE) to any individual (after the site is released for use without radiological restrictions) should not exceed 10 mrem above background and that the annual EDE from any specific source during decommissioning activities should not exceed 10 mrem above background.

## 1.4 LOCAL PERMITS

The Beverly Conservation Commission is concerned with protection of the water supply, groundwater, fisheries, shellfish areas, and wildlife habitat. In accordance with *301 CMR 10.00* a Notice of Intent must be filed at the Beverly City Administrators Office.

The Harbormaster must also be notified strictly for navigation and public safety purposes.

## Additional ARAR for the Ventron EE/CA Public Draft

| Regulatory Agency | Standard, Requirement, Criteria, or Limitation | Citation | Description of Requirement | Applicable or Relevant and Appropriate | Comment |
|---|---|---|---|---|---|
| Executive Office of Health and Human Services- Department of Public Health: Radiation Control Program | Vacating Premises | 105 *CMR* 120.291 | Requires that the Commonwealth of Massachusetts must be notified 30 days prior to vacating any premises which may have been contaminated with radioactive material. The Commonwealth of Massachusetts has the authority to require decontamination of the premises in such a manner that the annual effective dose equivalent (EDE) to any individual (after the site is released for use without radiological restrictions) should not exceed 10 mrem above background and that the annual EDE from any specific source during decommissioning activities should not exceed 10 mrem above background. | Applicable | This requirement provides a notification time requirement and the annual effective dose equivalent for decommissioning a radioactive area. |



141533

141533

# ATTACHMENT FOR

# APPENDIX E

# CONSULTATIONS WITH AGENCIES

138873

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Habitat and Protected
Resources Division
One Blackburn Drive
Gloucester, MA 01930-2298

141533

January 23, 1996

Mr. James D. Kopotic
Site Manager
Department of Energy
Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831-8723

Re: Ventron Site

Dear Mr. Kopotic:

This is in response to your letter dated November 22, 1995 concerning your proposed plans to conduct remedial actions at the Ventron Corporation site located in Beverly, Massachusetts on the Massachusetts Bay, approximately 15 miles northeast of Boston, at the confluence of the Bass and Danvers Rivers.

If your project is confined to the Bass and Danvers Rivers no endangered species are present and therefore no further consultation is necessary.

However, if you plan on disposing harbor sediments in Massachusetts Bay several species of sea turtles and whales are present in the Bay during certain months of the year. From June through November, turtles inhabit the area and from mid-February through November at least one whale species is present.

The following is a complete list of endangered and threatened species that may occur within the Massachusetts Bay area:

**Endangered**

| | |
|---|---|
| Blue whale | Balaenoptera musculus |
| Fin whale | Balaenoptera physalus |
| Sei whale | Balaenoptera borealis |
| Humpback whale | Megaptera novaeangliae |

138873

| | |
|---|---|
| Northern right whale | Eubalaena glacialis |
| Leatherback sea turtle | Dermochelys coriacea |
| Kemp's ridley sea turtle | Lepidochelys kempi |

141533

**Threatened**

| | |
|---|---|
| Loggerhead sea turtle | Caretta caretta |

Therefore, consultation pursuant to Section 7 of the Endangered Species Act will be necessary if you project plans involve the disposal of uranium sediments into Mass. Bay. In the likelihood that a Section 7 consultation is necessary and if you have any additional questions, contact Laurie Silva at 508-281-9291.

Sincerely,

Chris Mantzaris
Chief, Habitat and Protected
Resources Division

139113

Commonwealth of Massachusetts

# Division of Fisheries & Wildlife

41533

Wayne F. MacCallum, *Director*

30 January 1996

James D. Kopotic
Department of Energy
Oak Ridge Operations Office
P.O Box 2001
Oak Ridge, TE 37831-8723

Re: Ventron Site
Beverly, MA
**NHESP File No. 96-78**

Dear Mr. Kopotic:

Thank you for contacting the Natural Heritage and Endangered Species Program for information regarding state-listed rare species in the vicinity of the project referred to above.

At this time we are not aware of any rare plants or animals or exemplary natural communities that would be adversely affected by the proposed project.

This review concerns only rare species of plants and animals and ecologically significant natural communities for which the Program maintains site-specific records. This review does not rule out the possibility that more common wildlife or vegetation might be adversely affected by the project, especially if it will modify currently undeveloped areas. Should project plans change, or new rare species information become available, this evaluation may have to be reconsidered.

Please call me at (508)792-7270 Ext.154 if you have any questions.

Sincerely,

Holly Jewkes

Holly Jewkes
Environmental Review Assistant

**Natural Heritage & Endangered Species Program**
Route 135, Westborough, MA 01581 **Tel:** (508) 792-7270 x 200 **Fax:** (508) 792-7275
An Agency of the Department of Fisheries, Wildlife & Environmental Law Enforcement

139667

141533

RECEIVED

FEB 12 1996

MASS. HIST. COMM.

**Department of Energy**

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831—8723

February 1, 1996

Ms. Judith B. McDonough
Executive Director and
State Historic Preservation Officer
Massachusetts Historical Commission
220 Morrissey Boulevard
Boston, Massachusetts 02125

Dear Ms. McDonough:

**MORTON INTERNATIONAL (VENTRON) SITE - NHPA (SECTION 106) DETERMINATION**

In accordance with Section 106 of the National Historic Preservation Act (NHPA), the Department of Energy (DOE) has determined that the proposed removal of radiological contamination at the Morton International (Ventron) site located at 428 Congress Street in Beverly, Massachusetts, will have no effect on properties included, or eligible for inclusion, on the National Register of Historic Places.

A description of proposed site activities is enclosed, along with site maps and photographs. Your concurrence that this undertaking will have no effect on properties included, or eligible for inclusion, on the National Register of Historic Places is requested by March 1, 1996.

If you have any questions or if you need additional information, please call me at (423) 576-0273.

Sincerely,

Gary S. Hartman

Gary S. Hartman, Environmental Scientist
Former Sites Restoration Division

Enclosures

cc w/enclosures:
D. S. Browning, SAIC
M. E. Redmon, BNI
R. T. Moore, SE-311
J. D. Kopotic, EW-93
L. K. Price, EW-93
W. M. Seay, EW-93

CONCURRENCE: Judith B. McDonough

JUDITH B. MCDONOUGH
STATE HISTORIC
PRESERVATION OFFICER
MASSACHUSETTS
HISTORICAL COMMISSION

141533

FINAL
DOE/OR/21950-1014

# VENTRON ENGINEERING EVALUATION/COST ANALYSIS (EE/CA)

## BEVERLY, MASSACHUSETTS

MAY 1996

*prepared by*
U.S. Department of Energy, Oak Ridge Operations Office, Formerly Utilized Sites Remedial Action Program

*with technical assistance from*
Science Applications International Corporation ESC-FUSRAP
under Contract No. DE-AC05-91OR21950

141533

# TABLE OF CONTENTS


LIST OF FIGURES AND TABLES . . . . . v
ACRONYMS AND ABBREVIATIONS . . . . . vii
EXECUTIVE SUMMARY . . . . . ES-1

1. INTRODUCTION . . . . . 1-1
   1.1 OVERVIEW OF FUSRAP . . . . . 1-1
   1.2 SITE DESCRIPTION AND SETTING . . . . . 1-1
   1.3 SITE HISTORY . . . . . 1-3
   1.4 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS . . . . . 1-3

2. SITE CHARACTERIZATION RESULTS . . . . . 2-1
   2.1 CLEANUP GUIDELINES . . . . . 2-1
   2.2 SURVEY AND SAMPLING ACTIVITIES . . . . . 2-2
   2.3 SURVEY AND SAMPLING RESULTS . . . . . 2-4
      2.3.1 Harbor Sediment . . . . . 2-5
      2.3.2 On-Site Soil and Furnace Ash . . . . . 2-6
   2.4 CURRENT SITE CONDITIONS . . . . . 2-8
      2.4.1 Harbor Sediment . . . . . 2-9
      2.4.2 On-Site Soil and Furnace Ash . . . . . 2-9
   2.5 JUSTIFICATION FOR REMEDIAL ACTIONS . . . . . 2-10

3. IDENTIFYING AND EVALUATING CLEANUP OPTIONS . . . . . 3-1
   3.1 SCREENING OF PRELIMINARY OPTIONS . . . . . 3-1
   3.2 DESCRIPTIONS OF OPTIONS . . . . . 3-2
      3.2.1 Harbor Sediment . . . . . 3-2
      3.2.2 On-Site Soil and Furnace Ash . . . . . 3-3
   3.3 EVALUATION OF OPTIONS . . . . . 3-3
      3.3.1 Effectiveness . . . . . 3-4
         3.3.1.1 Harbor Sediment . . . . . 3-4
         3.3.1.2 On-Site Soil and Furnace Ash . . . . . 3-6
      3.3.2 Implementability . . . . . 3-7
         3.3.2.1 Harbor Sediment . . . . . 3-8
         3.3.2.2 On-Site Soil and Furnace Ash . . . . . 3-8
      3.3.3 Cost . . . . . 3-9
         3.3.3.1 Harbor Sediment . . . . . 3-9
         3.3.3.2 On-Site Soil and Furnace Ash . . . . . 3-9

4. COMPARISON OF THE CLEANUP OPTIONS . . . . . 4-1

5. SELECTION OF THE PREFERRED SITEWIDE CLEANUP OPTION . . . . . 5-1

141533

## TABLE OF CONTENTS (continued)


6. PUBLIC PARTICIPATION AND COMMUNITY RELATIONS . . . . . 6-1
   6.1 HOW TO PARTICIPATE IN THE DECISION-MAKING PROCESS . . . . . 6-1
   6.2 COMMUNITY RELATIONS PLAN . . . . . 6-1
      6.2.1 Community Background . . . . . 6-3
         6.2.1.1 Government Entities and Community Profile . . . . . 6-3
         6.2.1.2 Community Involvement . . . . . 6-3
         6.2.1.3 Summary of Community Concerns . . . . . 6-3
      6.2.2 Highlights of Community Relations Program . . . . . 6-4
      6.2.3 Community Relations Activities and Timing . . . . . 6-5
   6.3 LIST OF CONTACTS . . . . . 6-7

7. REFERENCES AND BIBLIOGRAPHY . . . . . 7-1

APPENDICES
APPENDIX A: RADIOLOGICAL DOSE ASSESSMENT
APPENDIX B: APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
APPENDIX C: COST
APPENDIX D: FLOODPLAINS AND WETLANDS ASSESSMENT
APPENDIX E: CONSULTATIONS WITH AGENCIES
APPENDIX F: RESPONSIVENESS SUMMARY

141533

## LIST OF FIGURES


| Figure | | Page |
|---|---|---|
| 1-1. | Location of the Ventron Site | 1-5 |
| 1-2. | Plan View of the Ventron Site | 1-6 |
| 1-3. | Ventron Site as Viewed from the Railroad Bridge, Looking North | 1-7 |
| 1-4. | Ventron Site as Viewed from the Railroad Bridge, Looking Northwest | 1-8 |
| 1-5. | Looking East from the South End of Building C | 1-9 |
| 1-6. | Furnaces in Room 30 of Building A | 1-10 |
| 2-1. | Probable Extent of Radiologically Impacted Areas | 2-11 |


## LIST OF TABLES


| Table | | Page |
|---|---|---|
| 1-1. | Chronology of Events for the Ventron Site | 1-11 |
| 2-1. | Summary of DOE Guidelines for Residual Radioactive Materials | 2-12 |
| 4-1. | Comparison of Cleanup Options for Harbor Sediment | 4-1 |
| 4-2. | Comparison of Cleanup Options for On-Site Soil and Furnace Ash | 4-2 |

141533

THIS PAGE INTENTIONALLY LEFT BLANK

## ACRONYMS AND ABBREVIATIONS

141533

| | |
|---|---|
| AEC | U. S. Atomic Energy Commission |
| ALARA | as low as reasonably achievable |
| ARAR | applicable or relevant and appropriate requirement |
| BNI | Bechtel National, Inc. |
| BNAE | base/neutral and acid extractable |
| CAA | Clean Air Act |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| $cm^2$ | square centimeter |
| CMR | Code of Massachusetts Regulations |
| COE | Corps of Engineers |
| cpm | counts per minute |
| CWA | Clean Water Act |
| CZMA | Coastal Zone Management Act |
| DEP | Department of Environmental Protection |
| DOE | U. S. Department of Energy |
| dpm | disintegrations per minute |
| DWPC | Division of Water Pollution Control |
| DWWR | Division of Wetlands and Waterways Regulations |
| EDE | effective dose equivalent |
| EE/CA | Engineering Evaluation/Cost Analysis |
| EIR | Environmental Impact Report |
| EOEA | Executive Office of Environmental Affairs |
| ENF | Environmental Notification Form |
| EPA | U. S. Environmental Protection Agency |
| ES&H | Environmental Safety and Health |
| FEMA | Federal Emergency Management Agency |
| FFA | Federal Facilities Agreement |
| $ft^2$ | square foot/feet |
| FUSRAP | Formerly Utilized Sites Remedial Action Program |
| ha | hectare |
| ICRP | International Commission on Radiological Protection |
| km | kilometer |
| L | liter |
| LSA | low specific activity |
| $m^2$ | square meters |
| MCZM | Massachusetts Coastal Zone Management |
| MED | Manhattan Engineer District |
| MEPA | Massachusetts Environmental Policy Act |
| MeV | mega electric volts |
| mi | mile |
| MGL | Massachusetts General Law |

## ACRONYMS AND ABBREVIATIONS (continued)

141533

| | |
|---|---|
| $\mu$R/hr | microRoentgen per hour |
| mrad | millirad |
| mrem | millirem |
| NAAQS | National Ambient Air Quality Standards |
| NCRP | National Council on Radiation Protection and Measurements |
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan |
| NEPA | National Environmental Policy Act |
| NPDES | National Pollutant Discharge Elimination System |
| NRC | U. S. Nuclear Regulatory Commission |
| NRCS | Natural Resource Conservation Service |
| NRHP | National Register of Historic Places |
| NESHAP | National Emission Standards for Hazardous Air Pollutants |
| ORNL | Oak Ridge National Laboratory |
| OSHA | Occupational Safety and Health Act |
| pCi/g | picocurie per gram |
| PCB | polychlorinated biphenyl |
| Ra | radium |
| RCRA | Resource Conservation and Recovery Act |
| RESRAD | RESidual RADioactivity Computer Code |
| RME | reasonable maximum exposure |
| SAFER | Streamlined Approach for Environemtnal Restoration |
| SIP | state implementation plan |
| TBC | To Be Considered |
| TCLP | toxicity characteristic leaching procedure |
| Th | thorium |
| TPH | total petroleum hydrocarbons |
| TSCA | Toxic Substances Control Act |
| U | uranium |
| $UCL_{95}$ | upper 95 percent confidence level |
| U.S. | United States |
| USDA | United Stated Department of Agriculture |
| WBS | work breakdown structure |
| WL | working level |
| $yd^2$ | square yard |
| yr | year |

# EXECUTIVE SUMMARY

The United States (U.S.) Department of Energy (DOE) has prepared this Engineering Evaluation/Cost Analysis (EE/CA) to evaluate potential cleanup options for a site currently owned by Morton International, Inc. (Morton) in Beverly, Massachusetts. The Metal Hydrides Corporation, which became the Ventron Corporation, formerly owned and operated the site. This document refers to the site as the Ventron site.

In the 1940s and 1950s, the federal government contracted with private firms to develop and perform projects on radioactive materials. Many of these projects included storage and processing of uranium and thorium. The sites where work was done were cleaned up according to the standards of that time. Since then, more stringent standards have been developed. Where necessary, additional cleanup is being performed to bring these sites into compliance with today's higher environmental standards.

The Formerly Utilized Sites Remedial Action Program (FUSRAP) was established in 1974 to identify sites previously used by the U. S. Army Corps of Engineers' (COE) Manhattan Engineer District (MED) and the Atomic Energy Commission (AEC) (DOE predecessor agencies) and to evaluate environmental conditions at the sites. The Ventron site was previously used by the MED and AEC and is being evaluated by FUSRAP.

Commercial operations involving uranium began at the Ventron site in the early 1940s. The Metal Hydrides Corporation (former site owner) was under contract to the MED from 1942 to 1947 to convert uranium oxide to uranium metal powder. Radiological surveys of the site performed by DOE in 1977 and 1980 through 1982 detected levels of radioactive materials, including uranium, above guidelines inside two buildings on interior surfaces and/or equipment, in a third building on a piece of equipment, in some surface and subsurface soil (including soil beneath three buildings), and in certain harbor sediment near the site. Based on these radiological survey data, DOE designated the Ventron site as a FUSRAP site in 1986.

All production operations at the Ventron site ceased in November 1994. Morton is in the process of removing all equipment free of radioactive materials from the facility and remediating the Ventron site for mercury and mineral oil in accordance with Massachusetts General Law (MGL), Chapter 21E.

DOE has the authority at the Ventron site for materials that contain uranium-238 (U-238) greater than DOE guidelines. Morton (and the former site owners) performed commercial work with uranium and thorium prior to and subsequent to MED-related activities until 1986. Remediation of materials that contain concentrations of U-238 greater than DOE guidelines and that are commingled with radium, thorium, and/or hazardous constituents is being negotiated between DOE and Morton. DOE and Morton are working together to expedite the cleanup of the Ventron site. Through the negotiations, DOE has agreed to remediate materials containing uranium, thorium and radium greater than DOE guidelines regardless of questions pertaining to the generator of such materials. Morton has agreed to provide access to the radioactive

materials in excess of guidelines by demolishing site buildings, disposing of the nonradioactive structural debris, and restoring the Ventron site.

DOE proposes to clean up the Ventron site in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). DOE relies on the CERCLA process for review of actions to be taken under CERCLA and has incorporated National Environmental Policy Act (NEPA) values into this EE/CA; therefore, no separate NEPA review process will be performed.

The media that contain levels of radioactive materials exceeding cleanup guidelines are the buildings surfaces and limited pieces of equipment, the site soil, and the harbor sediment. The buildings will be decontaminated, to the extent necessary, and demolished by Morton to provide access to the underlying impacted soil. The non-radioactive structural debris will be disposed by Morton. This EE/CA presents and evaluates the options being considered for the harbor sediment and for the on-site soil and furnace ash containing radioactive materials greater than DOE cleanup guidelines.

A brief discussion of the cleanup options for the harbor sediment and for the on-site soil and furnace ash is presented below.

**Harbor Sediment**: (1) *no action* represents a baseline of current conditions; (2) *removal of harbor sediment* would excavate harbor sediment containing uranium, radium, and for thorium greater than DOE cleanup guidelines, send the excavated harbor sediment off site for disposal, and allow for unrestricted future use of the harbor.

**On-site Soil and Furnace Ash**: (1) *no action* represents a baseline of current conditions; (2) *removal of on-site soil and furnace ash* would excavate on-site soil and furnace ash containing uranium, radium, and/or thorium greater than DOE cleanup guidelines, send the excavated soil and furnace ash off-site for disposal, and allow for unrestricted future use of the site.

DOE's preferred options are removal of both harbor sediment and on-site soil and furnace ash with concentrations of U-238 greater than DOE cleanup guidelines.

This EE/CA describes the site location and history, presents the results of prior characterization studies, and analyzes the benefits, risks, and costs of the cleanup options. In addition, this document addresses elements of public involvement including the availability of the document to the public, provides specific information concerning the public comment period, and presents the Community Relations Plan.

The public is encouraged to review this document during the public comment period, which starts February 12, 1996 and ends March 13, 1996. DOE will evaluate and respond to significant comments received during the public comment period. DOE is especially interested in input regarding the preferred options and any considerations for carrying out the cleanup remedy.

# 1. INTRODUCTION

## 1.1 OVERVIEW OF FUSRAP

This Engineering Evaluation/Cost Analysis (EE/CA) discusses cleanup options for harbor sediment and on-site soil and furnace ash containing U-238 concentrations greater than 50 picocuries per gram (pCi/g) at the Ventron site in Beverly, Massachusetts. The site is being addressed under the United States (U.S.) Department of Energy's (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP).

In the 1940s and 1950s, the federal government contracted with private firms to develop and perform projects on radioactive materials. Many of these projects included storage and processing of uranium and thorium. The sites where work was done were cleaned up according to the standards of that time. Since then, more stringent standards have been developed. Where necessary, additional cleanup is being performed to bring these sites into compliance with today's higher environmental standards.

FUSRAP was established in 1974 to identify sites previously used by the Manhattan Engineer District (MED) and the Atomic Energy Commission (AEC) (DOE predecessor agencies) and to evaluate environmental conditions at the sites.

Records are reviewed to compile a list of formerly utilized sites and to assess DOE's authority for cleanup of any residual radioactive material. Where appropriate, radiological surveys are performed to assess conditions at the sites. Survey data are used to decide whether the sites should be designated for cleanup or be eliminated from FUSRAP because they already meet today's environmental guidelines. At the sites designated for cleanup, either the radioactive material is stabilized in place and site use is restricted or the material is removed for disposal at another location.

DOE's Oak Ridge Operations Office in Tennessee manages FUSRAP, coordinating activities with federal, state, and local authorities, and has an active program to communicate with the regulators and the public.

The residual radioactivity being addressed at the Ventron site by DOE resulted from activities carried out under federal contracts during the early years of the nation's atomic energy and weapons programs.

## 1.2 SITE DESCRIPTION AND SETTING

The 1.2-ha (3-acre) Ventron site is located in Beverly, Massachusetts, on the Massachusetts Bay, approximately 24 km (15 mi) northeast of Boston, where the Bass and Danvers Rivers join (see Figure 1-1). The site is bounded by Congress Street to the north, the

Boston and Maine Railroad to the east, the Bass River to the west, and the Danvers River to the south. Although the site itself is industrial, much of the nearby area is residential.

Morton International (Morton) currently owns the Ventron site. All production operations at the Ventron site ceased in November 1994. Morton is in the process of removing all equipment free of radioactive materials from the facility. The Ventron site is being remediated by Morton for mercury and mineral oil materials, in accordance with Massachusetts General Law (MGL), Chapter 21E (The Massachusetts Contingency Plan 1993). Morton has completed the first phase of the remediation process and is in the process of completing the remaining four phases.

Figure 1-2 shows four groups of buildings (Alfa, A, B, and C), one chemical storage tank, two office buildings, and three other buildings (D, E, and F) used for storage and operations. Figures 1-3 and 1-4 are photographs of the site showing Ventron from the railroad bridge looking north and northwest. Ventron is built on fill material contained by a sea wall and is bounded by the Beverly Harbor (specifically, the Danvers and Bass Rivers). The tidal flats, exposed at low tide, are considered part of a sensitive ecosystem. With the exception of the coastal/tidal area, no wetlands or waterways exist on the site (see Appendix D).

Site soil is mainly coarse gravel and sand fill material, with topsoil of fine to medium sand (Cottrell and Carrier 1988). Surface water flows into the Danvers and Bass Rivers as surface sheet runoff or into Congress Street drainage structures through culverts or storm sewers. Groundwater resources in unconsolidated deposits are generally insignificant in coastal areas. Such deposits are generally thin and intruded by salt or brackish waters. This is the case in the Beverly area (CH2M Hill 1992).

The site is covered by buildings, paved areas, and a few small grass covered areas. Figure 1-5 is a photograph looking east from the south end of Building C, and Figure 1-6 shows the furnaces in Room 30 of Building A.

According to the State Historic Preservation Office (Cavanaugh 1992), no significant historical or archaeological resources are on the site. A current consultation is in progress to confirm that this is still the case (see Appendix E). No federally-listed or proposed threatened or endangered species under the jurisdiction of the U.S. Fish and Wildlife Service are known to occur in the Ventron site area with the exception of occasional transient bald eagles or peregrine falcons. No activities associated with the Ventron site remediation are expected to have an impact on these species. Consultation with the National Marine Fisheries Service, Habitat and Protected Resources Division, confirmed that no endangered or threatened species are known to occur in the Bass and Danvers Rivers where remediation of the Ventron site is proposed (see Appendix E).

## 1.3 SITE HISTORY

From 1942 to 1947, the Metal Hydrides Corporation, under contract to MED and its successor, AEC, converted uranium oxide to uranium metal powder at the Ventron site using calcium hydride. All MED/AEC-related work at the Ventron site involved natural uranium, during which time no depleted or enriched uranium was processed at the site. The Metal Hydrides Corporation also recovered uranium from scrap uranium materials and turnings resulting from operations at the slug fabrication plant in Hanford, Washington. Prior to and subsequent to the MED-related activities the site owner (Metal Hydrides Corporation then the Ventron Corporation) performed independent work at the Ventron site with uranium and thorium materials until 1986.

Two of the three buildings housing the foundry facilities were demolished sometime between 1948 and 1950, following AEC surveying and decontamination. Buildings B and F were built at these locations (Figure 1-2). The remaining original buildings (Buildings A and A-1) contained furnaces, leaching facilities, a mixing room, a drying room, and analytical laboratories.

In 1965, the Metal Hydrides Corporation became the Ventron Corporation and was later acquired by the Thiokol Corporation in 1976. In 1980, the Ventron Corporation became a division of Morton Thiokol, Inc. (BNI 1988), which was renamed Morton International in 1990. All production operations at the Ventron site ceased in November 1994.

Table 1-1 provides a brief chronology of events at Ventron and shows the series of characterization investigations that have been carried out. These characterization investigations are discussed in Sections 2.2 and 2.3.

## 1.4 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Applicable requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site" (*52 CFR 32496*, August 27, 1987).

Relevant and appropriate requirements are those "cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (*52 CFR 32496*).

Requirements under federal or state law may be either applicable or relevant and appropriate (ARAR) for compliance to be necessary. In the case where a federal and a state ARAR are available, or where there are two potential ARARs addressing the same issue, the more stringent regulation must be selected. In the absence of federal or state promulgated regulations, there are many criteria, advisories, guidance values, and proposed standards (e.g., DOE Orders) that are not legally binding, but may serve as useful guidance for setting protective cleanup levels. These are not potential ARARs, but are "to-be-considered" (TBC) guidance.

Appendix B contains the ARARs identified for the Ventron site. These ARARs will be evaluated and incorporated as appropriate into the remediation planning. DOE relies on the CERCLA process for review of actions to be taken under CERCLA and has incorporated National Environmental Policy Act (NEPA) values into this EE/CA; therefore, no separate NEPA review process will be performed.

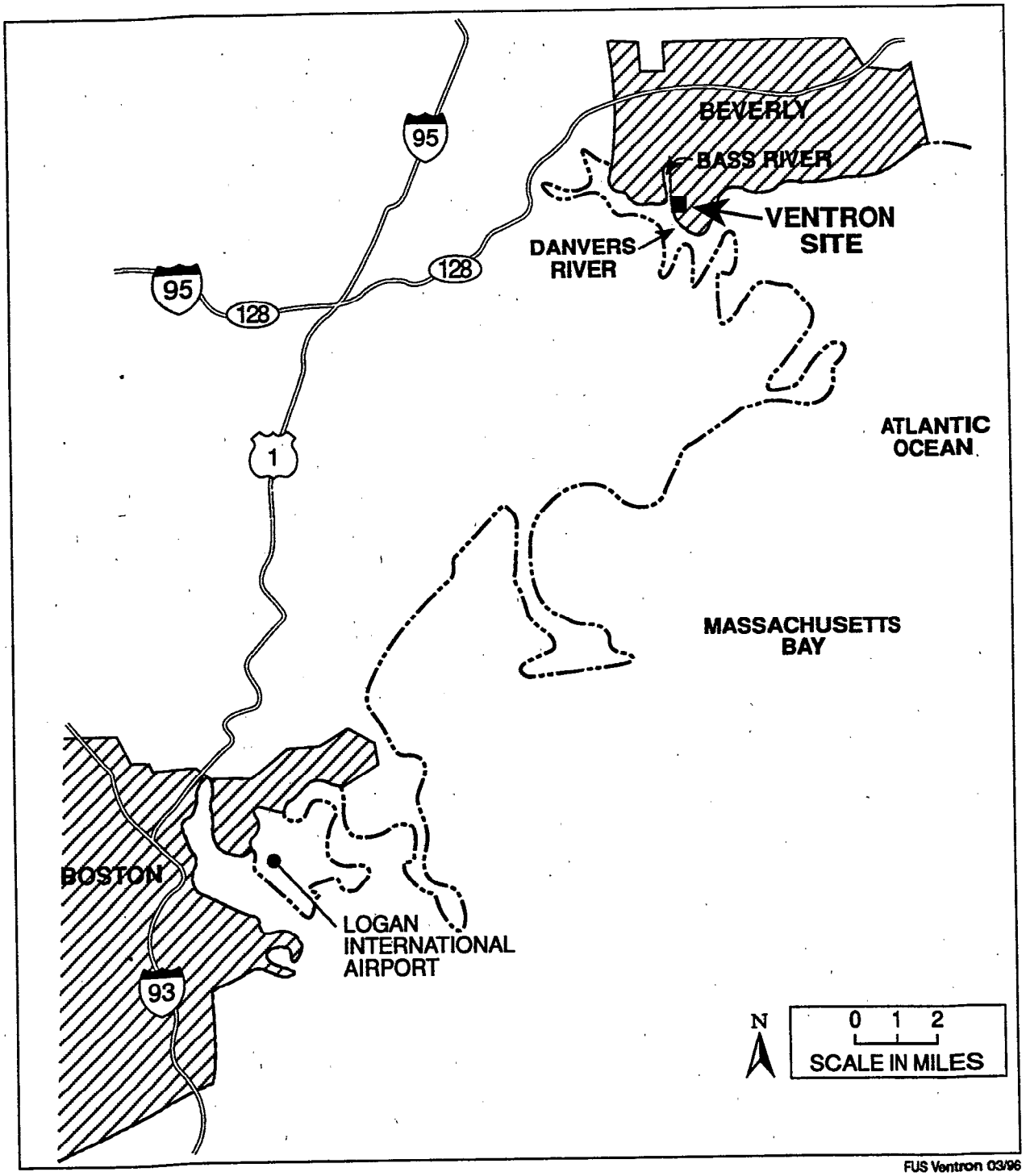



**Figure 1-1. Location of the Ventron Site**

141533

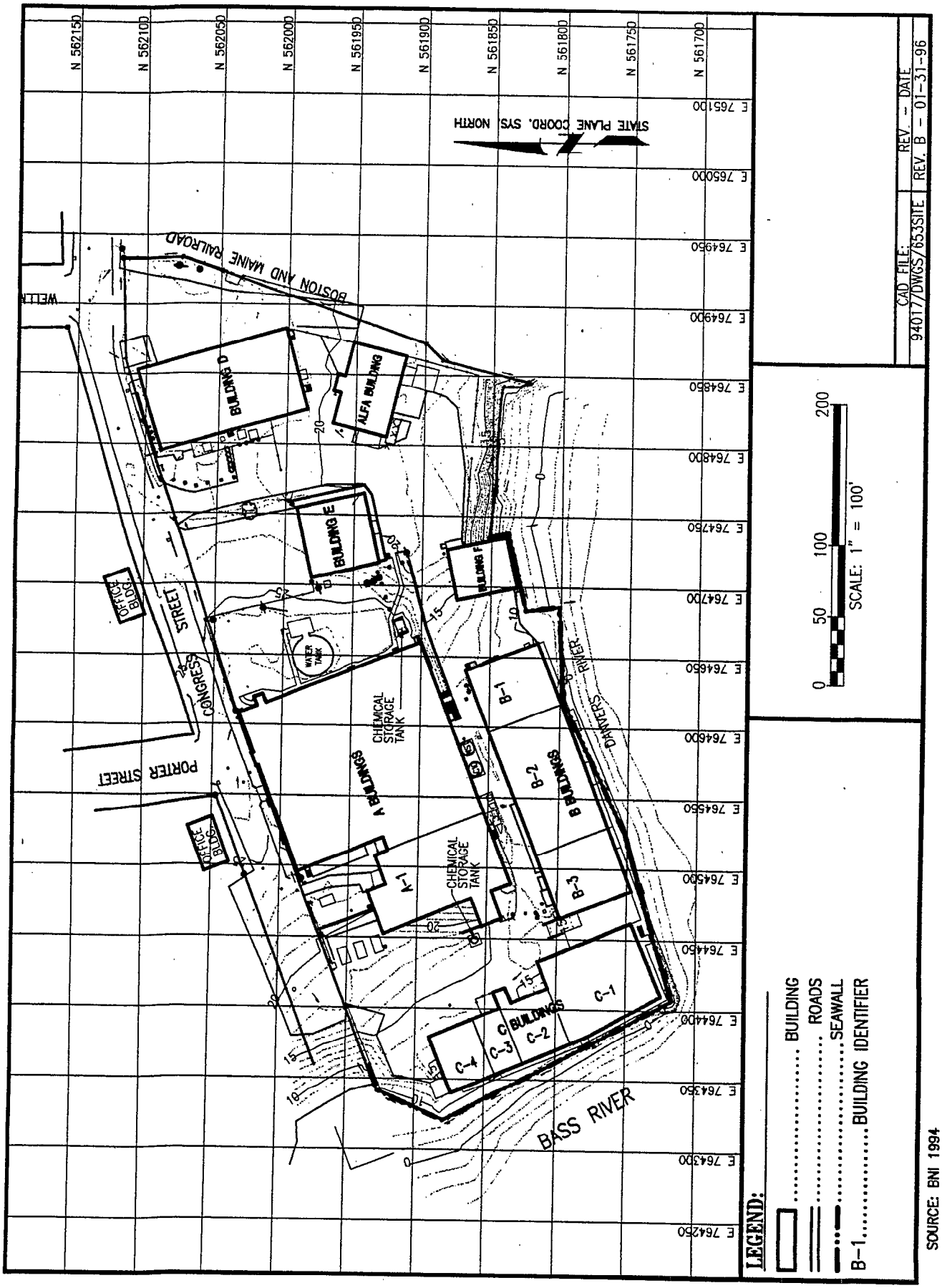



**Figure 1-2. Plan View of the Ventron Site**

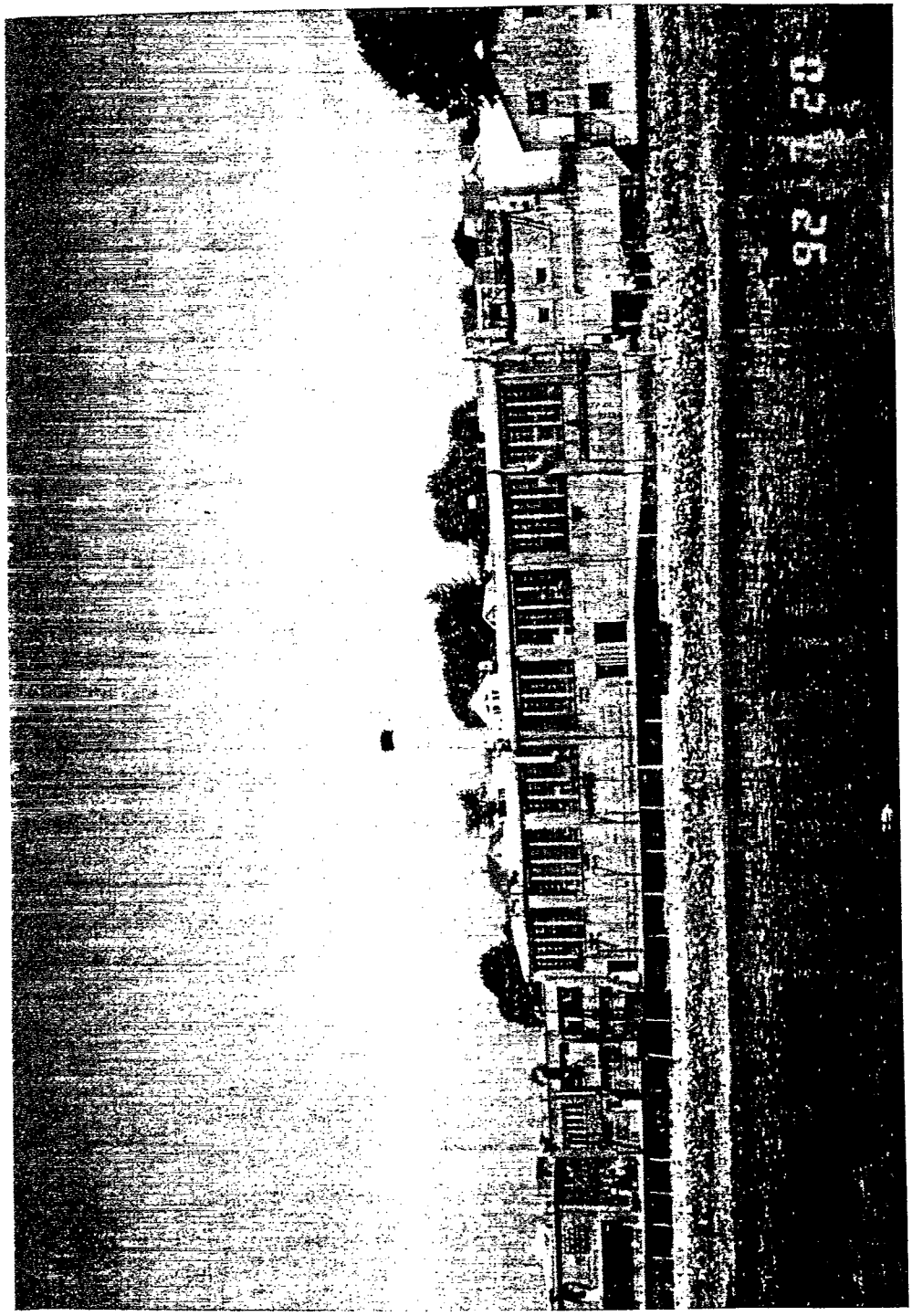



Figure 1-3. Ventron Site as Viewed from the Railroad Bridge, Looking North

141533

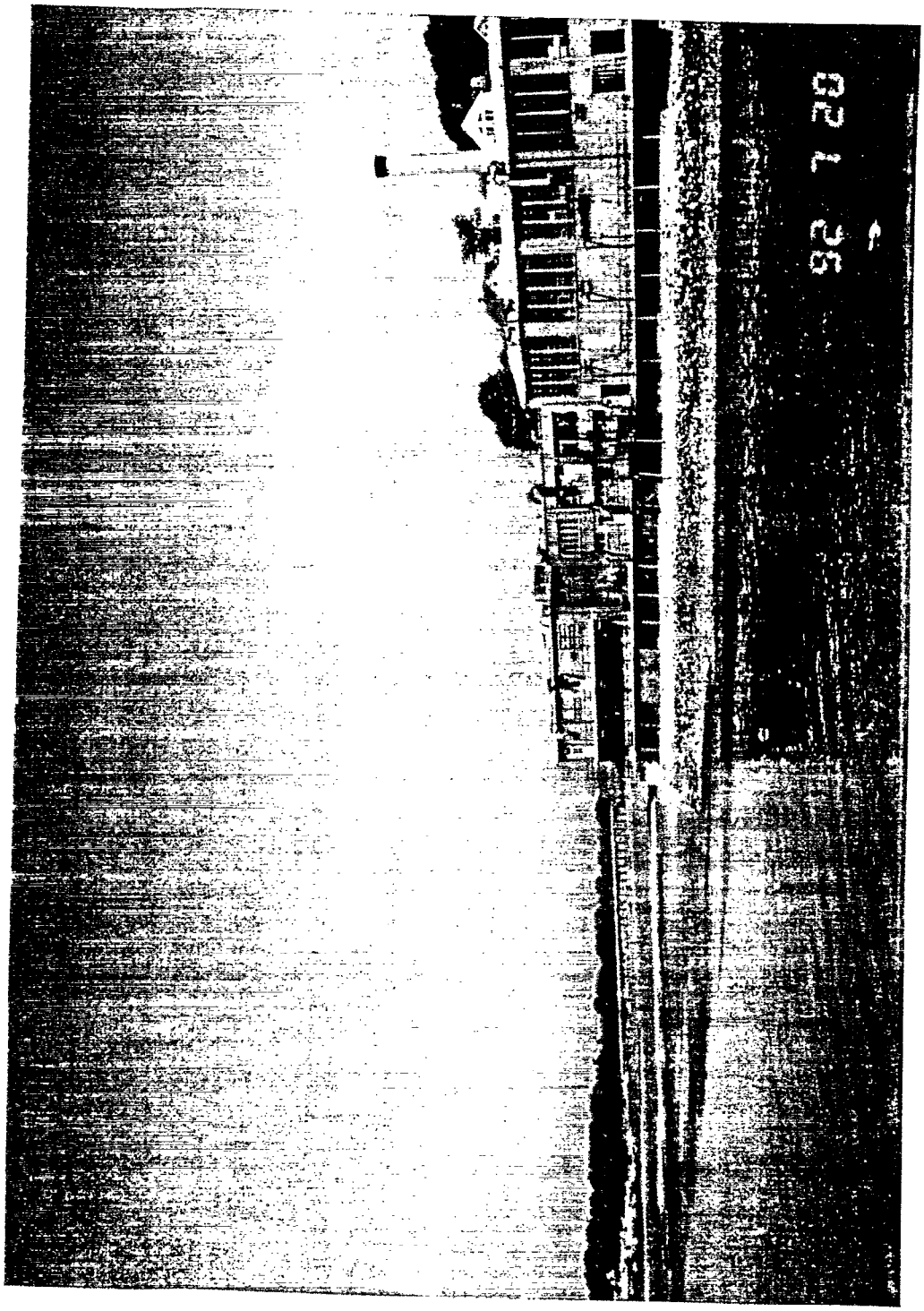



Figure 1-4. Ventron Site as Viewed from the Railroad Bridge, Looking Northwest

141533

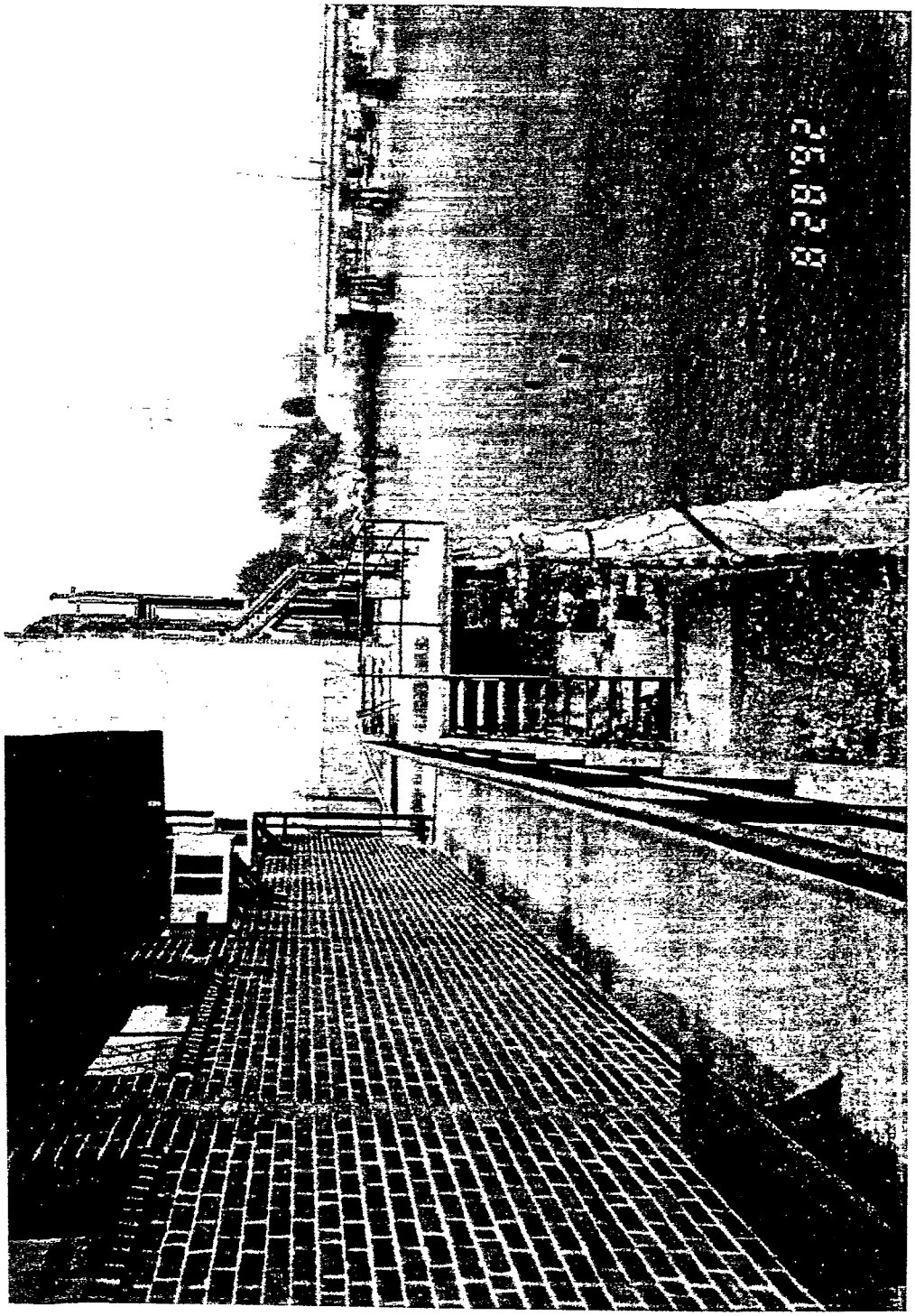



Figure 1-5. Looking East from the South End of Building C

141533

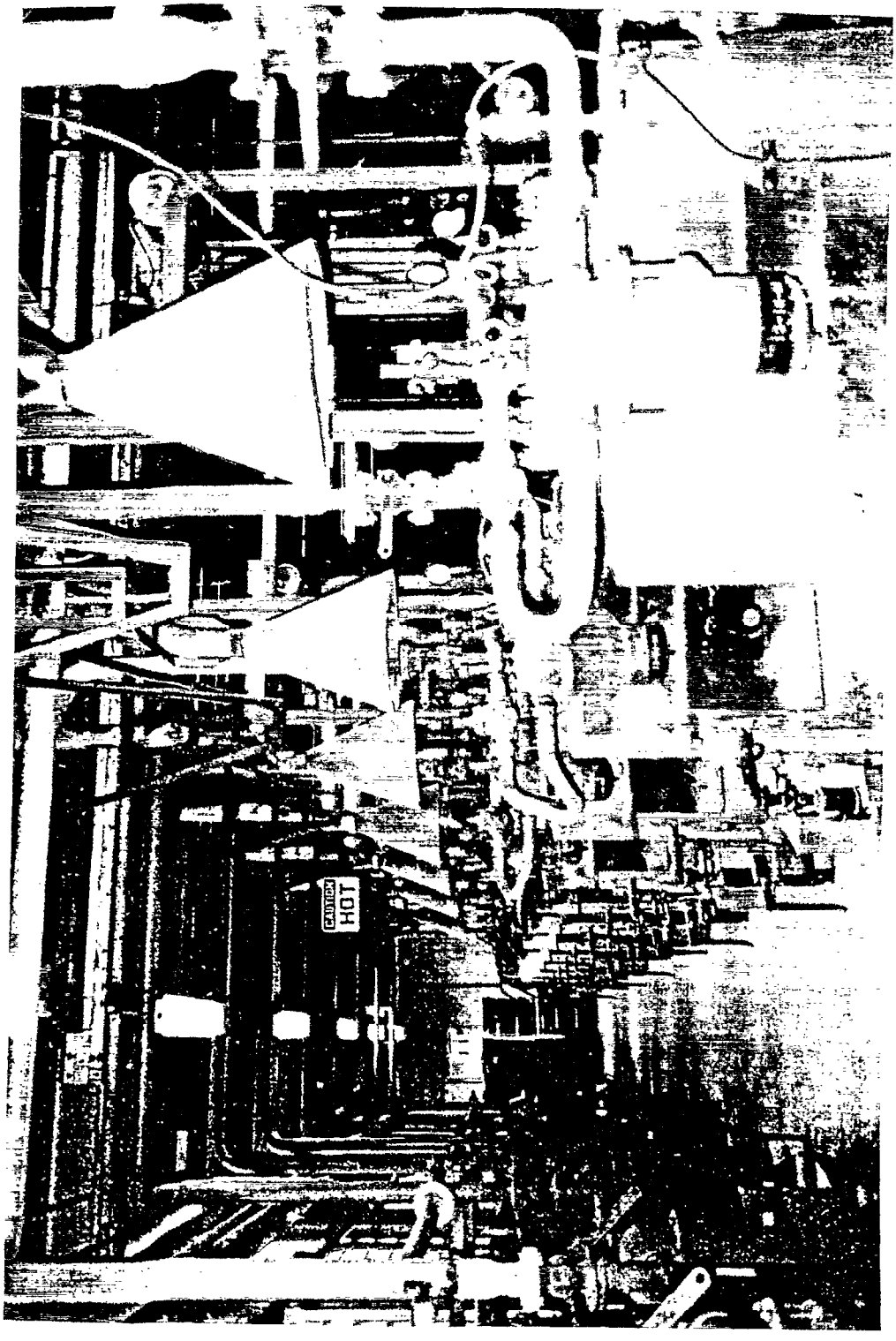



**Figure 1-6. Furnaces in Room 30 of Building A**

## Table 1-1. Chronology of Events for the Ventron site

| | |
|---|---|
| 1940 | • Metal Hydrides Corporation commercial operations involving uranium began. |
| 1942 to 1947 | • Metal Hydrides Corporation operated under contract to the MED to convert uranium oxide to uranium metal powder. |
| 1948 | • AEC conducted a radiological survey of the site.<br>• Decommissioning activities performed by AEC. |
| 1948 to 1950 | • Two of the three buildings that housed foundry facilities were demolished and two new buildings were later constructed in the same locations. |
| 1965 | • Metal Hydrides Corporation became Ventron Corporation. |
| 1976 | • Ventron Corporation acquired by Thiokol Corporation. |
| 1977 | • Radiological survey assessment (included both indoor and outdoor surveys of the Ventron site) performed for DOE by Oak Ridge National Laboratory (ORNL). |
| 1980 | • Ventron became a division of Morton Thiokol, Inc. |
| 1980 to 1982 | • More complete surveys of land and buildings at the Ventron site conducted for DOE by ORNL. |
| 1986 | • Congress designates the Ventron site to FUSRAP.<br>• Based upon the evaluation of the survey results, DOE determined that remedial action at the site was warranted.<br>• Underground tank removed by Morton Thiokol; DOE authorized health physics support to Morton Thiokol during this activity.<br>• Morton ceased all NRC licensed commercial operations at the Ventron site that involved uranium and thorium materials. |
| 1987 | • Roof containing radioactive material replaced by DOE and material disposed at the DOE Hanford facility. |
| 1987, 1988, 1991 | • DOE provided health physics support to Morton. |
| 1990 | • Ventron was renamed Morton International. |
| 1991 | • Off-site Vicinity Property Survey Investigation - Subsequent radiological survey performed for DOE by ORNL in May to determine if radioactive materials from plant operations had migrated off site. |
| 1992 | • Ventron site Characterization Investigation - To determine the nature and extent of radioactive materials at the Ventron site, further characterization of radioactive and chemical constituents was performed in September and October. Preliminary results revealed elevated levels of radioactivity in a few small, isolated areas of the site; inside two buildings, and beneath three other buildings.<br>• Information session held in Beverly, Massachusetts, in December to explain the results from the off-site vicinity property survey to the residents. |
| 1993 | • In September, health physics support provided to Morton in support of the state's request to sample sediment from Beverly Harbor.<br>• Composite sediment samples collected by DOE from Ventron site harbor area. |
| 1994 | • Discrete sediment samples collected by DOE from Ventron site harbor area.<br>• Production operations ceased by Morton International at the Ventron site in November 1994. |
| 1995 | • DOE conducted harbor characterization and removal activities. |

141533

THIS PAGE INTENTIONALLY LEFT BLANK

# 2. SITE CHARACTERIZATION RESULTS

## 2.1 CLEANUP GUIDELINES

Current safety and health regulations for radioactive materials are designed to protect the public and workers from radiation by limiting the dose that a person may receive. The recommended limit on the dose that an individual may receive each year is established by the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP). In the United States (U.S.), the U.S. Environmental Protection Agency (EPA), the Nuclear Regulatory Commission (NRC), and DOE base regulatory limits for radiation exposure on the recommendations of the ICRP and NCRP. The current limit recommended by the ICRP and NCRP for exposure of the general public is 100 millirem per year (mrem/yr) above background from all sources and pathways (excluding radon). To allow for the potential exposure of an individual to multiple sources of radiation, the potential radiation dose from a single source (e.g., the Ventron site) is typically limited to a fraction of the public dose limit (e.g., 25 to 30 mrem/yr).

For protection of the public from radiation exposure, DOE uses the 100 mrem/yr dose limit as well as generic guidelines for radium and thorium in soil, radon daughter concentrations, and indoor gamma exposure rates. The generic limits are taken from previously established federal regulations and are typically expressed as concentrations of radionuclides or exposure rates [e.g., pCi/g, pCi/Liter (L), microRoentgen per hour ($\mu$R/hr)]. These generic limits apply only to specific radionuclides and conditions and are not appropriate for use with all radionuclides. For radionuclides such as uranium (the primary contaminant of concern at Ventron) for which no generic cleanup guidelines are applicable, a site-specific cleanup guideline must be developed using the public dose limit (100 mrem/yr) as the initial basis for derivation. To determine the cleanup guideline for uranium, a site-specific dose assessment is conducted using a series of mathematical equations to model the impact of possible future activities at the site. This dose assessment is used to calculate the concentration of uranium that, if left in the soil, could expose an individual (either currently or in the future) to the dose limit of 100 mrem/yr. Once the concentration of uranium is determined that could cause exposure of 100 mrem/yr, the actual cleanup guideline is set by using the as low as reasonably achievable (ALARA) process to further reduce the cleanup guideline to as far below the 100 mrem/yr limit as is reasonably achievable, taking into account technical, economical, safety, and social considerations.

A site-specific uranium guideline for the Ventron site was developed by Argonne National Laboratory (Loureio et al. 1992) using the DOE RESidual RADioactivity Computer Code (RESRAD) (Yu et al. 1993). The results from the uranium guideline derivation showed that under the most conservative future land use assumption (residential farming at the site, with drinking water from an off-site source), a residual U-238 concentration of approximately 240 pCi/g would be equivalent to an annual dose of 100 mrem. Using the ALARA process, this derived estimate was reduced to a site cleanup guideline of 50 pCi/g above background levels

for U-238 in soil or sediment. This cleanup guideline is equivalent to approximately 6 mrem/yr for an industrial worker and approximately 21 mrem/yr for residential farming use, assuming that off-site water is used for drinking water purposes (DOE 1993a). Remediation of materials that contain concentrations of U-238 greater than 50 pCi/g commingled with radium, thorium, and/or hazardous constituents is being negotiated between DOE and Morton.

## 2.2 SURVEY AND SAMPLING ACTIVITIES

Several characterization investigations have occurred at the Ventron site since the site was used for uranium conversion, recovery, and metal production operations under MED/AEC contracts. The most notable investigations include the following:

- initial survey and decontamination and decommissioning activities by the AEC in 1948,
- screening survey by DOE in 1977 to determine compliance with DOE guidelines,
- comprehensive radiological surveys of on-site buildings and land by DOE from 1980 to 1982,
- radiological survey of 24 off-site residential/municipal properties and the Beverly Harbor tidal flats area by DOE in 1991,
- comprehensive site characterization investigation by DOE in 1992, and
- limited additional harbor characterizations by DOE in 1993, 1994, and 1995.

Each of these characterization investigations is summarized briefly below.

*Initial AEC Survey and Decommissioning (1948)*

The first radiological survey in support of cleanup actions at the Ventron site was conducted by the AEC in 1948. Results from this survey indicated the presence of residual radioactive material in the two foundry buildings and on various pieces of equipment. Decontamination and decommissioning activities performed by AEC in 1948 included demolishing the foundry buildings, sandblasting painted surfaces on equipment, and removing concrete floors and platforms. These cleanup activities were performed in accordance with guidelines in effect at that time (Cottrell and Carrier 1988).

*DOE Screening Survey (1977)*

DOE conducted a radiological site screening survey in 1977 to determine compliance with current cleanup guidelines. The results from the initial exploratory measurements showed residual radioactive materials above guidelines and indicated a need for a more comprehensive radiological survey of the entire site.

*DOE Comprehensive Radiological Surveys (1980-1982)*

In 1980 DOE initiated the first comprehensive radiological survey at the site. This survey included both outdoor and indoor radiation measurements and sampling of soil and sediment. The outdoor survey was conducted from September 19-25, 1980, and included surface and 1 m (3-ft) gamma exposure rate scanning measurements; surface and subsurface soil sampling with analyses for U-238, radium (Ra)-226, and thorium (Th)-232; downhole gamma logging of augered boreholes; and analysis of radionuclide concentrations from sediment samples taken from storm sewer manholes (Cottrell and Carrier 1988). The indoor survey was conducted during the period from February 22-28, 1982, and included gamma exposure rate measurements at the floor surface and at 1 m (3 ft) above the floor at selected locations; surface beta-gamma dose rate measurements; direct and transferrable alpha and beta-gamma measurements; and subslab soil sampling and analyses for U-238, Ra-226, and Th-232.

*DOE Beverly Harbor Survey and Off-Site Properties (1991)*

DOE performed a subsequent radiological survey in 1991 to determine if radioactive materials from plant operations had migrated off site to neighboring areas including the Beverly Harbor (Foley and Johnson 1992). The survey included gamma exposure rate scans and analysis for radionuclides in harbor sediment and biological media (lobsters) from the tidal flat areas adjacent to the facility. In addition, a survey was performed on 24 off-site residential/municipal properties. The survey of the off-site properties included surface gamma scans, beta-gamma scans, and analysis of soil samples.

*DOE Site Characterization (1992)*

The radiological survey of the Ventron site conducted by DOE in 1992 was to define the site areas where environmental remediation will be required under FUSRAP (DOE 1994). The DOE 1992 characterization followed the Streamlined Approach for Environmental Restoration (SAFER) (DOE 1992), and included the following characterization measurements:

- analysis of background samples for radionuclides (U-238, Th-230, and Ra-226) and chemical constituents [Resource Conservation and Recovery Act (RCRA)] characteristics, toxicity characteristic leaching procedure (TCLP) metals, polychlorinated biphenyls (PCBs), total petroleum hydrocarbons (TPH), and base/neutral and acid extractable organic compounds (BNAEs) in soil, surface water, and sediment;

- near surface gamma scans over all accessible outside areas of the site to determine locations with elevated radioactivity;
- indoor and outdoor gamma exposure rate measurements to verify previous survey results;
- limited surface measurements to determine the extent of fixed and/or removable MED-related radioactive material within site structures;
- analysis of soil samples for radionuclides and chemicals to investigate the impact from potential source areas and other suspect areas as identified by previous ORNL surveys;
- analysis of harbor sediment and surface water samples for radiological and chemical parameters to further define affected areas previously identified by the ORNL sediment sampling of Beverly Harbor;
- analysis of samples from the ash piles beneath the furnaces in Building A for radiological and chemical parameters to determine the extent of elevated constituents in the ash;
- analysis of samples of scale, dirt, sludge, and sediment from the sewer line between Buildings A and B for radiological parameters (results from these analyses were used to determine if radioactive material is moving off site through the sewer system); and
- analysis of composite samples from mussels collected from the mussel beds in the intertidal zone near the south side of the site for radiological and chemical parameters (results from these samples were compared to results from the analysis of mussels taken from background locations to determine if radioactive material is being assimilated by biota near the site).

*DOE Harbor Characterizations (1993, 1994, and 1995)*

Composite and discrete samples were collected by DOE in 1993 and 1994 during Morton's sampling activities to determine if Morton's sampling activities would be impacted by elevated levels of radioactivity in the harbor sediment.

In 1995, DOE surveyed and collected samples from the harbor area to further characterize areas of elevated radioactivity and manually remove such areas prior to Morton's mercury removal activities.

## 2.3 SURVEY AND SAMPLING RESULTS

The following sections summarize the results from the most recent investigations (since 1980) at the Ventron site. The results from the later investigations are the best documented and are most representative of current site conditions. The results summarized in the following

sections represent the aggregate results from these studies for the harbor sediment and for the on-site soil and furnace ash. These results form the basis for analysis of the cleanup options in the Ventron EE/CA.

### 2.3.1 Harbor Sediment

Harbor sediment was sampled during the 1991, 1992, 1993, 1994, and 1995 DOE characterization efforts.

The 1991 DOE survey focused on the area immediately adjacent to the Ventron site and most harbor sediment samples were taken within approximately 15 m (50 ft) of the seawall. The 1992 DOE harbor study was intended to bound the extent of radioactive materials in the harbor sediment; thus, all of the samples collected during this study were taken at locations greater than 15 m (50 ft) away from the site seawall. Both the 1991 and 1992 DOE studies included samples of marine organisms (lobsters in 1991 and mussels in 1992) to determine if bottom-feeding marine organisms were being affected by radioactive materials. DOE collected samples of the harbor sediment again in 1993 and 1994 to determine if sampling activities being conducted by Morton would be impacted by elevated levels of radioactive materials. The 1995 DOE characterization and removal effort was conducted to determine the exact locations of radioactive materials prior to Morton's mercury removal actions in the harbor.

The results of the 1991 DOE harbor sediment samples showed that the presence of radioactive material in the tidal flats area is nonuniform, with isolated areas of elevated uranium and thorium concentrations near the seawall. In at least one case, the elevated concentrations were attributable to a metal fragment (containing 210,000 pCi/g of U-238). The maximum concentrations of U-238, Th-232 and Ra-226 in the tidal flats sediment (excluding the metal fragment discussed above) were 22,000 pCi/g, 27 pCi/g, and 1.6 pCi/g, respectively. Elevated levels of radioactivity were limited to three general areas, the area south and west of Building F, a narrow strip of the tidal flats south of the B Buildings, and an area south and west of Building C-1 (ORNL 1991, Foley and Johnson 1992).

Harbor sediment samples collected during the DOE 1992 characterization activities were taken at locations greater than 15 m (50 ft) from the seawall. All of theses samples contained U-238 less than 50 pCi/g, and Ra-226 and Th-232 less than 5 pCi/g.

The results from samples of lobsters, taken by DOE in 1991, and mussels, taken by DOE in 1992, showed no difference between concentrations of U-238, Th-232, and Ra-226 in samples collected from background locations and samples collected near the Ventron site.

Additional sampling of the harbor area was conducted by DOE in 1993 and 1994. In September 1993, Morton collected numerous samples in the harbor area for hazardous constituent analysis. DOE split samples with Morton and prepared two composite samples. The samples were collected west of Building C-1. The first composite consisted of five samples collected at low tide at a depth of 0 to .67 m (0 to 2.2 ft). The second composite consisted of

five samples collected at a depth of 0 to .46 m (0 to 1.5 ft) next to the seawall. All results were below 50 pCi/g of U-238 (DOE 1993b).

In 1994, 22 sediment samples were collected from the harbor during a joint sampling effort by DOE and Morton. The first four samples were collected from a distance ranging from approximately 9.0 m to 18.0 m (30 ft to 60 ft) southwest and northwest of the outlet pipe in the seawall. One sample was collected directly below the seawall. The next five samples were collected right next to the seawall from approximately 0.6 m to 3.0 m (2 ft to 10 ft) north and south of the outlet pipe. The next set of samples was collected further out at distances ranging from approximately 18.0 m to 91.0 m (60 ft to 300 ft) from the seawall. Samples were also collected (1) about 50 yards from the bridge to Salem, (2) from sandbars, (3) adjacent to the beach, (4) 100 yards from the seawall, and (5) in the main channels of the Bass and Danvers Rivers. All results were below 50 pCi/g for U-238 (DOE 1995).

In 1995, DOE performed an extensive characterization/removal action in the harbor to clearly delineate and remove, if feasible, sediment containing U-238 greater than 50 pCi/g prior to Morton's mercury removal activities in the harbor. All areas of sediment containing elevated levels of U-238 that could be manually excavated were removed and placed into storage boxes. Approximately 16 $yd^3$ of sediment were excavated and are currently being stored by DOE on the Ventron site in the Alfa Building. This material will be shipped off site for disposal along with other wastes generated during the site remediation activities. One area southeast of Building B-1, immediately adjacent to the seawall, was not removed as the extent was such that manual excavation was not feasible. The maximum depth of the remaining radioactive material is suspected to be 1.5 m (4.5 ft). The maximum U-238 concentration detected in this area was 431.2 pCi/g, measured at a depth of approximately 1 m (3.5 ft) adjacent to the seawall.

### 2.3.2 On-Site Soil and Furnace Ash

On-site soil was sampled during both the 1980 and 1992 DOE site characterizations. The 1980 characterization effort included surface soil sampling in outdoor areas within the site boundary and around the site perimeter. Subsurface soil samples were taken around and beneath Buildings C-1, B-1, B-2, and B-3; in asphalt areas between the buildings; and at the loading dock area between Buildings A and A-1. Soil samples collected were analyzed for U-238, Th-232, and Ra-226.

The 1992 characterization included soil samples around Buildings A-1, C-1, C-2, C-3, C-4, the Alfa building, the former machine shop, and Building F. In addition, samples were taken from the loading areas on the west and north sides of Building A-1, from an area between Buildings B and F in the vicinity of the former barge pier, beneath Buildings A-1 and C-2, and from the ash piles beneath the furnaces in Building A. All soil samples were analyzed for U-238, Th-232, and Ra-226, and selected samples were analyzed for Th-230, RCRA characteristics, total metals, PCBs, BNAEs, and TPHs.

The following sections provide summaries of the current conditions for the on-site soil and furnace ash, based on combined results from the characterization efforts.

*Building A*

The area west of Building A and north of Building A-1 contained an isolated area where U-238 was detected at 200 pCi/g during the 1980 characterization effort. PCBs (Aroclor-1260 and Aroclor-1254) were detected in two soil samples adjacent to Building A, but the maximum detected concentration of 2.3 mg/kg (2.3 parts per million (ppm)) is well below the Toxic Substances Control Act (TSCA) standard of 25 ppm for an industrial site (40 *CFR* 761.125). The ash piles in Building A did not contain concentrations of U-238 greater than 50 pCi/g; however, the samples did contain Ra-226 greater than 5 pCi/g. Chemical analyses of the ash pile samples showed elevated levels of metals (chromium, lead, nickel, and zinc), and one sample failed the RCRA ignitability test.

*Building A-1*

Results from samples collected under Building A-1 showed one of four samples with U-238 and Th-230 at 190 pCi/g and 44.5 pCi/g, respectively. Chemical analyses of samples from below Building A-1 showed no results greater than applicable guidelines.

*B Buildings*

Results from analyses of soil around and under Buildings B-1, B-2, and B-3 showed numerous locations with U-238 greater than 50 pCi/g. Concentrations of U-238 in soil outside the B Buildings ranged from 1.7 to 62,000 pCi/g. Concentrations of U-238 in soil underneath the B Buildings were similar, ranging from 1.8 to 71,000 pCi/g and averaging 1,800 pCi/g. Concentrations of Ra-226 and Th-232 around and under the B buildings were lower than the U-238 concentrations, but Ra-226 exceeded 15 pCi/g. The maximum detected concentrations for Ra-226 and Th-232 at the B Buildings were 37 and 2.2 pCi/g, respectively.

Radioactive materials are present primarily under Buildings B-1 and B-2, with some possibly extending into the area under B-3. The approximate maximum depth of uranium greater than 50 pCi/g under the B Buildings is 2 m (6.6 ft). Elevated concentrations of radioactive materials range in depth from zero to 1 m (3 ft) over most of the other areas under Buildings B-1 and B-2.

*C Buildings*

The presence of radioactive materials is evident around and beneath the C Buildings (C-1, C-2, and C-3). Surface soil samples around these buildings show Th-232 concentrations up to 1,300 pCi/g and U-238 concentrations up to 44,000 pCi/g. A subsurface U-238 concentration of 1,400 pCi/g was detected under Building C-1. In addition, lead was detected at levels greater than the TCLP limits in one sample.

The maximum depth of elevated radionuclides measured under the basements of Buildings C-1 and C-2 are 2.15 m (7 ft) and 1.22 m (4 ft), respectively.

*Building F*

Uranium-238 greater than 50 pCi/g was not detected in samples from three soil borings in the area around Building F. No pesticides or PCBs were detected, and no TCLP guidelines were exceeded in samples from around Building F.

*Alfa Building*

Some surface soil south of the Alfa Building contains Th-232 greater than 5 pCi/g, and two sample locations have U-238 levels greater than 50 pCi/g (93 and 54.8 pCi/g). Thorium-232 concentrations sampled in surface soil around the Alfa Building range from 16.7 pCi/g to 3,900 pCi/g.

*Building D*

Based on the results of walkover gamma scan surveys, it is suspected that surface soil in an area east of Building D contains residual radioactive material; however, no samples were taken in this area. Additional characterization of this area will be conducted during remedial activities at the site.

*Off-Site Buildings and Properties*

In 1991, DOE performed a radiological investigation of the residential housing area adjacent to the Ventron site. This radiological investigation included radiological surveys of approximately 24 off-site residential and municipal properties. The objective of the survey was to determine whether or not radioactive constituents from the Ventron site had migrated off-site to neighboring areas, and, if so, to what extent. Based on the survey data, no detectable radiological constituents had migrated into the vicinity properties and no further investigation was warranted (ORNL 1992a through 1992s).

In 1992, DOE collected soil samples in the basements of two houses (now used as office buildings) at 11 and 15 Congress Street, across the street from the Ventron site. None of these samples showed concentrations of radioactive materials exceeding cleanup guidelines.

*Storm Sewers*

Storm sewer sediment samples from the most recent sampling indicated that the sewers did not contain U-238 greater than 50 pCi/g (DOE 1995).

## 2.4 CURRENT SITE CONDITIONS

The following sections provide general conclusions regarding current conditions at the Ventron site. These conclusions are based on the results of the investigations described in

Section 2.3. The probable extent of radioactive material in harbor sediment and on-site soil and furnace ash is shown in Figure 2-1.

### 2.4.1 Harbor Sediment

The following general conclusions are relevant to remedial actions for the harbor sediment.

- Uranium-238 greater than 50 pCi/g is confined to an area approximately 7 m (23 ft) by 12 m (39 ft) southeast of Building B-1, adjacent to the seawall.
- Within this area, U-238 concentrations range from less than 1.7 pCi/g (minimum) to 431.2 pCi/g (maximum).
- The maximum depth of the harbor sediment with elevated U-238 concentrations is expected to be 1.5 m (4.5 ft).
- Residual radioactive material in harbor sediment has not had a detectable impact on marine life in the Beverly Harbor.

### 2.4.2 On-Site Soil and Furnace Ash

The following general conclusions are relevant to remedial actions for the on-site soil and furnace ash.

- The ash piles in Building A contain Ra-226 greater than 5 pCi/g and may contain hazardous constituents. It is expected that soil and the bedrock surface beneath the ash piles under Building A contain elevated radionuclides (primarily Ra-226).
- Soil directly under the basement of Building A-1 contains Th-230 greater than 15 pCi/g. The extent of elevated levels of radioactivity in soil under Building A-1 is unknown but is assumed to be limited because only one of four samples showed concentrations greater than cleanup guidelines.
- Uranium-238 greater than 50 pCi/g is present in soil beneath the B Buildings and Buildings C-1 and C-2 (possibly extending to C-3). Generally, the elevated concentrations are highest in the depth intervals immediately under the surface (building slab), and decrease with depth. Samples from borings drilled to a maximum depth of 2.15 m (7 ft) under Buildings B-2 and C-1 showed U-238 greater than 50 pCi/g.
- Surface soil south of the Alfa Building contains Th-232 greater than 5 pCi/g. Two soil samples south of the Alfa Building contained U-238 greater than 50 pCi/g.

- Based on the results of walkover gamma scan surveys, it is suspected that residual radioactive material is present in an area east of Building D. The concentration levels and extent are unknown and should be investigated further during remedial actions.

## 2.5 JUSTIFICATION FOR REMEDIAL ACTIONS

To determine the need for remedial actions at the Ventron site, potential radiation doses to humans were evaluated under current and likely future exposure conditions, assuming no cleanup of soil or harbor sediment containing residual radioactive material. Doses were also evaluated for the cleanup option as a means of comparing the effectiveness of complete removal of material containing radioactivity greater than the cleanup guidelines. The results of the dose assessment showed that though current radiation doses are very low, estimated radiation doses under likely future land uses exceed the 100 mrem/yr public dose limit.

Because land use around the Ventron site is primarily residential, future land use was assumed to be residential for dose assessment purposes. Because the property would have to be renovated prior to sale, doses to a renovation worker were also evaluated as part of the no-action scenario. In addition, the dose assessment considered doses from recreational exposures on the tidal flats if harbor sediment containing radioactive material is left in place.

Doses to future renovation workers at the site were estimated as 233 mrem/yr under uncontrolled renovation activity exposures to soil containing radioactive material (see Appendix A). Future residential doses were estimated as 290 mrem/yr, also assuming uncontrolled access to soil containing radioactive material. Recreational activities in the tidal flats area would result in an estimated future dose of 5 mrem/yr, assuming no further removal of harbor sediment. These doses are based on conservative assumptions of future exposure conditions, which would allow much higher exposures than those possible under current conditions. The site is currently not operational, and access is controlled through fencing and a security service. Thus, exposures to current workers on the site are negligible.

The threats posed by radioactive materials at the Ventron site are of a non-time-critical nature (i.e., no immediate risk to human health or the environment currently exists at this property that would require emergency cleanup within 6 months). However, because future radiation exposures could exceed the public dose limits, the site conditions do meet criteria listed in the National Contingency Plan (NCP) for conducting removal actions to prevent potential future exposures to nearby human populations.

141533

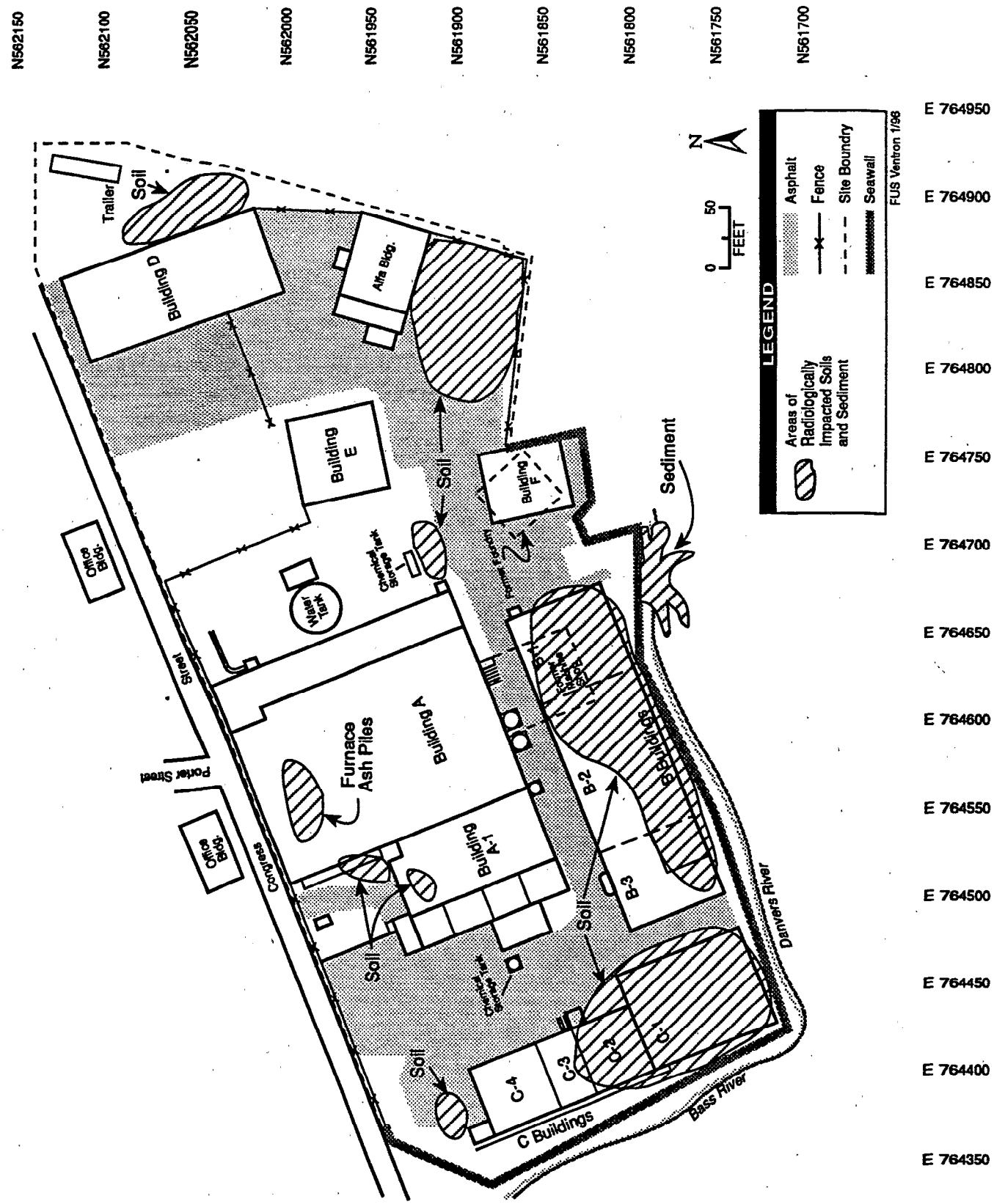



Figure 2-1. Probable Extent of Radiologically Impacted Areas

## Table 2-1. Summary of DOE Guidelines for Residual Radioactive Material

**BASIC DOSE LIMITS**

The basic limit for the annual radiation dose (excluding radon) received by an individual member of the general public is 100 mrem/yr. In implementing this limit, DOE applies ALARA principles to set site-specific guidelines.

**SOIL GUIDELINES**

| Radionuclide | Soil Concentration (pCi/g) Above Background[a,b,c] |
|---|---|
| Ra-226, Ra-228, Th-230, and Th-232 | 5 pCi/g when averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over any 15-cm thick soil layer more than 15 cm below the surface. |
| Other radionuclides | Site-specific U-238 guideline of 50 pCi/g and a total-uranium guideline of 100 pCi/g were developed for the Ventron site soil. |

**STRUCTURE GUIDELINES**

**Airborne Radon Decay Products**

0.02 WL[d] average, not to exceed 0.03 WL.

**External Gamma Radiation**

20 $\mu$R/hr above background (inside habitable structures).

**Indoor/Outdoor Structure Surface Radioactivity**

| | Allowable Surface Residual Radioactivity (dpm/100 cm$^2$)[e] | | |
|---|---|---|---|
| Radionuclide[f] | Average[g,h] | Maximum[h,i] | Removable[h,j] |
| Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129[k] | 100 $\alpha$ | 300 $\alpha$ | 20 $\alpha$ |
| Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133 | 1,000 $\alpha$ | 3,000 $\alpha$ | 200 $\alpha$ |
| U-Natural, U-235, U-238, and associated decay products | 5,000 $\alpha$ | 15,000 $\alpha$ | 1,000 $\alpha$ |
| Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above[l] | 5,000 $\beta$-$\gamma$ | 15,000 $\beta$-$\gamma$ | 1,000 $\beta$-$\gamma$ |

## Table 2-1. (continued)

[a] These guidelines take into account ingrowth of Ra-226 from Th-230 and of Ra-228 from Th-232 and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that: 1) the dose for the mixtures will not exceed the basic dose limit, or 2) the sum of ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed 1 ("unity").

[b] These guidelines represent allowable residual concentrations above background averaged across any 15 cm-thick layer to any depth and over any contiguous 100 $m^2$ surface area.

[c] If the average concentration in any surface or below-surface area less than or equal to 25 $m^2$ exceeds the authorized limit or guideline by a factor of $(100/A)^{1/2}$, where A is the area of the elevated region in square meters, limits for hotspots shall also be applicable. Procedures for calculating these hotspot limits, which depend on the extent of the elevated local concentrations, are given in the supplement of the FUSRAP Summary Protocol. In addition, every reasonable effort shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit for soil, irrespective of the average concentration in the soil.

[d] A working level (WL) is any combination of the short-lived radon decay products in 1 L of air that will result in the ultimate emission of $1.3 \times 10^5$ mega electric volts (MeV) of potential alpha energy.

[e] As used in this table, disintegrations per minute (dpm) means the rate of emission by radioactive material as determined by correcting the counts per minute (cpm) measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[f] Where surface impacted by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

[g] Measurements of radionuclides should not be averaged over an area of more than 1 $m^2$. For objects of less surface area, the average should be derived for each.

[h] The average and maximum dose rates associated with surfaces impacted from beta-gamma emitters should not exceed 0.2 millirad per hour (mrad/hr) and 1.0 mrad/hr, respectively, at a depth of 1 cm.

[i] The maximum level for isotopes of concern applies to an area of not more than 100 $cm^2$.

[j] The amount of removable radioactive material per 100 $cm^2$ of surface area should be determined by wiping an area of that size with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable radioactivity on objects of surface area less than 100 $cm^2$ is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable radioactivity levels if direct scan surveys indicate that total residual impacted surface levels are within the limits for removable radioactivity.

[k] Guidelines for these radionuclides are not given in DOE Order 5400.5; however, these guidelines are considered applicable until guidance is provided.

[l] This category of radionuclides includes mixed fission products, including the Sr-90 that is present in them. It does not apply to Sr-90, which has been separated from the other fission products, or to mixtures where the Sr-90 has been enriched.

*Sources: 40 CFR 192, DOE 1986, DOE 1990.*

141533

THIS PAGE INTENTIONALLY LEFT BLANK

# 3. IDENTIFYING AND EVALUATING CLEANUP OPTIONS

Cleanup options were developed and evaluated separately for each of the media: the harbor sediment and on-site soil and furnace ash. Several cleanup options were considered in an early screening process and were dismissed from further consideration. A brief description of these cleanup options, by media, is presented in Section 3.1. Descriptions of the options retained for detailed evaluation are presented in Sectibn 3.2.

## 3.1 SCREENING OF PRELIMINARY OPTIONS

For harbor sediment, the options considered in the early screening process were as follows:

A) No action
B) Removal of harbor sediment greater than DOE cleanup guidelines
C) Selective removal of harbor sediment in accordance with supplemental cleanup guidelines

Option A, no action, was retained for detailed evaluation as a baseline for comparison to the other options. Option B, removal of harbor sediment, was considered feasible and retained for detailed evaluation. Option C, selective removal, was dismissed from further evaluation.

In Option C, harbor sediment greater than the current DOE cleanup guidelines would remain in the tidal flats. It was anticipated that the dose estimate associated with this option would be protective of human health and the environment. However, as the Ventron site is located in a residential area and the harbor is used for recreational activity, DOE dismissed this option on the basis that it would not be in the best interest of the community.

For the on-site soil and furnace ash, the options considered early in the screening process were:

A) No action
B) Selective removal in accordance with supplemental cleanup guidelines
C) Removal of on-site soil and furnace ash greater than DOE cleanup guidelines
D) Capping the site
E) Treatment of the on-site soils and furnace ash to reduce the volume requiring off-site disposal as a low-level radioactive waste

Option A, no action, was retained for detailed evaluation as a baseline for comparison to the other options. Option C, removal of on-site soil and furnace ash, was considered feasible and was retained for detailed evaluation. Options B, selective removal; D, capping in place; and E, treatment, were dismissed from further evaluation.

In Option B, on-site soil greater than the current DOE cleanup guidelines would remain on the Ventron site. It was anticipated that the dose estimates associated with this option would not be protective of human health and the environment. In addition, as the Ventron site is

located in a residential area and could be developed for residential purposes in the future, this option was not believed to be in the best interest of the community.

In Option D, the cap would minimize migration of radioactive constituents caused by infiltration of rainwater; however, a cap would not minimize migration of radioactive material caused by tidal infiltration. In addition, capping the Ventron site would likely require zoning restrictions as radioactive materials would remain on the site. Such zoning restrictions could limit future development of the site.

Option E, treatment, was dismissed early in the screening process as the limited volume of radioactive material was not expected to justify the cost associated with the development and implementation of a treatment process.

## 3.2 DESCRIPTIONS OF SELECTED OPTIONS

The quantities of harbor sediment and soil and furnace ash, as well as the costs presented in this document, are based on preliminary engineering estimates. Though these estimates are likely to change when the preliminary engineering is completed, they are useful for presenting the conceptual remediation approach and establishing the relative ranking among the options for the harbor sediment and on-site soil and furnace ash.

### 3.2.1 Harbor Sediment

*Option 1: No Action*

A no action option provides a baseline for comparison with the other option. Under this option, DOE would conduct no further activity at the site. Any current potential for human exposure to radioactive material would continue to exist in both the short and long-term.

*Option 2: Removal of Harbor Sediment*

This option involves removal and off-site disposal of harbor sediment containing U-238 greater than 50 pCi/g, shipment of the removed harbor sediment off site, and unrestricted future use of the tidal flats. In this option, public access to the impacted harbor area would be restricted; then, harbor sediment containing U-238 greater than 50 pCi/g would be excavated using standard construction equipment working at low tide. The excavated harbor sediment would be placed into a front-end loader located above the seawall on the site property. The excavated sediment would be dewatered by placing it in drying beds on site or by mixing with site soil. Dewatered harbor sediment would be shipped to an off-site disposal facility designed for waste with low levels of radioactivity.

Approximately 51 $m^3$ (67 $yd^3$) of harbor sediment would require disposal (Redmon 1996). In this option, dewatered harbor sediment would be transported from the site in a secure manner to an off-site disposal facility.

### 3.2.2 On-Site Soil and Furnace Ash

*Option 1: No Action*

A no action option provides a baseline for comparison with the other option. Under this option, DOE would conduct no further activity at the site. Any current potential for human exposure to radioactive material would continue to exist in both the short- and the long-term.

*Option 2: Removal of On-Site Soil and Furnace Ash*

This option involves the removal of on-site soil and furnace ash containing U-238 greater than 50 pCi/g, shipment of the removed material off site, and unrestricted future use of the site.

In order to conduct this option, the fence surrounding the work area would be inspected and repaired if necessary, and any furnace ash containing U-238 greater than 50 pCi/g would be removed from Building A and treated to render it nonhazardous. DOE would decontaminate portions of Buildings A-1, A, and the Alfa Building, as necessary. Then Morton would demolish the site buildings and dispose of the nonradioactive structural debris. If required, the structural debris would be crushed by DOE prior to disposal.

On-site soil containing U-238 greater than 50 pCi/g would be excavated. The excavated soil and treated furnace ash would be sampled to ensure they meet the waste disposal acceptance criteria prior to being shipped off site for disposal. Excavated soil and treated furnace ash would be shipped to an off-site disposal facility designed for waste with low levels of radioactivity. Upon completion of the work by DOE, Morton will, where necessary, backfill, grade, and seed the site.

The in situ volume of soil requiring excavation for this option is estimated to be 1,270 $m^3$ (1,660 $yd^3$) (Redmon 1996). The volume of excavated soil requiring disposal is estimated to be 1,650 $m^3$ (2,160 $yd^3$) (conservatively assuming a 30 percent volume increase due to excavation). The volume of furnace ash to be removed is estimated to be 1.5 $m^3$ (2 $yd^3$). The volume of treated ash requiring disposal is estimated to be 3 $m^3$ (4 $yd^3$) (conservatively assuming a 100 percent volume increase due to the stabilization/solidification treatment process).

This option assumes that the excavated soil and treated furnace ash would be transported from the site in a secure manner to an off-site disposal facility.

## 3.3 EVALUATION OF OPTIONS

The options identified in Section 3.2 were evaluated against three general requirements: (1) how well the cleanup option works (effectiveness), (2) how easily the cleanup can be done (implementability), and (3) cost.

The evaluation of the options was based on the following assumptions:

- Morton would demolish Buildings A-1, B, and C to provide access to the impacted soil and
- future land use could include residential development.

Findings of the evaluations are summarized in Sections 3.3.1 through 3.3.3.

### 3.3.1 Effectiveness

The effectiveness of a cleanup option is based on how well it protects human health and the surrounding environment from risks of exposure to radioactive materials both during and after implementation. Measures of effectiveness include:

- potential health risks from exposure to or contact with the radioactive materials both during and after cleanup;
- compliance with ARARs and other guidelines and environmental regulations that apply to the cleanup activities (see Appendix B);
- how quickly the cleanup can be completed; and
- the ability to lower the harmful effects (toxicity), reduce the movement of the radioactive materials (mobility), and decrease the volume of impacted material.

The evaluations of the cleanup options' effectiveness are presented in Sections 3.3.1.1 and 3.3.1.2.

#### 3.3.1.1 Harbor Sediment

*Potential Health Impacts*

A radiological dose assessment (see Appendix A) was performed to provide a basis for comparing the potential health risks from the cleanup options under likely current and future conditions at the site. Four primary exposure scenarios have been identified to represent the likely current and future exposure possibilities at Ventron: (1) a current or future renovation worker involved in demolition or construction activities at the site, (2) future residents living at the site (after building removal or renovation), (3) future recreational exposures, from radioactive materials in harbor sediment, to residents living at or near the site, and (4) potential ecological exposures to marine life caused by radioactive materials in the harbor sediment. The methodology and assumptions used in the radiological dose assessment are contained in Appendix A.

For the harbor sediment, the primary potential receptors are humans involved in recreational activities and ecological receptors (e.g., mussels, clams, etc.). Both human and ecological receptors could be exposed through ingestion of impacted surface water and harbor

sediment, and by direct external gamma radiation from harbor sediment containing residual radioactive material.

The ecological exposure scenario was not evaluated quantitatively for the harbor sediment in the dose assessment because samples from mussels and lobsters to date have not shown evidence of being impacted; furthermore, assessment of radiation doses to aquatic organisms is highly uncertain. The ecological exposure scenario, however, was considered in the assessment of environmental impacts.

Under Option 1, no action, the total estimated dose under a recreational scenario was 5 mrem/yr, primarily because of external gamma radiation from localized radioactive material in the harbor sediment. This dose is well below the public dose limit of 100 mrem/yr; and it is significantly below the average exposure received in the U.S. from normal background radiation (approximately 300 mrem/yr).

Under Option 2, complete removal, the total estimated dose to a member of the public for recreational activities, following the removal action, was estimated as 0.1 mrem/yr. This option assumes that after removal of harbor sediment containing U-238 greater than 50 pCi/g, the predicted remaining U-238 $UCL_{95}$ concentration is approximately 16 pCi/g.

The transportation risk estimates the potential for a traffic accident that would cause a fatality. (Any waste spilled during an accident would be removed according to cleanup requirements and is not expected to result in any unacceptable exposures). In general, the further the destination and the greater the number of vehicle trips involved, the higher the risk of a transportation accident involving a fatality. When comparing transportation modes, truck transportation has a higher fatality per mile ratio than rail transportation. For the purposes of this analysis, the disposal facility was assumed to be an existing facility located in Utah that is approximately 2,376 miles away from the Ventron site (round trip of 4,752 miles) (Rand McNally and Company 1994). In addition, both rail and truck transportation in bimodal containers were evaluated. Transporting the materials for disposal in Option 2 presents a risk of fatality of $2.3 \times 10^{-4}$.

*Potential Environmental Impacts*

The harbor sediment in the tidal flats at the Ventron site is located within the 100-year floodplain, a coastal wetland, and the Massachusetts coastal zone (see Appendix D). Under Option 1, no action, sediment with levels of U-238 above guidelines would remain in place, allowing potential radiation exposure to ecological receptors. However, this option would avoid the physical disturbance associated with excavation.

Some minor environmental impacts could occur during excavation of the harbor sediment. The magnitude of these impacts is directly related to the quantity of sediment to be excavated. Harbor organisms may experience some disturbance under Option 2; however, these impacts are expected to be minimal (see Appendix D). Such impacts include increased suspended sediment in the water, which may increase exposure of marine and estuarine[1] organisms to uranium.

[1]The lower portion or mouth of a river where the saltwater tide meets the freshwater current.

In the short term, immediate and direct negative impacts would affect those individual organisms present at excavation (e.g., mussels, clams, crabs, etc.). The localized extent and limited duration of excavation would prevent major population-level impacts. Furthermore, removal of sediment containing residual radioactive material would likely have a beneficial effect on estuarine and marine populations in the long term.

During cleanup, wading and diving birds could experience minor impacts, but these impacts would be temporary. As in the case of estuarine and marine organisms, removal of the sediment containing residual radioactive material would likely be beneficial in the long term.

Potentially significant impacts to marine and estuarine organisms could also occur if water leaking into the excavation area became impacted and was subsequently pumped into the harbor. However, the potential for this occurrence could be minimized by monitoring the water pumped into the harbor.

Based on consultations with the U.S. Fish and Wildlife Service and National Marine Fisheries Service, no threatened or endangered species under their jurisdiction occur in the Ventron site area (see Appendix E).

*Compliance with Guidelines, Laws, and Regulations*

Option 1, no action, would not comply with the site-specific cleanup guidelines as harbor sediments containing concentrations of U-238 greater than DOE cleanup guidelines would remain in the harbor. Option 2 would fully comply with the site-specific cleanup guidelines and applicable regulatory requirements. Following the implementation of Option, 2 no restrictions on the use of the harbor would be required and the harbor risks would be essentially eliminated.

A list of environmental and safety requirements that may be used at the Ventron site is contained in Appendix B.

3.3.1.2 On-Site Soil and Furnace Ash

*Potential Health Impacts*

For the on-site soil and furnace ash, the most significant potential radiological exposures at the site would be to a renovation worker or to a future resident after renovation of the site (with radioactive material remaining).

Under Option 1, no action, the estimated dose to a renovation worker is 233 mrem/yr; inhalation of dust and direct gamma radiation would contribute the majority of the dose. Exposure to on-site soil and furnace ash containing elevated levels of U-238 under residential conditions results in a total estimated dose of 290 mrem/yr, also primarily due to inhalation of dust and direct gamma radiation. Both of these dose estimates exceed the public dose limit of 100 mrem/yr.

Under Option 2, complete removal, the primary contributors to the dose are inhalation of dust and direct gamma radiation. Option 2 results in an estimated dose rate of 14 mrem/yr to a renovation worker and 21 mrem/yr to a resident. These estimated dose rates are well below the public dose limit of 100 mrem/yr.

Transporting the materials for disposal in Option 2 would present a fatality risk of $3.3 \times 10^{-3}$.

*Potential Environmental Impacts*

Ventron is a developed site and has little, if any, terrestrial habitat to support ecological receptors. No prime farmlands are on the site. Impacts of remediation within the floodplains and coastal wetlands buffer zone and within the Massachusetts coastal zone would be temporary and could be mitigated (see Appendix D). Based on consultations with the U.S. Fish and Wildlife Service and National Marine Fisheries Service, no threatened or endangered species under their jurisdiction occur in the Ventron site area (see Appendix E).

For Option 2, some minor environmental impacts could occur during excavation of the soil. For example, disturbed areas would be susceptible to wind and water erosion. Effects from runoff or dust entrainment could be minimized or eliminated by using preventive measures such as dust suppression techniques and barriers to minimize exposed dirt moving off site during rainstorms.

The seawall that borders the excavation areas could be damaged during the excavation activities. Damage or collapse of the seawall could cause significant impacts to marine and estuarine organisms. Damage to the seawall could be minimized by shoring the excavation area and possibly grouting the seawall.

Potentially significant impacts to marine and estuarine organisms could also occur if water leaking or flowing into the excavated area became impacted and was subsequently pumped or flowed back into the harbor. However, the potential for this occurrence could be minimized by monitoring the water pumped or flowing back into the harbor.

*Compliance with Guidelines, Laws, and Regulations*

Option 1, no action, would not comply with the site-specific cleanup guidelines, as materials containing concentrations of U-238 greater than 50 pCi/g would remain at the Ventron site. Option 2 would fully comply with the site-specific cleanup guidelines and applicable regulatory requirements. Following implementation of Option 2, no restrictions on the use of the site would be required and the site risks would be significantly minimized.

A list of environmental and safety requirements that may be used at the Ventron site are contained in Appendix B.

### 3.3.2 Implementability

The implementability of an option is determined by: (1) its technical feasibility; (2) the availability of equipment, skilled workers, and disposal locations; and (3) its acceptability to the state, local community, and DOE (administrative feasibility).

The evaluations of the cleanup options' implementability are presented in Sections 3.3.2.1 and 3.3.2.2.

3.3.2.1 Harbor Sediment

*Technical Feasibility*

Both of the options are technically feasible. Option 1 involves no action. Option 2 would involve excavating impacted sediment from the tidal flats at low tide using standard construction equipment. This is a standard excavation technique that has been used successfully in coastal areas. The excavated sediment would be dewatered on site by placing on drying beds or mixing with excavated site soil. There is adequate room on the Ventron site to accommodate drying beds.

Disposal of the dewatered sediment generated during cleanup is technically feasible because disposal facilities currently exist. Under Option 2, the harbor area would be cleaned to below the DOE cleanup guidelines. Long-term maintenance would not be required and the harbor area would be released for unrestricted use.

*Availability of Services and Materials*

All of the equipment, services, and materials required to implement Option 2 are readily available. No specially made equipment or materials would be required.

*Administrative Feasibility*

Both options are administratively feasible. Under Option 1, sediment containing U-238 greater than 50 pCi/g would remain in the harbor. However, the dose rate estimate of 5 mrem/yr for Option 1 is low and is protective of human health and the environment.

Option 2 is expected to have a positive effect on the community as all sediment containing U-238 greater than DOE cleanup guidelines would be removed from the harbor and the dose would be essentially eliminated.

3.3.2.2 On-Site Soil and Furnace Ash

*Technical Feasibility*

Both of the options are technically feasible. Option 1 involves no action. Option 2 involves removing soil containing U-238 greater than DOE cleanup guidelines, using standard excavation equipment and techniques. Option 2 may require some shoring of the excavation area for safety and structural support and/or repairing, or supporting, the seawall during excavation activities adjacent to the seawall. In Option 2, the furnace ash would be manually removed from beneath the furnaces in Building A and treated by solidification/stabilization to render the waste nonhazardous. Solidification/stabilization techniques for metal-containing hazardous waste are widely recognized as effective treatment processes for rendering waste nonhazardous.

Disposal of the excavated soil and treated furnace ash generated during cleanup is technically feasible because disposal facilities currently exist. Under Option 2, the site soil would be cleaned to below the DOE cleanup guidelines. Long-term maintenance would not be required and the site area would be released for unrestricted use.

*Availability of Services and Materials*

All of the equipment, services, and materials required to implement Option 2 are readily available. No specially made equipment or materials would be required.

*Administrative Feasibility*

Option 1, no action, is not administratively feasible. Taking no action could allow the public to have access to areas where radioactive material is above acceptable levels and could result in the spread of radioactive material if the site area were altered in the future. Therefore, it would not comply with DOE Orders requiring protection of the public health and the environment and would not comply with similar applicable state and federal requirements.

Option 2 is administratively feasible. Similar cleanup projects have been successfully completed. Administrative activities may include interagency agreements or waivers, as well as obtaining input from state health and environmental agencies, local officials, and the community.

Option 2 would be expected to have a positive effect on the community. Under Option 2, soil containing U-238 greater than DOE cleanup guidelines would be removed and the site could then be developed for residential use without radiological restrictions.

### 3.3.3 Cost

The costs presented in this section are preliminary engineering estimates based on conceptual remediation approaches. These estimates are presented to establish the relative ranking among the cleanup options. The cost comparisons for the cleanup options are discussed below. The methodology and assumptions used in developing the cost estimates, as well as the detailed estimates, are contained in Appendix C.

#### 3.3.3.1 Harbor Sediment

Because no action would be taken, no costs are associated with Option 1.

Option 2 would involve excavating approximately 51 $m^3$ (67 $yd^3$) of harbor sediment from the tidal flats at low tide. Due to the low volume of harbor sediment being excavated, it is expected to take minimal time to complete. If necessary, a drying bed would be constructed on site to dewater the harbor sediment. The dewatered sediment would be transported by truck to a railyard, then transported by train to the disposal facility.

Based on a disposal volume of 51 $m^3$ (67 $yd^3$), the cost for Option 2 is $ 932,000.

#### 3.3.3.2 On-Site Soil and Furnace Ash

Because no action would be taken, no costs are associated with Option 1.

In Option 2, the fencing around the work area would be inspected and repaired, if necessary. DOE would decontaminate, as needed, the interiors of Buildings A and A-1. Furnace ash containing U-238 greater than DOE cleanup guidelines would be removed from

Building A and solidified/stabilized on site to render it nonhazardous. Morton would then demolish, at a minimum, Buildings A-1, B, and C to provide access to the underlying impacted soil. Following building demolition, soil containing U-238 greater than DOE cleanup guidelines would be removed using standard construction equipment. Following DOE remediation activities, the site would be backfilled, graded, and seeded as required by Morton.

The soil and stabilized ash would be transported by truck to a railyard, then transported by train to the disposal facility. Structural debris meeting DOE's criteria for release for unrestricted use would be disposed of by Morton.

Based on a disposal volume of 1650 $m^3$ (2,160 $yd^3$) for soil and 3 $m^3$ (4 $yd^3$) for treated furnace ash, the cost for Option 2 is $ 3,697,000.

# 4. COMPARISON OF THE CLEANUP OPTIONS

The two cleanup options for the Ventron site were compared with each other using the three evaluation requirements: effectiveness, implementability, and cost. Tables 4-1 and 4-2 compare options for each of the media. DOE's preferred sitewide cleanup option combines the options chosen by DOE from the evaluation performed for each of the media. The preferred sitewide cleanup option is presented in Section 5.

Table 4-1 compares the cleanup options for the harbor sediment; Table 4-2 compares the cleanup options for the on-site soil and furnace ash.

**Table 4-1. Comparison of Cleanup Options for Harbor Sediment**

| Options | Effectiveness | Implementability | Cost |
|---|---|---|---|
| **Option 1**<br><br>**No Action** | Not effective in reducing potential human health risks, but estimated radiation dose (5 mrem/yr) does not exceed public dose limit. Not effective in reducing long-term environmental impact. | Technically implementable; administratively feasible, but there is public concern over elevated uranium levels in the harbor. | 0 |
| **Option 2**<br><br>**Removal of Harbor Sediment** | Effective in reducing human health risks (dose = 0.1 mrem/yr) and long-term environmental impacts. Long-term environmental protection, but potential short-term environmental impacts during remediation. Complies with ARARs. | Technically implementable, administratively feasible. | $ 932,000 |

Option 1, no action, allows harbor sediment with U-238 above the site-specific guideline of 50 pCi/g to remain. Although this option avoids the short-term environmental impacts of excavation to ecological receptors, it allows long-term potential radiation exposures.

Option 2, removal of harbor sediment, has greater short-term impacts but also has greater long-term benefits by removing sediment with U-238 levels above DOE cleanup guidelines. DOE recognizes the importance of public concern over elevated uranium levels in the harbor sediment.

**Table 4-2. Comparison of Cleanup Options for On-site Soil and Furnace Ash**

| Options | Effectiveness | Implementability | Cost |
|---|---|---|---|
| **Option 1**<br><br>**No Action** | Not effective in reducing potential human health risks; estimated radiation dose (233-290 mrem/yr) exceeds public dose limit. Less risk of potential short-term environmental impacts than other option. Does not comply with the site-specific DOE cleanup guidelines or ARARs. | Technically implementable; not administratively feasible. | 0 |
| **Option 2**<br><br>**Removal of On-Site Soil and Furnace Ash** | Effective in reducing potential human health risk (14-21 mrem/yr). Long-term environmental protection, but potential short-term environmental risks. Complies with ARARs. | Technically implementable; administratively feasible. | $ 3,697,000 |

Option 1, no action, allows soil with U-238 levels above guidelines to remain as a source of potential exposure, with an estimated radiation dose exceeding public dose limits. Option 2, removal of on-site soil and furnace ash, is protective of human health and the environment and permits unrestricted release of the site.

# 5. SELECTION OF THE PREFERRED SITEWIDE CLEANUP OPTION

DOE has selected Option 2 in each case for both the harbor sediment and the on-site soil and furnace ash as the preferred sitewide cleanup option. These options are protective of human health and the environment and would allow for future use of the property with no radiological restrictions. Risks associated with excavation and transportation activities would be minimized by using best management practices. All removed material would be disposed at appropriate existing waste disposal facilities. Once this action is completed, no future restrictions such as fencing, warning signs, deed restrictions, or long-term environmental surveillance would be necessary.

Under the selected sitewide cleanup option, furnace ash containing U-238 greater than DOE cleanup guidelines would be removed from Building A, treated, and containerized. DOE would decontaminate, as necessary, Building A, A-1, and the Alfa Building. Then site buildings would be demolished by Morton. On-site soil containing U-238 greater than DOE cleanup guidelines would be excavated and containerized. Then harbor sediment containing U-238 greater than DOE cleanup guidelines would be excavated, dewatered, and containerized. The excavated materials would be transported to an appropriate existing off-site radioactive waste disposal facility.

To verify the site meets release criteria, samples would be collected for analysis from the excavated area prior to backfilling. Following verification that the areas meet cleanup guidelines, the site would be backfilled and restored, as necessary, by Morton.

In summary, the proposed action would include the following:

(1) Removal of the furnace ash from Building A and treatment to render the ash nonhazardous.

(2) Decontamination, as necessary, of Buildings A-1, A, and the Alfa Building.

(3) Demolition of, at a minimum, Buildings A-1, B, and C by Morton.

(4) Loading and packaging of nonradioactive waste materials by Morton.

(5) Transport of nonradioactive waste materials to an appropriate off-site disposal facility by Morton.

(5) Removal of soil containing U-238 greater than 50 pCi/g.

(6) Removal of harbor sediment containing U-238 greater than 50 pCi/g.

(7) Dewatering of harbor sediment, as necessary.

(8) Loading and packaging of radioactive waste materials.

(9) Transport of radioactive waste materials to an appropriate off-site disposal facility.

(10) Systematic verification sampling from the excavated areas to confirm compliance with cleanup requirements.

(11) Site restoration activities by Morton, as necessary, to restablize the excavated areas.

The combined cost of the preferred sitewide option is $4,842,800.

# 6. PUBLIC PARTICIPATION AND COMMUNITY RELATIONS

## 6.1 HOW TO PARTICIPATE IN THE DECISION-MAKING PROCESS

The public, Massachusetts Department of Environmental Protection, and other state and local government officials are invited to review this document. Written comments on the document and DOE's preferred option may be made during a 30-day public comment period that starts February 12, 1996 and ends March 13, 1996. Comments for the administrative record will be accepted any time during the public comment period.

Copies of the EE/CA for the Ventron site and administrative record files are available at the following location:

Beverly Public Library
32 Essex Street
Beverly, MA 01915
(508) 921-6062

Hours of Operation

Monday - Thursday 9:00 a.m. - 9:00 p.m.
Friday and Saturday 9:00 a.m. - 5:00 p.m.

Reference Librarian: Ms. Suzanne Nichelson

Copies of this document will also be provided upon request. Call DOE's toll-free number, 1-800-253-9759.

DOE will evaluate and respond to comments received during the public comment period. DOE is especially interested in input regarding the preferred sitewide option and any considerations for carrying out the cleanup remedy. Final selection of the cleanup option will not be made until comments have been evaluated. Written comments should be addressed to:

Mr. James Kopotic
U.S. Department of Energy
Former Sites Restoration Division
Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, TN 37831

## 6.2 COMMUNITY RELATIONS PLAN

Issues of community concern regarding the Ventron site, with respect to environmental cleanup efforts there, are of utmost importance to DOE. As support to the upcoming cleanup, this plan outlines community relations activities that will be integrated into the effort.

This community relations plan has been prepared to guide DOE in proceeding with a community relations program tailored to the needs of the local community. Community relations activities ensure that the local public is given the opportunity to provide input regarding DOE actions and is kept informed about the status of those actions.

The development of this plan is based on DOE's experience at the Ventron site, on information sharing with community relations representatives from Morton, and on DOE interactions with local stakeholders. The plan has been developed to meet provisions of the National Contingency Plan (NCP) and CERCLA, and, through its inclusion in the EE/CA, is a part of the official administrative record. This plan has been developed in accordance with EPA guidance (EPA 1992).

Basic community relations activities regarding the Ventron site will include the following:

- broadly publicizing pertinent information about the remedial action at the Ventron site;
- scheduling and publicizing the start of the 30-day public comment period on the EE/CA;
- preparing a responsiveness summary to address the comments received;
- preparing and distributing a fact sheet(s) as necessary;
- conducting topical workshops as needed or requested to help members of the public understand and participate in the decision-making process;
- meeting with local officials to keep the city informed of DOE's work in the area and to solicit input;
- establishing and maintaining an administrative record and local information repository;
- publicizing the toll-free number for contacting the DOE site manager and project representatives;
- coordinating public announcements with local officials;
- scheduling meetings with state and local officials to discuss DOE site activities;
- responding directly to citizens' inquiries; providing speakers to small, informal meetings regarding site activities; and conducting site tours as requested;
- maintaining information contacts for the media, local officials, and the public (see List of Contacts in Section 6.3).

### 6.2.1 Community Background

141533

#### 6.2.1.1 Government Entities and Community Profile

The city of Beverly is located in an urban, industrialized area of Essex County, approximately 24 km (15 miles) northeast of Boston. The populations of Essex County and the city of Beverly, respectively, are approximately 692,859 and 41,266.

The city is governed by an elected mayor and a nine-member council and includes a public health director. Essex County is governed by a three-member county commission.

The Ventron site is in the 6th U.S. Congressional District, Massachusetts Senate District 2 (Essex) and Massachusetts House of Representatives District 6 (Essex).

#### 6.2.1.2 Community Involvement

DOE has established an administrative record file and information repository for the Ventron site at the Beverly Public Library. Documents included in the record are intended to provide information about the site and insight into how site-related decisions are made. The repository contains information of more general interest to the public, such as fact sheets, newspaper articles, and other information materials pertaining to the site. (For locations, hours of operation, and phone numbers, see Section 6.1.)

#### 6.2.1.3 Summary of Community Concerns

DOE's presence in the Beverly community to date has been limited, because only minimal on-site work has yet been performed by the agency and its contractors. During the time since responsibility for radiological cleanup at the Ventron site was assigned to FUSRAP in 1986, DOE representatives have met with local officials, local representatives of Morton, and community members to discuss work plans and progress, such as characterization activities, maintenance issues, environmental compliance, cleanup scenarios, and other site-specific issues.

Because DOE has had limited on-site activity, there has not been an abundant display of community concern regarding the radiological materials located there. There have occasionally been media reports regarding the site's role in MED activities. Such reports typically result in increased community interest and basic curiosity about the DOE connection to site. But the interactions that have taken place generally have been positive and rooted in cooperation. Residents of the neighborhood adjacent to the site were understandably concerned and engaging when, in 1991, radiological surveys were performed on 24 residential properties to determine whether any radiological material from the site had spread off site. No radioactive materials were found off site. A very positive, post-survey, public information session was held to cover the details of the work with affected property owners and other interested parties. Close cooperation between DOE and Morton, and timely, informative contact with community members, were key to the effort's success and helped foster trust between the neighborhood and DOE.

Community interest in DOE's stake at the site also increased in conjunction with state plans to construct a bridge nearby. Some area residents expressed concern that the work may

spread radioactive materials associated with the Ventron site. A resident once noticed that DOE workers were on site just prior to planned bridge construction and surmised that there was a issue related to radioactive materials and bridge work. DOE corresponded several times with local residents and area and state representatives, explaining that the DOE workers were there to provide health physics support to Morton, at their request, for some work Morton was doing, and that DOE's assessment of the bridge construction project left the agency with no reason to suspect any radioactive materials in the area of the proposed bridge.

Generally, community understanding of the radiological conditions at the site – that the materials are contained and are not moving offsite – is good. A recent DOE characterization and sampling effort in the adjacent harbor generated some inquiries, but those who called were most interested in the schedule to complete site-wide cleanup and were glad to see that radiological material was being removed from harbor sediments. The presence of the materials in the harbor had concerned some residents who wondered if the uranium could get into the water or could affect animals in the harbor. (An ORNL study of sea life, such as lobster, in the area waters showed no uptake of site-related radiological materials by the animal population.)

One aspect of the site that is of apparent high concern to the community is not related to radiological impacts to the public and environment, but centers on the disposition of the property once the cleanup is complete. The neighborhood adjacent to the site is very favorably situated next to the Beverly Harbor and some residents fear that future construction on the property could impact their property values. While this community concern is real and worthy of local consideration, it is outside the realm of DOE's involvement with the site. Since the site is not owned by DOE, DOE is not in a position to regulate or guide the disposition of the property, and it will eventually be released from the FUSRAP program following cleanup.

### 6.2.2 Highlights of Community Relations Program

Through effective community relations, FUSRAP seeks to further an atmosphere of trust, partnership, understanding, and cooperation in communities affected by the program. DOE recognizes that it is in everyone's best interest that a site cleanup be an open and interactive process. The agency will establish lines of communication, providing ample opportunity for public input and comment, while keeping the community apprised of all significant developments and activities.

The community relations program provides an opportunity for the public to learn about a FUSRAP site's history, the type of materials requiring remedial attention, and the cleanup plans being considered. The program is designed to empower stakeholders to participate effectively in the decision-making process.

The person with the primary responsibility for implementing community relations activities for the Ventron site is James Kopotic, of DOE. He is also the primary spokesperson for the site to the media. Mr. Kopotic is assisted in this role by FUSRAP Community Affairs representative Wayne Scarbrough. Mr. Kopotic can be contacted at DOE's Former Sites Restoration Division, P.O. Box 2001, Oak Ridge, TN, 37831-8723, or by phone at (423) 576-9441. Mr. Scarbrough can be reached at (423) 576-6563. Both Mr. Kopotic and Mr. Scarbrough can also be contacted through DOE's 24-hour, toll-free information line at 1-800-253-9759.

Objectives of the Ventron site community relations program are to:

- enlist the support and participation of local officials and other stakeholders in coordinating community relations activities;
- inform the public about the site conditions and the process by which a cleanup plan is developed;
- provide coordinated background information and comments to the news media;
- solicit public input, which enables DOE to ensure that issues of community importance are identified early so that the input can be used to help guide DOE's decision making;
- conduct a formal 30-day comment period for the EE/CA followed by a responsiveness summary to comments received;
- maintain interface with stakeholders throughout the cleanup process.

### 6.2.3 Community Relations Activities and Timing

DOE conducts community relations activities to ensure that the public is well informed and able to participate in the decision-making process. Community relations activities for the Ventron site are intended to address possible community concerns and information needs as identified through stakeholder interaction.

To date, DOE has communicated with persons interested in the Ventron site through personal contacts, fact sheets, media announcements, and presentations at meetings. These and other mechanisms will be used to inform the public of DOE plans and decisions throughout the cleanup process.

The following community relations activities have been or will be conducted relative to DOE's work at the Ventron site:

| *Project Milestone* | *Community Relations Activities* |
|---|---|
| Preparation of EE/CA | Designate information contact; |
| | Establish administrative record and information repository; |
| | Conduct meetings with stakeholders to discuss site status and plans, as needed; |
| | Prepare site fact sheet and include in administrative record. |

| | |
|---|---|
| Issuance of EE/CA for public comment | Include draft document in administrative record; |
| | Conduct information session, if interest warrants, to discuss cleanup plans/issues; |
| | Include community relations plan as part of the EE/CA; |
| | Provide speakers for local groups, if requested; |
| | Publish notice of EE/CA and information repository availability; |
| | Provide 30-day comment period of the draft EE/CA; |
| | Distribute draft EE/CA to key stakeholders; |
| | Respond to inquiries. |
| Issuance of final EE/CA and action memorandum | Prepare responsiveness summary addressing comments received during public comment period; |
| | Conduct meetings with state and local officials, as needed, to discuss cleanup plans; |
| | Issue news release about cleanup; |
| | Respond to inquiries; |
| | Include final document, with responsiveness summary, and action memorandum in administrative record. |
| Remedial Action | Respond to inquiries; |
| | Issue news release upon completion. |

To implement these activities, the following communications tools and materials may be required:

- Mailing list that includes members of various stakeholder groups;
- Media kit containing FUSRAP booklet and fact sheets, site fact sheets, and other pertinent information;
- Display advertisements to promote various public participation opportunities.

DOE F 1325.8
(4/93)

141757 96-223

United States Government

**Department of Energy**
Oak Ridge Operations Office

# memorandum

DATE: May 1, 1996

REPLY TO
ATTN OF: EW-93

SUBJECT: **VENTRON SITE - ACTION MEMORANDUM FOR REMEDIAL ACTION**

TO: File

The purpose of this memorandum is to document selection of cleanup measures for radioactively contaminated materials at the Ventron site in Beverly, Massachusetts. Remedial action at this site is being conducted under the U.S. Department of Energy's (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP). The selected alternative is to remove residual radioactive materials exceeding the site-specific cleanup criteria for off-site disposal.

An Engineering Evaluation/Cost Analysis (EE/CA) describing removal alternatives was issued to the public on February 12, 1996, for review and comment. DOE published a display advertisement announcing the availability of the EE/CA and the 30-day public comment period which ended on March 13, 1996. A letter from the Site Manager transmitting a copy of the draft EE/CA was also sent to individuals and members of organizations who had previously expressed interest in the Ventron site.

The comments received were limited but were favorable toward the proposed action. A responsiveness summary was prepared and has been incorporated into the final EE/CA document, which will be placed in the administrative record file for the site located at the Beverly Public Library, Beverly, Massachusetts.

Based upon the EE/CA and comments received during the public review period, the recommended action is considered appropriate and will be implemented in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended. A review of the proposed action in accordance with the National Environmental Policy Act (NEPA) determined that it meets the requirements for a categorical exclusion.

Lester K. Price

Lester K. Price, Director
Former Sites Restoration Division

141533

1044.960425.001

**Science Applications International Corporation**
*An Employee-Owned Company*

April 25, 1996

U.S. Department of Energy
Oak Ridge Field Office
P.O. Box 2001
Oak Ridge, TN 37831-8758

Attention: Mr. James D. Kopotic
Opportunity Sites Manager, FUSRAP

**Subject: Contract DE-AC05-91OR21950**
**VENTRON - ENGINEERING EVALUATION AND COST ANALYSIS (EE/CA) RESPONSIVENESS SUMMARY AND ERRATA SUMMARY**

Dear Mr. Kopotic:

Enclosed are the Ventron Engineering Evaluation/Cost Analysis (EE/CA) Responsiveness Summary, which includes the Errata Summary, and a hard copy and disk copy of the Action Memorandum for the cleanup of the harbor sediment and on-site soil and furnace ash.

Submittal of these deliverables will complete the SAIC May 1, 1996 performance measurement milestone upon signature by Les Price.

Please feel free to contact me with any questions regarding these documents.

Sincerely,

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

Debbie S Browning

Debbie S. Browning, P.E.
Opportunity Sites Manager

DSB:sh

Enclosure 1: Responsiveness Summary
Enclosure 2: Action Memorandum

cc: L. Price, FSRD (w/o)
B. Seay, FSRD (w/o)
S. Oldham, FSRD (w/e #1)
M. Redmon, BNI (w/e #1)
C. Dimbauer, BNI (w/e #1)
L. Rudek, BNI (w/e #1)
W. Scarbrough, BNI (w/e #1)
R. Weber, BNI (w/o)
PDCC, BNI (w/e #1 & 2)
J. Beck, ORISE (w/e #1)

| | Name | Initials | Date |
|---|---|---|---|
| Originator | D. Browning | DSB | 4-25-96 |
| Concurrence | N/A | | |
| Approved | J.D. Waddell | | 4-25-96 |

No. 1044.960425.001
Internal Distribution

J. Waddell
D. Browning
G. Stephens
M. Wilson
DRC
CRF
K. Renfro (w/o)

800 Oak Ridge Turnpike, P.O. Box 2502, Oak Ridge, Tennessee 37831 (423) 481-4600
Albuquerque, Boston, Colorado Springs, Dayton, Huntsville, Las Vegas, Los Angeles, McLean, Orlando, Palo Alto, San Diego, Seattle, Tucson

141533

FINAL
DOE/OR/21950-1014

# RESPONSIVENESS SUMMARY: VENTRON ENGINEERING EVALUATION/ COST ANALYSIS (EE/CA)

## BEVERLY, MASSACHUSETTS

APRIL 1996

*prepared by*
U.S. Department of Energy, Oak Ridge Operations Office, Formerly Utilized Sites Remedial Action Program

*with technical assistance from*
Science Applications International Corporation ESC-FUSRAP
under Contract No. DE-AC05-91OR21950

# TABLE OF CONTENTS

141533

PREFACE . . . . . iii

RESPONSIVENESS SUMMARY . . . . . 1

ATTACHMENT: ERRATA SUMMARY

# PREFACE

The Department of Energy published the Ventron Engineering Evaluation/Cost Analysis (EE/CA) Public Draft in February 1996. A 30-day public comment or, Public Draft period was held February 12, 1996 through March 13, 1996. Written responses to comments received during the public comment period are provided in this Responsiveness Summary. Revised replacement pages for the EE/CA are included as an attachment (Errata Summary) to this Responsiveness Summary. The Public Draft of the EE/CA with the attachment of revised replacement pages will be considered the Final EE/CA. No further publications of the document will be made.

## Responsiveness Summary for the Ventron Engineering Evaluation/Cost Analysis (EE/CA) Public Draft, February 1996

| Topic | Page(s) | Comment Summary | Response |
|---|---|---|---|
| Site Background, History | 1-3<br>1-11<br>General | Provide additional information on the manufacturing processes that occurred at the Ventron facility and the degradation process for the radioisotopes associated with the manufacturing. | The Engineering Evaluation/Cost Analysis (EE/CA) is designed to be a decision document for selecting a cost-effective, implementable, and technologically feasible method for a non-time critical removal action. The information requested is presented in the Ventron Characterization Report, available directly from the Department of Energy (DOE) or in the Administrative Record at the Beverly Public Library. |
| Site Characterization | 2-4, 2-5, 2-8, 2-9, General | Provide more information to delineate the extent of contamination. Review underground piping plans for the facility. Provide more definitive discussion of the harbor sediment characterization, including location, spacing, and depth of sediment samples, and reevaluate the adequacy of the volumetric estimate for sediment removal. How were background levels determined, and what statistical approach was used? Reevaluate the use of composite samples (for mussels, for background, and for contaminant distribution). | The information requested is presented in the Ventron Characterization Report, available directly from DOE or in the Administrative Record at the Beverly Public Library. The EE/CA provides summary information rather than a detailed characterization report. Evaluation of the underground piping system will be performed as part of the remedial design and remedial action. |
| | | Were homes of former employees sampled during the 1991 residential housing evaluation? | No. The residential housing surveys included houses on the bluff surrounding the Ventron site and directly across the street from the site. While former employee's homes were not specifically surveyed, DOE does evaluate information on suspected locations of MED constituents to determine whether a survey is warranted. Any such information should be submitted directly to DOE. |



141533

| Responsiveness Summary for the Ventron Engineering Evaluation/Cost Analysis (EE/CA) Public Draft, February 1996 | | | |
|---|---|---|---|
| **Topic** | **Page(s)** | **Comment Summary** | **Response** |
| Specific Contaminants | 2-7, 2-8 | Provide additional information on polychlorinated biphenyls (PCBs) (i.e., detection limit, and location and frequency of detection). Explain, "elevated levels of metals" in terms of the toxicity characteristic leaching procedure (TCLP) exceedances. Explain, "one sample failed the [Resource Conservation and Recovery Act] RCRA ignitability test." | The information requested is presented in the Ventron Characterization Report, available directly from DOE or in the Administrative Record at the Beverly Public Library. Morton is responsible for the remediation of the chemical constituents in accordance with Massachusetts General Law, Chapter 21E. Chemical characterization data is presented by DOE in the Ventron Characterization Report and EE/CA for completeness. |



141533

| Responsiveness Summary for the Ventron Engineering Evaluation/Cost Analysis (EE/CA) Public Draft, February 1996 | | | |
|---|---|---|---|
| **Topic** | **Page(s)** | **Comment Summary** | **Response** |
| Cleanup criteria | ES-1, ES-2<br>2-1, 2-12<br>General | Explain the development of "DOE Guidelines" and how they compare with site-specific background. The cleanup level should be background instead of 50 picocuries per gram (pCi/g) and should consider other radionuclides (uranium-235 [U-235], americium-241 [Am-241], radium-226 [Ra-226]) and hazardous materials. | Section 2-1 includes a description of how the cleanup guidelines were established for the Ventron site. A summary of the applicable cleanup guidelines is shown in Table 2-1. These guidelines represent the amount of uranium, radium, or thorium (and their decay products) above the natural background levels that can be safely left in place (i.e., site-specific background concentrations are subtracted from the measured soil concentration, and the result is compared to the cleanup guideline). Generic limits have been established for allowable concentrations of radium and thorium in soil, whereas limits for uranium must be derived on a site-specific basis. The site-specific cleanup guideline derivation process includes consideration of the contributions from the major uranium isotopes (U-238, U-235, and U-234) expected to be present in uranium metal, as well as the decay products expected from uranium metal [such as protactinium-234 (Pa-234), Pa-234m, and thorium-234 (Th-234)]. The site-specific cleanup guideline derivation process does not include consideration of non-radioactive hazardous materials or other radionuclides such as Am-241, which are not associated with Manhattan Engineer District/Atomic Energy Commission (MED/AEC) activities conducted at the Ventron site, and which DOE has no authority to remediate. |
| | | Table 2-1 should include a comparison to DOE guidelines and site-specific background. | Site-specific background concentrations used in the EE/CA dose assessment include 0.84 pCi/g for Ra-226, 0.84 pCi/g for Th-232, 0.89 pCi/g for U-238, and 0.59 pCi/g for Th-230 (Table A-4).<br><br>Background concentrations are shown in Table A-4. |



141533

| Responsiveness Summary for the Ventron Engineering Evaluation/Cost Analysis (EE/CA) Public Draft, February 1996 | | | |
|---|---|---|---|
| **Topic** | **Page(s)** | **Comment Summary** | **Response** |
| Compliance with National Contingency Plan | 2-6, 2-10, 6-1 | Explain how the 1995 removal action was in compliance with the National Contingency Plan (NCP). Justify how DOE's proposed removal action satisfies the NCP, citing compliance with 40 *CFR* 300. Preliminary options should be compared with the nine criteria of the NCP. | Tidal work was conducted as time critical to protect Morton workers during Morton's removal activities. The public was informed about the activity by a newspaper announcement and establishment of the Administrative Record. In addition, local regulators were contacted and apprised of the work.<br><br>Remedial alternatives were evaluated with respect to effectiveness, implementability, and cost in accordance with EPA guidance for non-time critical removal actions under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (EPA/540-R-93/057). While these criteria are structured somewhat differently from the nine criteria described in the NCP, the considerations are functionally equivalent. The EE/CA is consistent with the EPA EE/CA guidance document and 40 *CFR* 300 requirements. |
| | | A written response to public comments is required for final selection of the cleanup option. | This Responsiveness Summary and the attachment of revised replacement pages (errata summary) are the written response to significant comments received during the public comment period and will precede release of the Action Memorandum. |

141533

| Responsiveness Summary for the Ventron Engineering Evaluation/Cost Analysis (EE/CA) Public Draft, February 1996 | | | |
|---|---|---|---|
| **Topic** | **Page(s)** | **Comment Summary** | **Response** |
| Consultation with Agencies | 1-2, 1-3 | The National Oceanic and Atmospheric Administration (NOAA) should be consulted regarding possible impacts to trustee resources (e.g., anadromous fish). | 40 CFR 135(k) allows for consultation with either Department of the Interior or NOAA. Both agencies were consulted. The relevant consultation for marine resources was made with the National Marine Fisheries Service, a component of NOAA; the response letter from the Habitat and Protected Resources Division was included in Appendix E of the EE/CA. |
| | | Please provide a copy of the consultation with the State Historic Preservation Office (SHPO) that was in progress at the time of publication of the EE/CA Public Draft. | A copy of the SHPO consultation letter has been included in the Administrative Record and the errata summary to be provided with this Responsiveness Summary. |



141533

| Responsiveness Summary for the Ventron Engineering Evaluation/Cost Analysis (EE/CA) Public Draft, February 1996 | | | |
|---|---|---|---|
| **Topic** | **Page(s)** | **Comment Summary** | **Response** |
| Risk Assessment | 1-1, 2-9, 4-1 | The risk assessment should include synergistic risks from both radionuclides and hazardous chemicals to human health and ecological receptors (marine life). | The dose assessment in the EE/CA is not intended as a comprehensive (or baseline) risk assessment, and thus it does not address chemical or potential synergistic (radiological and chemical) risks. The dose assessment presented in Appendix A of the EE/CA is used only to justify removal actions and to provide a basis for comparisons of removal alternatives. It is not used to establish cleanup guidelines. Cleanup guidelines are established on the basis of ARARs and a more comprehensive dose assessment as summarized in Section 2-1 of the EE/CA.<br><br>The dose assessment was developed using EPA guidance for streamlined risk evaluations as part of conducting non-time-critical removal actions under CERCLA (EPA/540-R-93-057). The intent of a streamlined risk evaluation is to provide justification for a removal action and to identify what current or potential exposures should be prevented. At the Ventron site, removal actions are sufficiently justified by addressing only the most important exposure pathways and contaminants of concern (i.e., direct gamma exposures from soil containing uranium, inhalation of dust containing uranium, and incidental ingestion of soil containing uranium). |
| | | Consumption of marine organisms should be included as a risk pathway. | Consumption of marine organisms was not considered in the dose assessment since no uranium was detected in the mussel and lobster samples collected during characterization sampling. This pathway is not expected to contribute significantly to potential doses compared with the soil ingestion, inhalation, and direct gamma pathways. |

141533

| Responsiveness Summary for the Ventron Engineering Evaluation/Cost Analysis (EE/CA) Public Draft, February 1996 | | | |
|---|---|---|---|
| **Topic** | **Page(s)** | **Comment Summary** | **Response** |
| Editorial Comments | 1-5<br>6-3 | Provide a "North" arrow on the location map. Change the location of Beverly from "150 miles" to "20 miles" northeast of Boston; change "New Brunswick" to "Beverly."<br><br>The name of the public library should be consistent with that on page 6-1. | An errata summary has been issued for the EE/CA, with the following changes:<br>Arrow added to map.<br><br>Page 6-3 has been corrected for consistency with page 1-1, which states that Beverly is approximately 24 km (15 mi) northeast of Boston.<br><br>The name of the Public Library has been corrected for consistency with page 6-1, which includes an address and telephone number. |
| ARARs | 1-3 | NOAA Trustee applicable or relevant and appropriate requirement (ARAR) was missing from the EE/CA. Incorporate information available in the "Superfund Removal Procedures: Guidance on the Consideration of ARARs During Removal Actions" (OSWER EPA/540/P-91/011, September 1991). | The authors are aware of the document, and the EE/CA ARARs are consistent with it. The NOAA Trustee ARAR was not missing; it is a CERCLA requirement and as such is not included in the ARARs, because CERCLA is not an ARAR for itself. However, the NOAA consultation response is included in Appendix E. |

141533

| Responsiveness Summary for the Ventron Engineering Evaluation/Cost Analysis (EE/CA) Public Draft, February 1996 | | | |
|---|---|---|---|
| **Topic** | **Page(s)** | **Comment Summary** | **Response** |
| Miscellaneous | ES-2 | Provide a discussion relative to the Massachusetts General Law, Chapter 21E. | DOE is responsible for cleanup of radioactive constituents associated with former MED/AEC operations. Requirements for cleanup of radioactivity are specified in DOE Order 5400.5. Massachusetts General Law, Chapter 21E applies to the cleanup of chemical constituents. Cleanup of chemical constituents regulated under Massachusetts General Law, Chapter 21E is being conducted separately by Morton. |
| | 2-8 | Discuss the relative integrity of the seawall. Could contaminated soils in contact with tidal fluctuations be eroded from underneath the sea wall into the harbor? | The integrity of the seawall will be evaluated during the remedial design. Migration of contaminated soils under the seawall will be monitored during remedial action. Sampling will be performed following the remedial action to ensure all soils and harbor sediment exceeding DOE guidelines have been removed or evaluate whether alternative limits may be warranted. |

141533

141533

# ATTACHMENT

# ERRATA SUMMARY

# ERRATA SUMMARY

141533

Page

EE/CA Cover
EE/CA Title Page

| | |
|---|---|
| vii | Acronyms and Abbreviations |
| 1-5 | Figure 1-1 |
| 6-3 | Sections 6.2.1.1 and 6.2.1.2 |

APPENDIX B

| | |
|---|---|
| iv | Table of Contents (continued) |
| B-8 | Section 1.3.6 |
| B-9 | Section 1.3.7 |
| B-20 | Additional ARAR |

APPENDIX E

| | |
|---|---|
| E-1 | NOAA Consultation Letter |
| E-6 | Commonwealth of Massachusetts Division of Fisheries and Wildlife Consultation Letter |
| E-7 | NHPA (Section 106) Determination Letter |

141053

Vol. 61 No. 56 Thursday, March 21, 1996 p 11621 (Notice) 1/107

Notice of Floodplain and Wetland Involvement for the Ventron Site, Essex County, Massachusetts

AGENCY: Former Sites Restoration Division, Department of Energy (DOE).

ACTION: Notice of floodplain and wetland involvement.

SUMMARY: DOE proposes to remediate sediment and soil containing elevated levels of uranium-238 from a floodplain and wetland, a floodplain and wetland buffer zone, and from the Massachusetts coastal zone in Essex County, Massachusetts. In accordance with 10 CFR 1022, DOE has prepared a floodplain and wetlands assessment and will perform this proposed action in a manner so as to avoid or minimize potential harm to or within the affected floodplain and wetland resources.

DATES: Comments are due to the address below no later than April 5, 1996.

FOR FURTHER INFORMATION ON THIS PROPOSED ACTION OR TO COMMENT ON THE ACTION, CONTACT: Mr. Jim Kopotic, Ventron Site Manager, Former Sites Restoration Division, U.S. Department of Energy, P.O. Box 2001, Oak Ridge, TN 37831-8541, Phone: (423) 576-9441, FAX: (423) 576-0956.

FOR FURTHER INFORMATION ON GENERAL DOE FLOODPLAIN/WETLANDS ENVIRONMENTAL REVIEW REQUIREMENTS, CONTACT: Carol Borgstrom, Director, Office of NEPA Oversight, EH-42, U.S. Department of Energy, 1000 Independence Avenue, SW., Washington, DC 20585, (202) 586-4600 or (800) 472-2756.

SUPPLEMENTARY INFORMATION: Ventron is a privately-owned site that processed natural uranium oxide, salts, and metal between 1942 and 1948 for the Manhattan Engineer District (MED) and later for the Atomic Energy Commission (AEC). No enriched or depleted uranium was used at the site. Prior to and subsequent to MED- and AEC-related activities at the site, other radioactive elements including thorium compounds and hazardous chemicals were processed at the Ventron site in work unrelated to MED, AEC, or DOE contracts. DOE has authority at the site for remediation of media containing elevated levels of natural uranium (uranium-238). DOE is remediating the

---- page 11622 ----

Ventron site in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The Ventron site is currently an inactive facility and is being cleaned up by the current owner, Morton International, in a separate but related action.

Risks from exposure to radioactive materials at the Ventron site for future workers and residents at the site exceed DOE's public dose limit (100 mrem/yr), thereby meeting DOE's criteria for conducting removal actions to prevent potential future exposures

o nearby humans under the no-action alternative. Although sediment nd soil with elevated levels of uranium-238 at the Ventron ite pose no immediate threats to human or ecological health, he remediation of the site could proceed to prevent radiation xposure to workers involved in Morton's remedial activities.

The implementation of the remedial action alternatives at he Ventron site would involve activity in a floodplain and tidal wetland, a floodplain and wetland buffer zone, and the lassachusetts coastal zone. In accordance with DOE regulations or compliance with floodplain and wetlands environmental review equirements (10 CFR 1022), DOE will prepare a floodplain and etland assessment for this proposed DOE action. DOE will evaluate emedial options affecting two media at the site: harbor sediment nd on-site soil and furnace ash. Remedial action for the affected arbor sediment may include: no action, or complete removal f sediment containing uranium levels above DOE guidelines. emedial action for on-site soil and furnace ash may include: o action or, complete removal of soil and furnace ash containing ranium levels above DOE guidelines. Access to affected sediment nd soil may require decontamination and demolition of structures in the floodplain and wetland buffer zone and Massachusetts oastal zone. DOE would temporarily store excavated material nsite before transport offsite to an approved, licensed waste isposal facility. A floodplain and wetlands assessment that incorporates the values of the National Environmental Policy Act will be included in the engineering evaluation and cost analysis being prepared for the proposed project. Upon completion and approval of the assessment DOE will publish a floodplain Statement of Findings in the Federal Register that describes the proposed action and measures DOE would implement to prevent environmental damage to floodplain resources at the Ventron site.

Issued in Oak Ridge, Tennessee on March 8, 1996.

James L. Elmore,
Alternate NEPA Compliance Officer.

[FR Doc. 96-6838 Filed 3-20-96; 8:45 am]
BILLING CODE 6450-01-P

---

The Contents entry for this article reads as follows:

Floodplain and wetlands protection; environmental review determinations; availability, etc.:
Ventron Site, MA, 11621

Vol. 61 No. 100 Wednesday, May 22, 1996 p 25656 (Notice) 143177



# Floodplain Statement of Findings for Remedial Action at the Ventron Site and Adjacent Harbor Sediment in Essex County, Massachusetts

AGENCY: Former Sites Restoration Division, Department of Energy (DOE).

SUBJECT: Floodplain statement of findings.

SUMMARY: This is a Floodplain Statement of Findings prepared in accordance with 10 CFR Part 1022, Compliance with Floodplain/Wetlands Environmental Review Requirements. DOE proposes to remediate sediment and soil with elevated levels of uranium-238 from the 100-year floodplain of the Bass and Danvers Rivers and from the floodplain buffer zone adjacent to the 100-year floodplain at the Ventron site in Essex County, Massachusetts. DOE prepared a Floodplain and Wetlands Assessment describing the effects, alternatives, and measures designed to avoid or minimize potential harm to or within the affected floodplain. DOE would endeavor to allow 15 days of public review after publication of the Statement of Findings before implementation of the proposed action.

FOR FURTHER INFORMATION ON THIS PROPOSED ACTION OR TO COMMENT ON THE ACTION, CONTACT: Mr. Jim Kopotic, Ventron Site Manager, Former Sites Restoration Division, U.S. Department of Energy, P.O. Box 2001, Oak Ridge, TN 37831-8541, Phone: (423) 576-4991, FAX: (423) 576-0956.

FOR FURTHER INFORMATION ON GENERAL DOE FLOODPLAIN AND WETLANDS ENVIRONMENTAL REVIEW REQUIREMENTS, CONTACT: Carol M. Borgstrom, Director, Office of NEPA Oversight, EH-42, U.S. Department of Energy, 1000 Independence Avenue SW., Washington, DC 20585, (202) 586-4600 or (800) 472-2756.

SUPPLEMENTARY INFORMATION: This is a Floodplain Statement of Findings prepared in accordance with 10 CFR Part 1022. A Notice of Floodplain and Wetland Involvement was published in the Federal Register (Vol. 61, pp. 11621-11622) on March 21, 1996, and a Floodplain and Wetlands Assessment was incorporated in the engineering evaluation and cost analysis prepared for the Ventron site. DOE proposes to remediate sediment and soil with elevated levels of uranium-238 that are located in the 100-year floodplain of the Bass and Danvers Rivers and the 100-yr floodplain buffer zone adjacent to the floodplain at the Ventron site in Essex County, Massachusetts. The entire Ventron site is also within the Massachusetts coastal zone. The proposed action would be in a floodplain because levels of uranium-238 in some sediment and soil in the floodplain at the site exceed guidelines for residual radioactivity and future use without radiological restrictions of the site. DOE has structured potential cleanup options by affected media: harbor sediments and on-site soil and furnace ash. Alternative actions considered for harbor sediments are no action or, complete removal of harbor sediment with levels of uranium-238 over 50 pCi/g. Alternative actions considered for on-site soil and furnace ash also include no action or, complete removal of on-site soil and furnace ash with levels of uranium-238 over 50 pCi/g. Access to sediment and soil may

require decontamination and demolition of structures at the site. There is no practicable alternative to the proposed action. The proposed action would conform to applicable state and local floodplain protection standards.

The following steps would be taken to minimize potential harm to or within the affected floodplain:

1. The design and performance of excavation activities would incorporate standard best management practices in accordance with U.S. Department of Agriculture Natural Resource Conservation Service (formerly the Soil Conservation Service) methods, or the equivalent, to control erosion and siltation from excavations.
2. Remediation operations would confine the areas of sediment and soil disturbance to the minimum necessary for successful completion of the project.
3. Care would be exercised to provide minimum practicable exposure of sediment and soil to erosion.
4. All erosion and sediment barriers would remain in place until the excavation is successfully stabilized by applicable measures.
5. Disturbed sediment and soil in or adjacent to the floodplain, waterways, wetlands, coastal zone, and areas subject to tidal action and excavations would be stabilized or otherwise protected to prevent off-site migration, as conditions warrant, in accordance with Massachusetts soil erosion and sediment control standards or their equivalent.
6. DOE would not dispose waste rubble, sediment, or soil in the floodway or within the tidal zone. Waste mulch not serving to control erosion or sediment would also not be disposed of in channels or on waterway banks.
7. Remediation would not obstruct any streams or tidal areas and all streams and tidal zones would retain their original capacity for storing floodwaters. The proposed action would not impede flow or increase flooding.
8. All areas excavated in or adjacent to the floodplain, wetlands, the Massachusetts coastal zone, and areas subject to tidal action would be restored to grade by the current owner, Morton International, as required, and the proposed activities would not subject lives or property to any increased risk of flooding.
9. DOE would not use areas within the floodplain for temporary or permanent storage of excavated sediment, soil, or demolition rubble; however, some areas within the floodplain and wetland buffer zone, and the Massachusetts coastal zone may be used for temporary storage of excavated materials with appropriate measures in place to properly contain excavated materials.
10. The proposed action would conform to applicable state and local floodplain, wetland, and coastal zone protection standards and would be consistent with Massachusetts' coastal zone management policies.
11. The proposed action would not result in the destruction of any floodplain or wetland and would be consistent with the President's policy of ``no net loss'' of wetlands in the United States and Executive Orders 11988 and 11990.

DOE will endeavor to allow 15 days of public review after publication of the Statement of Findings before implementation of the proposed action.

143177

Issued in Oak Ridge, Tennessee on May 6, 1996.

James L. Elmore,
Alternate NEPA Compliance Officer.

[FR Doc. 96-12825 Filed 5-21-96; 8:45 am]
BILLING CODE 6450-01-P

---

The Contents entry for this article reads as follows:

Floodplain and wetlands protection; environmental review determinations; availability, etc.:
Ventron Site, MA, 25656

142126

96-237

**Department of Energy**

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831— 8723

May 9, 1996

James J. Fuerholzer
President, Morton Adhesives and Chemical Specialties
Morton International, Inc.
100 North Riverside Plaza
Chicago, Illinois 60606-1598

Dear Mr. Fuerholzer:

**VENTRON SITE - MEMORANDUM OF AGREEMENT**

Enclosed is the final signed Memorandum of Agreement (MOA) supporting upcoming remediation activities at the Ventron Site. I appreciate you and your staff's efforts in developing this mutually beneficial document which also supports the acceleration of the Department of Energy's (DOE) planned remediation activities at the site. DOE is currently planning on mobilizing to the site by mid-June 1996, following Morton's completion of the building demolition effort, with a planned completion in Fall 1996.

On March 27, 1996, a meeting was held at the site with state personnel to tour the site and discuss planned remediation activities. Representatives included Morton International, Massachusetts Departments of Environmental Protection and Radiation Control, and DOE. State personnel were in agreement with the planned remediation approach, but requested additional monitoring which DOE agreed to do.

Again, I appreciate Morton's efforts in helping to develop the MOA, and I look forward to working with your staff toward the successful remediation of the site. It has been a pleasure working with Alicia Raddatz of your staff, and I will continue to coordinate all aspects of DOE's remediation activities at the site with her. Because the MOA addresses joint DOE and Morton responsibilities, I want to stress the importance of close coordination between Morton and DOE to ensure we keep State and Federal officials/agencies, public, and other stakeholders accurately informed of our activities and progress at the site.

If you have any questions regarding the MOA or DOE's remediation plans at the site I can be reach at (423) 576-9441.

Sincerely,

James Kopotic

James D. Kopotic, Site Manager
Former Sites Restoration Division

Enclosure

cc w/enclosure:
A. S. Johnson, EM-421, CL

142126 ~~148458~~

# MEMORANDUM OF AGREEMENT

MORTON INTERNATIONAL, INC. (the "Owner") owns certain real property located in Beverly, Massachusetts, identified as Parcel No. 1 shown on City of Beverly Property No. 1 and filed in Deed Book 10091, page 339 in the records of Essex County, Massachusetts, and shown on the attached Exhibit 1 (the "Premises").

The Department of Energy (the "DOE") is conducting remedial action at sites, including the Premises, used by contractors and/or subcontractors to the Manhattan Engineer District and the Atomic Energy Commission, as part of the Formerly Utilized Sites Remedial Action Program ("FUSRAP").

DOE has previously defined the extent of contamination of the Premises. The following is an agreement reached between the parties of some of the actions to be undertaken by the parties in order that the remediation of the Premises can be accomplished:

1. The Owner will demolish and remove at its expense Buildings B and C (as shown in Exhibit 1) and any equipment located therein, and disconnect power service to the buildings and remove associated service lines and poles. These buildings are not contaminated with radioactive materials. However, the soils underneath Buildings B and C are contaminated, and the DOE will remediate radioactively contaminated soil. The Owner expects that the demolition and removal of Buildings B and C will be completed by the end of May 1996. DOE expects to initiate soil remediation activities within 4 weeks after Buildings B and C have been demolished and removed.

2. As necessary, DOE will decontaminate radioactive interior portions of Buildings A, A-1, and J (former Alfa Laboratory, as shown in Exhibit 1) and any radioactive equipment located therein. Upon completion of such decontamination the Owner will demolish and remove Buildings A, A-1, J and the equipment located therein. After Buildings A, A-1, and J have been demolished and removed, DOE will initiate remediation of radioactive soils beneath or surrounding Buildings A, A-1, and J. DOE will dispose of radioactive residues resulting from the decontamination of Buildings A, A-1, and J.

3. Any buildings to be demolished by the Owner will be taken down to the basement floor slab, including any support structures. DOE will have

responsibility for decontaminating (or otherwise remediating) the radiological component of building foundations and subsurface utilities and structures and for disposing of any such foundations and subsurface utilities and structures that remain radioactive above the clean-up criteria agreed to by DOE and the Commonwealth of Massachusetts Departments of Environmental Protection and Public Health, Radiation Control Program (hereinafter "clean-up criteria"). DOE will remove any building foundations and subsurface utilities or structures that it needs in order to get to radioactive contamination. If such removed foundations and subsurface utilities and structures are not radioactive contaminated above clean-up criteria their ultimate disposition will be the responsibility of the Owner.

4. DOE will be responsible for the remediation, decontamination, and disposition of radiological contamination above clean-up criteria and any non-radiological contaminants that are mixed with such radiological contamination, whether located in or under Buildings A, A-1, B, C, or J, or elsewhere on the Premises.

5. DOE's responsibilities under this agreement will be limited to remediation, decontamination, and disposition of radiological contamination above clean-up criteria and any non-radiological contaminants that are mixed with such radiological contamination, and the owner will be responsible for the disposition of any materials remediated or decontaminated in accordance with the clean-up criteria.

6. Upon completion of the work by DOE, the Owner will, where necessary, backfill, grade and seed the site. DOE expects to notify the Owner in writing, based on existing data, that the Premises meet applicable cleanup criteria, within 6 months of completion of the remediation work,

7. DOE expects to begin its remediation activities in May 1996 with a tentative remediation time of 6 to 8 months. DOE expects to provide a copy of the Post Remedial Action Report to the Owner within 18 months after completion of all remediation activities.

8. The Owner has appointed Alicia Raddatz as the person on site to be contacted by the DOE for matters pertaining to the remediation work. The DOE has appointed Jim Kopotic as the person to be contacted by the Owner and its contractors for matters pertaining to the remediation work.

9. Obligations of the DOE under this agreement are subject to the Anti-Deficiency Act, 31 USC Section 1341, as amended, and to the availability of funds appropriated by Congress which DOE may legally spend for such purposes and nothing in this agreement implies that Congress shall appropriate such funds.

10. Access to the Premises and the work to be performed by the DOE and/or its contractors is governed by Real Estate License No. 7-95-0160, as amended, signed by the Owner on 3/20/96.

11. Each party reserves the right to renegotiate this Agreement in the event of significant changes in scope, cost, or discovery of unknown factors. If the Parties, in good faith, are unable to agree to revisions of this Agreement in order to address such events, either Party may terminate this Agreement, by providing 30 days prior written notice to the other Party.

12. DOE's responsibilities under this agreement shall terminate when DOE issues the Federal Register notice and certification docket for the Premises.

The parties hereto have executed the Memorandum of Agreement this 18th of MARCH, 1996.

THE UNITED STATES OF AMERICA
By: DEPARTMENT OF ENERGY

By: Peter K. Preuss

Title: Director, Former Sites Restoration Div.

MORTON INTERNATIONAL, INC.

By: James Rushlow

Title: Group Vice President

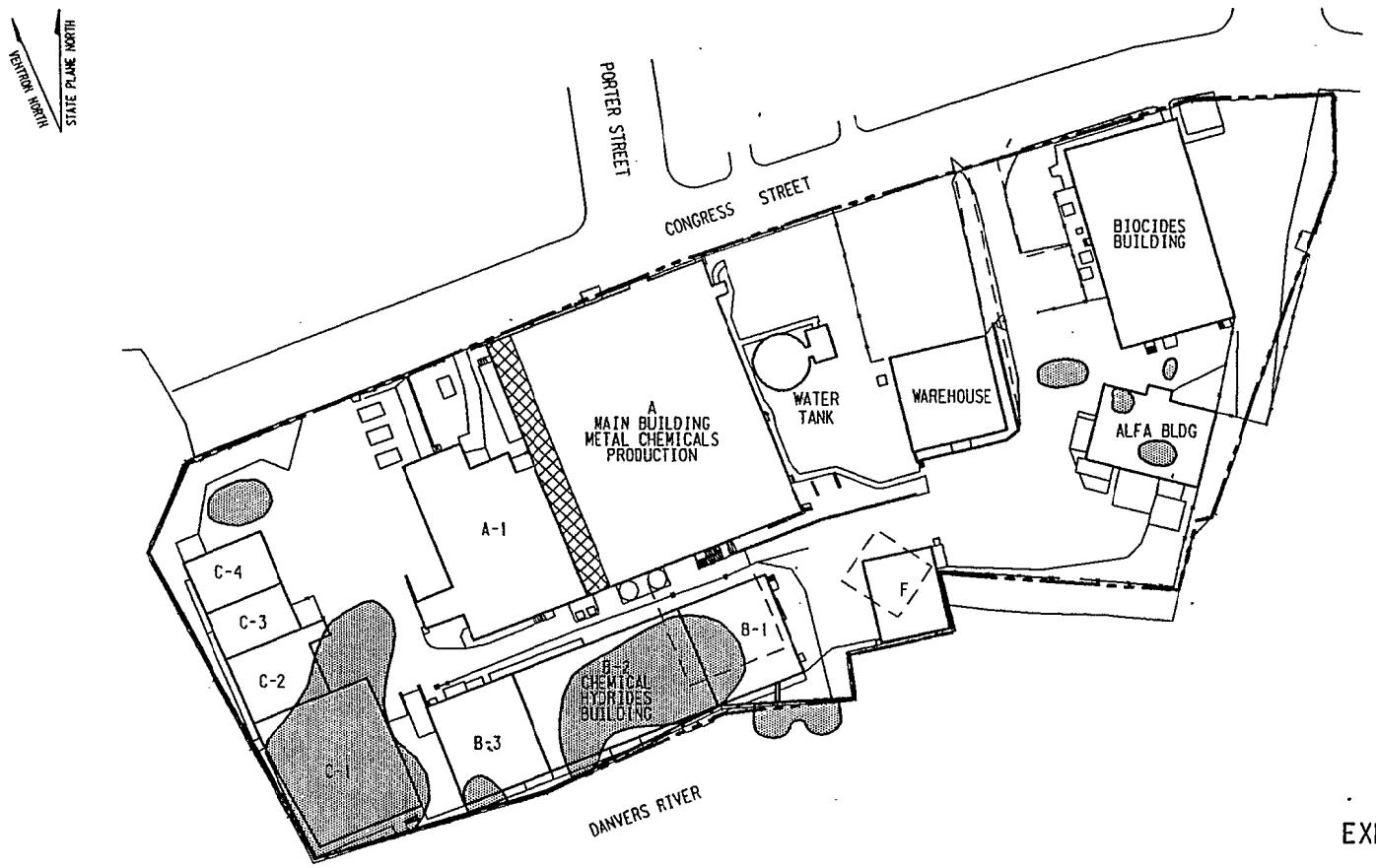



EXHIBIT 1

- TUNNEL AREA
- RADIOLOGICAL CONTAMINATION
- BUILDING
- FENCE
- SITE BOUNDARY
- SITES OF FORMER FOUNDRY FACILITIES DEMOLISHED BETWEEN 1948 AND 1950

SCALE

0 50 100 FEET

0 15 30 METERS

142126

142126

96-237

# Department of Energy

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831— 8723

May 9, 1996

James J. Fuerholzer
President, Morton Adhesives and Chemical Specialties
Morton International, Inc.
100 North Riverside Plaza
Chicago, Illinois 60606-1598

Dear Mr. Fuerholzer:

**VENTRON SITE - MEMORANDUM OF AGREEMENT**

Enclosed is the final signed Memorandum of Agreement (MOA) supporting upcoming remediation activities at the Ventron Site. I appreciate you and your staff's efforts in developing this mutually beneficial document which also supports the acceleration of the Department of Energy's (DOE) planned remediation activities at the site. DOE is currently planning on mobilizing to the site by mid-June 1996, following Morton's completion of the building demolition effort, with a planned completion in Fall 1996.

On March 27, 1996, a meeting was held at the site with state personnel to tour the site and discuss planned remediation activities. Representatives included Morton International, Massachusetts Departments of Environmental Protection and Radiation Control, and DOE. State personnel were in agreement with the planned remediation approach, but requested additional monitoring which DOE agreed to do.

Again, I appreciate Morton's efforts in helping to develop the MOA, and I look forward to working with your staff toward the successful remediation of the site. It has been a pleasure working with Alicia Raddatz of your staff, and I will continue to coordinate all aspects of DOE's remediation activities at the site with her. Because the MOA addresses joint DOE and Morton responsibilities, I want to stress the importance of close coordination between Morton and DOE to ensure we keep State and Federal officials/agencies, public, and other stakeholders accurately informed of our activities and progress at the site.

If you have any questions regarding the MOA or DOE's remediation plans at the site I can be reach at (423) 576-9441.

Sincerely,

James Kopotic

James D. Kopotic, Site Manager
Former Sites Restoration Division

Enclosure

cc w/enclosure:
A. S. Johnson, EM-421, CL

EW-93:Jim Kopotic:6-9941:MDyke:6-4452:5/9/96
N:/JDK/Fuerholzer.MOA

CONCURRENCES

| RTG SYMBOL | INITIALS/SIG. | DATE |
|---|---|---|
| CC-10 | Miskelly | |
| EW-93 | Kopotic JDK | 5-9-96 |
| EW-93 | Seay WS | 5/9/96 |
| EW-93 | Price WS for | 5/9/96 |
| | | |
| | | |
| | | |
| | | |
| | | |

133599

**Department of Energy**

Oak Ridge Operations
P.O. Box 2001
Oak Ridge, Tennessee 37831—

August 24, 1995

James J. Fuerholzer
Executive Vice President
Morton International, Inc.
100 North Riverside Plaza
Chicago, Illinois 60606

Dear Mr. Fuerholzer:

**REAL ESTATE LICENSE REORDOER-7-95-0160, METAL HYDRIDES, INC. (VENTRON CORP.), BEVERLY, MA**

Enclosed for your records is a copy of the fully executed license between Morton International, Inc. and the Department of Energy. Thank you for your cooperation in this matter. If you have any questions concerning the real estate instrument, please feel free to contact me at 615-576-0977 or Cindy Hunter at 615-576-4431.

Sincerely,

Katy Kates

Katy Kates
Realty Officer

Enclosure
As stated

cc: Sally Haywood, Bechtel FUSRAP

133599

REAL ESTATE LICENSE NO.
REORDOER-7- 95-0160

# DEPARTMENT OF ENERGY

## LICENSE

**PROJECT:** METAL HYDRIDES, INC. (VENTRON CORP.), BEVERLY, MA
**PURPOSE:** SAMPLING, REMEDIAL ACTION

THIS LICENSE, between Morton, International, Inc. _____, known as the "Grantor" and the U.S. Department of Energy, known as the "Grantee", is subject to the following terms and conditions.

1. Rights Granted - The Grantor grants to the Grantee, its agents, employees, or representatives permission to use the premises or facilities, together with ingress and egress, for the purpose of performing radiological surveys through sampling and removing contaminated material, if any _____ at the location shown depicted on Exhibit(s) "A" attached to this instrument and more specifically identified in whole or in part as Parcel No.(s) 1 shown on City of Beverly Property Map No. 1, and filed in Deed Book 10091, Page 339 in the records of Essex County, Massachusetts.

2. Term/Termination Rights - This License is effective upon the date of execution by the Grantee of this instrument and shall continue in effect for a period of/thru five (5) years unless terminated by either of the parties on not less than thirty (30) days prior written notice given to the other; provided, however, that the Grantor may not terminate this License without the Grantee's approval.

3. Consideration - Upon execution of this License by the Grantee, the Grantee shall initiate action to pay to the Grantor the sum of $_____ ($_____) as full and complete payment for the rights granted within this License.

DELETE

4. Authority to License - The Grantor represents and warrants that it is the owner of the property and has full right, power, and authority to enter into this License and grant the rights set out in this License.

5. Grantor Responsibility - The Grantor responsibility is set out within the terms and conditions of the rights granted under this License. The Grantor makes no representation as to the suitability or fitness of the premises for the intended purpose.

6. Grantee Responsibility - The Grantee, its agents, employees, or representatives will be responsible for property damage or injury to persons caused by the sole and direct negligence of their respective employees in performing on the Grantor's premises the activities and restoration which are the subject of this License. Grantee shall obtain all necessary permits, licenses, and approvals in connection with the activities to be conducted by the Grantee on the premises. During the performance of the activities specified in this License, the Grantee shall not unreasonably interfere with the use and enjoyment of the premises by the Grantor.

7. Access - During the term of this License, the Grantee, its agents, employees, or representatives shall have the right of access to and egress from the premises as needed and shall have the right to bring necessary equipment upon the premises in connection with the performance of the Grantee's activities as set out in Condition 1.

8. Title to Equipment, Fixtures - Title to all equipment, fixtures, appurtenances, and other improvements furnished and installed in connection with the Grantee's activities under this License shall remain with the Grantee.

9. Restoration - Upon termination of this License, the Grantee shall remove all its equipment, fixtures, appurtenances, and other improvements furnished and installed on the premises in connection with the Grantee's activities under this License. The Grantee shall restore the premises, when such restoration is required in connection with the Grantee's activities, to the extent reasonably practical, to the condition existing at the time of initiation of the Grantee's activities. With the consent of the Grantor, the Grantee may abandon Grantee-owned equipment, fixtures, appurtenances, and other improvements in place in lieu of restoration when it is in the best interests of the Grantee.

10. Successors in Interest - This License and the parties' commitments within, shall be binding on both parties, their successors, and assigns.

11. Funding - Obligations of the Grantee under this License shall be subject to the availability of funds appropriated by the Congress which the Grantee may legally spend for such purposes and nothing in this License implies that Congress will appropriate funds to perform this License.

12. Notices - All notices regarding the specific terms and conditions of this License, and within the restrictions of this License, shall be in writing and shall be deemed effectively given upon personal delivery, upon verified facsimile receipt, or upon mailing by registered or certified mail, postage prepaid, and addressed to the parties at the following respective addresses, or to such other persons or at such other addresses as may be designated in writing by either party to the other.

| If to the Grantee: | If to the Grantor: |
|---|---|
| Katy Kates<br>Realty Officer<br>Department of Energy<br>P.O. Box 2001<br>Oak Ridge, Tennessee 37831 | James J. Fuerholzer<br>~~Executive~~ Vice-President<br>Morton International, Inc.<br>~~10-12 Congress Street~~ 100 N. Riverside Plaza<br>~~Beverly, Massachusetts 01915~~ Chicago, IL 60606 |

13. Entire Agreement - This License represents the entire understanding of the parties on this matter and no oral statements or collateral documents (except as noted within) may modify this License.

14. Amendment - This License may not be amended or superseded except by an agreement in writing executed by the Grantor and Grantee.

That prior to execution of this License certain Conditions were deleted, revised, and/or added (with the additions being as set out below or as designated as Page(s) N/A and being made a part of this License) in the following manner:

Condition No. 3 is deleted in its entirety.

REAL ESTATE LICENSE NO.
REORDOER-7-95-0160

The above terms and conditions are acknowledged and agreed upon as indicated by the signatures affixed below:

| | | | |
|---|---|---|---|
| GRANTOR: | Morton International, Inc. | GRANTEE: | U.S. Department of Energy |
| By: | [signature] | By: | Katy Katas<br>DOE Real Estate Office |
| Title: | V.P. DOE - Pres. Dev't | Title: | Realty Officer |
| Date: | August 22, 1995 | Date: | 8-24-95 |

141131

**Bechtel**

Oak Ridge Corporate Center
151 Lafayette Drive
P.O. Box 350
Oak Ridge, Tennessee 37831-0350

Telephone: (423) 220-2000

DOE Contract No. DE-AC05-91OR21949
Code: 2600/WBS: 127
Job No. 14501 FUSRAP Project

April 15, 1996

James J. Fuerholzer
Executive Vice President
Morton International, Inc.
100 North Riverside Plaza
Chicago, Illinois 60606

Dear Mr. Fuerholzer:

**Supplemental Agreement to Real Estate License - REORDOER-7-95-0160**

Enclosed for your records is the fully executed supplemental agreement between Morton International, Inc. and the Department of Energy. If you have any questions concerning the supplemental agreement, please call me at (423) 576-5914 or Cindy Hunter, DOE Realty Officer, at (423) 576-4431.

Sincerely,

Doug Shook

Doug Shook
FUSRAP Real Estate Specialist

Enclosure
Supplemental Agreement

141131 ~~148458~~

# SUPPLEMENTAL AGREEMENT OF INGRANT

SUPPLEMENTAL AGREEMENT NO. 1 EFFECTIVE DATE 8-24-95

TYPE OF GRANT LICENSE GRANT NUMBER REORDOER-7-95-0160

GRANTOR MORTON INTERNATIONAL, INC. GRANTEE U.S. DEPARTMENT OF ENERGY

PROJECT FUSRAP - VENTRON, BEVERLY, MA PURPOSE SAMPLING, REMEDIAL ACTION

The above numbered grant is modified in the following respects:

In Condition No. 1 delete the words: "performing radiological surveys through sampling and removing contaminated material, if any" and substitute in lieu thereof: "performing the activities set forth in the Memorandum of Agreement, attached hereto as Exhibit "B", and incorporated by reference herein."

In Condition No. 9 delete the second sentence: "The Grantee shall restore the premises, when such restoration is required in connection with the Grantee's activities, to the extent reasonably practical, to the condition existing at the time of initiation of the Grantee's activities."

Except as provided herein, all terms and conditions of the document referred to above remain unchanged and in full force and effect.

The above terms and conditions are acknowledged and agreed upon as indicated by the signatures affixed below:

GRANTOR: Morton International, Inc.

By: James J. Fuerholzer

Title: Vice President

Date: March 20, 1996

GRANTEE: U.S. Department of Energy

By: Cindy B. Hunter
DOE Real Estate Office

Title: Realty Officer

Date: 4-17-96

DOE-RE FORM 70-GN (10-31-94)

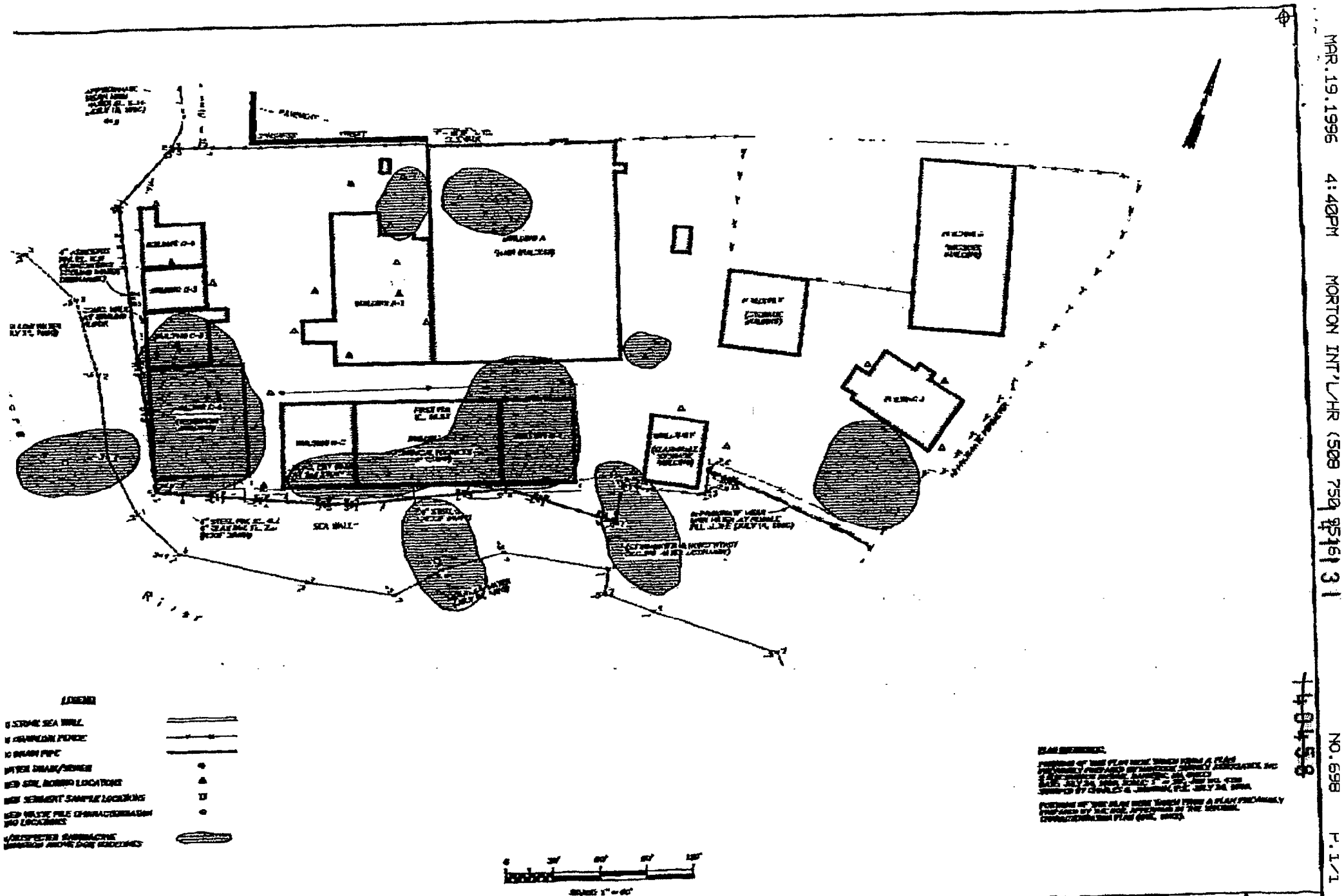



Figure 4-1
DOE, FUSRAP Site Plan Showing Proposed Locations for Chemical and Radiological Analysis

Morton International Inc.
Beverly, Massachusetts

WARNING OF DOCUMENTS

R. van Hoort
J. Rendall
A. Isaline

144008

WORK INSTRUCTION (WI) FUSRAP - JOB NO. 14501 WI-96-128 REV. 0

SHEET 1 of 2

WI TITLE: FUSRAP PRASP Implementation for the Ventron Site

EXPECTED COMPLETION DATE: September 30, 1996

SITE NAME(S) Ventron SITE WBS NO. 127

ORIGINATING DEPARTMENT: Engineering and Technology

IMPLEMENTING DEPARTMENT: Engineering and Technology / Melissa Kucera

WORK DESCRIPTION AND INSTRUCTIONS:

## 1.0 SCOPE

The work involves the implementation of the FUSRAP PRASP (attached) for the Ventron Site with additional site specific information as outlined in this WI.

## 2.0 PPE/TRAINING

The safety and health of the field personnel will be addressed by the FUSRAP project Safety and Health procedures manual and all work will be performed within the requirements of the Ventron site specific Safety and Health Plan. All personnel must have OSHA 40-hour hazardous worker training and a current medical exam approved by POMS. A Hazardous Work Permit (HWP) will be completed listing the PPE requirements for the work and listing any hazards associated with the work. Workers will be briefed on HWP contents prior to starting work.

SUPERSEDES: ATTACHED: ____ QAA, ✓ QAA NEED EVALUATION

CONCURRENCE/OPTIONAL -- PE OR DEPT MGR. TO DETERMINE

DEPARTMENT/NAME W.J.

S&H/ Elizabeth Alley

DEPARTMENT/NAME

DEPARTMENT/NAME

Tim Kiy

ORIGINATOR

Melissa A Kucera

TEAM LEAD OR GROUP SUPERVISOR

APPROVED BY: _____

PE OR DEPT. MGR.

NOTE: A DOCUMENT ISSUE MEMORANDUM IS REQUIRED TO IMPLEMENT THIS WI.

CLOSE-OUT (IMPLEMENTING DEPT.)

THE TASK HAS BEEN COMPLETED PER THIS WORK INSTRUCTION.

IMPLEMENTOR (NAME/POSITION): _____ DATE: _____

PE OR DEPT MGR.: _____ DATE: _____

144008

WORK INSTRUCTION (WI) FUSRAP - JOB NO. 14501 WI-96-128 REV. 0
SHEET 1 of 2

WI TITLE: FUSRAP PRASP Implementation for the Ventron Site

EXPECTED COMPLETION DATE: September 30, 1996

SITE NAME(S) Ventron SITE WBS NO. 127

ORIGINATING DEPARTMENT: Engineering and Technology

IMPLEMENTING DEPARTMENT: Engineering and Technology / Melissa Kucera

WORK DESCRIPTION AND INSTRUCTIONS:

## 1.0 SCOPE

The work involves the implementation of the FUSRAP PRASP (attached) for the Ventron Site with additional site specific information as outlined in this WI.

## 2.0 PPE/TRAINING

The safety and health of the field personnel will be addressed by the FUSRAP project Safety and Health procedures manual and all work will be performed within the requirements of the Ventron site specific Safety and Health Plan. All personnel must have OSHA 40-hour hazardous worker training and a current medical exam approved by POMS. A Hazardous Work Permit (HWP) will be completed listing the PPE requirements for the work and listing any hazards associated with the work. Workers will be briefed on HWP contents prior to starting work.

SUPERSEDES: ATTACHED: ____ QAA, ✓ QAA NEED EVALUATION

CONCURRENCE/OPTIONAL - PE OR DEPT MGR. TO DETERMINE

DEPARTMENT/NAME

S&H / Elizabeth Alley

DEPARTMENT/NAME

DEPARTMENT/NAME

Tim Kay
ORIGINATOR

Melissa A. Kucera
TEAM LEAD OR GROUP SUPERVISOR

APPROVED BY: [signature]
PE OR DEPT. MGR.

NOTE: A DOCUMENT ISSUE MEMORANDUM IS REQUIRED TO IMPLEMENT THIS WI.

CLOSE-OUT (IMPLEMENTING DEPT.)

THE TASK HAS BEEN COMPLETED PER THIS WORK INSTRUCTION.

IMPLEMENTOR (NAME/POSITION): _____ DATE: _____

PE OR DEPT MGR.: _____ DATE: _____

## 3.0 Site Specific Criteria

The site specific guideline for total uranium is 100 pCi/g. Post remedial action sampling will only be performed in areas where excavation has occurred.

## 4.0 Site Specific Sampling Procedures

### 4.1 Sampling at the Base of the Seawall

Due to excavation restrictions imposed during removal of soil near the seawall to prevent a major wall failure the areas to be verified will be smaller than the normal 100 $m^2$. Normal verification sampling calls for 25 evenly-spaced samples per 100 $m^2$ to be composited into one sample. For areas less than 100 $m^2$, the number of samples for each composite will be reduced proportionally to the reduction in area. During the verification sampling that occurs within 10 feet of the seawall, the composite sample shall be generated at the proportionally reduced ratio equivalent to 25 samples per 100 $m^2$ or a minimum of 4 samples per area composited into one sample, whichever is greater. For example, if the area to be sampled is only 4 $m^2$ only one sample would be required to be collected according to the ratio of 25 samples per 100 $m^2$. In this instance, a minimum of 4 samples shall be composited for the verification sample rather than only 1 sample.

All sampling within 10 feet of the seawall shall be performed remotely utilizing orchard augers with extension handles. Field survey equipment shall be equipped with cables sufficient in length to allow surveying of the excavated areas without personnel having to enter the area.

### 4.2 Seawall Surface Measurements

In the instance where surface contamination is found on the landside face of the seawall, direct and transferable survey measurements shall be taken to assist in the development of a hazard assessment. Instruments used for these surveys will also have to be equipped with cables sufficient in length to allow surveying of the areas without personnel entering the area. The number of measurements will depend on the contaminated surface area and shall be directed by the onsite ET representative or the home office.

### 4.3 Sampling of Soil submerged in water

In areas where the remediated areas are submerged in water, sampling and field scanning will be performed on the soil in the bucket as it is excavated. This scenario is only expected to occur in two very small locations at the site.

## 5.0 Miscellaneous Information

All sampling equipment shall be decontaminated according to Instruction Guide 191-IG-011, Rev. 5. All samples shall be packaged and shipped in accordance with PI R4.7.

A list of D numbers from the data generated will be attached to the closed WI.

144008

# FUSRAP POST-REMEDIAL ACTION SURVEY PLAN

WI-96-128

## PURPOSE

The purpose of this plan is to describe the methodologies that Bechtel, functioning as the project management contractor (PMC) for the Department of Energy's (DOE's) Formerly Utilized Sites Remedial Action Program (FUSRAP), will use for radiological surveys, sampling, and analysis to document the final condition of remediated properties as free of radioactive contamination above the release standards in DOE Order 5400.5 (reference 1). Where radioactive contaminants are commingled with chemical contaminants, and where chemical contaminants are the result of former DOE activities, the remediation will include remediation of the chemical contaminants. Criteria for chemical contaminant remediation, when appropriate, will be negotiated with the DOE, EPA, and appropriate state agencies on a site specific basis following the DOE guidelines for chemically contaminated sites (reference 2).

Nothing herein is intended to compromise the Independent Verification Contractor's (IVC) independence; the purpose is to document the methodology the PMC will employ to direct its radiological support subcontractor (RSS) to conduct post-remedial action (post-RA) surveying and sampling activities, how these survey and sampling activities will be documented (and the information provided to the IVC), and how post-RA and verification surveys will be coordinated with the IVC (Oak Ridge National Lab or the Oak Ridge Institute of Science and Education). This plan follows the DOE protocol for verification and certification of sites under FUSRAP (reference 3).

## RESIDUAL CONTAMINATION GUIDELINES

### Soil Guideline

Generic guidelines for residual radioactive material in soils from DOE Order 5400.5, chapter IV for $Ra^{226}$, $Ra^{228}$, $Th^{230}$, and $Th^{232}$ are:

> Soil Concentration Above Background[a]
> 5 pCi/g when averaged over the first 15-cm-thick layer of soil.[b]
>
> 15 pCi/g averaged over 15-cm-thick layers of soil more than 15 cm below the surface.

[a] These guidelines take into account ingrowth of radium-226 from thorium-230 and of radium-228 from thorium-232, and assume secular equilibrium. If either thorium-230 and radium-226 or thorium-232 and radium-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the sum of the ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide shall not exceed one.

[b] This is the limit for <u>any</u> 15-cm-thick layer of soil located on residential properties in Maywood, New Jersey (reference 4).

Guidelines for other radionuclides present are derived from the basic dose limit by means of environmental pathway analysis (e.g., RESRAD modelling) using site specific property data and exposure scenarios. Final soil criteria are negotiated with the appropriate regulatory agencies. For mixtures of individual radionuclides in soil, the sum of the ratios of the individual soil concentrations to the allowable limit shall not exceed one.

Surface Contamination Guidelines

The residual contamination guidelines for fixed and removable radioactive contamination (dpm/100 $cm^2$) from 10 CFR 835, Appendix D are as follow:

| Radionuclide | Average | Maximum | Removable |
|---|---|---|---|
| U-nat, $U^{235}$, $U^{238}$, and associated decay product alpha emitters | 5,000 | 15,000 | 1,000 |
| Th-nat, $Th^{232}$, $I^{125}$, $I^{131}$, $I^{133}$, $U^{232}$, $Ra^{223}$, $Ra^{224}$, and $Sr^{90}$ | 1,000 | 3,000 | 200 |
| $Ra^{226}$, $Ra^{228}$, $Th^{230}$, $Th^{228}$, $I^{125}$, $I^{129}$, $Pa^{231}$, $Ac^{227}$, and transuranics | 500 | 1,500 | 20 |
| Beta-gamma emitters (except as noted above) | 5,000 | 15,000 | 1,000 |

Radon

When the residual radioactivity contributing to a radon concentration above criteria at a site is of DOE origin, remedial action and verification of compliance with the radon and radon decay product (working level) criteria is required as part of the post-RA process. The applicable criteria are as follows:

| | |
|---|---|
| $Radon^{222}$ | 3.0 pCi/L |
| $Radon^{220}$ | 3.0 pCi/L |
| Radon Decay Products | 0.03 Working Levels (WL) |

When both isotopes of radon are present, the sum of the ratios of the individual concentrations to the allowable limit must be less than one

When there is reasonable assurance that the residual radioactivity requiring remediation at a site is either:

- not a potential source of radon (i.e., no radium present above background concentrations) or;
- is not of DOE origin, then

remedial action and compliance with the radon concentration and radon decay product criteria is not required.

External Gamma Exposure Rates

The average external gamma exposure rate inside a building or habitable structure on a site to be released without radiological restrictions shall not exceed background by more than 20 $\mu$R/hr and shall comply with the basic dose limit (100 mrem/yr) when an "appropriate-use" scenario is considered. This requirement is not applicable to structures scheduled for demolition or to buried foundations.

External gamma exposure rates on open lands shall also comply with the basic dose limit (100 mrem/yr, excluding radon) and the ALARA process, considering appropriate-use scenarios for the area.

POST-REMEDIATION SURVEYS AND SAMPLING

Post-RA survey and sampling activities focus on confirming that soil and structures that remain after remedial action do not contain residual radioactive contamination at concentrations exceeding applicable guidelines. Following remediation, the RSS performs post-remedial action surveys and sampling to determine the completeness of the remedial action and to document that the site complies with the applicable criteria.

Survey Equipment

The equipment used by FUSRAP for delineation of the contaminant boundaries (determination of "hot spots") during remediation and post-RA surveys of soils includes, but is not limited to:

- Field Instrument for Detection of Low Energy Radiation (FIDLER) (calibration source: Am-241)

- Gamma Scintillation Detector (Eberline SPA-3 or equivalent), or low range/high range HP-270 or equivalent (calibration source: Cs-137)

- Reuter-Stokes Pressurized Ion Chamber (PIC) (calibrated by manufacturer) or Ludlum "$\mu$R Meter".

- Canberra® In-situ Gamma Spectrometer (calibration source: mixture of uranium and thorium utilizing EML standards)

- Canberra® 96-6697 Procount Gamma Spectroscopy system (calibration source: mixture of uranium and thorium utilizing EML standards)

The equipment used by FUSRAP for Post-RA surveys of structures includes, but is not limited to:

- Alpha Scintillation detector (Eberline AC-3 or equivalent) (calibration source: Th-230)

- Beta/Gamma Pancake GM detector (7 mg/cm$^2$ mylar shielded, Eberline HP-210 or equivalent) (calibration sources: Sr-90, Y-90)

- Alpha Scintillation Counter (Eberline SAC-4 or equivalent) (calibration source: Th-230)

The same type calibration sources (i.e., same radionuclide) and methods for instrument calibration will be used whenever possible by the PMC and the IVC to ensure compatibility and reproducibility of survey results.

Background Measurements

Prior to performing post-remedial action surveys, the RSS will obtain site-specific background measurements and samples from three remote background locations in the general vicinity (0.5 to 3 miles) of the site being remediated according to Thermo NUtech (TN) procedure 3C.2 (reference 5G). The location for background measurements will be selected by the PMC and the RSS to be representative of site conditions yet unaffected by operations at the site. Background measurements and samples will be taken at each location by the RSS and the IVC.

If similar materials (concrete, mortar, brick, asphalt, etc.) cannot be found within 0.5 to 3 miles of the site, then samples of materials taken from uncontaminated portions of the facility may be used for determining background.

Structural Surveys

After completion of surface decontamination of structures, the RSS shall conduct post-RA surveys to verify satisfactory decontamination of the area. A survey grid shall be established at the site, conforming to the specifications in TN procedure 3A.1 (reference 5B) and the "Instruction Guide for Post-Remediation Radiological Survey of Structures" (191-IG-031, reference 6). Surveys shall be conducted in each 1 m by 1 m (1 $m^2$) grid. The IVC will use the same coordinate grid to locate direct and transferable measurement locations.

Interior external gamma radiation exposure rates should be taken at a frequency of one per 100 $m^2$ of floor area, or one per room, whichever yields a greater frequency.

Excavation Surveys

After completion of excavation of contaminated soils, the RSS shall conduct post-RA surveys to verify satisfactory decontamination of the area. A survey grid shall be established at the site, conforming to the specifications in TN procedure 3B.1 (reference 5F) and the "Instruction Guide for Post-Remediation Survey of Soil" (191-IG-032, reference 7), and surveys shall be conducted in each square of a suggested 10 m by 10 m grid (100 $m^2$). When deviating from the 10 m by 10 m grid (due to small irregularities in the area of contamination), the total area of each grid shall not exceed 100 $m^2$. The IVC will use the same coordinate grid to locate post-RA survey measurements and sample locations.

After all visible loose dirt has been removed, structures (foundations, culverts, etc.) in the formerly contaminated areas will be surveyed for release in accordance with TN procedure 2C.1 (reference 5A).

The RSS will obtain a sufficient number of external gamma radiation exposure rate measurements at a height of 1 m in the center of the 10 m by 10 m grid using methods in accordance with TN procedure 3B.3 (reference 5F) to adequately determine the average external gamma exposure rate within the remediated area.

Soil Sampling

The RSS shall also collect post-RA soil samples to verify satisfactory remediation of the area. Samples shall be collected from an approximately 100 $m^2$ grid (suggested 10 m by 10 m) as directed in 191-IG-032, and TN procedure 4A.1 (references 7 and 5H).

Point Sources ("Hot Spots") will be evaluated by using the averaging criteria contained in "A Manual for Implementing Residual Radioactive Material Guidelines" (reference 8) and DOE Order 5400.5, Chapter IV, Section 4. Where appropriate, a "hybrid grid" (made up of portions of one or more site grids) will be implemented to bound, by sampling or instrument readings, and assign the area (in square meters) to each "hot spot" in question to determine compliance.

Composite samples will be collected from each remediated grid by taking individual samples (at a frequency of 25 per 100 $m^2$) from each sample grid and compositing these individual samples into one sample for that grid. The IVC may collect splits of the composite concurrently.

Samples from each grid square shall be collected using properly decontaminated sampling equipment (reference 9).

On-site analytical techniques (gamma and alpha spectroscopy) will be used (where/when available) to analyze all composite soil samples on site. Ten percent (10%) of the samples shall also be shipped to the TN laboratory in Oak Ridge, TN to be analyzed using gamma spectroscopy (Gamma List 1). Preliminary lab results should be available within 3 days of receipt of the sample by the lab.

Hazard Assessment

In accordance with DOE Order 5400.5, supplemental limits may be recommended in areas where the dose to members of the public, as well as environmental harm, is low and the cost of remediation is relatively high. If supplemental limits are recommended, a hazard assessment would be developed to estimate doses from current and future use scenarios. Sufficient sampling, as determined by the PMC and the IVC, would be performed in order to define contaminant concentration boundaries and average concentrations in order to aid in the development of the supplemental standards.

Safety and Health

Safety and health risks associated with tasks described herein are identified and addressed by the generic and site specific Health and Safety Plans and the FUSRAP Project Health and Safety Manual (reference 10) and the FUSRAP Radiation Safety Manual (reference 11). Where applicable, all work will be performed under a Hazardous Work Permit and an Activity Safety Envelope specific to the survey activities.

Quality Assurance/Quality Control

QA/QC field duplicate samples and measurements shall be collected at a frequency of one additional sample/measurement for each 20 collected.

Rinse blanks from decontaminated sampling equipment will not be required for decontaminated post-RA survey and sampling equipment unless post-decon smears indicate surface contamination in excess of twice background. When chemical post-RA sampling is required, rinse blanks shall be collected at the rate of one rinse blank per day of sampling. Rinse blanks shall be collected according to the recommendations in 191-IG-028 (reference 12).

Data Quality Objectives

Quality indicator goals shall be as follows: Precision, ± 2 sigma; completeness, 100%; Accuracy range, 75 to 125%. QA QC samples are discussed in the previous section.

PMC/IVC COORDINATION

Bechtel, functioning as the PMC, is the contractor responsible for completing the remedial action. To define the areas for remediation, Bechtel uses data collected during designation, as well as supplemental information obtained by Bechtel as part of pre-RA planning and scoping activities (characterization, waste classification, and boundary delineation sampling activities).

Upon completion of remediation, the RSS will perform post-RA surveys, and the IVC will commence verification of the remediated property. The results of this survey shall be used to determine whether there are areas requiring additional remediation. This survey is expected to include all areas previously identified as being contaminated on the designated properties. The Bechtel Site Superintendent will notify the IVC when remediation of an area is complete, and the IVC will perform independent verification surveys of the area. Bechtel will assist the IVC in this survey by interfacing with the property owner in advance to secure approval for property access.

Bechtel will initiate remediation of areas identified by the IVC that require additional remediation. The remediation of these additional areas will occur concurrently with the IVC's verification activities, to the extent that remediation does not interfere with verification.

Data Transmittal

Bechtel will provide the IVC copies of all final (reviewed and verified) post-remediation survey and sample results as they become available. Post-RA survey data shall be documented per the appropriate TN procedure for the type survey or sampling being performed and shall include sufficient information to document the final remediated condition of the site, including the location, average concentration, and approximate area of "hot spots" as defined in DOE Order 5400.5. See attachment A for example post-RA survey form.

Comparability

Measurements taken by Bechtel and the IVC, at identical locations, should agree within the 95 percent confidence interval for the analytical methods used (reference 2). For consistency and ease of data comparison, Bechtel's RSS and the IVC shall utilize the same type of calibration techniques, calibration sources, and survey techniques in conducting the surveys. Bechtel and the IVC shall utilize the same survey grid and shall conduct their surveys referring to that grid.

Site Release Documentation

Prior to demobilization from a site, the IVC will provide the Site Superintendent with written documentation that indicates all the samples and instrument readings needed to verify the area as clean have been obtained (see attachment B for example form). After all soil samples have been analyzed by the IVC, final documentation releasing the area of interest should be faxed to the Site Superintendent.

Once it has been established that the site meets the applicable DOE criteria as determined by direct measurements and analytical results, Bechtel will proceed to restore the site to the condition agreed upon by the property owner(s).

Bechtel will prepare a draft post-remedial action report (PRAR) for DOE review (copies to the acting IVC) within three months of demobilization from the site.

REFERENCES

(1) DOE Order 5400.5, Radiation Protection of the Public and Environment, Washington, D.C.

(2) CCN 063475, Fiore to Gross, "Chemical Contamination at FUSRAP Sites", August 24, 1989.

(3) DOE, 1990, Verification and Certification Protocol for the Office of Environmental Restoration FUSRAP and D&D Program, Revision 3, November.

(4) CCN 114978, Muszynski to LaGrone , "EPA Region 2's Position on the Dispute Regarding Cleanup Levels for Radionuclide Contamination", March 23, 1994.

(5) Thermo NUtech (TN), Health Physics Operational Procedures Manual.

A) 2C.1 "Release of Equipment and Materials"
B) 3A.1 "Radiological Survey of Structures"
C) 3A.2 "Direct Surface Contamination Survey"
D) 3A.3 "Transferable Surface Contamination Survey"
E) 3B.1 "Delineation of Survey Areas in Open Land"
F) 3B.3 "Gamma Ray Exposure Rate Surveys at 1-Meter in Open and Enclosed Areas"
G) 3C.2 "Determination of Background"
H) 4A.1 "Systematic and Bias Surface Soil Sampling (Radiological)"

(6) BNI, 1993, Instruction Guide for Post-Remediation Radiological Survey of Structures, 191-IG-031, Rev. 0.

(7) BNI, 1993, Instruction Guide for Post-Remediation Radiological Survey of Soil, 191-IG-032, Revision 0.

(8) DOE/CH/8901, A Manual For Implementing Residual Radioactive Material Guidelines, June 1989.

(9) BNI, 1992, Instruction Guide for Decontamination of Field Sampling Equipment at FUSRAP Sites, 191-IG-011, Revision 5.

(10) FUSRAP Project Safety and Health Manual

(11) FUSRAP Radiation Safety Manual

(12) BNI, 1993, Instruction Guide for Surface Water and Sediment Sampling Activities, 191-IG-028, Revision 0.

THERMO NUTECH
RADIATION SURVEY DATA SHEET

144008

Survey Type Interior ___ Exterior ___

Date _____

Scaler: _____

Detector: _____

S/N: _____

Conversion: _____

Bkg.: _____

Action Level: _____ (cpm ___ or uR/hr ___)

Coordinates W<——>E

<—m—>

<—m—>

Coordinates S<—>N

EXAMPLE

Reference E_____
Coordinate N_____

General Location / Description: _____

Remarks: _____

Physical Conditions: _____

Hot Spots: (Denoted by: △ )

1 _____ cpm (scan) _____ pCi/g (sample activity) _____ m2 (area)

2 _____ cpm (scan) _____ pCi/g (sample activity) _____ m2 (area)

3 _____ cpm (scan) _____ pCi/g (sample activity) _____ m2 (area)

Bounding Samples denoted by ◯

Technician _____ print / sign

Reviewed By _____ print / sign

144008

B&T METALS SITE

FINDINGS OF INDEPENDENT VERIFICATION SURVEY

PROPERTY _____ AREA _____

SURVEY DATE S _____

SURVEYOR(S) _____, _____, _____

---

PRELIMINARY FIELD DATA REVIEW:

_____No Discrepancies _____Discrep[illegible]ified

MEASUREMENT PERFORMED:

_____Beta/Gamma _____[illegible]able Activity Smear

_____Other (describe [illegible] [illegible]rect Measurements

SAMPLES COLLECTED:

_____Sys[illegible] _____Bias

APPLIC[illegible]

[illegible] Soil Concentration Above Background

Total Uranium 35 pCi/g any depth

For fixed and transferable radioactive contamination (total):
5000 dpm/100 cm², average total
15,000 dpm/100 cm², maximum total
1000 dpm/100 cm², removable

STATUS (pending final sample results):

_____Meets Guidelines _____Does Not Meet Guidelines

Explain Discrepancies: _____

_____

Remarks: _____

_____

I acknowledge that all the samples and instrument readings needed to verify this area as clean have been taken.

Prepared by: _____Date: _____

EXAMPLE

ATTACHMENT B

144008

Bechtel National, Inc.
Formerly Utilized Sites
Remedial Action Program
(FUSRAP) Job 14501

WI 96-133



# QUALITY ASSURANCE ASSESSMENT (QAA) NEED EVALUATION

Site Identification Ventron Site

Field Activity Description:

The work involves the implementation of the FUSRAP PRASP for the Ventron Site with additional site specific information.

Justification that QAA is not applicable for this work activity:

Work under this work instruction does not involve potential significant failures. The safety and health of the field personnel will be addressed by the FUSRAP project Safety and Health procedures manual. On-site personnel will receive health and safety training prior to the start of work activities. The work will be performed by medically certified and OSHA trained personnel. The final report and closed out Work Instruction will be reviewed by Bechtel to ensure that appropriate methods have been employed and the work has been satisfactorily completed. Should field conditions change (ie., new potential risks arise), the need for a QAA will be re-evaluated.

| Originator | Concurrence Safety & Health Manager |
|---|---|
| Tim Kiy | Elizabeth Kelley |
| 7-11-96 | 7/11/96 |

# POST-REMEDIAL ACTION SURVEY PLAN FOR THE VENTRON HARBOR

## PURPOSE

The purpose of this plan is to describe the methodologies that the Formerly Utilized Sites Remedial Action Program (FUSRAP) will use for radiological surveys, sampling, and analysis to document the final condition of Ventron Harbor portion of the Ventron Site at Beverly, Massachusetts as free of radioactive contamination above the release standards of the Department of Energy (DOE) Order 5400.5 (reference 1). Nothing herein is intended to compromise the Independent Verification Contractor's (IVC) independence; the purpose is to document the Prime Management Contractor's (PMC's) plans to conduct post-remedial action surveying/sampling and our understanding of how we will coordinate with the IVC. Specifically, the harbor area adjacent to the Ventron facility will be addressed in this plan. This plan addresses the DOE protocol for verification and certification of sites under FUSRAP (reference 2).

Bechtel National, Inc. (BNI) will be the FUSRAP PMC, and the Oak Ridge Institute for Science and Education (ORISE) will act as the IVC.

## BACKGROUND

The Metal Hydrides Corporation facility (which became the Ventron Corporation in 1965) performed work under contract to the Manhattan Engineer District (MED) and the Atomic Energy Commission (AEC). Operations conducted under government contract at this site included the procurement, storage, and processing of uranium oxides, salts, and metals, and the machining of these products. As a result of these activities this site has become radioactively contaminated with small amounts of material which has resulted in low level contamination on this property.

## RESIDUAL CONTAMINATION GUIDELINES

At the Ventron Site, natural uranium is the primary radioactive contaminant. DOE responsibility is limited to the uranium. The applicable residual contamination guidelines are as follow:

| Radionuclide[a] | Soil Concentration Above Background[b] |
|---|---|
| Total Uranium | 100 pCi/g averaged over any 15-cm-thick soil layer. |
| Ra-226, Th-232 | 5 pCi/g when averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over any 15 cm thick soil layer below the surface layer. |

a The uranium guideline is site specific. Radium and thorium guidelines are from Reference 1.

b These guidelines take into account ingrowth of radium-226 from thorium-230 and of radium-228 from thorium-232, and assume secular equilibrium. If either thorium-230 and radium-226 or thorium-232 and radium-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the sum of the ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed 1.00.

The residual contamination guidelines for fixed and removable radioactive contamination (dpm/100 $cm^2$) are as follow:

| | Alpha | Beta |
|---|---|---|
| Removable: | 1000 | 1000 |
| Fixed: (average) | 5000 | 5000 |
| (maximum) | 15000 | 15000 |

DECONTAMINATION ACTIVITIES

The area of Ventron (Beverly) Harbor adjacent to the Ventron Site is the designated area addressed in this plan.

All areas of contamination are limited to soil.

A Real Estate Instrument shall be in place prior to remedial action.

At a minimum, remediation of the site will consist of excavation of approximately 550 cubic yards of soil exceeding the site specific criteria.

Post-remedial action surveys and sampling will focus on confirming that soil which remains after remedial action, does not contain radioactive contamination at concentrations exceeding applicable guidelines. If contaminant concentrations remain above the applicable guidelines after the remedial action is complete, supplemental standards will be developed and applied to the Harbor standards. To the extent necessary, equipment used during the decontamination activity will be cleaned and surveyed according to Thermo Nuclear Services (TNS) procedure 2C.1 "Release of Equipment and Materials" (reference 4A). prior to release.

Areas where remediation activities will be conducted will include, but not be limited to, those identified in the site designation report (reference 3) and the following figure: 127F021.

The design drawing (see above) delineates those general areas that will be excavated.

## POST-REMEDIATION SURVEYS AND SAMPLING

Following remediation, the FUSRAP Radiological Support Subcontractor (TNS) will perform post-remedial action surveys and sampling to determine the completeness of the removal action and to document that the site now complies with the residual contamination guidelines (DOE Order 5400.5, reference 1), or that the development of supplemental standards is required.

### Survey Equipment

The recommended equipment for use by FUSRAP for identification and boundary delineation of hot spots includes:

- Field Instrument for Detection of Low Energy Radiation (FIDLER)
  (calibration source: Am-241)

- Gamma Scintillation Detector (Eberline SPA-3 or equivalent), or low range/high range HP-270 or equivalent
  (calibration source: Cs-137 for SPA-3, Sr-90 for HP-270)

The recommended equipment for use by FUSRAP for Post-RA Surveys includes:

- Gamma Scintillation Detector
  (calibration source: Cs-137 and/or Am-241)

- Reuter-Stokes Pressurized Ion Chamber (PIC)
  (calibrated by manufacturer, response checked daily using Cs-137)

The recommended equipment for use by FUSRAP for release of equipment and materials from the site includes:

- Alpha Scintillation detector (Eberline AC-3 or equivalent)
  (calibration source: Th-230)

- Beta/Gamma Pancake GM detector (7 mg/cm$^2$ mylar shielded, Eberline HP-210 or equivalent)
  (calibration sources: SrY-90)

- Alpha Scintillation Counter (Eberline SAC-4 or equivalent)
  (calibration source: Th-230)

The same type calibration sources (i.e., same radionuclide) and methods for instrument calibration will be used by Bechtel and ORISE to insure compatibility and reproducibility of survey results.

133725

Background Measurements

Prior to performing post-remedial action surveys, TNS will obtain site-specific instrument background measurements from three remote background locations in the general vicinity of the site (0.5 to 3 miles) according to TNS procedure 3C.2 (reference 4B). The location for background measurements will be selected by Bechtel and TNS, and background measurements will be made at each location by TNS and ORISE.

Surveys

After completion of excavation of the contaminated soils, TNS shall conduct post-remedial action surveys to verify satisfactory decontamination of the area. A survey grid shall be established at the site, conforming to the specifications in TNS procedure 3B. 1 (reference 4C) and the "Instruction Guide for Post-Remediation Radiological Survey of Soil" (191-IG-032, reference 5), and surveys shall be conducted in each square of a suggested 10 m by 10 m grid (100 $m^2$). When deviating from the 10 m by 10 m grid (due to small irregularities in area of contamination), total area shall not exceed 100 $m^2$.

TNS will measure external gamma radiation exposure at a height of 1 m in the center of each 10 m by 10 m grid as required by 191-IG-032 (reference 5) using methods in accordance with TNS procedure 3B.3 (reference 4D). In addition, a minimum of one PIC measurement shall be taken from each survey grid.

Uncontaminated soils which have been excavated will be stockpiled, surveyed, and sampled to confirm that they are uncontaminated.

Soil Sampling

TNS shall also collect post-remedial action soil samples to verify satisfactory remediation of the area. Samples shall be collected from an approximately 100 $m^2$ grid (suggested 10 m by 10 m) as directed in 191-IG-032, and TNS procedure 4A. 1 (references 5 and 4G).

Point Sources ("Hot Spots") will be taken into account by using the averaging criteria contained in "A Manual for Implementing Residual Radioactive Material Guidelines" (reference 11) and DOE Order 5400.5, Chapter IV, Section 4. Where appropriate, a "hybrid grid" (made up of portions of one or more site grids) will be implemented to bound and assign the area (in square meters) to each "hot spot" in question.

Based on current estimates of anticipated areas of excavation, a minimum of 20 composite samples will be collected. Composite samples will be collected by taking individual samples (25 per 100 $m^2$, Figure 1) from each sample grid and compositing these individual samples into one composite sample for that grid. ORISE may collect splits concurrently.

Samples from each grid square shall be collected using properly decontaminated sampling equipment (reference 6).

TNS samples shall be handled using the sample custody and labeling methodology described for sediment samples in the "Instruction Guide for Surface Water and Sediment Sampling Activities" 191-IG-028 (reference 7) and the sample surveying, packaging, and shipping methodology in PI R4.7 "How to Ship Samples from a FUSRAP Site" (reference 8).

Samples shall be shipped to the TNS laboratory in Oak Ridge, TN prepared and analyzed using alpha spectroscopy (Isotopic U, Isotopic Th, and Ra-226) or gamma spectroscopy. A three day turn around time shall be requested. Samples may be sent to the Wayne Site for analysis by gamma spectroscopy on an as needed basis.

Safety and Health

Safety and health risks associated with tasks described herein have been identified and addressed by the Health and Safety Plan for the Ventron Site (reference 9).

The work will be performed under a Hazardous Work Permit specific to the survey activities.

Quality Assurance/Quality Control

QA/QC field duplicate samples and measurements shall be collected at a frequency of one additional sample/measurement for each 20 collected.

Rinse blanks from decontaminated sampling equipment shall be collected at the rate of one rinse per day of sampling. Rinse blanks shall be collected according to the recommendations in 191-IG-028 (reference 7).

Data Quality Objectives

Quality indicator goals shall be as follows: Precision, $\pm$ 2 sigma; completeness, 100% ; Accuracy, $\pm$ 25 %). QA/QC samples are discussed in the previous section.

BECHTEL/ORISE COORDINATION

Bechtel is the contractor responsible for completing the remedial action. To define the areas for remediation, Bechtel used data collected by ORISE during designation, as well as supplemental information obtained by Bechtel as part of pre-RA planning and scoping activities.

Bechtel will have responsibility for excavation of contaminated soil. Upon completion of these activities Radiological Site Support (RSS) will perform post-RA survey, then ORISE

will commence verification of the remediation of the property. The result of this walkover survey shall be used to determine whether there are areas requiring additional remediation. This survey is expected to include all areas previously identified as being contaminated on the designated properties. Bechtel will assist ORISE in this survey by interfacing with the property owner in advance to secure approval for property access.

Bechtel will initiate remediation concurrent with ORISE verification activities, to the extent that remediation does not interfere with verification. Bechtel will provide ORISE access to remediation results as they become available. The Bechtel Site Superintendent will notify ORISE when remediation of an area is complete, and ORISE will perform independent verification surveys of the area. ORISE may collect soil sample splits concurrent with Bechtel sampling efforts.

Measurements taken by Bechtel and ORISE at identical locations should agree within the 95 percent confidence interval for the analytical methods used (reference 2). For consistency and ease of data comparison, Bechtel and ORISE shall utilize the same type of calibration techniques, calibration sources, and survey techniques in conducting the surveys. Bechtel and ORISE shall utilize the same survey grid across the decontaminated areas and shall conduct their surveys referring to that grid.

Once it has been established that the site meets criteria for future use with out radiological restrictions as determined by direct measurements and analytical results, Bechtel will proceed (at risk) to restore the site to the condition agreed upon by the property owner(s).

Bechtel will provide final verified sample results to ORISE as soon as they are available. Bechtel will prepare a post-remedial action report (PRAR) for DOE review (copy to ORISE) within 3 months following demobilization. The Certification Docket will be completed after the completion of remediation of the Ventron Site.

133725

## REFERENCES


(1) DOE Order 5400.5, Radiation Protection of the Public and Environment, Washington, D.C.

(2) DOE, 1990, Verification and Certification Protocol for the Office of Environmental Restoration FUSRAP and D&D Program, Revision 3, November.

(3) ORNL/RASA-91/29, Radiological Survey Results at Beverly Harbor, Beverly, Massachusettes, August 1990.

(4) Thermo Nuclear Services (TNS), Health Physics Operational Procedures Manual.

A) 2C.1 "Release of Equipment and Materials"
B) 3C.2 "Determination of Background"
C) 3B.1 "Delineation of Survey Areas in Open Land"
D) 3B.3 "Gamma Ray Exposure Rate Surveys at 1-Meter in Open and Enclosed Areas"
E) 3A.2 "Direct Surface Contamination Survey"
F) 3A.3 "Transferable Surface Contamination Survey"
G) 4A.1 "Systematic and Bias Surface Soil Sampling (Radiological)"

(5) BNI, 1993, Instruction Guide for Post-Remediation Survey of Soil, 191-IG-032, Revision 0.

(6) BNI, 1992, Instruction Guide for Decontamination of Field Sampling Equipment at FUSRAP Sites, 191-IG-011, Revision 5.

(7) BNI, 1993, Instruction Guide for Surface Water and Sediment Sampling Activities, 191-IG-028, Revision 0.

(8) BNI, 1994, How to Ship Samples from a FUSRAP Site, PI R4.7, Revision 2.

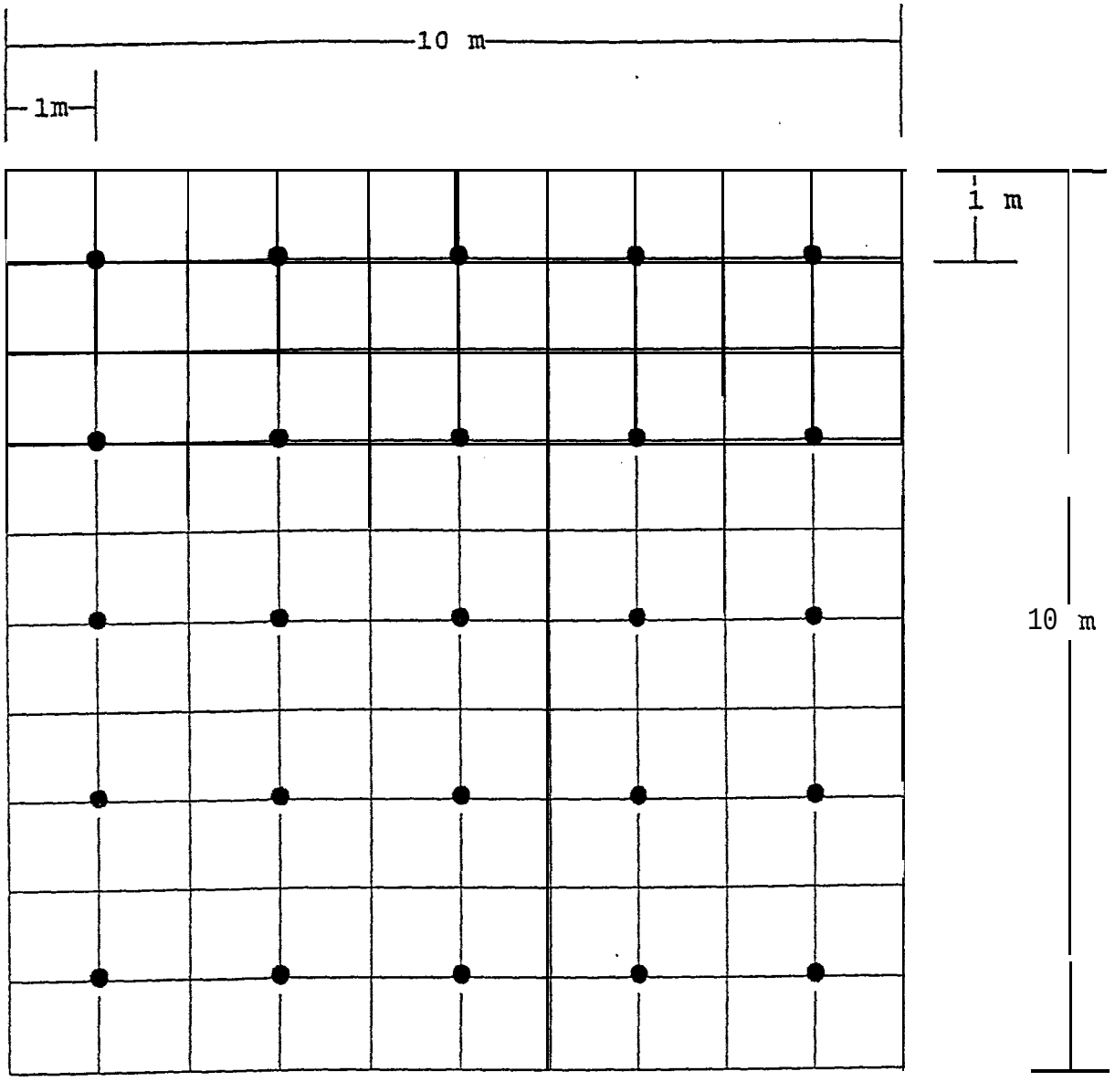
(9) DOE/OR/21949-347, June 1992, Health and Safety Plan for the Ventron Site.

(10) DOE/CH/8901, A Manual For Implementing Residual Radioactive Material Guidelines, June 1989.

133725

# ATTACHMENTA

133725




● Sample Locations

FIGURE 1: Survey Grid - 10 m x 10 m

Document No. 2144

Formerly Utilized Sites Remedial Action Program (FUSRAP)
Contract No. DACW45-98-D-0028

# Post-Remedial Action Report for the Remedial Action at the Ventron Site

# Beverly, Massachusetts

March 2003

z4.43 2557.2

# POST-REMEDIAL ACTION REPORT

# FOR THE

# REMEDIAL ACTION AT THE VENTRON SITE

# BEVERLY, MASSACHUSETTS

March 2003

Prepared for

United States Department of Energy

Under Contract No. DACW45-98-D0028

By

Bechtel National, Inc.

Oak Ridge, Tennessee

Bechtel Job No. 14501

## CONTENTS


Page

FIGURES ..... iv

ACRONYMS ..... v

UNITS OF MEASURE ..... v

1.0 INTRODUCTION ..... 1
- 1.1 BACKGROUND ..... 1
- 1.2 REGULATORY COMPLIANCE ..... 4
- 1.3 HISTORY ..... 4
- 1.4 SITE DESCRIPTION ..... 5

2.0 REMEDIAL ACTION GUIDELINES ..... 8

3.0 REMEDIAL ACTION ..... 12
- 3.1 OVERVIEW ..... 12
- 3.2 CONTAMINATION CONTROL DURING THE CLEANUP ..... 13
- 3.3 POST-REMEDIAL ACTION ACTIVITIES ..... 16
  - 3.3.1 Overview ..... 16
  - 3.3.2 Survey Techniques ..... 17

4.0 POST-REMEDIAL ACTION MEASUREMENTS ..... 18
- 4.1 BUILDINGS ..... 18
- 4.2 EXCAVATIONS ..... 18
- 4.3 OTHER AREAS OF REMEDIATION ..... 25

5.0 SUPPLEMENTAL SAMPLING TO CONFIRM DATA SUFFICIENCY ..... 26

6.0 POST-REMEDIAL ACTION STATUS ..... 30

REFERENCES ..... R-1

GLOSSARY ..... G-1

APPENDICES

A – DOE/MORTON MEMORANDUM OF AGREEMENT ..... A-1

B – 1995 HARBOR REMEDIAL ACTION REPORT ..... B-1

C – JULY 1997 SUPPLEMENTAL SAMPLING REPORT ..... C-1

D – POST-REMEDIAL ACTION SAMPLING DATA ..... D-1

## FIGURES


| Figure | Title | Page |
|---|---|---|
| 1-1 | Location of the Ventron Site | 2 |
| 1-2 | Ventron Site Vicinity Map, Beverly, MA | 3 |
| 1-3 | Ventron Site Plan | 7 |
| 2-1 | Approximate Background Sampling Locations, Ventron Site, Beverly, MA | 11 |
| 3-1 | Ventron Site Expected Areas of Contamination | 14 |
| 3-2 | Ventron Site Areas of Remediation of Depth of Excavation | 15 |
| 4-1 | Excavation and Location of Samples | 19 |
| 5-1 | Supplemental Sampling Locations | 27 |
| D-1 | Ventron Site Verification Grids and Post-Remedial Sample Locations | D-4 |
| D-2 | Ventron Site Location of Samples Taken Near the Seawall Site | D-12 |


## TABLES


| Table | Title | Page |
|---|---|---|
| 2-1 | Summary of DOE Guidelines for Residual Radioactive Contamination at the Ventron Site | 9 |
| 5-1 | Post-Remedial Action Data, July 1997 Supplemental Sampling | 28 |
| D-1 | Building A &A-1 Demolition Data | D-1 |
| D-2 | Alfa Building Demolition Data | D-2 |
| D-3 | Post-Remedial Action Data, Excavations 1,2, and 3 | D-3 |
| D-4 | Post-Remedial Action Data, Excavation 4 (Alfa Building) | D-5 |
| D-5 | Post-Remedial Action Data, Excavation 5 (Harbor) | D-7 |
| D-6 | Post-Remedial Action Data, Excavation 6 (Seawall Locations) | D-10 |
| D-7 | Post-Remedial Action Data, Excavation 6 (Seawall Locations) | D-13 |
| D-8 | Post-Remedial Action Data, Excavation 7 | D-15 |
| D-9 | Post-Remedial Action Data, Excavations 8, 9, 10, & 11 | D-16 |
| D-10 | Post-Remedial Action Data, Soil Beneath Building A Slab | D-17 |
| D-11 | Post-Remedial Action Data, Gamma Exposure Rate Data | D-18 |

## ACRONYMS

| | |
|---|---|
| AEC | U.S. Atomic Energy Commission |
| BNI | Bechtel National, Inc. |
| CERCLA | Comprehensive Environmental Response Compensation and Liability Act |
| DCG | derived concentration guide |
| DOE | U.S. Department of Energy |
| FIDLER | field instrument for the detection of low-energy radiation |
| FUSRAP | Formerly Utilized Sites Remedial Action Program |
| IVC | independent verification contractor |
| MARSSIM | Multi-Agency Radiation Survey Site Investigation Manual |
| MED | Manhattan Engineer District |
| ORNL | Oak Ridge National Laboratory |
| OSHA | Occupational Safety and Health Administration |
| PIC | pressurized ionization chamber |
| PPE | personal protective equipment |
| PMC | project management contractor |
| SAIC | Science Applications International Corporation |

## UNITS OF MEASURE

| | |
|---|---|
| μCi | microcurie |
| μR | microroentgen |
| cm | centimeter |
| cpm | counts per minute |
| dpm | disintegrations per minute |
| ft | foot |
| h | hour |
| ha | hectare |
| in. | inch |
| km | kilometer |
| m | meter |
| mL | milliliter |
| mrem | millirem |
| pCi | picocurie |
| y | year |

# 1.0 INTRODUCTION

## 1.1 BACKGROUND

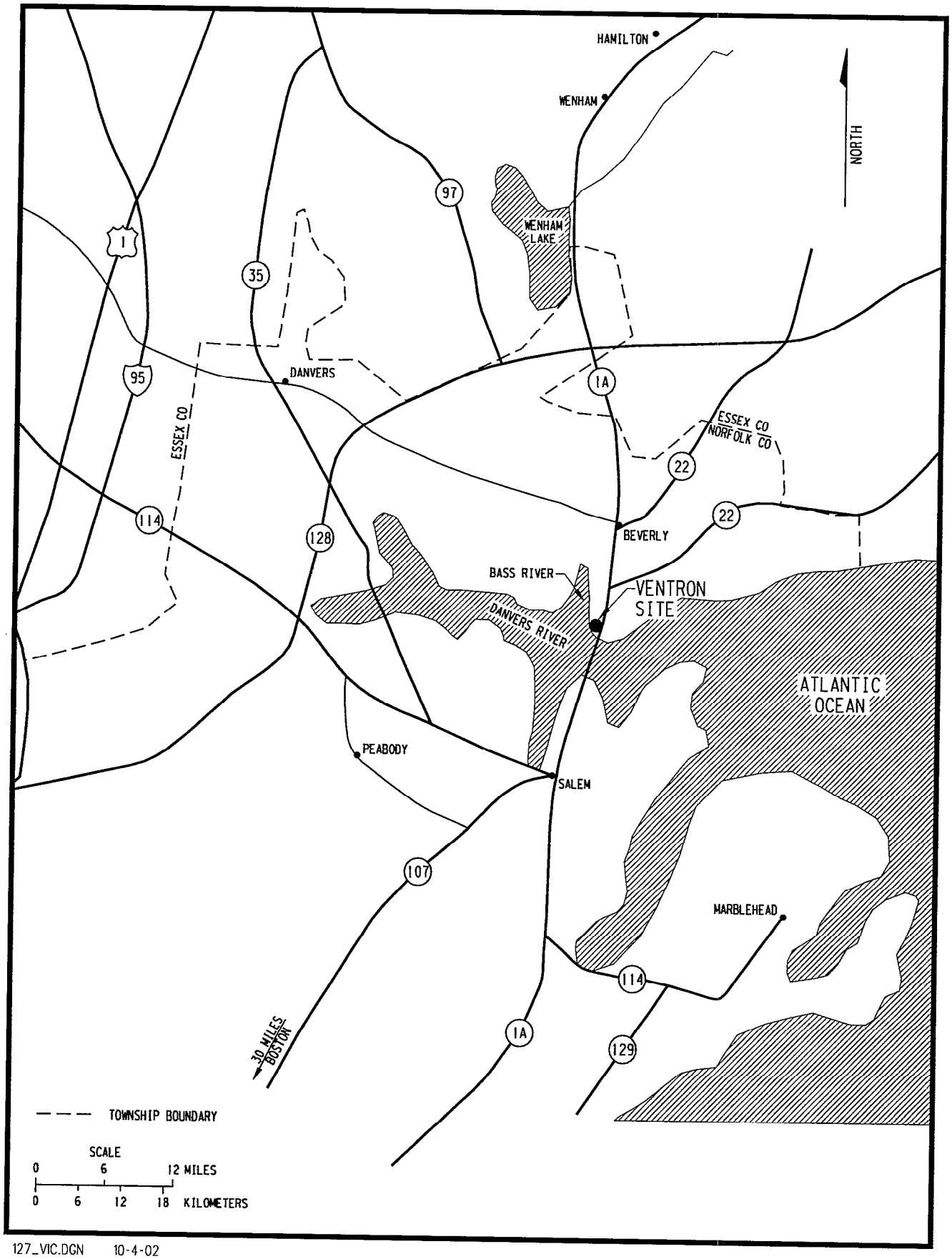
This report documents the remedial action conducted by the Department of Energy (DOE) at the former Ventron Corporation site in Beverly, Massachusetts (see Figures 1-1 and 1-2). The site is located on Massachusetts Bay at the confluence of the Bass and Danvers rivers, approximately 24 km (15 miles) northeast of Boston. DOE cleanup activities documented by this report include initial remediation of site tidal flats (harbor) in September 1995 and remediation of the remainder of the site from May 1996 to March 1997.

Remedial action at Ventron was conducted under the Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP was established in 1974 by the U.S. Atomic Energy Commission (AEC) under the Atomic Energy Act of 1954, as amended. Its mission is to identify and clean up or otherwise control sites where residual radioactive contamination (exceeding current federal guidelines) remains from contract work for the Manhattan Engineer District (MED) or AEC.

FUSRAP's objectives at the Ventron site were to

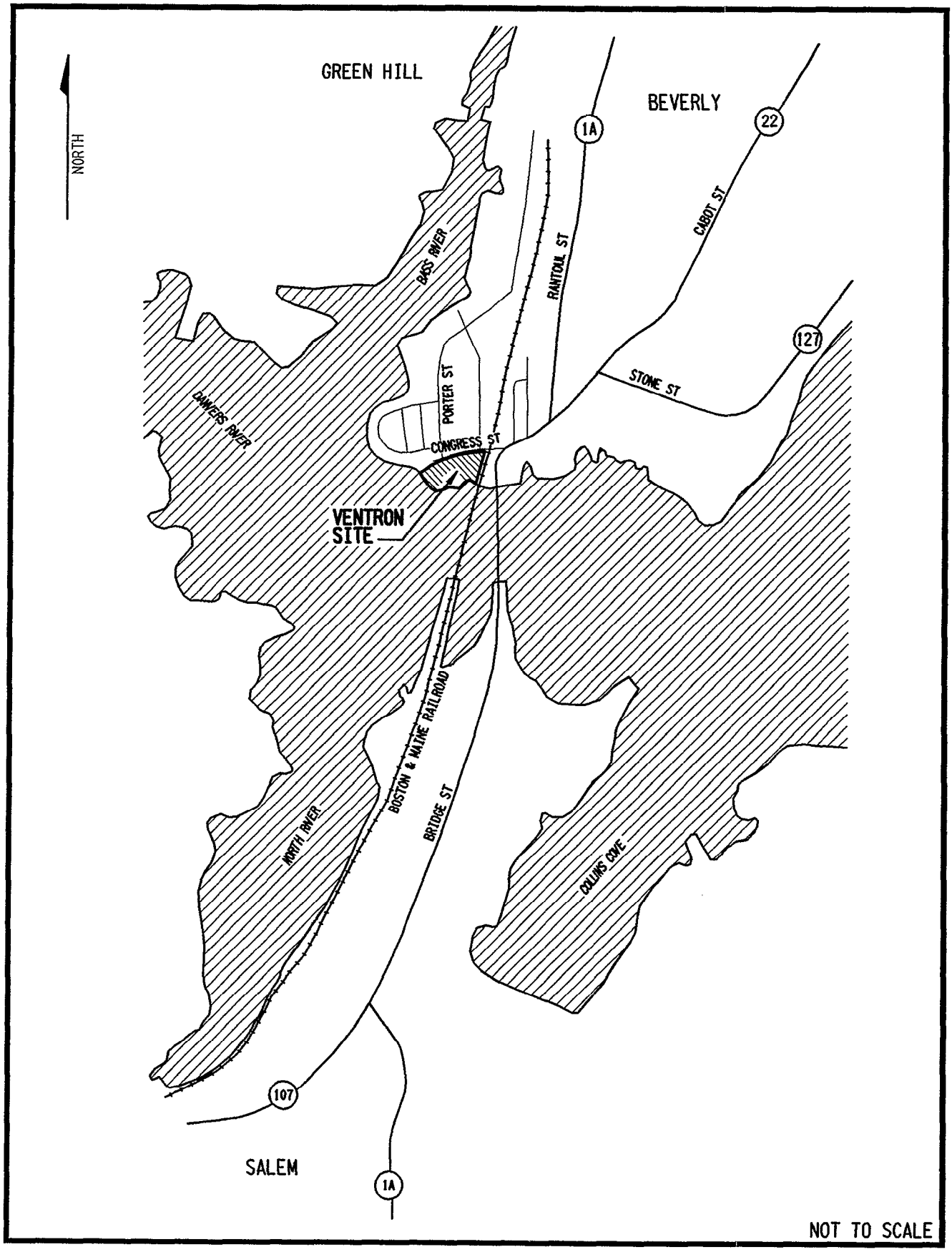
- identify and evaluate areas formerly used to support MED/AEC nuclear development activities;
- remove or otherwise control radioactive contamination above current federal guidelines;
- achieve and maintain compliance with applicable criteria for the protection of human health and the environment; and
- certify the site, to the extent possible, for use without radiological restrictions after remediation.

Bechtel National, Inc. (BNI), the FUSRAP project management contractor, assisted in planning, management, and implementation of the DOE remedial action at the Ventron site. Science Applications International Corporation (SAIC) was the environmental studies contractor. Oak Ridge National Laboratory (ORNL) conducted designation surveys for the site, and Oak Ridge Institute for Science and Education (ORISE) served as the independent verification contractor (IVC) for final remediation. Health physics and laboratory functions were provided by Thermo NUtech Services and Safety and Ecology Corporation, the radiological support subcontractors. The owner of the Ventron site during the time of DOE remediation was Morton International, Inc. (Morton).




127_VIC.DGN 10-4-02

Figure 1-1
Location of the Ventron Site
Beverly, MA




127F054.DGN

**Figure 1-2**
**Ventron Site Vicinity Map**
**Beverly, MA**

## 1.2 REGULATORY COMPLIANCE

FUSRAP cleanup activities at the Ventron site were conducted in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Remediation in the harbor area during 1995 was conducted as a time-critical removal action to support other required site remediation activities. Excavation activities during the sitewide cleanup effort in 1996–1997 followed CERCLA requirements for non-time-critical removal actions. The engineering evaluation/cost analysis prepared for site activities was issued for public comment on February 12, 1996, and was finalized with responses to public comments in April 1996 (DOE 1996b). An Administrative Record was established and made available at the City of Beverly Library on November 6, 1995.

Environmental assessments required by the National Environmental Policy Act were incorporated in CERCLA documentation prepared for the site. An investigation was conducted in accordance with 10 CFR 1022, and floodplains, wetlands, and coastal tidal areas were determined to be present; however, proposed activities were determined to have minimal short-term and positive long-term environmental effects. Consultations with regulators regarding natural resources and endangered and threatened species determined that proposed activities would have no negative effect on these resources. Consultations with historic preservation officials determined that no protected historical or archaeological resources would be adversely affected by cleanup activities.

Cleanup activities were conducted in full compliance with federal and state waste management and transportation requirements.

## 1.3 HISTORY

From 1942 to 1948, the Metal Hydrides Corporation (predecessor of the Ventron Corporation), conducted uranium processing operations under contract to the MED and its successor agency, the AEC. MED/AEC contract operations at the Ventron site involved conversion of uranium oxide to uranium metal powder using calcium hydride (DOE 1995). In a process used later at the facility, uranium oxide was reacted with hydrogen fluoride to produce uranium tetrafluoride, which was mixed with magnesium and heated to produce uranium metal (ORNL 1988). Other operations at the site included recovery of uranium from scrap and turnings resulting from operations at a fuel fabrication plant in Hanford, Washington. MED/AEC contract work at Ventron involved only natural uranium; no depleted or enriched uranium was processed.

Two of the four original buildings used for MED/AEC work were demolished between 1948 and 1950 (after completion of AEC surveying and decommissioning), and two other buildings (Buildings B and F) were erected at these locations. The remaining original buildings (Buildings A and A-1) contained furnaces, leaching facilities, a mixing room, a drying room, and analytical laboratories. The Alfa Building (Building J) was used in later non-MED-related thorium operations, reportedly involving purification of thorium compounds.[1] The primary radioactive contaminant resulting from this work was thorium-232.

Radiological surveys of the land and buildings were conducted by ORNL in 1977 and in 1980 to 1982. In 1986, the Ventron site was designated for inclusion in FUSRAP. Additional radiological surveys of the site were performed by ORNL in 1987 to 1988, and in 1991, surveys were performed of properties in the vicinity of the site to determine if radiological contamination from plant operations had migrated offsite. Further characterization of radiological and chemical conditions at the site was performed by BNI for DOE in 1992.

In 1976, the Ventron Corporation was acquired by the Thiokol Corporation, which became a division of Morton Thiokol, Inc., in 1980, and was subsequently renamed Morton International in 1990. In 1994, Morton production activity at the Ventron site ceased. In 1996, DOE and Morton International finalized a Memorandum of Agreement (MOA) regarding the allocation of cleanup responsibilities between the parties at the site (see Appendix A). DOE radiological decontamination of the site concluded in 1997.

## 1.4 SITE DESCRIPTION

The Ventron site is located in Beverly, Massachusetts. The site occupies 1.2 ha (3 acres) on Massachusetts Bay, at the confluence of the Bass and Danvers rivers. The property is bordered by Congress Street on the north, the Boston and Maine Railroad on the east, the Bass River on the west, and the Danvers River on the south. A seawall composed primarily of granite boulders surrounds the property along its boundaries with the Danvers and Bass rivers. The western and southern boundaries of the property extend beyond the seawall to the low tide mark of the adjacent harbor.

Before remedial action began, the site was a fully operational chemical manufacturing facility comprised of three groups of buildings: the A buildings (A and A-1); the B buildings (B-1, B-2,

[1] Designation of the Alfa Building as Building J is as it is identified in the 1996 DOE/Morton Memorandum of Agreement (MOA), provided as Appendix A of this report.

and B-3; and the C buildings (C-1, C-2, C-3, and C-4). In addition, buildings E and F; the Alfa Building (Building J, the former Alfa Laboratory); and the Biocides Building[2] also existed onsite (see Figure 1-3).

Buildings A and A-1 were the original buildings used by the MED for uranium oxide storage during processing. A concrete loading pad adjacent to Building A-1 is thought to have been used for uranium oxide storage and transfer activities. Elevated levels of radioactivity were detected on interior building surfaces, on MED-related equipment, on the roof, in retort tunnels beneath Building A, and in soil beneath Building A-1. A contaminated portion of the roof was removed and replaced by DOE in 1987.

Buildings B-1, B-2, and B-3 were adjoining buildings and faced the harbor to the south. Buildings B-1 and B-2 were erected over the location of a machine shop used during MED operations. The machine shop was demolished between 1948 and 1950 after being surveyed and decommissioned according to standards in effect at that time. No residual radioactivity was detected within the B buildings; however, soil beneath the buildings was radioactively contaminated.

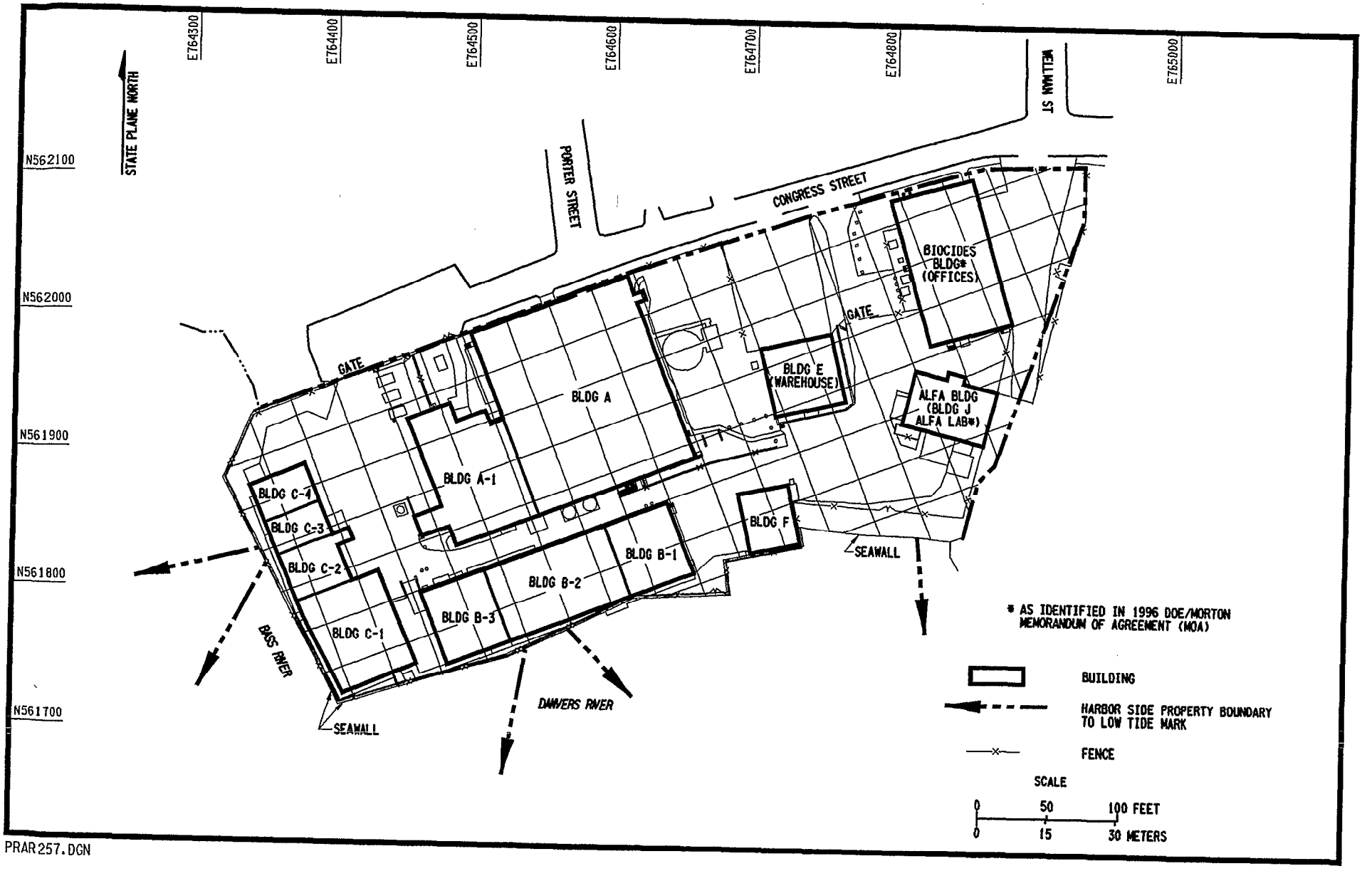
Buildings C-1, C-2, C-3, and C-4 were joined and faced the harbor to the west. During MED operations, two subsurface waste pits reportedly were active in the vicinity of these buildings. No residual radioactivity was detected within the buildings. Soil beneath and adjacent to the buildings was contaminated.

The Biocides Building and Building E were constructed after MED operations were completed. No MED activities were conducted in or on the site of these two buildings. The Biocides Building was in use as company offices and Building E was in use as a storage warehouse.

Building F was constructed after MED operations were completed. The foundry, which it replaced, was active during MED-related activities.

---

[2] Designation of the Biocides Building is as it is identified in the 1996 DOE/Morton MOA, provided as Appendix A. In contractor documents, the Biocides Building is identified as either Building D (SAIC) or J (BNI).




PRAR257.DGN

**Figure 1-3**
**Ventron Site Plan**

## 2.0 REMEDIAL ACTION GUIDELINES

DOE criteria for radionuclides are provided in DOE Order 5400.5, "Radiation Protection of the Public and Environment" (DOE 1990). Chapter IV of the Order addresses release criteria for surfaces and soil contaminated with residual radioactivity. Established release criteria exists for different types of radiation and some radionuclides. Criteria for radionuclides without established concentrations are developed on a site-specific basis, in accordance with procedures established in the Order. Established criteria also may be modified, or supplemented, when conditions delineated in the Order are met.

Radioactive contaminants of concern at the Ventron site were uranium-238, thorium-232, and radium-226. Uranium-238 was identified as the primary radioactive contaminant associated with MED/AEC activities (DOE 1995). Table 2-1 summarizes DOE criteria applicable to the Ventron site.

For indoor and outdoor structural surfaces, remedial action guidelines for alpha activity from natural uranium, uranium-235, uranium-238, and associated decay products are 5,000 dpm/100 $cm^2$ averaged over the entire surface area; 15,000 dpm/100 $cm^2$ (maximum); and 1,000 dpm/100 $cm^2$ (removable). Guidelines for thorium-232 and associated decay products on indoor and outdoor structural surfaces are 1,000 dpm/100 $cm^2$ averaged over the entire surface area; 3,000 dpm/100 $cm^2$ (maximum); and 200 dpm/100 $cm^2$ (removable). Guidelines for radium-226 and associated decay products on indoor and outdoor structural surfaces are 500 dpm/100 $cm^2$ averaged over the entire surface area; 1,500 dpm/100 $cm^2$ (maximum); and 20 dpm/100 $cm^2$ (removable). At the Ventron site, this criteria was applicable to radioactively contaminated equipment and undemolished surfaces such as building slabs.

In addition, because Buildings A and A-1 were planned to be demolished by Morton, supplemental standards were approved by DOE for use on demolition rubble from these buildings, in lieu of established surface guidelines for structural surfaces (DOE 1996d). The rationale for supplemental limits was that established surface criteria would not be applicable to the resulting rubble/debris and that the rubble would more appropriately be compared with volumetric criteria. The approved supplemental standards for masonry rubble, metal surfaces, and other material comprising building rubble are provided in Table 2-1. The DOE approach to building rubble was provided to state regulators (DOE 1996a; MDEP 1996a and b).

**Table 2-1**
**Summary of DOE Guidelines for Residual Radioactive Contamination at the Ventron Site**

**Basic Dose Limits**

Basic dose limit of 100 mrem/y (excluding radon) for member of the general public. In implementing this limit, DOE applies as-low-as- reasonably-achievable principles to set site-specific guidelines where necessary.

**Site-Specific Soil Guidelines**

| | |
|---|---|
| Uranium[3] | 100 pCi/g above background for total uranium; 50 pCi/g above background for uranium-238 |
| Thorium-232<br>Radium-226 | 5 pCi/g above background averaged over the surface 15-cm (6-in.) layer of soil, and 15 pCi/g above background averaged over any 15-cm (6-in.) -thick layer of soil (below the 6-in. surface layer) regardless of depth |

**Building Rubble[4]**

| | |
|---|---|
| Uranium | 100 pCi/g for total uranium; 50 pCi/g for uranium-238 |
| Thorium-232 | 15 pCi/g |
| Radium-226 | 15 pCi/g |

**Indoor/Outdoor Structural Surface Contamination**

Residual contamination guidelines for fixed and transferable radioactive contamination (dpm/100 $cm^2$) (DOE Order 5400.5):

| Radionuclide | Average | Maximum | Removable |
|---|---|---|---|
| Natural uranium, U--235, U-238, and associated decay products | 5,000 (alpha) | 15,000 (alpha) | 1,000 (alpha) |
| Beta/gamma emitters (radionuclides with decay modes other than alpha emissions) | 5,000 (beta/gamma) | 15,000 (beta/gamma) | 1,000 (beta/gamma) |
| Thorium-232 | 1,000 | 3,000 | 200 |
| Radium-226 | 500 | 1,500 | 20 |

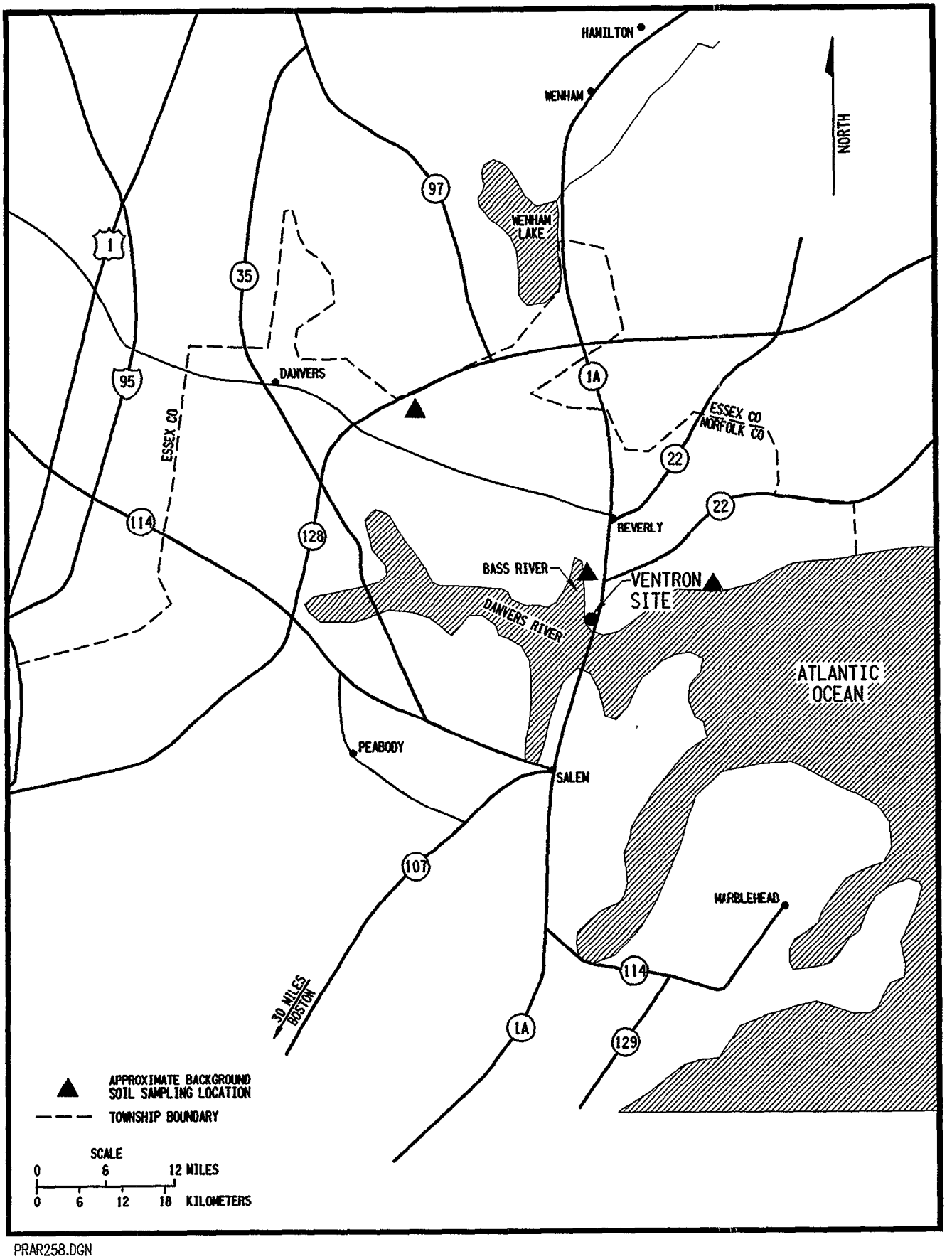
[3] DOE 1993.
[4] DOE 1996c, 1996d.

Because no established criteria exist for uranium in soil, a DOE site-specific criterion was developed and presented to regulators (DOE 1993; DOE 1996a). The DOE site-specific criterion for residual radioactive material in soil at Ventron was 100 pCi/g above background for total uranium and 50 pCi/g above background for uranium-238, regardless of depth. Generic soil guidelines for thorium-232 and radium-226 contained in the Order were applied. The criteria for thorium-232 and radium-226 are 5 pCi/g for residual radioactive material in the first 15 cm (6 in.) of soil and 15 pCi/g for depths greater than 15 cm (6 in.).

To establish the levels of naturally occurring background radioactivity in soils near the site, samples were taken at three offsite locations. Establishment of background levels is important because cleanup guidelines are based on concentrations of radionuclides above background. Background data serve as a frame of reference for evaluating site data because they represent conditions typical of the areas unaffected by activities at the site. During remedial action, soil samples were obtained from three remote background locations in the general area of the Ventron site. Background sampling locations were selected on the basis of their proximity to the site, relative independence from potential site influence, and representativeness of area land uses.

Background sampling locations are shown in Figure 2-1. Samples from these locations were analyzed for radium-226, thorium-232, and uranium-238. Background external gamma exposure rates were also measured at these three locations using a pressurized ionization chamber (PIC). The average background concentration for uranium-238 was 2.3 pCi/g, with a range of 1.3 to 3.6 pCi/g. The average concentration of thorium-232 in background samples was 0.86 pCi/g, with a range of 0.51 to 1.2 pCi/g. The average background concentration of radium-226 was 0.59 pCi/g, with a range of 0.37 to 0.89 pCi/g. The average background external gamma exposure rate was determined to be 9.0 μR/h.

Asbestos-containing material found in retort tunnels beneath Building A was the only nonradioactive constituent mingled with residual radioactive materials at concentrations requiring remedial action. The asbestos-containing material was contaminated with radium-226 at concentrations greater than 5 pCi/g. All asbestos materials containing residual radioactive material were removed from the site and transported to Envirocare of Utah, a facility licensed for the disposal of radioactively contaminated asbestos. Although mercury was present in the harbor tidal flats, it was not commingled with residual radioactive materials at concentrations requiring remedial action.




PRAR258.DGN

**Figure 2-1**
**Ventron Site**
**Background Sampling Locations**

# 3.0 REMEDIAL ACTION

## 3.1 OVERVIEW

Radiological decontamination of the Ventron site by the DOE occurred in two phases: in September 1995 and from May 1996 to March 1997. Supplemental sampling of the site to verify the adequacy of radiological remediation was performed in July 1997 (see Section 5.0).

In September 1995, the first phase of DOE remediation of site tidal flats (harbor) adjacent to the seawall began to ensure that radioactive material was removed from the area before Morton began its harbor remedial activities. During this first phase of remediation, a walkover was performed over the entire harbor down to the low-tide mark, and areas with readings above 20,000 cpm were targeted for remediation. Elevated readings were found in three areas. Excavations were completed in grids 15 and 32, and post-remedial action samples were collected. Excavation was halted in the third area (grids 28 and 29) because contamination in that area was too extensive to be removed by manual methods. Post-remedial action sampling was performed on all grids except 20, 28, 29, 30, 44, 45, and 46, which were remediated during the second phase of the remedial action. Included as Appendix B is the report on this first phase of cleanup activities.

Pursuant to the MOA between the parties, onsite buildings A, A-1, B-1, B-2, B-3, C-1, C-2, C-3, C-4, and F were demolished by Morton before the second phase of DOE remediation began. Crushed rubble from the demolition of Buildings A and A-1 was sampled. Rubble meeting DOE criteria was stockpiled and used as backfill along the seawall. As excavation progressed, demolition of the Alfa Building (Building J) became necessary in order to access and remove contaminated soil beneath the building. Material from the Alfa Building was sampled to characterize its radiological content. Building slabs were surveyed and either decontaminated and left in place or removed and disposed of with other contaminated material.

Excavation of contaminated materials was the primary remedial action technique used at the Ventron site. Eleven discrete areas of the site were excavated and verified for compliance with radiological cleanup criteria. Excavations occurred beneath demolished buildings, in the northwest corner of the site, and in harbor grids 20, 28, and 29. To prevent failure of the seawall, areas within 4 m (12 ft) of the wall were excavated and sampled separately from the surrounding excavation. Residual radioactivity within the seawall was not remediated because of its stability. The average activity of total uranium in the seawall, if reduced to rubble, was estimated to be 0.72 pCi/g (BNI 1997).

Walkover scans were conducted during remedial action to direct the excavation. As remediation was completed, exposure rate measurements were taken with a PIC to confirm that radiation levels were in compliance with applicable guidelines, and soil samples were collected and analyzed to establish that residual radioactive material exceeding applicable criteria had been removed (see Section 4.0 for a presentation of sampling results). Sampling of soil beneath the slab of Building A also was performed to demonstrate that the majority of the area beneath the slab was uncontaminated.

Figure 3-1 shows the expected areas of excavation for the site. Figure 3-2 shows the actual areas of excavation, depth of excavation, and the location of the retort tunnels where material within the tunnels was removed.

Following remedial action, areas were restored to the condition agreed upon by the property owner. Restoration primarily involved placement of sufficient buttress in adjacent areas of the seawall to maintain seawall integrity. Backfilling of the open excavations was the responsibility of Morton, as specified in the MOA (see Appendix A).

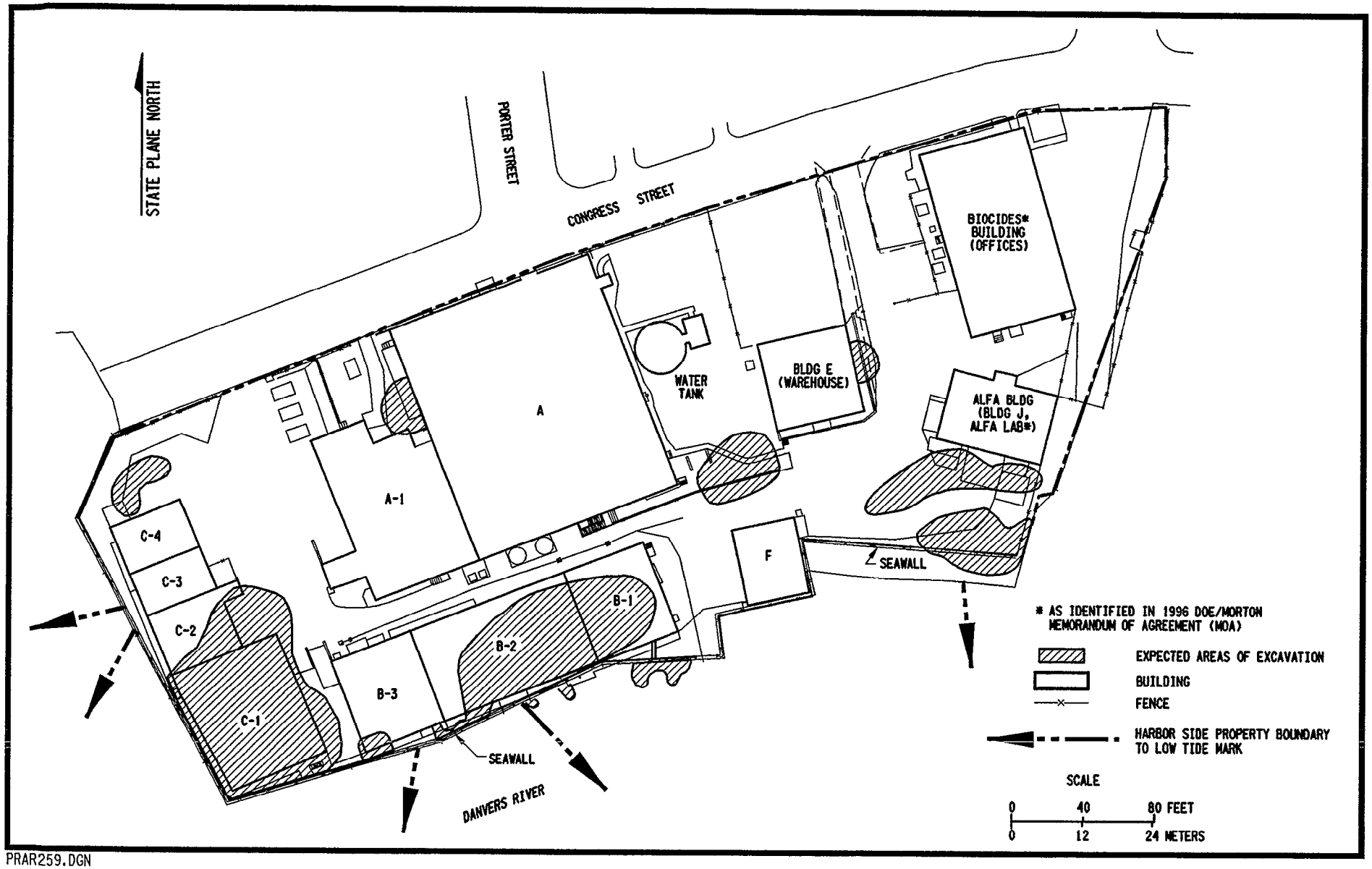
Neither of the two structures remaining onsite (the Biocides Building and Building E) was involved in work with radiological materials. However, interior gamma radiation exposure rates were taken of these structures at a frequency of approximately one per 100 $m^2$ of floor area, or one per room, whichever yielded a greater frequency.

## 3.2 CONTAMINATION CONTROL DURING THE CLEANUP

During remedial action, engineering controls, administrative controls, and monitoring were used to protect remediation workers and members of the general public from potential exposure to radiation above applicable standards. These controls are outlined in the health and safety instructions for the site.

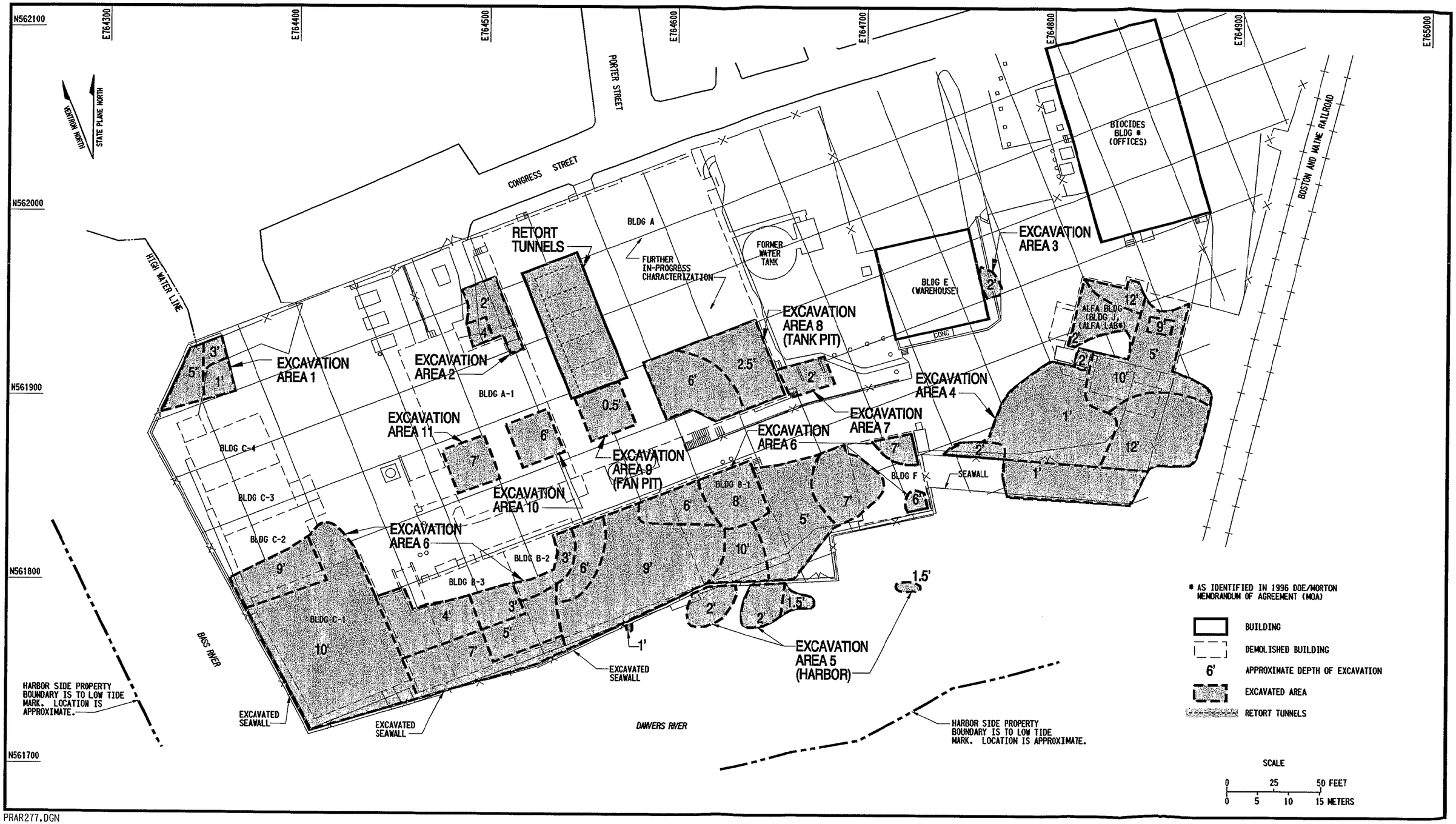
All personnel working in radioactively contaminated areas were required to wear disposable coveralls, booties, gloves, safety glasses, and hard hats. When conditions warranted, additional protective clothing and personal protective equipment (PPE) such as hoods, face shields, and respirators were required, as specified in the health and safety instructions.

Workers exiting radioactively contaminated work areas were subjected to a whole-body scan (frisked) at the control point with a hand-held radiation detection instrument by personnel who had received Radiological Worker II training; the scan ensured that protective clothing was not contaminated and prevented spread of contamination to clean areas. Workers were resurveyed




PRAR259.DGN

**Figure 3-1**
**Ventron Site**
**Expected Areas of Excavation**




PRAR277.DGN

**Figure 3-2**
**Ventron Site**
**Areas of Retort Tunnels and Excavation, and Further Excavation Depth Characterization**

(boots and hands) after removing PPE to ensure that no material was transferred to personal clothing or skin. Contaminated PPE was placed in containers and shipped for disposal as low-level radioactive waste. Uncontaminated PPE was disposed of as solid waste.

The primary potential pathways by which persons onsite and offsite could be exposed to radioactive material generated at the site during removal activities are inhalation and ingestion of radioactively contaminated airborne dust generated during excavation. During remedial action, the spread of contamination and personnel exposure were minimized by the following measures:

- A fine water mist was sprayed as needed to control dust during soil removal and transport.
- Trucks hauling contaminated materials were fitted with liners, and the loads were covered to prevent loss of the contents.
- Silt fences were placed around excavated areas to prevent runoff of potentially contaminated sediment until sampling results confirmed that contamination had been removed.

Perimeter air particulate sampling adjacent to areas being remediated was conducted to ensure that no member of the general public was exposed to radioactivity above applicable guidelines (DOE 1990). The derived concentration guide (DCG) for air represents the concentration of a particular radionuclide that would yield a committed effective dose equivalent of 100 mrem/y (the DOE basic dose limit) to an individual continuously exposed to the radionuclide by inhalation for an entire year. This guideline was established to protect members of the general public against undue risk from radiation. High-volume air samplers were used to collect air samples for calculation of the air particulate concentration. The samples were collected and counted daily after sufficient time was allowed for radon progeny decay. Concentrations of uranium-238 measured by area particulate air samplers ranged from $5.38 \times 10^{-15}$ µCi/mL ($2.0 \times 10^{-6}$ pCi/L) to $9.87 \times 10^{-13}$ µCi/mL (0.001 pCi/L). The DCG for uranium-238 is $2.0 \times 10^{-12}$ µCi/mL (0.002 pCi/L), which is 2.0 times greater than any activity detected at the site.

## 3.3 POST-REMEDIAL ACTION ACTIVITIES

### 3.3.1 Overview

Following remediation, samples and surveys were done by the project management contractor (PMC) to verify compliance with radiological cleanup criteria. Samples and surveys were also done by ORISE, the independent verification contractor (IVC), to verify compliance with criteria in effect at the time of remediation. The following section provides a discussion of PMC verification procedures. A discussion of IVC procedures is provided in Section 6.

### 3.3.2 Survey Techniques

After the material was excavated, the site was subdivided into 100-$m^2$ grids (10 m by 10 m). In some areas, the grids were smaller because of physical limitations of the site. A gamma walkover survey was performed in each grid using an Eberline SPA-3 gamma scintillation detector or a field instrument for detection of low-energy radiation (FIDLER). After survey results indicated that remediation was complete, post-remedial action samples were collected from the excavated area in accordance with the post-remedial action survey plan (BNI 1996).

Radiological walkovers were performed in each survey grid to detect the emission of high and low energy gamma radiation. The low energy gamma radiation was detected with a Bicron FIDLER equipped with a 5-in.-diameter by 0.063-in.-thick sodium iodide crystal. The high-energy gamma radiation was detected with the Eberline SPA-3 equipped with a 2-in. by 2-in. sodium iodide crystal. Table 6-7, page 6-47 in the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM), Revision 1 (DoD et al 2000), lists the scan MDCs for the SPA-3 as: 2.8 pCi/g (104 Bq/kg) Ra-226, 1.8 pCi/g (677 Bq/kg) Th-232, and 80 pCi/g (2,960 Bq/kg) total uranium. Each 10-m by 10-m grid was divided into approximately ten 1-m-wide transects which were walked over, with the instruments being moved from side to side covering approximately a 1-m-wide swath with each stride.

Normal verification sampling was conducted by collecting 25 evenly spaced samples per 100-$m^2$. These 25 samples were then composited into a single sample. For grids of less than 100-$m^2$, the composite sample was generated at the proportionally reduced ratio equivalent to 25 samples per 100-$m^2$ or a minimum of four samples per area composited. Locations next to the sea wall (see Figure D-2) were all less than 100-$m^2$ and were treated in this manner.

In general, discrete samples were taken using one of three different methods. The first method was to take a sample from the portion of the grid with the highest SPA-3 readings ("Highest Area"). The second method, used primarily in Phase II of the Alfa Building excavation, is to take evenly spaced discrete samples from the entire excavation. The third method, used primarily in the Harbor excavation, is to take five discrete samples in an X pattern from each survey grid.

The soil samples were analyzed on a lead-shielded FIDLER and then sent to either the ThermoNUtech laboratory in Oak Ridge, Tennessee, or the field laboratory at the Wayne Interim Storage Site in Wayne, New Jersey, for gamma spectral analysis to ensure that all soil above cleanup criteria had been removed. If the analysis (or the lead-shielded FIDLER readings) indicated residual radioactive material above criteria, additional excavation was performed, and additional post-remedial action samples were collected and analyzed. The rationale for the sampling program and analytical results are presented in Section 4.

## 4.0 POST-REMEDIAL ACTION MEASUREMENTS

The following section presents the results of post-remedial action measurements taken by BNI following demolition of radioactively contaminated buildings or the completion of areas of excavation to demonstrate compliance with radiological criteria in effect at the conclusion of remediation. IVC post-remediation measurements and conclusions are provided in a separate report.

Data presented in this section are gross sampling results, without the subtraction of background concentrations. Tables referenced in this section are provided in Appendix D.

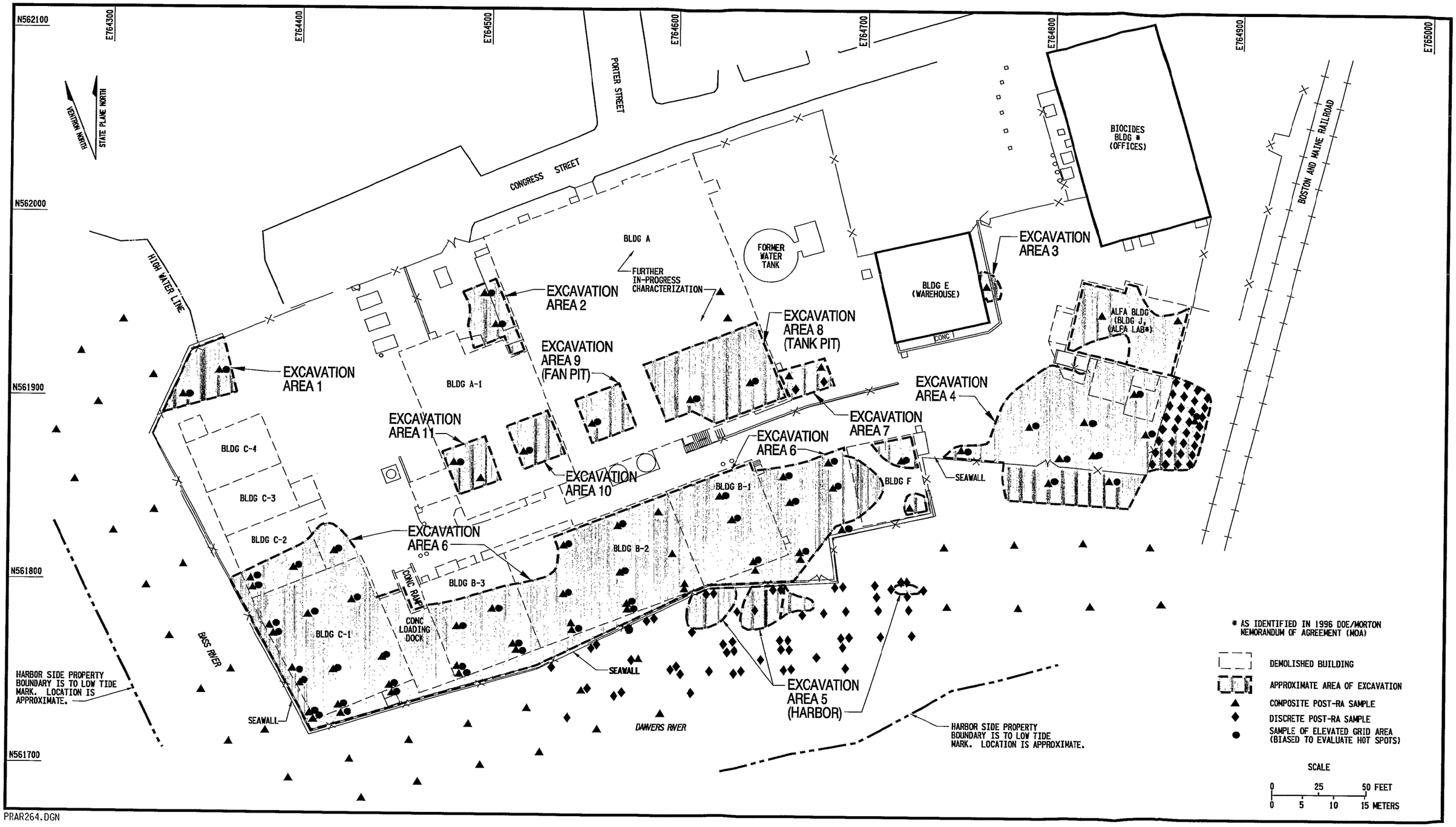
### 4.1 BUILDINGS

Before soil excavation began, buildings A, A-1, B-1, B-2, B-3, C-1, C-2, C-3, C-4, and F were demolished by Morton. The debris from buildings B (B-1, B-2, B-3), C (C-1, C-2, C-3, C-4), and F was shipped to a Class II industrial landfill for disposal. Debris from buildings A and A-1 was crushed, sampled, and stockpiled for use as backfill (see Table D-1). The building debris was sampled by creating a pile of the material crushed each day and taking several composite samples from the pile. Data for the crushed debris from buildings A and A-1 indicated that the concentrations of uranium-238, thorium-232, and radium-226 were below supplemental limit criteria. Uranium-238 concentrations ranged from 0.23 to <4.2 pCi/g (average 2.36 pCi/g). Concentrations of thorium-232 ranged from <0.23 to <1.3 pCi/g (average 0.72 pCi/g), and radium-226 concentrations ranged from <0.16 to 1.2 pCi/g (average 0.60 pCi/g).

As soil remediation progressed, demolition of the Alfa Building (Building J) became necessary in order to access and remove contaminated soil beneath the building. Data from the building material are presented in Table D-2. Uranium-238 concentrations ranged from 0.57 to <9.70 pCi/g (average 3.84 pCi/g). Concentrations of thorium-232 ranged from <0.53 to <2.7 pCi/g (average 1.24 pCi/g), and radium-226 concentrations ranged from <0.37 to <1.60 pCi/g (average 0.97 pCi/g).

### 4.2 EXCAVATIONS

The northwest corner of the site was the first area to be excavated. The actual area of Excavation 1 shown in Figure 4-1 did not vary significantly from the area expected to be excavated. As shown in Table D-3, post-remedial action concentrations of uranium-238 in composite soil samples from Excavation 1 ranged from 6.8 to 8.8 pCi/g (average 7.8 pCi/g). Post-remedial action uranium-238 concentrations in discrete samples collected from the portion




PRAR264.DGN

Figure 4-1
Ventron Site
Areas of Excavation and Post-Remedial Sampling Locations

of the survey grids showing the highest readings during the walkover ranged from 6.6 to 12.7 pCi/g (average 9.7 pCi/g). Post-remedial action concentrations of thorium-232 ranged from 0.79 to 0.92 pCi/g (average 0.86 pCi/g) in composite soil samples and from 0.43 to 1.7 pCi/g (average 1.07 pCi/g) in discrete samples from the portion of the survey grids with the highest walkover survey readings. Post-remedial action concentrations of radium-226 ranged from 0.64 to 1.0 pCi/g (average 0.82 pCi/g) in composite soil samples and from 0.44 to 1.3 pCi/g (average 0.87 pCi/g) in discrete samples from the portion of the survey grids with the highest walkover survey readings. The gamma exposure rate for Excavation 1 ranged from 10.7 to 11.5 μR/h (Table D-11).

Excavation 2 (Figure 4-1) was adjacent to Buildings A and A-1. The excavated area did not vary significantly from the expected area of excavation and did not overlap the contamination from Building A or Building A-1. As shown in Table D-3, post-remedial action concentrations of uranium-238 ranged from 9.9 to 15.8 pCi/g (average 12.9 pCi/g) in composite soil samples and from 14.1 to 34.1 pCi/g (average 24.1 pCi/g) in discrete samples taken from the portion of the survey grids with the highest readings during the walkover. Post-remedial action concentrations of thorium-232 ranged from 0.89 to 1.2 pCi/g (average 1.05 pCi/g) in composite soil samples and from 0.7 to 1.3 pCi/g (average 0.67 pCi/g) in discrete samples from the portion of the survey grids with the highest readings during the walkover. Post-remedial action concentrations of radium-226 ranged from 0.6 to 0.88 pCi/g (average 0.74 pCi/g) in composite soil samples and from 0.65 to 1.0 pCi/g (average 0.83 pCi/g) in discrete samples from the portion of the survey grids with the highest readings during the walkover. The gamma exposure rate for Excavation 2 ranged from 10.7 to 11.5 μR/h (Table D-11).

Excavation 3 (Figure 4-1) was adjacent to Building E (warehouse). During characterization, above-criteria concentrations of uranium-238 (50 pCi/g) were detected in one sample from Excavation 3; however, no above-criteria concentrations of uranium-238 were detected during remediation. It is likely that the contamination was removed during characterization. As shown in Table D-3, post-remedial action radionuclide concentrations in composite soil samples from Excavation 3 were 2.9 pCi/g for uranium-238, <0.81 pCi/g for thorium-232, and 0.6 pCi/g for radium-226. The gamma exposure rate for Excavation 3 was 9.0 μR/h (Table D-11).

Excavation 4 (Figure 4-1) consisted of an area adjacent to the Alfa Building (Phase I), a small area that extended onto the railroad property (Phase II), and the area beneath the Alfa Building (Phase III). The excavated area was larger than expected because additional contamination was discovered as the excavation proceeded. Removal of the additional contamination required the unplanned demolition of the Alfa Building and excavation onto the adjacent railroad property. Although these areas were contiguous, the excavation was conducted in separate phases and the post-remedial action results are treated separately in the following discussion.

As shown in Table D-4, post-remedial action concentrations of uranium-238 in composite soil samples from Excavation 4 Phase I, area south of Alfa Building, ranged from <2.9 to 36.3 pCi/g (average 12.53 pCi/g). Post-remedial action concentrations of uranium-238 in discrete samples from Excavation 4 (Phase I), taken from the portion of the survey grids with the highest readings during the walkover, ranged from <1.9 to 32.6 pCi/g (average 11.8 pCi/g). The post-remedial action concentrations of thorium-232 in composite soil samples from Excavation 4 (Phase I) ranged from <0.66 to 2.1 pCi/g (average 1.23 pCi/g). Post-remedial action concentrations of thorium-232 in discrete samples for the Alfa Building and adjacent area, which were taken from the portion of the survey grids with the highest readings during the walkover, ranged from <0.56 to 7.74 pCi/g (average 2.5 pCi/g). The sample with the highest reading (7.74 pCi/g) was taken from an area of one square meter; this reading is well below the 50 pCi/g criterion for areas of radiological anomaly. The post-remedial action concentrations of radium-226 in composite soil samples for the Alfa Building (Phase I) ranged from 0.49 pCi/g to 1.1 pCi/g (average 0.72 pCi/g). Post-remedial action concentrations of radium-226 in discrete samples for the Alfa Building (Phase I) taken from the portion of the survey grids with the highest readings during the walkover, ranged from <0.3 to 1.15 pCi/g (average 0.67 pCi/g). The gamma exposure rate for Excavation 4 ranged from 10.3 to 14.6 μR/h (Table D-11).

Because remedial action progressed offsite onto an adjacent property used by an active rail line, the schedule for completion of this excavation was closely coordinated with the railroad property owners. To avoid having to access the area more than once for sampling, discrete samples were collected and analyzed along with one composite sample and four samples from the elevated areas. As shown in Table D-4, post-remedial action radionuclide concentrations in the composite sample from the railroad excavation were 16.96 pCi/g for uranium-238, 0.92 pCi/g for thorium-232, and 0.89 pCi/g for radium-226. Post-remedial action concentrations in discrete soil samples from the railroad property (Alfa Building Phase II) ranged from 0.15 to 39.49 pCi/g (average 12.17 pCi/g) for uranium-238; from 0.48 pCi/g to 2.00 pCi/g (average 0.95 pCi/g) for thorium-232; and from 0.45 to 1.46 pCi/g (average 0.81 pCi/g) for radium-226. Post-remedial action concentrations in discrete samples from the portion of the survey grids with the highest readings during the walkover ranged from 24.87 to 46.63 pCi/g (average 36.48 pCi/g) for uranium-238; from 0.98 to 1.4 pCi/g (average 1.18 pCi/g) for thorium-232; and from 0.72 to 0.88 pCi/g (average 0.84 pCi/g) for radium-226.

Excavation 4 Phase III consisted of the area under the Alfa Building (Figure 4-1). As shown in Table D-4 (Phase III), post-remedial action concentrations of uranium-238 in composite soil samples ranged from 7.42 to 35.08 pCi/g (average 20.76 pCi/g). The post-remedial action concentrations of thorium-232 in composite soil samples from Excavation 4 (Phase III) ranged from 0.78 to 0.91 pCi/g (average 0.84 pCi/g). The post-remedial action concentrations of

radium-226 in composite soil samples for the Alfa Building (Phase III) ranged from 0.61 pCi/g to 0.81 pCi/g (average 0.70 pCi/g). No discrete samples were taken during Phase III of Excavation 4.

Excavation 5 (Figure 4-1) consisted of the harbor area. During September 1995 (Phase I), most of the harbor area was excavated and surveyed. Post-remedial action data indicated that grids 1 through 19, 21 through 27, and 31 through 43 (Appendix E, Figure D-1) met radiological release criteria. The remaining grids (20, 28 through 30, and 44 through 46) were remediated and surveyed during the remedial action conducted from May 1996 through March 1997 (Phase II). Grids 20, 28, 29, and 30 required excavation; grids 44, 45, and 46 were surveyed and found to meet radiological release criteria. As shown in Table D-5, post-remedial action concentrations of uranium-238 in soil samples (composite) for grids (1–19, 21–27, and 31–43) ranged from 0.37 to 21.5 pCi/g (average 3.86 pCi/g). Post-remedial action concentrations of thorium-232 in composite soil samples for Phase I grids ranged from 0.26 to 3.60 pCi/g (average 0.65 pCi/g). Post-remedial action concentrations of radium-226 in composite soil samples for Phase I grids ranged from 0.29 to 1.00 pCi/g (average 0.50 pCi/g). The gamma exposure rate for Excavation 5 Phase I ranged from 8.0 to 12.0 μR/h (Table D-11).

Post-remedial action concentrations of uranium-238 in Phase II samples (grids 20, 21, 28 through 32, and 44 through 46) ranged from 1.1 to 37.6 pCi/g (average 5.42 pCi/g). Post-remedial action concentrations of thorium-232 in Phase II samples ranged from 0.35 to 2.00 pCi/g (average 0.69 pCi/g). Post-remedial action concentrations of radium-226 in Phase II samples ranged from 0.26 to 1.3 pCi/g (average 0.62 pCi/g). The gamma exposure rate for Excavation 5 Phase II ranged from 8.0 to 10.0 μR/h (Table D-11).

Excavation 6 (Figure 4-1) was comprised of two discrete areas: the area within 12 ft of the seawall and the area extending from the Building C slab, across the Building B slab, to the Building F slab. The excavation area was flooded except during periods of low tide, during which time excavation could proceed

Before work began in Excavation 6, the area within approximately 4 m (12 ft) of the seawall was excavated, verified, and backfilled. Engineering constraints imposed by the instability of the seawall required that no more than a 3-m- (10-ft) -wide section of the wall be exposed at any given time during excavation in the vicinity of the seawall. Additionally, the exposed section was to be backfilled within 24 hours of the excavation. To facilitate backfilling, a lead-shielded FIDLER was used to screen samples. The FIDLER was calibrated by taking readings from samples that had been analyzed at an offsite laboratory, and a control chart was developed using the laboratory results for those samples. The use of the lead-shielded FIDLER resulted in substantial cost savings for the project by reducing stand-down time while still meeting remedial action guidelines.

As shown in Table D-6, post-remedial action concentrations of uranium-238 ranged from 3.78 to 38.1 pCi/g (average 18.71 pCi/g) in composite soil samples and from 2.2 to 29.6 pCi/g (average 12.44 pCi/g) in discrete samples from the portion of the survey grids with the highest reading during the walkover. Post-remedial action concentrations of thorium-232 ranged from 0.52 to 1.6 pCi/g (average 0.83 pCi/g) in composite soil samples and from 0.42 to 2.59 pCi/g (average 0.90 pCi/g) in discrete samples from the portion of the survey grids with the highest reading during the walkover. Post- remedial action concentrations of radium-226 ranged from 0.34 to 1.9 pCi/g (average 0.71 pCi/g) in composite soil samples and from 0.34 to 2.24 pCi/g (average 0.73 pCi/g) in discrete samples from the portion of the survey grids with the highest reading during the walkover.

With regards to the remainder of Excavation 6, the excavated area was much larger than expected because additional contamination was discovered as the excavation proceeded. As shown in Table D-7, post-remedial action concentrations of uranium-238 ranged from 4.17 to 45.79 pCi/g (average 22.41 pCi/g) in composite soil samples and from <4.03 to 48.50 pCi/g (average 21.0 pCi/g) in discrete samples from the portion of the survey grids with the highest readings during the walkover. Post-remedial action concentrations of thorium-232 ranged from 0.45 to 1.18 pCi/g (average 0.80 pCi/g) in composite soil samples and from 0.55 to 2.55 pCi/g (average 0.93 pCi/g) in discrete samples from the portion of the survey grids with the highest readings during the walkover. Post-remedial action concentrations of radium-226 ranged from 0.45 to 1.08 pCi/g (average 0.70 pCi/g) in composite soil samples and from 0.38 to 2.24 pCi/g (average 0.74 pCi/g) in discrete samples from the portion of the survey grids with the highest readings during the walkover. The gamma exposure rate for Excavation 6 ranged from 9.0 to 12.0 μR/h (Table D-11).

Excavation 7 (Figure 4-1) consisted of an area between Buildings A and E. Characterization data indicated above-criteria concentrations of uranium-238 (57 pCi/g and 97 pCi/g) in two samples from this area; however, no uranium-238 concentrations above criteria were detected during remediation. It is likely that the contamination was removed during characterization. As shown in Table D-8, post-remedial action concentrations of uranium-238 ranged from <4.52 to <4.63 pCi/g (average 4.56 pCi/g) in composite soil samples and from <3.82 to 10.89 pCi/g (average 7.36 pCi/g) in discrete samples from the portion of the survey grids with the highest reading during the walkover. Post-remedial action concentrations of thorium-232 ranged from 0.67 to 0.94 pCi/g (average 0.81 pCi/g) in composite soil samples and from 0.69 to 0.84 pCi/g (average 0.77 pCi/g) in discrete samples from the portion of the survey grids with the highest reading during the walkover. Post-remedial action concentrations of radium-226 ranged from 0.56 to 0.68 pCi/g (average 0.62 pCi/g) in composite soil samples and from 0.6 to 0.7 pCi/g (average 0.65 pCi/g) in discrete samples from the portion of the survey grids with the highest reading during the walkover. Only one gamma exposure rate measurement was made for Excavation 7 with a value of 11.0 μR/h (Table D-11).

Excavation 8 entailed the removal of material beneath the leach tank pit in Building A (Figure 4-1). The leach tank pit was an area that contained a tank used in the batch process leaching of ores during MED/AEC activities. Contaminated soils and pipes were discovered below the concrete floor of the pit, necessitating the excavation of this area. As shown in Table D-9, post-remedial action concentrations of radionuclides in the composite soil sample were 8.38 pCi/g for uranium-238, 1.03 pCi/g for thorium-232, and 0.71 pCi/g for radium-226.

Excavation 9 was the area beneath the fan pit. The fan pit contained a fan used to exhaust the retort ovens in Building A (Figure 4-1). Soil beneath the concrete floor of the fan pit was found to be contaminated and required excavation. As shown in Table D-9, post-remedial concentrations of uranium-238 were 6.72 pCi/g in the composite soil sample and 13.75 pCi/g in the discrete sample from the portion of the survey grid with the highest reading during the walkover. Post-remedial action concentrations of thorium-232 were 0.51 pCi/g in the composite soil sample and 1.42 pCi/g in the discrete sample from the portion of the survey grid with the highest reading during the walkover. Post-remedial action concentrations of radium-226 were 0.42 pCi/g in the composite soil sample and 1.16 pCi/g in the discrete sample from the portion of the survey grid with the highest reading during the walkover.

Excavation 10 was an area of soil contamination beneath Building A-1 adjacent to Building A. During site remediation the Building A-1 slab was broken up, walked over with scanning instruments, and subslab contaminated soil was discovered (Figure 4-1). This area was excavated to a depth of approximately six feet. Due to the small size of this excavation (smaller than a survey grid) one composite sample and one discrete sample (from the area of highest walkover instrument reading) were taken. As shown in Table D-9, the post-remedial action concentration of uranium-238 was 4.18 pCi/g in the composite soil sample and 1.52 pCi/g in the discrete soil sample. The post-remedial action concentration of thorium-232 was 1.08 pCi/g in the composite soil sample and 2.2 pCi/g in the discrete soil sample. The post-remedial action concentration of radium-226 was 1.03 pCi/g in the composite sample and 2.62 pCi/g in the discrete sample.

Excavation 11 was an area of soil contamination beneath Building A-1 that was not contiguous with Excavation 10. During site remediation, contaminated soil was discovered here (Figure 4-1) and was excavated to a depth of approximately seven ft. Due to the small size of this excavation (smaller than a survey grid) one composite sample and one discrete sample (from the area of highest walkover instrument reading) were taken. As shown in Table D-9, the post-remedial action concentration of uranium-238 was 3.89 pCi/g in the composite soil sample and 22.51 pCi/g in the discrete soil sample. The post-remedial action concentration of thorium-232 was 2.46 pCi/g in the composite soil sample and 0.90 pCi/g in the discrete soil sample. The post-

remedial action concentration of radium-226 was 2.69 pCi/g in the composite sample and 1.01 pCi/g in the discrete sample.

## 4.3 OTHER AREAS OF REMEDIATION

Several other areas of the site were addressed during remediation as follows.

To demonstrate that the soil beneath the majority of Building A slab was uncontaminated, 21 discrete samples were taken from various locations (see Figure 4-1). Uranium-238 concentrations in these soil samples ranged from 2.40 to 10.20 pCi/g (average 3.88 pCi/g). Concentrations of thorium-232 ranged from 0.60 to 2.50 pCi/g (average 1.50 pCi/g), and radium-226 concentrations ranged from 0.48 to 2.70 pCi/g (average 1.83 pCi/g) (see Table D-10).

The bank of retort ovens in Building A exhausted into a tunnel directly beneath the building (Figure 4-1). The tunnel contained radioactively contaminated material that was also contaminated with asbestos. The asbestos-contaminated material was removed by Morton from the retort tunnel, bagged, packaged in accordance with 49 CFR 173.1050 and Occupational Safety and Health Administration (OSHA) regulations in 29 CFR 1926.1101, and shipped for disposal as low-level radioactive waste at a commercial disposal facility. All asbestos work was performed in accordance with applicable OSHA and Massachusetts State standards to protect workers from inadvertent exposure to the asbestos material.

The seawall at the Ventron site is on the order of 100 years old and is composed primarily of granite boulders stacked one on another to a height of approximately 12 ft. The seawall is roughly 640 ft long and forms the western and southern boundaries of the site. The thickness of the wall varies from about four feet at the base to about two feet at the top and is estimated to be 20 percent void space.

Residual contamination within the seawall could not be remediated because of its stability and safety concerns. To estimate potential concentrations of total uranium in the rubble if the seawall were demolished, a calculation was performed using data obtained during remedial action. The total activity on the outer surfaces of the rocks was assumed to be dispersed throughout the rubble. The calculation results indicated that the total uranium concentration in the rubble (0.72 pCi/g total uranium) would be less than 1 percent of the volumetric soil guideline of 100 pCi/g established for the Ventron site (BNI 1997). Based on results of the calculation, total uranium concentrations for the seawall are below applicable guidelines, and the seawall required no further action.

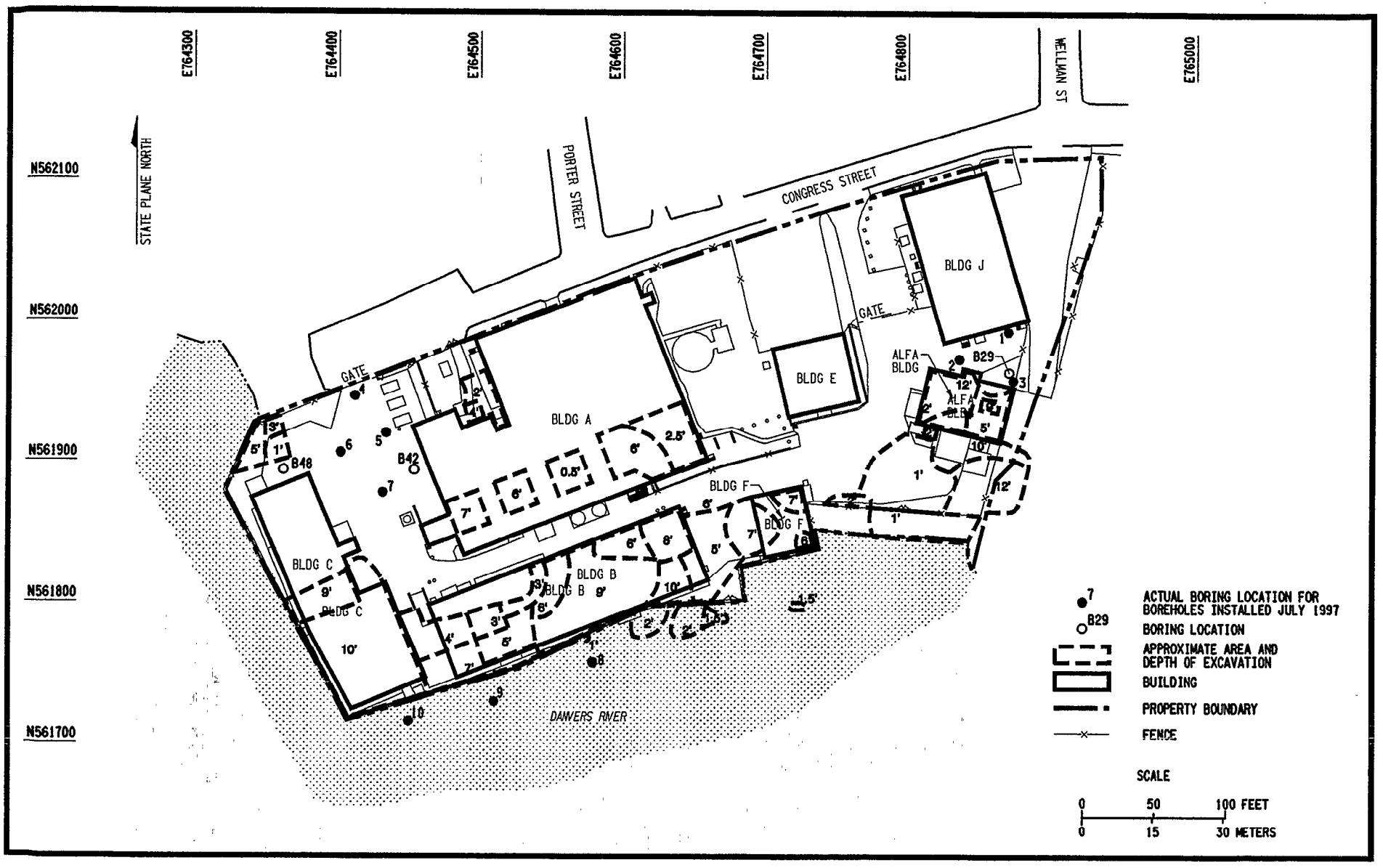
## 5.0 SUPPLEMENTAL SAMPLING TO CONFIRM DATA SUFFICIENCY

Because of concerns about the final radiological status of the Ventron site, additional sampling was performed during July 1997. Seven onsite boreholes and three boreholes in the harbor were drilled and sampled (see Figure 5-1 and Table 5-1). Samples were collected from each 1-ft increment until refusal for the onsite boreholes. The majority of the samples in the harbor were collected in 6-in. increments, with one sample being collected from a 1-ft increment. All samples were analyzed for uranium-238, radium-226, and thorium-232.

Uranium-238 concentrations in the onsite soil samples ranged from 1.14 to 24.57 pCi/g (average 6.24 pCi/g). Concentrations of thorium-232 ranged from 0.50 to 1.77 pCi/g (average 0.82 pCi/g), and radium-226 concentrations ranged from 0.51 to 2.09 pCi/g (average 0.73 pCi/g).

Uranium-238 concentrations in the harbor soil samples ranged from 2.39 to 13.17 pCi/g (average 5.30 pCi/g). Concentrations of thorium-232 ranged from 0.38 to 0.60 pCi/g (average 0.49 pCi/g), and radium-226 concentrations ranged from 0.36 to 0.59 pCi/g (average 0.43 pCi/g).

All supplemental sample results were well below the cleanup criteria of 50 pCi/g U-238; 5 pCi/g thorium-232; and 5 pCi/g radium-226. This supplemental post-remedial action data addresses the issues concerning the sufficiency of the data to demonstrate site-wide compliance with the cleanup criteria. The report on this activity is provided as Appendix C.




O:\14501\REPORTS\R108\R108F10.DGN
11/27/2001

**Figure 5-1**
**Supplemental Sampling Locations at Ventron**

## Table 5-1
## Post-Remedial Action Data, July 1997 Supplemental Sampling

| Borehole | Sample ID | Depth (ft) | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| **Onsite** | | | | | |
| 1 (Alfa Building) | 127-RS-0800 | 0 – 1 | <2.55 | 0.6 +/- 0.06 | 0.55 +/- 0.04 |
| 1 (Alfa Building) | 127-RS-0801 | 1 – 2 | 4.30 +/- 1.36 | 0.78 +/- 0.07 | 0.64 +/- 0.05 |
| 1 (Alfa Building) | 127-RS-0802 | 2 – 3 | 6.61 +/- 1.28 | 0.51 +/- 0.06 | 0.65 +/- 0.04 |
| 1 (Alfa Building) | 127-RS-0803 | 3 – 4 | 3.31 +/- 1.00 | 0.65 +/- 0.06 | 0.65 +/- 0.04 |
| 1 (Alfa Building) | 127-RS-0804 | 4 – 5 | 1.98 +/- 1.06 | 0.61 +/- 0.07 | 0.65 +/- 0.05 |
| 1 (Alfa Building) | 127-RS-0805 | 5 – 5.5 | 2.27 +/- 1.13 | 0.61 +/- 0.07 | 0.51 +/- 0.05 |
| | | | | | |
| 2 (Alfa Building) | 127-RS-0806 | 0 – 1 | 4.15 +/- 0.93 | 0.55 +/- 0.06 | 0.52 +/- 0.04 |
| 2 (Alfa Building) | 127-RS-0807 | 1 – 2 | 8.57 +/- 1.18 | 0.72 +/- 0.06 | 0.55 +/- 0.04 |
| 2 (Alfa Building) | 127-RS-0808 | 2 – 3 | 16.29 +/- 1.67 | 0.61 +/- 0.06 | 0.61 +/- 0.04 |
| 2 (Alfa Building) | 127-RS-0814 | 3 – 3.75 | 12.42 +/- 1.49 | 0.74 +/- 0.06 | 0.55 +/- 0.04 |
| | | | | | |
| 3 (Alfa Building) | 127-RS-0809 | 0 – 1 | 11.70 +/- 1.49 | 0.71 +/- 0.07 | 0.66 +/- 0.04 |
| 3 (Alfa Building) | 127-RS-0810 | 1 – 2 | 24.57 +/- 1.24 | 0.67 +/- 0.06 | 0.63 +/- 0.04 |
| 3 (Alfa Building) | 127-RS-0811 | 2 – 3 | 13.11 +/- 1.31 | 0.61 +/- 0.06 | 0.60 +/- 0.04 |
| 3 (Alfa Building) | 127-RS-0812 | 3 – 4 | 17.33 +/- 1.73 | 0.73 +/- 0.07 | 0.61 +/- 0.04 |
| 3 (Alfa Building) | 127-RS-0813 | 4 – 5 | 14.35 +/- 1.59 | 0.66 +/- 0.07 | 0.61 +/- 0.04 |
| | | | | | |
| 4 (Building A/C Area) | 127-RS-0815 | 0 – 1 | 2.24 +/- 1.04 | 1.16 +/- 0.07 | 1.39 +/- 0.06 |
| 4 (Building A/C Area) | 127-RS-0816 | 1 – 2 | <4.08 | 1.77 +/- 0.10 | 2.09 +/- 0.08 |
| 4 (Building A/C Area) | 127-RS-0817 | 2 – 3 | 4.71 +/- 1.22 | 0.97 +/- 0.08 | 1.08 +/- 0.05 |
| 4 (Building A/C Area) | 127-RS-0818 | 3 – 4 | 2.94 +/- 1.39 | 1.59 +/- 0.09 | 1.35 +/- 0.06 |
| | | | | | |
| 5 (Building A/C Area) | 127-RS-0819 | 0 – 1 | <2.95 | 0.50 +/- 0.05 | 0.55 +/- 0.04 |
| 5 (Building A/C Area) | 127-RS-0820 | 1 – 2 | 2.98 +/- 1.37 | 0.71 +/- 0.06 | 0.74 +/- 0.05 |
| 5 (Building A/C Area) | 127-RS-0821 | 2 – 3 | 4.28 +/- 1.09 | 0.68 +/- 0.06 | 0.73 +/- 0.05 |
| 5 (Building A/C Area) | 127-RS-0822 | 3 – 4 | 5.10 +/- 1.13 | 0.81 +/- 0.07 | 0.78 +/- 0.05 |
| | | | | | |
| 6 (Building A/C Area) | 127-RS-0823 | 0 – 1 | <3.17 | 0.56 +/- 0.06 | 0.65 +/- 0.04 |
| 6 (Building A/C Area) | 127-RS-0824 | 1 – 2 | 1.14 +/- 0.96 | 0.57 +/- 0.06 | 0.62 +/- 0.04 |
| 6 (Building A/C Area) | 127-RS-0825 | 2 – 3 | 1.77 +/- 0.94 | 0.78 +/- 0.06 | 0.69 +/- 0.04 |
| 6 (Building A/C Area) | 127-RS-0826 | 3 – 4 | 4.19 +/- 1.24 | 0.90 +/- 0.07 | 0.64 +/- 0.04 |
| 6 (Building A/C Area) | 127-RS-0827 | 4 – 5 | 2.77 +/- 1.19 | 0.74 +/- 0.07 | 0.71 +/- 0.04 |
| | | | | | |
| 7 (Building A/C Area) | 127-RS-0828 | 0 – 1 | 3.72 +/- 1.01 | 0.69 +/- 0.06 | 0.51 +/- 0.04 |
| 7 (Building A/C Area) | 127-RS-0829 | 1 – 2 | 3.90 +/- 1.25 | 0.67 +/- 0.07 | 0.66 +/- 0.04 |
| 7 (Building A/C Area) | 127-RS-0830 | 2 – 3 | <3.37 | 0.84 +/- 0.07 | 0.56 +/- 0.05 |
| 7 (Building A/C Area) | 127-RS-0831 | 3 – 4 | 2.79 +/- 1.14 | 0.86 +/- 0.07 | 0.72 +/- 0.05 |
| | | | | | |

**Table 5-1 (continued)**

| Borehole | Sample ID | Depth (ft) | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| **Harbor** | | | | | |
| 8 (Grid 31) | 127-RS-0832 | 2 – 3 | <2.55 | 0.60 +/- 0.06 | 0.43 +/- 0.04 |
| 8 (Grid 31) | 127-RS-0833 | 3 – 3.5 | <2.39 | 0.44 +/- 0.05 | 0.37 +/- 0.04 |
| | | | | | |
| 9 (Grid 33) | 127-RS-0834 | 2 – 2.5 | <2.72 | 0.53 +/- 0.06 | 0.59 +/- 0.04 |
| | | | | | |
| 10 (Grid 16) | 127-RS-0835 | 2 – 2.5 | 13.17 +/- 1.26 | 0.52 +/- 0.06 | 0.39 +/- 0.04 |
| 10 (Grid 16) | 127-RS-0836 | 2.5 – 3 | 5.68 +/- 0.96 | 0.38 +/- 0.06 | 0.36 +/- 0.03 |

## 6.0 POST-REMEDIAL ACTION STATUS

Analytical results of post-remedial action surveys indicate that the levels of radioactivity in the remediated areas are in compliance with applicable cleanup guidelines for radioactive contamination. The IVC reviewed the post-remedial action survey methods and results to determine whether the radiological measurements confirm that the remediated areas comply with the guidelines established for the site.

The IVC is responsible for preparing a plan outlining the procedures used in conducting verification activities. These procedures specify a verification process requiring two methods of review (Types A and B). Type A verification consists of reviewing the post-remedial action survey results and collecting and analyzing additional samples as required. The Type B verification review consists of an independent site survey by the IVC including direct radiological measurements, review of post-remedial action survey methods and results, sampling, and laboratory analysis of separate soil samples. The IVC conducted both types of review, in full conformance with the approved verification plan.

After completing the verification study, the IVC will report its findings and recommendations to DOE. DOE will review the report to verify that the remedial action was successful. The IVC's published verification report will then become part of the CERCLA Administrative Record file for the Ventron site.

## REFERENCES


BNI (Bechtel National, Inc.), 1988. "Site Plan for Ventron Division of Morton Thiokol, Inc., Beverly, Massachusetts," DOE/OR/20722-117, Revision 1, Oak Ridge, Tenn. (July).

BNI, 1995. "Post-Remedial Action Survey Plan for the Ventron Harbor," CCN 133725 (August).

BNI, 1996. "FUSRAP PRASP Implementation for the Ventron Site," CCN 144008 (July).

BNI, 1.997. "Total Uranium in Seawall Rubble at the Ventron Site," Calculation No. 127-CV-07, Rev. 0, Oak Ridge, TN, (September).

DOE (U.S. Department of Energy), 1990. "Radiation Protection of the Public and the Environment," DOE Order 5400.5, Chapter IV, *Residual Radioactive Material,* Office of Environment, Safety, and Health, Washington, D. C. (February).

DOE, 1993. Letter from A. Williams (DOE-HQ) to L. Price (DOE-FSRD), "Uranium Guidelines for Ventron Site, Beverly, MA," CCN 108174, September 1.

DOE, 1995. "Characterization Report for the Ventron Site, Beverly, Massachusetts," DOE/OR/21950-1011, Oak Ridge, Tenn. (December).

DOE, 1996a. Letters from J. Kopotic (DOE-FSRD) to L. Alexander (Massachusetts Department of Environmental Protection) and T. O'Connell (Massachusetts Department of Health), "Ventron Site Transmittal of Dose Calculation and Remedial Action Approach," CCN 140242, March 15, 1996, with attachment CCN 140210, March 18, 1996, and CCN 142718, May 30.

DOE, 1996b. "Engineering Evaluation/Cost Analysis for the Ventron Site, Beverly, Massachusetts," DOE/OR/21950-1014, Oak Ridge, Tenn. (May).

DOE, 1996c. Letter from J. Kopotic (DOE-FSRD) to A. Raddatz (Morton International), "Ventron Site – Disposal of Building Demolition Debris," CCN 142976, June 3.

DOE, 1996d. Memorandum from A. Johnson (DOE-HQ) to L. Price (DOE-FSRD), "Ventron - Approval of Proposed Remediation Approach for Residual Radioactive Material," CCN 142335, May 17.

DOE, 1997a. Memorandum from J. Kopotic (DOE-FSRD) to A. Williams (DOE-HQ), "Request for Approval of Proposed Remediation Approach for Residual Radioactive Material at the Ventron Site," CCN 127-GOA-GAM-00006, September 22.

DOE, 1997b. Memorandum from A. Johnson (DOE-HQ) to W. Seay (DOE-FSRD), "Ratification, Confirmation, and Changes to Supplemental Standards for Residual Radioactive Material at the Ventron Site, Beverly, Massachusetts," CCN 127-GOA-GAM-00007, September 29.

DoD, DOE, EPA, NRC, 2000. Table 6.7, "Nal (TI) Scintillation Detector Scan MDCs for Common Radiological Contaminants," *Multi-Agency Radiation Survey and Site Investigation Manual,* Revision 1, p. 6-47 (August).

MDEP (Massachusetts Department of Environmental Protection), 1996a. Letter from L. Alexander (MDEP) to J. Kopotic (DOE-FSRD), "Demolition of Building A & A-1; Risk Characterization Report," CCN 143797, June 21.

MDPH (Massachusetts Department of Public Health), 1996b. Letter from T. O'Connell to J. Koptic (DOE), "Approval of Remediation Approach," CNN 143840, June 21.

ORNL (Oak Ridge National Laboratory), 1988. "Results of the Radiological Survey at the Ventron Site, Beverly, Massachusetts," ORNL/TM-10053, Oak Ridge, Tenn. (May).

# GLOSSARY

**Alpha-emitting** - See **Radiation.**

**Ambient Background Radiation** - Ambient background radiation refers to naturally occurring radiation emitted from either cosmic (i.e., from the sun) or terrestrial (i.e., from the earth) sources. Exposure to this type of radiation is unavoidable, and its level varies greatly depending on geographic location. For example, New Jersey typically receives 100 mrem/y, Colorado receives about 115 mrem/y, and some areas in South America receive up to 7,000 mrem/y. Naturally occurring terrestrial radionuclides include uranium, radium, potassium, and thorium (see **Radionuclide**). The dose levels do not include the concentrations of naturally occurring radon inside buildings.

**Beta/gamma-emitting** - See **Radiation.**

**Centimeter** - A centimeter (cm) is a metric unit of measure for length; 1 in. is equal to 2.54 cm; 1 ft is equal to approximately 30 cm.

**Contamination** - The term "contamination" is used generally to mean a concentration of one or more radioactive materials that exceeds naturally occurring levels. Contamination may or may not exceed the DOE cleanup guidelines.

**Disintegrations per minute** - Disintegrations per minute (dpm) is the measurement indicating the amount of radiation being released from a substance per minute.

**Dose** - As used in this report, dose is actually dose equivalent and is used to relate absorbed dose (mrad) to an effect on the body. Dose is measured in millirems (mrem). For comparison, a dose of 500,000 mrem to the whole body within a sort time causes death in 50 percent of the people who receive it; a dose of 5,000,000 mrem may be delivered to a cancerous tumor during radiation treatment; normal background radiation at or near sea level results in an annual dose of about 100 mrem; DOE radiation protection standards limit the dose that may be received by members of the general public to 100 mrem/y above background levels; living in a brick house typically results in a dose of about 75 mrem/y above the background level.

**Exposure Rate** - Exposure rate is the rate at which radiation imparts energy to the air. Exposure is typically measured in microroentgens (μR), and exposure rate is typically expressed as μR/h. The dose to the whole body can be approximated by multiplying the exposure rate by the number of hours of exposure. For example, if an individual were exposed to gamma radiation at a rate of 20

μR/h for 168 h/week (continuous exposure) for 52 weeks/y, the whole-body dose would be approximately 175 mrem/y.

**Gamma Radiation** - See **Radiation.**

**Meter** - A meter (m) is a metric unit of length; 1 m is equal to approximately 39 in.

**Microroentgen** - A microroentgen (μR) is a unit used to measure radiation exposure. For further information, **see Exposure Rate.**

**Millirem** - The millirem (mrem) is the unit used to measure radiation dose to man. The DOE dose limit is 100 mrem above background radiation levels within any 1-year period for members of the general public. Naturally occurring radioactive substances in the ground result in a yearly exposure of about 100 mrem to each member of the population. To date, no difference can be detected between the health of population groups exposed to 100 mrem/y above background and the health of groups who are not exposed.

**Natural Background Radiation** - Natural background radiation refers to radiation emitted from the naturally occurring radionuclides found in manmade materials. The concentrations of the radionuclide, and thus the radiation, will vary widely because of variations in the composition of the materials.

**Radiation** - There are three primary types of radiation: alpha, beta, and gamma. Alpha radiation travels less than an inch in air before it stops, and it cannot penetrate the outer layers of human skin. Beta radiation can penetrate the outer layers of skin but cannot reach the internal organs. Gamma radiation, the most penetrating type, can usually reach the internal organs.

**Radionuclide** - Radioactive elements are also referred to as radionuclides. For example, uranium-235 is a radionuclide, uranium-238 is another, thorium-232 is another, and so on.

**Remedial Action** - Remedial action is a general term used to mean "cleanup of contamination that exceeds DOE guidelines." It refers to any action required so that a property may be certified as being in compliance with guidelines and may therefore be released for future use. Remedial action also includes restoring remediated properties to their original conditions as far as possible.

**Uranium** - Uranium is a naturally occurring radioactive element. The principal use of refined uranium is for the production of fuel for nuclear reactors. Uranium in its natural form is not suitable for use as a fuel source.

# APPENDIX A

# DOE/MORTON MEMORANDUM OF AGREEMENT

142126

96 237

# Department of Energy

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831— 8723

May 9, 1996

James J. Fuerholzer
President, Morton Adhesives and Chemical Specialties
Morton International, Inc.
100 North Riverside Plaza
Chicago, Illinois 60606-1598

Dear Mr. Fuerholzer:

**VENTRON SITE - MEMORANDUM OF AGREEMENT**

Enclosed is the final signed Memorandum of Agreement (MOA) supporting upcoming remediation activities at the Ventron Site. I appreciate you and your staff's efforts in developing this mutually beneficial document which also supports the acceleration of the Department of Energy's (DOE) planned remediation activities at the site. DOE is currently planning on mobilizing to the site by mid-June 1996, following Morton's completion of the building demolition effort, with a planned completion in Fall 1996.

On March 27, 1996, a meeting was held at the site with state personnel to tour the site and discuss planned remediation activities. Representatives included Morton International, Massachusetts Departments of Environmental Protection and Radiation Control, and DOE. State personnel were in agreement with the planned remediation approach, but requested additional monitoring which DOE agreed to do.

Again, I appreciate Morton's efforts in helping to develop the MOA, and I look forward to working with your staff toward the successful remediation of the site. It has been a pleasure working with Alicia Raddatz of your staff, and I will continue to coordinate all aspects of DOE's remediation activities at the site with her. Because the MOA addresses joint DOE and Morton responsibilities, I want to stress the importance of close coordination between Morton and DOE to ensure we keep State and Federal officials/agencies, public, and other stakeholders accurately informed of our activities and progress at the site.

If you have any questions regarding the MOA or DOE's remediation plans at the site I can be reach at (423) 576-9441.

Sincerely,

James Kopotic

James D. Kopotic, Site Manager
Former Sites Restoration Division

Enclosure

cc w/enclosure:
A. S. Johnson, EM-421, CL

142126 ~~140450~~

# MEMORANDUM OF AGREEMENT

MORTON INTERNATIONAL, INC. (the "Owner") owns certain real property located in Beverly, Massachusetts, identified as Parcel No. 1 shown on City of Beverly Property No. 1 and filed in Deed Book 10091, page 339 in the records of Essex County, Massachusetts, and shown on the attached Exhibit 1 (the "Premises").

The Department of Energy (the "DOE") is conducting remedial action at sites, including the Premises, used by contractors and/or subcontractors to the Manhattan Engineer District and the Atomic Energy Commission, as part of the Formerly Utilized Sites Remedial Action Program ("FUSRAP").

DOE has previously defined the extent of contamination of the Premises. The following is an agreement reached between the parties of some of the actions to be undertaken by the parties in order that the remediation of the Premises can be accomplished:

1. The Owner will demolish and remove at its expense Buildings B and C (as shown in Exhibit 1) and any equipment located therein, and disconnect power service to the buildings and remove associated service lines and poles. These buildings are not contaminated with radioactive materials. However, the soils underneath Buildings B and C are contaminated, and the DOE will remediate radioactively contaminated soil. The Owner expects that the demolition and removal of Buildings B and C will be completed by the end of May 1996. DOE expects to initiate soil remediation activities within 4 weeks after Buildings B and C have been demolished and removed.

2. As necessary, DOE will decontaminate radioactive interior portions of Buildings A, A-1, and J (former Alfa Laboratory, as shown in Exhibit 1) and any radioactive equipment located therein. Upon completion of such decontamination the Owner will demolish and remove Buildings A, A-1, J and the equipment located therein. After Buildings A, A-1, and J have been demolished and removed, DOE will initiate remediation of radioactive soils beneath or surrounding Buildings A, A-1, and J. DOE will dispose of radioactive residues resulting from the decontamination of Buildings A, A-1, and J.

3. Any buildings to be demolished by the Owner will be taken down to the basement floor slab, including any support structures. DOE will have

responsibility for decontaminating (or otherwise remediating) the radiological component of building foundations and subsurface utilities and structures and for disposing of any such foundations and subsurface utilities and structures that remain radioactive above the clean-up criteria agreed to by DOE and the Commonwealth of Massachusetts Departments of Environmental Protection and Public Health, Radiation Control Program (hereinafter "clean-up criteria"). DOE will remove any building foundations and subsurface utilities or structures that it needs in order to get to radioactive contamination. If such removed foundations and subsurface utilities and structures are not radioactive contaminated above clean-up criteria their ultimate disposition will be the responsibility of the Owner.

4. DOE will be responsible for the remediation, decontamination, and disposition of radiological contamination above clean-up criteria and any non-radiological contaminants that are mixed with such radiological contamination, whether located in or under Buildings A, A-1, B, C, or J, or elsewhere on the Premises.

5. DOE's responsibilities under this agreement will be limited to remediation, decontamination, and disposition of radiological contamination above clean-up criteria and any non-radiological contaminants that are mixed with such radiological contamination, and the owner will be responsible for the disposition of any materials remediated or decontaminated in accordance with the clean-up criteria.

6. Upon completion of the work by DOE, the Owner will, where necessary, backfill, grade and seed the site. DOE expects to notify the Owner in writing, based on existing data, that the Premises meet applicable cleanup criteria, within 6 months of completion of the remediation work,

7. DOE expects to begin its remediation activities in May 1996 with a tentative remediation time of 6 to 8 months. DOE expects to provide a copy of the Post Remedial Action Report to the Owner within 18 months after completion of all remediation activities.

8. The Owner has appointed Alicia Raddatz as the person on site to be contacted by the DOE for matters pertaining to the remediation work. The DOE has appointed Jim Kopotic as the person to be contacted by the Owner and its contractors for matters pertaining to the remediation work.

142126 ~~140458~~

9. Obligations of the DOE under this agreement are subject to the Anti-Deficiency Act, 31 USC Section 1341, as amended, and to the availability of funds appropriated by Congress which DOE may legally spend for such purposes and nothing in this agreement implies that Congress shall appropriate such funds.

10. Access to the Premises and the work to be performed by the DOE and/or its contractors is governed by Real Estate License No. 7-95-0160, as amended, signed by the Owner on 3/20/96.

11. Each party reserves the right to renegotiate this Agreement in the event of significant changes in scope, cost, or discovery of unknown factors. If the Parties, in good faith, are unable to agree to revisions of this Agreement in order to address such events, either Party may terminate this Agreement, by providing 30 days prior written notice to the other Party.

12. DOE's responsibilities under this agreement shall terminate when DOE issues the Federal Register notice and certification docket for the Premises.

The parties hereto have executed the Memorandum of Agreement this 18th of March, 1996.

THE UNITED STATES OF AMERICA
By: DEPARTMENT OF ENERGY

By: Peter K. Prem

Title: Director, Formerly Used Sites Restoration Div.

MORTON INTERNATIONAL, INC.

By: James J. Rusch

Title: Group Vice President

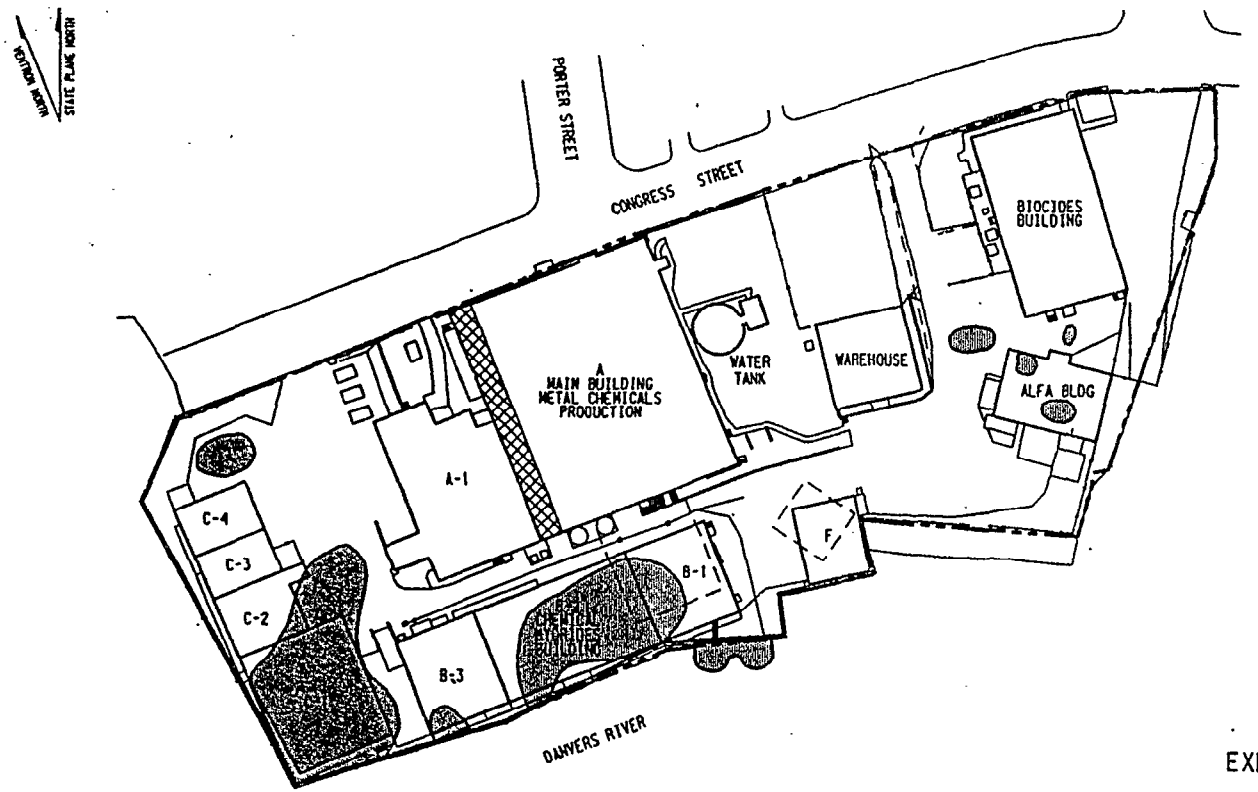



EXHIBIT 1

- TUNNEL AREA
- RADIOLOGICAL CONTAMINATION
- BUILDING
- FENCE
- SITE BOUNDARY
- SITES OF FORMER FOUNDRY FACILITIES DEMOLISHED BETWEEN 1948 AND 1950

SCALE

0 50 100 FEET

0 15 30 METERS

142126

# APPENDIX B

# 1995 HARBOR REMEDIAL ACTION REPORT

138013

FUSRAP Project
Job 14501

127-96-002
NO. _____ REV. NO. 0
DATE: 01-02-96

# FUSRAP TECHNICAL BULLETIN

| Prepared by | Team Lead Approval | Project Engineer Approval | Project Manager Approval |
|---|---|---|---|
| Tim King | Andrew Gerger for Melissa Rivera | | |

## Introduction

### Purpose

This technical bulletin presents information obtained during remedial action at the Ventron Site in Beverly, Massachusetts. The remedial action was limited to the harbor adjacent to the seawall that surrounds the site.

### Selection of Sampling Points

A grid was established in the harbor in an attempt to establish as many 10 meter by 10 meter grids as possible since post remedial action sampling is performed in areas of 100 $m^2$ or less. The grid established is shown in Figure 1. One 25 plug composite sample was collected from each grid following FUSRAP protocol (191-IG-032). In addition to post remedial action samples, characterization samples were collected to assist in the control of the remedial action. The cleanup guideline for the Ventron Site is 50 pCi/g for U-238 (CCN 136542).

## Methodology

### Field Methods

Field methods are outlined in Work Instruction #95-156 and Post-Remedial Action Survey Plan for the Ventron Harbor (CCN 133725). The first activity was to establish a correlation between the FIDLER readings and pCi/g. Based on these samples and background levels for the FIDLER a count rate of 20,000 cpm was used as guidance in the field. The pre-remedial action walkover data is attached in Appendix I. After the walkover was completed areas above 20,000 cpm were targeted for excavation. Three areas were determined to be elevated and are shown on figure 1. Excavations were completed in grids 15 and 32 and post-remedial action samples were collected. The third area in grids 29 and 28 (Figure 1) was to extensive to be removed by manual methods so excavation was halted. This area will be addressed when the onsite remedial action is initiated. Since contamination remains in grids 28 and 29 the adjacent grids (30, 44, 45, 46, and 20) were not released for independent verification. Post-remedial action sampling was performed on all of the remaining grids. For each grid, 25 plugs per 100 $m^2$ were collected and composited into one sample. For grids less than 100 $m^2$ the plugs were reduced proportionally and composited. Soil samples were sent to a dedicated gamma spectroscopy lab at the Wayne site. The Wayne lab provided a quick turn around time to assist decisions made in the field. Splits of the post-remedial action samples were sent to the Oak Ridge Thermo NuTech Laboratory for final analysis. Along with the composite post-remedial action samples boreholes were installed in areas where ORNL had previously detected subsurface contamination and in random locations. The borehole locations are shown in Figure 2. In addition to sampling, gamma exposure rate measurements were taken in each grid.

**Quality Control**

Quality control measures implemented during this effort include a Quality Assurance Assessment (QAA-127G-01).

**Results**

A summary of the composite sample results are shown in Table 1 and borehole data is shown in Table 2. Gamma exposure rate measurements are shown in Table 3. As can be seen in Tables 1 and 2 all soil results are below the U-238 guideline of 50 pCi/g. Table 4 lists the data package "D" numbers that were generated during this effort.

**Summary and Conclusions**

The post-remedial action data, indicate that all grids (1-19, 21-27, 31-43) meet the radiological release criteria for unrestricted use. Although the post-remedial action data for grid 20 was below criteria the IVC detected some elevated areas in the grid. These areas will be addressed during the site remedial action.

Table 1
Ventron Harbor Post-Remedial Action Sample Results

| Sample # | | Grid # | Radionuclide Concentration (pCi/g) U-238 | Ra-226 | Th-232 |
|---|---|---|---|---|---|
| | | | | | |
| 12795006 | | 1 | 0.37 +/- 0.46 | 0.60 +/- 0.09 | 0.46 +/- 0.10 |
| 12795007 | | 2 | <1.90 | 0.47 +/- 0.07 | <0.58 |
| 12795008 | | 3 | <1.70 | 0.44 +/- 0.10 | 0.48 +/- 0.11 |
| 12795009 | | 4 | <1.80 | 0.52 +/- 0.12 | 0.36 +/- 0.19 |
| 12795010 | | 5 | <1.70 | 0.36 +/- 0.09 | <0.53 |
| 12795011 | | 6 | <1.80 | 0.45 +/- 0.07 | 0.27 +/- 0.10 |
| 12795012 | | 7 | <1.50 | 0.39 +/- 0.08 | 0.41 +/- 0.11 |
| 12795013 | | 8 | 1.70 +/- 0.67 | 0.61 +/- 0.11 | 0.26 +/- 0.13 |
| 12795014 | | 9 | 2.70 +/- 0.87 | 0.52 +/- 0.10 | 0.47 +/- 0.07 |
| 12795015 | | 10 | 2.10 +/- 0.81 | 0.39 +/- 0.08 | 0.33 +/- 0.16 |
| 12795016 | | 11 | 8.10 +/- 2.20 | 0.29 +/- 0.09 | 0.58 +/- 0.09 |
| 12795017 | | 12 | <2.70 | 0.45 +/- 0.11 | 0.54 +/- 0.11 |
| 12795018 | | 13 | 1.30 +/- 0.65 | 0.51 +/- 0.10 | 0.65 +/- 0.13 |
| 12795036 | | 14 | <3.10 | 0.40 +/- 0.15 | <0.86 |
| 12795019 | | 15 | 5.60 +/- 1.60 | 0.50 +/- 0.10 | 0.59 +/- 0.11 |
| 12795020 | | 16 | 13.30 +/- 1.70 | 0.43 +/- 0.12 | 0.38 +/- 0.11 |
| 12795031 | | 17 | 9.50 +/- 2.60 | 0.56 +/- 0.08 | 0.34 +/- 0.1[illegible] |
| 12795021 | | 18 | 21.50 +/- 4.40 | 0.57 +/- 0.11 | 0.60 +/- 0.08 |
| 12795022 | | 19 | 3.00 +/- 0.98 | 0.43 +/- 0.11 | 0.71 +/- 0.[illegible] |
| 12795023 | | 20 | 7.70 +/- 2.20 | 0.49 +/- 0.14 | 0.93 +/- 0.14 |
| 12795024 | | 21 | 6.10 +/- 1.70 | 0.70 +/- 0.13 | 0.77 +/- 0.12 |
| 12795025 | | 22 | <2.20 | 0.37 +/- 0.07 | 0.61 +/- 0.11 |
| 12795026 | | 23 | 3.60 +/- 1.10 | 0.53 +/- 0.10 | 0.39 +/- 0.08 |
| 12795027 | | 24 | <2.00 | 0.39 +/- 0.07 | 0.55 +/- 0.13 |
| 12795028 | | 25 | <2.10 | 0.38 +/- 0.08 | 0.78 +/- 0.13 |
| 12795029 | | 26 | <1.90 | 0.56 +/- 0.09 | 0.38 +/- 0.08 |
| 12795030 | | 27 | 1.80 +/- 0.73 | 0.45 +/- 0.10 | 0.35 +/- 0.08 |
| 12795032 | | 31 | 9.80 +/- 2.90 | 0.47 +/- 0.18 | 3.60 +/- 0.67 |
| 12795033 | | 33 | 4.20 +/- 1.30 | 0.52 +/- 0.10 | <0.59 |
| 12795041 | | 34 | <2.40 | 0.44 +/- 0.13 | 0.59 +/- 0.15 |
| 12795042 | | 35 | 0.74 +/- 0.70 | 0.43 +/- 0.13 | 0.67 +/- 0.11 |
| 12795043 | | 36 | 1.10 +/- 0.65 | 0.48 +/- 0.12 | <0.62 |
| 12795044 | | 37 | 1.80 +/- 0.79 | 0.46 +/- 0.13 | <0.64 |
| 12795037 | | 38 | <4.10 | 0.51 +/- 0.13 | 0.36 +/- 0.13 |
| 12795038 | | 39 | <3.10 | 0.51 +/- 0.18 | 0.56 +/- 0.20 |
| 12795039 | | 40 | <4.00 | 0.61 +/- 0.13 | 0.84 +/- 0.19 |
| 12795040 | | 41 | <4.40 | 1.00 +/- 0.28 | 0.60 +/- 0.37 |
| 12795034 | | 42 | <4.40 | 0.52 +/- 0.21 | <1.50 |
| 12795035 | | 43 | 1.30 +/- 1.10 | 0.83 +/- 0.17 | 0.91 +/- 0.19 |

Note: Data in this table can be found in data packages D-23003, D-23034, D-23045, and D-23073
All post-remedial action samples were analyzed at the Oak Ridge Laboratory

Table 2
Ventron Harbor Borehole Sample Results

| Sample # | Borehole # | Depth (ft) | Radionuclide Concentration (pCi/g) U-238 | Ra-226 | Th-232 |
|---|---|---|---|---|---|
| | | | | | |
| 12795045 | 45 | 1-1.5 | 19.10+/-2.30 | 0.44+/-0.10 | <0.78 |
| 12795046 | 46 | 1-1.5 | 24.00+/-2.50 | 0.39+/-0.11 | 0.57+/-0.09 |
| 12795047 | 47 | 1-1.5 | 33.40+/-3.40 | 0.74+/-0.14 | 0.99+/-0.12 |
| 12795048 | 48 | 1-1.5 | 18.10+/-1.90 | 0.34+/-0.09 | 0.44+/-0.07 |
| 12795049 | 49 | 1-1.5 | 6.30+/-1.70 | 0.38+/-0.08 | 0.43+/-0.07 |
| 12795050 | 50 | 1-1.5 | 4.00+/-1.20 | 0.36+/-0.09 | <0.40 |
| 12795051 | 51 | 1-1.5 | 31.10+/-3.10 | 0.38+/-0.08 | 0.84+-/0.13 |
| 12795052 | 52 | 1-1.5 | 14.40+/-3.90 | <0.42 | 0.56+/-0.15 |
| 12795053 | 53 | 1-1.5 | 16.20+/-1.80 | 0.32+/-0.08 | 0.47+/-0.12 |
| 12795060AB | 60 | 0-0.5 | 8.29+/-1.76 | 0.44+/-0.08 | <0.54 |
| 12795060BC | 60 | 0.5-1.0 | 12.30+/-2.28 | 0.41+/-0.09 | <0.50 |
| 12795060CD | 60 | 1.0-1.5 | 5.32+/-1.35 | 0.38+/-0.09 | <0.47 |
| 12795060DE | 60 | 1.5-2.0 | 5.24+/-1.38 | 0.34+/-0.09 | <0.55 |
| 12795060EF | 60 | 2.0-2.5 | 3.04+/-1.13 | 0.25+/-0.84 | <0.52 |
| 12795061AB | 61 | 0-0.5 | 23.09+/-3.79 | 0.83+/-0.09 | 0.82+/-0.14 |
| 12795061BC | 61 | 0.5-1.0 | 26.23+/-4.29 | 0.55+/-0.10 | 0.97+/-0.16 |
| 12795061CD | 61 | 1.0-1.5 | 28.44+/-4.61 | 0.63+/-0.11 | 0.77+/-0.16 |
| 12795061DE | 61 | 1.5-2.0 | 12.18+/-2.26 | 0.39+/-0.09 | 0.55+/-0.12 |
| 12795061EF | 61 | 2.0-2.5 | 19.88+/-3.41 | 0.55+/-0.09 | <0.57 |
| 12795063AB | 63 | 0-0.5 | 6.88+/-1.60 | 0.36+/-0.08 | 0.80+/-0.14 |
| 12795063BC | 63 | 0.5-1.0 | 22.77+/-5.55 | 0.46+/-0.10 | 0.93+/-0.16 |
| 12795063CD | 63 | 1.0-1.5 | 6.84+/-1.60 | 0.50+/-0.09 | 0.54+/-0.14 |
| 12795063DE | 63 | 1.5-2.0 | <0.32 | 0.36+/-0.08 | <0.54 |
| 12795063EF | 63 | 2.0-2.5 | 1.49+/-1.07 | 0.41+/-0.09 | 0.69+/-0.14 |

Note: Data in this table can be found in data packages D-23242, D-23046, D-23431, and D-23432

Table 3
Gamma Exposure Rate Measurements

| Grid # | uR/hr |
|---|---|
| | |
| 1 | 12 |
| 1 | 11 |
| 2 | 12 |
| 2 | 12 |
| 3 | 11 |
| 4 | 11 |
| 4 | 11 |
| 5 | 11 |
| 5 | 10 |
| 6 | 12 |
| 7 | 12 |
| 8 | 10 |
| 8 | 10 |
| 9 | 8 |
| 9 | 9 |
| 10 | 9 |
| 10 | 9 |
| 11 | 8 |
| 11 | 8 |
| 12 | 8 |
| 12 | 8 |
| 13 | 10 |
| 14 | 10 |
| 15 | 10 |
| 15 | 8 |
| 16 | 9 |
| 16 | 8 |
| 17 | 10 |
| 17 | 9 |
| 18 | 9 |
| 18 | 8 |
| 19 | 9 |
| 19 | 10 |
| 20 | 10 |
| 20 | 10 |
| 21 | 9 |
| 21 | 10 |
| 22 | 9 |
| 22 | 9 |
| 23 | 9 |
| 23 | 9 |
| 24 | 8 |
| 24 | 9 |
| 25 | 8 |
| 25 | 8 |
| 26 | 10 |
| 27 | 10 |
| 27 | 10 |
| 30 | 12 |
| 30 | 9 |
| 31 | 10 |
| 31 | 9 |
| 32 | 10 |
| 32 | 10 |
| 33 | 9 |
| 33 | 9 |
| 34 | 9 |
| 35 | 9 |
| 36 | 8 |
| 37 | 8 |
| 38 | 8 |
| 39 | 9 |
| 40 | 8 |
| 41 | 8 |
| 42 | 10 |
| 43 | 9 |
| 44 | 10 |
| 45 | 10 |
| 46 | 9 |

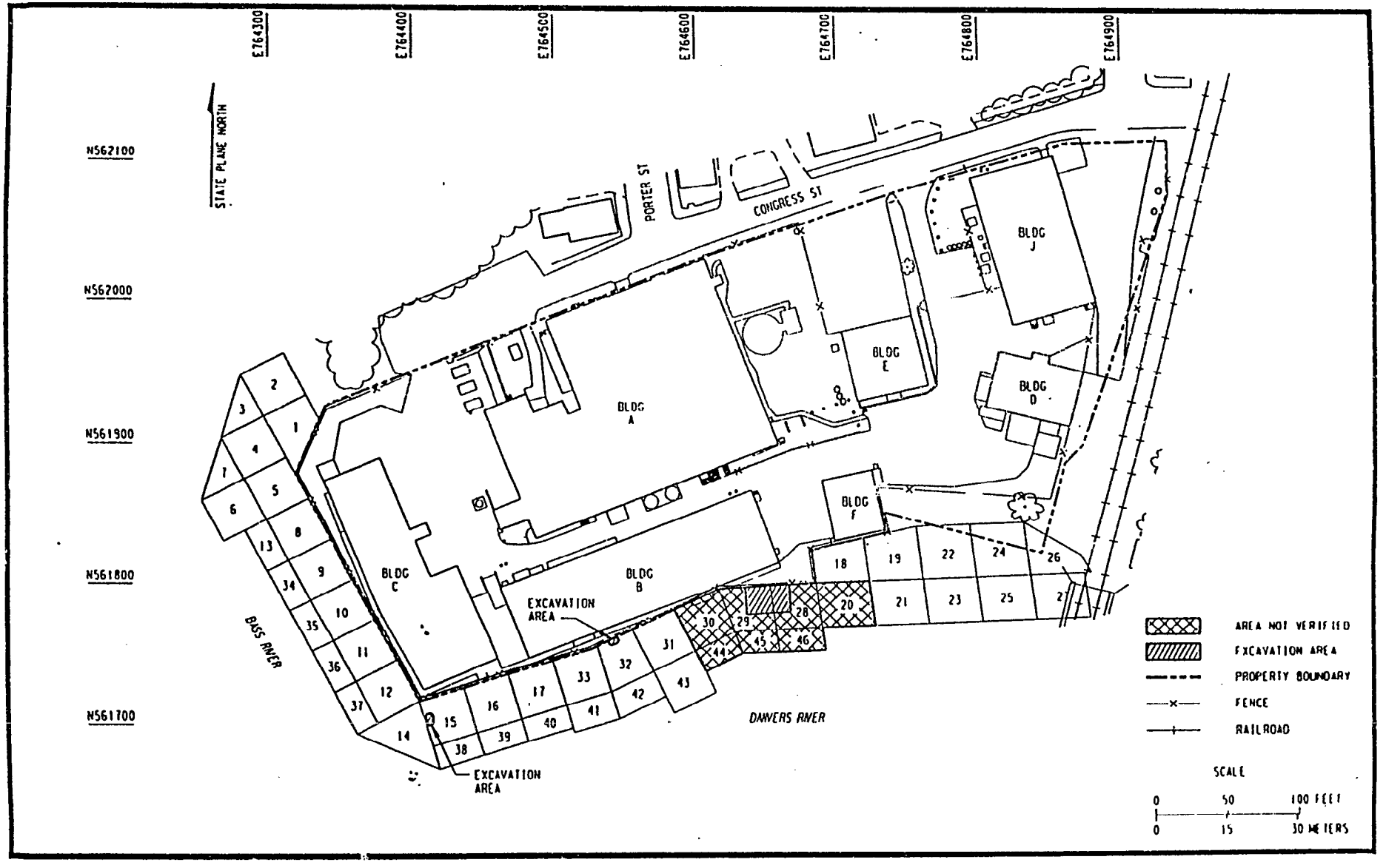
Note: Data in this table can be found in data package D-22865

138013

Table 4

Data Packages Generated During The Ventron Harbor Remedial Action

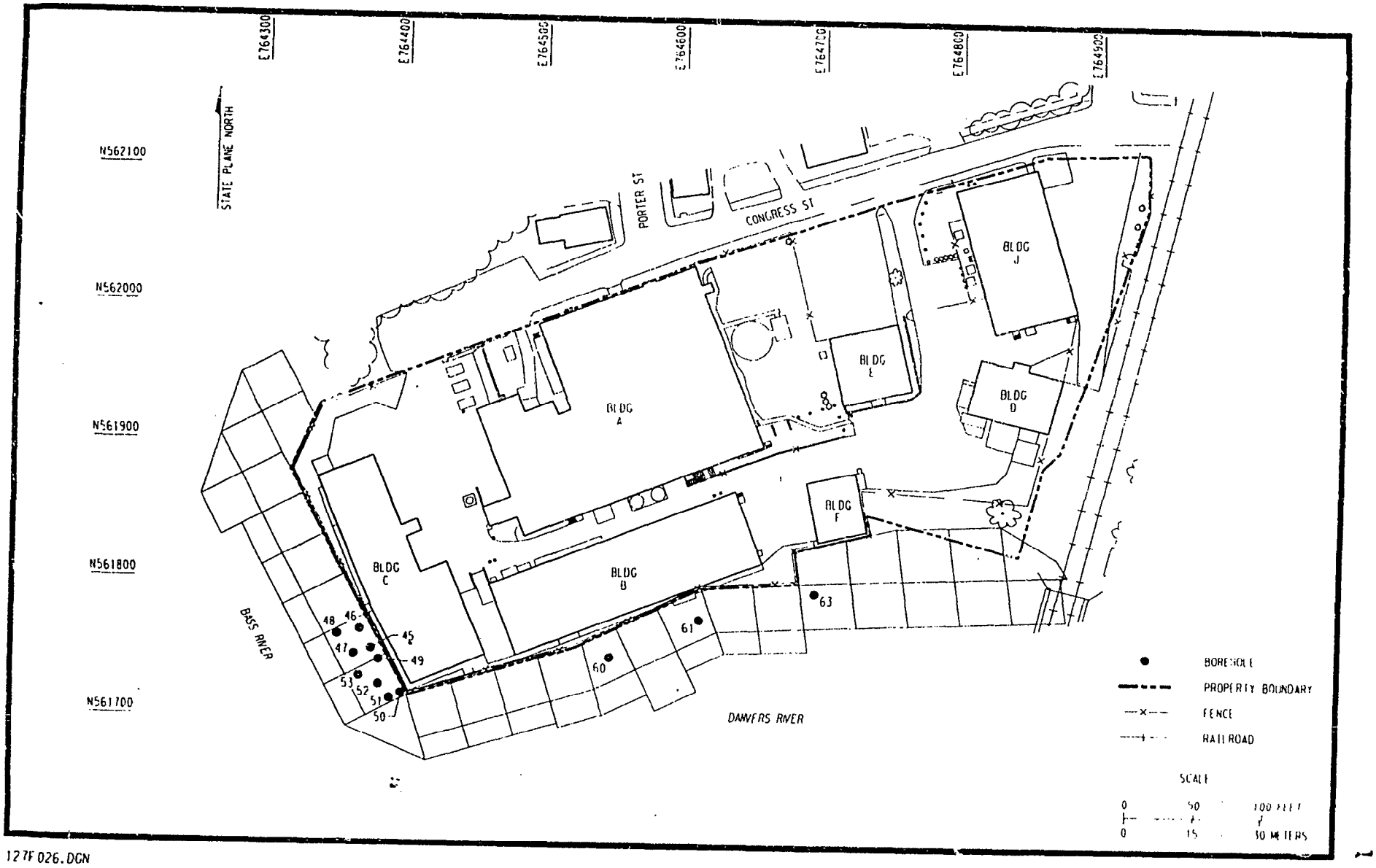
| |
|---|
| D-23003 |
| D-23034 |
| D-23045 |
| D-23046 |
| D-23073 |
| D-23242 |
| D-23431 |
| D-23432 |
| D-22865 |




127F026.DGN

Figure 1
Ventron Site
Verification Grid

138013




127F026.DGN

Figure 2
Ventron Site
Borehole Locations

138013

# APPENDIX C

# JULY 1997 SUPPLEMENTAL SAMPLING REPORT

FUSRAP Project
Job 14501

127-97-001
NO. _____ REV. NO. 0
DATE: 8-5-97

# FUSRAP TECHNICAL BULLETIN

| Prepared by | Team Lead Approval | Project Engineer Approval | Project Manager Approval |
|---|---|---|---|
| Tim Kley | Mohan Kuan | 8/5/97 | for S.G. Wilkinson 8/5/97 |

## Introduction

This technical bulletin presents the data obtained from additional sampling performed during July 1997 at the Ventron site in Beverly, Massachusetts. This sampling was performed, based on direction from DOE-HQ (Ref. 1), to close issues concerning the sufficiency of data to demonstrate site-wide compliance with the cleanup criteria. A sampling plan was agreed upon by BNI, FSRD, DOE-HQ, and ORISE prior to the initiation of sampling (Ref. 2). Other data collected to document the post remedial action status of the site can be found in the draft Post Remedial Action Report (Ref. 3) for the site.

## Description

Seven onsite boreholes and three boreholes in the harbor were drilled and sampled. The borehole locations are shown on Figure 1. Samples were collected from every one foot increment until refusal for the onsite boreholes. The majority of the samples in the harbor were collected in 6-inch increments with one sample being collected from a one foot increment. All samples were analyzed for U-238, Ra-226, and Th-232. Sample analyses results and depths are shown in Table 1.

### Harbor

3 boreholes (8,9,10) were sampled. Sampling began below the backfill that was placed in the harbor by Morton following their mercury removal action. The purpose of this sampling was to ensure that contamination was not present at depth due to sediment deposition resulting from normal tidal cycles. Data for U-238, the primary contaminant, ranged from <2.39 to 13.17 pCi/g.

### ALFA Building Area

3 boreholes (1,2,3) were sampled. Samples were collected and analyzed from surface to refusal. This area was investigated due to an elevated sample from characterization borehole B29. Results for U-238 ranged from 1.98 to 24.57 pCi/g.

Building A/C Area

4 boreholes (4,5,6,7) were sampled. Samples were collected and analyzed from surface to borehole refusal. This area was sampled due to a lack of data density in the area, as well as elevated results from characterization boreholes B42 and B48. Results for U-238 ranged from 1.14 to 5.10 pCi/g.

Conclusion

As shown by the data presented in Table 1, all sample results are well below the cleanup criteria of 100 pCi/g total U (50 pCi/g U-238). With the collection of this data, all areas of the site including the 3 areas in question, have been addressed and compliance with the site cleanup criteria has been demonstrated. Figure 2 shows a compilation of all "clean data" (characterization and remedial action) collected from the Ventron site which illustrates the sufficiency of data for the site to be released without radiological restrictions.

References:

1) Bechtel National, Inc. Ventron Sampling Plan, July 1997

2) Bechtel National, Inc. Post-Remedial Action Report for the Remedial Action at the Ventron Site (1st draft). May 1997

3) Johnson, Albert S. to Seay, W. Resolution of Open Issues at Ventron Site, Beverly, Massachusetts, June 1997

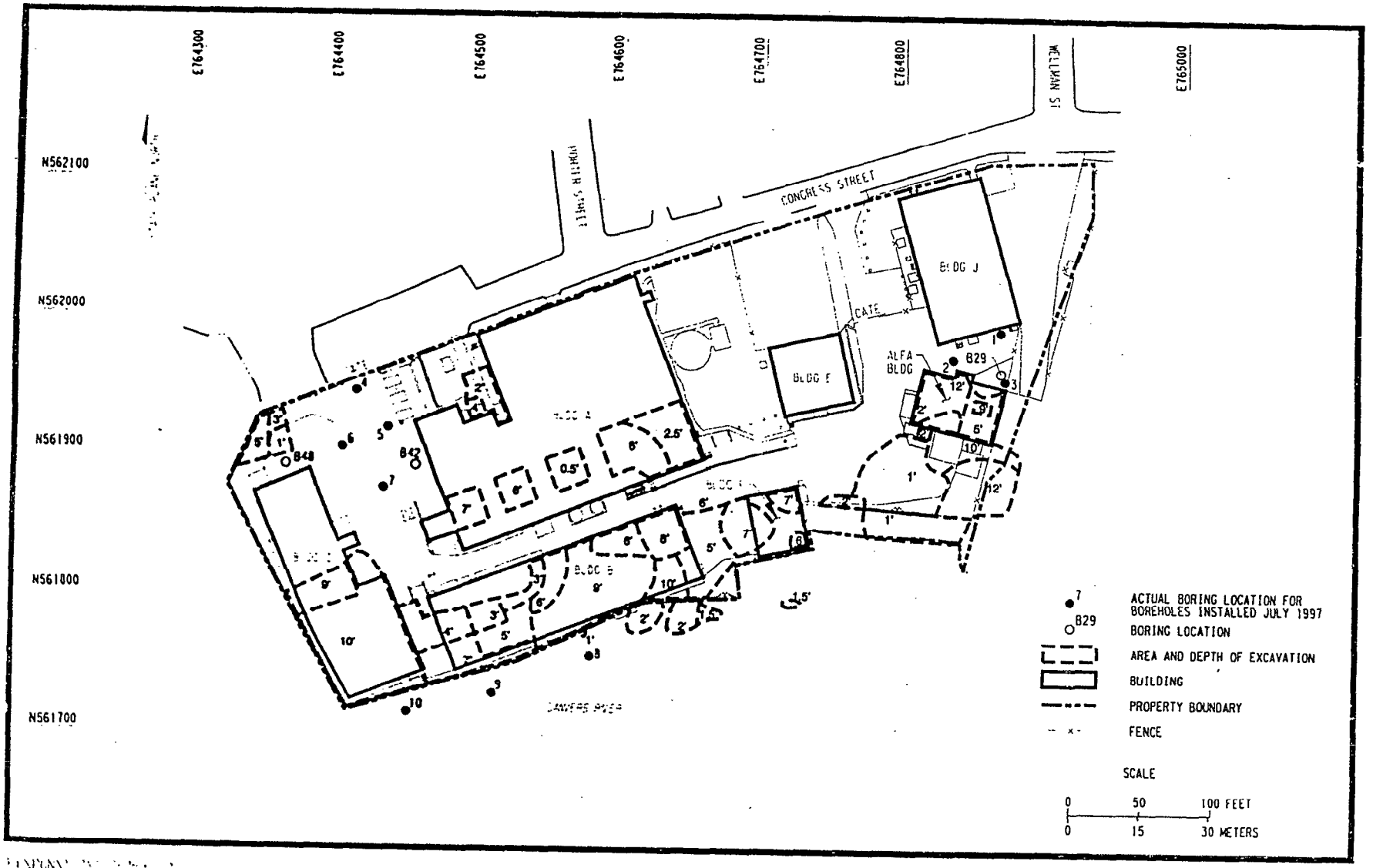



Figure 1
Additional Sampling Locations at
Ventron

## Table 1
## Sample Results From July 1997

| Borehole # | Sample ID | Depth (ft) | Ra-226 | Th-232 | U-238 |
|---|---|---|---|---|---|
| **Onsite** | | | | | |
| 1 | 127RS0800 | 0-1 | 0.55 +/- 0.04 | 0.60 +/- 0.06 | <2.55 |
| | 127RS0801 | 1-2 | 0.64 +/- 0.05 | 0.78 +/- 0.07 | 4.30 +/- 1 36 |
| | 127RS0802 | 2-3 | 0.65 +/- 0.04 | 0.51 +/- 0.06 | 6.61 +/- 1.28 |
| | 127RS0803 | 3-4 | 0.65 +/- 0.04 | 0.65 +/- 0.06 | 3.31 +/- 1.00 |
| | 127RS0804 | 4-5 | 0.65 +/- 0.05 | 0.61 +/- 0.07 | 1.98 +/- 1.06 |
| | 127RS0805 | 5-5.5 | 0.51 +/- 0.05 | 0.61 +/- 0.07 | 2.27 +/- 1.13 |
| 2 | 127RS0806 | 0-1 | 0.52 +/- 0.04 | 0.55 +/- 0.06 | 4.15 +/- 0.93 |
| | 127RS0807 | 1-2 | 0.55 +/- 0.04 | 0.72 +/- 0.06 | 8.57 +/- 1.18 |
| | 127RS0808 | 2-3 | 0.61 +/- 0.04 | 0.61 +/- 0.06 | 16.29 +/- 1.67 |
| | 127RS0814 | 3-3.75 | 0.55 +/- 0.04 | 0.74 +/- 0.06 | 12.42 +/- 1.49 |
| 3 | 127RS0809 | 0-1 | 0.66 +/- 0.04 | 0.71 +/- 0.07 | 11.70 +/- 1.49 |
| | 127RS0810 | 1-2 | 0.63 +/- 0.04 | 0.67 +/- 0.06 | 24.57 +/- 1.24 |
| | 127RS0811 | 2-3 | 0.60 +/- 0.04 | 0.61 +/- 0.06 | 13.11 +/- 1.31 |
| | 127RS0812 | 3-4 | 0.61 +/- 0.04 | 0.73 +/- 0.07 | 17.22 +/- 1.73 |
| | 127RS0813 | 4-5 | 0.61 +/- 0.04 | 0.66 +/- 0.07 | 14.35 +/- 1.59 |
| 4 | 127RS0815 | 0-1 | 1.39 +/- 0.06 | 1.16 +/- 0.07 | 2.24 +/- 1.04 |
| | 127RS0816 | 1-2 | 2.09 +/- 0.08 | 1.77 +/- 0.10 | <4.08 |
| | 127RS0817 | 2-3 | 1.08 +/- 0.05 | 0.97 +/- 0.08 | 4.71 +/- 1.22 |
| | 127RS0818 | 3-4 | 1.35 +/- 0.06 | 1.59 +/- 0.09 | 2.94 +/- 1.39 |
| 5 | 127RS0819 | 0-1 | 0.55 +/- 0.04 | 0.50 +/- 0.05 | <2.95 |
| | 127RS0820 | 1-2 | 0.74 +/- 0.05 | 0.71 +/- 0.06 | 2.98 +/- 1.37 |
| | 127RS0821 | 2-3 | 0.73 +/- 0.05 | 0.68 +/- 0.06 | 4.28 +/- 1.09 |
| | 127RS0822 | 3-4 | 0.78 +/- 0 05 | 0.81 +/- 0.07 | 5.10 +/- 1.13 |
| 6 | 127RS0823 | 0-1 | 0.65 +/- 0.04 | 0.56 +/- 0.06 | <3.17 |
| | 127RS0824 | 1-2 | 0.62 +/- 0.04 | 0.57 +/- 0.06 | 1.14 +/- 0.96 |
| | 127RS0825 | 2-3 | 0.69 +/- 0.04 | 0 78 +/- 0.06 | 1.77 +/- 0.94 |
| | 127RS0826* | 3-4 | 0.64 +/- 0.04 | 0.90 +/- 0.07 | 4.19 +/- 1.24 |
| | 127RS0827 | 4-5 | 0.71 +/- 0.04 | 0.74 +/- 0.07 | 2.77 +/- 1.19 |
| 7 | 127RS0828 | 0-1 | 0.51 +/- 0 04 | 0 69 +/- 0.06 | 3.72 +/- 1.01 |
| | 127RS0829 | 1-2 | 0 66 +/- 0 04 | 0 67 +/- 0.07 | 3.90 +/- 1 25 |
| | 127RS0830 | 2-3 | 0 56 +/- 0 05 | 0 84 +/- 0.07 | <3.37 |
| | 127RS0831 | 3-4 | 0 72 +/- 0 05 | 0 86 +/- 0.07 | 2.79 +/- 1.14 |
| **Harbor** | | | | | |
| 8 | 127RS0832 | 2-3 | 0 43 +/- 0 04 | 0 60 +/- 0 06 | <2.55 |
| | 127RS0833 | 3-3.5 | 0.37 +/- 0 04 | 0.44 +/- 0 05 | <2.39 |
| 9 | 127RS0834 | 2-2.5 | 0 59 +/- 0.04 | 0.53 +/- 0.06 | <2.72 |
| 10 | 127RS0835 | 2-2.5 | 0.39 +/- 0.04 | 0 52 +/- 0.06 | 13.17 +/- 1.26 |
| | 127RS0836 | 2.5-3 | 0.36 +/- 0 03 | 0.38 +/- 0.06 | 5.68 +/- 0.96 |

## APPENDIX D

## POST-REMEDIAL ACTION SAMPLING DATA

### Figures

D-1 Verification Grids and Sample Locations....D-4
D-2 Ventron Site Location of Samples Taken Near the Seawall....D-12

### Tables (Gross Results Presented)

D-1 Buildings A and A-1 Demolition Data....D-1
D-2 Alfa Building Demolition Data....D-2
D-3 Post-Remedial Action Data, Excavations 1, 2, and 3....D-3
D-4 Post-Remedial Action Data, Excavation 4 (Alfa Building)....D-5
D-5 Post-Remedial Action Data, Excavation 5 (Harbor)....D-7
D-6 Post-Remedial Action Data, Seawall Locations....D-10
D-7 Post-Remedial Action Data, Excavation 6....D-13
D-8 Post-Remedial Action Data, Excavation 7....D-15
D-9 Post-Remedial Action Data, Excavations 8, 9, 10, and 11....D-16
D-10 Building A Soil Beneath Slab Samples....D-17
D-11 Gamma Exposure Rate Survey Data....D-18

**Table D-1**
**Buildings A and A-1 Demolition Data**

| Sample ID | Pile Location | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|
| 127-RS-097 | Quadrant A | <2.00 | <0.57 | 0.45 +/- 0.06 |
| 127-RS-098 | Quadrant A | <1.50 | 0.57 +/- 0.08 | 0.43 +/- 0.05 |
| 127-RS-099 | Quadrant A | <1.30 | 0.53 +/- 0.08 | 0.43 +/- 0.04 |
| 127-RS-100 | Quadrant A | <1.30 | 0.70 +/- 0.10 | 0.36 +/- 0.05 |
| 127-RS-101 | Quadrant A | <2.10 | 0.63 +/- 0.13 | 0.59 +/- 0.06 |
| 127-RS-102 | Quadrant A | 1.20 +/- 0.53 | 0.75 +/- 0.10 | 0.44 +/- 0.05 |
| 127-RS-103 | Quadrant A | <2.00 | 0.59 +/- 0.09 | 0.47 +/- 0.06 |
| 127-RS-104 | Quadrant A | <2.50 | 0.63 +/- 0.14 | 0.61 +/- 0.08 |
| 127-RS-105 | Quadrant A | <2.30 | 0.49 +/- 0.12 | 0.62 +/- 0.06 |
| 127-RS-106 | Quadrant B | <2.30 | 0.65 +/- 0.14 | 0.62 +/- 0.07 |
| 127-RS-107 | Quadrant B | <3.20 | <0.89 | 0.61 +/- 0.10 |
| 127-RS-108 | Quadrant B | 3.60 +/- 1.30 | <0.98 | 0.95 +/- 0.14 |
| 127-RS-109 | Quadrant B | 3.10 +/- 1.60 | <1.30 | 1.20 +/- 0.15 |
| 127-RS-110 | Quadrant B | <2.60 | 0.95 +/- 0.14 | 0.90 +/- 0.08 |
| 127-RS-111 | Quadrant B | <3.70 | 1.10 +/- 0.16 | 0.78 +/- 0.11 |
| 127-RS-112 | Quadrant B | 1.30 +/- 1.00 | 1.10 +/- 0.16 | 1.00 +/- 0.10 |
| 127-RS-113 | Quadrant B | <3.40 | 0.88 +/- 0.18 | 0.67 +/- 0.09 |
| 127-RS-114 | Quadrant B | <3.20 | 0.71 +/- 0.14 | 0.82 +/- 0.09 |
| 127-RS-115 | Quadrant C | 0.40 +/- 0.46 | <0.48 | 0.39 +/- 0.05 |
| 127-RS-116 | Quadrant C | <3.70 | 0.78 +/- 0.18 | 0.55 +/- 0.10 |
| 127-RS-117 | Quadrant C | <3.20 | <0.79 | 0.59 +/- 0.08 |
| 127-RS-118 | Quadrant C | <2.40 | 0.85 +/- 0.15 | 0.62 +/- 0.07 |
| 127-RS-119 | Quadrant C | <2.70 | 0.82 +/- 0.15 | 0.57 +/- 0.08 |
| 127-RS-120 | Quadrant C | <1.90 | 0.71 +/- 0.12 | 0.55 +/- 0.06 |
| 127-RS-121 | Quadrant C | 2.80 +/- 1.30 | 0.89 +/- 0.19 | 0.76 +/- 0.13 |
| 127-RS-122 | Quadrant C | 1.70 +/- 0.89 | <0.75 | 0.73 +/- 0.09 |
| 127-RS-123 | Quadrant C | <3.60 | 0.94 +/- 0.20 | 0.74 +/- 0.10 |
| 127-RS-124 | Quadrant D | <3.50 | 0.91 +/- 0.24 | 0.98 +/- 0.13 |
| 127-RS-125 | Quadrant D | <4.20 | <1.10 | <0.76 |
| 127-RS-126 | Quadrant D | <2.20 | <0.58 | 0.45 +/- 0.07 |
| 127-RS-127 | Quadrant D | <2.40 | <0.61 | 0.63 +/- 0.08 |
| 127-RS-128 | Quadrant D | <3.00 | <0.76 | 0.42 +/- 0.09 |
| 127-RS-129 | Quadrant D | <2.10 | <0.53 | 0.38 +/- 0.07 |
| 127-RS-130 | Quadrant D | 1.20 +/- 0.87 | <0.78 | <0.51 |
| 127-RS-131 | Quadrant D | <3.50 | <0.95 | <0.60 |
| 127-RS-132 | Quadrant D | <3.20 | 0.50 +/- 0.16 | 0.54 +/- 0.10 |
| 127-RS-133 | Quadrant D | <0.90 | <0.23 | <0.16 |
| 127-RS-134 | Quadrant D | <0.84 | <0.24 | <0.16 |
| 127-RS-135 | Pile Grab | <2.20 | 0.69 +/- 0.12 | 1.20 +/- 0.08 |
| 127-RS-142 | Quadrant E | <1.90 | 0.55 +/- 0.10 | 0.58 +/- 0.06 |
| 127-RS-143 | Quadrant E | <2.40 | 0.43 +/- 0.11 | <0.37 |

**Table D-1**
**(continued)**

| Sample ID | Pile Location | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|
| 127-RS-144 | Quadrant E | <2.70 | 0.90 +/- 0.13 | 0.61 +/- 0.07 |
| 127-RS-145 | Quadrant E | 1.60 +/- 0.67 | 0.76 +/- 0.10 | 0.60 +/- 0.06 |
| 127-RS-146 | Quadrant E | 0.23 +/- 0.69 | <0.76 | 0.52 +/- 0.08 |
| 127-RS-147 | Quadrant E | 2.40 +/- 0.77 | <0.46 | 0.30 +/- 0.06 |
| 127-RS-148 | Quadrant E | <2.80 | 0.54 +/- 0.12 | 0.46 +/- 0.07 |
| 127-RS-149 | Quadrant E | 3.20 +/- 0.97 | 0.61 +/- 0.10 | 0.61 +/- 0.06 |
| 127-RS-150 | Quadrant E | 1.70 +/- 0.80 | <0.52 | 0.42 +/- 0.06 |

**Table D-2**
**Alfa Building (Building J) Demolition Data**

| Sample ID | Material | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|
| 127-RS-610 | Metal | 0.57 +/- 0.74 | <0.53 | <0.37 |
| 127-RS-611 | Roofing | <3.00 | <1.10 | <0.62 |
| 127-RS-612 | Concrete | <2.10 | 0.64 +/- 0.10 | 1.30 +/- 0.08 |
| 127-RS-613 | Wood | <9.70 | <2.70 | <1.60 |

## Table D-3
## Post-Remedial Action Data, Excavations 1, 2, and 3

### Excavation 1 (NW Corner of Site)

| Grid Location | Sample ID | Sample Type | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| S0 - E0 | 127-RS-088 | Composite | 8.8 +/- 2.3 | 0.92 +/- 0.12 | 1.0 +/- 0.08 |
| S3 - E9 | 127-RS-136 | Highest Area | 6.6 +/- 1.8 | 0.43 +/- 0.10 | 0.44 +/- 0.06 |
| S0 - E10 | 127-RS-091 | Composite | 6.8 +/- 1.80 | 0.79 +/- 0.10 | 0.64 +/- 0.06 |
| S2 - E14 | 127-RS-137 | Highest Area | 12.7 +/- 3.30 | 1.7 +/- 0.16 | 1.3 +/- 0.11 |

### Excavation 2 (Near Buildings A and A-1 Slabs)

| Grid Location | Sample ID | Sample Type | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| S0 - E50 | 127-RS-092 | Composite | 9.9 +/- 2.70 | 0.89 +/- 0.16 | 0.88 +/- 0.11 |
| S0 - E50 | 127-RS-093 | Highest Area | 14.1 +/- 3.60 | 0.7 +/- 0.12 | 0.65 +/- 0.07 |
| S10 - E50 | 127-RS-094 | Composite | 15.8 +/- 4.10 | 1.2 +/- 0.21 | 0.6 +/- 0.10 |
| S10 - E50 | 127-RS-095 | Highest Area | 34.1 +/- 2.50 | 1.3 +/- 0.15 | 1 +/- 0.09 |

### Excavation 3 (Near Building E)

| Grid Location | Sample ID | Sample Type | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| S30 - E130 | 127-RS-096 | Composite | 2.9 +/- 1.10 | <0.81 | 0.6 +/- 0.09 |

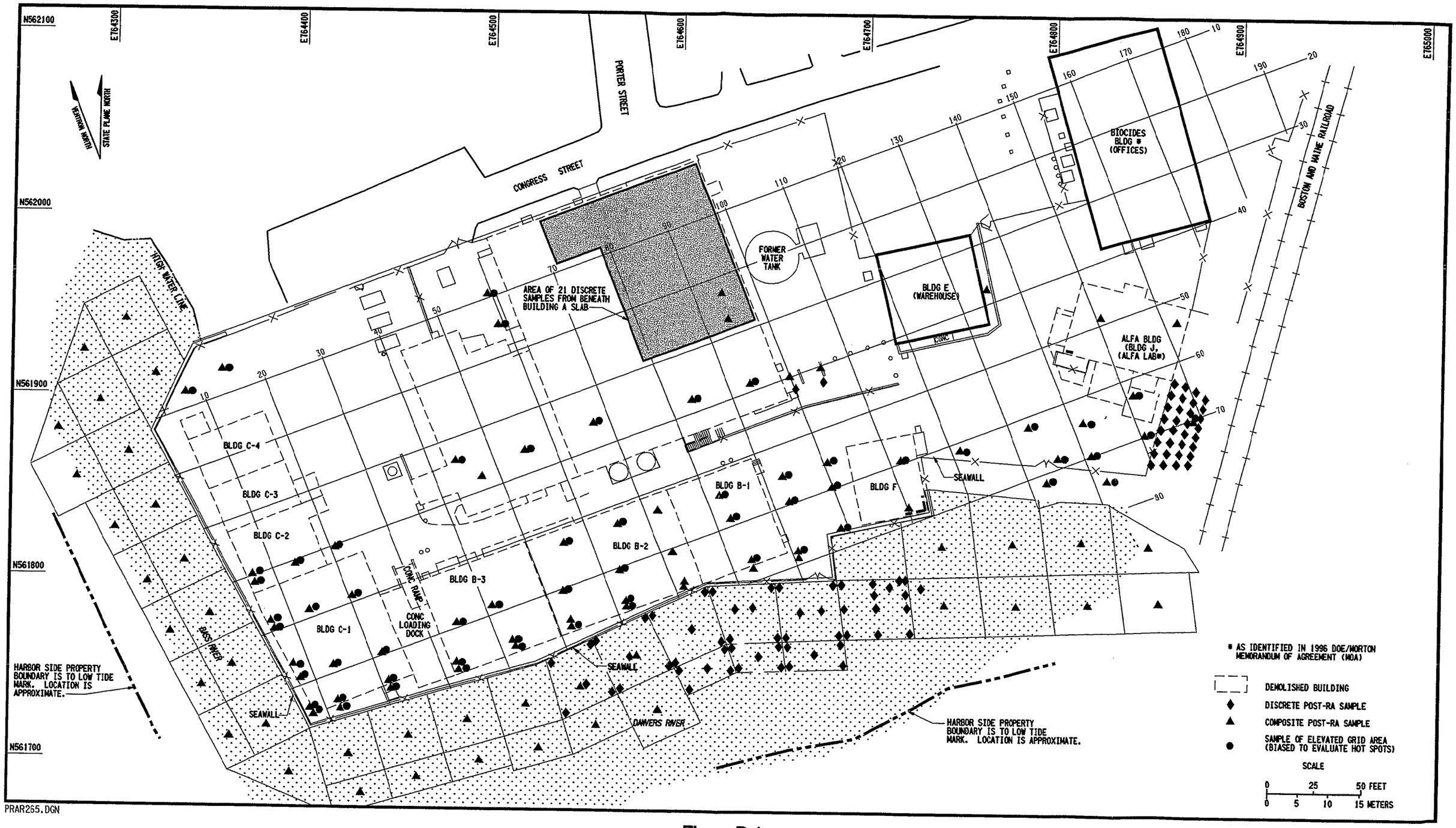



**Figure D-1**
**Ventron Site**
**Verification Grids and Post-Remedial Action Sampling Locations**

**Table D-4**
**Post-Remedial Action Data, Excavation 4**
**Alfa Building (Building J)**

| Grid Location | Sample ID | Sample Type | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| **Phase I – Area South of Alfa Building** | | | | | |
| S60 - E150 | 127-RS-232 | Composite | 36.3 +/- 4.9 | <0.66 | 0.66 +/- 0.08 |
| S60 - E150 | 127-RS-231 | Highest Area | 32.6 +/- 2.00 | 1.2 +/- 0.15 | 0.62 +/- 0.08 |
| S70 - E140 | 127-RS-228 | Composite | <2.9 | 1.4 +/- 0.13 | 0.49 +/- 0.07 |
| S70 - E140 | 127-RS-227 | Highest Area | 5.4 +/- 1.6 | <0.56 | 0.67 +/- 0.07 |
| S50 - E150 | 127-RS-230 | Composite | 11.4 +/- 3.3 | 1.3 +/- 0.19 | 0.76 +/- 0.11 |
| S50 - E150 | 127-RS-229 | Highest Area | 20.6 +/- 1.6 | 1.5 +/- 0.17 | 1 +/- 0.09 |
| S70 - E130 | 127-RS-222 | Composite | <3.2 | 1.6 +/- 0.15 | 0.63 +/- 0.08 |
| S70 - E130 | 127-RS-221 | Highest Area | <3.1 | 3 +/- 0.2 | <0.45 |
| S60 - E140 | 127-RS-226 | Composite | 8.3 +/- 2.3 | 1.5 +/- 0.15 | 0.67 +/- 0.09 |
| S60 - E140 | 127-RS-225 | Highest Area | <2.90 | 2.6 +/- 0.15 | 0.41 +/- 0.07 |
| S60 - E130 | 127-RS-220 | Composite | <3.90 | 2.1 +/- 0.19 | 1.1 +/- 0.11 |
| S60 - E130 | 127-RS-289 | Highest Area | <4.95 | 7.74 +/- 0.36 | 1.15 +/- 0.15 |
| S50 - E140 | 127-RS-224 | Composite | 7.2 +/- 2.0 | 1.3 +/- 0.13 | 0.63 +/- 0.08 |
| S50 - E140 | 127-RS-223 | Highest Area | <1.9 | 0.8 +/- 0.12 | <0.3 |
| S50 - E130 | 127-RS-287 | Composite | 7.7 +/- 0.83 | 1.4 +/- 0.12 | 0.74 +/- 0.06 |
| S50 - E130 | 127-RS-288 | Highest Area | 23.1 +/- 5.8 | 2.6 +/- 0.19 | 0.77 +/- 0.11 |
| S50/60-E130/140 | 127-RS-290 | Composite | 4.84 +/- 1.36 | 1.75 +/- 0.13 | 0.83 +/- 0.07 |
| **Phase II - Railroad Excavation (uses special grid)** | | | | | |
| 0E - 0S | 127-RS-527 | Discrete | 10.83 +/- 2.65 | 1.11 +/- 0.09 | 0.81 +/- 0.06 |
| 0E - 2S | 127-RS-528 | Discrete | 16.82 +/- 2.77 | 1.26 +/- 0.11 | 1 +/- 0.06 |
| 0E - 4S | 127-RS-529 | Discrete | 22.9 +/- 2.75 | 0.83 +/- 0.09 | 0.97 +/- 0.06 |
| 0E - 6S | 127-RS-530 | Discrete | 25.0 +/- 3.16 | 1.17 +/- 0.10 | 0.89 +/- 0.06 |
| 0E - 8S | 127-RS-531 | Discrete | 8.63 +/- 2.21 | 0.64 +/- 0.09 | 0.84 +/- 0.06 |
| 0E - 10S | 127-RS-532 | Discrete | 39.49 +/- 3.72 | 1.10 +/- 0.11 | 0.95 +/- 0.07 |
| 0E - 12S | 127-RS-533 | Discrete | 1.87 +/- 2.26 | 0.76 +/- 0.10 | 0.91 +/- 0.07 |
| 2E - 0S | 127-RS-534 | Discrete | 25.57 +/- 3.43 | 1.44 +/- 0.12 | 1.46 +/- 0.08 |
| 2E - 2S | 127-RS-535 | Discrete | 21.75 +/- 3.06 | 2.00 +/- 0.12 | 1.04 +/- 0.06 |
| 2E - 4S | 127-RS-536 | Discrete | 15.11 +/- 2.86 | 1.13 +/- 0.11 | 0.82 +/- 0.07 |
| 2E - 6S | 127-RS-537 | Discrete | 21.3 +/- 3.04 | 1.12 +/- 0.11 | 0.89 +/- 0.07 |
| 2E - 8S | 127-RS-538 | Discrete | 7.52 +/- 2.42 | 0.83 +/- 0.09 | 0.79 +/- 0.06 |
| 2E - 10S | 127-RS-539 | Discrete | 12.05 +/- 1.96 | 0.77 +/- 0.09 | 0.77 +/- 0.06 |
| 2E - 12S | 127-RS-540 | Discrete | 9.96 +/- 2.05 | 0.88 +/- 0.09 | 0.77 +/- 0.06 |

**Table D-4**
**(continued)**

| Grid Location | Sample ID | Sample Type | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| **Phase II - Railroad Excavation (continued) (uses special grid)** | | | | | |
| 4E - 0S | 127-RS-541 | Discrete | 3.60 +/- 1.64 | 0.48 +/- 0.08 | 0.50 +/- 0.05 |
| 4E - 2S | 127-RS-542 | Discrete | 34.92 +/- 3.66 | 1.17 +/- 0.10 | 0.91 +/- 0.07 |
| 4E - 4S | 127-RS-543 | Discrete | 24.38 +/- 3.47 | 1.38 +/- 0.12 | 1.20 +/- 0.08 |
| 4E - 6S | 127-RS-544 | Discrete | 6.69 +/- 2.60 | 0.89 +/- 0.11 | 0.78 +/- 0.06 |
| 4E - 8S | 127-RS-545 | Discrete | 11.47 +/- 2.39 | 0.88 +/- 0.10 | 0.72 +/- 0.06 |
| 4E - 10S | 127-RS-546 | Discrete | 7.66 +/- 1.93 | 0.82 +/- 0.08 | 0.65 +/- 0.05 |
| 4E – 12S | 127-RS-547 | Discrete | 0.74 +/- 1.90 | 0.55 +/- 0.08 | 0.68 +/- 0.05 |
| 4E – 14S | 127-RS-548 | Discrete | 3.47 +/- 1.93 | 0.79 +/- 0.09 | 0.71+/- 0.05 |
| 6E - 0S | 127-RS-549 | Discrete | 0.58 +/- 2.06 | 0.81 +/- 0.08 | 0.76 +/- 0.05 |
| 6E - 2S | 127-RS-550 | Discrete | <3.03 | 0.66 +/- 0.08 | 0.51 +/- 0.04 |
| 6E - 4S | 127-RS-551 | Discrete | 0.65 +/- 1.94 | 0.70 +/- 0.07 | 0.49 +/- 0.04 |
| 6E - 6S | 127-RS-552 | Discrete | <3.03 | 0.64 +/- 0.07 | 0.45 +/- 0.04 |
| 6E - 8S | 127-RS-553 | Discrete | 19.72 +/- 2.83 | 0.80 +/- 0.10 | 0.88 +/- 0.06 |
| 6E – 10S | 127-RS-554 | Discrete | 2.70 +/- 1.83 | 0.73 +/- 0.09 | 0.60 +/- 0.05 |
| 6E – 12S | 127-RS-555 | Discrete | 0.15 +/- 2.35 | 1.13 +/- 0.09 | 0.75 +/- 0.05 |
| 6E – 14S | 127-RS-556 | Discrete | 3.56 +/- 1.72 | 0.98 +/- 0.09 | 0.75 +/- 0.06 |
| Area Comp. | 127-RS-557 | Composite | 16.96 +/- 2.67 | 0.92 +/- 0.10 | 0.89 +/- 0.07 |
| Highest Area | 127-RS-558 | Discrete | 38.15 +/- 3.60 | 1.24 +/- 0.10 | 0.73 +/- 0.06 |
| Highest Area | 127-RS-559 | Discrete | 43.81 +/- 3.95 | 1.15 +/- 0.10 | 0.96 +/- 0.07 |
| 3E - 4S | 127-RS-568 | Highest Area | 27.36 +/- 3.06 | 1.27 +/- 0.10 | 0.72 +/- 0.06 |
| 3E - 4S | 127-RS-569 | Highest Area | 46.63 +/- 3.43 | 0.98 +/- 0.09 | 0.86 +/- 0.06 |
| 1E - 5S | 127-RS-570 | Highest Area | 38.08 +/- 3.48 | 1.4 +/- 0.10 | 0.88 +/- 0.06 |
| 1E - 5S | 127-RS-571 | Highest Area | 24.87 +/- 2.99 | 1.04 +/- 0.09 | 0.88 +/- 0.06 |
| **Phase III - Under Alfa Building** | | | | | |
| 150/140E - 40/40S | 127-RS-633 | Composite | 26.67 +/- 2.17 | 0.9 +/- 0.06 | 0.81 +/- 0.04 |
| 150E - 50S | 127-RS-632 | Composite | 21.1 +/- 1.86 | 0.91 +/- 0.06 | 0.68 +/- 0.03 |
| 160E – 50S | 127-RS-630 | Composite | 13.51 +/- 1.94 | 0.79 +/- 0.07 | 0.7 +/- 0.04 |
| 160E – 60S | 127-RS-631 | Composite | 7.42 +/- 1.40 | 0.78 +/- 0.06 | 0.71 +/- 0.04 |
| Alfa Pit (150E – 50S) Bottom | 127-RS-646 | Composite | 35.08 +/- 3.18 | 0.84 +/- 0.08 | 0.61 +/- 0.05 |

**Table D-5**
**Post-Remedial Action Data, Excavation 5 (Harbor)**

| Grid Location | Sample ID | Sample Type | Phase I U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| Grid 1 | 12795006 | Composite | 0.37 +/- 0.46 | 0.46 +/- 0.10 | 0.60 +/- 0.09 |
| Grid 2 | 12795007 | Composite | <1.90 | <0.58 | 0.47 +/- 0.07 |
| Grid 3 | 12795008 | Composite | <1.70 | 0.48 +/- 0.11 | 0.44 +/- 0.10 |
| Grid 4 | 12795009 | Composite | <1.80 | 0.36 +/- 0.19 | 0.52 +/- 0.12 |
| Grid 5 | 12795010 | Composite | <1.70 | <0.53 | 0.36 +/- 0.09 |
| Grid 6 | 12795011 | Composite | <1.90 | 0.27 +/- 0.10 | 0.45 +/- 0.07 |
| Grid 7 | 12795012 | Composite | <1.50 | 0.41 +/- 0.11 | 0.39 +/- 0.08 |
| Grid 8 | 12795013 | Composite | 1.70 +/- 0.67 | 0.26 +/- 0.13 | 0.61 +/- 0.11 |
| Grid 9 | 12795014 | Composite | 2.70 +/- 0.87 | 0.47 +/- 0.07 | 0.52 +/- 0.10 |
| Grid 10 | 12795015 | Composite | 2.10 +/- 0.81 | 0.33 +/- 0.16 | 0.39 +/- 0.08 |
| Grid 11 | 12795016 | Composite | 8.10 +/- 2.20 | 0.58 +/- 0.09 | 0.29 +/- 0.09 |
| Grid 12 | 12795017 | Composite | <2.70 | 0.54 +/- 0.11 | 0.45 +/- 0.11 |
| Grid 13 | 12795018 | Composite | 1.30 +/- 0.65 | 0.65 +/- 0.13 | 0.51 +/- 0.10 |
| Grid 14 | 12795036 | Composite | <3.10 | <0.86 | 0.40 +/- 0.15 |
| Grid 15 | 12795019 | Composite | 5.60 +/- 1.60 | 0.59 +/- 0.11 | 0.50 +/- 0.10 |
| Grid 16 | 12795020 | Composite | 13.30 +/- 1.70 | 0.38 +/- 0.11 | 0.43 +/- 0.12 |
| Grid 17 | 12795031 | Composite | 9.50 +/- 2.60 | 0.34 +/- 0.11 | 0.56 +/- 0.08 |
| Grid 18 | 12795021 | Composite | 21.50 +/- 4.40 | 0.60 +/- 0.08 | 0.57 +/- 0.11 |
| Grid 19 | 12795022 | Composite | 3.00 +/- 0.98 | 0.71 +/- 0.16 | 0.43 +/- 0.11 |
| Grid 21 | 12795024 | Composite | 6.10 +/- 1.70 | 0.77 +/- 0.12 | 0.70 +/- 0.13 |
| Grid 22 | 12795025 | Composite | <2.20 | 0.61 +/- 0.11 | 0.37 +/- 0.07 |
| Grid 23 | 12795026 | Composite | 3.60 +/- 1.10 | 0.39 +/- 0.08 | 0.53 +/- 0.10 |
| Grid 24 | 12795027 | Composite | <2.00 | 0.55 +/- 0.13 | 0.39 +/- 0.07 |
| Grid 25 | 12795028 | Composite | <2.10 | 0.78 +/- 0.13 | 0.38 +/- 0.08 |
| Grid 26 | 12795029 | Composite | <1.90 | 0.38 +/- 0.08 | 0.56 +/- 0.09 |
| Grid 27 | 12795030 | Composite | 1.80 +/- 0.73 | 0.35 +/- 0.08 | 0.45 +/- 0.10 |
| Grid 31 | 12795032 | Composite | 9.80 +/- 2.90 | 3.60 +/- 0.67 | 0.47 +/- 0.18 |
| Grid 33 | 12795033 | Composite | 4.20 +/- 1.30 | <0.59 | 0.52 +/- 0.10 |
| Grid 34 | 12795041 | Composite | <2.40 | 0.59 +/- 0.15 | 0.44 +/- 0.13 |
| Grid 35 | 12795042 | Composite | 0.74 +/- 0.70 | 0.67 +/- 0.11 | 0.43 +/- 0.13 |
| Grid 36 | 12795043 | Composite | 1.10 +/- 0.65 | <0.62 | 0.48 +/- 0.12 |
| Grid 37 | 12795044 | Composite | 1.80 +/- 0.79 | <0.64 | 0.46 +/- 0.13 |
| Grid 38 | 12795037 | Composite | <4.10 | 0.36 +/- 0.13 | 0.51 +/- 0.13 |
| Grid 39 | 12795038 | Composite | <3.10 | 0.56 +/- 0.20 | 0.51 +/- 0.18 |
| Grid 40 | 12795039 | Composite | <4.00 | 0.84 +/- 0.19 | 0.61 +/- 0.13 |

**Table D-5**
**(continued)**

| Grid Location | Sample ID | Sample Type | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| **Phase I (continued)** | | | | | |
| Grid 41 | 12795040 | Composite | <4.40 | 0.60 +/- 0.37 | 1.00 +/- 0.28 |
| Grid 42 | 12795034 | Composite | <4.40 | <1.50 | 0.52 +/- 0.21 |
| Grid 43 | 12795035 | Composite | 1.30 +/- 1.10 | 0.91 +/- 0.19 | 0.83 +/- 0.17 |
| **Phase II** | | | | | |
| Grid 20 | 127-RS-151 | Discrete | 13.0 +/-1.1 | 1 +/- 0.12 | 0.47 +/- 0.07 |
| Grid 20 | 127-RS-152 | Discrete | 8.6 +/- 0.83 | 1 +/- 0.09 | 0.57 +/- 0.05 |
| Grid 20 | 127-RS-153 | Discrete | 2.1 +/- 0.70 | 0.57 +/- 0.09 | 0.47 +/- 0.05 |
| Grid 20 | 127-RS-154 | Discrete | 2.4 +/- 0.83 | 0.46 +/- 0.10 | 0.33 +/- 0.06 |
| Grid 20 | 127-RS-155 | Discrete | 4.3 +/- 1.30 | 0.7 +/- 0.11 | 0.88 +/- 0.07 |
| Grid 20 | 127-RS-156 | Discrete | 6.6 +/- 1.80 | 0.61 +/- 0.11 | 0.69 +/- 0.06 |
| Grid 20 | 127-RS-157 | Discrete | 12.9 +/- 1.2 | 0.77 +/- 0.13 | 0.51 +/- 0.08 |
| Grid 20 | 127-RS-158 | Discrete | 6.7 +/- 0.83 | 0.98 +/- 0.13 | 0.47 +/- 0.06 |
| Grid 20 | 127-RS-159 | Discrete | <3.3 | 0.64 +/- 0.15 | 0.55 +/- 0.10 |
| Grid 20 | 127-RS-160 | Discrete | 17.3 +/- 4.3 | 0.75 +/- 0.11 | 0.48 +/- 0.08 |
| Grid 21 | 127-RS-639 | Composite | 37.6 +/- 2.95 | 0.91 +/- 0.08 | 0.59 +/- 0.04 |
| Grid 21 | 127-RS-647 | Discrete | 11.0 +/- 2.46 | 0.79 +/- 0.11 | 0.62 +/- 0.06 |
| Grid 21 | 127-RS-650 | Discrete | 18.1 +/- 2.60 | 1.50 +/- 0.11 | 0.64 +/- 0.05 |
| Grid 21 | 127-RS-651 | Discrete | 12.3 +/- 3.01 | 0.85 +/- 0.12 | 0.74 +/- 0.07 |
| Grid 28 | 127-RS-172 | Discrete | <2.4 | <0.6 | 0.84 +/- 0.08 |
| Grid 28 | 127-RS-175 | Discrete | 1.1 +/- 0.53 | 0.39 +/- 0.08 | 0.37 +/- 0.05 |
| Grid 28 | 127-RS-181 | Discrete | 3.3 +/- 0.93 | 0.49 +/- 0.08 | 0.27 +/- 0.04 |
| Grid 28 | 127-RS-182 | Discrete | 5.6 +/- 1.5 | 0.64 +/- 0.10 | 0.43 +/- 0.06 |
| Grid 28 | 127-RS-183 | Discrete | 2.9 +/- 0.92 | <0.51 | 0.55 +/- 0.06 |
| Grid 29 | 127-RS-171 | Discrete | 7.4 +/- 2.0 | 0.83 +/- 0.12 | 0.36 +/- 0.07 |
| Grid 29 | 127-RS-173 | Discrete | 1.2 +/- 0.57 | 0.5 +/- 0.08 | 0.58 +/- 0.05 |
| Grid 29 | 127-RS-174 | Discrete | 8.8 +/- 1.0 | 0.75 +/- 0.11 | 0.53 +/- 0.07 |
| Grid 29 | 127-RS-176 | Discrete | 3.4 +/- 0.10 | 0.59 +/- 0.09 | <0.3 |
| Grid 29 | 127-RS-177 | Discrete | 7.8 +/- 2.00 | 0.65 +/- 0.09 | 0.56 +/- 0.06 |
| Grid 29 | 127-RS-178 | Discrete | 6.7 +/- 1.8 | 1.1 +/- 0.14 | 0.7 +/- 0.07 |
| Grid 29 | 127-RS-179 | Discrete | 8.5 +/- 2.2 | <0.39 | 0.26 +/- 0.04 |
| Grid 29 | 127-RS-180 | Discrete | 16.5 +/- 1.2 | 0.37 +/- 0.10 | <0.29 |
| Grid 30 | 127-RS-166 | Discrete | 1.3 +/- 0.61 | 0.59 +/- 0.10 | 0.88 +/- 0.06 |
| Grid 30 | 127-RS-167 | Discrete | <2.3 | 0.63 +/- 0.11 | 1.3 +/- 0.07 |
| Grid 30 | 127-RS-168 | Discrete | 11.4 +/- 2.9 | 0.93 +/- 0.12 | 0.69 +/- 0.07 |
| Grid 30 | 127-RS-169 | Discrete | 9.3 +/- 0.94 | 0.44 +/- 0.10 | 0.97 +/- 0.07 |
| Grid 30 | 127-RS-170 | Discrete | 1.6 +/- 0.65 | 0.61 +/- 0.11 | 0.77 +/- 0.06 |

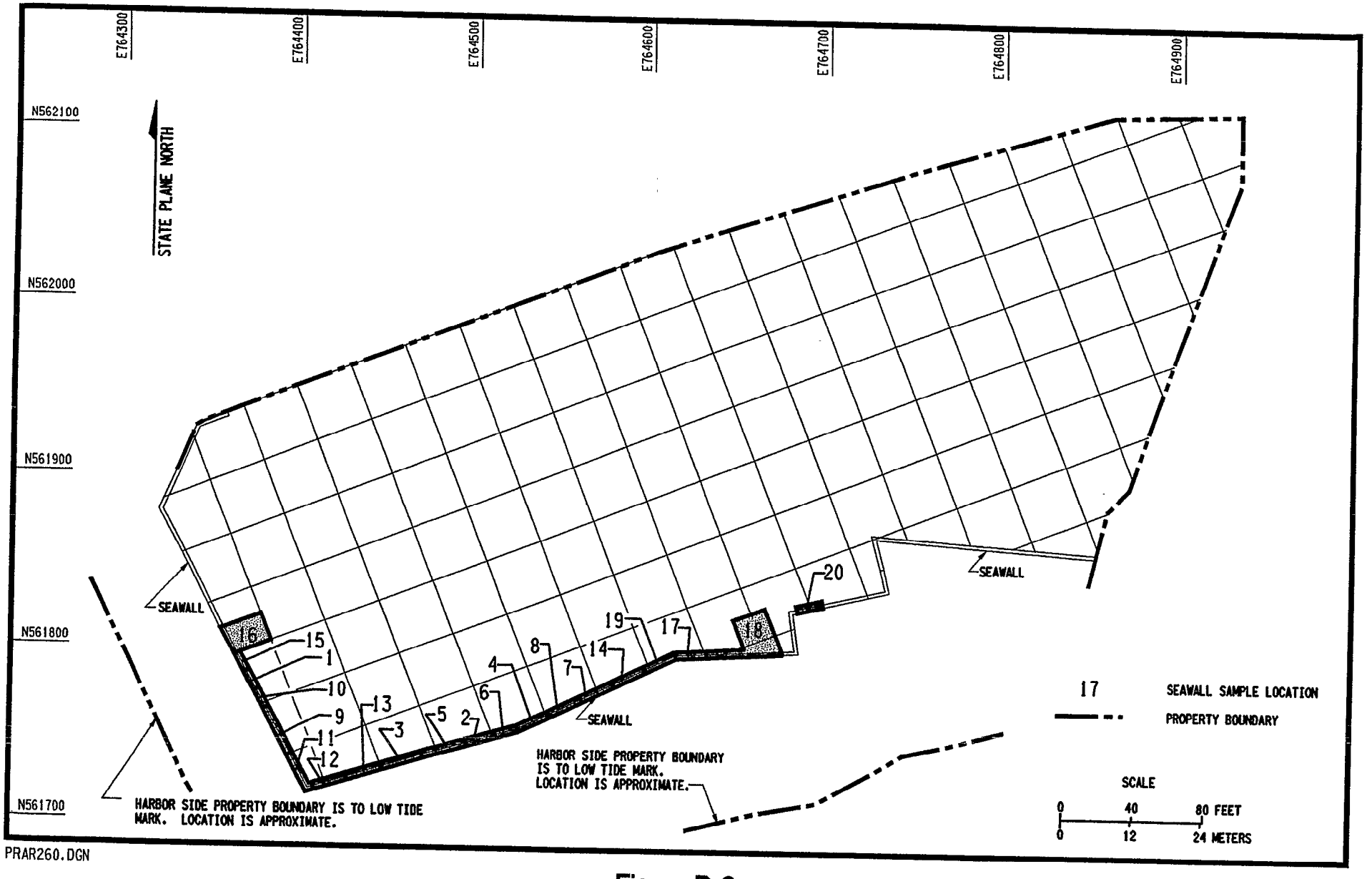
**Table D-5**
**(continued)**

| Grid Location | Sample ID | Phase II (continued) Sample Type | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| Grid 31 | 127-RS-161 | Discrete | <2.8 | <0.64 | 1.1 +/- 0.08 |
| Grid 31 | 127-RS-162 | Discrete | 2.9 +/- 0.89 | 0.58 +/- 0.09 | 0.87 +/- 0.06 |
| Grid 31 | 127-RS-163 | Discrete | 3 +/- 1.0 | 0.84 +/- 0.10 | 0.7 +/- 0.07 |
| Grid 31 | 127-RS-164 | Discrete | 2.9 +/- 0.90 | 0.76 +/- 0.09 | 1.1 +/- 0.07 |
| Grid 31 | 127-RS-165 | Discrete | <2.1 | 0.68 +/- 0.11 | 0.92 +/- 0.07 |
| Grid 32 | 127-RS-197 | Discrete | <1.81 | <0.42 | <0.33 |
| Grid 32 | 127-RS-198 | Discrete | <2.25 | 0.73 +/- 0.13 | 1.1 +/- 0.07 |
| Grid 32 | 127-RS-199 | Discrete | <2.17 | 0.57 +/- 0.11 | 0.83 +/- 0.07 |
| Grid 32 | 127-RS-200 | Discrete | 5.76 +/- 1.64 | 0.89 +/- 0.14 | 0.9 +/- 0.08 |
| Grid 32 | 127-RS-201 | Discrete | <1.93 | 0.67 +/- 0.12 | 0.81 +/- 0.06 |
| Grid 44 | 127-RS-202 | Discrete | <2.43 | 0.51 +/- 0.12 | 0.86 +/- 0.08 |
| Grid 44 | 127-RS-203 | Discrete | <1.86 | 0.74 +/- 0.11 | 1.14 +/- 0.07 |
| Grid 44 | 127-RS-204 | Discrete | 2.72 +/- 0.96 | 0.51 +/- 0.16 | 0.53 +/- 0.08 |
| Grid 44 | 127-RS-205 | Discrete | <1.54 | <0.43 | 0.85 +/- 0.06 |
| Grid 44 | 127-RS-206 | Discrete | <3.19 | <0.55 | <0.35 |
| Grid 45 | 127-RS-212 | Discrete | <2.3 | 0.62 +/- 0.10 | 0.58 +/- 0.07 |
| Grid 45 | 127-RS-213 | Discrete | 2.9 +/- 1.1 | 0.96 +/- 0.19 | 0.75 +/- 0.11 |
| Grid 45 | 127-RS-214 | Discrete | 2.3 +/- 0.84 | 0.7 +/- 0.11 | 0.48 +/- 0.06 |
| Grid 45 | 127-RS-215 | Discrete | 2.9 +/- 0.99 | <0.68 | 0.5 +/- 0.07 |
| Grid 45 | 127-RS-216 | Discrete | 1.5 +/- 0.66 | 0.62 +/- 0.09 | 0.43 +/- 0.05 |
| Grid 46 | 127-RS-207 | Discrete | <2.33 | 0.77 +/- 0.13 | 0.5 +/- 0.07 |
| Grid 46 | 127-RS-208 | Discrete | <2.5 | <0.63 | 0.38 +/- 0.07 |
| Grid 46 | 127-RS-209 | Discrete | <2.9 | 2 +/- 0.15 | 0.44 +/- 0.08 |
| Grid 46 | 127-RS-210 | Discrete | <2.0 | 0.35 +/- 0.10 | 0.55 +/- 0.06 |
| Grid 46 | 127-RS-211 | Discrete | 1.8 +/- 0.81 | 0.67 +/- 0.15 | 0.41 +/- 0.08 |
| Grid 29/30 HS Removal | 127-RS-253 | Discrete | 3.4 +/- 0.10 | 0.64 +/- 0.10 | 0.51 +/- 0.05 |
| Grid 29/30 HS Removal | 127-RS-254 | Discrete | 2.7 +/- 0.98 | 0.52 +/- 0.08 | 0.38 +/- 0.05 |
| Grid 29/30 HS Removal | 127-RS-255 | Discrete | <1.9 | 0.55 +/- 0.08 | 0.3 +/- 0.05 |
| Grid 29/30 HS Removal | 127-RS-256 | Discrete | <1.9 | 0.5 +/- 0.09 | 0.4 +/- 0.05 |

**Table D-6**
**Post-Remedial Action Data, Excavation 6**
**Samples Near Vicinity of Seawall**

| Seawall Proximity Location | Sample ID | Sample Type | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| Location 1 | 127-RS-285 | Composite | 12.3 +/- 3.10 | 0.79 +/- 0.08 | 0.40 +/- 0.05 |
| | 127-RS-286 | Highest Area | 15.1 +/- 3.80 | 1.1 +/- 0.14 | 0.47 +/- 0.08 |
| Location 2 | 127-RS-296 | Composite | 25.89 +/- 1.93 | 1.16 +/- 0.15 | 0.86 +/- 0.08 |
| | 127-RS-297 | Composite | 18.1 +/- 4.51 | 0.77 +/- 0.13 | 0.69 +/- 0.07 |
| | 127-RS-298 | Highest Area | 5.3 +/- 1.39 | 0.42 +/- 0.07 | 0.42 +/- 0.06 |
| Location 3 | 127-RS-295 | Composite | 21.16 +/- 1.52 | 0.69 +/- 0.69 | 0.34 +/- 0.07 |
| | 127-RS-294 | Composite | 29.31 +/- 2.07 | 0.59 +/- 0.10 | 0.52 +/- 0.06 |
| | 127-RS-293 | Highest Area | 16.73 +/- 4.28 | <0.94 | 0.52 +/- 0.11 |
| Location 4 | 127-RS-299 | Composite | 22.7 +/- 1.90 | 1.6 +/- 0.17 | 1.6 +/- 0.11 |
| | 127-RS-300 | Composite | 24.9 +/- 6.20 | <0.96 | 1.3 +/- 0.11 |
| | 127-RS-301 | Highest Area | 26.1 +/- 6.40 | 0.86 +/- 0.17 | 1.3 +/- 0.10 |
| Location 5 | 127-RS-302 | Composite | 8.4 +/- 2.20 | 0.61 +/- 0.11 | 0.6 +/- 0.06 |
| | 127-RS-303 | Composite | 15.6 +/- 4.00 | 0.84 +/- 0.14 | 0.77 +/- 0.10 |
| | 127-RS-304 | Highest Area | 11.3 +/- 1.00 | 0.71 +/- 0.11 | 0.61 +/- 0.07 |
| Location 6 | 127-RS-305 | Composite | 8.3 +/- 2.40 | 1.2 +/- 0.19 | 0.97 +/- 0.12 |
| | 127-RS-306 | Composite | 27.6 +/- 6.90 | <1.1 | 1.9 +/- 0.15 |
| | 127-RS-307 | Highest Area | 19.0 +/- 1.7 | 1.7 +/- 0.18 | 1.3 +/- 0.11 |
| Location 7 | 127-RS-308 | Composite | 14.8 +/- 1.2 | 0.72 +/- 0.11 | 0.57 +/- 0.06 |
| | 127-RS-309 | Composite | 38.1 +/- 2.50 | <0.94 | 0.77 +/- 0.10 |
| | 127-RS-310 | Highest Area | 7.2 +/- 1.90 | <0.61 | <0.35 |
| Location 8 | 127-RS-311 | Composite | 16 +/- 1.40 | 1 +/- 0.14 | 1.2 +/- 0.09 |
| | 127-RS-312 | Composite | 18.7 +/- 4.80 | <1.2 | <0.77 |
| | 127-RS-313 | Highest Area | 8.8 +/- 0.89 | 0.57 +/- 0.12 | 0.86 +/- 0.07 |
| Location 9 | 127-RS-314 | Composite | 20.7 +/- 1.50 | 0.59 +/- 0.08 | 0.50 +/- 0.05 |
| | 127-RS-315 | Composite | 23.6 +/- 1.60 | 0.55 +/- 0.12 | 0.45 +/- 0.07 |
| | 127-RS-316 | Highest Area | 29.6 +/- 1.70 | 0.61 +/- 0.12 | <0.35 |
| Location 10 | 127-RS-317 | Composite | 15 +/- 1.20 | 0.61 +/- 0.09 | 0.55 +/- 0.05 |
| | 127-RS-318 | Composite | 11.5 +/- 3.00 | <0.62 | 0.58 +/- 0.07 |
| | 127-RS-319 | Highest Area | 8.1 +/- 2.10 | 0.92 +/- 0.09 | 0.61 +/- 0.06 |
| Location 11 | 127-RS-320 | Composite | 12.8 +/- 3.20 | 0.72 +/- 0.12 | 0.45 +/- 0.07 |
| | 127-RS-321 | Composite | 12.5 +/- 3.10 | 1.1 +/- 0.10 | 0.52 +/- 0.05 |
| | 127-RS-322 | Highest Area | 3.7 +/- 1.10 | 0.43 +/- 0.09 | 0.34 +/- 0.05 |
| Location 12 | 127-RS-323 | Composite | 16.5 +/- 1.30 | 0.78 +/- 0.09 | 0.56 +/- 0.06 |
| | 127-RS-324 | Composite | 25.9 +/- 6.4 | <0.64 | 0.5 +/- 0.08 |
| | 127-RS-325 | Highest Area | 2.2 +/- 0.83 | <0.75 | 0.81 +/- 0.08 |
| Location 13 | 127-RS-326 | Composite | 11.6 +/- 1.20 | <0.58 | 0.42 +/- 0.07 |
| | 127-RS-327 | Composite | 24.2 +/- 1.80 | 0.65 +/- 0.10 | 0.42 +/- 0.05 |

| Seawall Proximity Location | Sample ID | Sample Type | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| | 127-RS-328 | Highest Area | 5.7 +/- 1.50 | 0.54 +/- 0.09 | 0.37 +/- 0.06 |
| Location 14 | 127-RS-414 | Composite | 36.88 +/- 3.42 | 0.75 +/- 0.08 | 0.53 +/- 0.05 |
| | 127-RS-415 | Highest Area | 21.79 +/- 2.47 | 1.17 +/- 0.10 | 0.75 +/- 0.07 |
| Location 15 | 127-RS-336 | Composite | 28.9 +/- 3.02 | 0.97 +/- 0.09 | 0.64 +/- 0.06 |
| | 127-RS-337 | Highest Area | <2.76 | 0.51 +/- 0.07 | 0.45 +/- 0.04 |
| Location 16 | 127-RS-334 | Composite | 22.5 +/- 2.49 | 0.9 +/- 0.10 | 0.89 +/- 0.06 |
| | 127-RS-335 | Highest Area | 12.98 +/- 2.32 | 2.59 +/- 0.18 | 2.24 +/- 0.12 |
| Location 17 | 127-RS-460 | Composite | 4.75 +/- 1.68 | 0.52 +/- 0.06 | 0.59 +/- 0.04 |
| Location 18 | 127-RS-464 | Composite | 18.8 +/- 2.46 | 0.76 +/- 0.07 | 0.57 +/- 0.04 |
| Location 19 | 127-RS-477 | Composite | 3.78 +/- 1.63 | 0.73 +/- 0.08 | 0.54 +/- 0.05 |
| Location 20 | 127-RS-518 | Composite | 6.98 +/- 1.59 | 0.88 +/- 0.12 | 0.64 +/- 0.07 |
| | 127-RS-522 | Highest Area | 15.13 +/- 1.86 | 0.93 +/- 0.14 | 0.7 +/- 0.08 |




PRAR260.DGN

**Figure D-2**
**Ventron Site**
**Location of Samples Taken Near the Seawall**

**Table D-7**
**Post-Remedial Action Data, Excavation 6**
**(From Building C Slab, Across Building B Slab, to Building F Slab)**

| Grid Location | Sample ID | Sample Type | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| S30 - E0 | 127-RS-334 | Composite | 22.5 +/- 2.49 | 0.9 +/- 0.10 | 0.89 +/- 0.06 |
| S30 - E0 | 127-RS-335 | Highest Area | 12.98 +/- 2.32 | 2.55 +/- 0.18 | 2.24 +/- 0.12 |
| S30 - E10 | 127-RS-338 | Composite | 7.36 +/- 1.32 | 1.11 +/- 0.11 | 0.94 +/- 0.06 |
| S30 - E10 | 127-RS-339 | Highest Area | 19.8 +/- 2.44 | 1.39 +/- 0.12 | 1.13 +/- 0.08 |
| S30 - E20 | 127-RS-340 | Composite | 5.31 +/- 1.13 | 0.87 +/- 0.09 | 0.86 +/- 0.06 |
| S30 - E20 | 127-RS-341 | Highest Area | <6.23 | 1.67 +/- 0.14 | 1.96 +/- 0.10 |
| S40 - E0 | 127-RS-342 | Composite | 44.3 +/- 3.87 | 1.18 +/- 0.10 | 0.9 +/- 0.06 |
| S40 - E0 | 127-RS-343 | Highest Area | 37.5 +/- 3.57 | 1.06 +/- 0.10 | 1.13 +/- 0.07 |
| S40 - E10 | 127-RS-344 | Composite | 22.4 +/- 2.37 | 0.81 +/- 0.08 | 0.78 +/- 0.05 |
| S40 - E10 | 127-RS-345 | Highest Area | 29.5 +/- 3.18 | 0.85 +/- 0.09 | 0.6 +/- 0.06 |
| S40 - E20 | 127-RS-347 | Composite | 9.84 +/- 1.39 | 0.69 +/- 0.08 | 0.58 +/- 0.05 |
| S40 - E20 | 127-RS-348 | Highest Area | 7.63 +/- 1.25 | 0.58 +/- 0.08 | 0.58 +/- 0.05 |
| S50 - E0 | 127-RS-465 | Composite | 8.87 +/- 2.17 | 0.83 +/- 0.08 | 0.82 +/- 0.06 |
| S50 - E0 | 127-RS-356 | Highest Area | 45.03 +/- 4.51 | 1.22 +/- 0.11 | 0.78 +/- 0.07 |
| S50 - E10 | 127-RS-357 | Composite | 41.89 +/- 3.61 | 1.13 +/- 0.09 | 0.79 +/- 0.06 |
| S50 - E10 | 127-RS-358 | Highest Area | 35.26 +/- 3.18 | 0.55 +/- 0.08 | 0.38 +/- 0.05 |
| S50 - E20 | 127-RS-373 | Composite | 20.7 +/- 2.29 | 0.63 +/- 0.08 | 0.51 +/- 0.05 |
| S50 - E20 | 127-RS-374 | Highest Area | 17.94 +/- 2.12 | 0.78 +/- 0.10 | 0.56 +/- 0.05 |
| S60 - E0 | 127-RS-359 | Composite | 45.79 +/- 3.66 | 0.85 +/- 0.08 | 0.72 +/- 0.05 |
| S60 - E0 | 127-RS-360 | Highest Area | 30.34 +/- 2.93 | 0.76 +/- 0.08 | 0.58 +/- 0.05 |
| S60 - E10 | 127-RS-361 | Composite | 21.08 +/- 2.23 | 0.59 +/- 0.07 | 0.54 +/- 0.05 |
| S60 - E10 | 127-RS-362 | Highest Area | 7.51 +/- 1.29 | 0.65 +/- 0.09 | 0.45 +/- 0.05 |
| S60 - E20 | 127-RS-370 | Composite | 23.05 +/- 2.35 | 0.45 +/- 0.06 | 0.45 +/- 0.04 |
| S60 - E20 | 127-RS-371 | Highest Area | <4.03 | 0.67 +/- 0.08 | 0.43 +/- 0.05 |
| S50 - E30 | 127-RS-380 | Composite | 44.7 +/- 4.02 | 0.89 +/- 0.09 | 0.85 +/- 0.06 |
| S50 - E30 | 127-RS-439 | Highest Area | 48.50 +/- 4.79 | 0.93 +/- 0.10 | 0.80 +/- 0.06 |
| S60 - E30 | 127-RS-364 | Composite | 32.87 +/- 3.17 | 0.79 +/- 0.10 | 0.61 +/- 0.05 |
| S60 - E30 | 127-RS-365 | Highest Area | 13.82 +/- 1.83 | 0.73 +/- 0.09 | 0.62 +/- 0.05 |
| S50 - E40 | 127-RS-382 | Composite | 26.92 +/- 2.81 | 0.65 +/- 0.08 | 0.76 +/- 0.06 |
| S50 - E40 | 127-RS-383 | Highest Area | 23.34 +/- 2.60 | 0.77 +/- 0.10 | 0.77 +/- 0.06 |
| S60 - E40 | 127-RS-366 | Composite | 40.38 +/- 3.96 | 0.9 +/- 0.10 | 1.08 +/- 0.07 |
| S60 - E40 | 127-RS-379 | Highest Area | <13.6 | <2.12 | <1.14 |
| S50 - E50 | 127-RS-399 | Composite | 31.67 +/- 2.97 | 0.68 +/- 0.08 | 0.64 +/- 0.05 |
| S50 - E50 | 127-RS-431 | Highest Area | 18.15 +/- 2.45 | 0.56 +/- 0.07 | 0.48 +/- 0.04 |
| S60 - E50 | 127-RS-430 | Composite | 34.8 +/- 4.23 | 0.91 +/- 0.10 | 0.61 +/- 0.06 |
| S40 - E60 | 127-RS-412 | Composite | 42.05 +/- 3.70 | 0.73 +/- 0.08 | 0.6 +/- 0.05 |
| S40 - E60 | 127-RS-413 | Highest Area | 40.16 +/- 3.47 | 0.58 +/- 0.08 | 0.59 +/- 0.05 |
| S50 - E60 | 127-RS-441 | Composite | 38.3 +/- 4.61 | 1.09 +/- 0.10 | 1.04 +/- 0.07 |

**Table D-7**
**(continued)**

| Grid Location | Sample ID | Sample Type | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| S50 - E60 | 127-RS-440 | Highest Area | 40.59 +/- 4.05 | 0.77 +/- 0.09 | 0.74 +/- 0.06 |
| S60 - E60 | 127-RS-458 | Composite | 12.8 +/- 1.96 | 0.64 +/- 0.07 | 0.78 +/- 0.05 |
| S60 - E60 | 127-RS-415 | Highest Area | 21.79 +/- 2.47 | 1.17 +/- 0.10 | 0.75 +/- 0.07 |
| S40 - E70 | 127-RS-463 | Composite | 8.0 +/- 1.76 | 0.79 +/- 0.07 | 0.69 +/- 0.04 |
| S50 - E70 | 127-RS-462 | Composite | 17.21 +/- 2.29 | 0.96 +/- 0.08 | 0.68 +/- 0.05 |
| S60 - E70 | 127-RS-461 | Composite | 16.43 +/- 2.11 | 0.73 +/- 0.07 | 0.49 +/- 0.04 |
| S40 - E80 | 127-RS-510 | Composite | 12.46 +/- 1.88 | 0.74 +/- 0.10 | 0.69 +/- 0.07 |
| S40 - E80 | 127-RS-511 | Highest Area | 11.31 +/- 1.40 | 0.82 +/- 0.13 | 0.69 +/- 0.07 |
| S50 - E80 | 127-RS-512 | Composite | 35.43 +/- 4.25 | 0.78 +/- 0.10 | 0.68 +/- 0.07 |
| S50 - E80 | 127-RS-513 | Highest Area | 31.47 +/- 2.95 | 0.85 +/- 0.14 | 0.64 +/- 0.07 |
| S60 - E80 | 127-RS-514 | Composite | 34.97 +/- 3.99 | 0.66 +/- 0.10 | 0.62 +/- 0.06 |
| S60 - E80 | 127-RS-515 | Highest Area | 32.15 +/- 3.11 | 0.68 +/- 0.12 | 0.65 +/- 0.07 |
| S40 - E90 | 127-RS-580 | Composite | 14.1 +/- 2.58 | 0.70 +/- 0.08 | 0.62 +/- 0.05 |
| S40 - E90 | 127-RS-581 | Highest Area | 16.22 +/- 2.61 | 0.76 +/- 0.08 | 0.60 +/- 0.05 |
| S50 - E90 | 127-RS-582 | Composite | 11.76 +/- 1.91 | 0.62 +/- 0.07 | 0.53 +/- 0.04 |
| S50 - E90 | 127-RS-583 | Highest Area | 10.27 +/- 1.87 | 0.69 +/- 0.07 | 0.50 +/- 0.04 |
| S60 - E90 | 127-RS-584 | Composite | 5.59 +/- 1.97 | 0.68 +/- 0.07 | 0.60 +/- 0.04 |
| S60 - E90 | 127-RS-585 | Highest Area | 8.55 +/- 1.71 | 0.59 +/- 0.07 | 0.49 +/- 0.04 |
| S70 - E90 | 127-RS-586 | Composite | 4.43 +/- 1.86 | 0.81 +/- 0.09 | 0.63 +/- 0.05 |
| S40 - E100 | 127-RS-587 | Composite | 14.64 +/- 2.02 | 0.71 +/- 0.07 | 0.59 +/- 0.05 |
| S40 - E100 | 127-RS-588 | Highest Area | 13.58 +/- 2.15 | 0.74 +/- 0.08 | 0.58 +/- 0.05 |
| S50 - E100 | 127-RS-589 | Composite | 22.8 +/- 2.77 | 0.91 +/- 0.09 | 0.62 +/- 0.05 |
| S50 - E100 | 127-RS-590 | Highest Area | 20.6 +/- 2.57 | 0.91 +/- 0.09 | 0.59 +/- 0.05 |
| S60 - E100 | 127-RS-591 | Composite | 18.44 +/- 2.57 | 0.84 +/- 0.09 | 0.64 +/- 0.05 |
| S60 - E100 | 127-RS-592 | Highest Area | 18.23 +/- 2.65 | 0.80 +/- 0.08 | 0.49 +/- 0.05 |
| S60 - E110 | 127-RS-595 | Composite | 4.17 +/- 2.36 | 0.71 +/- 0.09 | 0.59 +/- 0.05 |
| S60 - E110 | 127-RS-596 | Highest Area | 6.78 +/- 2.54 | 0.76 +/- 0.10 | 0.54 +/- 0.06 |
| S50 - E110 | 127-RS-593 | Composite | 8.92 +/- 2.12 | 0.86 +/- 0.09 | 0.61 +/- 0.05 |
| S50 - E110 | 127-RS-594 | Highest Area | 8.08 +/- 2.24 | 0.79 +/- 0.09 | 0.60 +/- 0.05 |

**Table D-8**
**Post-Remedial Action Data, Excavation 7**
**(Between Building A Slab and Building E)**

| Grid Location | Sample ID | Sample Type | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| S30 - E100 | 127-RS-349 | Composite | <4.63 | 0.67 +/- 0.10 | 0.56 +/- 0.06 |
| S30 - E100 | 127-RS-350 | Highest Area | <3.82 | 0.69 +/- 0.11 | 0.7 +/- 0.07 |
| S30 - E110 | 127-RS-352 | Composite | <4.52 | 0.94 +/- 0.94 | 0.68 +/- 0.06 |
| S30 - E110 | 127-RS-353 | Highest Area | 10.89 +/- 1.77 | 0.84 +/- 0.11 | 0.6 +/- 0.08 |

## Table D-9
## Post-Remedial Action Data, Excavations 8, 9, 10, and 11

### Excavation 8 (Building A Leach Tank Pit)

| Grid Location | Sample ID | Sample Type | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| S30 - E80 | 127-RS-438 | Composite | 8.38 +/- 2.46 | 1.03 +/- 0.09 | 0.71 +/- 0.06 |

### Excavation 9 (Building A Fan Pit)

| Grid Location | Sample ID | Sample Type | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| S27 - E66 | 127-RS-454 | Composite | 6.72 +/- 1.92 | 0.51 +/- 0.07 | 0.42 +/- 0.04 |
| S27 - E66 | 127-RS-455 | Highest Area | 13.75 +/- 2.62 | 1.42 +/- 0.12 | 1.16 +/- 0.08 |

### Excavation 10

| Grid Location | Sample ID | Sample Type | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| S20 - E50 | 127-RS-442 | Composite | 4.18 +/- 1.92 | 1.08 +/- 0.10 | 1.03 +/- 0.07 |
| S20 - E50 | 127-RS-441A | Highest Area | 1.52 +/- 3.36 | 2.2 +/- 0.17 | 2.62 +/- 0.12 |

### Excavation 11

| Grid Location | Sample ID | Sample Type | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| S20 - E40 | 127-RS-438A | Composite | 3.89 +/- 3.00 | 2.46 +/- 0.17 | 2.69 +/- 0.12 |
| S20 - E40 | 127-RS-439A | Highest Area | 22.51 +/- 3.37 | 0.90 +/- 0.10 | 1.01 +/- 0.07 |

## Table D-10
## Building A Soil Beneath Slab Samples

### Building A Subslab Samples

| Sample Number | Sample ID | Sample Type | U-238 (pCi/g) | Th-232 (pCi/g) | Ra-226 (pCi/g) |
|---|---|---|---|---|---|
| 1 | 127-RS-257 | Discrete | <4.40 | 1.70 +/- 0.25 | 2.20 +/- 0.14 |
| 2 | 127-RS-258 | Discrete | <3.60 | 2.50 +/- 0.20 | 2.60 +/- 0.14 |
| 3 | 127-RS-259 | Discrete | <2.90 | 1.70 +/- 0.15 | 1.70 +/- 0.10 |
| 4 | 127-RS-260 | Discrete | 10.20 +/- 2.80 | <1.40 | 2.50 +/- 0.16 |
| 5 | 127-RS-261 | Discrete | <3.50 | 2.20 +/- 0.21 | 2.20 +/- 0.13 |
| 6 | 127-RS-262 | Discrete | <4.30 | <1.20 | 2.10 +/- 0.14 |
| 7 | 127-RS-263 | Discrete | 2.90 | 2.20 +/- 0.22 | 2.00 +/- 0.12 |
| 8 | 127-RS-264 | Discrete | <4.10 | <1.20 | 2.20 +/- 0.14 |
| 9 | 127-RS-265 | Discrete | 2.60 | 1.40 +/- 0.15 | 1.70 +/- 0.09 |
| 10 | 127-RS-266 | Discrete | <2.50 | 0.81 +/- 0.15 | 0.93 +/- 0.08 |
| 11 | 127-RS-267 | Discrete | 4.20 | 1.80 +/- 0.16 | 1.80 +/- 0.10 |
| 12 | 127-RS-268 | Discrete | <3.40 | 1.80 +/- 0.20 | 2.70 +/- 0.14 |
| 13 | 127-RS-269 | Discrete | <4.70 | 2.10 +/- 0.25 | 2.40 +/- 0.17 |
| 14 | 127-RS-270 | Discrete | <3.7 | 1.3 +/- 0.22 | 1.8 +/- 0.12 |
| 15 | 127-RS-271 | Discrete | <3.3 | 0.9 +/- 0.17 | 1.3 +/- 0.11 |
| 16 | 127-RS-272 | Discrete | <2.60 | 1.50 +/- 0.16 | 1.40 +/- 0.09 |
| 17 | 127-RS-273 | Discrete | <2.40 | <0.73 | 0.47 +/- 0.08 |
| 18 | 127-RS-274 | Discrete | <2.50 | <0.79 | 1.60 +/- 0.10 |
| 19 | 127-RS-422 | Discrete | <5.49 | 1.93 +/- 0.16 | 2.33 +/- 0.11 |
| 20 | 127-RS-423 | Discrete | <5.74 | 1.68 +/- 0.17 | 2.09 +/- 0.12 |
| 21 | 127-RS-426 | Discrete | <2.59 | 0.60 +/- 0.07 | 0.48 +/- 0.04 |

**Table D-11**
**Gamma Exposure Rate Survey Data**

| Excavation | Grid Location | µR/h |
|---|---|---|
| Excavation 1 | S0 - E0 | 11.5 |
| Excavation 1 | S0 - E10 | 10.7 |
| Excavation 2 | S0 - E50 | 10.7 |
| Excavation 2 | S10 - E50 | 11.5 |
| Excavation 3 | S30 - E130 | 9.0 |
| Excavation 4 | S50 - E130 | 10.5 |
| Excavation 4 | S50 - E140 | 10.6 |
| Excavation 4 | S50 - E150 | 13.1 |
| Excavation 4 | S60 - E140 | 10.6 |
| Excavation 4 | S60 - E150 | 14.6 |
| Excavation 4 | S70 - E130 | 10.75 |
| Excavation 4 | S70 - E140 | 10.3 |
| Excavation 4 | S50 - E140 | 13.0 |
| Excavation 4 | S50 - E150 | 14.0 |
| Excavation 4 | S50 - E160 | 12.0 |
| Excavation 5 | Harbor Grid 1 | 12.0 |
| Excavation 5 | Harbor Grid 2 | 12.0 |
| Excavation 5 | Harbor Grid 3 | 11.0 |
| Excavation 5 | Harbor Grid 4 | 11.0 |
| Excavation 5 | Harbor Grid 5 | 11.0 |
| Excavation 5 | Harbor Grid 6 | 12.0 |
| Excavation 5 | Harbor Grid 7 | 12.0 |
| Excavation 5 | Harbor Grid 8 | 10.0 |
| Excavation 5 | Harbor Grid 9 | 8.0 |
| Excavation 5 | Harbor Grid 10 | 9.0 |
| Excavation 5 | Harbor Grid 11 | 8.0 |
| Excavation 5 | Harbor Grid 12 | 8.0 |
| Excavation 5 | Harbor Grid 13 | 10.0 |
| Excavation 5 | Harbor Grid 14 | 10.0 |
| Excavation 5 | Harbor Grid 15 | 10.0 |
| Excavation 5 | Harbor Grid 16 | 9.0 |
| Excavation 5 | Harbor Grid 17 | 10.0 |
| Excavation 5 | Harbor Grid 18 | 9.0 |
| Excavation 5 | Harbor Grid 19 | 9.0 |
| Excavation 5 | Harbor Grid 20 | 8.0 |
| Excavation 5 | Harbor Grid 21 | 9.0 |
| Excavation 5 | Harbor Grid 22 | 9.0 |
| Excavation 5 | Harbor Grid 23 | 9.0 |
| Excavation 5 | Harbor Grid 24 | 9.0 |
| Excavation 5 | Harbor Grid 25 | 8.0 |

**Table D-11**
**(continued)**

| Excavation | Grid Location | µR/h |
|---|---|---|
| Excavation 5 | Harbor Grid 26 | 10.0 |
| Excavation 5 | Harbor Grid 27 | 10.0 |
| Excavation 5 | Harbor Grid 28 | 10.0 |
| Excavation 5 | Harbor Grid 29 | 8.0 |
| Excavation 5 | Harbor Grid 30 | 10.0 |
| Excavation 5 | Harbor Grid 31 | 10.0 |
| Excavation 5 | Harbor Grid 32 | 10.0 |
| Excavation 5 | Harbor Grid 33 | 9.0. |
| Excavation 5 | Harbor Grid 34 | 9.0 |
| Excavation 5 | Harbor Grid 35 | 9.0 |
| Excavation 5 | Harbor Grid 36 | 8.0 |
| Excavation 5 | Harbor Grid 37 | 8.0 |
| Excavation 5 | Harbor Grid 38 | 8.0 |
| Excavation 5 | Harbor Grid 39 | 9.0 |
| Excavation 5 | Harbor Grid 40 | 8.0 |
| Excavation 5 | Harbor Grid 41 | 8.0 |
| Excavation 5 | Harbor Grid 42 | 10.0 |
| Excavation 5 | Harbor Grid 43 | 9.0 |
| Excavation 5 | Harbor Grid 44 | 10.0 |
| Excavation 5 | Harbor Grid 45 | 10.0 |
| Excavation 5 | Harbor Grid 46 | 8.0 |
| Excavation 6 | S30 - E0 | 9.0 |
| Excavation 6 | S40 - E0 | 9.0 |
| Excavation 6 | S50 - E0 | 10.0 |
| Excavation 6 | S60 - E0 | 10.0 |
| Excavation 6 | S30 - E10 | 9.0 |
| Excavation 6 | S40 - E10 | 10.0 |
| Excavation 6 | S50 - E10 | 9.0 |
| Excavation 6 | S60 - E10 | 9.0 |
| Excavation 6 | S30 - E10 | 10.0 |
| Excavation 6 | S40 - E20 | 11.0 |
| Excavation 6 | S50 - E20 | 11.0 |
| Excavation 6 | S60 - E20 | 10.0 |
| Excavation 6 | S50 - E30 | 9.0 |
| Excavation 6 | S60 - E30 | 9.0 |
| Excavation 6 | S50 - E40 | 9.0 |
| Excavation 6 | S60 - E40 | 9.0 |
| Excavation 6 | S50 - E50 | 10.0 |
| Excavation 6 | S50 - E70 | 10.0 |
| Excavation 6 | S50 - E80 | 9.0 |
| Excavation 6 | S50 - E90 | 10.0 |

**Table D-11**
**(continued)**

| Excavation | Grid Location | µR/h |
|---|---|---|
| Excavation 6 | S50 - E100 | 10.0 |
| Excavation 6 | S50 - E110 | 10.0 |
| Excavation 6 | S60 - E50 | 11.0 |
| Excavation 6 | S60 - E60 | 10.0 |
| Excavation 6 | S60 - E70 | 10.0 |
| Excavation 6 | S60 - E80 | 10.0 |
| Excavation 6 | S60 - E90 | 10.0 |
| Excavation 6 | S60 - E100 | 10.0 |
| Excavation 6 | S60 - E110 | 12.0 |
| Excavation 7 | S30 - E100 | 11.0 |

ORISE
OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

March 17, 2003

Mr. Robert Atkin
U.S. Department of Energy
Oak Ridge Operations
P. O. Box 2001
Oak Ridge, TN 37831-8723

**SUBJECT: FINAL REPORT—VERIFICATION SURVEY OF THE VENTRON SITE, BEVERLY, MASSACHUSETTS**

Dear Mr. Atkin:

The Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education conducted verification surveys of the Formerly Utilized Sites Remedial Action Program's (FUSRAP) Ventron Site in Beverly, Massachusetts during the period September 1995 through March 1997. Enclosed are five copies of the final report detailing the procedures and results of these verification survey activities.

Please contact me at (865) 576-0065 or Tim Vitkus at (865) 576-5073 should you have any questions, comments, or require any additional information.

Sincerely,

Wade C. Adams
Project Leader/Health Physicist
Environmental Survey and
Site Assessment Program

WCA:ar

Enclosure

cc: E. Abelquist, ORISE/ESSAP
T. Vitkus, ORISE/ESSAP
W. Beck, ORISE/ESSAP
V. Spicer, Bechtel
File/331

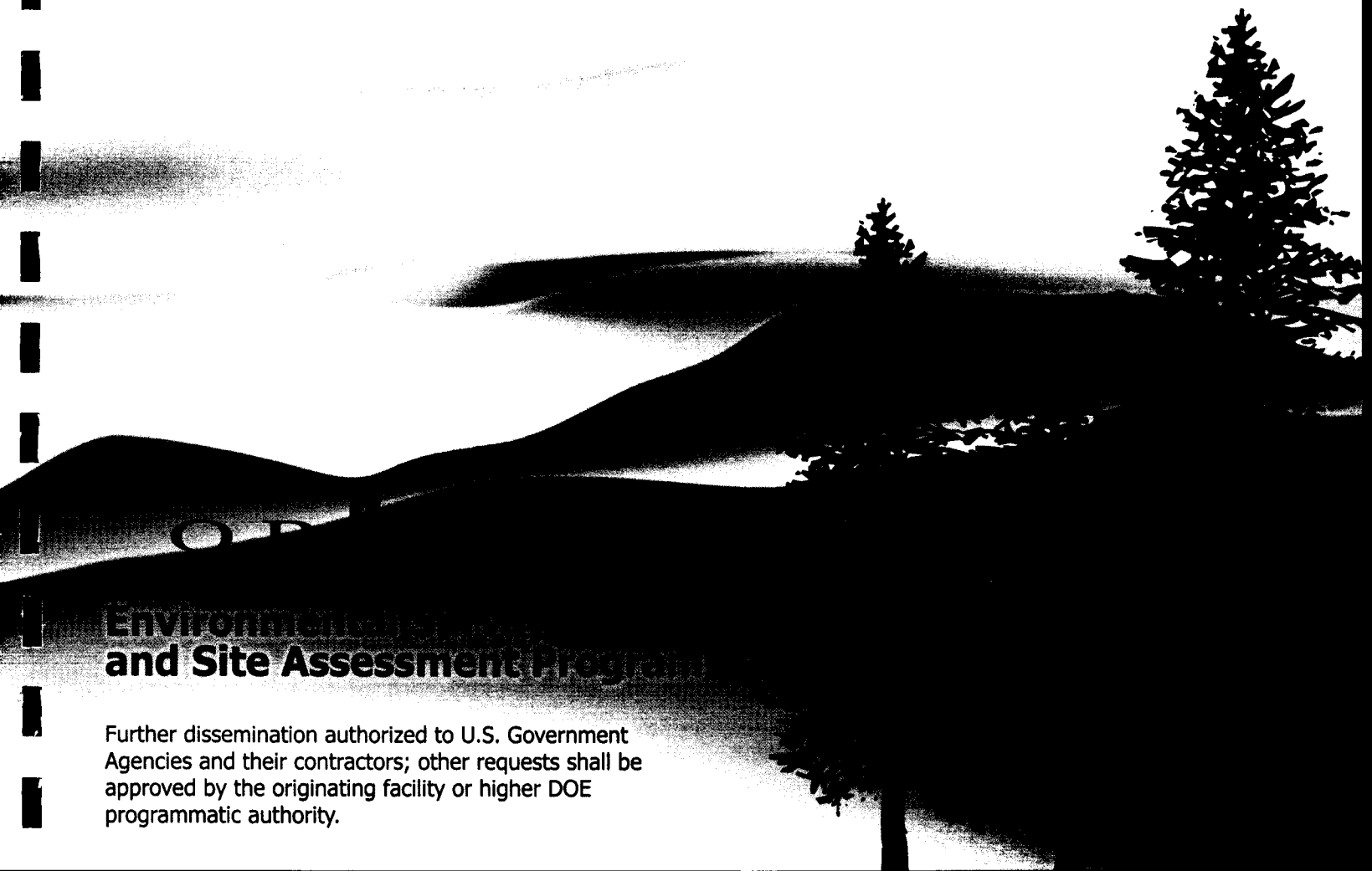
P. O. BOX 117, OAK RIDGE, TENNESSEE 37831-0117

Operated by Oak Ridge Associated Universities for the U.S. Department of Energy

# VERIFICATION SURVEY OF THE VENTRON SITE BEVERLY, MASSACHUSETTS

W. C. ADAMS

Prepared for the
Office of Environmental Management
U.S. Department of Energy



Environmental Survey and Site Assessment Program

Further dissemination authorized to U.S. Government Agencies and their contractors; other requests shall be approved by the originating facility or higher DOE programmatic authority.

# VERIFICATION SURVEY OF THE VENTRON SITE BEVERLY, MASSACHUSETTS

Prepared by

W. C. Adams

Environmental Survey and Site Assessment Program
Radiological Safety, Assessments and Training
Oak Ridge Institute for Science and Education
Oak Ridge, Tennessee 37831-0117

Prepared for the

Office of Environmental Management
U.S. Department of Energy

**FINAL REPORT**

**FEBRUARY 2003**

This report is based on work performed under contract number DE-AC05-00OR22750 with the U.S. Department of Energy.

**VERIFICATION SURVEY**
**OF THE**
**VENTRON SITE**
**BEVERLY, MASSACHUSETTS**

Prepared by: Wade C Adams Date: 3/6/03
W. C. Adams, Project Leader
Environmental Survey and Site Assessment Program

Reviewed by: Timothy J Vitkus Date: 3/6/2003
T. J. Vitkus, Survey Projects Manager
Environmental Survey and Site Assessment Program

Reviewed by: R. D. Condra Date: 3/6/2003
R. D. Condra, Laboratory
Environmental Survey and Site Assessment Program

Reviewed by: Ann T Payne Date: 3/5/03
A. T. Payne, Quality Assurance/Safety Manager
Environmental Survey and Site Assessment Program

Reviewed by: W L Beck Date: 3/6/03
W. L. Beck, Assistant Program Director
Environmental Survey and Site Assessment Program

Reviewed by: Eric W. Abelquist Date: 3/6/2003
E. W. Abelquist, Program Director
Environmental Survey and Site Assessment Program

## ACKNOWLEDGMENTS

The author would like to acknowledge the significant contributions of the following past and present staff members:

### FIELD STAFF

E. W. Abelquist
J. L. Brock
E. G. Bullington
T. D. Herrera
E. H. Montalvo
J. R. Morton
S. E. Potter

### LABORATORY STAFF

R. D. Condra
J. S. Cox
M. J. Laudeman
S. T. Shipley

### CLERICAL STAFF

T. S. Bunch
D. K. Herrera
K. E. Waters
K. L. Pond
A. Ramsey

### ILLUSTRATORS

T. L. Brown
T. D. Herrera
J. R. Morton

# TABLE OF CONTENTS


| | PAGE |
|---|---|
| List of Figures | ii |
| List of Tables | iv |
| Abbreviations and Acronyms | v |
| Introduction and Site History | 1 |
| Site Description | 3 |
| Project Organization and Responsibility | 3 |
| Objectives | 4 |
| Document Review | 4 |
| Procedures | 4 |
| Findings and Results | 8 |
| Comparison of Results with Guidelines | 18 |
| Summary | 20 |
| Figures | 22 |
| Tables | 46 |
| References | 72 |

Appendices:

Appendix A: Major Instrumentation

Appendix B: Survey and Analytical Procedures

Appendix C: Residual Radioactive Material Guidelines Summarized from DOE Order 5400.5

## LIST OF FIGURES


PAGE

FIGURE 1: Beverly, Massachusetts Area—Location of Ventron Site . . . . . 23

FIGURE 2: Plot Plan of the Ventron Site Prior to Remedial Actions—Beverly, Massachusetts . . . . . 24

FIGURE 3: Ventron Site—Surveyed Areas . . . . . 25

FIGURE 4: Ventron Site—Plot Plan of Ventron Site Grid Blocks . . . . . 26

FIGURE 5: Ventron Site—Plot Plan of Tidal Flat Grid Blocks . . . . . 27

FIGURE 6: Ventron Site, Sea Wall—Measurement and Sampling Locations . . . . . 28

FIGURE 7: Ventron Site, Asphalt and Concrete Slab Surfaces—Measurement and Sampling Locations . . . . . 29

FIGURE 8: Ventron Site, Excavation #1, Area Northwest of Building C—Measurement and Sampling Locations . . . . . 30

FIGURE 9: Ventron Site, Excavation #2, Area Northwest of Building A—Measurement and Sampling Locations . . . . . 31

FIGURE 10: Ventron Site, Excavation #3, Area East of Building E—Measurement and Sampling Locations . . . . . 32

FIGURE 11: Ventron Site, Excavation #4, Alfa Building Area—Measurement and Sampling Locations . . . . . 33

FIGURE 12: Ventron Site, Excavation #6, Southwest Section Along Sea Wall—Measurement and Sampling Locations . . . . . 34

FIGURE 13: Ventron Site, Excavation #6, Southern Section Along Sea Wall—Measurement and Sampling Locations . . . . . 35

FIGURE 14: Ventron Site, Excavation #7, Area Southwest of Building E—Measurement and Sampling Locations . . . . . 36

FIGURE 15: Ventron Site, Building A-1 Slab Excavations—Measurement and Sampling Locations . . . . . 37

## LIST OF FIGURES (Continued)

**PAGE**


FIGURE 16: Ventron Site, Leach Tank Pit Excavation—Measurement and Sampling Locations . . . . . 38

FIGURE 17: Ventron Site, Fan Pit Excavation—Measurement and Sampling Locations . . . . 39

FIGURE 18: Ventron Site, Miscellaneous Area Soil Samples—Measurement and Sampling Locations . . . . . 40

FIGURE 19: Ventron Site, Railroad Excavation—Measurement and Sampling Locations . . . 41

FIGURE 20: Ventron Site, Excavation #5, Southwest Section of Tidal Flats—Measurement and Sampling Locations . . . . . 42

FIGURE 21: Ventron Site, Excavation #5, Southern Section of Tidal Flats—Measurement and Sampling Locations . . . . . 43

FIGURE 22: Ventron Site, Excavation #5, Southeast Section of Tidal Flats—Measurement and Sampling Locations . . . . . 44

FIGURE 23: Ventron Site—Background Measurement and Sampling Locations . . . . . 45

## LIST OF TABLES


**PAGE**

TABLE 1: Surface Activity Levels . . . . . 47

TABLE 2: Exposure Rates and Radionuclide Concentrations in Onsite Soil Samples . . . . . 48

TABLE 3: Radionuclide Concentrations in Railroad Soil Samples . . . . . 59

TABLE 4: Exposure Rates and Radionuclide Concentrations in Beverly Harbor Tidal Flat Soil/Sediment Samples . . . . . 61

TABLE 5: Analytical Comparison Data for Post-RA Ventron Sea Wall Soil Samples . . . . 69

TABLE 6: Background Exposure Rates and Radionuclide Concentrations in Soil Samples . . . . . 71

## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| μR/h | microroentgens per hour |
| μrem/h | microrem per hour |
| AEC | U.S. Atomic Energy Commission |
| ALARA | as low as reasonably achievable |
| ASME | American Society of Mechanical Engineers |
| BKG | background |
| BNI | Bechtel National, Inc. |
| cm | centimeter |
| $cm^2$ | square centimeter |
| cpm | counts per minute |
| DOE | U.S. Department of Energy |
| DOE-HQ | U.S. Department of Energy-Headquarters |
| DOE-ORO | U.S. Department of Energy-Oak Ridge Operations |
| dpm/100 $cm^2$ | disintegrations per minute per 100 square centimeters |
| EML | Environmental Measurements Laboratory |
| EPA | Environmental Protection Agency |
| ESSAP | Environmental Survey and Site Assessment Program |
| FIDLER | Field Instrument for the Detection of Low-Energy Radiation |
| FSRD | Former Sites Restoration Division |
| FUSRAP | Formerly Utilized Sites Remedial Action Program |
| GM | Gieger-Muller |
| IVC | Independent Verification Contractor |
| kg | kilogram |
| km | kilometer |
| m | meter |
| mm | millimeter |
| $m^2$ | square meter |
| MDC | minimum detectable concentration |
| MED | Manhattan Engineer District |
| MeV | million electron volts |
| mrem/yr | millirem per year |
| NaI | sodium iodide |
| NIST | National Institute of Standards and Technology |
| NRC | U.S. Nuclear Regulatory Commission |
| ORISE | Oak Ridge Institute for Science and Education |
| ORNL | Oak Ridge National Laboratory |
| pCi/g | picocuries per gram |
| PMC | Project Management Contractor |
| PRAR | post-remedial action report |
| RA | remedial action |
| Ra | radium |
| SAIC | Science Applications International Corporation |
| Th | thorium |
| Tl | thallium |
| U | uranium |

# VERIFICATION SURVEY
# OF THE
# VENTRON SITE
# BEVERLY, MASSACHUSETTS

## INTRODUCTION AND SITE HISTORY

The Metals Hydride Corporation operated the Ventron site, located in Beverly, Massachusetts, from 1942 to 1948 under contract to the U.S. Army Corps of Engineers Manhattan Engineer District (MED) and its successor, the U.S. Atomic Energy Commission (AEC), predecessor organizations to the U.S. Department of Energy (DOE). The site was used to convert uranium oxide to uranium metal powder using calcium hydride. All MED/AEC work at the site involved the handling of natural processed uranium (uranium separated from remaining progeny in the decay series); no depleted or enriched uranium was processed. Other activities involved the recovery of uranium from scrap uranium materials and turnings from operations at the slug fabrication plant in Hanford, Washington. Morton International (Morton) is the current owner/operator of the Ventron site.

During the MED/AEC contract operations, three buildings were used for uranium processing. At the completion of the MED/AEC operations, it was suggested that contaminated surfaces and equipment be cleaned or removed after the final radiation surveys were performed by the AEC in 1948. The site was decontaminated to cleanup standards applicable at the time (SAIC 1995). Two of the buildings located on the waterfront contained the foundry facilities that were demolished between 1948 and 1950. Soil remediation efforts were not conducted at this time and subsequently other buildings had been erected at these locations (Buildings B and C). The remaining original buildings (Buildings A and A-1) contained furnaces, leaching facilities, a mixing room, a drying room, and analytical laboratories (DOE 1995a).

Site records indicate that between 1947 and 1986 all forms of uranium and thorium were licensed at the Beverly site, with thorium being the primary radioactive material used. Use of these materials was regulated under U.S. Nuclear Regulatory Commission (NRC) licenses. However, the use of thorium occurred after the MED period and was not related to MED contracts (DOE 1995a). Morton ceased all site operations involving uranium and thorium in 1986.

A 1977 site radiological screening survey and a 1980 radiological survey, both performed by Oak Ridge National Laboratory (ORNL), revealed residual radioactive contamination above guidelines. As a result, the site was designated in 1986 for remedial action under the Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP was created in 1974 to identify, investigate, and cleanup or control sites where contamination above current guidelines remains from the early years of the Nation's atomic energy program. ORNL next conducted a radiological survey in 1991 to determine if radiological contamination from plant operations had migrated offsite to neighboring areas, including the Beverly Harbor. This survey identified uranium contamination in the harbor tidal flat sediments.

Based on the available historical information, uranium (U)-238, radium (Ra)-226, thorium (Th)-232 and Th-230 were identified as the contaminants of concern. DOE's responsibilities at the site were limited to the MED/AEC-associated contamination—uranium and Th-232 when commingled with uranium. Morton was responsible for all contamination that may have occurred as a result of non-MED related activities at the site. However, an agreement was reached between Morton and DOE in which DOE also agreed to remove Ra-226 and Th-232 contamination from the site (DOE 1996a and 1996b).

Bechtel National, Inc., (BNI) was the project management contractor (PMC) for FUSRAP and during the period of August through September 1995, performed an interim remedial response action of the tidal flats by excavating the areas identified with residual uranium contamination. Morton International then excavated additional soil from the tidal flats that had become contaminated with mercury as a result of previous Morton site operations. At the conclusion of these remedial activities, excavated areas were backfilled.

BNI conducted remedial actions on the plant site itself during the period of September 1995 through March 1997. Remedial activities on the plant site included excavations of the remaining contaminated soil areas which were: along the northwest corner of Building C-4; beneath the slabs of Buildings B-1, B-2, B-3, C-1, C-2, and F; beneath the slab of the Alfa Building to beyond the sea wall; along the northwest corner of Building A-1; along the southeast corner of Building A; along a portion of the east side of Building E; and, within various locations beneath the slabs of Buildings A and A-1, which included the Leach Tank Pit and the Fan Pit. Several buildings were also demolished during the site remediation.

It is the policy of the DOE to perform independent (third party) verification of the effectiveness of remedial actions conducted within FUSRAP. The Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education (ORISE) was designated by DOE as the organization responsible for this task at Ventron. Verification activities were conducted between September 1995 through March 1997. These activities, which are the subject of this report, included reviews of pertinent documents and independent radiological measurements and sampling of remediated areas.

## SITE DESCRIPTION

The Ventron site is located in Beverly, Massachusetts on Massachusetts Bay, approximately 24 kilometers [km (15 miles)] northeast of Boston, at the confluence of the Bass and Danvers Rivers (Figure 1). The site is bounded by Congress Street to the north, the Boston and Maine Railroad to the east, and the Bass and Danvers Rivers to the west and south, respectively, where the tidal flats area is located (Figure 2). The only remaining structures are Buildings E and J, which serve as office and storage facilities, and the slabs of Buildings A and A-1 (Figure 3).

## PROJECT ORGANIZATION AND RESPONSIBILITY

DOE Headquarters provided overview and coordination for all FUSRAP activities. The DOE Oak Ridge Operations (DOE-ORO) was responsible for implementation of FUSRAP and the Former Sites Restoration Division (FSRD), then known as the FUSRAP Group of DOE-ORO, managed the daily activities.

Under the standard FUSRAP protocol, an initial investigation/survey of a potential site was performed by ORISE or ORNL, under contract to DOE Headquarters. If appropriate, DOE Headquarters designated the site into FUSRAP based upon the results provided by the initial investigation. DOE's PMC for FUSRAP was BNI. BNI was responsible for the planning and the implementation of FUSRAP activities and managing the site characterization and remedial actions. The final phase for a FUSRAP site was independent verification provided by an independent verification contractor [IVC (ORISE or ORNL)] after remedial action was completed. This verification process provided independent (third party) data to assist DOE in evaluating the accuracy of the post-remedial action status of the site, as presented by the PMC, and in assuring that

the documentation accurately and adequately described the condition of the site. DOE Headquarters used the information developed by the remediation and verification activities to certify that a site can be released for use, without radiological restrictions.

## OBJECTIVES

Through document reviews and verification surveys, an independent evaluation was performed. The purpose of the evaluation was to validate that procedures and methods utilized by BNI were adequate in demonstrating the final radiological status of the Ventron site. In addition, independent verification provides assurance that the post-remediation data are sufficient, accurate, and demonstrates that remedial actions were accomplished in accordance with appropriate standards and guidelines, and that authorized limits were met.

## DOCUMENT REVIEW

ESSAP reviewed background, field, and laboratory data, BNI's post-remedial action survey plan, the predecisional and final draft post-remedial action reports (PRAR), and other supporting documentation concerning site remediation activities (DOE 1992 and 1995a; BNI 1991, 1995, 1996a and b, 1997a, b, c, and d, and 2001a and b; and ORNL 1992). The information was reviewed for general thoroughness, accuracy, and consistency between documents. The field data were evaluated to assure that areas identified as exceeding site guidelines had undergone decontamination and that residual radioactive material and exposure rate levels satisfied the established guidelines.

## PROCEDURES

During the period September 19, 1995 to March 7, 1997, ESSAP personnel visited the Ventron site on nine occasions and performed visual inspections and independent measurements and sampling of remediated areas in accordance with the Ventron survey plans dated September 19, 1995 and July 22, 1996, previously submitted to and approved by DOE Headquarters (ORISE 1995a, 1996a and b, and DOE 1995b and 1996c). Procedures were in accordance with the ORISE/ESSAP Survey Procedures and Quality Assurance Manuals (ORISE 1995b and c). The initial verification survey that was performed on the Beverly Harbor tidal flats during the period of September 19 through 23,

1995, included gamma scans and soil sampling. A preliminary report, documenting the results of this survey, was submitted to the DOE (ORISE 1995d). Other site verification activities included beta and gamma surface scans of the sea wall and the remaining building slabs and asphalt roadways, gamma surface scans of the tidal flats and excavated soil surfaces, exposure rate measurements, and surface and subsurface soil sampling. This report summarizes the procedures and results of all verification survey activities.

## REFERENCE GRID

Measurement and sampling locations were referenced to BNI designated sampling grid blocks, each having an area of approximately 100 $m^2$ (Figures 4 and 5). Measurement and sampling locations outside the designated grid blocks were referenced to the grid or to prominent site features.

## SURFACE SCANS

Surface scans for gamma radiation were conducted over 100 percent of the entire site, including all excavations, the contiguous area of the sea wall, the tidal flats, and over unremediated soil surfaces adjacent to the excavations. Surface scans were performed using NaI scintillation detectors coupled to ratemeters with audible indicators. Miscellaneous structures or items including remaining building concrete slabs, remaining paved areas, the Building A furnace flues, and portions of the sea wall were scanned at a coverage of 100 percent for gamma radiation and 25 percent for beta radiation using NaI scintillation and GM detectors, respectively, coupled to ratemeters or ratemeter-scalers with audible indicators. Areas of elevated direct radiation identified by scans were marked for further investigation.

## SURFACE ACTIVITY MEASUREMENTS

Direct measurements to determine total beta surface activity levels were performed at 34 randomly selected locations on the sea wall. Forty additional measurements were performed on remaining concrete slabs and asphalt roadway areas. All measurements were performed using GM detectors coupled to ratemeter-scalers. Measurement locations are illustrated on Figures 6 and 7.

## EXPOSURE RATE MEASUREMENTS

Background exposure rate measurements were performed at four locations within 0.5 to 10 km of the site with a microrem meter (Figure 23). Exposure rate measurements were performed at 217 on-site locations at one meter (m) above the surface using a microrem meter (Figures 8 through 22).

## SOIL SAMPLING

### Ventron Site Excavations

ORISE collected a total of 126 surface soil (0 to 15 cm) samples from systematically selected locations and/or locations of elevated direct gamma radiation identified from surface scans (Figures 8 through 17). These soil samples were collected from 24 randomly selected grid blocks within remediated portions of the site. Soil samples from these grid blocks were typically collected from five locations (five-point configuration)—one at the center and one each at four points equidistant between the center and grid block corners. If the total grid area accessible for sampling was less than 100 $m^2$, then fewer samples were collected from that grid. Due to some of the initial verification soil sampling results exceeding release criteria, BNI performed additional remedial actions on several grid blocks—therefore, several grid blocks were sampled more than once. Four soil samples were collected immediately adjacent to the land side of the sea wall in Grid Block 60S, 20E (Figure 12, samples 333 to 336). These samples were collected at different depths during sea wall excavation activities—the data were used to determine if excavation activities along the sea wall were successful. Additionally, five soil samples were collected from three miscellaneous locations, two from the west side of Building C, two from the south side of Building A, and one from the Northwest Scrap Pile (Figure 18).

### Railroad Excavations

Due to the need for site-specific railroad safety training, ESSAP personnel could not enter the Railroad Excavation Area; therefore, gamma surface scans and exposure rate measurements were not performed. However, at the direction of ESSAP personnel, BNI personnel collected 14 verification soil samples from seven locations within two grid blocks of the railroad excavation. Due to the slope of the excavation, at each of the sampling locations, a sample was collected from 0 to

15 cm in both the horizontal and vertical direction. The samples were collected systematically, ten samples from a five-point configuration from Grid 2 and four soil samples from two locations in Grid 1. Soil sampling locations are shown on Figure 19.

## Tidal Flat Excavations

ESSAP collected 98 soil samples from 16 grid blocks within remediated portions of the tidal flats (Figures 20 through 22). Sample locations were selected either randomly or from areas of elevated direct gamma radiation identified from surface scans. Soil samples were collected at various depths (primarily from the 30 to 60 cm interval) to account for the possibility of subsurface contamination. This was necessary because the gamma ray emissions would be attenuated by the high water content of the soil and therefore not be detected by surface scans. Soil samples from these grid blocks were typically collected from five locations—one at the center and one each at four points equidistant between the center and grid block corners. If the total grid area accessible for sampling was less than 100 $m^2$, fewer samples were collected from that grid.

Due to the findings of the initial ESSAP verification survey activities within the tidal flats and the remedial actions conducted by Morton for mercury contaminated sediments, DOE-HQ requested that ESSAP collect a single soil sample from the center of 16 accessible grid blocks that were remediated by Morton (Figures 20 through 22). An additional sample was also collected at that time from Grid Block 16. These samples were collected at a depth of 0.3 meters which was beneath the layer of clean backfill placed in these areas after Morton completed the mercury remediation. Three additional soil samples were collected during excavation activities in Grid Block 29 along the sea wall (Figure 22).

## Confirmatory Analysis/Sea Wall (Land Side) Excavation Samples

Due to the immediate need by BNI to backfill the sea wall excavations (areas immediately adjacent to the sea wall) to maintain the structural integrity of the sea wall and because ESSAP could not maintain continuous on-site presence to collect independent soil samples from this area, ESSAP requested and received 20 BNI post-remedial action (RA) soil samples for verification analysis and data comparison.

## Background Soil Samples

Background soil samples were collected from each of the background exposure rate measurement locations (Figure 23).

### SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and survey data were returned to ORISE's ESSAP Laboratory in Oak Ridge, Tennessee for analysis and interpretation. Sample analysis was in accordance with the ORISE/ESSAP Laboratory Procedures Manual (ORISE 1995e). Soil samples were initially analyzed by solid-state gamma spectroscopy. Spectra were reviewed for the radionuclides of interest, natural uranium, Ra-226, and Th-232. Spectra were also reviewed for any other identifiable photopeaks. Analytical results for soil were reported in units of picocuries per gram (pCi/g). Direct measurement data were converted to units of disintegrations per minute per 100 square centimeters (dpm/100 $cm^2$). Exposure rates were reported in microroentgens per hour (μR/h).

Additional information concerning major instrumentation, sampling equipment, and analytical procedures is provided in Appendices A and B. Results were compared to generic and site-specific DOE guidelines which are provided in Appendix C.

# FINDINGS AND RESULTS

### DOCUMENT REVIEW

ORISE reviewed the background, field, and post-RA data, the post-RA survey plan, the predecisional draft and final draft PRAR's, the additional sampling data, and other available documentation and provided comment letters to the DOE (BNI 1991, 1995, 1996a and b, 1997d and 2001a and b, ORISE 1991, 1992, 1994, 1995f, 1996c, and 1997a, b, c, and d).

After completion of remedial activities, review of all available post-RA data, and the preliminary results of initial verification survey activities, it was ESSAP's opinion that there was insufficient information to accurately assess the radiological status of the following areas: the southern portion of the tidal flats; beneath the asphalt roadway; and, beneath the Building A/A-1 slab. ESSAP's

concerns were discussed with DOE and BNI personnel and documented (ORISE 1997a). The PMC responded to these concerns in a letter dated April 29, 1997 (BNI 1997a). To resolve remaining open issues, a meeting was held with BNI, DOE-FSRD, DOE-HQ, and ESSAP to discuss the status of the Ventron site and to identify all outstanding issues related to site closure. As a result, DOE-HQ requested actions to resolve the outstanding issues for specific areas of the site (DOE 1997).

The DOE-HQ requests resulted in BNI performing supplemental survey activities to address these issues and to demobilize from the site (BNI 1997b). The documentation of outstanding issues resolution was provided by BNI in a FUSRAP Technical Bulletin (BNI 1997c).

After the completion of these supplemental activities, most deficiencies in BNI's survey procedures and documentation that ESSAP identified were addressed. The field data results and supporting documents provided reasonable documentation of the radiological status of the site relative to the 100 $m^2$ average residual radionuclide concentrations in soils.

The review of the final draft PRAR indicated that ORISE comments on the predicisional draft PRAR had been incorporated (BNI 2001a).

## INDEPENDENT VERIFICATION OF CONCRETE SLABS, ASPHALT ROADWAYS AND THE SEA WALL

Surface scans of the site identified several locations of elevated direct gamma radiation within excavations and on concrete slabs—elevated direct gamma radiation was not detected on the asphalt roadway. Further investigations of the concrete slabs and sea wall indicated the presence of elevated residual beta activity as well. A summary of the total beta activity levels is presented in Table 1.

Total beta activity levels for the sea wall ranged from -590 to 5,000 dpm/100 $cm^2$—measurement locations are shown on Figure 6. With one exception, total beta activity levels for the various asphalt areas, concrete slabs, and furnace flues ranged from -63 to 2,900 dpm/100 $cm^2$. The exception was a location on a remaining portion of a wall (at the wall/slab interface) between Buildings A and A-1 with a total beta activity of 93,000 dpm/100 $cm^2$ (Figure 7).

## INDEPENDENT VERIFICATION OF VENTRON SITE EXCAVATIONS

The data for exposure rates and radionuclide concentrations in soils, including background, that are discussed below are provided in Table 2. The following is a summary of findings and results for the individual excavations on the site.

### Excavation #1-Area Northwest of Building C

Surface scans did not identify any locations of elevated direct gamma radiation. ESSAP collected five systematic surface soil samples, in a five-point configuration, from the excavation. Exposure rate and soil sampling locations for Excavation #1 are shown on Figure 8.

Exposure rates ranged from 8 to 10 μR/h. Radionuclide concentration ranges were as follows: less than 0.3 to 2.3 pCi/g for Ra-226, 0.6 to 2.1 pCi/g for Th-232, 0.4 to 1.2 pCi/g for U-235, 4.7 to 27.8 pCi/g for U-238, and 8.8 to 57 pCi/g for total uranium.

### Excavation #2-Area Northwest of Building A

Surface scans did not identify any locations of elevated direct gamma radiation. ESSAP collected five systematic surface soil samples, in a five-point configuration, from the excavation. Exposure rate and soil sampling locations for Excavation #2 are shown on Figure 9.

Exposure rates ranged from 10 to 12 μR/h. Radionuclide concentration ranges were as follows: 0.6 to 0.7 pCi/g for Ra-226, 0.6 to 0.9 pCi/g for Th-232, 0.5 to 1.6 pCi/g for U-235, 7.3 to 28.1 pCi/g for U-238, and 15 to 58 pCi/g for total uranium.

Due to site logistics during other site excavations, excavated contaminated soil was stockpiled in this area after the verification survey activities occurred. Therefore, this area was resurveyed and sampled when the soil pile was removed. Surface scans did not identify any locations of elevated direct gamma radiation. ESSAP collected two additional random surface soil samples from this excavation to supplement the original verification data (Figure 9).

The exposure rate at the two additional sample locations was 8 μR/h. Radionuclide concentration ranges for the two soil samples collected after the removal of an on-site soil pile were as follows: 0.7 to 0.9 pCi/g for Ra-226, 0.7 to 1.0 pCi/g for Th-232, less than 0.4 to 0.6 pCi/g for U-235, 6.1 to 10.7 pCi/g for U-238, and less than 13 to 22 pCi/g for total uranium.

**Excavation #3-Area East of Building E**

Surface scans did not identify any locations of elevated direct gamma radiation. ESSAP collected two random surface soil samples from the excavation. Exposure rate and soil sampling locations for Excavation #3 are shown on Figure 10.

Exposure rates ranged from 5 to 7 μR/h. Radionuclide concentrations for the two soil samples were as follows: less than 0.4 pCi/g for Ra-226, 0.8 and 0.9 pCi/g for Th-232, less than 0.5 for U-235, 2.0 and 2.1 pCi/g for U-238, and less than 4.7 pCi/g for total uranium.

**Excavation #4-Alfa Building Area**

Surface scans identified several locations of elevated direct gamma radiation within Alfa Building excavation Grid Blocks (50S, 150E), (60S, 150E), and (70S, 130E). ESSAP initially collected seventeen soil samples (samples 300 through 316)—sixteen surface (0 to 15 cm) and one subsurface (15 to 30 cm)—from sixteen locations within the excavation.

Initial exposure rates ranged from 8 to 17 μR/h. Initial radionuclide concentration ranges were as follows: less than 0.7 to 2.7 pCi/g for Ra-226, less than 0.8 to 12.8 pCi/g for Th-232, less than 0.7 to 24.4 pCi/g for U-235, 1.5 to 301.0 pCi/g for U-238, and less than 11 to 630 pCi/g for total uranium. Six of the sample locations had elevated concentrations of uranium while two sample locations demonstrated elevated concentrations of thorium. As a result, BNI performed additional remedial activities in these areas.

Upon completion of the additional remediation by BNI, ESSAP again performed verification activities during subsequent survey visits that included gamma surface scans, exposure rate measurements, and independent soil sampling.

ESSAP's subsequent surface scans again identified several locations of elevated direct gamma radiation within this excavation. Therefore, BNI performed further remediation within this excavation and afterwards, ESSAP resurveyed the area and collected systematic surface soil samples, in a five-point configuration from one grid block (45S, 150E). Final verification exposure rate measurement and sampling locations for Excavation #4 are shown on Figure 11. Final exposure rates, including initial measurement locations within guidelines, ranged from 9 to 12 μR/h. Final radionuclide concentrations ranges for the individual soil samples, after remediation of three locations, were as follows: less than 0.2 to 1.2 pCi/g for Ra-226, 0.7 to 2.3 pCi/g for Th-232, less than 0.3 to 2.7 pCi/g for U-235, 2.2 to 50.2 pCi/g for U-238, and less than 6.3 to 100 pCi/g for total uranium.

**Excavation #6-Southwest and Southern Sections of the Site**

Surface scans identified several locations of elevated direct gamma radiation within the remediated area and ESSAP collected soil samples from these locations. BNI requested that they analyze these samples using their on-site portable FIDLER counting system in order to quickly evaluate the samples. ESSAP samples were provided to BNI for the sample screening which was performed under the supervision of ESSAP personnel to ensure sample integrity.

Based on the results of the sample screening, BNI performed further remediation in several areas. ESSAP initially collected ten surface (0 to 15 cm) soil samples from three grid blocks [(50S, 70E), (50S, 80E), and (60S, 80E)] within the excavation. Initial exposure rates ranged from 6 to 13 μR/h. The radionuclide concentration ranges in these initial samples were as follows: 0.5 to 1.1 pCi/g for Ra-226, 0.6 to 1.7 pCi/g for Th-232, 0.3 to 16.9 pCi/g for U-235, and 3.6 to 338.0 pCi/g for U-238. Upon completion of the additional remediation, ESSAP resurveyed the area during subsequent survey visits and collected a total of 46 systematic soil samples, in a five-point configuration, from 11 grid blocks. Final verification exposure rate and sampling locations for Excavation #6 are shown on Figures 12 and 13.

Final surface scans did not identify any locations of elevated direct gamma radiation. Final exposure rates ranged from 5 to 14 μR/h. Final radionuclide concentrations ranges for the individual soil samples within the grid blocks, with the exception of those labeled as initial verification survey and the Sea Wall Excavation (Grid Block 60S, 20E), were as follows: less than 0.2 to 1.3 pCi/g for

Ra-226, less than 0.5 to 1.5 pCi/g for Th-232, less than 0.3 to 3.7 pCi/g for U-235, 2.0 to 66.0 pCi/g for U-238, and less than 9.0 to 140 pCi/g for total uranium.

Surface scans of a portion of the soil behind the sea wall in Grid Block 60S, 20E identified one location of elevated residual gamma activity. BNI performed additional remedial activities and ESSAP subsequently resurveyed the additional excavations until direct gamma radiation levels were slightly greater than background levels. After additional excavations in this area, the final soil sample (336) had the following radionuclide concentrations: 0.6 pCi/g for Ra-226, 0.8 pCi/g for Th-232, 1.3 pCi/g for U-235, 24.3 pCi/g for U-238, and 50 pCi/g for total uranium.

**Excavation #7-Area Southwest of Building E**

Surface scans did not identify any locations of elevated direct gamma radiation. ESSAP collected five systematic surface soil samples, in a five-point configuration, from the excavation. Exposure rate and soil sampling locations for Excavation #7 are shown on Figure 14.

Exposure rates ranged from 6 to 8 μR/h. Radionuclide concentration ranges for the individual soil samples were as follows: 0.7 to 0.9 pCi/g for Ra-226, 0.8 to 1.1 pCi/g for Th-232, less than 0.3 to 0.6 pCi/g for U-235, 1.2 to 12.3 pCi/g for U-238, and less than 5.2 to 25 pCi/g for total uranium.

**Building A-1 Slab Excavations**

Surface scans did not identify any locations of elevated direct gamma radiation. ESSAP collected five systematic surface soil samples, in a five-point configuration, from one grid block and five individual samples from two other small excavations in this area. Exposure rate and soil sampling locations for the Building A-1 Slab Excavations are shown on Figure 15.

Exposure rates ranged from 9 to 15 μR/h. Radionuclide concentration ranges for the individual soil samples were as follows: 0.5 to 2.6 pCi/g for Ra-226, 0.3 to 2.5 pCi/g for Th-232, less than 0.2 to 0.8 pCi/g for U-235, 0.6 to 14.1 pCi/g for U-238, and less than 4.8 to 23 pCi/g for total uranium.

## Leach Tank Pit Excavation

Surface scans did not identify any locations of elevated direct gamma radiation. ESSAP collected five systematic surface soil samples, in a five-point configuration, from one grid block in this area. Exposure rate and soil sampling locations for the Leach Tank Pit Excavation are shown on Figure 16.

Exposure rates ranged from 9 to 11 μR/h. Radionuclide concentration ranges for the individual soil samples were as follows: 0.4 to 1.1 pCi/g for Ra-226, 0.3 to 6.0 pCi/g for Th-232, 0.3 to 0.6 pCi/g for U-235, 5.8 to 9.9 pCi/g for U-238, and 12 to 20 pCi/g for total uranium.

## Fan Pit Excavation

Surface scans identified one location of elevated direct gamma radiation. ESSAP collected one soil sample from the elevated gamma radiation location and two surface soil samples from the contiguous area. Exposure rate measurements were not performed. Soil sampling locations for the Fan Pit Excavation are shown on Figure 17.

Radionuclide concentrations for the sample collected from the area of elevated gamma radiation were as follows: 1.8 pCi/g for Ra-226, 1.8 pCi/g for Th-232, 6.0 pCi/g for U-235, 115.6 pCi/g for U-238, and 240 pCi/g for total uranium. Upon completion of additional remediation of the area by BNI, ESSAP collected another soil sample. Final radionuclide concentrations ranges for the three individual soil samples within the Fan Pit Excavation were as follows: less than 0.2 to 1.0 pCi/g for Ra-226, 0.9 to 11.0 pCi/g for Th-232, less than 0.4 to 0.8 pCi/g for U-235, 5.0 to 14.4 pCi/g for U-238, and 10 to 30 pCi/g for total uranium.

## Miscellaneous Areas

Surface scans did not identify any locations of elevated direct gamma radiation in miscellaneous areas. ESSAP collected two soil samples from along the west side of Building C, two soil samples along the south side of Building A and one soil sample from the Northwest Scrap Pile. Exposure rate and soil sampling locations for the Miscellaneous Areas are shown on Figure 18.

Exposure rates ranged from 6 to 8 μR/h. Radionuclide concentration ranges for the individual soil samples were as follows: 0.7 to 1.1 pCi/g for Ra-226, 0.6 to 1.0 pCi/g for Th-232, less than 0.4 to 0.9 pCi/g for U-235, 1.1 to 22.7 pCi/g for U-238, and less than 9.4 to 46 pCi/g for total uranium.

## INDEPENDENT VERIFICATION OF THE RAILROAD EXCAVATION

Gamma surface scans and exposure rate measurements were not performed. Radionuclide concentrations, including background, for the Railroad Excavation are summarized in Table 3. Radionuclide concentration ranges were as follows: 0.4 to 0.7 pCi/g for Ra-226, 0.6 to 1.5 pCi/g for Th-232, less than 0.2 to 1.7 pCi/g for U-235, 1.1 to 33.8 pCi/g for U-238, and less than 7.4 to 69 pCi/g for total uranium. Soil sampling locations for the Railroad Excavation are shown on Figure 19.

## INDEPENDENT VERIFICATION OF THE BEVERLY HARBOR TIDAL FLATS

Exposure rates and radionuclide concentrations in tidal flats soil, including background, are summarized in Table 4. Measurement and sampling locations for the tidal flats are shown on Figures 20 through 22.

During the initial tidal flats verification survey activities of September 1995 and July 1996, gamma surface scans identified several areas of elevated direct radiation. Additional investigations of these areas identified subsurface contamination (greater than 15 cm below the surface) within Grid Block 20. Samples were collected from these subsurface locations and the analytical results showed residual contamination levels up to approximately 920 pCi/g for total uranium (453 pCi/g for U-238). It is ESSAP's opinion that this level of contamination was not identified during the original BNI surface scans because the overlaying "clean" soil/sediment, combined with the wet soil conditions, attenuated the low-energy uranium progeny gamma emissions thereby decreasing the effectiveness of gamma radiation scans in the tidal flats. Due to the findings in Grid Block 20, further subsurface investigations identified six other subsurface locations of elevated direct gamma radiation within Grid Blocks 11, 30, 31, and 32. ESSAP initially collected biased soil samples from these locations of elevated gamma radiation. Several randomly collected soil samples also demonstrated that subsurface contamination, in some areas, was not detected by surface scans because the contamination was at a depth underlying the first 15 cm of soil/sediment. The total

uranium concentrations for the initial surface and subsurface soil samples from these grid blocks ranged from less than 12 to 790 pCi/g for Grid Block 11; 9.5 to 920 pCi/g for Grid Block 20; less than 9.2 to 510 pCi/g for Grid Block 30; less than 28 to 130 pCi/g for Grid Block 31; and 7.8 to 840 pCi/g for Grid Block 32 (Table 4).

Based on the results of the initial verification surveys in September 1995 and July 1996, BNI performed additional remedial activities in several areas of the tidal flats. Upon completion of the additional remediation, ESSAP resurveyed each area during subsequent survey visits. With the exception of Grid Block 20 and the Grid Block 29 Sea Wall Excavation, final surface scans did not identify any locations of elevated direct gamma radiation. ESSAP collected systematic surface soil samples, in a five-point configuration, from ten grid blocks in the tidal flats area. Final exposure rates ranged from 4 to 13 μR/h. Final radionuclide concentrations ranges for the individual soil samples within the grid blocks, exclusive of Grid Blocks 20 and 29, were as follows: less than 0.5 to 3.3 pCi/g for Ra-226, less than 0.7 to 1.2 pCi/g for Th-232, less than 0.5 to 0.9 pCi/g for U-235, less than 1.2 to 15.6 pCi/g for U-238, and less than 14 to 59 for total uranium.

The results of the July 1996 ESSAP verification survey of Grid Block 20 showed that the grid block average for total uranium was 23 pCi/g. However, while BNI personnel performed routine monitoring surveys during February/March 1997, residual contamination was identified again within Grid Block 20 and the area was remediated by BNI a second time. ESSAP re-verified Grid Block 20 during a March 1997 survey trip, by collecting sixteen soil samples from nine locations. BNI used their portable counting system to screen ESSAP's samples and based on the results, elected to perform additional remedial activities. These activities continued in an iterative process until sample screening indicated that contamination was reduced to acceptable levels. Final exposure rates for Grid Block 20 ranged from 6 to 10 μR/h and final radionuclide concentration ranges were as follows: less than 0.2 to 0.8 pCi/g for Ra-226, less than 0.5 to 2.8 pCi/g for Th-232, 0.2 to 2.4 pCi/g for U-235, 5.2 to 43.1 pCi/g for U-238, and 11 to 89 pCi/g for total uranium.

During the initial verification survey activities of Grid Block 29, elevated gamma radiation was detected along the sea wall portion of the grid block. BNI personnel performed remedial actions on the soil in the immediate vicinity of the sea wall; during these activities it was determined that residual contamination remained in the sea wall construction material and in the soil immediately adjacent to the sea wall. The sea wall was not remediated due to structural integrity and safety

concerns (BNI 1997). With the exception of the soil immediately adjacent to the sea wall, final radionuclide concentration ranges for the soil samples from the remainder of the grid block were as follows: 0.5 to 1.2 pCi/g for Ra-226, 0.8 to 1.0 pCi/g for Th-232, less than 0.3 to 1.2 pCi/g for U-235, 2.0 to 25.1 pCi/g for U-238, and less than 6.1 to 51.0 pCi/g for total uranium. Post-RA sea wall verification soil sample results are provided in the section below.

During the Spring of 1996, Morton completed the mercury remediation activities and backfilled the remediated portions of the tidal flats, from Grid Blocks 1 through 31, with clean fill. Remedial activities for mercury contamination resulted in an average excavation depth, within this portion of the tidal flats, of 0.5 m (1.5 feet). Final surface scans of the grid blocks which were remediated by Morton due to mercury contamination did not identify any locations of elevated direct gamma radiation and exposure rates for these grid blocks ranged from 3 to 10 μR/h. Final radionuclide concentration ranges for the individual soil samples within these grid blocks were as follows: less than 0.5 to 1.4 pCi/g for Ra-226, less than 0.5 to 1.3 pCi/g for Th-232, less than 0.5 to 1.4 pCi/g for U-235, less than 1.7 to 26.7 pCi/g for U-238, and less than 8.4 to 55 pCi/g for total uranium.

## INDEPENDENT VERIFICATION OF CONFIRMATORY/SEA WALL EXCAVATION POST-RA SAMPLES

Radionuclide concentrations in post-RA sea wall samples received from BNI are summarized in Table 5. BNI concentration ranges were as follows: <0.77 to 1.9 pCi/g for Ra-226, less than 1.2 pCi/g for Th-232, and 11.5 to 38.1 pCi/g for U-238 for samples previously submitted to BNI's Oak Ridge laboratory at Thermo-NuTech. These same samples, when analyzed by ESSAP, had concentration ranges as follows: 0.4 to 1.6 pCi/g for Ra-226, 0.7 to 1.3 pCi/g for Th-232, and 16.8 to 56.8 pCi/g for U-238. For BNI samples counted at the Wayne laboratory, concentration ranges were 0.53 to 0.89 pCi/g for Ra-226, 0.52 to 0.97 pCi/g for Th-232, and 3.78 to 36.9 pCi/g for U-238—the ESSAP results were less than 0.2 to 0.8 pCi/g for Ra-226, 0.7 to 1.0 pCi/g for Th-232, and 4.0 to 33.9 pCi/g for U-238.

## BACKGROUND EXPOSURE RATE MEASUREMENTS AND SOIL SAMPLES

Background exposure rates and radionuclide concentrations are provided in Table 6—measurement and sampling locations are shown on Figure 23.

Background exposure rates ranged from 8 to 12 μR/h and averaged 9 μR/h. Background radionuclide concentration ranges were as follows: 0.7 to 1.0 pCi/g for Ra-226, 0.7 to 0.9 pCi/g for Th-232, less than 0.4 pCi/g for U-235, 0.8 to 1.6 pCi/g for U-238, and less than 3.1 for total uranium. The background radionuclide concentration averages were as follows: 0.9 pCi/g for Ra-226, 0.8 pCi/g for Th-232, less than 0.4 for U-235, 1.2 pCi/g for U-238, and less than 2.7 pCi/g for total uranium.

## COMPARISON OF RESULTS WITH GUIDELINES

The DOE guidelines for residual radioactive material are summarized in Appendix C (DOE 1990). The applicable surface contamination guidelines are as follows:

For natural uranium:

Total Activity

5,000 α dpm/100 $cm^2$, averaged over a 1 $m^2$ area

15,000 α dpm/100 $cm^2$, maximum in a 100 $cm^2$ area

Removable Activity

1,000 α dpm/100 $cm^2$

The uranium guidelines specify alpha activity. However, based on the equivalent alpha to beta decay ratio, beta activity levels may be considered representative of uranium surface activity and are used for guideline comparison. All direct surface measurements were below the average guidelines with the exception of two locations—one on the west portion of the sea wall and one on the concrete slab of Building A-1 (Figures 6 and 7). The location on the sea wall had a beta activity level of 5,000 dpm/100 $cm^2$—however, the size of the contaminated area was small (less than 200 $cm^2$), isolated, and less than the maximum guideline value of 15,000 dpm/100 $cm^2$, therefore, remedial actions were not necessary and the 1 $m^2$ average was less than 5,000 dpm/100 $cm^2$. The measurement on the slab of Building A-1 had an activity of 93,000 dpm/100 $cm^2$, well in excess of the maximum guideline. Remedial activities were not performed at this location because the slab will be rubblized by Morton at a later date and volumetric criteria will be used to demonstrate compliance (BNI 1997b).

Soil sample results were compared to the generic and site-specific soil concentration guidelines (DOE 1990 and 1993). These guidelines are as follows:

| Radionuclide | Soil Concentration Above Background |
|---|---|
| Th-232, Ra-226 | 5 pCi/g averaged over the first 15 cm of soil below the surface; 15 pCi/g, averaged over 15 cm thick layers of soil greater than 15 cm below the surface. |
| Total uranium | 100 pCi/g (U-238, 50 pCi/g) (DOE 1992) |

Radionuclide concentrations in soil samples for Excavations #1, #2, #3, and #7 and for the Leach Tank Pit, Building A-1 Slab Excavations, and the miscellaneous areas (West Side of Building C, South Side of Building A, and the Northwest Scrap Pile) were all below the guideline levels.

Of the final verification soil samples, four soil samples exceeded the guideline of 100 pCi/g for total uranium. These samples were 337, 425, 638, and 619 and were located in Excavation #4 (Grid Block 50S, 150E), Excavation #6 (Grid Blocks 50S, 30E and 50S, 70E), and Excavation #5 (Tidal Flat Grid Block 29). However, the guidelines permit averaging the radionuclide concentration over an area of 100 $m^2$ and application of the hot spot criteria. For these grid blocks, the final average total uranium concentrations of 45, 60, 56, and 54 pCi/g, respectively, satisfied the guideline.

Sample numbers 446 and 462 collected from the Leach Tank Pit and Fan Pit, respectively, had Th-232 concentrations of 6.0 and 11 pCi/g which exceeded the surface guideline value but were less than the subsurface guideline. Because the surface this sample was collected from was originally, and will be again following backfill, at a depth greater than 15 cm, the subsurface guideline is applicable and has been satisfied.

BNI's gamma spectroscopy data indicated the presence of Ra-226 contamination that exceeded the 5 pCi/g guideline (samples 127-RS-017 through 127-RS-028) for samples collected from the furnace crawlspace under the A-1 Building slab. The contamination in this area is most likely not from DOE activities and the elevated activity's origin was not addressed. A letter from A. Williams (DOE/HQ) to P. Goldberg (Morton International) dated on May 29, 1996 states that "DOE will remove the

residual radium and thorium..." contamination in return for assistance provided by Morton International in the remediation of the site (DOE 1996b). The data package provided by BNI does not indicate that remedial actions were performed in this area.

Three soil samples collected from tidal flat Grid Block 29 had Ra-226 concentrations of 13.8, 21.5, and 15.9 pCi/g—two of the samples exceeded the subsurface guideline values.The area containing these sample locations was approximately 2 $m^2$ and was immediately adjacent to the sea wall. Because the guidelines permit averaging the radionuclide concentration over an area of 100 $m^2$ and application of the hot spot criteria, this area, when averaged with the other Ra-226 soil concentrations for this grid, satisfied the guideline.

The basic dose limit for exterior land areas is 100 millirem per year (mrem/yr), which includes external exposure plus the sum of all other pathways. In implementing this limit, the DOE also applies as low as reasonably achievable (ALARA) principles (DOE 1990). Exterior exposure rates were comparable to background levels and together with residual radionuclide concentration levels satisfy the basic dose limit.

## SUMMARY

During the period of September 19, 1995 through March 14, 1997, the Environmental Survey and Site Assessment Program of the Oak Ridge Institute for Science and Education made nine site visits and performed verification activities at the Ventron Site located in Beverly, Massachusetts. Verification activities included document and data reviews; beta and gamma surface scans; direct measurements for total beta activity; exposure rate measurements; and soil sampling.

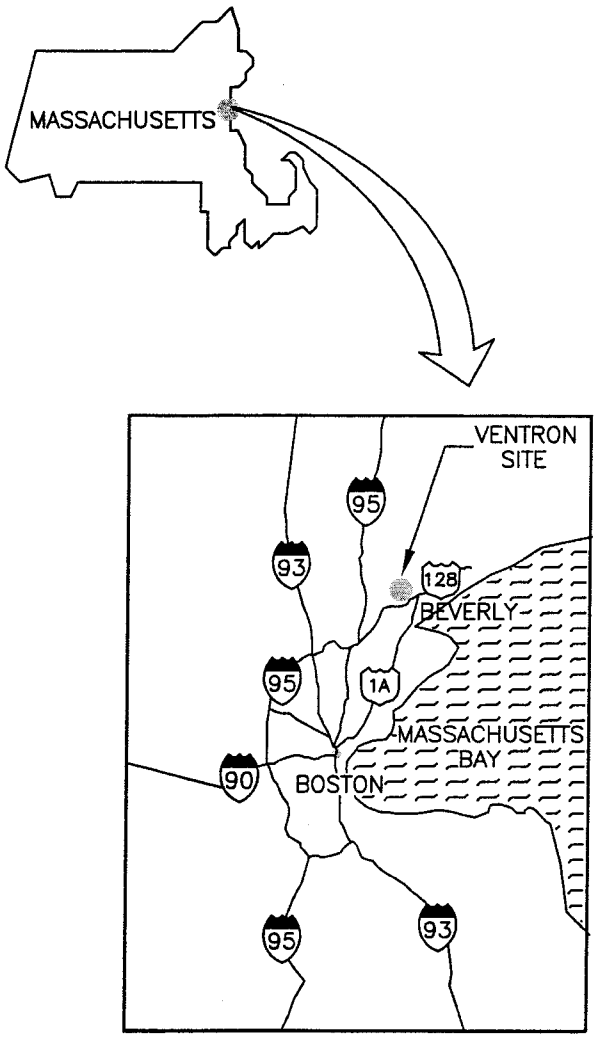
Verification gamma surface scans identified several areas of residual contamination in exposed soil surfaces. ESSAP personnel collected soil samples from these locations and/or notified BNI personnel of the findings. When additional remedial activities were required by BNI, ESSAP resurveyed the areas.

After the completion of remedial activities, ESSAP reviewed all available post-RA data, and evaluated the preliminary verification survey data. It was ESSAP's opinion that there was insufficient information to accurately assess the radiological status of the following areas: the

southern portion of the tidal flats; beneath the asphalt roadway; and beneath the Building A/A-1 slab. ESSAP's concerns were discussed with DOE and BNI personnel and a decision was made by DOE that additional sampling was needed in several site areas in order to address these outstanding issues. BNI therefore collected additional samples and submitted the supplemental data which addressed these concerns.

The results of BNI's primary and supplemental post-RA data indicated that the site specific DOE guidelines have been satisfied. All of ESSAP's exposure rate levels were comparable to background levels. All final independent verification radionuclide concentrations in soil samples collected by ESSAP from the Ventron Site, including the tidal flats and railroad area, were all below the surface and/or hot spot criteria guideline values for the radionuclides of concern. Based on the post-RA data, the independent verification measurements and sampling data, and the supplemental standards for the building slabs that have been left in-place, it is ESSAP's opinion that the Ventron site satisfies the DOE requirements for release for unrestricted use.

# FIGURES



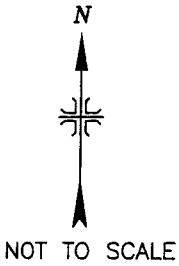




FIGURE 1: Beverly, Massachusetts Area – Location of Ventron Site

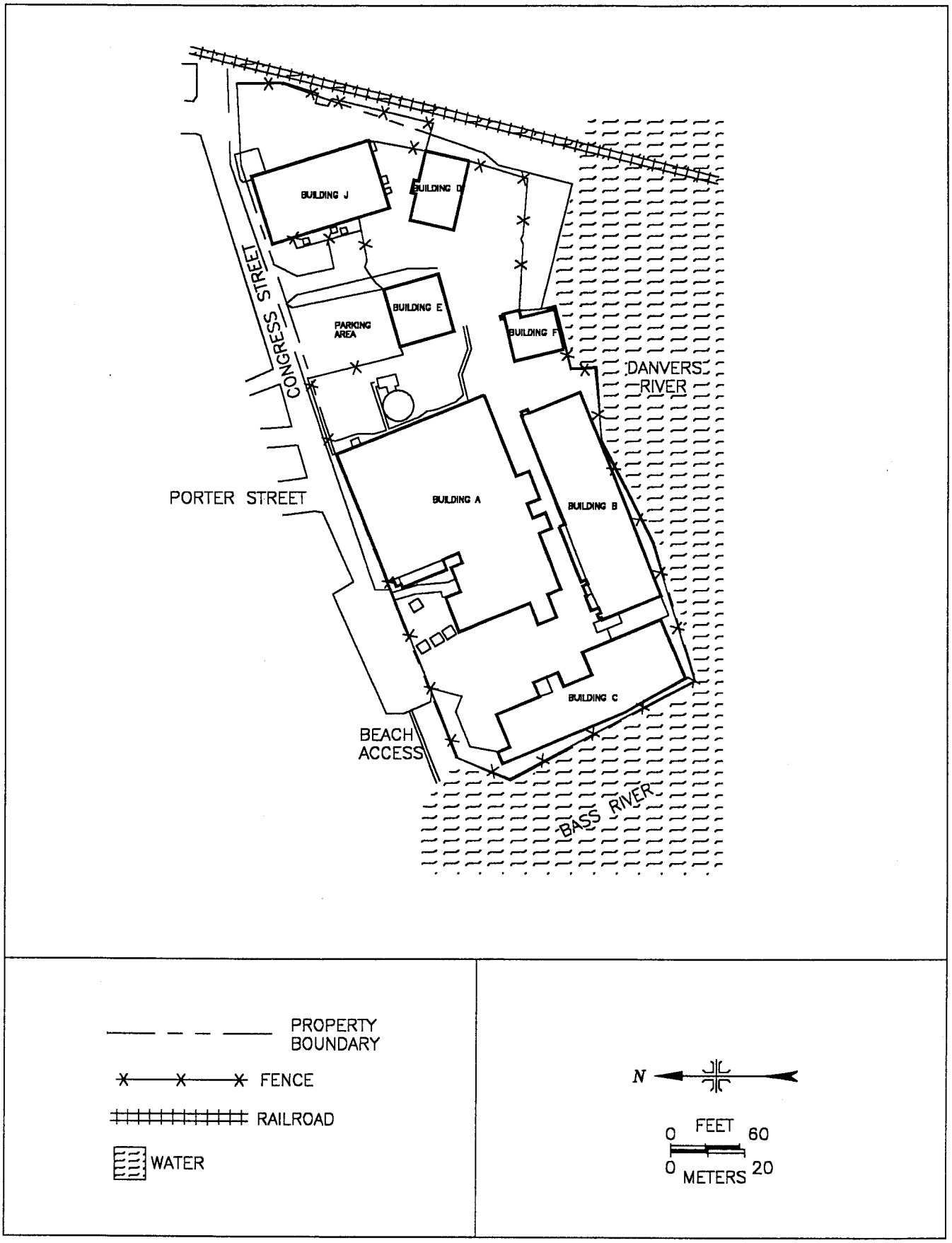



FIGURE 2: Plot Plan of the Ventron Site Prior to Remedial Actions – Beverly, Massachusetts

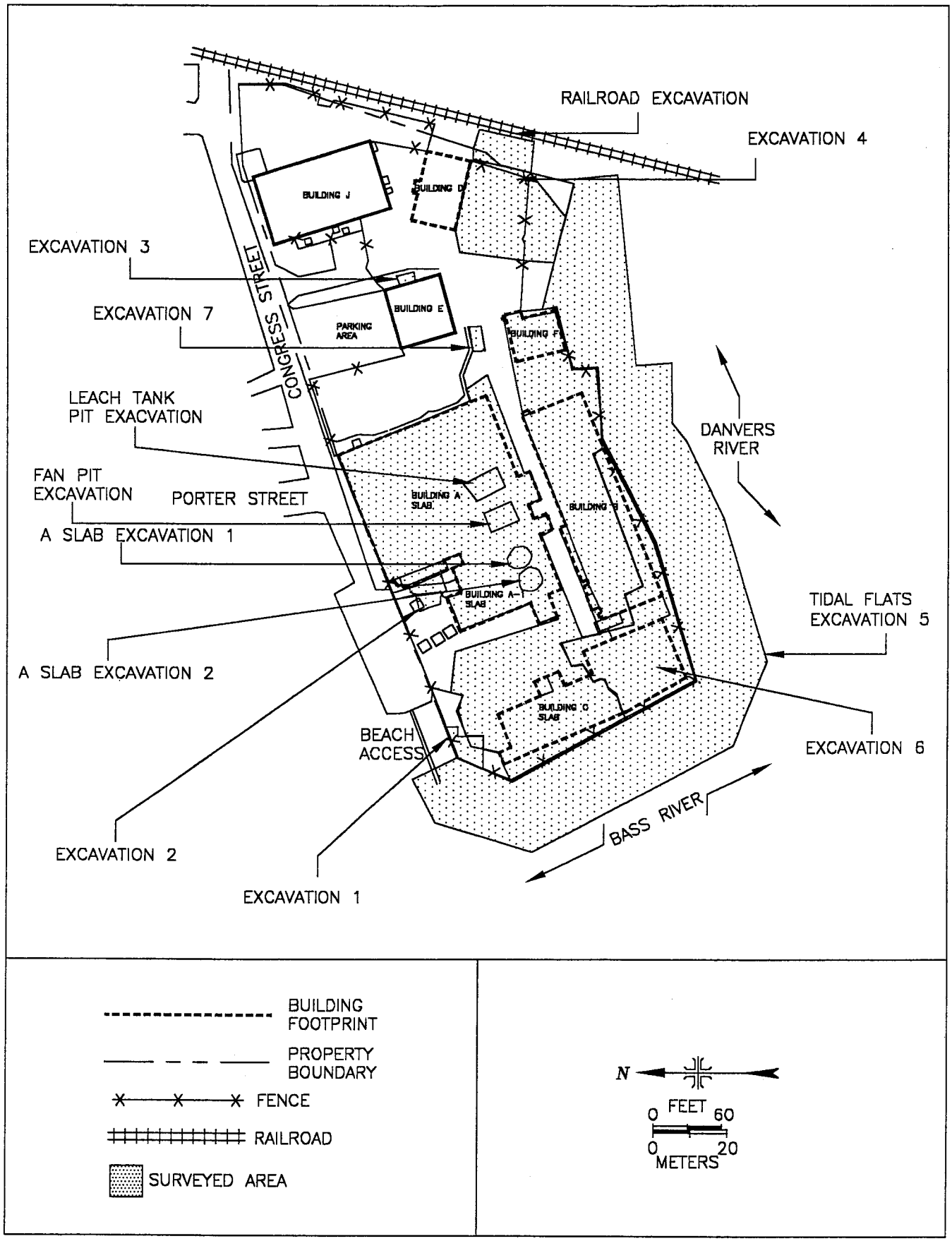



FIGURE 3: Ventron Site – Surveyed Areas

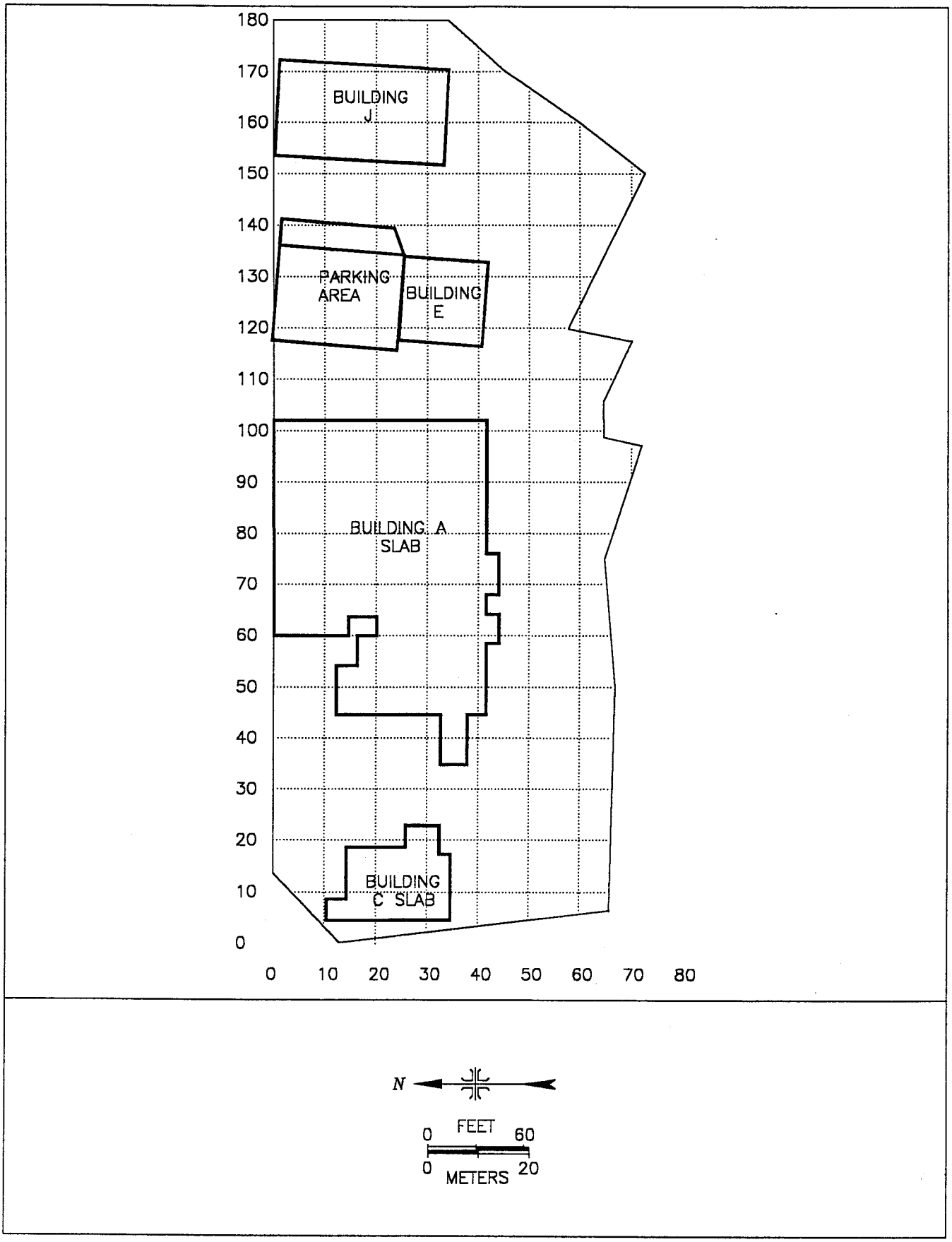



FIGURE 4: Ventron Site – Plot Plan of Ventron Site Grid Blocks

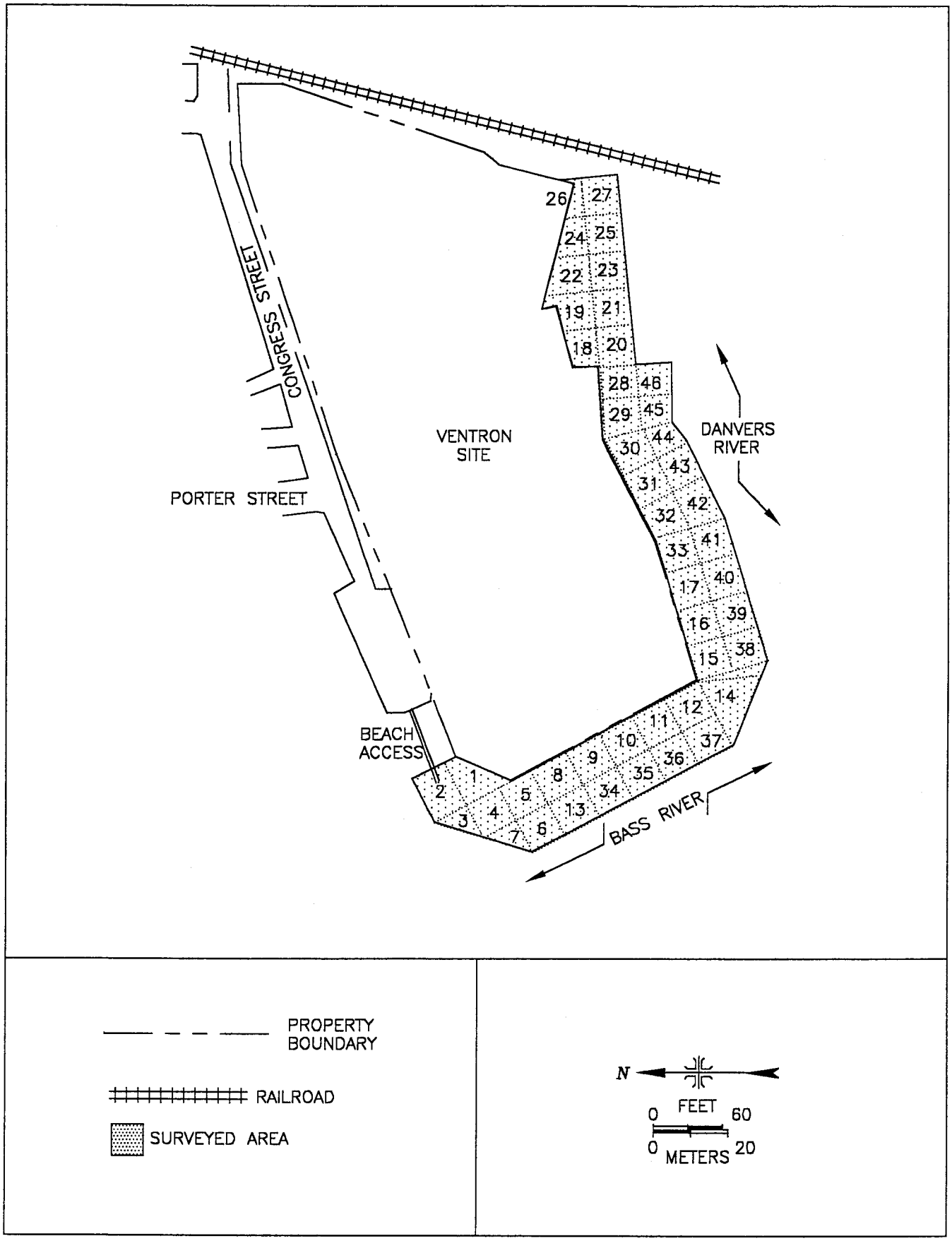



FIGURE 5: Ventron Site – Plot Plan of Tidal Flat Grid Blocks

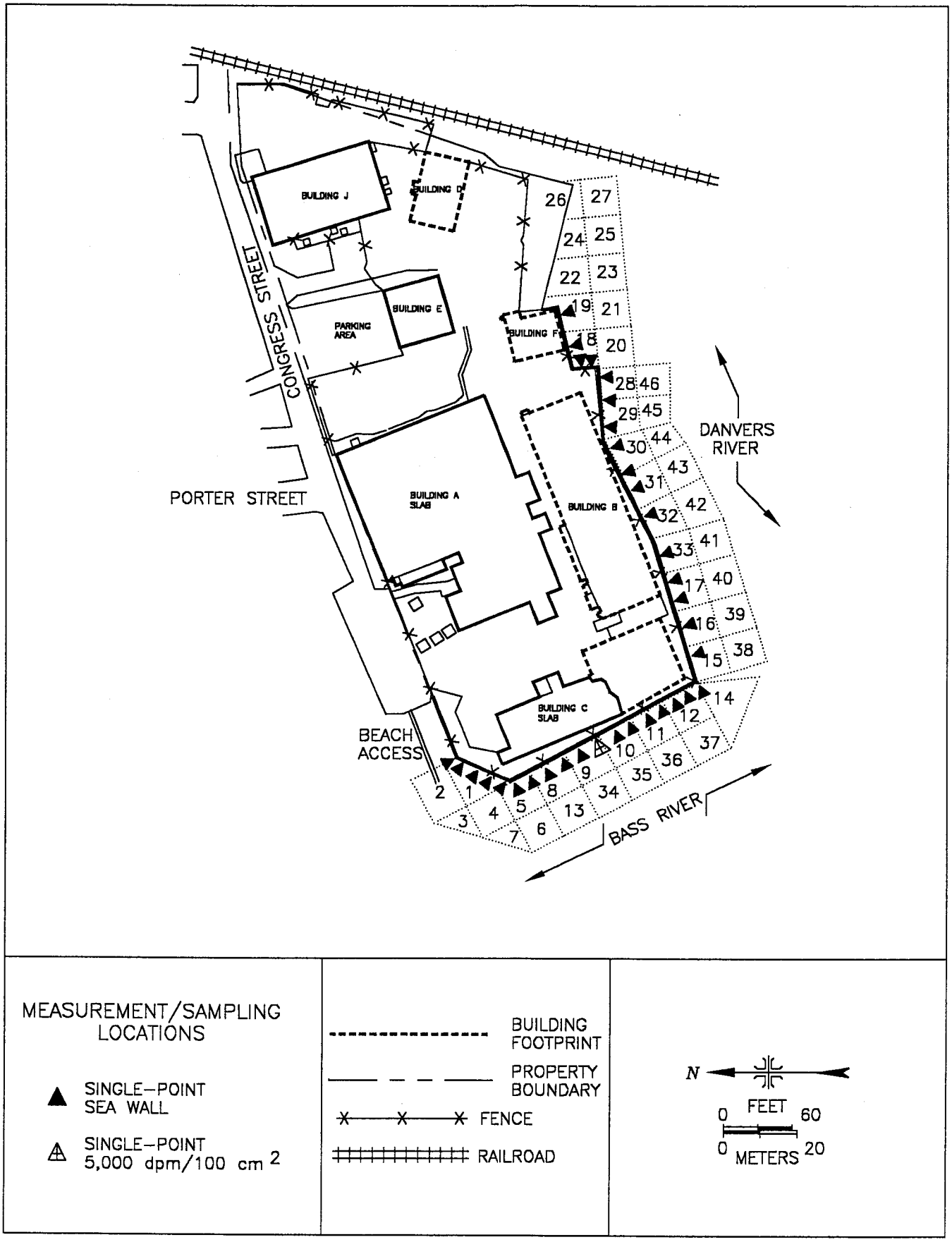



FIGURE 6: Ventron Site, Sea Wall – Measurement and Sampling Locations

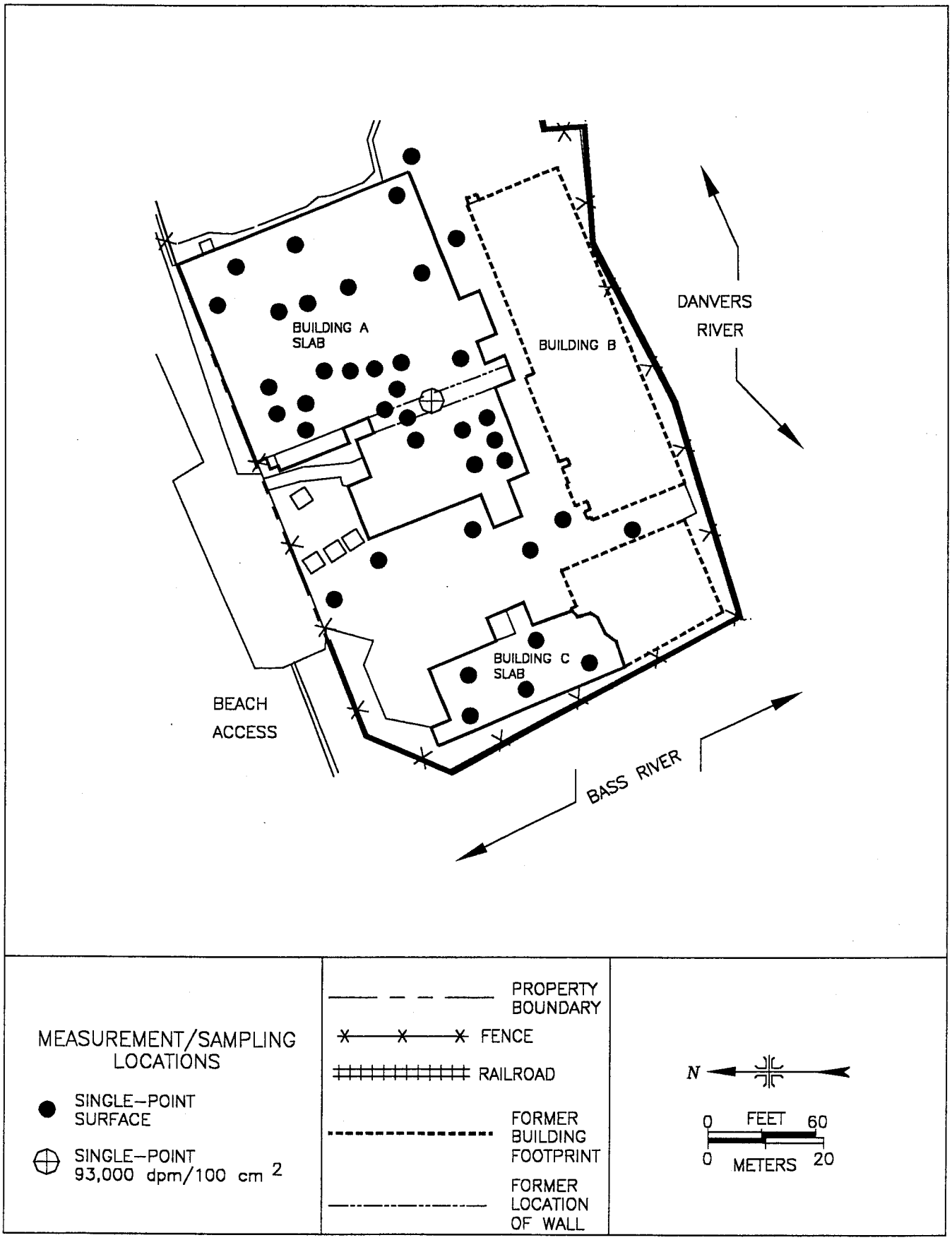



FIGURE 7: Ventron Site, Asphalt and Concrete Slab Surfaces – Measurement and Sampling Locations

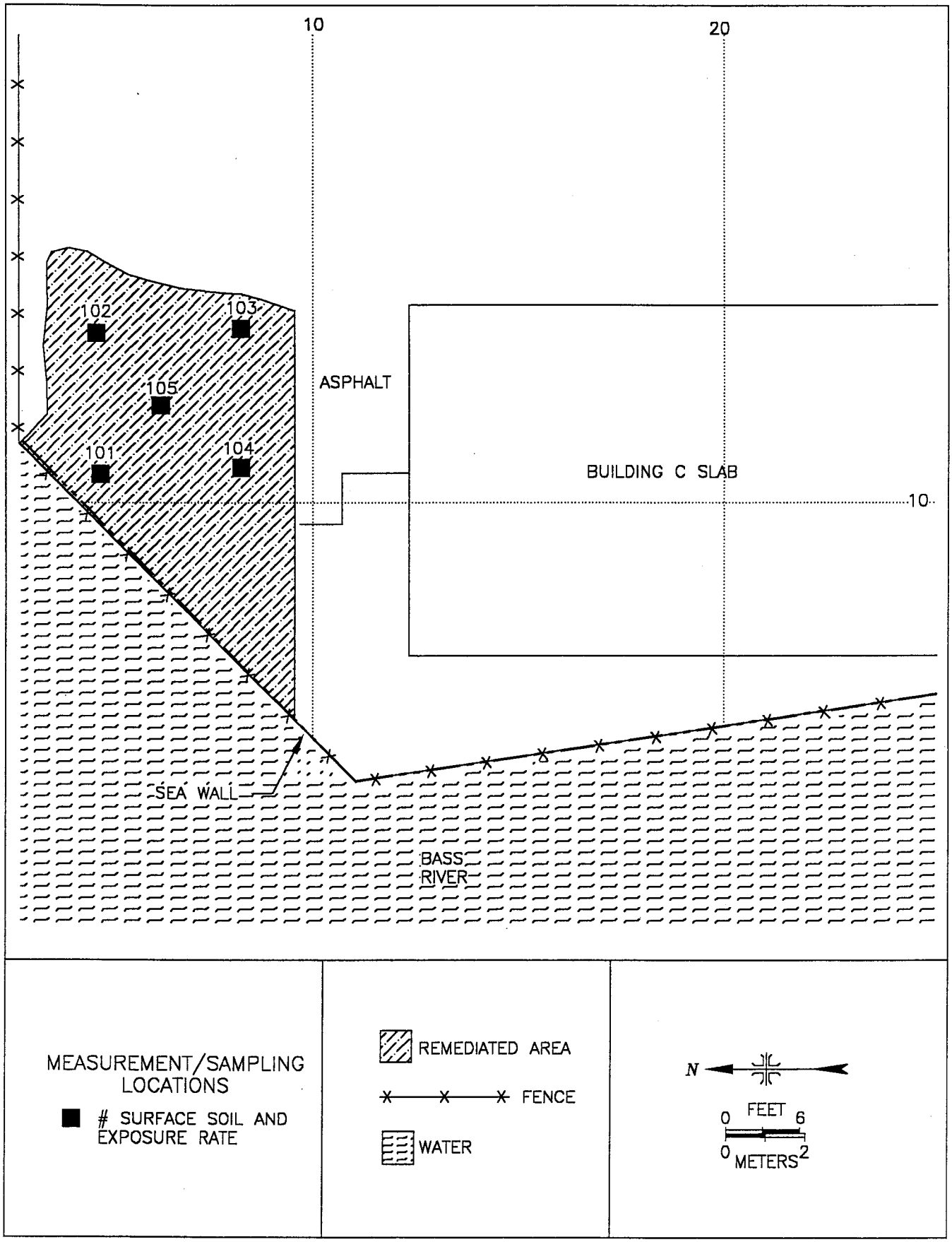
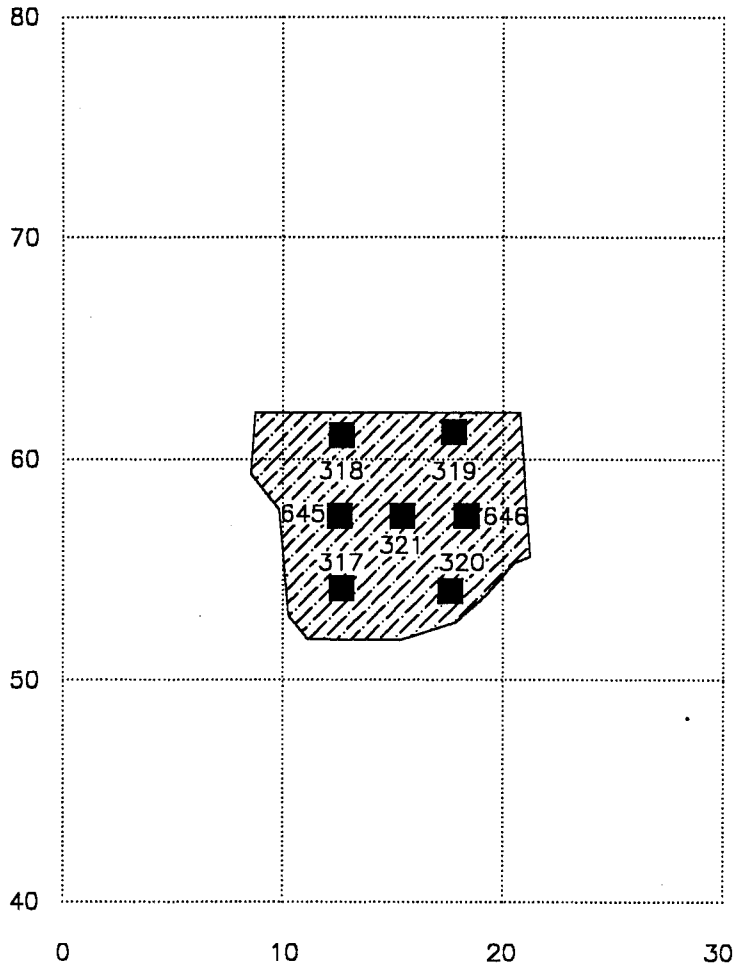



FIGURE 8: Ventron Site, Excavation #1, Area Northwest of Building C – Measurement and Sampling Locations




MEASUREMENT/SAMPLING LOCATIONS

■ # SURFACE SOIL AND EXPOSURE RATE

EXCAVATED AREA

N

FEET 0 24

METERS 0 8

FIGURE 9: Ventron Site, Excavation #2, Area Northwest of Building A – Measurement and Sampling Locations

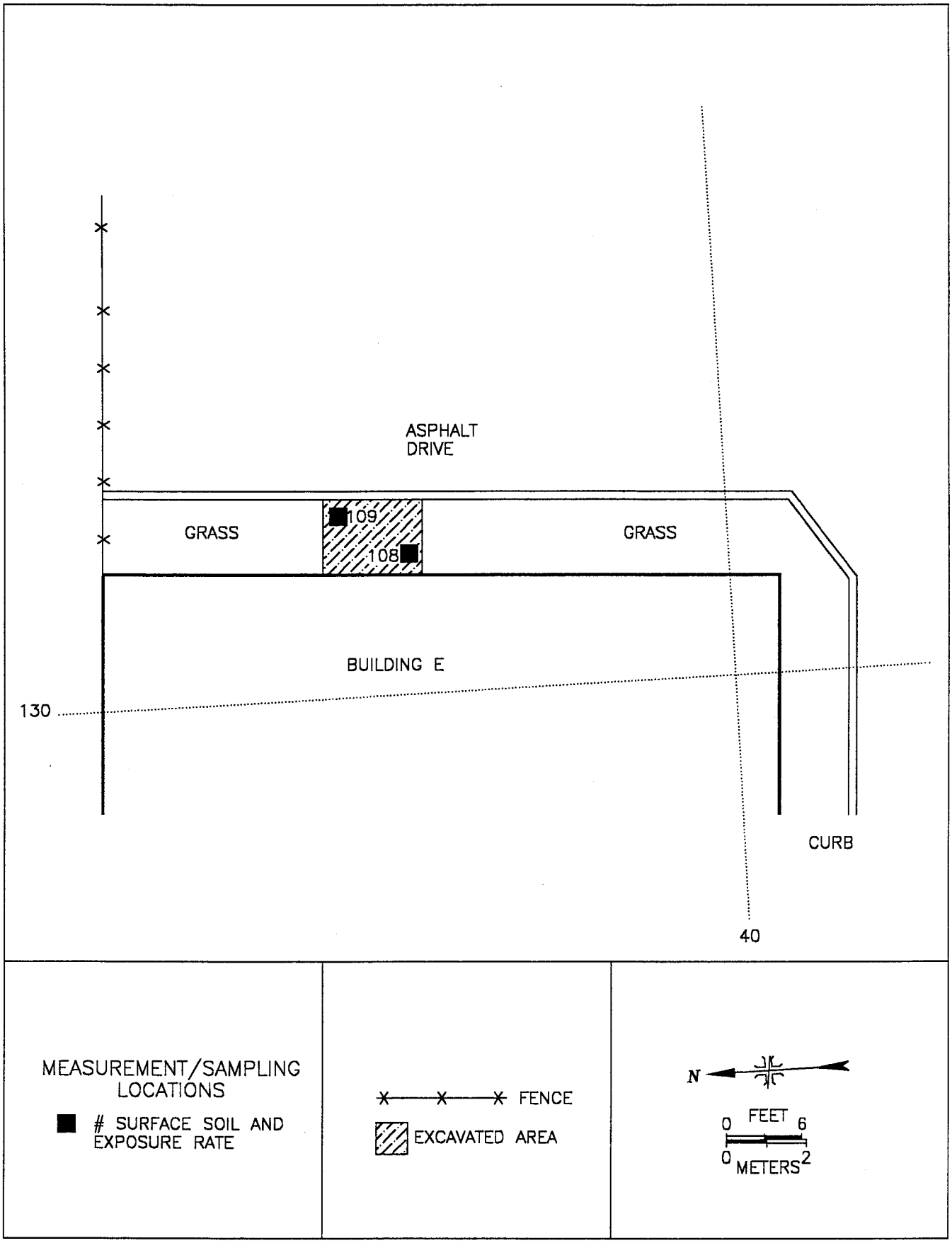



FIGURE 10: Ventron Site, Excavation #3, Area East of Building E – Measurement and Sampling Locations

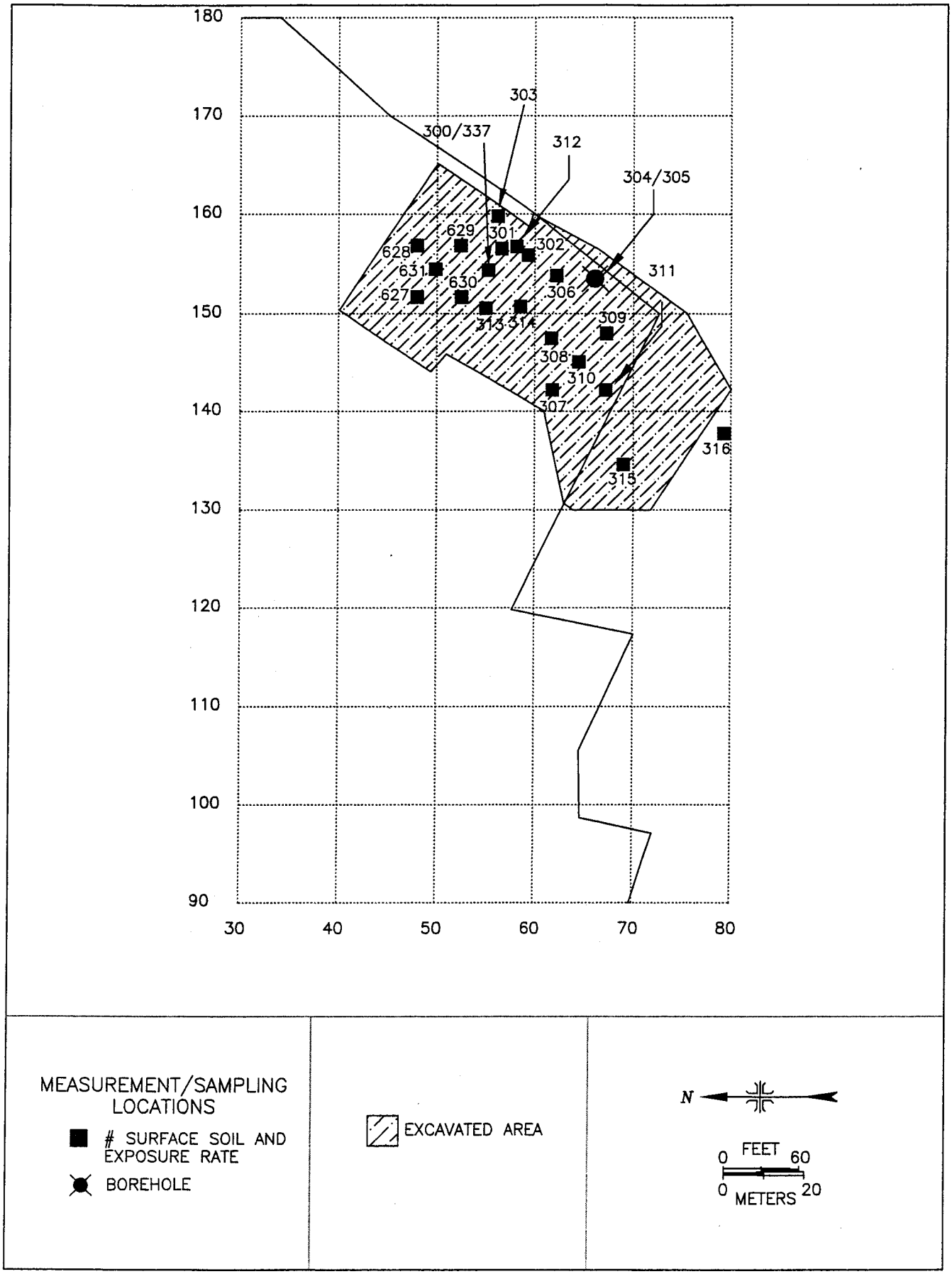



FIGURE 11: Ventron Site, Excavation #4, Alfa Building Area – Measurement and Sampling Locations

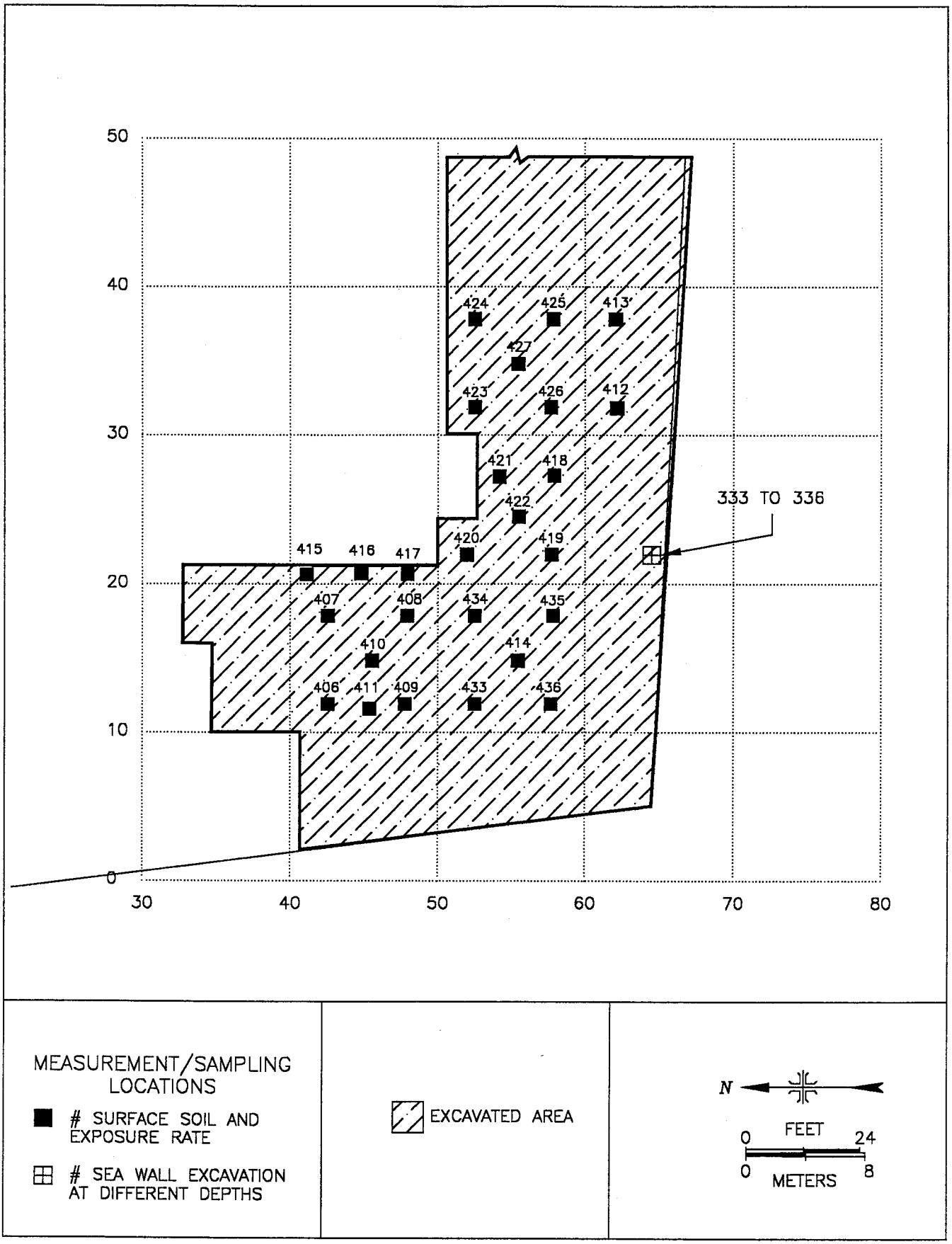



FIGURE 12: Ventron Site, Excavation #6, Southwest Section Along Sea Wall – Measurement and Sampling Locations

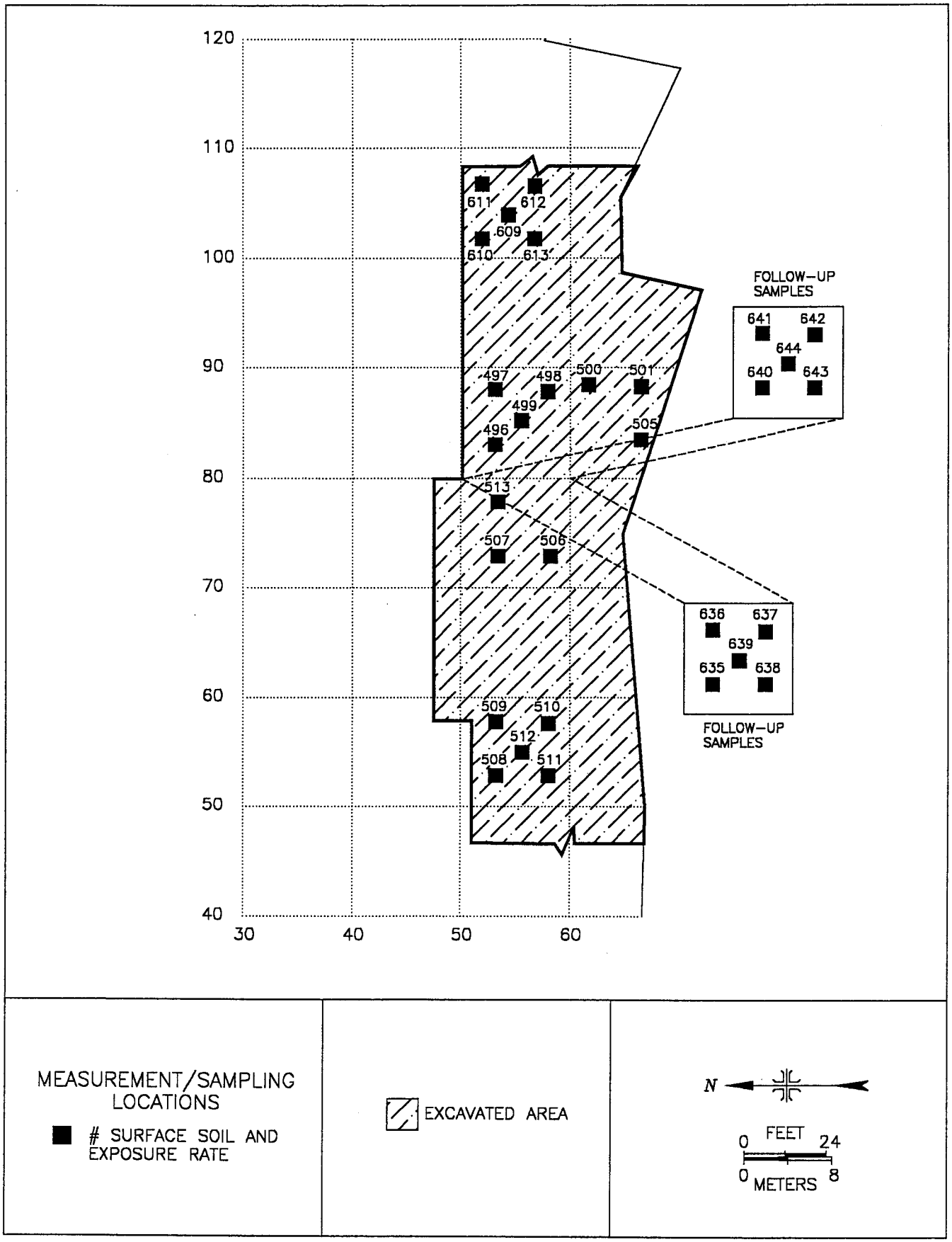
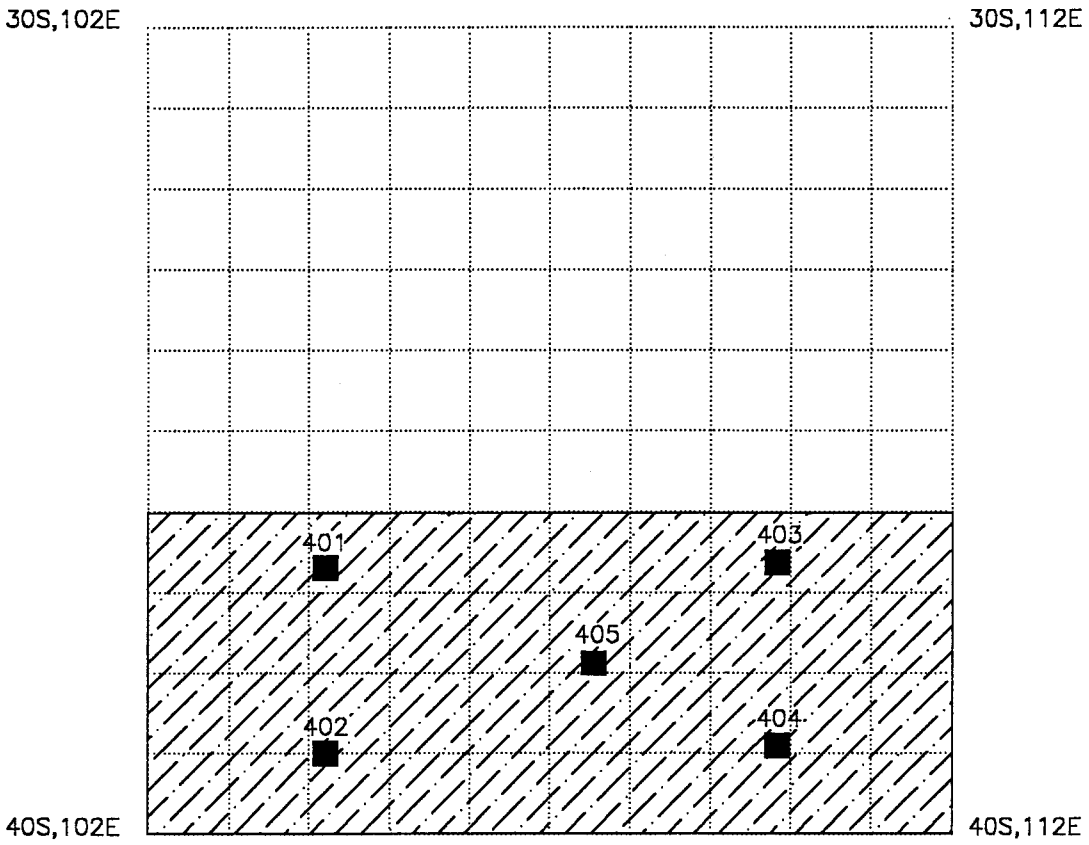



FIGURE 13: Ventron Site, Excavation #6, Southern Section Along Sea Wall – Measurement and Sampling Locations




MEASUREMENT/SAMPLING LOCATIONS

■ # SURFACE SOIL AND EXPOSURE RATE

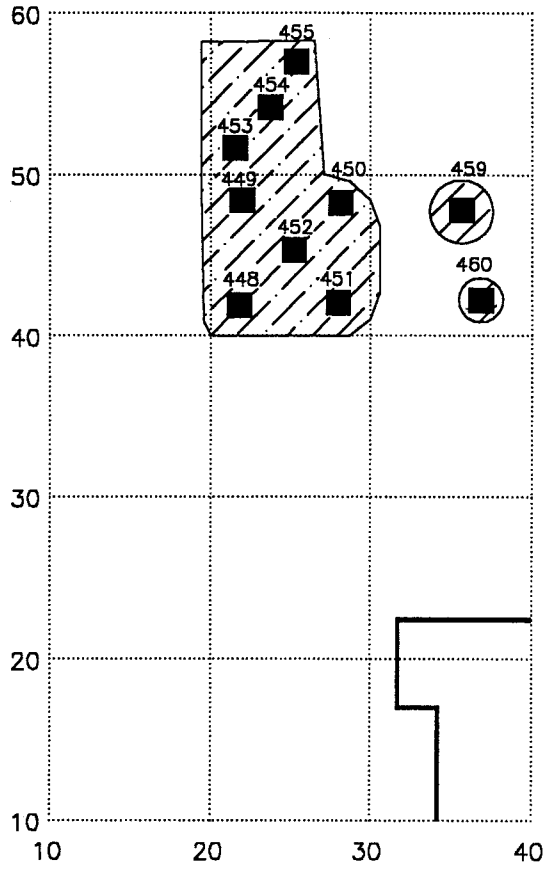
REMEDIATED AREA

N

FEET 0 6

METERS 0 2

FIGURE 14: Ventron Site, Excavation #7, Area Southwest of Building E – Measurement and Sampling Locations




MEASUREMENT/SAMPLING LOCATIONS

■ # SURFACE SOIL AND EXPOSURE RATE

EXCAVATED AREA

N

FEET
0 30
0 10
METERS

FIGURE 15: Ventron Site, Building A–1 Slab Excavations – Measurement and Sampling Locations

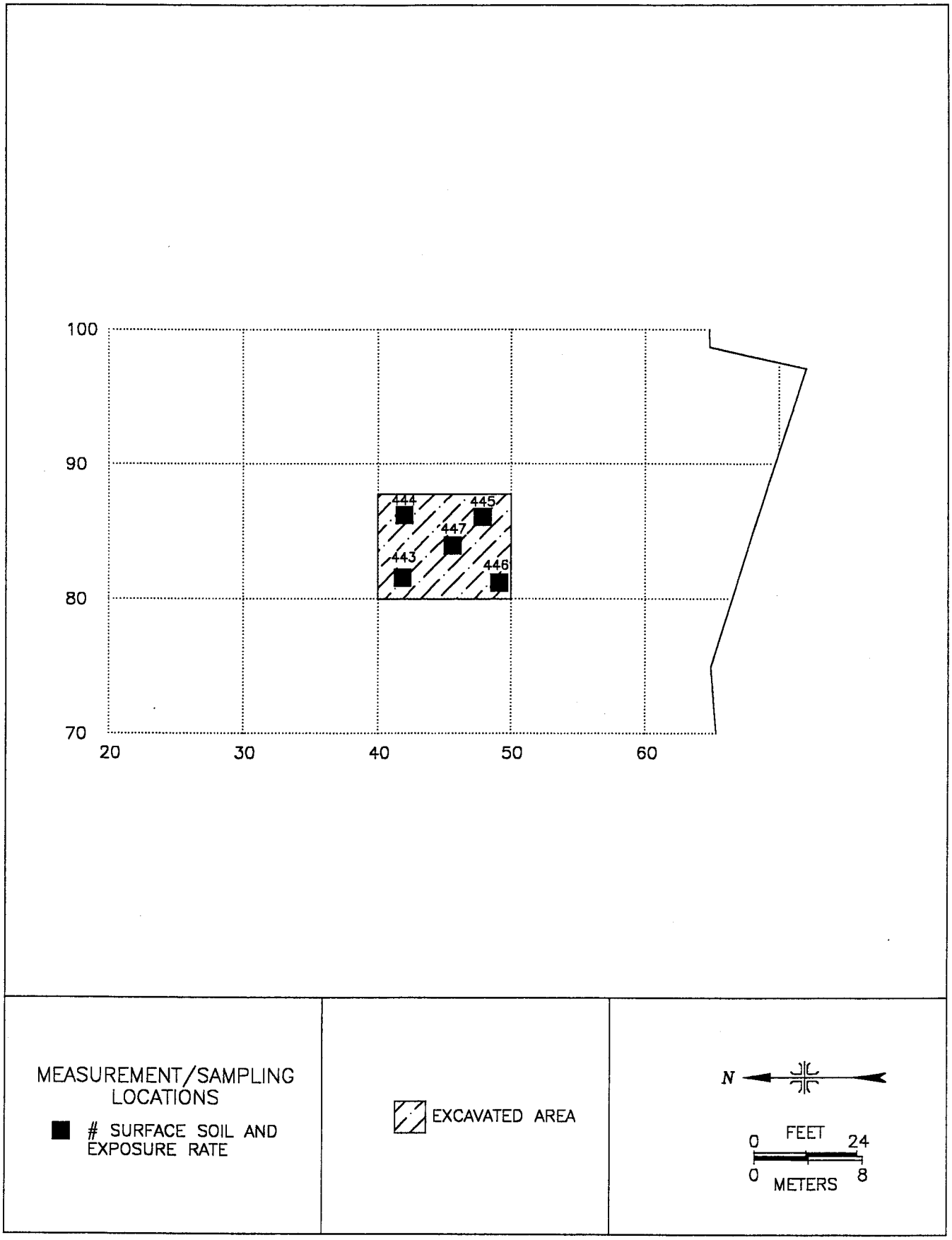



FIGURE 16: Ventron Site, Leach Tank Pit Excavation – Measurement and Sampling Locations

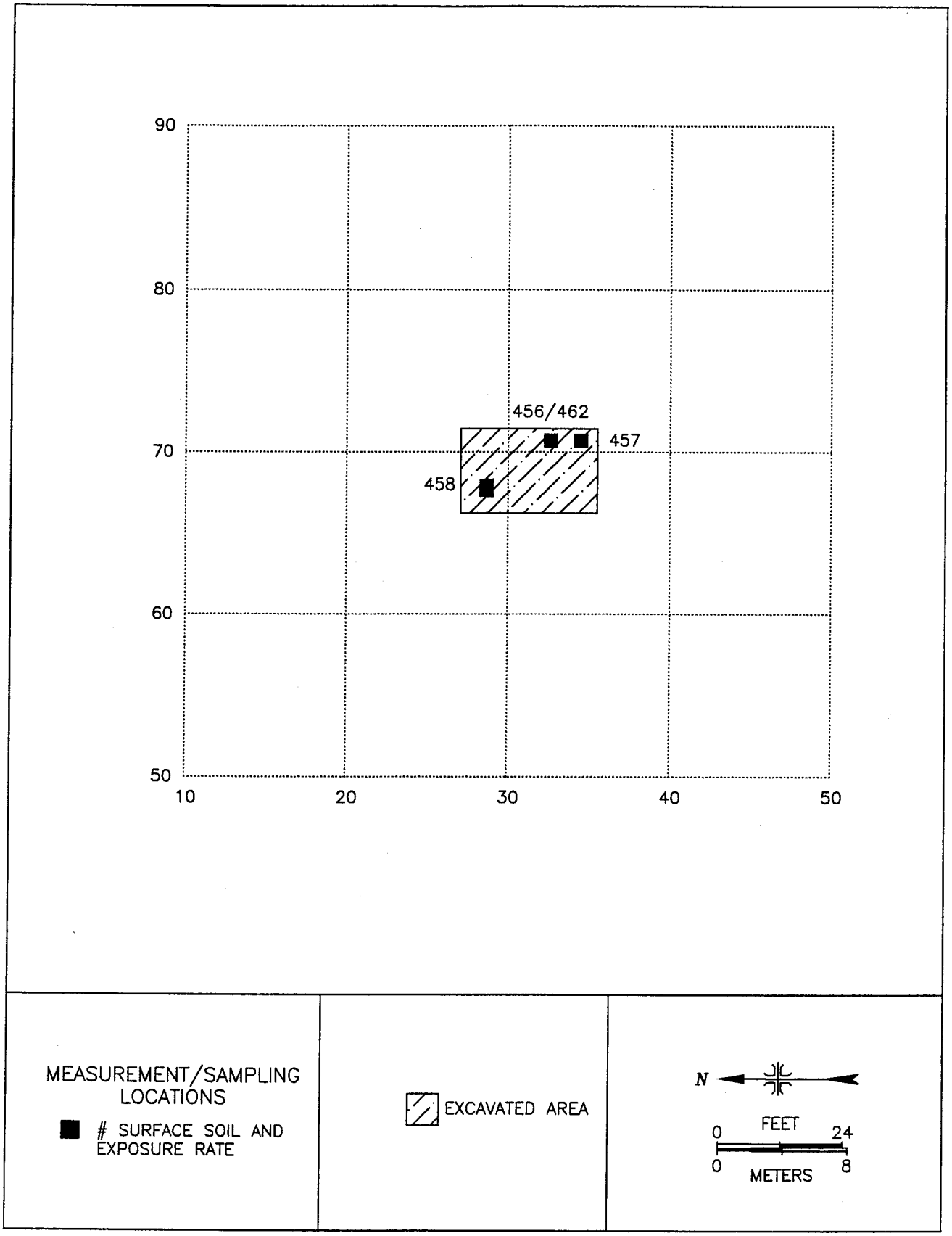



FIGURE 17: Ventron Site, Fan Pit Excavation – Measurement and Sampling Locations

331–043 (4)

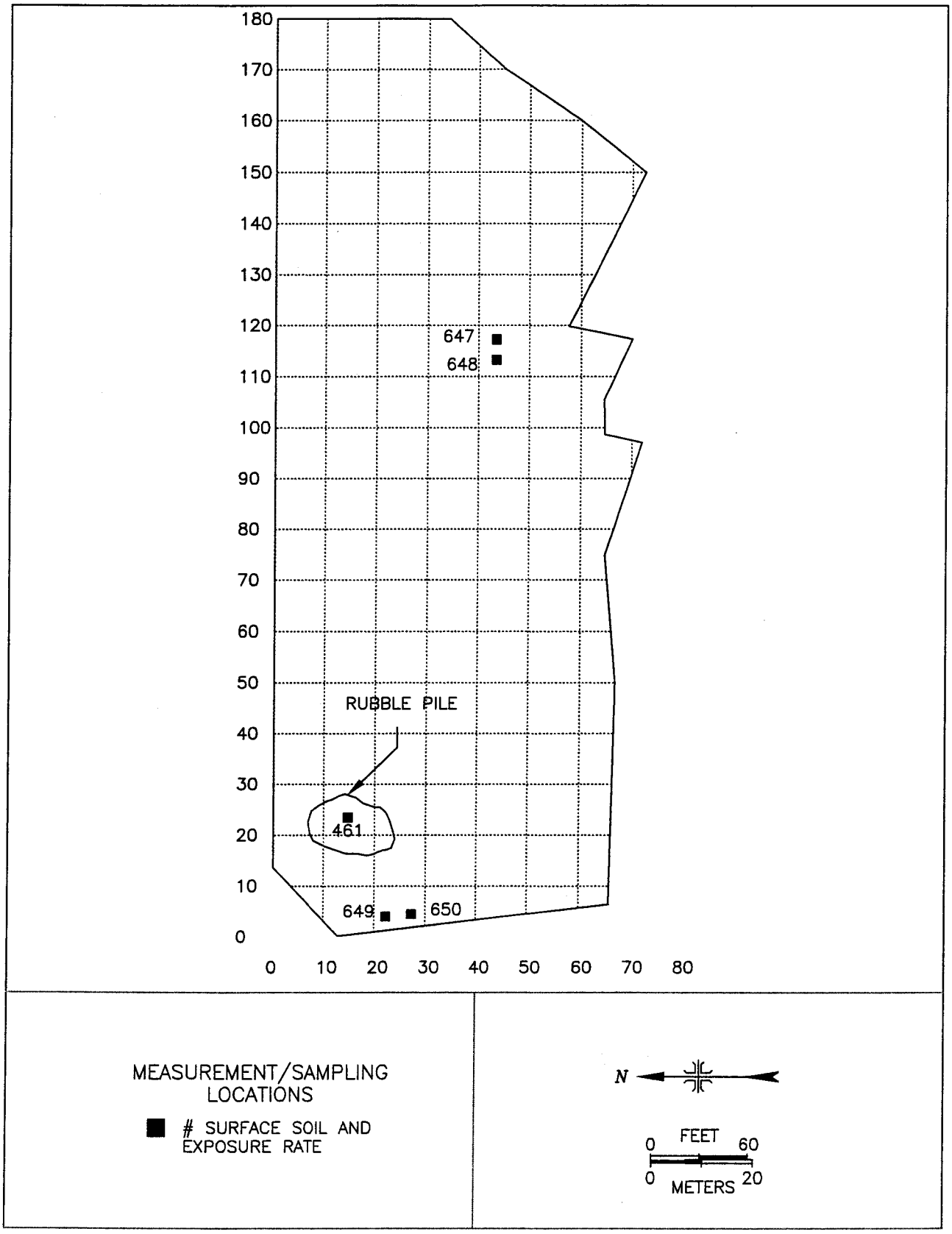
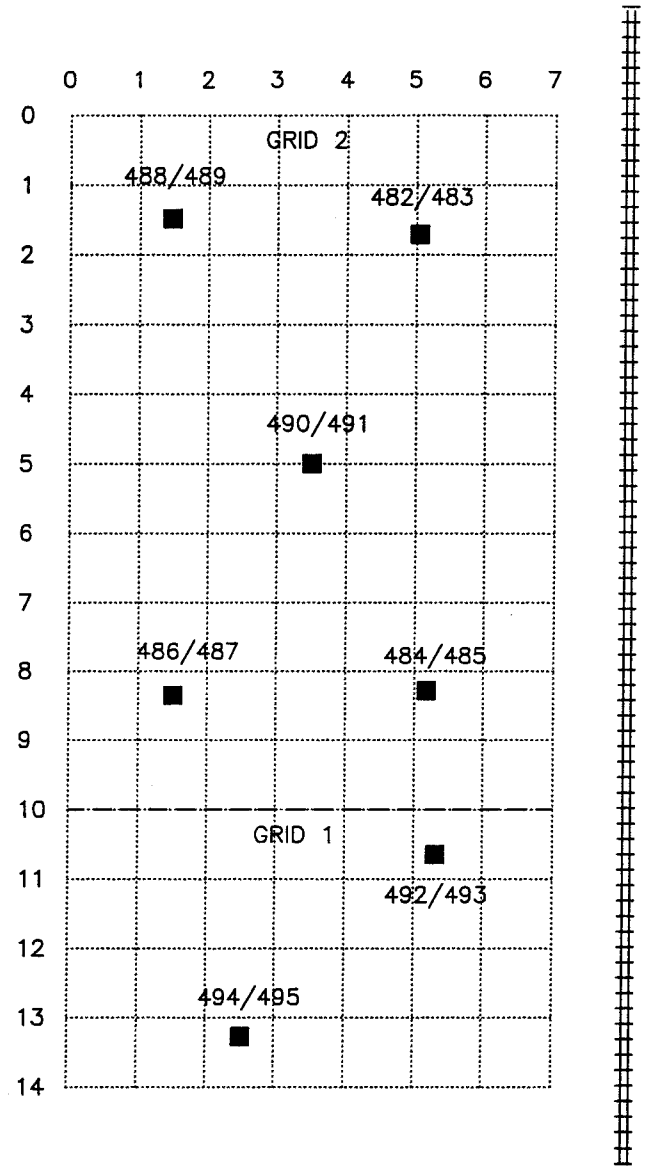



FIGURE 18: Ventron Site, Miscellaneous Area Soil Samples – Measurement and Sampling Locations




NOTE: The two sample numbers indicate that separate soil samples were collected at the 0–15cm depth in both the horizontal and vertical directions.

MEASUREMENT/SAMPLING LOCATIONS

■ # SURFACE SOIL AND EXPOSURE RATE

RAILROAD

N

0 FEET 60

0 METERS 20

FIGURE 19: Ventron Site, Railroad Excavation – Measurement and Sampling Locations

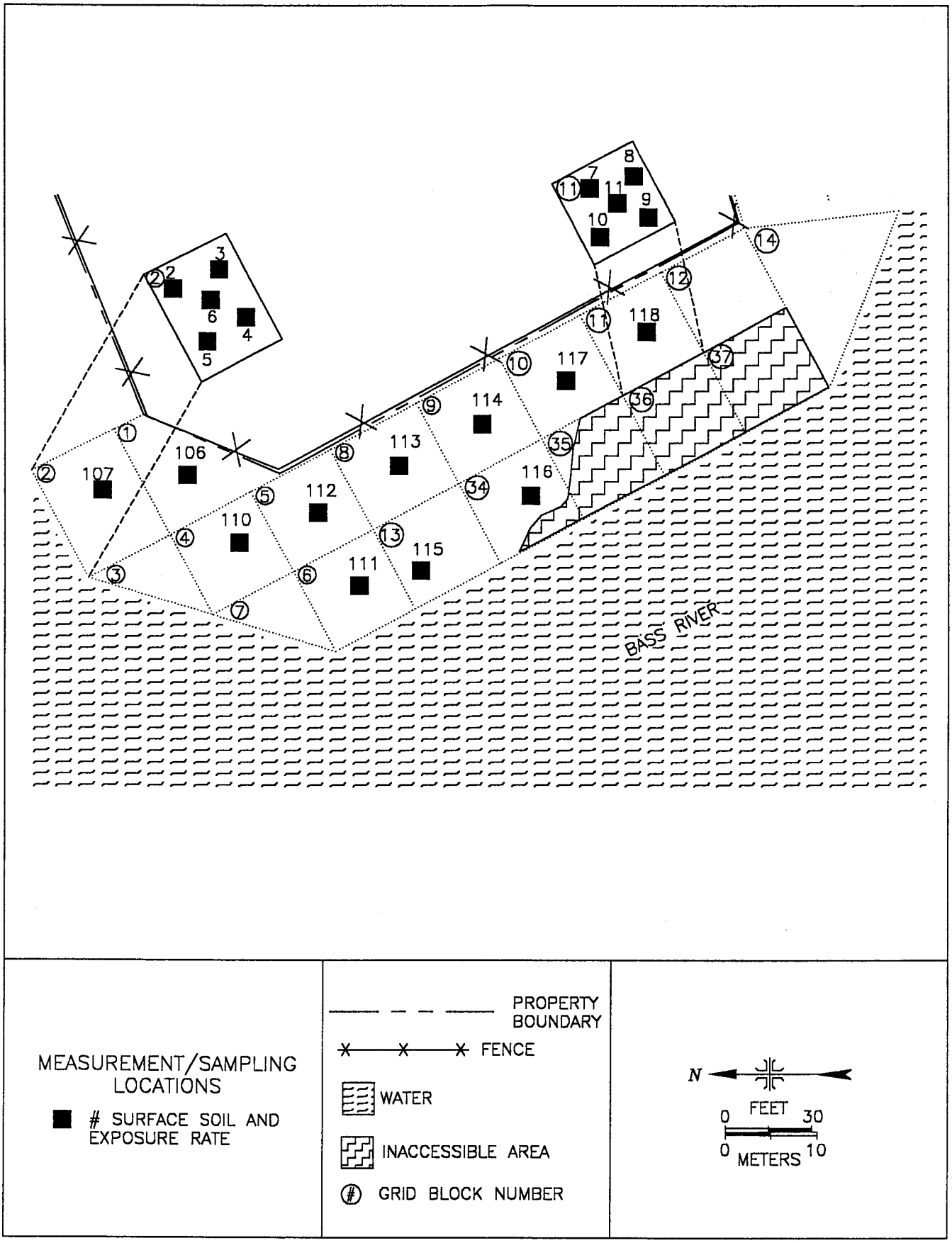



FIGURE 20: Ventron Site, Excavation #5, Southwest Section of Tidal Flats – Measurement and Sampling Locations

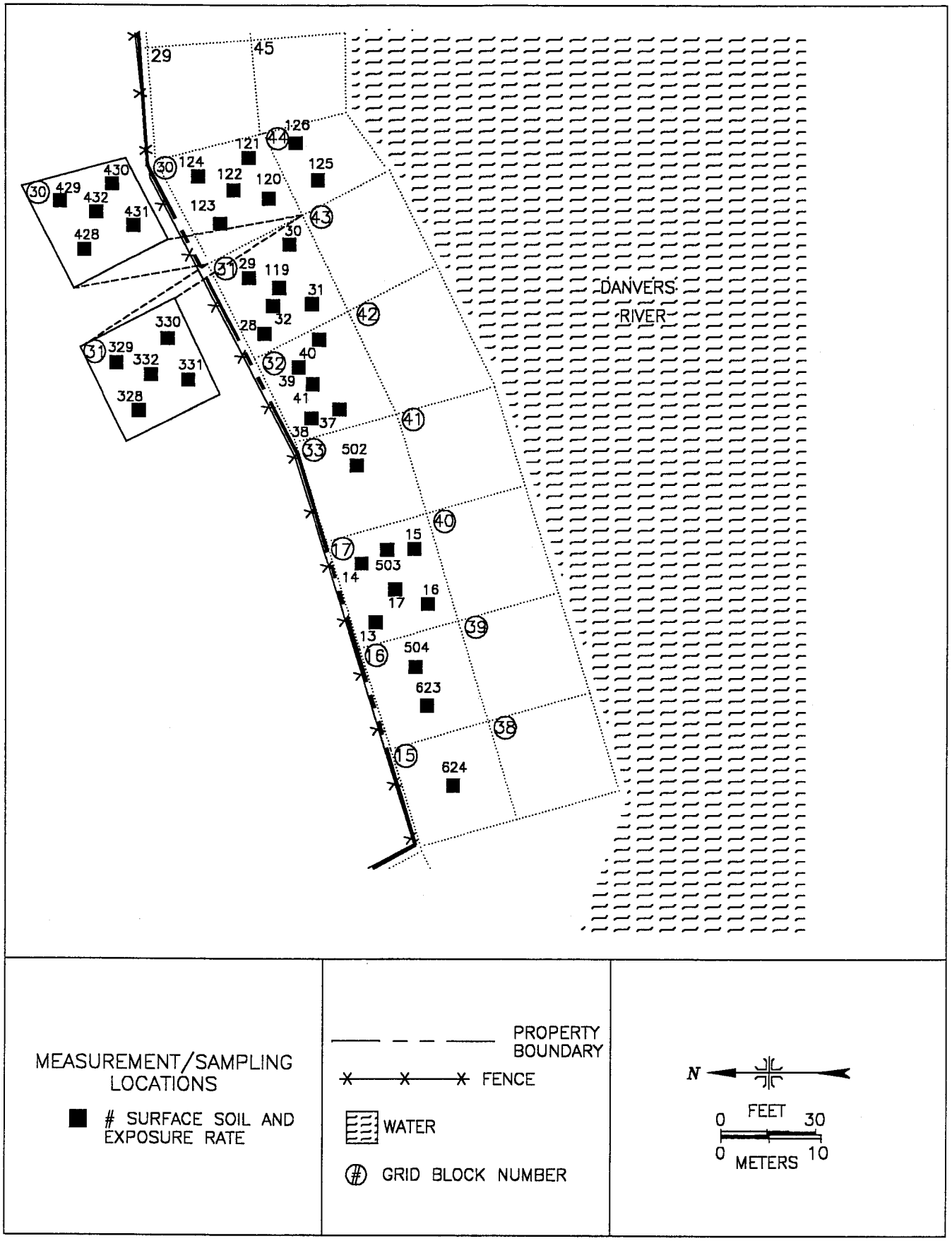



FIGURE 21: Ventron Site, Excavation #5, Southern Section of Tidal Flats – Measurement and Sampling Locations

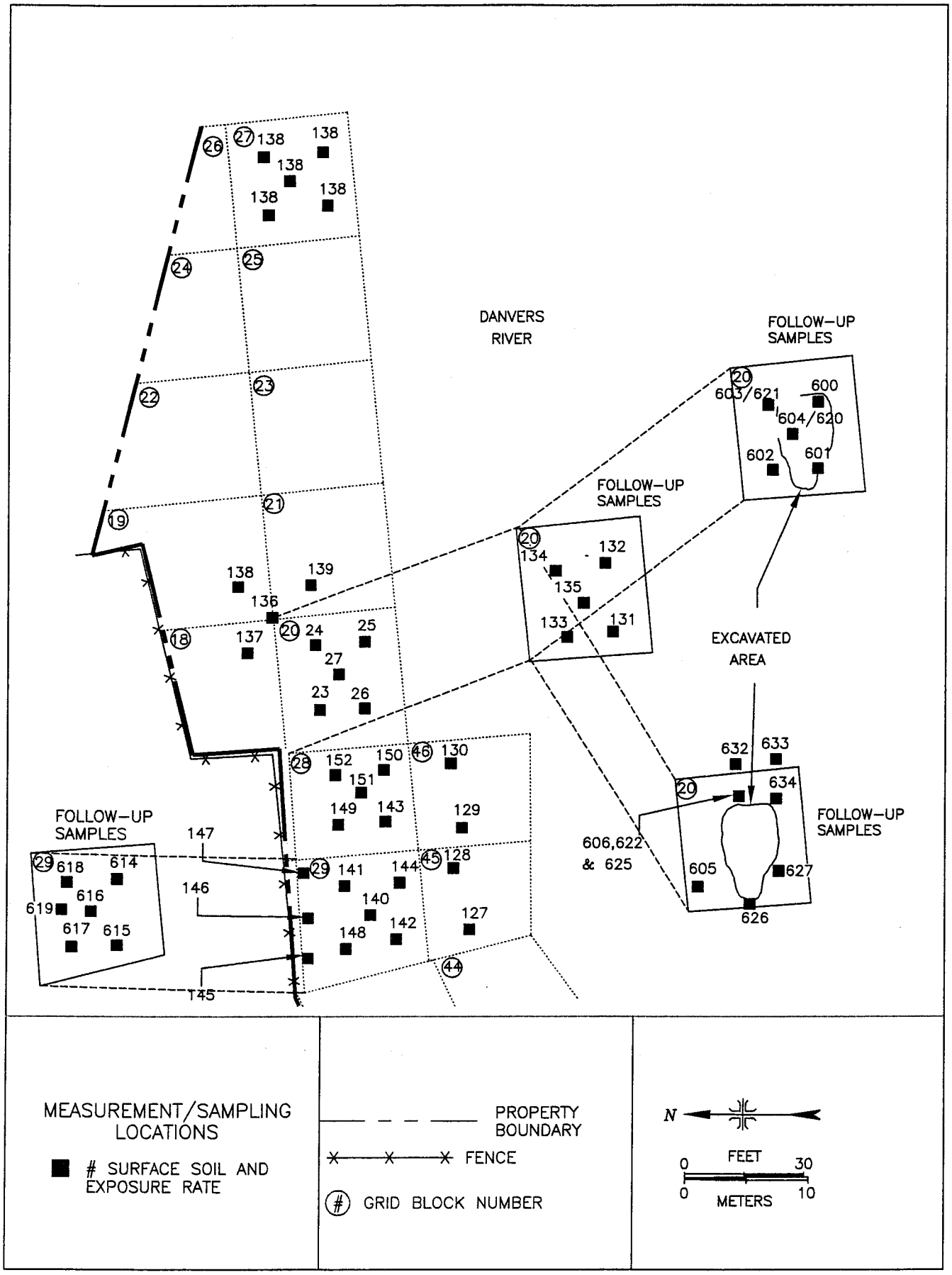



FIGURE 22: Ventron Site, Excavation #5, Southeast Section of Tidal Flats – Measurement and Sampling Locations

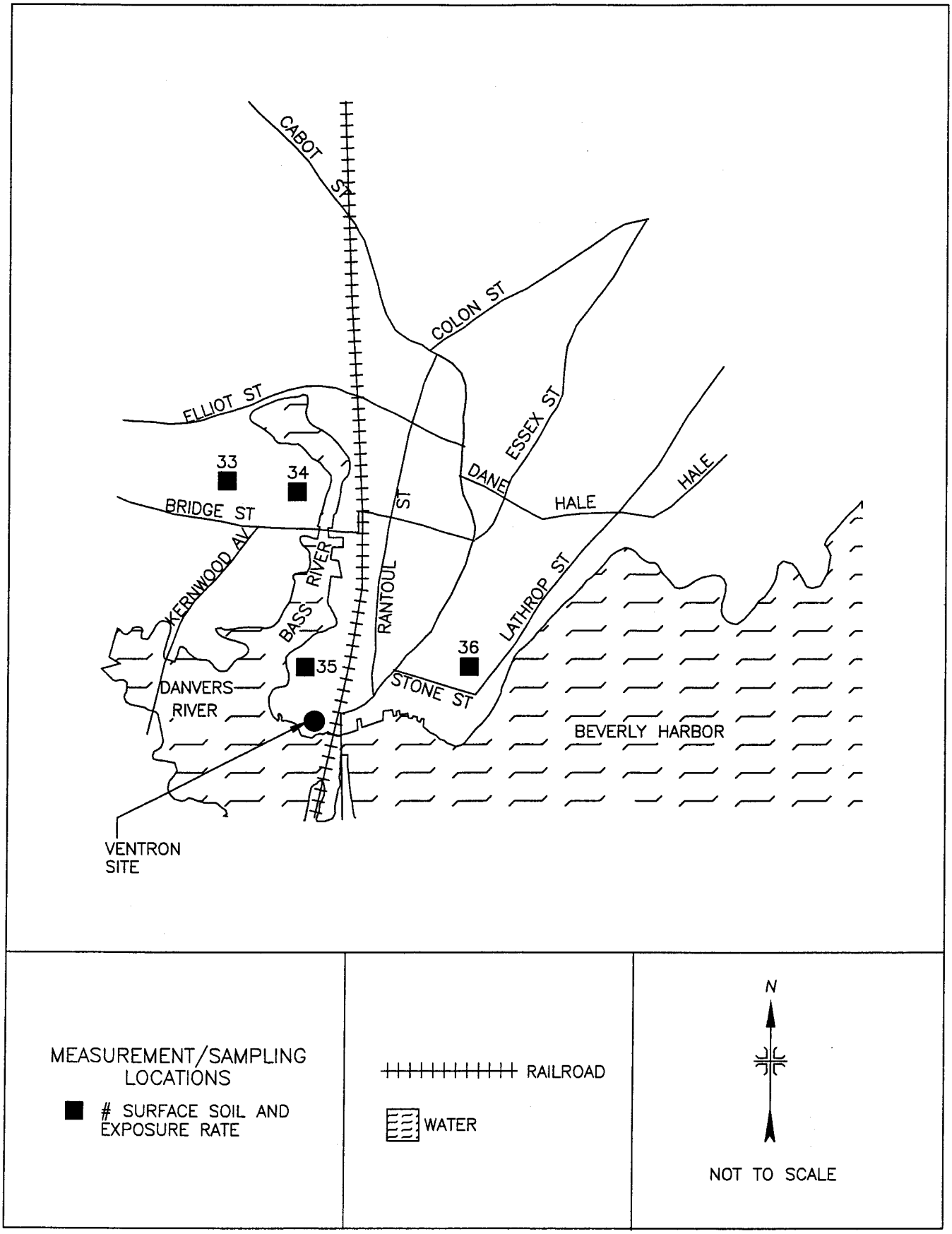



FIGURE 23: Ventron Site – Background Measurement and Sampling Locations

# TABLES

## TABLE 1

## SURFACE ACTIVITY LEVELS
## VENTRON SITE
## BEVERLY, MASSACHUSETTS

| Location[a] | Number of Measurements | Beta Activity Range (dpm/100 $cm^2$) |
|---|---|---|
| Sea Wall | 34 | -590 to 5,000[b] |
| Building A and A-1 Concrete Slabs | 32 | -63 to 93,000[c] |
| Building A Furnace Flues | 4 | -21 to 1,900 |
| Holes in Building A Slab Adjacent to Furnace Flues | 3 | 780 to 2,600 |
| Building A Trench East of Furnace Flues | 1 | 960 |

[a]Refer to Figures 6 and 7.

[b]One location along western portion of the sea wall at 1 m from the top of the wall, had a residual surface activity of 5,000 dpm/100 $cm^2$. This location was isolated and the contiguous 1 $m^2$ average meets the guidelines.

[c]One location on the Building A-1 concrete slab had a residual surface activity level that exceeded the guideline levels. However, the pad will be removed and crushed at a later date by Morton International and samples of the rubble will be collected and analyzed by BNI to determine compliance with volumetric criteria.

## TABLE 2

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN ONSITE SOIL SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **EXCAVATION #1 - AREA NORTHWEST OF BUILDING C** | | | | | | |
| **Grid Block (10S, 10E)** | | | | | | |
| 101 | 10 | <0.3 | 1.3 ± 0.4[c] | 0.8 ± 0.4 | 10.0 ± 2.1 | 21 |
| 102 | 8 | 1.2 ± 0.2 | 1.3 ± 0.3 | 0.8 ± 0.4 | 14.6 ± 2.2 | 30 |
| 103 | 9 | 2.3 ± 0.3 | 2.1 ± 0.5 | 0.9 ± 0.4 | 11.0 ± 2.3 | 23 |
| 104 | 9 | <0.2 | 0.6 ± 0.2 | 0.4 ± 0.3 | 4.7 ± 1.4 | 8.8 |
| 105 | 9 | 0.9 ± 0.2 | 1.1 ± 0.3 | 1.2 ± 0.4 | 27.8 ± 2.8 | 57 |
| **EXCAVATION #2 - AREA NORTHWEST OF BUILDING A** | | | | | | |
| **Grid Blocks (10S, 50E) and (10S, 60E)** | | | | | | |
| 317 | 11 | 0.7 ± 0.1 | 0.9 ± 0.2 | 0.5 ± 0.2 | 7.3 ± 1.3 | 15 |
| 318 | 11 | 0.7 ± 0.1 | 0.7 ± 0.2 | 0.9 ± 0.2 | 13.2 ± 1.4 | 27 |
| 319 | 12 | 0.7 ± 0.1 | 0.7 ± 0.2 | 0.8 ± 0.2 | 12.5 ± 1.4 | 26 |
| 320 | 10 | 0.7 ± 0.1 | 0.6 ± 0.2 | 0.7 ± 0.3 | 12.5 ± 1.5 | 26 |
| 321 | 10 | 0.6 ± 0.1 | 0.7 ± 0.2 | 1.6 ± 0.3 | 28.1 ± 2.1 | 58 |
| **Grid Blocks (10S, 50E) and (10S, 60E) - After Soil Pile Removed** | | | | | | |
| 645[d] | 8 | 0.9 ± 0.1 | 1.0 ± 0.2 | 0.6 ± 0.3 | 10.7 ± 1.6 | 22 |
| 646[d] | 8 | 0.7 ± 0.2 | 0.7 ± 0.3 | <0.4 | 6.1 ± 1.6 | <13 |
| **EXCAVATION #3 - AREA EAST OF BUILDING E** | | | | | | |
| 108 | 5 | <0.2 | 0.9 ± 0.3 | <0.4 | 2.0 ± 1.2 | <4.4 |
| 109 | 7 | <0.4 | 0.8 ± 0.3 | <0.5 | 2.1 ± 1.7 | <4.7 |

## TABLE 2 (Continued)

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN ONSITE SOIL SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **EXCAVATION # 4 - ALFA BUILDING AREA** | | | | | | |
| **Grid Block (50S, 150E) - Initial Verification Survey** | | | | | | |
| 301 | 16 | 1.6 ± 0.2 | 1.5 ± 0.4 | 7.3 ± 0.6 | 142.9 ± 4.1 | 290 |
| 302 | 12 | 1.4 ± 0.2 | 1.5 ± 0.2 | 2.7 ± 0.4 | 52.6 ± 2.5 | 110 |
| 312 (After additional remediation of Locations 301 and 302) | 12 | 1.0 ± 0.1 | 1.3 ± 0.3 | 0.7 ± 0.3 | 8.2 ± 1.3 | 17 |
| 313 | 12 | 1.2 ± 0.1 | 0.9 ± 0.3 | 0.4 ± 0.2 | 7.2 ± 1.3 | 14 |
| 314 | 9 | 1.1 ± 0.2 | 1.3 ± 0.3 | 1.0 ± 0.4 | 18.3 ± 2.0 | 38 |
| 300 | 11 | 0.9 ± 0.2 | 1.1 ± 0.3 | 7.7 ± 0.6 | 148.1 ± 3.1 | 300 |
| 337 (After additional remediation of Location 300) | 12 | 0.9 ± 0.1 | 1.2 ± 0.2 | 2.7 ± 0.4 | 50.2 ± 2.4 | 100 |
| **Average[e]** | 11 | 1.1 | 1.2 | 3.2 | 21.0 | 45 |
| **Grid Block (60S, 140E) - Initial Verification Survey** | | | | | | |
| 307 | 10 | 0.8 ± 0.1 | 0.9 ± 0.3 | <0.3 | 2.9 ± 1.1 | <6.1 |
| 308 | 9 | 1.1 ± 0.2 | 1.4 ± 0.4 | 1.0 ± 0.4 | 21.8 ± 2.2 | 45 |
| 309 | 11 | 0.9 ± 0.1 | 1.1 ± 0.2 | <0.3 | 3.0 ± 0.9 | <6.3 |
| 311 | 11 | 0.8 ± 0.2 | 2.3 ± 0.4 | <0.3 | 2.2 ± 1.2 | <4.7 |
| 310 | 10 | 1.0 ± 0.1 | 1.2 ± 0.2 | 0.4 ± 0.2 | 4.2 ± 1.0 | 8.8 |

## TABLE 2 (Continued)

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN ONSITE SOIL SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **ALFA BUILDING-HOT SPOTS IDENTIFIED BY SURFACE SCANS[f] - Initial Verification** | | | | | | |
| 303 | 17 | 1.4 ± 0.3 | 3.2 ± 0.6 | 9.6 ± 1.0 | 186.7 ± 6.8 | 380 |
| 304 | 15 | <0.7 | <0.8 | 24.4 ± 1.7 | 301.0 ± 8.2 | 630 |
| 305 (304 @ 30 cm) | NA[g] | 0.9 ± 0.1 | 0.7 ± 0.2 | 0.7 ± 0.2 | 13.7 ± 1.4 | 28 |
| 306 | 15 | 2.1 ± 0.3 | 2.7 ± 0.6 | 3.2 ± 0.7 | 62.0 ± 4.2 | 130 |
| 315 | 8 | 2.7 ± 0.3 | 8.4 ± 0.6 | <0.7 | 5.0 ± 2.1 | <11 |
| 316 | 13 | <0.3 | 12.8 ± 0.6 | <0.5 | 1.5 ± 1.2 | <3.5 |
| **Grid Block (45S, 150E) - Final Verification Survey** | | | | | | |
| 627[d] | 9 | 0.6 ± 0.2 | 0.7 ± 0.3 | 1.2 ± 0.4 | 27.7 ± 2.9 | 57 |
| 628[d] | 9 | 0.7 ± 0.2 | 0.7 ± 0.3 | 0.8 ± 0.4 | 13.9 ± 1.9 | 29 |
| 629[d] | 11 | <0.2 | 0.8 ± 0.3 | <0.3 | 4.8 ± 1.2 | <9.9 |
| 630[d] | 10 | 0.9 ± 0.2 | 1.3 ± 0.3 | 0.7 ± 0.4 | 18.3 ± 2.2 | 37 |
| 631[d] | 9 | 0.6 ± 0.1 | 0.9 ± 0.3 | 1.0 ± 0.4 | 16.3 ± 2.3 | 34 |

## TABLE 2 (Continued)

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN ONSITE SOIL SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **EXCAVATION #6 - SOUTHWEST AND SOUTHERN SECTIONS OF THE SITE** | | | | | | |
| **Grid Block (40S, 10E)** | | | | | | |
| 406 | 9 | 0.7 ± 0.1 | 0.9 ± 0.2 | 0.6 ± 0.2 | 14.4 ± 1.5 | 29 |
| 407 | 10 | 0.9 ± 0.1 | 1.1 ± 0.2 | 0.8 ± 0.3 | 16.9 ± 1.7 | 35 |
| 408 | 8 | 1.1 ± 0.1 | 1.3 ± 0.3 | 1.8 ± 0.4 | 36.4 ± 2.2 | 75 |
| 409 | 10 | 1.0 ± 0.1 | 1.0 ± 0.2 | 1.6 ± 0.3 | 33.9 ± 2.3 | 69 |
| 410 | 9 | 0.7 ± 0.1 | 0.7 ± 0.2 | 1.7 ± 0.3 | 31.8 ± 1.9 | 65 |
| 411 | 10 | 1.3 ± 0.1 | 1.5 ± 0.3 | 0.5 ± 0.2 | 7.5 ± 1.4 | 16 |
| **Grid Block (40S, 20E)** | | | | | | |
| 415 | 11 | 0.7 ± 0.1 | 0.9 ± 0.2 | 0.2 ± 0.2 | 4.4 ± 0.9 | 9.0 |
| 417 | 8 | 0.8 ± 0.1 | 0.8 ± 0.3 | 0.5 ± 0.2 | 10.7 ± 1.3 | 22 |
| 416 | 8 | <0.2 | 0.8 ± 0.2 | 0.2 ± 0.2 | 3.5 ± 1.1 | 7.2 |
| **Grid Block (50S, 10E)** | | | | | | |
| 433 | 14 | 1.1 ± 0.1 | 1.1 ± 0.3 | 2.4 ± 0.4 | 46.1 ± 2.2 | 95 |
| 434 | 8 | 1.3 ± 0.2 | 1.5 ± 0.3 | 1.7 ± 0.4 | 30.7 ± 2.2 | 63 |
| 435 | 10 | 0.6 ± 0.1 | 0.5 ± 0.2 | 0.6 ± 0.3 | 16.6 ± 1.4 | 34 |
| 436 | 9 | 0.6 ± 0.1 | 0.8 ± 0.2 | 1.0 ± 0.3 | 19.8 ± 1.7 | 41 |
| 414 | 7 | 0.7 ± 0.1 | 0.8 ± 0.2 | 1.6 ± 0.4 | 37.2 ± 2.2 | 76 |

## TABLE 2 (Continued)

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN ONSITE SOIL SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **Grid Block (50S, 20E)** | | | | | | |
| 420 | 7 | 0.5 ± 0.1 | 0.6 ± 0.2 | 0.2 ± 0.2 | 2.5 ± 0.8 | 5.2 |
| 421 | 9 | 0.6 ± 0.1 | 0.9 ± 0.2 | <0.2 | 3.3 ± 1.1 | <6.8 |
| 418 | 6 | 0.4 ± 0.1 | 0.6 ± 0.2 | 0.6 ± 0.2 | 12.9 ± 1.3 | 26 |
| 419 | 5 | 0.5 ± 0.1 | 1.0 ± 0.2 | 1.8 ± 0.4 | 34.4 ± 1.8 | 71 |
| 422 | 8 | 0.4 ± 0.1 | 0.6 ± 0.2 | 0.2 ± 0.3 | 12.5 ± 1.3 | 25 |
| **Grid Block (50S, 30E)** | | | | | | |
| 423 | 7 | 0.6 ± 0.1 | 0.9 ± 0.2 | 0.4 ± 0.2 | 6.7 ± 1.1 | 14 |
| 424 | 7 | 0.7 ± 0.1 | 0.8 ± 0.2 | 0.5 ± 0.3 | 6.7 ± 0.9 | 14 |
| 425 | 8 | 0.9 ± 0.1 | 0.9 ± 0.3 | 3.6 ± 0.5 | 66.0 ± 2.7 | 140 |
| 426 | 7 | 0.7 ± 0.1 | 1.1 ± 0.2 | 1.3 ± 0.3 | 25.3 ± 1.7 | 52 |
| 427 | 8 | 0.8 ± 0.1 | 0.8 ± 0.2 | 2.0 ± 0.3 | 42.2 ± 1.8 | 86 |
| **Average** | 7 | 0.7 | 0.9 | 1.6 | 29.4 | 60 |
| **Grid Block (50S, 50E)** | | | | | | |
| 508 | 8 | 0.4 ± 0.1 | 0.5 ± 0.1 | 0.1 ± 0.1 | 2.5 ± 0.5 | 5.1 |
| 509 | 7 | 0.4 ± 0.1 | 0.5 ± 0.1 | 0.2 ± 0.1 | 5.2 ± 0.7 | 11 |
| 510 | 7 | 0.5 ± 0.1 | 0.6 ± 0.2 | 0.7 ± 0.2 | 12.7 ± 0.3 | 26 |
| 511 | 5 | <0.1 | 0.7 ± 0.2 | 0.5 ± 0.2 | 7.2 ± 1.0 | 15 |
| 512 | 6 | 0.5 ± 0.1 | 0.6 ± 0.2 | 0.5 ± 0.1 | 10.8 ± 1.1 | 22 |

## TABLE 2 (Continued)

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN ONSITE SOIL SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **Grid Block (50S, 70E) - Initial Verification Survey** | | | | | | |
| 507 | 8 | 0.5 ± 0.1 | 0.7 ± 0.2 | 0.3 ± 0.2 | 3.6 ± 0.7 | 7.5 |
| 513 | 6 | 0.7 ± 0.1 | 0.9 ± 0.2 | 2.6 ± 0.3 | 56.7 ± 3.4 | 120 |
| 506 | 13 | 1.1 ± 0.1 | 1.7 ± 0.3 | 2.7 ± 0.3 | 64.8 ± 4.3 | 130 |
| **Average** | 9 | 0.8 | 1.1 | 1.9 | 41.7 | 85 |
| **Grid Block (50S, 70E) - After Additional Remediation** | | | | | | |
| 635[d] | 8 | <0.2 | 0.5 ± 0.3 | 1.0 ± 0.3 | 13.9 ± 1.9 | 29 |
| 636[d] | 7 | 0.7 ± 0.1 | 0.6 ± 0.2 | 0.5 ± 0.3 | 14.4 ± 1.6 | 29 |
| 637[d] | 10 | 0.7 ± 0.2 | 1.1 ± 0.3 | 1.1 ± 0.5 | 23.4 ± 2.8 | 48 |
| 638[d] | 10 | <0.2 | 0.8 ± 0.3 | 3.7 ± 0.6 | 61.6 ± 4.1 | 130 |
| 639[d] | 7 | 0.7 ± 0.1 | 0.7 ± 0.2 | 1.1 ± 0.3 | 21.9 ± 2.2 | 45 |
| **Average[e]** | 8 | <0.5 | 0.7 | 1.5 | 27.0 | 56 |
| **Grid Block (50S, 80E) - Initial Verification Survey** | | | | | | |
| 496 | 9 | 0.5 ± 0.1 | 0.7 ± 0.2 | 0.7 ± 0.2 | 13.5 ± 1.2 | 28 |
| 497 | 7 | 0.6 ± 0.1 | 1.0 ± 0.2 | 2.3 ± 0.3 | 48.7 ± 3.1 | 100 |
| 498 | 9 | 0.5 ± 0.1 | 0.8 ± 0.2 | 0.9 ± 0.2 | 18.3 ± 1.5 | 38 |
| 499 | 9 | 0.5 ± 0.1 | 0.7 ± 0.2 | 2.8 ± 0.3 | 52.2 ± 3.1 | 110 |
| **Average** | 9 | 0.5 | 0.8 | 1.7 | 33.2 | 68 |

## TABLE 2 (Continued)

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN ONSITE SOIL SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **Grid Block (50S, 80E) - After Additional Remediation** | | | | | | |
| 640[d] | 11 | 0.5 ± 0.1 | 0.8 ± 0.3 | 0.7 ± 0.3 | 8.0 ± 1.6 | 17 |
| 641[d] | 10 | 0.7 ± 0.1 | 0.7 ± 0.2 | <0.3 | 2.3 ± 1.0 | <4.9 |
| 642[d] | 7 | 0.7 ± 0.1 | 0.7 ± 0.2 | <0.2 | 2.0 ± 0.8 | <4.2 |
| 643[d] | 8 | 0.7 ± 0.1 | 0.8 ± 0.3 | 0.2 ± 0.3 | 4.4 ± 1.2 | <9.0 |
| 644[d] | 8 | 0.8 ± 0.2 | 0.6 ± 0.3 | <0.3 | 2.5 ± 1.0 | <5.3 |
| **Grid Block (50S, 100E)** | | | | | | |
| 610[d] | 7 | 0.8 ± 0.2 | 0.9 ± 0.3 | 0.6 ± 0.3 | 15.6 ± 1.9 | 32 |
| 611[d] | 6 | 0.7 ± 0.1 | 0.8 ± 0.2 | 1.1 ± 0.3 | 19.0 ± 2.0 | 39 |
| 612[d] | 8 | 0.8 ± 0.1 | <0.5 | <0.3 | 2.3 ± 1.2 | <4.9 |
| 613[d] | 7 | 0.7 ± 0.1 | 0.9 ± 0.3 | 0.5 ± 0.3 | 10.4 ± 1.7 | 21 |
| 609[d] | 8 | <0.2 | 0.9 ± 0.3 | 0.5 ± 0.4 | 12.3 ± 2.1 | 25 |
| **Grid Block (60S, 20E) - Sea Wall Along Excavation #6 at C2** | | | | | | |
| 333[f] | 7 | 0.7 ± 0.1 | 1.0 ± 0.2 | 1.9 ± 0.4 | 34.6 ± 1.8 | 71 |
| 334[f] | 7 | 0.7 ± 0.1 | 0.8 ± 0.2 | 3.9 ± 0.4 | 71.0 ± 2.0 | 150 |
| 335[f] | 7 | 0.6 ± 0.1 | 0.8 ± 0.2 | 1.5 ± 0.3 | 23.3 ± 1.9 | 48 |
| 336 | 8 | 0.6 ± 0.1 | 0.8 ± 0.2 | 1.3 ± 0.3 | 24.3 ± 1.5 | 50 |

## TABLE 2 (Continued)

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN ONSITE SOIL SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (µR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **Grid Block (60S, 30E)** | | | | | | |
| 412 | 8 | 1.0 ± 0.1 | 0.9 ± 0.3 | 1.6 ± 0.4 | 30.8 ± 2.1 | 63 |
| 413 | 7 | 0.7 ± 0.1 | 0.7 ± 0.2 | 0.9 ± 0.3 | 21.3 ± 2.0 | 44 |
| **Grid Block (60S, 80E) - Initial Verification Survey** | | | | | | |
| 500 | 8 | 0.5 ± 0.1 | 0.6 ± 0.1 | 1.1 ± 0.2 | 22.3 ± 1.6 | 46 |
| 501 | 8 | 0.7 ± 0.1 | 0.9 ± 0.2 | 0.4 ± 0.2 | 7.8 ± 1.2 | 16 |
| hotspot/505[f] | 13 | 0.5 ± 0.1 | 0.6 ± 0.2 | 16.9 ± 1.0 | 338 ± 17 | 690 |
| **EXCAVATION #7 - AREA SOUTHWEST OF BUILDING E** | | | | | | |
| **Grid Block (30S, 100E)** | | | | | | |
| 401 | 8 | 0.9 ± 0.1 | 1.0 ± 0.2 | <0.3 | 1.2 ± 0.9 | <2.7 |
| 402 | 8 | 0.7 ± 0.1 | 0.9 ± 0.2 | 0.2 ± 0.2 | 4.6 ± 1.1 | 9.4 |
| 403 | 6 | 0.8 ± 0.1 | 1.0 ± 0.3 | 0.3 ± 0.2 | 3.9 ± 1.2 | 8.1 |
| 404 | 8 | 0.8 ± 0.1 | 0.8 ± 0.3 | 0.6 ± 0.2 | 12.3 ± 1.4 | 25 |
| 405 | 8 | 0.8 ± 0.1 | 1.1 ± 0.2 | <0.2 | 2.5 ± 0.6 | <5.2 |
| **BUILDING A-1 SLAB EXCAVATIONS** | | | | | | |
| **Grid Block (20S, 40E)** | | | | | | |
| 448 | 9 | 0.5 ± 0.1 | 0.5 ± 0.1 | <0.1 | 1.3 ± 0.5 | <2.7 |
| 449 | 10 | 1.6 ± 0.1 | 1.4 ± 0.2 | <0.2 | 2.2 ± 0.6 | <4.6 |
| 450 | 10 | 2.6 ± 0.3 | 2.3 ± 0.4 | 0.4 ± 0.3 | 2.3 ± 1.2 | 5.0 |
| 451 | 11 | 1.0 ± 0.1 | 0.9 ± 0.2 | <0.2 | 1.2 ± 0.5 | <2.6 |
| 452 | 12 | 1.1 ± 0.1 | 0.9 ± 0.2 | <0.2 | 1.1 ± 0.5 | <2.4 |

## TABLE 2 (Continued)

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN ONSITE SOIL SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **Grid Block (20S, 50E)** | | | | | | |
| 453 | 10 | 1.8 ± 0.2 | 0.7 ± 0.2 | 0.8 ± 0.2 | 14.1 ± 1.1 | 23 |
| 454 | 10 | 0.8 ± 0.1 | 0.3 ± 0.1 | <0.1 | 0.6 ± 0.4 | <1.3 |
| 455 | 10 | 1.0 ± 0.1 | 0.4 ± 0.1 | 0.1 ± 0.1 | 1.3 ± 0.5 | 2.7 |
| **Grid Block (30S, 40E)** | | | | | | |
| 459 | 15 | 1.9 ± 0.2 | 1.9 ± 0.3 | <0.2 | 1.7 ± 0.8 | <3.6 |
| 460 | 13 | 2.6 ± 0.2 | 2.5 ± 0.4 | <0.2 | 2.3 ± 0.8 | <4.8 |
| **LEACH TANK PIT EXCAVATION** | | | | | | |
| **Grid Block (40S, 80E)** | | | | | | |
| 443 | 9 | 1.1 ± 0.1 | 1.0 ± 0.2 | 0.5 ± 0.1 | 9.4 ± 1.1 | 19 |
| 444 | 11 | 0.7 ± 0.1 | 1.4 ± 0.2 | 0.5 ± 0.2 | 8.5 ± 1.1 | 17 |
| 445 | 11 | 0.4 ± 0.1 | 0.3 ± 0.1 | 0.6 ± 0.1 | 9.9 ± 0.8 | 20 |
| 446 | 11 | 0.9 ± 0.1 | 6.0 ± 0.7 | 0.3 ± 0.2 | 9.8 ± 1.3 | 20 |
| 447 | 11 | 0.8 ± 0.1 | 1.2 ± 0.2 | 0.4 ± 0.2 | 5.8 ± 0.7 | 12 |

## TABLE 2 (Continued)

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN ONSITE SOIL SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **FAN PIT EXCAVATION** | | | | | | |
| **Grid Block (20S, 60E)** | | | | | | |
| 456 | NA | 1.8 ± 0.2 | 1.8 ± 0.3 | 6.0 ± 0.4 | 115.6 ± 5.9 | 240 |
| 462 (After additional remediation of Location 456) | NA | <0.2 | 11.0 ± 1.2 | <0.4 | 5.0 ± 1.3 | 10 |
| 457 | NA | 0.8 ± 0.1 | 1.1 ± 0.2 | 0.7 ± 0.2 | 14.4 ± 1.3 | 30 |
| 458 | NA | 1.0 ± 0.1 | 0.9 ± 0.2 | 0.8 ± 0.2 | 13.5 ± 1.3 | 28 |
| **MISCELLANEOUS AREAS** | | | | | | |
| **West Side of Building C** | | | | | | |
| 649[d] | 8 | 0.8 ± 0.2 | 1.0 ± 0.3 | <0.4 | 4.5 ± 1.3 | <9.4 |
| 650[d] | 6 | 1.1 ± 0.2 | 0.8 ± 0.3 | <0.4 | 1.1 ± 1.0 | <2.5 |
| **South Side of Building A** | | | | | | |
| 647[d] | 7 | 0.7 ± 0.2 | 0.6 ± 0.3 | <0.4 | 3.3 ± 1.4 | <7.0 |
| 648[d] | 8 | 0.7 ± 0.1 | 1.0 ± 0.2 | 0.3 ± 0.3 | 4.1 ± 1.2 | 8.5 |

## TABLE 2 (Continued)

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN ONSITE SOIL SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **MISCELLANEOUS AREAS (Continued)** | | | | | | |
| **Northwest Scrap Pile** | | | | | | |
| 461 | NA | 0.8 ± 0.1 | 0.9 ± 0.2 | 0.9 ± 0.2 | 22.7 ± 1.5 | 46 |

[a]Refer to Figures 8 through 18.
[b]Total uranium was calculated by multiplying the U-238 concentration by a factor of 2 and adding the U-235 concentration—these results include background.
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.
[d]A non-conformance was identified in the chain-of-custody procedures for these samples. Although there was no evidence of sample tampering, the data presented here should only be used for qualitative purposes.
[e]Average value does not include the initial sample locations that were subsequently remediated.
[f]Additional remedial actions performed by BNI in this area removed these localized areas of contamination. Some sample locations in this area are not included in the figure since additional excavations have removed their locations.
[g]NA = Measurement not performed.

## TABLE 3

## RADIONUCLIDE CONCENTRATIONS IN RAILROAD SOIL SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/Sample Number[a] | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|
| | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **GRID 2A** | | | | | |
| 482-vertical | 0.7 ± 0.1[c] | 0.9 ± 0.2 | 1.0 ± 0.2 | 20.7 ± 1.8 | 42 |
| 483-horizontal | 0.4 ± 0.1 | 0.6 ± 0.2 | <0.2 | 1.1 ± 0.6 | <2.4 |
| **GRID 2B** | | | | | |
| 484-vertical | 0.4 ± 0.1 | 0.8 ± 0.2 | <0.2 | 1.5 ± 0.6 | <3.2 |
| 485-horizontal | 0.6 ± 0.1 | 1.4 ± 0.3 | <0.2 | 3.6 ± 0.9 | <7.4 |
| **GRID 2C** | | | | | |
| 486-vertical | 0.6 ± 0.1 | 1.5 ± 0.3 | 1.4 ± 0.3 | 30.6 ± 2.3 | 63 |
| 487-horizontal | 0.6 ± 0.1 | 1.2 ± 0.3 | 1.3 ± 0.3 | 29.2 ± 2.2 | 60 |
| **GRID 2D** | | | | | |
| 488-vertical | 0.7 ± 0.1 | 1.2 ± 0.3 | 1.7 ± 0.3 | 33.8 ± 2.3 | 69 |
| 489-horizontal | 0.7 ± 0.1 | 1.2 ± 0.2 | 1.0 ± 0.2 | 22.4 ± 1.8 | 46 |
| **GRID 2E** | | | | | |
| 490-vertical | 0.7 ± 0.1 | 1.3 ± 0.3 | 1.1 ± 0.3 | 20.1 ± 1.9 | 41 |
| 491-horizontal | 0.7 ± 0.1 | 1.1 ± 0.3 | 1.0 ± 0.3 | 20.2 ± 1.4 | 41 |
| **GRID 1 NORTH** | | | | | |
| 492-vertical | 0.5 ± 0.1 | 0.8 ± 0.2 | 0.7 ± 0.2 | 14.7 ± 1.4 | 30 |
| 493-horizontal | 0.5 ± 0.1 | 0.9 ± 0.3 | 0.9 ± 0.3 | 14.7 ± 1.1 | 30 |

## TABLE 3 (Continued)

## RADIONUCLIDE CONCENTRATIONS IN RAILROAD SOIL SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/Sample Number[a] | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|
| | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **GRID 1 SOUTH** | | | | | |
| 494-vertical | 0.7 ± 0.2 | 1.0 ± 0.3 | 0.5 ± 0.2 | 6.7 ± 1.2 | 14 |
| 495-horizontal | 0.6 ± 0.1 | 1.1 ± 0.2 | 0.2 ± 0.2 | 6.2 ± 1.1 | 13 |

[a]Refer to Figure 19.

[b]Total uranium was calculated by multiplying the U-238 concentration by a factor of 2 and adding the U-235 concentration—these results include background.

[c]Uncertainties represent the 95% confidence level, based only on counting statistics.

## TABLE 4

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN BEVERLY HARBOR TIDAL FLAT SOIL/SEDIMENT SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **TIDAL FLATS GRID BLOCKS REMEDIATED BY MORTON DUE TO MERCURY CONTAMINATION (Samples collected @ 30 cm or until original soil was identified)** | | | | | | |
| Grid Block 1/106 | 7 | <0.4 | 0.9 ± 0.3[c] | <0.4 | 1.8 ± 1.2 | <4.0 |
| Grid Block 2/107 | 8 | <0.2 | 0.8 ± 0.2 | <0.3 | 0.9 ± 0.7 | <2.1 |
| Grid Block 4/110 | 10 | <0.2 | 0.7 ± 0.3 | <0.3 | 0.6 ± 0.9 | <1.5 |
| Grid Block 6/111 | 4 | <0.2 | <0.5 | <0.3 | 1.0 ± 1.1 | <2.3 |
| Grid Block 5/112 | 9 | <0.5 | 0.6 ± 0.3 | <0.5 | 2.5 ± 1.2 | <5.5 |
| Grid Block 8/113 | 7 | <0.3 | 0.9± 0.3 | <0.3 | 1.5 ± 1.3 | <3.3 |
| Grid Block 9/114 | 7 | 1.2 ± 0.2 | 0.9 ± 0.3 | <0.4 | 1.5 ± 1.5 | <3.4 |
| Grid Block 10/117 | 8 | 1.2 ± 0.2 | 0.9 ± 0.3 | <0.4 | <1.7 | <3.8 |
| Grid Block 11/118 | NA[d] | <0.4 | 0.7 ± 0.3 | <0.5 | 1.3 ± 1.0 | <3.1 |
| Grid Block 13/115 | 3 | <0.4 | 0.5 ± 0.3 | <0.4 | 1.6 ± 1.1 | <3.6 |
| Grid Block 15/624[e] | 7 | 1.2 ± 0.6 | 0.7 ± 0.3 | <0.4 | 4.0 ± 1.3 | <8.4 |
| Grid Block 16/504 | 7 | 0.6 ± 0.1 | 0.8 ± 0.2 | 0.7 ± 0.2 | 12.0 ± 1.2 | 25 |
| Grid Block 16/623[e] | 8 | 1.2 ± 0.5 | 0.4 ± 0.2 | 1.4 ± 0.3 | 26.7 ± 2.3 | 55 |
| Grid Block 17/503 | 6 | 0.4 ± 0.1 | 0.4 ± 0.1 | 0.3 ± 0.1 | 3.4 ± 0.8 | 7.1 |
| Grid Block 31/119 | 7 | 1.4 ± 0.2 | 1.3 ± 0.3 | <0.4 | 4.1 ± 1.3 | 8.6 |
| Grid Block 33/502 | 7 | 0.7 ± 0.1 | 0.7 ± 0.2 | 0.1 ± 0.1 | 1.2 ± 0.7 | 2.5 |
| Grid Block 34/116 | 6 | <0.3 | 0.7 ± 0.3 | <0.3 | 2.3 ± 1.4 | <4.9 |

## TABLE 4 (Continued)

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN BEVERLY HARBOR TIDAL FLAT SOIL/SEDIMENT SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **GRID BLOCK 2** | | | | | | |
| 2 | 13 | 0.5 ± 0.1 | <0.4 | <0.1 | 0.2 ± 1.0 | <0.5 |
| 3 | 13 | <0.3 | 0.7 ± 0.3 | <0.1 | 1.0 ± 0.7 | <2.1 |
| 4 | 13 | 0.5 ± 0.1 | 0.6 ± 0.2 | <0.1 | 1.2 ± 0.9 | <2.5 |
| 5 | 13 | 0.6 ± 0.2 | 0.6 ± 0.4 | <0.1 | <1.2 | <2.5 |
| 6 | 13 | 0.6 ± 0.1 | 0.7 ± 0.3 | <0.1 | 2.1 ± 1.2 | <4.3 |
| **GRID BLOCK 11** | | | | | | |
| 7 | 11 | 0.5 ± 0.1 | 0.6 ± 0.2 | 0.4 ± 0.1 | 10.7 ± 6.2 | 22 |
| 8 | 11 | <0.2 | 0.7 ± 0.3 | <0.1 | 6.0 ± 1.5 | <12 |
| 9 | 11 | 0.3 ± 0.1 | <0.6 | 0.9 ± 0.1 | 29 ± 11 | 59 |
| 10 | 11 | 0.4 ± 0.1 | 0.6 ± 0.3 | 0.7 ± 0.1 | 11.0 ± 7.2 | 23 |
| 11 | 11 | 0.4 ± 0.1 | 0.4 ± 0.2 | 0.6 ± 0.1 | 14.7 ± 7.8 | 30 |
| 12[f] | 11 | <0.4 | <0.7 | 12.7 ± 0.4 | 388 ± 32 | 790 |
| **GRID BLOCK 17** | | | | | | |
| 13 | 9 | 0.5 ± 0.2 | 0.6 ± 0.3 | <0.1 | 2.6 ± 1.3 | <5.3 |
| 14 | 9 | 0.6 ± 0.2 | 0.7 ± 0.3 | 0.4 ± 0.1 | 10.0 ± 6.4 | 20 |
| 15 | 9 | <0.3 | 0.5 ± 0.3 | <0.1 | 1.4 ± 1.0 | <2.9 |
| 16 | 9 | 0.3 ± 0.2 | <0.7 | <0.1 | 3.4 ± 1.2 | <6.9 |
| 17 | 9 | <0.2 | <0.5 | <0.2 | 3.9 ± 1.1 | <8.0 |

## TABLE 4 (Continued)

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN BEVERLY HARBOR TIDAL FLAT SOIL/SEDIMENT SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **GRID BLOCKS 18-21** | | | | | | |
| 137 | 5 | 0.8 ± 0.2 | 0.9 ± 0.3 | 0.8 ± 0.4 | 5.5 ± 1.4 | 12 |
| 138 | 7 | <0.4 | <0.7 | <0.4 | 1.4 ± 1.3 | <3.2 |
| 139 | 5 | <0.4 | 1.2 ± 0.3 | 0.4 ± 0.3 | 9.7 ± 1.8 | 20 |
| 134 | 5 | <0.3 | 1.2 ± 0.3 | <0.4 | 5.6 ± 1.6 | <12 |
| 136 | 9 | <0.2 | 1.0 ± 0.3 | <0.5 | 3.7 ± 1.2 | <7.9 |
| **GRID BLOCK 20 - INITIAL VERIFICATION SURVEY (9/95)** | | | | | | |
| 23 | 10 | 0.7 ± 0.7 | <0.7 | 2.4 ± 0.2 | 63 ± 13 | 130 |
| 24 | 10 | <0.5 | 1.4 ± 0.6 | 18.9 ± 0.5 | 453 ± 36 | 920 |
| 25 | 10 | 0.6 ± 0.2 | 0.7 ± 0.3 | 0.7 ± 0.1 | 22 ± 12 | 45 |
| 26 | 10 | 0.6 ± 0.1 | 0.8 ± 0.3 | 0.3 ± 0.1 | 4.6 ± 1.2 | 9.5 |
| 27 | 10 | <0.4 | 0.9 ± 0.3 | 10.8 ± 0.3 | 255 ± 25 | 560 |
| **GRID BLOCK 20 - AFTER ADDITIONAL REMEDIAL ACTION (7/96)** | | | | | | |
| 131 | 7 | <0.3 | 0.9 ± 0.3 | <0.4 | 5.8 ± 1.4 | <12 |
| 132 | 5 | <0.3 | 1.2 ± 0.3 | <0.4 | 5.6 ± 1.6 | <12 |
| 133 | 9 | <0.3 | <0.6 | 1.4 ± 0.4 | 20.5 ± 2.0 | 42 |
| 134 | 4 | 0.6 ± 0.2 | 0.9 ± 0.3 | <0.3 | 4.9 ± 1.4 | 10 |
| 135 | 8 | <0.4 | 0.9 ± 0.3 | 1.2 ± 0.5 | 19.8 ± 2.2 | 41 |
| **Average[g]** | 7 | <0.4 | <0.9 | <0.7 | 11.3 | 23 |

## TABLE 4 (Continued)

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN BEVERLY HARBOR TIDAL FLAT SOIL/SEDIMENT SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **GRID BLOCK 20 - FINAL VERIFICATION SURVEY (3/97)** | | | | | | |
| 602[e] | 8 | 0.7 ± 0.1 | 1.0 ± 0.3 | 0.5 ± 0.3 | 9.5 ± 1.4 | 20 |
| 603[e,f] | 8 | 0.8 ± 0.2 | 0.9 ± 0.3 | 0.3 ± 0.3 | <1.8 | <3.9 |
| 621[e] (After additional remediation of Location 603) | 8 | <0.2 | 0.5 ± 0.3 | 0.4 ± 0.3 | 6.4 ± 1.5 | 13 |
| 600[e] | 7 | 0.4 ± 0.1 | 0.8 ± 0.2 | 0.7 ± 0.3 | 17.7 ± 2.0 | 36 |
| 601[e] | 8 | 0.7 ± 0.1 | <0.5 | 0.2 ± 0.2 | 5.2 ± 1.4 | 11 |
| 604[e,f] | 7 | 1.0 ± 0.2 | 0.9 ± 0.3 | 1.2 ± 0.4 | 19.4 ± 2.3 | 40 |
| 620[e] (After additional remediation of Location 604) | 8 | 0.7 ± 0.1 | 0.7 ± 0.3 | 0.5 ± 0.2 | 15.3 ± 1.6 | 31 |
| 605[e] | 6 | 0.8 ± 0.2 | 0.7 ± 0.4 | 0.3 ± 0.3 | 6.2 ± 1.5 | 13 |
| 606[e,f] | 6 | 0.6 ± 0.2 | 1.3 ± 0.4 | 8.1 ± 0.8 | 154.7 ± 9.0 | 320 |
| 622[e] (After additional remediation of Location 606) | 9 | <0.2 | 0.8 ± 0.3 | 1.5 ± 0.4 | 26.5 ± 2.6 | 55 |
| 625[e] (After additional remediation of Location 622) | 7 | 0.6 ± 0.1 | 0.8 ± 0.3 | 2.4 ± 0.5 | 43.1 ± 3.5 | 89 |

## TABLE 4 (Continued)

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN BEVERLY HARBOR TIDAL FLAT SOIL/SEDIMENT SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **GRID BLOCK 20 - FINAL VERIFICATION SURVEY (3/97) (Continued)** | | | | | | |
| 632[e] (bound 625) | 8 | 0.6 ± 0.2 | 0.9 ± 0.4 | 1.1 ± 0.4 | 22.0 ± 2.5 | 45 |
| 633[e] (bound 625) | 8 | 0.7 ± 0.2 | 0.7 ± 0.4 | 0.5 ± 0.3 | 7.6 ± 1.7 | 16 |
| 634[e] (bound 625) | 8 | 0.6 ± 0.1 | 0.8 ± 0.3 | 1.3 ± 0.4 | 21.1 ± 2.2 | 44 |
| 607[e] | 10 | 0.8 ± 0.2 | 2.8 ± 0.5 | 1.5 ± 0.4 | 30.3 ± 3.1 | 62 |
| 626[e] | 7 | 0.8 ± 0.1 | 1.2 ± 0.3 | 0.7 ± 0.3 | 10.9 ± 1.6 | 23 |
| **Average[e,g]** | 10 | <0.6 | <0.9 | 0.9 | 17.7 | 36 |
| **GRID BLOCK 27** | | | | | | |
| 18 | NA | 0.5 ± 0.1 | 0.8 ± 0.2 | <0.1 | 1.7 ± 0.9 | <3.5 |
| 19 | NA | 0.6 ± 0.2 | 0.7 ± 0.3 | <0.1 | 0.6 ± 0.8 | <1.3 |
| 20 | NA | 0.6 ± 0.1 | 0.6 ± 0.3 | <0.1 | 3.1 ± 1.3 | <6.3 |
| 21 | NA | 0.4 ± 0.1 | 0.8 ± 0.2 | 0.1 ± 0.1 | 2.1 ± 0.9 | 4.3 |
| 22 | NA | 0.4 ± 0.1 | <0.6 | 0.1 ± 0.1 | 2.1 ± 0.9 | 4.3 |
| **GRID BLOCK 28** | | | | | | |
| 149 | 7 | <0.2 | 0.6 ± 0.3 | 0.7 ± 0.3 | 15.6 ± 2.1 | 32 |
| 152 | 5 | <0.3 | 0.8 ± 0.3 | <0.4 | 6.7 ± 1.9 | <14 |
| 150 | 6 | <0.4 | 0.9 ± 0.3 | <0.5 | 4.1 ± 1.6 | <8.7 |
| 143 | NA | <0.2 | 0.7 ± 0.3 | 0.4 ± 0.3 | 6.8 ± 2.0 | 14 |
| 151 | 5 | 0.7 ± 0.2 | 1.0 ± 0.3 | 0.5 ± 0.3 | 13.2 ± 1. | 27 |

## TABLE 4 (Continued)

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN BEVERLY HARBOR TIDAL FLAT SOIL/SEDIMENT SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **GRID BLOCK 29 - INITIAL VERIFICATION ACTIVITIES (7/96)** | | | | | | |
| 148 | 7 | 0.6 ± 0.1 | 0.9 ± 0.3 | 0.4 ± 0.3 | 9.5 ± 1.8 | 19 |
| 141 | 6 | <0.2 | 0.9 ± 0.3 | 1.2 ± 0.4 | 25.9 ± 2.6 | 53 |
| 144 | 5 | <0.2 | 0.9 ± 0.3 | 0.9 ± 0.4 | 16.0 ± 2.1 | 33 |
| 142 | NA | 0.7 ± 0.2 | 0.8 ± 0.3 | 0.4 ± 0.3 | 7.1 ± 1.4 | 15 |
| 140 | 5 | <0.2 | 1.0 ± 0.3 | 0.8 ± 0.3 | 15.4 ± 2.1 | 32 |
| 145 - West | NA | 13.8 ± 1.4 | 0.8 ± 0.3 | 1.0 ± 0.3 | 20.0 ± 2.3 | 40 |
| 146 - Middle | NA | 21.5 ± 1.5 | 0.9 ± 0.3 | 1.6 ± 0.4 | 28.1 ± 2.4 | 58 |
| 147 - East | NA | 15.9 ± 1.5 | 0.8 ± 0.3 | 1.0 ± 0.4 | 20.8 ± 2.1 | 43 |
| **GRID BLOCK 29 - FINAL VERIFICATION ACTIVITIES (3/97)** | | | | | | |
| 617[e] | 8 | 0.7 ± 0.1 | 0.8 ± 0.2 | 0.6 ± 0.3 | 14.4 ± 1.7 | 29 |
| 618[e] | 8 | 0.5 ± 0.2 | 1.0 ± 0.3 | 1.2 ± 0.4 | 25.1 ± 2.7 | 51 |
| 614[e] | 8 | 1.2 ± 0.2 | 0.9 ± 0.2 | 0.2 ± 0.2 | 3.5 ± 1.2 | 7.2 |
| 615[e] | 9 | 1.2 ± 0.2 | 0.8 ± 0.3 | <0.3 | 2.9 ± 1.4 | <6.1 |
| 616[e] | 9 | 1.2 ± 0.2 | 0.8 ± 0.3 | <0.3 | 2.0 ± 1.0 | <4.3 |
| 619[e,h] | 10 | 0.5 ± 0.2 | 0.7 ± 0.3 | 5.6 ± 0.7 | 109.1 ± 7.3 | 220 |
| **Average[e,g]** | 9 | 1.1 | 0.8 | <1.4 | 26.2 | <54 |
| **GRID BLOCK 30 - INITIAL VERIFICATION ACTIVITIES (7/96)** | | | | | | |
| 120 | 9 | 1.5 ± 0.2 | 0.9 ± 0.3 | <0.4 | 1.5 ± 1.4 | <3.4 |
| 121 | 9 | 1.6 ± 0.2 | 0.7 ± 0.2 | <0.5 | 2.6 ± 1.6 | <5.7 |
| 122 | 9 | 1.5 ± 0.2 | 1.0 ± 0.2 | <0.4 | 4.4 ± 1.4 | <9.2 |

## TABLE 4 (Continued)

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN BEVERLY HARBOR TIDAL FLAT SOIL/SEDIMENT SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **GRID BLOCK 30 - INITIAL VERIFICATION ACTIVITIES (7/96) (Continued)** | | | | | | |
| 123 | 9 | 1.3 ± 0.3 | 1.0 ± 0.3 | <0.4 | 3.6 ± 2.0 | <7.6 |
| 124 | 9 | 1.0 ± 0.3 | 2.5 ± 0.5 | 13.9 ± 1.3 | 247.7 ± 7.0 | 510 |
| **GRID BLOCK 30 - FINAL VERIFICATION ACTIVITIES (11/96)** | | | | | | |
| 428 | 10 | 1.9 ± 0.2 | 0.9 ± 0.3 | <0.4 | 2.9 ± 1.0 | <6.2 |
| 429 | 9 | 1.1 ± 0.1 | 0.7 ± 0.2 | 0.4 ± 0.2 | 5.0 ± 1.3 | 10 |
| 430 | 10 | 2.0 ± 0.2 | 1.0 ± 0.2 | <0.3 | 2.0 ± 1.2 | <4.3 |
| 431 | 9 | 1.6 ± 0.2 | 0.7 ± 0.3 | <0.4 | 3.4 ± 1.0 | <7.2 |
| 432 | 11 | 1.5 ± 0.1 | 0.9 ± 0.2 | 0.3 ± 0.2 | 2.2 ± 1.4 | 4.7 |
| **GRID BLOCK 31 - INITIAL VERIFICATION ACTIVITIES (9/95)** | | | | | | |
| 28 | NA | 0.7 ± 0.2 | 1.6 ± 0.4 | 1.6 ± 0.1 | 30 ± 10 | 62 |
| 29 | NA | <0.3 | 1.0 ± 0.4 | 2.4 ± 0.1 | 64 ± 11 | 130 |
| 30 | NA | <0.4 | <0.8 | 0.3 ± 0.1 | <14 | <28 |
| 31 | NA | 0.5 ± 0.2 | 0.2 ± 0.3 | <0.1 | <12 | <24 |
| 32 | NA | 0.7 ± 0.1 | 0.8 ± 0.3 | 0.8 ± 0.1 | 21 ± 12 | 43 |
| **GRID BLOCK 31 - FINAL VERIFICATION ACTIVITIES (9/96)** | | | | | | |
| 328 | 9 | 1.1 ± 0.2 | <0.5 | 0.4 ± 0.3 | 4.3 ± 1.1 | 9.0 |
| 329 | 10 | 2.0 ± 0.2 | 0.9 ± 0.2 | <0.3 | 2.6 ± 1.1 | <5.5 |
| 330 | 11 | 1.6 ± 0.2 | 1.2 ± 0.3 | <0.3 | 3.5 ± 1.2 | <7.3 |
| 331 | 9 | 1.3 ± 0.1 | 0.7 ± 0.2 | <0.3 | 2.5 ± 1.0 | <5.3 |
| 332 | 10 | 1.4 ± 0.1 | 1.0 ± 0.2 | <0.3 | 5.6 ± 1.2 | <12 |

## TABLE 4 (Continued)

## EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN BEVERLY HARBOR TIDAL FLAT SOIL/SEDIMENT SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location/ Sample Number[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **GRID BLOCK 32 - (9/95)** | | | | | | |
| 37[f] | NA | <0.4 | 1.0 ± 0.4 | 13.2 ± 0.3 | 412 ± 28 | 840 |
| 38[f] | NA | 0.7 ± 0.2 | 1.0 ± 0.3 | 5.0 ± 0.2 | 134 ± 16 | 270 |
| 39[f] | NA | <0.3 | 0.9 ± 0.3 | 0.6 ± 0.1 | 18.1 ± 6.1 | 37 |
| 40[f] | NA | 0.5 ± 0.2 | 1.6 ± 0.4 | 5.4 ± 0.2 | 160 ± 20 | 330 |
| 41[f] | NA | 0.5 ± 0.1 | 0.9 ± 0.2 | 0.2 ± 0.1 | 3.8 ± 1.1 | 7.8 |
| **GRID BLOCK 44** | | | | | | |
| 125 | 6 | <0.5 | 1.0 ± 0.3 | <0.5 | 1.5 ± 1.3 | <3.5 |
| 126 | 8 | 0.9 ± 0.2 | 0.7 ± 0.3 | <0.5 | 3.0 ± 1.2 | <6.5 |
| **GRID BLOCK 45** | | | | | | |
| 127 | 7 | 1.1 ± 0.2 | 0.8 ± 0.3 | <0.3 | 2.3 ± 1.2 | <4.9 |
| 128 | 7 | 1.0 ± 0.1 | 0.8 ± 0.3 | <0.4 | 2.3 ± 1.6 | <5.0 |
| **GRID BLOCK 46** | | | | | | |
| 129 | 7 | 3.3 ± 1.0 | 0.9 ± 0.5 | <0.5 | 3.3 ± 1.6 | <7.1 |
| 130 | 4 | 3.1 ± 1.2 | <0.5 | <0.4 | 3.3 ± 1.3 | <7.0 |

[a]Refer to Figures 20 through 22.

[b]Total uranium was calculated by multiplying the U-238 concentration by a factor of 2 and adding the U-235 concentration—these results include background.

[c]Uncertainties represent the 95% confidence level, based only on counting statistics.

[d]NA = Measurement not performed.

[e]A non-conformance was identified in the chain-of-custody procedures for these samples. Although there was no evidence of sample tampering, the data presented here should only be used for qualitative purposes.

[f]BNI remediated this grid block/sample location. Post-RA scans did not detect any areas of elevated direct radiation.

[g]Average value does not include the initial samples at locations that were subsequently remediated.

[h]Post-RA sample result for Sea Wall Soil Samples are in Table 5. The post-RA result for Grid Block 29 is listed as Sea Wall Location Number 18.

## TABLE 5

## ANALYTICAL COMPARISON DATA FOR POST-RA VENTRON SEA WALL SOIL SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| BNI Sample Number[a] | Sea Wall Location Number | Radionuclide Concentrations (pCi/g) | | | | | |
|---|---|---|---|---|---|---|---|
| | | BNI Results | | | ESSAP Results | | |
| | | Ra-226 | Th-232 | U-238 | Ra-226 | Th-232 | U-238 |
| **BNI SAMPLES ANALYZED BY OAK RIDGE LAB[b]** | | | | | | | |
| 127RS285 | 1 | 0.40 | 0.79 | 12.3 | 0.6 ± 0.1[c] | 1.0 ± 0.2 | 22.1 ± 1.6 |
| 127RS296 | 2 | 0.86 | 1.16 | 25.89 | 0.7 ± 0.1 | 1.3 ± 0.2 | 37.9 ± 2.4 |
| 127RS294 | 3 | 0.52 | 0.59 | 29.31 | 0.5 ± 0.1 | 0.8 ± 0.2 | 51.1 ± 2.7 |
| 127RS300 | 4 | 1.3 | <0.96 | 24.9 | 1.3 ± 0.1 | 1.2 ± 0.2 | 32.2 ± 2.2 |
| 127RS303 | 5 | 0.77 | 0.84 | 15.6 | 0.8 ± 0.1 | 0.9 ± 0.2 | 21.8 ± 1.6 |
| 127RS306 | 6 | 1.9 | <1.1 | 27.9 | 1.6 ± 0.2 | 1.1 ± 0.3 | 25.4 ± 1.8 |
| 127RS309 | 7 | 0.77 | <0.94 | 38.1 | 0.8 ± 0.1 | 1.2 ± 0.2 | 56.8 ± 3.3 |
| 127RS312 | 8 | <0.77 | <1.2 | 18.7 | 0.8 ± 0.2 | 1.0 ± 0.3 | 16.8 ± 1.3 |
| 127RS315 | 9 | 0.45 | 0.55 | 23.6 | 0.5 ± 0.1 | 0.9 ± 0.2 | 41.8 ± 2.3 |
| 127RS318 | 10 | 0.58 | <0.62 | 11.5 | 1.0 ± 0.1 | 0.9 ± 0.2 | 21.5 ± 1.5 |
| 127RS320 | 11 | 0.45 | 0.72 | 12.8 | 0.6 ± 0.1 | 1.0 ± 0.2 | 19.6 ± 1.4 |
| 127RS324 | 12 | 0.5 | <0.64 | 25.9 | 0.5 ± 0.1 | 0.7 ± 0.2 | 39.0 ± 2.3 |
| 127RS327 | 13 | 0.42 | 0.65 | 24.2 | 0.4 ± 0.1 | 0.7 ± 0.2 | 38.5 ± 2.3 |
| **BNI SAMPLES ANALYZED BY WAYNE LAB[d]** | | | | | | | |
| 127RS414 | 14 | 0.53 | 0.75 | 36.9 | <0.2 | 0.7 ± 0.2 | 33.9 ± 2.4 |
| 127RS336 | 15 | 0.64 | 0.97 | 28.9 | 0.6 ± 0.1 | 0.9 ± 0.2 | 27.6 ± 1.7 |
| 127RS334 | 16 | 0.89 | 0.9 | 22.5 | 0.8 ± 0.1 | 0.8 ± 0.3 | 26.2 ± 2.2 |

## TABLE 5 (continued)

## ANALYTICAL COMPARISON DATA FOR POST-RA VENTRON SEA WALL SOIL SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| BNI Sample Number[a] | Sea Wall Location Number | Radionuclide Concentrations (pCi/g) | | | | | |
|---|---|---|---|---|---|---|---|
| | | BNI Results | | | ESSAP Results | | |
| | | Ra-226 | Th-232 | U-238 | Ra-226 | Th-232 | U-238 |
| **BNI SAMPLES ANALYZED BY WAYNE LAB[d] (Continued)** | | | | | | | |
| 127RS460 | 17 | 0.59 | 0.52 | 4.75 | 0.6 ± 0.1 | 0.7 ± 0.2 | 5.9 ± 0.8 |
| 127RS464 | 18 | 0.57 | 0.76 | 18.8 | 0.7 ± 0.1 | 1.0 ± 0.2 | 23.2 ± 1.6 |
| 127RS477 | 19 | 0.54 | 0.73 | 3.78 | 0.6 ± 0.1 | 0.8 ± 0.2 | 4.0 ± 0.8 |
| 127RS518 | 20 | 0.64 | 0.88 | 6.98 | 0.6 ± 0.1 | 0.9 ± 0.2 | 5.2 ± 0.8 |

[a]Sample numbers assigned by BNI.

[b]Samples analyzed by the BNI contractor laboratory in Oak Ridge, Tennessee. These BNI sample results were not in agreement with the ESSAP sample results for the same samples.

[c]Uncertainties represent the 95% confidence level, based only on counting statistics.

[d]Samples analyzed by the BNI contractor laboratory located at their Wayne, New Jersey facility. These BNI sample results were in good agreement with the ESSAP sample results for the same samples.

## TABLE 6

## BACKGROUND EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES VENTRON SITE BEVERLY, MASSACHUSETTS

| Location[a] | Exposure Rate (μR/h) | Radionuclide Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|
| | | Ra-226 | Th-232 | U-235 | U-238 | Total Uranium[b] |
| **BACKGROUND SAMPLES** | | | | | | |
| Carver Street | 8 | 1.0 ± 0.2[c] | 0.9 ± 0.3 | <0.4 | 1.6 ± 1.3 | <3.0 |
| Ayer Ryal-Side School | 9 | 0.7 ± 0.2 | 0.7 ± 0.3 | <0.4 | 0.8 ± 1.2 | <2.0 |
| Gillis Park | 8 | 0.8 ± 0.1 | 0.7 ± 0.2 | <0.3 | 1.5 ± 1.0 | <2.7 |
| Stone Street Playground | 12 | 1.0 ± 0.2 | 0.7 ± 0.3 | <0.3 | 1.4 ± 1.0 | <3.1 |
| **Background Average** | 9 | 0.9 | 0.8 | <0.4 | 1.2 | <2.7 |

[a]Refer to Figure 23.

[b]Total uranium was calculated by multiplying the U-238 concentration by a factor of 2 and adding the U-235 concentration.

[c]Uncertainties represent the 95% confidence level, based only on counting statistics.

## REFERENCES


Bechtel National, Inc. (BNI). Field Sampling Plan for the Ventron Site, Beverly, Massachusetts. Oak Ridge, Tennessee; 1991.

Bechtel National, Inc. Post-Remedial Action Survey Plan for the Ventron Harbor. Oak Ridge, Tennessee; August 1995.

Bechtel National, Inc. FUSRAP Technical Bulletin No: 127-96-002; RE: Information Obtained During Remedial Action of Beverly Harbor. Oak Ridge, Tennessee; January 2, 1996a.

Bechtel National, Inc. Post-Remedial Action Survey Plan (PRASP). Oak Ridge, Tennessee; May 1996b.

Bechtel National, Inc. Letter from M. Redmon (BNI) to J. Kopotic (DOE-ORO), RE: Ventron Site - Bechtel Evaluation Regarding the Status of Remedial Action Efforts at the Ventron Site. Oak Ridge, Tennessee; April 29, 1997a.

Bechtel National, Inc. Memorandum from M. Redmon (BNI) to J. Kopotic (DOE-FSRD), RE: Sampling plan to resolve outstanding issues at the Ventron site, Oak Ridge. Tennessee; June 26, 1997b.

Bechtel National, Inc. FUSRAP Technical Bulletin, RE: Additional Sampling at Ventron Site in July 1997. Oak Ridge, Tennessee; August 5, 1997c.

Bechtel National, Inc. Post-Remedial Action Report for the Remedial Action at the Ventron Site, Beverly, Massachusetts. Predecisional Draft. Oak Ridge, Tennessee; September 1997d.

Bechtel National, Inc. Post-Remedial Action Report for the Remedial Action at the Ventron Site, Beverly, Massachusetts. Final Draft. Oak Ridge, Tennessee; November 2001a.

Bechtel National, Inc. Letter from D. Methot (BNI) to R. Atkin (DOE-ORO), RE: Ventron Site - Request for Approval to Publish Post-Remedial Action Report. Oak Ridge, Tennessee; November 28, 2001b.

Oak Ridge Institute for Science and Education (ORISE). Letter from M. Landis (ORISE) to R. Robertson (BNI/OR), RE: Comments on First Draft of the "Field Sampling Plan for the Ventron Site, Beverly, Massachusetts." Oak Ridge, Tennessee; March 27, 1991.

Oak Ridge Institute for Science and Education. Letter from W. Adams (ORISE) to R. Kennedy (DOE-FUSRAP), RE: Contract DE-AC05-91OR21950 - Review of Characterization Report for Ventron Site. Oak Ridge, Tennessee; April 8, 1992.

Oak Ridge Institute for Science and Education. Letter from T. Vitkus (ORISE) to J. Kopotic (DOE-FSRD) RE: Comments on the Ventron Characterization Report - Second Draft. Oak Ridge, Tennessee; December 20, 1994.

## REFERENCES (Continued)

Oak Ridge Institute for Science and Education. Verification Survey Plan for the Ventron Harbor Tidal Flats - Beverly, Massachusetts. Oak Ridge, Tennessee; September 19, 1995a.

Oak Ridge Institute for Science and Education. Survey Procedures Manual for the Energy/Environment Systems Division, Environmental Survey and Site Assessment Program, Revision 9. Oak Ridge, Tennessee; April 30, 1995b.

Oak Ridge Institute for Science and Education. Quality Assurance Manual for the Energy/Environment Systems Division, Environmental Survey and Site Assessment Program, Revision 9. Oak Ridge, Tennessee; January 31, 1995c.

Oak Ridge Institute for Science and Education. Draft - Preliminary Report for the Verification Survey of the Beverly Harbor at the Ventron Site in Beverly, Massachusetts. Oak Ridge, Tennessee; November 6, 1995d.

Oak Ridge Institute for Science and Education. Laboratory Procedures Manual for the Energy/Environment Systems Division, Environmental Survey and Site Assessment Program, Revision 9. Oak Ridge, Tennessee; January 31, 1995e.

Oak Ridge Institute for Science and Education. Letter from W. Adams (ORISE) to J. Kopotic (DOE-FSRD) RE: Comments on the FUSRAP Post - Remedial Action Survey Plan for the Ventron Harbor. Oak Ridge, Tennessee; September 14, 1995f.

Oak Ridge Institute for Science and Education. Proposed - Verification Survey Plan for the Ventron Facility - Beverly, Massachusetts. Oak Ridge, Tennessee; July 19, 1996a.

Oak Ridge Institute for Science and Education. Verification Survey Plan for the Ventron Facility - Beverly, Massachusetts. Oak Ridge, Tennessee; July 22, 1996b.

Oak Ridge Institute for Science and Education. Letter from T. Vitkus (ORISE) to J. Woods (BNI), RE: Comments on the FUSRAP Post - Remedial Action Survey Plan (PRASP). Oak Ridge, Tennessee; May 9, 1996c.

Oak Ridge Institute for Science and Education. Letter from W. Adams (ORISE) to J. Kopotic (DOE - FSRD), RE: Concerns for the Successful Remediation of the Ventron Site. Oak Ridge, Tennessee; March 27, 1997a.

Oak Ridge Institute for Science and Education. Electronic-mail from T. Vitkus (ORISE) to M. Redmon (BNI), RE: Review of Sampling Plan to Resolve Outstanding Issues at the Ventron Site. Oak Ridge, Tennessee; July 9, 1997b.

Oak Ridge Institute for Science and Education. Electronic-mail from T. Vitkus (ORISE) to M. Redmon (BNI), RE: Ventron Verification. Oak Ridge, Tennessee; August 8, 1997c.

## REFERENCES (Continued)

Oak Ridge Institute for Science and Education. Letter from W. Adams (ORISE) to M. Otis (U.S. ACE), RE: Comments on the Post-Remedial Action Report for the Remedial Action at the Ventron Site, Beverly, Massachusetts. Oak Ridge, Tennessee; December 2, 1997d.

Oak Ridge National Laboratory (ORNL). Radiological Survey Results at Beverly Harbor, Beverly, Massachusetts (VB025). ORNL/RASA-91/29. Oak Ridge, Tennessee; August 1992.

Science Applications International Corporation (SAIC). Ventron Corporation Historical File Review. Oak Ridge, Tennessee; September 19, 1995.

U.S. Department of Energy (DOE). Radiation Protection of the Public and the Environment. Washington, DC: DOE Order 5400.5; February 1990.

U.S. Department of Energy. Ventron Characterization Plan - Beverly, Massachusetts. DOE/OR/21950-123. Oak Ridge, Tennessee; August 1992.

U.S. Department of Energy. Memorandum from J. Wagoner (DOE-HQ) to L. Price (DOE-ORO), RE: Uranium Guidelines for the Ventron Site, Beverly, Massachusetts. Germantown, Maryland; September 1, 1993.

U.S. Department of Energy. Characterization Report for the Ventron Site - Beverly, Massachusetts. DOE/OR/21950-1011. Oak Ridge, Tennessee; December 1995a.

U.S. Department of Energy. Letter from A. Williams (DOE-HQ) to W. Adams (ORISE), RE: Comments on "Draft Verification Survey Plan for the Ventron Harbor Tidal Flats, Beverly, Massachusetts" Draft dated September 19, 1995. Germantown, Maryland; September 27, 1995b.

U. S. Department of Energy. Ventron Site - Memorandum of Agreement. Department of Energy, Oak Ridge Operations Office. Oak Ridge, Tennessee; May 9, 1996a.

U. S. Department of Energy. Letter from Alexander Williams (DOE-HQ) to Paul Goldberg (NRC). Germantown, Maryland; May 29, 1996b.

U.S. Department of Energy. Letter from A. Williams (DOE-HQ) to W. Adams (ORISE), RE: Comments on "Proposed - Verification Survey Plan for the Ventron Facility, Beverly, Massachusetts" Draft dated July 19, 1996. Germantown, Maryland; July 22, 1996c.

U.S. Department of Energy. Letter from A. Johnson (DOE-HQ) to W. Seay (DOE-ORO), RE: Resolution of Open Issues at Ventron Site, Beverly, Massachusetts. Germantown, Maryland; June 6, 1997.

# APPENDIX A

# MAJOR INSTRUMENTATION

The display of a specific product is not to be construed as an endorsement of the product or its manufacturer by the author or his employers.

## DIRECT RADIATION MEASUREMENT

### Instruments

Eberline Pulse Ratemeter
Model PRM-6
(Eberline, Santa Fe, NM)

Ludlum Ratemeter-Scaler
Model 2221
(Ludlum Measurements, Inc., Sweetwater, TX)

### Detectors

Bicron NaI Scintillation Detector
Model G5 "Fidler"
(Bicron Corporation, Newburg, OH)

Bicron Micro-Rem Meter
(Bicron Corporation, Newburg, OH)

Eberline GM Detector
Model HP-260
Physical Probe Area, 20 $cm^2$
(Eberline, Sante Fe, NM)

Victoreen NaI Scintillation Detector
Model 489-55
3.2 cm x 3.8 cm Crystal
(Victoreen, Cleveland, OH)

## LABORATORY ANALYTICAL INSTRUMENTATION

High-Purity Extended Range Intrinsic Detectors
Model No: ERVDS 30-25195
(Tennelec, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-11
(Nuclear Lead, Oak Ridge, TN) and
Multichannel Analyzer
3100 Vax Workstation
(Canberra, Meriden, CT)

High-Purity Extended Range Intrinsic Detectors
Model No: GMX-45200-5
(EG&G ORTEC, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model SPG-16-K8
(Nuclear Data, Meriden, CT) and
Multichannel Analyzer
3100 Vax Workstation
(Canberra, Meriden, CT)

High-Purity Germanium Detector
Model No: GMX-23195-S
(EG&G ORTEC, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-16
(Gamma Products, Palos Hills, IL) and
Multichannel Analyzer
3100 Vax Workstation
(Canberra, Meriden, CT)

Low-Background Gas Proportional Counter
Model LB-5100-W
(Oxford, Oak Ridge, TN)

# APPENDIX B

# SURVEY AND ANALYTICAL PROCEDURES

# APPENDIX B
# SURVEY AND ANALYTICAL PROCEDURES

## SURVEY PROCEDURES

### Surface Scans

Surface scans were performed by passing the detectors slowly over the surface; the distance between the detector and the surface was maintained at a minimum—nominally about 1 cm for beta scans and 10 cm for gamma scans. The paved surfaces were scanned using small area (20 $cm^2$) hand-held detectors. Identification of elevated levels was based on increases in the audible signal from the recording and/or indicating instrument. Combinations of detectors and instruments used for the scans were:

| | | |
|---|---|---|
| Beta-Gamma | - | GM detector with ratemeter-scaler |
| Gamma | - | NaI scintillation detector with ratemeter |
| Gamma | - | FIDLER detector with ratemeter-scaler |

### Surface Activity Measurements

Measurements of total beta activity levels were performed using GM detectors coupled with portable ratemeter-scalers. Count rates in counts per minute (cpm), which were integrated over one minute in a static position, were converted to activity levels in disintegrations per minute per 100 square centimeters (dpm/100 $cm^2$) by dividing the net rate by the 4 $\pi$ efficiency and correcting for the physical area of the detector. The beta activity background count rate for the GM detectors was 53 cpm. Net count rates were determined by subtracting the background from the gross count rate for each measurement location. Beta efficiency factors ranged from 0.23 to 0.24 for GM detectors calibrated to T1-204. The beta minimum detectable concentrations (MDC) for the GM detectors ranged from 763 to 788 dpm/100 $cm^2$. The physical window area for the GM detectors was 20 $cm^2$.

## Exposure Rate Measurements

Measurements of dose equivalent rates in microrem per hour (μrem/h) were performed at one meter above the surface using a Bicron microrem meter. Although the instrument displays data in μrem/h, the μrem/h to microroentgen per hour (μR/h) conversion is essentially unity.

## Soil Sampling

Approximately 1 kg of soil was collected at each sample location. Collected samples were placed in a plastic bag, sealed, and labeled in accordance with ESSAP survey procedures.

# ANALYTICAL PROCEDURES

## Gamma Spectrometry

Soil samples were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in a 0.5-liter Marinelli beaker or other appropriate container. The quantity placed in the beaker was chosen to reproduce the calibrated counting geometry. Net material weights were determined and the samples counted using intrinsic germanium detectors coupled to a pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system.

All photopeaks associated with the radionuclides of concern were reviewed for consistency of activity. Energy peaks used for determining the activities of radionuclides of concerns were:

| | |
|---|---|
| Ra-226 | 0.351 MeV from Pb-214* |
| Th-232 | 0.911 MeV from Ac-228* |
| U-235 | 0.143 MeV |
| U-238 | 0.063 MeV from Th-234* |

*Secular equilibrium assumed.
Spectra were also reviewed for other identifiable photopeaks.

## UNCERTAINTIES AND DETECTION LIMITS

The uncertainties associated with the analytical data presented in the table of this report represent the 95% confidence level for that data. These uncertainties were calculated based on both the gross sample count levels and the associated background count levels. Additional uncertainties, associated with sampling and measurement procedures, have not been propagated into the data presented in this report.

Detection limits, referred to as minimum detectable concentration (MDC), were based on 2.71 plus 4.65 times the standard deviation of the background count [$2.71 + 4.65\sqrt{BKG}$]. When the activity was determined to be less than the MDC of the measurement procedure, the result was reported as less than MDC. Because of variations in background levels, measurement efficiencies, and contributions from other radionuclides in samples, the detection limits differ from sample to sample and instrument to instrument.

## CALIBRATION AND QUALITY ASSURANCE

Calibration of all field and laboratory instrumentation was based on standards/sources, traceable to NIST, when such standard/sources were available. In cases where they were not available, standards of an industry-recognized organization were used.

Analytical and field survey activities were conducted in accordance with procedures from the following documents of the Environmental Survey and Site Assessment Program:

- Survey Procedures Manual, Revision 9 (April 1995)
- Laboratory Procedures Manual, Revision 9 (January 1995)
- Quality Assurance Manual, Revision 7 (January 1995)

The procedures contained in these manuals were developed to meet the requirements of DOE Order 5700.6C and ASME NQA-1 for Quality Assurance and contain measures to assess processes during their performance.

Quality control procedures include:

- Daily instrument background and check-source measurements to confirm that equipment operation is within acceptable statistical fluctuations.
- Participation in EPA and EML laboratory Quality Assurance Programs.
- Training and certification of all individuals performing procedures.
- Periodic internal and external audits.

# APPENDIX C

# RESIDUAL RADIOACTIVE MATERIAL GUIDELINES SUMMARIZED FROM DOE ORDER 5400.5

# APPENDIX C

## RESIDUAL RADIOACTIVE MATERIAL GUIDELINES SUMMARIZED FROM DOE ORDER 5400.5 (DOE 1990)

### BASIC DOSE LIMITS

The basic limit for the annual radiation dose (excluding radon) received by an individual member of the general public is 100 mrem/yr. In implementing this limit, DOE applies as low as reasonable achievable principles to set site-specific guidelines (DOE 1987).

### STRUCTURE GUIDELINES

#### INDOOR/OUTDOOR STRUCTURE SURFACE CONTAMINATION

| | **Allowable Total Residual Surface Contamination** (dpm/100 cm$^2$)[b] | | |
|---|---|---|---|
| Radionuclides[a] | Average[c,d] | Maximum[d,e] | Removable[f] |
| Transuranics, Ra-226, Ra-228, Th-230 Th-228, Pa-231, Ac-227, I-125, I-129[g] | 100 | 300 | 20 |
| Th-Natural, Th-232, Sr-90 (separated or enriched), Ra-223, Ra-224, U-232, I-126, I-131, I-133[h] | 1,000 | 3,000 | 200 |
| U-Natural, U-235, U-238, and associated decay products | 5,000α | 15,000α | 1,000α |
| Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) including Sr-90 as mixed fission product and others noted above[h] | 5,000β-γ | 15,000β-γ | 1,000β-γ |

#### EXTERNAL GAMMA RADIATION

The average level of gamma radiation inside a building or habitable structure on a site that has no radiological restriction on its use shall not exceed the background level by more than 20 μR/h and will comply with the basic dose limits when an appropriate-use scenario is considered.

## SOIL GUIDELINES

| Radionuclides | Soil Concentration (pCi/g) Above Background[i,j,k] |
|---|---|
| Radium-226<br>Radium-228<br>Thorium-230<br>Thorium-232 | 5 pCi/g when averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over any 15-cm-thick soil layer below the surface layer. |
| Uranium-238 | A site-specific guideline of 50 pCi/g was established using the DOE manual developed for this use. |

[a] Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

[b] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contamination should not be averaged over an area of more than 1 $m^2$. For objects of less surface area, the average should be derived for each such object.

[d] The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at a depth of 1 cm.

[e] The maximum contamination level applies to an area of not more than 100 $cm^2$.

[f] The amount of removable radioactive material per 100 $cm^2$ of surface area should be determined by wiping an area of that size with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 $cm^2$ is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels, if direct scan surveys indicate that total residual surface contamination levels are within the limits for removable contamination.

[g] Guidelines for these radionuclides are not given in DOE Order 5400.5; however, these guidelines are considered applicable until guidance is provided.

[h] This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90, which has been separated from the other fission products, or mixtures where the Sr-90 has been enriched.

[i] These guidelines take into account ingrowth of radium-226 from thorium-230 or thorium-232 and radium-228 and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that (1) the dose for the mixtures will not exceed the basic dose limit, or (2) the sum of ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed 1 ("unity").

[j] These guidelines represent allowable residual concentrations above background averaged across any 15-cm-thick layer to any depth and over any contiguous 100 $m^2$ surface area.

[k] If the average concentration in any surface or below-surface area, less than or equal to 25 $m^2$, exceeds the authorized limit of guideline by a factor of $(100/A)^{1/2}$, where A is the area or the elevated region in square meters, limits for "hot spots" shall also be applicable. Procedures for calculating these hot spot limits, which depend on the extent of the elevated local concentrations, are given in the DOE Manual for Implementing Residual Radioactive Materials Guidelines, DOE/CH/8901 (ANL 1989). In addition, every reasonable effort shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit for soil, irrespective of the average concentration in the soil.

## REFERENCES

Argonne National Laboratory (ANL). "A Manual for Implementing Residual Radioactive Material Guidelines", DOE/CH/8901, June 1989.

U.S. Department of Energy. Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites, Revision 2. Washington, DC March 1987.

U. S. Department of Energy (DOE). Radiation Protection of the Public and the Environment. Washington, DC: DOE Order 5400.5; February 8, 1990.

# CHARACTERIZATION OF RADIATION DOSE AND RISK FOLLOWING REMEDIATION OF THE VENTRON SITE

December 1997

Prepared by

U.S. Army Corps of Engineers
Formerly Utilized Sites Remedial Action Program

with technical assistance from

Argonne National Laboratory
Environmental Assessment Division

# CHARACTERIZATION OF RADIATION DOSE AND RISK FOLLOWING REMEDIATION OF THE VENTRON SITE

December 1997

Prepared by

U.S. Army Corps of Engineers
Formerly Utilized Sites Remedial Action Program

with technical assistance from

Argonne National Laboratory
Environmental Assessment Division

## CONTENTS


| | | Page |
|---|---|---|
| EXECUTIVE SUMMARY | | v |
| 1 | INTRODUCTION AND BACKGROUND | 1 |
| 2 | HAZARD IDENTIFICATION | 3 |
| 3 | DOSE-RESPONSE ASSESSMENT | 7 |
| 4 | EXPOSURE ASSESSMENT | 10 |
| 5 | DOSE AND RISK CHARACTERIZATION | 13 |
| 6 | UNCERTAINTY | 16 |
| 7 | CONCLUSIONS | 17 |
| 8 | REFERENCES | 18 |
| APPENDIX A: POST-REMEDIATION RADIONUCLIDE SAMPLING RESULTS | | A-1 |
| APPENDIX B: INPUT PARAMETERS FOR THE RESRAD ANALYSIS | | B-1 |
| APPENDIX C: RESRAD SUMMARY OUTPUT | | C-1 |
| APPENDIX D: NON-CANCER RISK CALCULATIONS | | D-1 |

## FIGURES


| | | Page |
|---|---|---|
| 1 | Ventron Site Location | 2 |
| 2 | Ventron Site Plan | 4 |
| 3 | Ventron Site Excavation Locations | 8 |
| 4 | Conceptual Site Model for the Ventron Site | 12 |


## TABLES


| | | |
|---|---|---|
| 1 | Summary of Background Sampling Results for the Ventron Site | 6 |
| 2 | Post-Remediation Radionuclide Concentrations | 9 |
| 3 | Estimates of Potential Radiation Dose and Risk Following Remediation | 14 |

# EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) conducted remediation activities at the Ventron site, located in Beverly, Massachusetts, during 1995-1997 to remove radiological contaminants of concern. Remediation activities were performed in the harbor area during September 1995 and for the entire site from May 1996 to March 1997. The radiological contaminants of concern were present at the site, at least in part, as a result of operations conducted under contract to the Manhattan Engineer District (MED) and Atomic Energy Commission (AEC) between 1942 and 1948. The site was designated for remedial action under the DOE Formerly Utilized Sites Remedial Action Program (FUSRAP). Under FUSRAP, DOE was authorized to remediate only radiological contaminants exceeding their respective authorized limits and any non-radiological contaminants that were commingled with such radiological contaminants. The primary radioactive contaminant of concern at the Ventron site was natural uranium, with much lower levels of radium and thorium. Following remediation, residual radioactive material concentrations exceed background concentrations only for uranium (i.e., residual concentrations of radium or thorium do not exceed background levels).

The purpose of this report is to evaluate the potential radiation doses and health risks that might be incurred by future site occupants from exposure to the post-remediation concentrations of residual uranium (i.e., residual concentrations of uranium which are present at levels above natural background but below site cleanup criteria). Predicted radiation doses to hypothetical future residents and commercial workers are estimated to be approximately 1 mrem/year or less, well below DOE and state criteria. Excess lifetime cancer risks to hypothetical future receptors are estimated at $9 \times 10^{-6}$ for residential exposure and $2 \times 10^{-6}$ for commercial exposure, both within the U. S. Environmental Protection Agency (EPA) target risk range of $10^{-4}$ to $10^{-6}$ and the Massachusetts Department of Environmental Protection (MADEP) target risk of $10^{-5}$. Similarly, non-cancer risks to hypothetical future receptors are estimated to be well within acceptable levels - i.e., the screening Hazard Index value of 0.01 to 0.06 is well below the acceptable level of 1. Thus, the radiological contaminants of concern are concluded to present no significant risk of harm to human health (including both cancer and non-cancer risk). In addition, the very low concentrations of residual radioactive material remaining at the site following remediation present no significant risk of harm to safety, public welfare or the environment.

Based on this analysis, the residual radioactive materials remaining at the site following completion of DOE's remedial action present **no significant risk of harm to human health, safety, public welfare, or the environment**.

---

NOTE: The Formerly Utilized Sites Remedial Action Program (FUSRAP) was transferred from the U. S. Department of Energy to the U. S. Army Corps of Engineers during 1997. The remediation activities described in this report at the Ventron site were conducted by DOE prior to this transfer.

# 1. INTRODUCTION AND BACKGROUND

The purpose of this analysis is to assess and characterize the potential radiation dose and health risks that might result from hypothetical exposure to residual radioactive materials at the Ventron site in Beverly, Massachusetts, following completion of remedial action conducted by the U.S. Department of Energy during 1995-1997. Remediation activities were performed in the harbor area during September 1995 and for the entire site from May 1996 to March 1997. The predicted doses and risks to hypothetical future receptors have been compared to pertinent Federal and Massachusetts regulatory requirements, and have been found to meet all pertinent requirements, as described in the following sections.

The Ventron Site, located in Beverly, Massachusetts (see Figure 1), was designated for remedial action under the Formerly Utilized Sites Remedial Action Program (FUSRAP) of the U.S. Department of Energy (DOE)[1], based on radiological surveys conducted in 1980 and 1982. FUSRAP was established in 1974 to identify and clean up or otherwise control sites where residual radioactive material (exceeding current guidelines) remains from the early years of the nation's atomic energy program. The Ventron site became contaminated as a result of operations conducted under contract to the Manhattan Engineer District (MED) and Atomic Energy Commission (AEC) between 1942 and 1948. The primary radioactive contaminant of concern at the site is natural uranium and its decay products.

Under FUSRAP, DOE had authority for remediation of MED/AEC-related radiological contaminants exceeding authorized limits and any non-radiological contaminants that were comingled with such radiological contaminants. A Memorandum of Agreement (MOA) between DOE and Morton International, the site owner, outlined the responsibilities of each party; under the MOA, DOE agreed to remediate all residual radioactive materials above DOE guidelines, while Morton agreed to demolish all onsite buildings and structures. All buildings and structures have been demolished by Morton and removed from the site. Therefore, the residual radioactive materials considered in this analysis are limited to onsite soils containing concentrations of uranium below the authorized limit for this site.

Remediation activities at the Ventron site were conducted by DOE under the authority of the Atomic Energy Act (AEA). Remediation was accomplished through a series of removal actions conducted in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). DOE activities at the Ventron site were coordinated with the Massachusetts Department of Pubic Health-Radiation Control Program (MADPH-RCP) and the Massachusetts Department of Environmental Protection (MADEP). State regulations for the control of radioactive materials are promulgated under Title 105 of the

[1]The Formerly Utilized Sites Remedial Action Program (FUSRAP) was transferred from the U. S. Department of Energy to the U. S. Army Corps of Engineers as of October 1, 1997. Remediation activities for the Ventron site described in this report were conducted by the DOE, prior to this transfer.

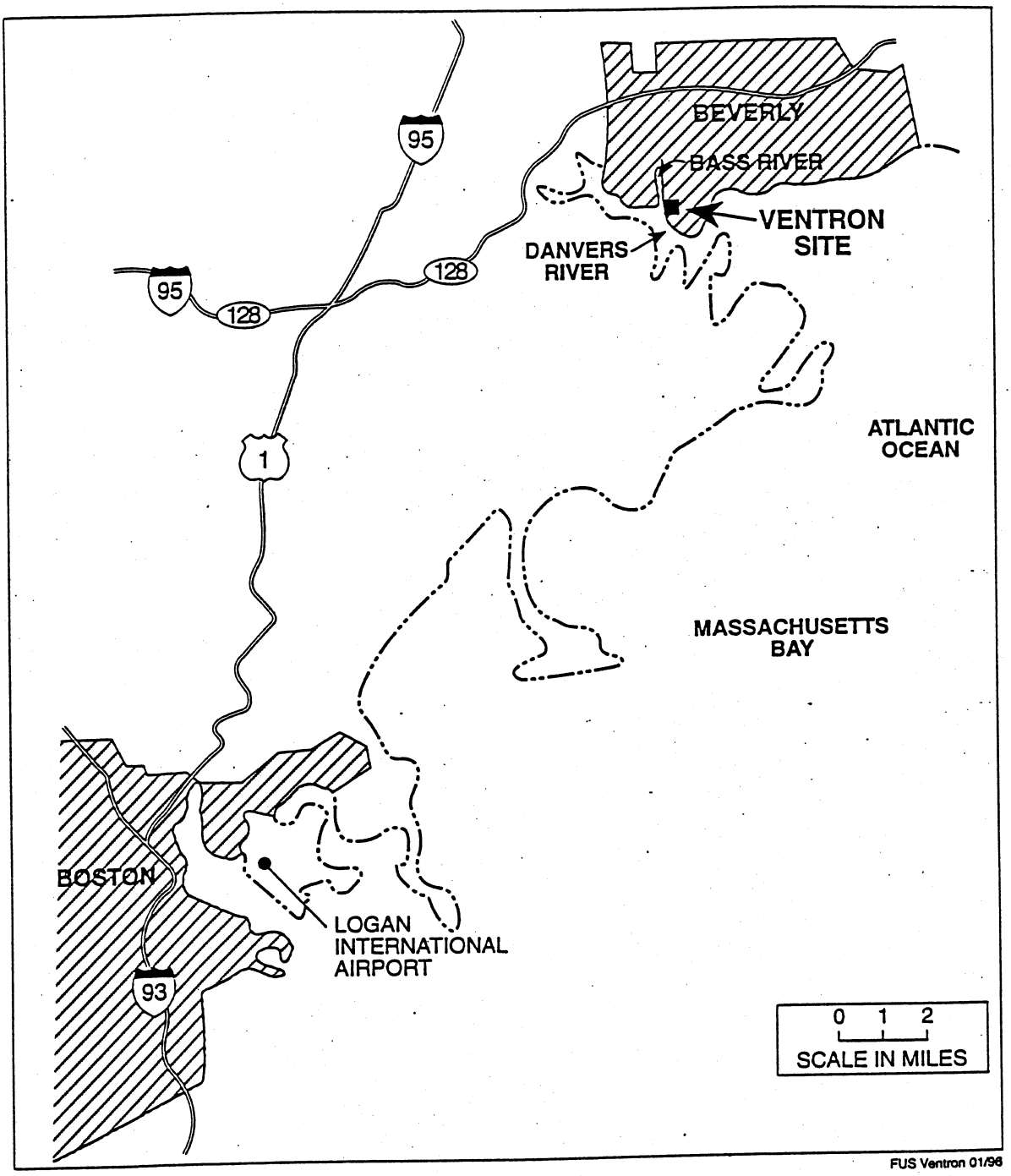



**Figure 1. Location of the Ventron Site**

Code of Massachusetts Regulations Part 120 (105 CMR 120.000). Under the requirements of § 120.291, "Vacating Premises", decontamination must be conducted in such a manner that "the annual effective dose equivalent (EDE) to any individual after the site is released for unrestricted use should not exceed ten millirem above background". The results presented in this report clearly indicate that the remedial actions at the Ventron site have satisfied this requirement.

In addition, this report also evaluates the post-remediation site conditions with respect to the risk objectives of the Massachusetts Oil and Hazardous Material Release Prevention and Response Act and the Massachusetts Contingency Plan (MCP). These requirements, as promulgated under Title 310 CMR Part 40, apply to response actions at sites where a release of oil or hazardous material has occurred. These requirements were not considered by DOE to be directly applicable to the remediation of radioactive contamination at the Ventron site, since the radiological contaminants of concern at this site are not included on the Massachusetts Oil and Hazardous Material List (MOHML). Nevertheless, DOE agreed to prepare this report so that all parties could have a high degree of confidence that the post-remediation site conditions satisfy the MADPH-RCP and MADEP dose and risk objectives. Within this context, this report has been developed to demonstrate functional equivalency with the risk objectives of the MCP; it is not intended to represent a comprehensive "Method 3" risk characterization prepared in accordance with the applicable MCP guidance (MADEP 1995). The results of this analysis indicate that the residual radioactive materials remaining at the site following completion of DOE's response actions present no significant risk of harm to human health, safety, public welfare, or the environment.

## 2. HAZARD IDENTIFICATION

### Site Description and Land Use

The 1.2 hectare (3-acre) Ventron site is located in Beverly, Massachusetts, on Massachusetts Bay, approximately 24 kilometers (15 miles) northeast of Boston (Figure 1) at the confluence of the Bass and Danvers Rivers. The site is bounded by Congress Street to the north, the Boston and Maine Railroad to the east, and the Bass and Danvers Rivers to the west and south, respectively (Figure 2).

Industrial operations at the Ventron site ceased in 1994. Previous operations included the processing of radioactive materials (uranium, thorium) from the early 1940s until 1986. These operations were conducted by Metal Hydrides Corporation, which became the Ventron Corporation in 1965. Ventron Corporation was subsequently acquired by Thiokol Corporation in 1976, and in 1982 the Ventron operations became a division of Morton Thiokol, Inc., which was subsequently renamed Morton International in 1990.

Although the land use at the Ventron site itself is industrial, much of the nearby area is residential. All onsite buildings have been demolished and the site owner has indicated an interest in releasing the site for potential redevelopment. Therefore, both industrial and residential land use scenarios are considered in evaluating potential risks from post-remediation

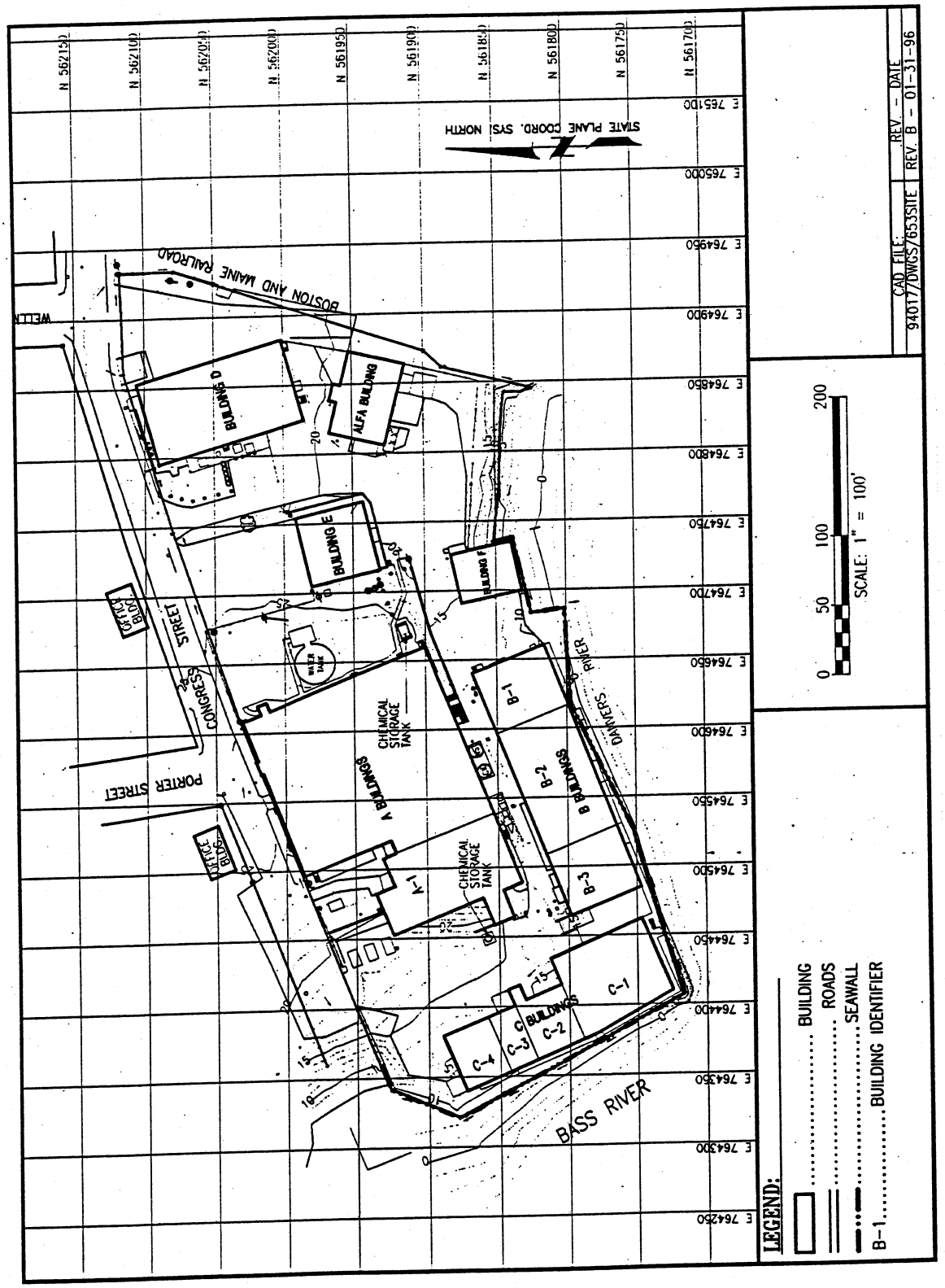



**Figure 2. Ventron Site Plan**

concentrations of residual radioactive materials.

Soil and Hydrologic Characteristics

Site soils include coarse gravel and sand fill which have been imported for site construction activities (i.e., fill materials have been imported to raise the site to its current elevation), and overlie native glacial till. The glacial till is unstratified and poorly sorted, ranging from fine sand to cobble. Depth to granitic bedrock varies between 2 and 20 feet below grade (DOE 1995).

Surface water at the site flows into the Danvers and Bass Rivers or into Congress Street drainage structures. Much of the site is covered by paved areas and foundations of the recently demolished site buildings.

Groundwater units present at the site include unconsolidated deposits and fractured bedrock. Throughout most of the site, the top of bedrock is above the mean groundwater table. Groundwater generally flows to the south-southwest toward the Danvers River, reflecting the overall topography of the area. Tidal influences in groundwater elevation have been observed, with elevation fluctuations near the seawall of 2 to 4 feet with the rise and fall in sea level. Bedrock appears to have a low conductivity, with flow primarily through fracture features. Due to tidal influences and brackish water quality, groundwater at the site is not considered potable.

Background Concentrations for Radionuclides of Potential Concern

Background concentrations of the radionuclides of potential concern at the Ventron site were characterized by a series of samples collected in the vicinity of the site during the site characterization and remediation process. As summarized in Table 1, a total of 12 background samples were collected (four data sets of three samples each). Three of these data sets (i.e., total of 9 samples) indicate very consistent results, while one data set (3 samples collected in 1991) indicate much higher background values, particularly for uranium. These discrepancies can be attributed to the analytical method - i.e., these 3 samples were analyzed using an inadequate counting time and the results are reported as being below the minimum detection level (minimum detectable activity) for each particular sample matrix and counting time. Therefore, in order to ensure a representative estimate of background concentrations, these three samples have been excluded from the calculation of background concentrations for each radionuclide for the purpose of this analysis.

The background concentration measurements in Table 1 are consistent with available literature data. While published background concentrations for the radionuclides of potential concern are not available for Massachusetts, data for the nearby states of New York, New Jersey, and Pennsylvania are consistent with the site-specific data.

**Table 1. Summary of Background Sampling Results for the Ventron Site**

| Sample ID | Date | Location | Concentration (pCi/g) | | |
|---|---|---|---|---|---|
| | | | U-238 | Ra-226 | Th-232 |
| VBOS1 | 9/80 | Sally Milligan City Park Beverly, MA | 1.31 | 1.04 | 1.16 |
| VBOS2 | 9/80 | Obear City Park Beverly, MA | 2.74 | 1.76 | 1.23 |
| VBOS3 | 9/80 | Kernwood Park Salem, MA | 0.92 | 1.11 | 0.98 |
| X001 | 5/91 | Boston & Main Railroad ROW - Salem, MA | 1.05 | 0.87 | 0.81 |
| X002 | 5/91 | Independence City Park Beverly, MA | 0.94 | 0.94 | 0.94 |
| X003 | 5/91 | Kernwood Park Salem, MA | 0.69 | 0.70 | 0.76 |
| SB1A | 9/92 | Greenhill Playground Beverly, MA | < 10.5 | 0.96 | 1.2 |
| SB1B | 9/92 | Tuck Point Playground Beverly, MA | < 5.1 | < 0.76 | 1.1 |
| SB1C | 10/92 | Prospect Hill Athletic Field - Beverly, MA | < 6 | < 0.85 | < 0.96 |
| RS-0035 | 5/96 | Gillis Memorial Park Beverly, MA | 1.3 | 0.89 | 0.86 |
| RS-0036 | 5/96 | Herathy Park Beverly, MA | < 3.6 | 0.51 | 1.2 |
| RS-0037 | 5/96 | Tuck Point Playground Beverly, MA | < 2.0 | 0.37 | < 0.51 |
| Average Concentration (Excluding Samples SB1A, SB1B & SB1C) | | | 1.6 | 0.91 | 0.94 |

Notes:

1. Values indicated with "<" indicate constituent detected at a level less than the lower limit of quantification (MDA) for the given sample matrix and counting time.
2. Samples VBOS1, VBOS2, and VBOS3 were collected during initial site investigations in September 1980 by Oak Ridge National Laboratory (ORNL); samples X001, X002, and X003 were collected by ORNL in May 1991. Samples SB1A, SB1B, and SB1C were collected by Bechtel National, Inc. (BNI) during site characterization efforts in 1992; samples RS-0035, RS-0036, and RS-0037 were collected by BNI immediately prior to remedial actions in 1996.

## Contaminants of Concern

The nature and extent of radioactive contamination at the Ventron site was characterized through a series of studies conducted from 1980 through 1995. These data are summarized in the Characterization Report (DOE 1995) and Engineering Evaluation/Cost Analysis (EE/CA) for the site (DOE 1996).

DOE requires that residual radioactive material guidelines for uranium must be derived on a site-specific basis, such that the 50-year committed effective dose equivalent to a hypothetical individual who lives or works in the immediate vicinity of the site should not exceed 100 mrem/yr following remedial action (DOE 1990). Guidelines for total uranium at the Ventron site derived in this manner ranged from 480 pCi/g for subsistence farming, to 1800 pCi/g for continued commercial/industrial use, to 3100 pCi/g for recreational land use (Loureiro et al, 1992). In setting the authorized limits for acceptable concentrations of residual uranium in soil at the site, DOE applied the "as low as reasonably achievable" (ALARA) policy (DOE 1990) to select the value 100 pCi/g for total uranium (DOE 1993).

Other radionuclides of potential concern at the Ventron site include radium (Ra-226) and thorium (Th-232). For these radionuclides, DOE has established generic concentration limits of 5 pCi/g in the surface 15-cm soil depth interval and 15 pCi/g in any subsequent 15-cm depth interval, averaged over an area of 100 $m^2$. The same limits have been promulgated by the U.S. Environmental Protection Agency (EPA) under 40 CFR 192.

The preferred removal action alternative selected under the EE/CA included removal of all soils and debris containing concentrations of radioactive materials exceeding the site-specific authorized limits: 100 pCi/g above background for total uranium (50 pCi/g for U-238 as an indicator), 5 pCi/g above background for Ra-226 and Th-232 within the surface 15-cm depth of soil and 15 pCi/g above background in any subsequent 15-cm depth interval. Post-remediation sampling results, however, indicate that much lower residual radionuclide concentrations were actually achieved at this site.

The approximate areal extent of remediated areas is summarized in Figure 3; radioactivity levels in other areas of the site were determined not to be significantly elevated above background levels. A complete tabulation of post-remediation sampling results is presented in Appendix A, and a summary of the residual radionuclide concentrations is presented in Table 2. Since residual concentrations of radium and thorium do not exceed natural background levels, only uranium is carried forward as a contaminant of concern for the analysis of post-remediation radiological risks.

## 3. DOSE-RESPONSE ASSESSMENT

Radioactive contamination at the Ventron site is characterized as low-level ionizing radiation. The primary detrimental health effect associated with exposure to ionizing radiation is considered to be an increase in the probability of cancer induction. While exposure to ionizing radiation also has been identified to increase the risk of detrimental genetic and developmental (e.g., teratogenic) effects, cancer risk is considered to be the predominant impact, and EPA risk guidance indicates that only cancer risk should be considered in evaluating risks from ionizing radiation (EPA 1989b).

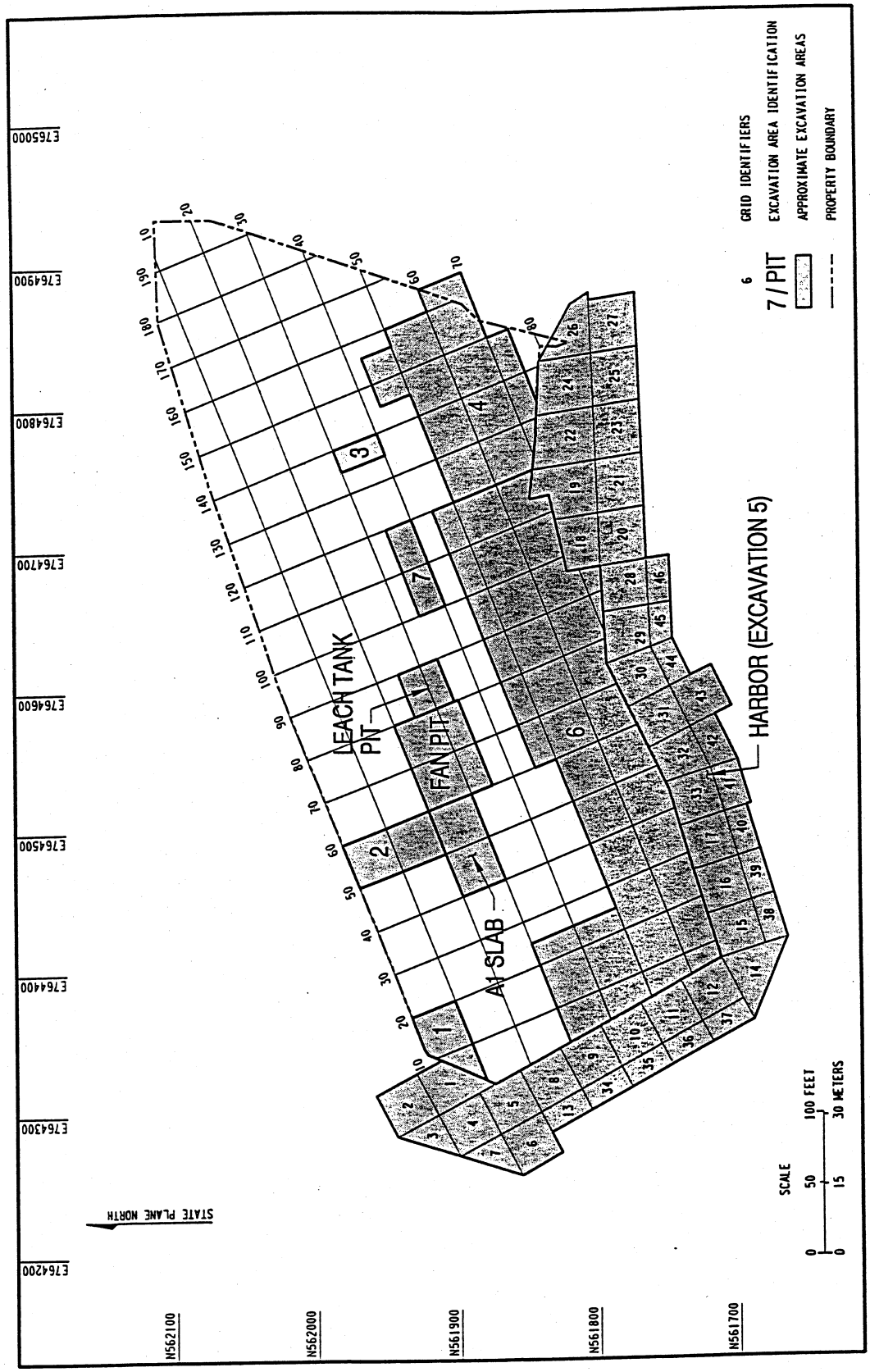



**Figure 3. Ventron Site Excavation Locations**

Table 2. Post-Remediation Radionuclide Concentrations

| Excavation Area (see Figure 3) | Area ($m^2$) | Average Concentration (pCi/g) | | |
|---|---|---|---|---|
| | | U-238 | Th-232 | Ra-226 |
| 1 | 15 | 8.73 | 0.96 | 0.85 |
| 2 | 20 | 18.5 | 1.02 | 0.78 |
| 3 | 5 | 2.9 | 0.81 | 0.60 |
| 4 | 110 | 15. | 1.25 | 0.77 |
| 5 | 3800 | 4.82 | 0.68 | 0.57 |
| 6 | 2800 | 19.6 | 0.86 | 0.72 |
| 7 | 10 | 5.97 | 0.79 | 0.64 |
| Building A-1 | 20 | 8.03 | 1.66 | 1.84 |
| Building A (Fan Pit & Leach Tank Pit) | 4 | 9.62 | 0.99 | 0.76 |
| Area-Weighted Avg Concentration | | 11. | 0.77 | 0.64 |

Radiation health effects for humans have been observed only at relatively high radiation doses or high dose rates with large populations. For low doses, health effects are presumed to occur but can only be estimated statistically. Because of the necessary extrapolation of effects from high doses and the assumptions regarding the dose-response relationships and the underlying mechanisms of radiation carcinogenesis, estimates of risks potentially resulting from exposures to low doses, such as those considered in this analysis, are associated with large uncertainties.

Potential cancer risks were estimated based upon radionuclide slope factors developed by the EPA and tabulated in the Health Effects Assessment Summary Tables (HEAST). The slope factors for a given radionuclide of concern represent the incremental risk of cancer induction resulting from chronic exposure to that radionuclide via the inhalation, ingestion or external exposure pathways.

Uranium is the radiological contaminant of concern at the Ventron site. Uranium is a heavy metal that occurs ubiquitously in the earth's crust. Natural uranium consists of three isotopes - uranium-238, uranium-235, and uranium-234 - in the relative abundance of 92.27%, 0.72%, and 0.0055% by weight, respectively. The richest uranium deposits are found in Africa, Europe, Australia, Brazil, Canada, and the western United States. The average uranium concentration in U.S. soils is approximately 3 mg/kg (2 pCi/g).

During radioactive decay, natural uranium emits alpha particles and gamma radiation. While the penetrating gamma radiation emitted by uranium contributes to external dose (i.e., dose to the body tissues from radioactive material outside the body), the internal exposure pathways (i.e., ingestion or inhalation) are typically most important for uranium. Uranium taken into the body by ingestion or inhalation may be absorbed into the bloodstream and preferentially deposited in bone and kidneys.

In addition to its radioactive properties, uranium also exhibits chemical toxicity. EPA has derived an oral Reference Dose (RfD) for soluble uranium salts based on the decreased body weight and moderate kidney damage in rabbits. A 1000-fold uncertainty factor was used in deriving this RfD to account for inter-species extrapolation, protection of sensitive human subpopulations, and use of the LOAEL instead of the NOAEL; the confidence level for this RfD was medium. No inhalation Reference Concentration (RfC) is available for uranium.

## 4. EXPOSURE ASSESSMENT

### Exposure Scenarios

The 1.2 hectare (3 acre) site is currently owned by Morton International, Inc. This former chemical manufacturing facility is currently inactive and undergoing demolition and restoration for potential future development. Surrounding land use includes both commercial and residential properties. Since the future use has not been determined, both commercial and residential use is considered for this analysis. While other land use scenarios could also be envisioned (e.g., development as a park for recreational use), potential human exposures which might result from such alternative land uses would typically be less restrictive than those for commercial or residential use, and are not considered here.

Since the site has been used as a commercial manufacturing facility for more than 50 years, redevelopment for continued commercial use is considered plausible. A hypothetical worker is assumed to spend 8 hours/day at the site (7 hours/day indoors and 1 hour/day outdoors) for 250 days/year (EPA 1989a, 1991). Exposure pathways for the worker scenario include external exposure to soil and sediment, inhalation of resuspended particulates, and incidental ingestion of soil or sediment. The worker is not assumed to consume any food products or drinking water from on-site sources.

Due to the relatively high land values and surrounding residential properties, future residential development of the site is also considered plausible, particularly in the form of a multi-unit residential complex (e.g., condominiums, apartments). Therefore, an urban resident scenario is considered here as the most conservative, plausible future land use scenario. This urban resident scenario differs from the resident farmer scenario considered in the 1992 analysis (Loureiro et al, 1992) used to derive uranium guidelines for the site, in that the urban resident is not assumed to produce any meat or milk from onsite livestock, and to obtain a small percentage of his/her produce from an onsite garden. Since groundwater at the site is saline and unsuited for drinking, household usage, or irrigation, no consumption of groundwater for drinking, household usage, or irrigation is assumed; the resident is assumed to obtain all water from a distant source not affected by site conditions (e.g., the current municipal water supply). Due to the geological and physical characteristics of the site, development of a fishing pond in the decontaminated area is also considered implausible; however, the hypothetical resident is assumed to ingest fish and seafood harvested from the harbor area.

Exposure parameter values for the hypothetical future resident were taken primarily from

MADEP and EPA recommendations and guidance. Based on MADEP recommendations, the hypothetical future resident was assumed to spend approximately 450 hours/year (3 hours/day x 150 days/year) outdoors at the site (5 days/week for the period April through October; MADEP 1995); these MADEP-recommended values for outdoor exposure time and frequency were used in this analysis since they are more conservative than the EPA-recommended values of 150 hours/year (0.5 hours/day x 350 days/year) for residential exposure scenarios (EPA 1989a). The hypothetical future resident also was assumed to spend approximately 5250 hours/year (15 hours/day x 350 days/year) indoors, based on EPA recommendations, with the remainder of time spent away from the site (EPA 1989a, 1991); the indoor exposure time and frequency values were taken to be the EPA-recommended values rather than the less restrictive MADEP values (5 days/week year-round) to ensure conservative estimates of dose and risk. An average breathing rate of 1.2 $m^3$/hour was assumed (MADEP 1995, EPA 1991), and the resident was assumed to inhale air containing a dust loading of 32 $\mu g/m^3$ of respirable particulates resuspended from site soils (MADEP 1995). The resident was assumed to ingest an average of 26 g/day of fish and seafoods (MADEP 1995).

Exposure Pathways

Potential exposure pathways considered in this analysis are depicted in the conceptual site model shown in Figure 4. For the commercial scenario, exposure pathways include: direct exposure to external radiation from the decontaminated soil and sediment, internal radiation from inhalation of dust, internal radiation from inhalation of emanating radon-222, and internal radiation from incidental ingestion of soil and sediment. For the residential scenario, these same pathways are considered along with internal radiation from ingestion of plant foods grown in an on-site garden. As noted above, the ingestion of animal products from livestock raised at the site and ingestion of water from an on-site well were not considered to be viable pathways due to the urban nature of the site and site-specific hydrogeological conditions. Potential ingestion of fish and seafood from the site vicinity also was considered under the residential scenario; however, it should be noted that site sampling data found no elevated concentrations of radionuclides in seafood in the site vicinity (DOE 1995), and this pathway also was found to be insignificant during the site modeling analyses, but was included here for completeness.

Several other potential exposure pathways were not considered in this analysis because they are not significant for the radionuclides of concern at this site; these include dermal absorption due to dermal exposure to soil or household water (e.g., showering, bathing, swimming), and volatilization of contaminants from household water (e.g., showering, cooking). Dermal exposure was not considered for evaluation of radiation dose and radiogenic cancer risk, in accordance with standard practice for radiological assessment; however, dermal exposure to soil and sediment was considered as an exposure pathway for evaluating non-cancer risks.

Exposure Point Concentrations

Exposure point concentrations represent the radionuclide concentrations in soil at the location where a receptor could be exposed. For this assessment, the exposure point

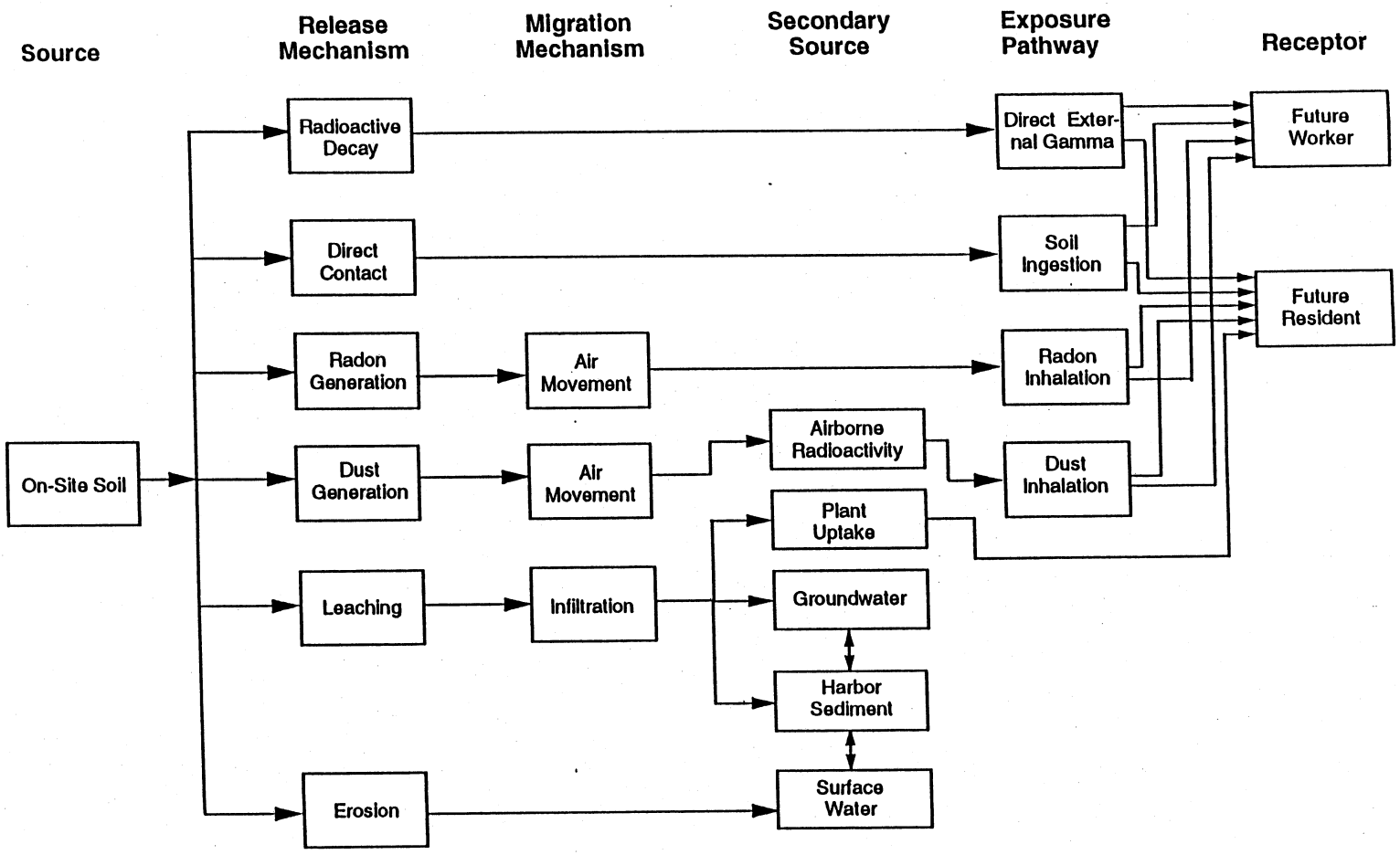



**Figure 4. Conceptual Site Model for the Ventron Site**

concentration was calculated as the area-weighted average concentration of uranium remaining in site soils following the completion of remediation, as shown in Table 2. In accordance with MADEP guidance (MADEP 1995), the background concentration of uranium at the site was not subtracted from the measured uranium concentrations used to compute the exposure point concentration. For the purpose of this analysis, post-remediation characterization data for site soils and harbor sediment were aggregated in computing the exposure point concentrations of residual uranium - i.e., receptors were assumed to be potentially exposed to both soils and sediments with respect to each of the pertinent exposure pathways.

Because the Ventron site primarily handled natural uranium, uranium-234 was assumed to be present at the same activity concentration as uranium-238 (i.e., secular equilibrium). Concentrations of uranium-235 and its decay products were assumed to be present at 4.6% of the uranium-238 activity, based on the natural activity concentration ratios of these radioisotopes.

## 5. DOSE & RISK CHARACTERIZATION

### Radiation Dose

Potential doses to hypothetical future receptors at the Ventron site were assessed using the RESRAD computer code, version 5.61 (Yu et al., 1993a). Where available, standard exposure scenario assumptions recommended by the EPA (EPA 1989a, 1989b, 1991) and/or the MADEP (MADEP 1995) were utilized. RESRAD default values (Yu et al. 1993a, 1993b) were assumed for parameters where site-specific data or EPA/MADEP-recommended standard default values were not available. Exposure parameter values used in the RESRAD calculations are tabulated in Appendix B, and the RESRAD summary output is presented in Appendix C.

The estimated radiation doses for each scenario are summarized in Table 3. In each case, the reported dose includes the contributions from all applicable exposure pathways (e.g., external exposure, inhalation, and ingestion). In all cases, the dose estimates are less than the guidelines recommended by DOE (100 mrem/yr from all sources, 30 mrem/yr from a single source), EPA (100 mrem/yr from all sources, 15 mrem/yr from a remediated source) or MADPH (100 mrem/yr from all sources, 10 mrem/yr from a decontaminated site). These dose estimates were computed under the very conservative assumptions that residual radioactive materials were present throughout the remediated site area with no clean soil cover.

### Radiogenic Cancer Risk

Estimates of the incremental lifetime cancer risk that is potentially attributable to the exposure to the residual radioactive materials at the site are also summarized in Table 3. These estimates are based on an exposure duration of 30 years for the resident and 25 years for the worker (EPA 1991, MADEP 1995). In each case, the risk estimates for the post-remediation site conditions are well within the EPA target risk range of $10^{-4}$ to $10^{-6}$ and below the MADEP target risk of $10^{-5}$.

**Table 3. Estimates of Potential Radiation Dose and Risk from Exposure to Residual Uranium at the Ventron Site.**

| Receptor/Scenario | Dose (mrem/yr) | Cancer Risk (probability of excess cancer) | Non-Cancer Risk (Hazard Index) |
|---|---|---|---|
| Resident | 1.0 | $9 \times 10^{-6}$ | 0.06 |
| Commercial/Industrial Worker | 0.3 | $2 \times 10^{-6}$ | 0.01 |

## Non-Cancer Risk

Since uranium also exhibits chemical toxicity, non-cancer risks due to uranium exposure were also evaluated. Non-cancer risk from exposure to a chemical of concern is represented by the Hazard Index (HI), which is calculated as the ratio of the average daily dose (ADD) or chronic daily intake (CDI) value for that chemical to the reference dose (RfD) for the chemical. A HI value of 1.0 or less indicates that the receptor's exposure is equal to or less than the allowable exposure level, and is unlikely to result in adverse health effects.

The RfD is defined as the average daily exposure (or intake) for the human population (including sensitive subpopulations) that is likely to be without an appreciable risk of deleterious health effects during a lifetime. The RfD is specific to the chemical of concern, the route of exposure, and the duration over which the exposure occurs. The reference dose for chronic ingestion of uranium (chronic oral RfD for soluble salts of uranium) is specified by EPA's Integrated Risk Information System (IRIS) as $3 \times 10^{-3}$ mg/kg-day.

EPA risk assessment guidance (EPA 1989b) and MADEP guidance (MADEP 1995) present methods for estimating contaminant exposures and potential noncarcinogenic risks. For the purposes of this report only, MADEP recommendations have been followed where the MADEP and EPA recommendations differ. Details of the non-cancer risk calculations are presented in Appendix D. As shown in Table 3, the Screening Hazard Index (i.e., summed over all pathways) is estimated to be much less than 1.0 for both residential and commercial exposure scenarios. This finding is consistent with a Response Action Outcome of "No Significant Risk" (of harm to human health from non-cancer risks).

## Risk to Safety

The residual radioactive materials at the Ventron site present no significant risk to safety either before or after remediation. Radioactive materials represent imminent threats to safety only at levels many orders of magnitude higher than the very low-level concentrations present at this site, even before remediation - i.e., acute health impacts from radiation exposure have been identified only at doses of approximately 100 rem or greater (EPA 1989b), at least 100,000-times greater than the predicted dose to future receptors at the Ventron site.

## Risk to Public Welfare

The residual radioactive materials at the site do not significantly impact public welfare. Uranium occurs naturally in the environment at levels similar to the site-specific conditions following remediation. No odor or taste impacts are associated with these residual radioactive materials, and their presence would not impact productive reuse of the site.

## Risk to the Environment

The residual radioactive materials present no significant risk to the environment. No federal- or state-listed threatened or endangered species are known to inhabit the site. The site has been used for industrial processes for more than 50 years, and provides no habitats that are unique or unusual, necessary for propagation of key species, or of special economic or aesthetic value.

The National Council on Radiation Protection and Measurements (NCRP) recommends that radiation exposures to aquatic biota should be limited to levels that would not exceed a dose rate of 1 rad/day (NCRP 1991). This limit is more than three orders of magnitude higher than the primary dose limit for human exposures of 100 mrem/year, and more than five orders of magnitude higher than the predicted doses to future human receptors following remediation of the site. Thus, compliance with current requirements for protection of human health will also ensure protection of the environment.

## 6. UNCERTAINTY

Uncertainty in the estimation of potential doses and health risks from radionuclide exposure arises from the distribution of possible input parameter values, as well as uncertainty in the conceptual model used to represent the site. Depending on the scenario, different parameters most strongly influence the results in each case. For the scenarios considered here, the external exposure, soil ingestion, and particulate inhalation pathways are the primary contributors to dose. Therefore, uncertainty in parameters affecting these pathways (e.g., occupancy factors, thickness of the contaminated zone, shielding provided by buildings and site features, mass loading of contaminated airborne particulates, inhalation rate) have the greatest impact on the model predictions, and parameters related to other pathways have relatively little impact. Because the maximum dose occurs at time zero (immediately following remediation) for these scenarios, uncertainties in parameters related to the leaching of radionuclides from the contaminated zone do not significantly affect the results.

For the purposes of this analysis, site-specific measurements and MADEP-recommended exposure parameters and assumptions have been used preferentially, where available. RESRAD default parameter values were used where no site-specific data or MADEP-recommended values were available; these default values are based on reasonable maximum values. Exposure point concentrations were based on actual measurements of post-remediation soil concentrations. For the purpose of this analysis, a contaminated zone thickness of 1 m uniformly distributed over the total remediated area of 6784 $m^2$ was assumed. However, these measurements often represent the soil concentrations measured at the final excavation depth (i.e., at the bottom of the hole), and do not consider the placement of clean backfill material used to restore the site grade. In reality, following remediation and restoration of the site, the average uranium concentrations to which an actual receptor is likely to be exposed would be expected to be much lower than the exposure point concentrations assumed here, which would be expected to occur only in localized and noncontiguous areas and generally at depth. Therefore, the calculated dose and risk estimates are considered to be very conservative (i.e., likely to overestimate actual doses).

Detrimental health effects from exposure to radioactive materials have been confirmed to occur only at high doses or dose rates. Impacts that may result from very low-level exposure, such as that considered in this analysis, can only be presumed based on extrapolation from high-dose data, and are subject to large uncertainties. The risk estimates presented here are considered to represent reasonable upper bounds on potential health risks, with a potential lower bound of zero risk (under some theories - e.g., hormesis - very low-level exposures to ionizing radiation may even be predicted to produce beneficial effects).

## 7. CONCLUSIONS

The U.S. Department of Energy conducted remediation activities at the Ventron site, located in Beverly, Massachusetts, during 1995-1997 to remove radiological contaminants of concern. Remediation activities were performed in the harbor area during September 1995 and for the entire site from May 1996 to March 1997. The predicted doses and risks to hypothetical future receptors following remediation have been compared to pertinent Federal and Massachusetts regulatory requirements.

The Ventron site became contaminated, in part, as a result of operations conducted under contract to the MED and AEC between 1942 and 1948. The site was designated for remedial action under the DOE Formerly Utilized Sites Remedial Action Program. Under FUSRAP, DOE was authorized to remediate only radiological contaminants exceeding their respective authorized limits and any non-radiological contaminants that were comingled with such radiological contaminants. The primary radioactive contaminant of concern at the Ventron site was natural uranium, with much lower levels of radium and thorium. Following remediation, residual radioactive material concentrations exceed background concentrations only for uranium (i.e., residual uranium concentrations are present at levels above natural background but below site cleanup criteria).

This report evaluates the potential radiation doses and health risks that might be incurred by future site occupants from exposure to the post-remediation concentrations of residual uranium. Predicted radiation doses to hypothetical future residents and commercial workers have been estimated to be approximately 1 mrem/year or less, well below DOE and MADPH criteria. Excess lifetime cancer risks to hypothetical future receptors range from $9 \times 10^{-6}$ for residential exposure to $2 \times 10^{-6}$ for commercial exposure. These values are within the EPA target risk range of $10^{-4}$ to $10^{-6}$ and the MADEP target risk of $10^{-5}$. Similarly, non-cancer risks to hypothetical future receptors have been estimated to be well within acceptable levels, with a screening Hazard Index value of 0.01 to 0.06.

Furthermore, the very low concentrations of residual radioactive material remaining at the site following remediation present no significant risk of harm to safety, public welfare, or the environment.

Based on this analysis, the residual radioactive materials remaining at the site following completion of DOE's remedial action present **no significant risk of harm to human health, safety, public welfare, or the environment.**

## 8. REFERENCES


Loureiro, C., C. Yu, and L. Jones, 1992, *Derivation of Uranium Residual Radioactive Material Guidelines for the Ventron Site*, Argonne National Laboratory, March 1992.

Massachusetts Department of Environmental Protection, 1995, *Guidance for Disposal Site Risk Characterization - In Support of the Massachusetts Contingency Plan*, Interim Final Policy WSC/ORS-95-141, July 1995.

Massachusetts Department of Environmental Protection, 1996, *Human Exposures at Industrial/Commercial Properties*, Draft Commercial/Industrial ShortForm, January 1996.

National Council on Radiation Protection and Measurements, 1991, *Effects of Ionizing Radiation on Aquatic Organisms*, NCRP Report No. 109.

U.S. Department of Energy, 1990, *Radiation Protection of the Public and the Environment*, DOE Order 5400.5, Washington, D.C., February 8.

U.S. Department of Energy, 1993, Memorandum from J. Wagoner to L. Price: *Uranium Guidelines for the Ventron Site, Beverly, Massachusetts*, September 1, 1993.

U.S. Department of Energy, 1995, *Characterization Report for the Ventron Site, Beverly, Massachusetts*, DOE/OR/21950-1011, December.

U.S. Department of Energy, 1996, *Ventron Engineering Evaluation/Cost Analysis (EE/CA), Beverly, Massachusetts*, DOE/OR/21950-1014, May.

U.S. Environmental Protection Agency, 1989a, *Exposure Factors Handbook*, EPA/600/8-89/043, July.

U.S. Environmental Protection Agency, 1989b, *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A), Interim Final*, EPA/540/1-89/002, December.

U.S. Environmental Protection Agency, 1991, *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors*, OSWER Directive 9285.6-03, March.

U.S. Environmental Protection Agency, 1996a, *Exposure Factors Handbook*, SAB Review Draft, EPA/600/P-95/002B, August.

U.S. Environmental Protection Agency, 1996b, *Reassessment of Radium and Thorium Soil Concentrations and Annual Dose Rates*, EPA Office of Radiation and Indoor Air, July 22.

Wang, Y.Y., B.M. Biwer, and C. Yu, 1993, *A Compilation of Radionuclide Transfer Factors for the Plant, Meat, Milk, and Aquatic Food Pathways and Suggested Default Values for the RESRAD Code*, ANL/EAIS/TM-103, Argonne National Laboratory, Argonne, Illinois, August.

Yu, C., et al., 1993a, *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD Version 5.0, Working Draft for Comment,* ANL/EAD/LD-2, Argonne National Laboratory, Argonne, Illinois, September.

Yu, C., et al., 1993b, *Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil,* ANL/EAIS-8, Argonne National Laboratory, Argonne, Illinois, April.

# APPENDIX A: POST-REMEDIATION RADIONUCLIDE SAMPLING RESULTS

Concentrations of each of the principal radionuclides of concern (uranium-238 as an indicator of total uranium, radium-226, and thorium-232) measured in soil or sediment at the Ventron site following FUSRAP remediation activities are presented in the following tabulation. Individual measurements and average values are presented separately for each excavation area addressed during remediation (refer to Figure 3 in the main text), as well as site-wide averages. In addition, an area-weighted average, which is considered to be most representative of the post-remediation site conditions is presented in Section 2 of the text (see Table 2). Under either averaging approach, post-remediation concentrations of radium-226 and thorium-232 do not exceed background concentrations, so only uranium has been carried forward for this dose and risk characterization report.

| | Area Averages | | | Site Wide Averages | | |
|---|---|---|---|---|---|---|
| Excavation 1 | U-238 | Th-232 | Ra-226 | U-238 | Th-232 | Ra-226 |
| | 8.80 | 0.92 | 1.00 | 8.80 | 0.92 | 1.00 |
| | 6.60 | 0.43 | 0.44 | 6.60 | 0.43 | 0.44 |
| | 6.80 | 0.79 | 0.64 | 6.80 | 0.79 | 0.64 |
| | 12.70 | 1.70 | 1.30 | 12.70 | 1.70 | 1.30 |
| Area 1 Average | 8.73 | 0.96 | 0.85 | 9.90 | 0.89 | 0.88 |
| | | | | 14.10 | 0.70 | 0.65 |
| Excavation 2 | | | | 15.80 | 1.20 | 0.60 |
| | 9.90 | 0.89 | 0.88 | 34.10 | 1.30 | 1.00 |
| | 14.10 | 0.70 | 0.65 | 2.90 | 0.81 | 0.60 |
| | 15.80 | 1.20 | 0.60 | 36.30 | 0.66 | 0.66 |
| | 34.10 | 1.30 | 1.00 | 32.60 | 1.20 | 0.62 |
| Area 2 Average | 18.48 | 1.02 | 0.78 | 2.90 | 1.40 | 0.49 |
| | | | | 5.40 | 0.56 | 0.67 |
| Excavation 3 | | | | 11.40 | 1.30 | 0.76 |
| | 2.90 | 0.81 | 0.60 | 20.60 | 1.50 | 1.00 |
| | | | | 3.20 | 1.60 | 0.63 |
| Excavation 4 | | | | 3.10 | 3.00 | 0.45 |
| | 36.30 | 0.66 | 0.66 | 8.30 | 1.50 | 0.67 |
| | 32.60 | 1.20 | 0.62 | 2.90 | 2.60 | 0.41 |
| | 2.90 | 1.40 | 0.49 | 3.90 | 2.10 | 1.10 |
| | 5.40 | 0.56 | 0.67 | 4.95 | 7.74 | 1.15 |
| | 11.40 | 1.30 | 0.76 | 7.20 | 1.30 | 0.63 |
| | 20.60 | 1.50 | 1.00 | 1.90 | 0.80 | 0.30 |
| | 3.20 | 1.60 | 0.63 | 7.70 | 1.40 | 0.74 |
| | 3.10 | 3.00 | 0.45 | 23.10 | 2.60 | 0.77 |
| | 8.30 | 1.50 | 0.67 | 4.84 | 1.75 | 0.83 |
| | 2.90 | 2.60 | 0.41 | 10.83 | 1.11 | 0.81 |
| | 3.90 | 2.10 | 1.10 | 16.82 | 1.26 | 1.00 |
| | 4.95 | 7.74 | 1.15 | 22.90 | 0.83 | 0.97 |
| | 7.20 | 1.30 | 0.63 | 25.00 | 1.17 | 0.89 |
| | 1.90 | 0.80 | 0.30 | 8.63 | 0.64 | 0.84 |
| | 7.70 | 1.40 | 0.74 | 39.49 | 1.10 | 0.95 |
| | 23.10 | 2.60 | 0.77 | 1.87 | 0.76 | 0.91 |
| | 4.84 | 1.75 | 0.83 | 25.57 | 1.44 | 1.46 |
| | 10.83 | 1.11 | 0.81 | 21.75 | 2.00 | 1.04 |
| | 16.82 | 1.26 | 1.00 | 15.11 | 1.13 | 0.82 |
| | 22.90 | 0.83 | 0.97 | 21.30 | 1.12 | 0.89 |
| | 25.00 | 1.17 | 0.89 | 7.52 | 0.83 | 0.79 |
| | 8.63 | 0.64 | 0.84 | 12.05 | 0.77 | 0.77 |
| | 39.49 | 1.10 | 0.95 | 9.96 | 0.88 | 0.77 |
| | 1.87 | 0.76 | 0.91 | 3.60 | 0.48 | 0.50 |
| | 25.57 | 1.44 | 1.46 | 34.92 | 1.17 | 0.91 |
| | 21.75 | 2.00 | 1.04 | 24.38 | 1.38 | 1.20 |
| | 15.11 | 1.13 | 0.82 | 6.69 | 0.89 | 0.78 |
| | 21.30 | 1.12 | 0.89 | 11.47 | 0.88 | 0.72 |

| | | | |
|---|---|---|---|
| | 7.52 | 0.83 | 0.79 |
| | 12.05 | 0.77 | 0.77 |
| | 9.96 | 0.88 | 0.77 |
| | 3.60 | 0.48 | 0.50 |
| | 34.92 | 1.17 | 0.91 |
| | 24.38 | 1.38 | 1.20 |
| | 6.69 | 0.89 | 0.78 |
| | 11.47 | 0.88 | 0.72 |
| | 7.66 | 0.82 | 0.65 |
| | 0.74 | 0.55 | 0.68 |
| | 3.47 | 0.79 | 0.71 |
| | 0.58 | 0.81 | 0.76 |
| | 3.03 | 0.66 | 0.51 |
| | 0.65 | 0.70 | 0.49 |
| | 3.03 | 0.64 | 0.45 |
| | 19.72 | 0.80 | 0.88 |
| | 2.70 | 0.73 | 0.60 |
| | 0.15 | 1.13 | 0.75 |
| | 3.56 | 0.98 | 0.75 |
| | 16.96 | 0.92 | 0.89 |
| | 38.15 | 1.24 | 0.73 |
| | 43.81 | 1.15 | 0.96 |
| | 27.36 | 1.27 | 0.72 |
| | 46.63 | 0.98 | 0.86 |
| | 38.08 | 1.40 | 0.88 |
| | 24.87 | 1.04 | 0.88 |
| | 26.67 | 0.90 | 0.81 |
| | 21.10 | 0.91 | 0.68 |
| | 13.51 | 0.79 | 0.70 |
| | 7.42 | 0.78 | 0.71 |
| | 35.08 | 0.84 | 0.61 |
| Area 4 Average | 15.00 | 1.25 | 0.77 |
| | | | |
| Excavation 5 | | | |
| | 0.37 | 0.46 | 0.60 |
| | 1.90 | 0.58 | 0.47 |
| | 1.70 | 0.48 | 0.44 |
| | 1.80 | 0.36 | 0.52 |
| | 1.70 | 0.53 | 0.36 |
| | 1.90 | 0.27 | 0.45 |
| | 1.50 | 0.41 | 0.39 |
| | 1.70 | 0.26 | 0.61 |
| | 2.70 | 0.47 | 0.52 |
| | 2.10 | 0.33 | 0.39 |
| | 8.10 | 0.58 | 0.29 |
| | 2.70 | 0.54 | 0.45 |
| | 1.30 | 0.65 | 0.51 |
| | 3.10 | 0.86 | 0.40 |
| | 5.60 | 0.59 | 0.50 |

| | | |
|---|---|---|
| 7.66 | 0.82 | 0.65 |
| 0.74 | 0.55 | 0.68 |
| 3.47 | 0.79 | 0.71 |
| 0.58 | 0.81 | 0.76 |
| 3.03 | 0.66 | 0.51 |
| 0.65 | 0.70 | 0.49 |
| 3.03 | 0.64 | 0.45 |
| 19.72 | 0.80 | 0.88 |
| 2.70 | 0.73 | 0.60 |
| 0.15 | 1.13 | 0.75 |
| 3.56 | 0.98 | 0.75 |
| 16.96 | 0.92 | 0.89 |
| 38.15 | 1.24 | 0.73 |
| 43.81 | 1.15 | 0.96 |
| 27.36 | 1.27 | 0.72 |
| 46.63 | 0.98 | 0.86 |
| 38.08 | 1.40 | 0.88 |
| 24.87 | 1.04 | 0.88 |
| 26.67 | 0.90 | 0.81 |
| 21.10 | 0.91 | 0.68 |
| 13.51 | 0.79 | 0.70 |
| 7.42 | 0.78 | 0.71 |
| 35.08 | 0.84 | 0.61 |
| 0.37 | 0.46 | 0.60 |
| 1.90 | 0.58 | 0.47 |
| 1.70 | 0.48 | 0.44 |
| 1.80 | 0.36 | 0.52 |
| 1.70 | 0.53 | 0.36 |
| 1.90 | 0.27 | 0.45 |
| 1.50 | 0.41 | 0.39 |
| 1.70 | 0.26 | 0.61 |
| 2.70 | 0.47 | 0.52 |
| 2.10 | 0.33 | 0.39 |
| 8.10 | 0.58 | 0.29 |
| 2.70 | 0.54 | 0.45 |
| 1.30 | 0.65 | 0.51 |
| 3.10 | 0.86 | 0.40 |
| 5.60 | 0.59 | 0.50 |
| 13.30 | 0.38 | 0.43 |
| 9.50 | 0.34 | 0.56 |
| 21.50 | 0.60 | 0.57 |
| 3.00 | 0.71 | 0.43 |
| 6.10 | 0.77 | 0.70 |
| 2.20 | 0.61 | 0.37 |
| 3.60 | 0.39 | 0.53 |
| 2.00 | 0.55 | 0.39 |
| 2.10 | 0.78 | 0.38 |
| 1.90 | 0.38 | 0.56 |
| 1.80 | 0.35 | 0.45 |

| | | |
|---|---|---|
| 13.30 | 0.38 | 0.43 |
| 9.50 | 0.34 | 0.56 |
| 21.50 | 0.60 | 0.57 |
| 3.00 | 0.71 | 0.43 |
| 6.10 | 0.77 | 0.70 |
| 2.20 | 0.61 | 0.37 |
| 3.60 | 0.39 | 0.53 |
| 2.00 | 0.55 | 0.39 |
| 2.10 | 0.78 | 0.38 |
| 1.90 | 0.38 | 0.56 |
| 1.80 | 0.35 | 0.45 |
| 9.80 | 3.60 | 0.47 |
| 4.20 | 0.59 | 0.52 |
| 2.40 | 0.59 | 0.44 |
| 0.74 | 0.67 | 0.43 |
| 1.10 | 0.62 | 0.48 |
| 1.80 | 0.64 | 0.46 |
| 4.10 | 0.36 | 0.51 |
| 3.10 | 0.56 | 0.51 |
| 4.00 | 0.84 | 0.61 |
| 4.40 | 0.60 | 1.00 |
| 4.40 | 1.50 | 0.52 |
| 1.30 | 0.91 | 0.83 |
| 13.00 | 1.00 | 0.47 |
| 8.60 | 1.00 | 0.57 |
| 2.10 | 0.57 | 0.47 |
| 2.40 | 0.46 | 0.33 |
| 4.30 | 0.70 | 0.88 |
| 6.60 | 0.61 | 0.69 |
| 12.90 | 0.77 | 0.51 |
| 6.70 | 0.98 | 0.47 |
| 3.30 | 0.64 | 0.55 |
| 17.30 | 0.75 | 0.48 |
| 37.60 | 0.91 | 0.59 |
| 11.00 | 0.79 | 0.62 |
| 18.10 | 1.50 | 0.64 |
| 12.30 | 0.85 | 0.74 |
| 2.40 | 0.60 | 0.84 |
| 1.10 | 0.39 | 0.37 |
| 3.30 | 0.49 | 0.27 |
| 5.60 | 0.64 | 0.43 |
| 2.90 | 0.51 | 0.55 |
| 7.40 | 0.83 | 0.36 |
| 1.20 | 0.50 | 0.58 |
| 8.80 | 0.75 | 0.53 |
| 3.40 | 0.59 | 0.30 |
| 7.80 | 0.65 | 0.56 |
| 6.70 | 1.10 | 0.70 |
| 8.50 | 0.39 | 0.26 |

| | | |
|---|---|---|
| 9.80 | 3.60 | 0.47 |
| 4.20 | 0.59 | 0.52 |
| 2.40 | 0.59 | 0.44 |
| 0.74 | 0.67 | 0.43 |
| 1.10 | 0.62 | 0.48 |
| 1.80 | 0.64 | 0.46 |
| 4.10 | 0.36 | 0.51 |
| 3.10 | 0.56 | 0.51 |
| 4.00 | 0.84 | 0.61 |
| 4.40 | 0.60 | 1.00 |
| 4.40 | 1.50 | 0.52 |
| 1.30 | 0.91 | 0.83 |
| 13.00 | 1.00 | 0.47 |
| 8.60 | 1.00 | 0.57 |
| 2.10 | 0.57 | 0.47 |
| 2.40 | 0.46 | 0.33 |
| 4.30 | 0.70 | 0.88 |
| 6.60 | 0.61 | 0.69 |
| 12.90 | 0.77 | 0.51 |
| 6.70 | 0.98 | 0.47 |
| 3.30 | 0.64 | 0.55 |
| 17.30 | 0.75 | 0.48 |
| 37.60 | 0.91 | 0.59 |
| 11.00 | 0.79 | 0.62 |
| 18.10 | 1.50 | 0.64 |
| 12.30 | 0.85 | 0.74 |
| 2.40 | 0.60 | 0.84 |
| 1.10 | 0.39 | 0.37 |
| 3.30 | 0.49 | 0.27 |
| 5.60 | 0.64 | 0.43 |
| 2.90 | 0.51 | 0.55 |
| 7.40 | 0.83 | 0.36 |
| 1.20 | 0.50 | 0.58 |
| 8.80 | 0.75 | 0.53 |
| 3.40 | 0.59 | 0.30 |
| 7.80 | 0.65 | 0.56 |
| 6.70 | 1.10 | 0.70 |
| 8.50 | 0.39 | 0.26 |
| 16.50 | 0.37 | 0.29 |
| 1.30 | 0.59 | 0.88 |
| 2.30 | 0.63 | 1.30 |
| 11.40 | 0.93 | 0.69 |
| 9.30 | 0.44 | 0.97 |
| 1.60 | 0.61 | 0.77 |
| 2.80 | 0.64 | 1.10 |
| 2.90 | 0.58 | 0.87 |
| 3.00 | 0.84 | 0.70 |
| 2.90 | 0.76 | 1.10 |
| 2.10 | 0.68 | 0.92 |

| | | | |
|---|---|---|---|
| | 16.50 | 0.37 | 0.29 |
| | 1.30 | 0.59 | 0.88 |
| | 2.30 | 0.63 | 1.30 |
| | 11.40 | 0.93 | 0.69 |
| | 9.30 | 0.44 | 0.97 |
| | 1.60 | 0.61 | 0.77 |
| | 2.80 | 0.64 | 1.10 |
| | 2.90 | 0.58 | 0.87 |
| | 3.00 | 0.84 | 0.70 |
| | 2.90 | 0.76 | 1.10 |
| | 2.10 | 0.68 | 0.92 |
| | 1.81 | 0.42 | 0.33 |
| | 2.25 | 0.73 | 1.10 |
| | 2.17 | 0.57 | 0.83 |
| | 5.76 | 0.89 | 0.90 |
| | 1.93 | 0.67 | 0.81 |
| | 2.43 | 0.51 | 0.86 |
| | 1.86 | 0.74 | 1.14 |
| | 2.72 | 0.51 | 0.53 |
| | 1.54 | 0.43 | 0.85 |
| | 3.19 | 0.55 | 0.35 |
| | 2.30 | 0.62 | 0.58 |
| | 2.90 | 0.96 | 0.75 |
| | 2.30 | 0.70 | 0.48 |
| | 2.90 | 0.68 | 0.50 |
| | 1.50 | 0.62 | 0.43 |
| | 2.33 | 0.77 | 0.50 |
| | 2.50 | 0.63 | 0.38 |
| | 2.90 | 2.00 | 0.44 |
| | 2.00 | 0.35 | 0.55 |
| | 1.80 | 0.67 | 0.41 |
| | 3.40 | 0.64 | 0.51 |
| | 2.70 | 0.52 | 0.38 |
| | 1.90 | 0.55 | 0.30 |
| | 1.90 | 0.50 | 0.40 |
| Area 5 Average | 4.82 | 0.68 | 0.57 |
| Excavation 6 | | | |
| | 22.50 | 0.90 | 0.89 |
| | 12.98 | 2.55 | 2.24 |
| | 7.36 | 1.11 | 0.94 |
| | 19.80 | 1.39 | 1.13 |
| | 5.31 | 0.87 | 0.86 |
| | 6.23 | 1.67 | 1.96 |
| | 44.30 | 1.18 | 0.90 |
| | 37.50 | 1.06 | 1.13 |
| | 22.40 | 0.81 | 0.78 |
| | 29.50 | 0.85 | 0.60 |
| | 9.84 | 0.69 | 0.58 |

| | | |
|---|---|---|
| 1.81 | 0.42 | 0.33 |
| 2.25 | 0.73 | 1.10 |
| 2.17 | 0.57 | 0.83 |
| 5.76 | 0.89 | 0.90 |
| 1.93 | 0.67 | 0.81 |
| 2.43 | 0.51 | 0.86 |
| 1.86 | 0.74 | 1.14 |
| 2.72 | 0.51 | 0.53 |
| 1.54 | 0.43 | 0.85 |
| 3.19 | 0.55 | 0.35 |
| 2.30 | 0.62 | 0.58 |
| 2.90 | 0.96 | 0.75 |
| 2.30 | 0.70 | 0.48 |
| 2.90 | 0.68 | 0.50 |
| 1.50 | 0.62 | 0.43 |
| 2.33 | 0.77 | 0.50 |
| 2.50 | 0.63 | 0.38 |
| 2.90 | 2.00 | 0.44 |
| 2.00 | 0.35 | 0.55 |
| 1.80 | 0.67 | 0.41 |
| 3.40 | 0.64 | 0.51 |
| 2.70 | 0.52 | 0.38 |
| 1.90 | 0.55 | 0.30 |
| 1.90 | 0.50 | 0.40 |
| 22.50 | 0.90 | 0.89 |
| 12.98 | 2.55 | 2.24 |
| 7.36 | 1.11 | 0.94 |
| 19.80 | 1.39 | 1.13 |
| 5.31 | 0.87 | 0.86 |
| 6.23 | 1.67 | 1.96 |
| 44.30 | 1.18 | 0.90 |
| 37.50 | 1.06 | 1.13 |
| 22.40 | 0.81 | 0.78 |
| 29.50 | 0.85 | 0.60 |
| 9.84 | 0.69 | 0.58 |
| 7.63 | 0.58 | 0.58 |
| 8.87 | 0.83 | 0.82 |
| 45.03 | 1.22 | 0.78 |
| 41.89 | 1.13 | 0.79 |
| 35.26 | 0.55 | 0.38 |
| 20.70 | 0.63 | 0.51 |
| 19.94 | 0.78 | 0.56 |
| 45.79 | 0.85 | 0.72 |
| 30.34 | 0.76 | 0.58 |
| 21.08 | 0.59 | 0.54 |
| 7.51 | 0.65 | 0.45 |
| 23.05 | 0.45 | 0.45 |
| 4.03 | 0.67 | 0.43 |
| 44.70 | 0.89 | 0.85 |

| | | |
|---|---|---|
| 7.63 | 0.58 | 0.58 |
| 8.87 | 0.83 | 0.82 |
| 45.03 | 1.22 | 0.78 |
| 41.89 | 1.13 | 0.79 |
| 35.26 | 0.55 | 0.38 |
| 20.70 | 0.63 | 0.51 |
| 19.94 | 0.78 | 0.56 |
| 45.79 | 0.85 | 0.72 |
| 30.34 | 0.76 | 0.58 |
| 21.08 | 0.59 | 0.54 |
| 7.51 | 0.65 | 0.45 |
| 23.05 | 0.45 | 0.45 |
| 4.03 | 0.67 | 0.43 |
| 44.70 | 0.89 | 0.85 |
| 49.04 | 0.94 | 0.78 |
| 32.87 | 0.79 | 0.61 |
| 13.82 | 0.73 | 0.62 |
| 26.92 | 0.65 | 0.76 |
| 23.34 | 0.77 | 0.77 |
| 40.38 | 0.90 | 1.08 |
| 13.60 | 2.12 | 1.14 |
| 31.67 | 0.68 | 0.64 |
| 18.15 | 0.57 | 0.48 |
| 34.80 | 0.91 | 0.61 |
| 42.05 | 0.73 | 0.60 |
| 40.16 | 0.58 | 0.59 |
| 38.30 | 1.09 | 1.04 |
| 40.59 | 0.77 | 0.74 |
| 12.80 | 0.64 | 0.78 |
| 21.79 | 1.17 | 0.75 |
| 8.00 | 0.79 | 0.69 |
| 17.21 | 0.96 | 0.68 |
| 16.43 | 0.73 | 0.49 |
| 12.46 | 0.74 | 0.69 |
| 11.31 | 0.82 | 0.69 |
| 35.43 | 0.78 | 0.68 |
| 31.47 | 0.85 | 0.64 |
| 34.97 | 0.66 | 0.62 |
| 32.15 | 0.68 | 0.65 |
| 14.10 | 0.70 | 0.62 |
| 16.22 | 0.76 | 0.60 |
| 11.76 | 0.62 | 0.53 |
| 10.27 | 0.69 | 0.50 |
| 5.59 | 0.68 | 0.60 |
| 8.55 | 0.59 | 0.49 |
| 4.43 | 0.81 | 0.63 |
| 14.64 | 0.71 | 0.59 |
| 13.58 | 0.74 | 0.58 |
| 22.80 | 0.91 | 0.62 |

| | | |
|---|---|---|
| 49.04 | 0.94 | 0.78 |
| 32.87 | 0.79 | 0.61 |
| 13.82 | 0.73 | 0.62 |
| 26.92 | 0.65 | 0.76 |
| 23.34 | 0.77 | 0.77 |
| 40.38 | 0.90 | 1.08 |
| 13.60 | 2.12 | 1.14 |
| 31.67 | 0.68 | 0.64 |
| 18.15 | 0.57 | 0.48 |
| 34.80 | 0.91 | 0.61 |
| 42.05 | 0.73 | 0.60 |
| 40.16 | 0.58 | 0.59 |
| 38.30 | 1.09 | 1.04 |
| 40.59 | 0.77 | 0.74 |
| 12.80 | 0.64 | 0.78 |
| 21.79 | 1.17 | 0.75 |
| 8.00 | 0.79 | 0.69 |
| 17.21 | 0.96 | 0.68 |
| 16.43 | 0.73 | 0.49 |
| 12.46 | 0.74 | 0.69 |
| 11.31 | 0.82 | 0.69 |
| 35.43 | 0.78 | 0.68 |
| 31.47 | 0.85 | 0.64 |
| 34.97 | 0.66 | 0.62 |
| 32.15 | 0.68 | 0.65 |
| 14.10 | 0.70 | 0.62 |
| 16.22 | 0.76 | 0.60 |
| 11.76 | 0.62 | 0.53 |
| 10.27 | 0.69 | 0.50 |
| 5.59 | 0.68 | 0.60 |
| 8.55 | 0.59 | 0.49 |
| 4.43 | 0.81 | 0.63 |
| 14.64 | 0.71 | 0.59 |
| 13.58 | 0.74 | 0.58 |
| 22.80 | 0.91 | 0.62 |
| 20.60 | 0.91 | 0.59 |
| 18.44 | 0.84 | 0.64 |
| 18.23 | 0.80 | 0.49 |
| 4.17 | 0.71 | 0.59 |
| 6.78 | 0.76 | 0.54 |
| 8.92 | 0.86 | 0.61 |
| 8.08 | 0.79 | 0.60 |
| 4.63 | 0.67 | 0.56 |
| 3.82 | 0.69 | 0.70 |
| 4.52 | 0.94 | 0.68 |
| 10.89 | 0.84 | 0.60 |
| 4.18 | 1.08 | 1.03 |
| 1.52 | 2.20 | 2.62 |
| 3.89 | 2.46 | 2.69 |

| | | | |
|---|---|---|---|
| | 20.60 | 0.91 | 0.59 |
| | 18.44 | 0.84 | 0.64 |
| | 18.23 | 0.80 | 0.49 |
| | 4.17 | 0.71 | 0.59 |
| | 6.78 | 0.76 | 0.54 |
| | 8.92 | 0.86 | 0.61 |
| | 8.08 | 0.79 | 0.60 |
| Area 6 Average | 21.80 | 0.86 | 0.72 |
| Excavation 7 | | | |
| | 4.63 | 0.67 | 0.56 |
| | 3.82 | 0.69 | 0.70 |
| | 4.52 | 0.94 | 0.68 |
| | 10.89 | 0.84 | 0.60 |
| Area 7 Average | 5.97 | 0.79 | 0.64 |
| Building A-1 | | | |
| | 4.18 | 1.08 | 1.03 |
| | 1.52 | 2.20 | 2.62 |
| | 3.89 | 2.46 | 2.69 |
| | 22.51 | 0.90 | 1.01 |
| Area Average | 8.03 | 1.66 | 1.84 |
| Building A | | | |
| | 6.72 | 0.51 | 0.42 |
| | 13.75 | 1.42 | 1.16 |
| | 8.38 | 1.03 | 0.71 |
| Area Average | 9.62 | 0.99 | 0.76 |
| Seawall Grids | | | |
| | 12.30 | 0.79 | 0.40 |
| | 15.10 | 1.10 | 0.47 |
| | 25.89 | 1.16 | 0.86 |
| | 18.10 | 0.77 | 0.69 |
| | 5.30 | 0.42 | 0.42 |
| | 21.16 | 0.69 | 0.34 |
| | 29.31 | 0.59 | 0.52 |
| | 16.73 | 0.94 | 0.52 |
| | 22.70 | 1.60 | 1.60 |
| | 24.90 | 0.96 | 1.30 |
| | 26.10 | 0.86 | 1.30 |
| | 8.40 | 0.61 | 0.60 |
| | 15.60 | 0.84 | 0.77 |
| | 11.30 | 0.71 | 0.61 |
| | 8.30 | 1.20 | 0.97 |
| | 27.60 | 1.10 | 1.90 |
| | 19.00 | 1.70 | 1.30 |
| | 14.80 | 0.72 | 0.57 |
| | 38.10 | 0.94 | 0.77 |
| | 22.51 | 0.90 | 1.01 |
| | 6.72 | 0.51 | 0.42 |
| | 13.75 | 1.42 | 1.16 |
| | 8.38 | 1.03 | 0.71 |
| | 12.30 | 0.79 | 0.40 |
| | 15.10 | 1.10 | 0.47 |
| | 25.89 | 1.16 | 0.86 |
| | 18.10 | 0.77 | 0.69 |
| | 5.30 | 0.42 | 0.42 |
| | 21.16 | 0.69 | 0.34 |
| | 29.31 | 0.59 | 0.52 |
| | 16.73 | 0.94 | 0.52 |
| | 22.70 | 1.60 | 1.60 |
| | 24.90 | 0.96 | 1.30 |
| | 26.10 | 0.86 | 1.30 |
| | 8.40 | 0.61 | 0.60 |
| | 15.60 | 0.84 | 0.77 |
| | 11.30 | 0.71 | 0.61 |
| | 8.30 | 1.20 | 0.97 |
| | 27.60 | 1.10 | 1.90 |
| | 19.00 | 1.70 | 1.30 |
| | 14.80 | 0.72 | 0.57 |
| | 38.10 | 0.94 | 0.77 |
| | 7.20 | 0.61 | 0.35 |
| | 16.00 | 1.00 | 1.20 |
| | 18.70 | 1.20 | 0.77 |
| | 8.80 | 0.57 | 0.86 |
| | 20.70 | 0.59 | 0.50 |
| | 23.60 | 0.55 | 0.45 |
| | 29.60 | 0.61 | 0.35 |
| | 15.00 | 0.61 | 0.55 |
| | 11.50 | 0.62 | 0.58 |
| | 8.10 | 0.92 | 0.61 |
| | 12.80 | 0.72 | 0.45 |
| | 12.50 | 1.10 | 0.52 |
| | 3.70 | 0.43 | 0.34 |
| | 16.50 | 0.78 | 0.56 |
| | 25.90 | 0.64 | 0.50 |
| | 2.20 | 0.75 | 0.81 |
| | 11.60 | 0.58 | 0.42 |
| | 24.20 | 0.65 | 0.42 |
| | 5.70 | 0.54 | 0.37 |
| | 36.88 | 0.75 | 0.53 |
| | 21.79 | 1.17 | 0.75 |
| | 28.90 | 0.97 | 0.64 |
| | 2.76 | 0.51 | 0.45 |
| | 22.50 | 0.90 | 0.89 |
| | 12.98 | 2.59 | 2.24 |
| | 4.75 | 0.52 | 0.59 |

| | | | |
|---|---|---|---|
| | 7.20 | 0.61 | 0.35 |
| | 16.00 | 1.00 | 1.20 |
| | 18.70 | 1.20 | 0.77 |
| | 8.80 | 0.57 | 0.86 |
| | 20.70 | 0.59 | 0.50 |
| | 23.60 | 0.55 | 0.45 |
| | 29.60 | 0.61 | 0.35 |
| | 15.00 | 0.61 | 0.55 |
| | 11.50 | 0.62 | 0.58 |
| | 8.10 | 0.92 | 0.61 |
| | 12.80 | 0.72 | 0.45 |
| | 12.50 | 1.10 | 0.52 |
| | 3.70 | 0.43 | 0.34 |
| | 16.50 | 0.78 | 0.56 |
| | 25.90 | 0.64 | 0.50 |
| | 2.20 | 0.75 | 0.81 |
| | 11.60 | 0.58 | 0.42 |
| | 24.20 | 0.65 | 0.42 |
| | 5.70 | 0.54 | 0.37 |
| | 36.88 | 0.75 | 0.53 |
| | 21.79 | 1.17 | 0.75 |
| | 28.90 | 0.97 | 0.64 |
| | 2.76 | 0.51 | 0.45 |
| | 22.50 | 0.90 | 0.89 |
| | 12.98 | 2.59 | 2.24 |
| | 4.75 | 0.52 | 0.59 |
| | 18.80 | 0.76 | 0.57 |
| | 3.78 | 0.73 | 0.54 |
| | 6.98 | 0.88 | 0.64 |
| | 15.13 | 0.93 | 0.70 |
| Area Average | 16.54 | 0.85 | 0.72 |

| | | | |
|---|---|---|---|
| | 18.80 | 0.76 | 0.57 |
| | 3.78 | 0.73 | 0.54 |
| | 6.98 | 0.88 | 0.64 |
| | 15.13 | 0.93 | 0.70 |
| Site Wide Average | 13.02 | 0.89 | 0.70 |

## APPENDIX B: INPUT PARAMETERS FOR THE RESRAD ANALYSIS

The parametric values used in the RESRAD code for the analysis of the Ventron site are listed in Table B.1. Site-specific parameter values and values recommended by MADEP and/or EPA guidance have been used preferentially, where available; where such values are not available, RESRAD default values have been used.

### Table B.1 Parameters Used in the RESRAD Code for the Analysis of the Ventron Site.

| Parameter [a] | Value | | |
|---|---|---|---|
| | Unit | Resident | Worker |
| Area of contaminated zone [b] | $m^2$ | 6784 | 6784 |
| Thickness of contaminated zone [b] | m | 1.0 | 1.0 |
| Length parallel to aquifer flow [b] | m | 80 | 80 |
| Cover depth | m | 0 | 0 |
| Cover erosion rate | m/yr | NA | NA |
| Density of contaminated zone | $g/cm^3$ | 1.76 | 1.76 |
| Contaminated zone erosion rate | m/yr | 0 | 0 |
| Contaminated zone total porosity [c] | - | 0.4 | 0.4 |
| Contaminated zone effective porosity [c] | - | 0.2 | 0.2 |
| Contaminated zone hydraulic conductivity [c] | m/yr | 10 | 10 |
| Contaminated zone b parameter | - | 5.3 | 5.3 |
| Evapotranspiration coefficient | - | 0.6 | 0.6 |
| Precipitation [c] | m/yr | 1.12 | 1.12 |
| Irrigation | m/yr | 0.2 | 0.2 |
| Irrigation mode | - | overhead | overhead |
| Runoff coefficient | - | 0.2 | 0.2 |
| Watershed area for pond | $m^2$ | not used | 0.2 |
| Density of saturated zone | $g/cm^3$ | 1.5 | 1.5 |
| Saturated zone total porosity [c] | - | 0.4 | 0.4 |
| Saturated zone effective porosity [c] | - | 0.2 | 0.2 |
| Saturated zone hydraulic conductivity [c] | m/yr | 100 | 100 |
| Saturated zone hydraulic gradient [c] | - | 0.02 | 0.02 |
| Saturated zone b parameter | - | 5.3 | 5.3 |
| Water table drop rate | m/yr | not used | not used |
| Well pump intake depth [c] (below water table) | m | not used | not used |
| Well pumping rate | $m^3/yr$ | not used | not used |
| Model: nondispersion (ND) or mass-balance (MB) | - | not used | not used |
| Number of unsaturated zone strata | - | 1 | 1 |
| Unsaturated zone 1 thickness [c] | m | 4 | 4 |
| Unsaturated zone 1 soil density | $g/cm^3$ | 1.5 | 1.5 |
| Unsaturated zone 1 total porosity [c] | - | 0.4 | 0.4 |
| Unsaturated zone 1 effective porosity [c] | - | 0.2 | 0.2 |
| Unsaturated zone 1 soil b parameter | - | 5.3 | 5.3 |
| Unsaturated zone 1 hydraulic conductivity [c] | m/yr | 100 | 100 |

| Parameter [a] | Value | | |
|---|---|---|---|
| | Unit | Resident | Worker |
| Distribution coefficient (all zones) | | | |
| Uranium-238+D | $cm^3/g$ | 50 | 50 |
| Uranium-235+D | $cm^3/g$ | 50 | 50 |
| Uranium-234 | $cm^3/g$ | 50 | 50 |
| Protactinium-231 | $cm^3/g$ | 50 | 50 |
| Thorium-232 | $cm^3/g$ | 60,000 | 60,000 |
| Thorium-230 | $cm^3/g$ | 60,000 | 60,000 |
| Thorium-228+D | $cm^3/g$ | 60,000 | 60,000 |
| Actinium-227+D | $cm^3/g$ | 20 | 20 |
| Radium-228+D | $cm^3/g$ | 70 | 70 |
| Radium-226+D | $cm^3/g$ | 70 | 70 |
| Lead-210+D | $cm^3/g$ | 100 | 100 |
| Inhalation rate [d,e] | $m^3/hr$ | 1.2 | 1.2 |
| Mass loading for inhalation [d] | $g/m^3$ | 0.000032 | 0.000032 |
| Indoor occupancy time fraction [d,e] | - | 0.60 | 0.20 |
| Outdoor occupancy time fraction [d,e] | - | 0.05 | 0.03 |
| Exposure Duration | yr | 30 | 25 |
| Shielding factor from external radiation afforded by indoor occupancy [f] | - | 0.4 | 0.4 |
| Fraction of outdoor dust present indoors | - | 0.4 | 0.4 |
| Shape factor, external gamma | - | 1 | 1 |
| Dilution length for airborne dust inhalation | m | 3 | 3 |
| Soil ingestion rate [d,e] | mg/day | 100 | 50 |
| Fruit, vegetable, and grain consumption | g/yr | 160 | not used |
| Leafy vegetable consumption | g/yr | 14 | not used |
| Milk consumption from on-site livestock | L/yr | not used | not used |
| Meat consumption from on-site livestock | g/yr | not used | not used |
| Fish consumption [d] | kg/yr | 9.5 | not used |
| Other seafood consumption | kg/yr | 0.9 | not used |
| Drinking water intake | L/yr | 700 | not used |
| Fraction of drinking water from on-site well | - | 0 | 0 |
| Fraction of aquatic food from on-site pond | - | not used | not used |
| Livestock fodder intake for meat | kg/d | not used | not used |
| Livestock fodder intake for milk | kg/d | not used | not used |
| Livestock water intake for meat | L/d | not used | not used |
| Livestock water intake for milk | L/d | not used | not used |
| Livestock intake of soil | kg/d | not used | not used |
| Mass loading for foliar deposition | $g/m^3$ | 0.0001 | not used |
| Depth of soil mixing layer | m | 0.15 | not used |
| Depth of roots | m | 0.9 | not used |
| Contamination fraction | | | |
| Drinking water | - | 0 | not used |
| Household water | - | 0 | not used |
| Livestock | - | 0 | not used |
| Irrigation | - | 0 | not used |
| Produce [g] | - | 0.043 | not used |
| Meat | - | 0 | not used |
| Milk | - | 0 | not used |

| Parameter [a] | Unit | Value | |
|---|---|---|---|
| | | Resident | Worker |
| Groundwater fractional usage (balance from surface water) | | | |
| Drinking water | - | 0 | not used |
| Household water | - | 0 | not used |
| Livestock water | - | not used | not used |
| Irrigation | - | 0 | not used |
| Total porosity of the house or building | - | 0.1 | 0.1 |
| Volumetric water content of cover material | - | 0.1 | 0.1 |
| Volumetric water content of the foundation | - | 0.03 | 0.03 |
| Diffusion coefficient for radon gas | $m^2/s$ | | |
| in cover material | | $2.0 \times 10^{-6}$ | $2.0 \times 10^{-6}$ |
| in foundation material | | $3.0 \times 10^{-7}$ | $3.0 \times 10^{-7}$ |
| in contaminated zone material | | $2.0 \times 10^{-6}$ | $2.0 \times 10^{-6}$ |
| Emanating power of radon gas | - | 0.25 | 0.25 |
| Radon vertical dimension of mixing | m | 2.0 | 2.0 |
| Average annual wind speed [c] | m/s | 4.5 | 4.5 |
| Average building air exchange rate | $hr^{-1}$ | 0.5 | 0.5 |
| Height of the building (room) | m | 2.5 | 2.5 |
| Bulk density of building foundation | $g/cm^3$ | 2.4 | 2.4 |
| Thickness of building foundation | m | 0.15 | 0.15 |
| Building indoor area factor | - | 0 | 0 |
| Building depth below ground surface | m | 1 | 1 |

[a] Parameter values listed are generic (RESRAD default) values except where indicated differently (Yu et al. 1993a, 1993b).
[b] Area of contaminated zone is taken as the total surface area of the site remediated; thickness of residual contaminated zone is conservatively taken to be 1 m, but is expected to be much smaller; no placement of cover material over the remediated area is assumed, although such cover was placed over much of the site during restoration activities.
[c] Reference: DOE 1996
[d] Reference: MADEP 1995, 1996
[e] Reference: EPA 1989a, 1991
[f] Reference: EPA 1996a
[g] Reference: EPA 1996b

# APPENDIX C: RESRAD SUMMARY OUTPUT

Summary output produced by the RESRAD computer code to document dose and risk calculations for the hypothetical future residential and commercial/industrial exposure scenarios discussed in Section 4 of the text are presented in the following pages. For both scenarios, the maximum dose and risk is predicted to occur for exposures beginning immediately after the site is released (time = 0). The estimates of radiation dose and incremental health risk computed by RESRAD for each exposure pathway and radionuclide of concern are presented as follows:

page C-2 - Effective Dose Equivalent (mrem/yr) for Residential Exposure
page C-3 - Excess Cancer Risk for Residential Exposure
page C-4 - Effective Dose Equivalent (mrem/yr) for Worker Exposure
page C-5 - Excess Cancer Risk for Worker Exposure

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

| dio- | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| uclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| 234 | 1.234E-03 | 0.0012 | 1.367E-01 | 0.1309 | 0.000E+00 | 0.0000 | 5.839E-02 | 0.0559 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 7.386E-02 | 0.0707 |
| J-235 | 1.058E-01 | 0.1013 | 5.904E-03 | 0.0057 | 0.000E+00 | 0.0000 | 2.554E-03 | 0.0024 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 3.231E-03 | 0.0031 |
| J-238 | 4.087E-01 | 0.3914 | 1.222E-01 | 0.1170 | 0.000E+00 | 0.0000 | 5.550E-02 | 0.0531 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 7.020E-02 | 0.0672 |
| tal | 5.158E-01 | 0.4939 | 2.647E-01 | 0.2535 | 0.000E+00 | 0.0000 | 1.164E-01 | 0.1115 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 1.473E-01 | 0.1411 |

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

| dio- | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All Pathways* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| uclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| 234 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 2.701E-01 | 0.2587 |
| 235 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 1.175E-01 | 0.1125 |
| J-238 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 6.566E-01 | 0.6288 |
| tal | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 1.044E+00 | 1.0000 |

*Sum of all water independent and dependent pathways.

Total Excess Cancer Risk CNRSI(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

| Radio- | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nuclide | risk | fract. | risk | fract. | risk | fract. | risk | fract. | risk | fract. | risk | fract. | risk | fract. |
| U-234 | 1.933E-09 | 0.0002 | 4.348E-07 | 0.0507 | 0.000E+00 | 0.0000 | 2.723E-07 | 0.0317 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 3.445E-07 | 0.0402 |
| U-235 | 1.132E-06 | 0.1319 | 1.872E-08 | 0.0022 | 0.000E+00 | 0.0000 | 1.349E-08 | 0.0016 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 1.706E-08 | 0.0020 |
| U-238 | 5.102E-06 | 0.5947 | 3.727E-07 | 0.0434 | 0.000E+00 | 0.0000 | 3.838E-07 | 0.0447 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 4.854E-07 | 0.0566 |
| Total | 6.236E-06 | 0.7269 | 8.263E-07 | 0.0963 | 0.000E+00 | 0.0000 | 6.696E-07 | 0.0781 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 8.470E-07 | 0.0987 |

Total Excess Cancer Risk CNRSI(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

| Radio- | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All pathways | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nuclide | risk | fract. | risk | fract. | risk | fract. | risk | fract. | risk | fract. | risk | fract. | risk | fract. |
| U-234 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 1.054E-06 | 0.1228 |
| U-235 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 1.181E-06 | 0.1377 |
| U-238 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 6.344E-06 | 0.7395 |
| Total | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 8.578E-06 | 1.0000 |

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

| Radio- | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| U-234 | 4.679E-04 | 0.0013 | 5.184E-02 | 0.1489 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 2.613E-02 | 0.0751 |
| U-235 | 4.012E-02 | 0.1152 | 2.240E-03 | 0.0064 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 1.143E-03 | 0.0033 |
| U-238 | 1.550E-01 | 0.4453 | 4.634E-02 | 0.1331 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 2.484E-02 | 0.0713 |
| Total | 1.956E-01 | 0.5619 | 1.004E-01 | 0.2884 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 5.212E-02 | 0.1497 |

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

| Radio- | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All Pathways* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| U-234 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 7.844E-02 | 0.2253 |
| U-235 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 4.351E-02 | 0.1250 |
| U-238 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 2.262E-01 | 0.6497 |
| Total | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 3.482E-01 | 1.0000 |

*Sum of all water independent and dependent pathways.

Total Excess Cancer Risk CNRSI(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

| adio- | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| lide | risk | fract. | risk | fract. | risk | fract. | risk | fract. | risk | fract. | risk | fract. | risk | fract. |
| -234 | 6.110E-10 | 0.0002 | 1.375E-07 | 0.0554 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 1.016E-07 | 0.0409 |
| -235 | 3.578E-07 | 0.1442 | 5.918E-09 | 0.0024 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 5.031E-09 | 0.0020 |
| 38 | 1.613E-06 | 0.6497 | 1.178E-07 | 0.0475 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 1.431E-07 | 0.0577 |
| otal | 1.971E-06 | 0.7941 | 2.612E-07 | 0.1052 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 2.497E-07 | 0.1006 |

Total Excess Cancer Risk CNRSI(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

| adio- | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All pathways | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| uclide | risk | fract. | risk | fract. | risk | fract. | risk | fract. | risk | fract. | risk | fract. | risk | fract. |
| 34 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 2.396E-07 | 0.0966 |
| -235 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 3.687E-07 | 0.1486 |
| 38 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 1.874E-06 | 0.7549 |
| otal | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 2.482E-06 | 1.0000 |

CNRSI(i,p,t) includes contribution from decay daughter radionuclides

# APPENDIX D: NON-CANCER RISK CALCULATIONS

EPA risk assessment guidance (EPA 1989b) indicates that only carcinogenic risk should be evaluated for all radionuclides, with the singular exception of uranium. For uranium, both carcinogenic risk (from radioactive characteristics of uranium) and noncarcinogenic risk (from chemical characteristics of uranium) should be considered. Non-cancer risk is evaluated by comparing the estimated exposure (intake) rate of uranium by potential the receptors to the acceptable dose, or Reference Dose (RfD), of that chemical. The non-cancer risk is characterized by the Hazard Index, which is calculated as the ratio of the average daily dose (ADD) or chronic daily intake (CDI) to the RfD. A HI value of 1.0 or less indicates that the receptor's exposure is equal to or less than the allowable exposure level, and is unlikely to result in adverse health effects.

The RfD is defined as the average daily exposure (or intake) for the human population (including sensitive subpopulations) that is likely to be without an appreciable risk of adverse health effects during a lifetime. The RfD is specific to the chemical of concern, the route of exposure, and the duration over which the exposure occurs. The reference dose for chronic ingestion of uranium (chronic oral RfD for soluble salts of uranium) is specified by EPA's Integrated Risk Information System (IRIS) as $3 \times 10^{-3}$ mg/kg-day. This RfD value is derived primarily from a 1949 study of uranium ingestion by rabbits, rats, and dogs, and includes an uncertainty factor of 1000; EPA has assigned a confidence rating of "moderate" to this value.

EPA risk assessment guidance (EPA 1989a, 1989b, 1991) and MADEP guidance (MADEP 1995) differ somewhat in their recommendations for estimating contaminant exposures and potential noncarcinogenic risks. For the purposes of this report only, MADEP recommendations have been followed where the MADEP and EPA recommendations differ. As discussed in the main text, both commercial/industrial and residential exposure scenarios are considered. For the commercial/industrial scenario, potential exposure pathways considered for evaluation of noncarcinogenic risks include inhalation of resuspended particulates, dermal exposure to soil and sediments, and incidental ingestion of soil and sediment. For the residential scenario, the additional pathway of ingestion of homegrown produce from a home garden is also considered.

Several other potential exposure pathways were not considered in this analysis because of the site-specific circumstances. The ingestion of animal products from livestock raised at the site and ingestion of water from an on-site well were not considered to be viable pathways due to the urban nature of the site and site-specific hydrogeological conditions. Since groundwater at the site is nonpotable and subject to tidal influences, no consumption of groundwater for drinking, household usage, or irrigation is assumed; all water is assumed to be obtained from a distant source not affected by site conditions (e.g., the municipal water supply currently serving the site area). Similarly, dermal exposure to household water (e.g., showering, bathing, swimming), and volatilization of contaminants from household water (e.g., showering, cooking) are not considered to be plausible exposure pathways.

The calculation of the average daily dose for each exposure scenario and pertinent exposure pathway is summarized below. For each receptor scenario, the average daily dose estimates for all pertinent exposure pathways are summed and compared to the RfD value to determine the Screening Hazard Index. Since the Screening HI value does not exceed 1.0 for either exposure scenario, more detailed consideration of endpoint-specific effects was not required.

## D.1 Commercial/Industrial Worker

Potential exposure pathways of concern for the hypothetical future commercial/industrial worker at the Ventron site include incidental ingestion of soil or sediment, dermal exposure to soil or sediment, and inhalation of resuspended particulates. Equations presented below for each pathway are taken from MADEP guidance (MADEP 1995); parameter values are taken from the same reference and from supplemental MADEP guidance "Human Exposures at Industrial/Commerical Properties" (MADEP 1996). The critical receptor was assumed to be an adult worker.

### Incidental Ingestion of Soil or Sediment

$$ADD_{soil\ ingestion} = \frac{[U]_{soil} * IR * RAF * EF * ED * EP * C}{BW * AP}$$

$$= 7.4E\text{-}6 \text{ mg/kg-day}$$

where:

$ADD_{soil\ ingestion}$ = Average daily dose of Uranium via the ingestion of soil/sediment (mg/kg-day).
$[U]_{soil}$ = Exposure point concentration for Uranium in soil/sediment = 11 pCi/g = 16 mg/kg.
IR = Daily soil ingestion rate = 50 mg/day.
RAF = Relative Absorption Factor = 1.86 (0.39/0.21 per Table B-11, MADEP 1995).
EF = Exposure Frequency = 0.35 (129 exposure events/year / 365 days/year; MADEP 1996).
ED = Exposure Duration = 1 day/exposure event.
EP = Exposure Period = 27 years (age 18-45 years assumed; MADEP 1996).
C = Conversion Factor = $10^{-6}$ kg/mg.
BW = Body weight of receptor during averaging period = 70 kg (adult).
AP = Averaging period = 27 years (age 18-45 years assumed; MADEP 1996).

### Dermal Exposure to Soil or Sediment

$$ADD_{dermal} = \frac{[U]_{soil} * SA * AF * RAF * EF * ED * EP * C}{BW * AP}$$

$$= 2.2E\text{-}5 \text{ mg/kg-day}$$

where:

$ADD_{dermal}$ = Average daily dose of Uranium via dermal absorption of soil/sediment (mg/kg-d).
$[U]_{soil}$ = Exposure point concentration for Uranium in soil/sediment = 11 pCi/g = 16 mg/kg.
SA = Skin surface area in contact with soil/sediment = 5400 $cm^2$/day (32% x 16900 $cm^2$).
AF = Mass of soil adhered to unit surface area of skin = 0.51 mg/$cm^2$.
RAF = Relative Absorption Factor = 0.14 (0.03/0.21 per Table B-11, MADEP 1995).
EF = Exposure Frequency = 0.35 (129 exposure events/year / 365 days/year; MADEP 1996).
ED = Exposure Duration = 1 day/exposure event.
EP = Exposure Period = 27 years (age 18-45 years assumed; MADEP 1996).
C = Conversion Factor = $10^{-6}$ kg/mg.
BW = Body weight of receptor during averaging period = 70 kg (adult).
AP = Averaging period = 27 years (age 18-45 years assumed; MADEP 1996).

Inhalation of Resuspended Soil or Sediment

$$ADD_{inhalation} = \frac{[U]_{soil} * [RP]_{air} * VR * RAF * EF * ED * EP * C}{BW * AP}$$

$$= 1.4E\text{-}7 \text{ mg/kg-day}$$

where:

$ADD_{inhalation}$ = Average daily dose of Uranium via the inhalation of resuspended soil/sediment (mg/kg-day).
$[U]_{soil}$ = Concentration of Uranium in respirable particulates (assumed to be equivalent to exposure point concentration in soil/sediment) = 11 pCi/g = 16 mg/kg.
$[RP]_{air}$ = Exposure point concentration of respirable particulates = 60 $\mu g/m^3$.
VR = Ventilation (inhalation) rate = 3.6 $m^3$/hr (MADEP 1996).
RAF = Relative Absorption Factor = 1 assumed (NA per Table B-11, MADEP 1995).
EF = Exposure Frequency = 0.35 (129 exposure events/year / 365 days/year; MADEP 1996).
ED = Exposure Duration = 8 hours/event (work day).
EP = Exposure Period = 27 years (age 18-45 years assumed; MADEP 1996).
C = Conversion Factor = $10^{-9}$ kg/$\mu$g.
BW = Body weight of receptor during averaging period = 70 kg (adult).
AP = Averaging period = 27 years (age 18-45 years assumed; MADEP 1996).

Screening Hazard Index

$$HI = (ADD_{soil\ ingestion} + ADD_{dermal} + ADD_{inhalation}) / RfD$$

$$= 2.95E\text{-}05 \text{ mg/kg-day} / 3.0E\text{-}3 \text{ mg/kg-day}$$
$$= 0.01$$

## D.2 Residential Exposure

Potential exposure pathways of concern for the hypothetical future resident at the Ventron site include incidental ingestion of soil or sediment, dermal exposure to soil or sediment, inhalation of resuspended particulates, and ingestion of produce from a home garden. The critical receptor is assumed to be a child of age 1-6 years.

### Incidental Ingestion of Soil or Sediment

$$ADD_{soil\ ingestion} = \frac{[U]_{soil} * IR * RAF * EF * ED * EP * C}{BW * AP}$$

$$= 8.1E\text{-}5 \text{ mg/kg-day}$$

where:

$ADD_{soil\ ingestion}$ = Average daily dose of Uranium via the ingestion of soil/sediment (mg/kg-day).
$[U]_{soil}$ = Exposure point concentration for Uranium in soil/sediment = 11 pCi/g = 16 mg/kg.
IR = Daily soil ingestion rate = 100 mg/day (MADEP 1996, EPA 1991).
RAF = Relative Absorption Factor = 1.86 (0.39/0.21 per Table B-11, MADEP 1995).
EF = Exposure Frequency = 0.41 (150 exposure events/year / 365 days/year; MADEP 1995).
ED = Exposure Duration = 1 day/exposure event.
EP = Exposure Period = 6 years (age 1 to 6 years assumed).
C = Conversion Factor = $10^{-6}$ kg/mg.
BW = Body weight of receptor during averaging period = 14 kg (average for age 1-6 years).
AP = Averaging period = 6 years (receptor age 1-6 years assumed).

### Dermal Exposure to Soil or Sediment

$$ADD_{dermal} = \frac{[U]_{soil} * SA * AF * RAF * EF * ED * EP * C}{BW * AP}$$

$$= 8.4E\text{-}5 \text{ mg/kg-day}$$

where:

$ADD_{dermal}$ = Average daily dose of Uranium via dermal absorption of soil/sediment (mg/kg-d).
$[U]_{soil}$ = Exposure point concentration for Uranium in soil/sediment = 11 pCi/g = 16 mg/kg.
SA = Skin surface area in contact with soil/sediment = 2500 $cm^2$/day (40% x 6250 $cm^2$).
AF = Mass of soil adhered to unit surface area of skin = 0.51 mg/$cm^2$ (MADEP 1995).
RAF = Relative Absorption Factor = 0.14 (0.03/0.21 per Table B-11, MADEP 1995).
EF = Exposure Frequency = 0.41 (150 exposure events/year / 365 days/year; MADEP 1995).
ED = Exposure Duration = 1 day/exposure event.
EP = Exposure Period = 6 years (age 1-6 years assumed).

C = Conversion Factor = $10^{-6}$ kg/mg.
BW = Body weight of receptor during averaging period = 14 kg (average for age 1-6 years).
AP = Averaging period = 6 years (age 1-6 years assumed).

Inhalation of Resuspended Soil or Sediment

$$ADD_{inhalation} = \frac{[U]_{soil} * [RP]_{air} * VR * RAF * EF * ED * EP * C}{BW * AP}$$

$$= 4.0E\text{-}8 \text{ mg/kg-day}$$

where:

$ADD_{inhalation}$ = Average daily dose of Uranium via the inhalation of resuspended soil/sediment (mg/kg-day).
$[U]_{soil}$ = Concentration of Uranium in respirable particulates (assumed to be equivalent to exposure point concentration in soil/sediment) = 11 pCi/g = 16 mg/kg.
$[RP]_{air}$ = Exposure point concentration of respirable particulates = 32 $\mu g/m^3$ (MADEP 1995).
VR = Ventilation (inhalation) rate = 0.9 $m^3$/hr (age 1-6, heavy exertion; MADEP 1995, B-4).
RAF = Relative Absorption Factor = 1 assumed (NA per Table B-11, MADEP 1995).
EF = Exposure Frequency = 0.41 (150 exposure events/year / 365 days/year; MADEP 1995).
ED = Exposure Duration = 3 hours/event (onsite time spent outdoors per exposure event).
EP = Exposure Period = 6 years (age 1-6 years assumed).
C = Conversion Factor = $10^{-9}$ kg/$\mu$g.
BW = Body weight of receptor during averaging period = 14 kg (average for age 1-6 years).
AP = Averaging period = 6 years (age 1-6 years assumed).

Ingestion of Food (Produce from Home Garden)

$$ADD_{produce\ ingestion} = \frac{[U]_{produce} * FI * RAF * EF * ED * EP * C}{BW * AP}$$

$$= 3.9E\text{-}6 \text{ mg/kg-day}$$

where:

$ADD_{produce\ ingestion}$ = Average daily dose of Uranium via the ingestion of soil/sediment (mg/kg-d).
$[U]_{produce}$ = Exposure point concentration for Uranium in produce = uranium concentration in soil (11 pCi/g = 16 mg/kg) x bio-uptake factor (2.5E-3; Wang 1993) = 0.04 mg/kg.
FI = Daily ingestion rate for homegrown produce = 600 mg/meal (MADEP 1995, Table B7).
RAF = Relative Absorption Factor = 1.86 (0.39/0.21 per Table B-11, MADEP 1995).
EF = Exposure Frequency = 0.41 (150 exposure events/year / 365 days/year; MADEP 1995).
ED = Exposure Duration = 3 meals/exposure event (day).

EP = Exposure Period = 6 years (age 1 to 6 years assumed).
C = Conversion Factor = $10^{-6}$ kg/mg.
BW = Body weight of receptor during averaging period = 14 kg (average for age 1-6 years).
AP = Averaging period = 6 years (receptor age 1-6 years assumed).

Screening Hazard Index

$$HI = (ADD_{soil\ ingestion} + ADD_{dermal} + ADD_{inhalation} + ADD_{produce\ ingestion}) / RfD$$

$$= 1.7E\text{-}04\ mg/kg\text{-}day\ /\ 3.0E\text{-}3\ mg/kg\text{-}day$$

$$= 0.06$$

## Comment Responsiveness Summary
## Characterization of Radiation Dose and Risk Following Remediation of the Ventron Site

| M. Harvey Comment | Alexander/Johnson Clarification | FUSRAP Response |
|---|---|---|
| 1. In accordance with the MCP, chemicals which are present at levels consistent with background are removed from the risk assessment process because, by definition, they pose a level of No Significant Risk. In order to eliminate a chemical from the risk assessment based on background, it must be demonstrated that levels of a chemical at the site are consistent with the background levels of that chemical. Such background comparisons are conducted medium-by-medium. If such a determination can be made, the chemical need not be evaluated in the risk assessment. However, if site levels of a chemical are not consistent with background, exposures to the concentrations present at the site must be evaluated in the risk assessment. In the Risk Characterization Report for the Ventron site, background levels of radionuclides were subtracted from the Exposure Point Concentrations. This is inconsistent with the MCP. EPCs should represent the average concentration to which a receptor is being exposed over time and should not have background levels subtracted. DOE should recalculate the EPCs to include background levels.<br><br>ORS notes that it has stated previously in comments on the Site Characterization Plan (Memorandum dated May 9, 1996) that the background data presented in the Site Characterization Plan are not adequate to characterize background conditions. | 1. The Risk Characterization report indicated that background levels of radionuclides had been subtracted from the exposure point concentrations (EPCs). (See page 5, paragraph 3 of the DOE Characterization report). It was not clear whether the report used site-specific background values or national values. Although subtraction of the background concentrations is a common way to deal with background levels of radiation in dose assessments, it is inconsistent with the way background is addressed under the MCP. Therefore, DOE must either recalculate the EPCs to include the background concentrations of uranium, thorium, and radium or provide a technically defensible argument for not doing so. | Exposure point concentrations for the revised Risk Characterization Report have been recalculated based on the DEP guidance. Statistical analysis of the post-remediation data indicates that the only radiological contaminant of concern is uranium (natural uranium, with U-238 as an indicator). Post-remediation concentrations of radium-226 and thorium-232 are not elevated above background concentrations, so these radionuclides have been dropped from the analysis, in accordance with the DEP guidance. Background concentrations of uranium have <u>not</u> been subtracted from the exposure point concentrations calculated for uranium in the revised analysis.<br><br>With regard to the adequacy of background data, DOE strongly disagrees with the ORS assertion that background concentrations for the radionuclides of potential concern at the Ventron site have not been adequately characterized. As shown in Table 2 in the revised report, background samples have been collected from 12 different locations in the vicinity of the site, and range from 0.37 to 1.76 pCi/g for Ra-226, <0.51 to 1.23 pCi/g for Th-232, and 0.69 to <10.5 pCi/g for U-238. [Note that the upper bound for U-238 is designated as "<", indicating that U-238 was detected in this sample at a level less than the lower limit of quantification (MDA) for the given sample matrix and counting time; the largest background concentration measured for U-238 above the quantification limit was 2.74 pCi/g.] For purposes of comparison, the average (area-weighted) post-remediation concentrations measured at the site were 11 pCi/g for U-238, 0.64 pCi/g for Ra-226 and 0.77 pCi/g for Th-232 (all including background). |

## Comment Responsiveness Summary - Continued
## Characterization of Radiation Dose and Risk Following Remediation of the Ventron Site

| M. Harvey Comment | Alexander/Johnson Clarification | FUSRAP Response |
|---|---|---|
| 2. The risks calculated in the Risk Characterization Report may not represent cumulative site risks to a residential receptor because the Risk Characterization Report has not addressed potential exposures to radioactive contaminants in all contaminated media at the site. The Risk Characterization Report only evaluates five exposure pathways (direct external exposure to soil, soil ingestion, radon inhalation, dust inhalation, ingestion of produce). Other potential exposure pathways such as external exposure to sediment and incidental ingestion of sediment have not been evaluated. In addition, the Report should evaluate whether exposure to groundwater is likely to occur. Under the MCP, a risk characterization must estimate cumulative site risks to appropriate receptor groups. Cumulative risks account for exposures that a receptor may receive from multiple chemicals in multiple media by multiple exposure routes. The Risk Characterization Report should identify all contaminated media at the site and should evaluate all exposures to such media, as appropriate.<br><br>On a related point, the Report states that the sampling data have identified no elevated concentrations of radionuclides in seafoods and therefore, this pathway was found to be insignificant. The Risk Characterization Report should fully describe the sampling program and data on which this statement is based. The Report should also present a compelling justification for eliminating ingestion of seafoods as [a] exposure route in the risk characterization. | 2. DOE's Risk Characterization report identifies several exposure pathways and calculates a cumulative cancer risk from those pathways but "may not represent cumulative site risk" since some other potential exposure pathways were not evaluated. ORS' comment refers specifically to incidental ingestion or dermal contact with sediments from the tidal flats. ORS also indicates that DOE should evaluate whether exposure to groundwater is likely to occur. In general, if an exposure pathway does not exist, it does not need to be evaluated. However, in some cases, for example, exposures to groundwater, the risk assessment should explicitly state why such exposures are not expected to occur and therefore, not evaluated. As will be specified below, there are some other exposure assumptions and pathways that may still need to be evaluated. | The estimates of potential radiation dose and radiogenic cancer risk to hypothetical future receptors at the Ventron site presented in the revised analysis represent cumulative site risk from radioactive contaminants of concern through all viable exposure pathways. Groundwater beneath the site is saline due to the tidal influence and is not potable; therefore, the installation of an onsite well to obtain water for drinking or other household uses is not considered to be a plausible exposure pathway. Potential exposure to residual radionuclides in sediment is included in the analysis through aggregation of the data for soil and sediment; complete exposure pathways are assumed to include direct external exposure, inhalation, and ingestion. Dermal contact with soil and sediment is not considered in the evaluation of cancer risk, in accordance with standard practice for radiological risk assessment and EPA guidance; essentially, the external exposure pathway for radionuclides takes the place of the dermal absorption pathway typically considered for certain chemicals. Dermal exposure is considered, however, in the evaluation of non-cancer risk, in accordance with EPA and DEP guidance.<br><br>Potential ingestion of impacted seafoods is considered as a potential exposure pathway in the RESRAD analysis, but does not contribute significantly to total dose or risk. Sampling data presented in the site characterization report (DOE 1995) for marine biota do not exceed background. |
| 3. The Risk Characterization Report does not evaluate exposures to radioactive contamination in storm sewers and underground utility lines. The Risk Characterization Report should evaluate direct exposure and ingestion exposure to a worker who could potentially come into contact with contamination in storm sewers or utility lines at or near the facility. | 3&4. It is DEP's understanding that all contaminated storm sewers and utility lines are currently being excavated from the site. Likewise, it is DEP's understanding that all buildings, foundations and contamination from beneath the buildings are currently being excavated and will be removed from the site. If these potential exposures no longer exist then they do not need to be evaluated in a Risk Characterization Addendum. However, it would be helpful if an Addendum detailed the available post-demolition/cleanup conditions and contaminant concentrations on the site. | All storm sewers and underground utility lines impacted by radiological contaminants of concern have been removed. Therefore, the utility worker is not considered as a separate exposure scenario. The occupational and residential scenarios considered in the revised analysis are considered to provide bounding estimates of potential radiation dose and risk. |

## Comment Responsiveness Summary - Continued
## Characterization of Radiation Dose and Risk Following Remediation of the Ventron Site

| M. Harvey Comment | Alexander/Johnson Clarification | FUSRAP Response |
|---|---|---|
| 4. The Risk Characterization Report does not evaluate the transport of contaminated onsite soil to surface water from erosion. Such potential impacts should be evaluated in the Risk Characterization Report. In particular, the Report should evaluate the potential for soil erosion from under buildings which may be removed under a future site use scenario. | 3&4. It is DEP's understanding that all contaminated storm sewers and utility lines are currently being excavated from the site. Likewise, it is DEP's understanding that all buildings, foundations and contamination from beneath the buildings are currently being excavated and will be removed from the site. If these potential exposures no longer exist then they do not need to be evaluated in a Risk Characterization Addendum. However, it would be helpful if an Addendum detailed the available post-demolition/cleanup conditions and contaminant concentrations on the site. | Erosion of surface soils is considered in the RESRAD analysis. All buildings have been removed down to the foundation slabs. No radiological contaminants of concern have been identified above action levels below the remaining building slabs. |
| 5. The Risk Characterization Report includes an evaluation of noncancer risks from exposure to uranium via ingestion of produce from an onsite garden. The Risk Characterization Report states that all other soil exposure would be incomplete because it is assumed that all residual radioactive materials would remain below a surface layer of clean soil backfill. ORS has several comments on this point:<br><br>• DOE's statement that all residual radioactive materials would remain below a layer of clean soil must be supported by additional information. As described above, DOE's proposed remedial action for soils and sediment involves only excavation of areas exceeding DOE's cleanup limit for uranium. Given this, it appears unlikely that all areas with contamination below DOE's cleanup limits will be covered with clean fill. However, even if DOE can support its assumption with additional information, the MCP requires that exposures to contamination at depth (up to 15 feet) be evaluated because of the possibility that future excavation could bring contaminated soils to the surface where exposure could occur. | 5. Comment # 5 raises two issues: noncancer risks via ingestion of produce from an onsite garden and "all other soil exposure pathways. ORS has several self-explanatory comments (see memo) which DOE must address.<br><br>At issue is DOE's assertion that all other soil exposure pathways (e.g., dermal contact, incidental ingestion) would be incomplete because residual radioactive materials would remain below a surface layer of clean fill. DOE had indicated that fill would be placed at the site at depths of 0.15 to 0.8 meters, or approximately 6 to 32 inches. It is not clear from the Risk Characterization Report whether the clean fill will only be placed as backfill in areas where excavation is expected to occur or if it will also be placed as cover over the entire site. This should be explicitly stated. Based on a telephone conversation subsequent to the receipt of the Risk Characterization report, it is DEP's current understanding that clean fill will only be placed in excavated areas and that there will likely be areas where surface soils have radiological contamination at or near the maximum cleanup guidelines. Since the issue here is whether these guidelines represent "no significant risk" under the MCP, the related exposure pathways (i.e., dermal contact, incidental ingestion) must be evaluated. Even if a minimum of 6 inches of backfill were to cover the entire site, this depth is not beyond the planting depth requirement of most plants, shrubs and trees and is well within the depth of root vegetables and flowering | In the revised analysis, no placement of clean soil fill is assumed. This is considered to be a highly conservative assumption (i.e., an assumption likely to overestimate potential exposures to residual radioactive materials at the site), because the post-remediation sampling data represents soil/sediment concentrations measured at the excavation depth (i.e., at the "bottom of the hole"). After the placement of fill materials, as necessary to restore the site to grade, the average concentrations for the residual radionuclides would be reduced by a significant (but unquantified) amount. In addition, only portions of the site identified to contain residual radioactive materials measurably above background levels were considered in calculating the EPCs. Throughout many areas of the site, radiological data were not significantly elevated above background levels. Therefore, the exposure point concentrations used in the revised analysis are considered to represent the average residual radionuclide concentrations in the contaminated areas of the site only, and exceed average concentrations for the entire site (including both impacted and nonimpacted areas). Thus, the estimated dose and risk presented in the revised analysis would be expected to provide highly conservative estimates of actual dose/risk. |

## Comment Responsiveness Summary - Continued
## Characterization of Radiation Dose and Risk Following Remediation of the Ventron Site

| M. Harvey Comment | Alexander/Johnson Clarification | FUSRAP Response |
|---|---|---|
| 5. Continued<br><br>• The evaluation of noncancer risks from uranium exposure only considers ingestion of uranium via soil ingestion and produce consumption. The evaluation of noncancer risks should also include dermal contact with soil.<br><br>• Noncancer risks from exposure to uranium should be considered in DOE's risk assessment in addition to the risk assessment that will be done at a later date for chemical contaminants at the Ventron site. As stated previously, the MCP requires an evaluation of cumulative cancer and noncancer risks at a site. Therefore, the evaluation of noncancer risks should include the contribution from both chemical and radiological contaminants. ORS notes that for cancer risks, it is not appropriate to add cancer risks from chemicals with radionuclides (EPA 1991). Therefore, the cancer risks from radionuclides are compared with MCP risk limits separately from cancer risks from chemicals. | bulbs. Therefore, it is not unrealistic to expect exposures to occur in any type of onsite gardening or landscaping, particularly in the shallower areas of backfilling.<br><br>In addition to this, it is DEP's understanding that there is a substantial body of research indicating that under certain conditions related to soil mineralogy and pH, some plants will selectively take up uranium and other radionuclides from both soil and groundwater, thereby concentrating them in the body of the plant. While this has evidently been useful at some sites as a remediation strategy, it suggests another potential exposure pathway that should be evaluated. If a level of "no significant risk" cannot be assured, an Activity and Use Limitation may have to be placed on the property following the cleanup, restricting the agricultural/gardening activities that might otherwise take place. Since it is DEP's understanding that a Class A Response Action Outcome with no Activity and Use Limitation is desired by the property owner, the final site-wide risk assessment must ultimately evaluate all potential exposure scenarios. | The RESRAD computer code includes consideration of the bioaccumulation of radionuclides of concern by plants from soil and groundwater, based on radionuclide-specific bioaccumulation factors from the scientific literature. The dose and risk resulting from such bio-uptake is reflected in the plant ingestion pathway in RESRAD.<br><br>Noncancer risks from uranium exposure via the soil ingestion, plant ingestion, and dermal exposure pathways have been evaluated using DEP-recommended methods. The dermal pathway is subject to large uncertainties due to the lack of available dermal absorption data for uranium.<br><br>While we cannot presume what disposition of this property is intended by the owner, the revised radiological risk characterization report clearly indicates a RAO of "no significant risk", such that no Activity and Use Limitations will be required as a result of residual uranium. |
| 6. As stated in the exposure scenario section, a resident was assumed to spend 16 hours per day indoors and 0.5 hours per day outdoors. The sources for this assumption are EPA's Exposure Factors Handbook and EPA's Supplemental Guidance: Standard Default Exposure Factors. Based on a review of these documents, ORS cannot find a reference to 0.5 hours per day.<br><br>For the purposes of risk characterizations performed under the MCP, the receptor group of concern should be characterized by those individuals whose activities (described by the frequency and duration of the activities) represent a *full and unrestricted use* of the site. ORS believes that assuming that a | 6. This item in ORS' memo is self explanatory; it may be addressed in a Risk Characterization Addendum. | The exposure parameters for indoor and outdoor occupancy (16 hours/day indoors, 0.5 hours/day outdoors) used in the May 1996 report are the standard values recommended by USEPA for Superfund risk assessments (EPA Exposure Factors Handbook, 1989). [Note: The Exposure Factors Handbook actually expresses the outdoor exposure frequency as 3.07 hours/week (Section 5.3.3).] More recently, EPA has recommended slightly reduced values of 14.9 hours/day indoors and 0.4 hours/day outdoors in the draft radiation site cleanup regulation 40 CFR 196. In both cases, these values represent daily occupancy averaged over 350 days/year and throughout the US; it would seem reasonable to assume that outdoor exposures at this site should be lower than the US |

## Comment Responsiveness Summary - Continued
## Characterization of Radiation Dose and Risk Following Remediation of the Ventron Site

| M. Harvey Comment | Alexander/Johnson Clarification | FUSRAP Response |
|---|---|---|
| 6. Continued<br>resident spends 0.5 hours per day outdoors in his or her yard does not represent "full use" of a backyard. This assumption is documented in a Memorandum from M. Harvey to C. Rowan West dated September 4, 1996. DOE could use an alternative assumption if there were reasons to believe that residents spend less time outdoors at this site than at other areas. However, such an argument may not be plausible given the nature of the site. | | average values due to the colder-than-average climate. Nevertheless, in deference to the DEP guidance, the DEP-recommended parameter values for outdoor occupancy have been used in the revised analysis for the hypothetical future resident; EPA-recommended values have been retained for indoor occupancy since these appear to be more conservative than DEP recommendations. For the occupational scenario, a standard 8-hour work-day for 50 weeks/year has been assumed (2000 hours/year). |
| 7. The report correctly states that DEP's default exposure frequency for residential exposures is approximately 150 days per year (5 days per year from April through October). However, such exposure frequency is for outdoor exposure. For the record, DEP notes that it also has a default exposure frequency of 212 days per year (7 days per week from October through April) for indoor exposures to a young child aged 1 to 6. | 7&8. These items in ORS' memo are clarifications for the record and do not require an amendment. | As noted in the previous comment response, DEP-recommended occupancy factors and exposure frequencies have been adopted for the revised analysis where these values are more conservative than EPA-recommended values. *[Note: A copy of the September 4, 1996, memorandum from M. Harvey to C. Rowan West referenced in Comment 6 is requested from DEP to provide better documentation for the DEP exposure assumptions.]* |
| 8. Exposure Point Concentrations were calculated as the 95% percentile confidence limit of the mean ($UCL_{95}$). This is standard EPA practice and DEP recognizes that a benefit of this practice is that it compensates for sampling uncertainty. However, it is DEP practice to calculate the EPC as the arithmetic mean. A benefit to using the arithmetic mean rather than the $UCL_{95}$ is that the arithmetic mean concentration used in the risk assessment can also be used to generate cleanup requirements. | | In the revised analysis, exposure point concentrations for uranium (the only radiological contaminant of concern) have been calculated as arithmetic mean values rather than the $UCL_{95}$ values recommended by EPA for Superfund risk assessment. The area-weighted arithmetic average of the post-remediation sampling results (i.e., area-weighted average of the average residual U-238 concentration in each remediated area = 11 pCi/g) was used to provide representative estimates of dose and risk. |
| 9. The Risk Characterization Report does not clearly present the data that were used to calculate the EPC. The Risk Characterization should provide enough detail so that the EPC can be reproduced easily. | 9. This item in ORS' memo is self explanatory; DOE may provide additional clarification in an addendum. | All data used to compute the exposure point concentrations are now tabulated in Appendix A of the revised report. |
| 10. The MCP requires that separate EPCs be calculated for hotspots. Hotspots are specifically defined in the MCP at 310 CMR 40.0006. The Risk Characterization Report does not include an evaluation of whether there are any hotspots at the Ventron site. The Report should be revised to address hotspots if they exist. | 10. Since the maximum radionuclide concentration at the site following the remediation will be within the site-specific cleanup guidelines, it does not appear that there will be any "hotspots" as defined in the MCP. | No "hotspots", as defined under 310 CMR 40.0006, have been identified at the Ventron site (i.e., no individual samples exceeding ten times the average). Therefore, no hotspot analysis is required. |

## Comment Responsiveness Summary - Continued
## Characterization of Radiation Dose and Risk Following Remediation of the Ventron Site

| M. Harvey Comment | Alexander/Johnson Clarification | FUSRAP Response |
|---|---|---|
| 11. Table 3 provides best estimates of cancer risk as well as upper bound estimates of cancer risk. The upper-bound estimate of cancer risk for the residential scenario slightly exceeds DEP's risk management criterion of $1 \times 10^{-5}$. ORS notes that "upper-bound" and "best estimate" are EPA terms. In exposure assessments done under the MCP, ORS uses a mix of conservative and mid-range exposure parameters to produce a realistic upper-end exposure estimate which will be protective of people making full and unrestricted use of the site. Default exposure parameters are contained in DEP Risk Assessment Guidance (DEP 1995).<br><br>The Risk Characterization Report states that the upper-bound estimate is less plausible than the best estimate and is not considered to accurately reflect post-remediation conditions at the site. However, the Report does not clearly present the exposure assumptions used to generate the upper-bound estimate. If DOE believes that the best estimate rather than the upper-bound estimate is more reasonable for post-remediation conditions, it must demonstrate that assumptions used to generate the best estimate are consistent with DEP's regulations and guidance. | 11. It appears that DOE's use of EPA risk guidance and use of the upper-bound estimate of risk may in fact be more conservative than the MCP requires. No amendment is required in this regard. ORS also commented that DOE "must demonstrate that assumptions used to generate the best estimate (of risk) are consistent with DEP's regulations and guidelines". Specifically, if the changes outlined in ORS' memo and in this letter are adequately addressed, DEP will accept those changes as sufficient demonstration that the evaluation of risk from radiological materials at this site is consistent with DEP's regulations and guidance. | The presentation of separate "upper-bound" and "best estimate" values of the predicted radiation dose and risk to hypothetical future receptors at the site has been eliminated from the revised report. A single estimate is now presented for each exposure scenario (occupational, residential) considered, based on the DEP-recommended exposure parameters. All exposure parameter values used in the analysis are tabulated in Appendix B of the revised report. |
| 12. In an effort to relate DOE's dose limits to cancer risks from radionuclides, DOE used the RESRAD computer code, version 5.61, to calculate potential radiation doses and cancer risks to receptors. The RESRAD code calculates cancer risk using EPA-published cancer slope factors for individual radionuclides. ORS has the following comments on the RESRAD model.<br><br>• The input parameters for the RESRAD code used to calculate risk include an assumption that radioactive contamination is covered by a depth of either 0.8 or 0.15 meters of clean soil. As stated in a previous comment, DOE's proposed remedial action for soils and sediment involves excavation only of areas exceeding DOE's cleanup limit for uranium. Given this, it appears unlikely that all areas with | 12. Comment # 12 also raises several issues. The first issue, regarding the site being covered with clean fill, was already discussed above in item 5. The issue of radon is raised next. Regarding radon, if it has come to be located at the site as a result of the Manhattan Engineering District activities which DOE is under authority to remediate, then it needs to be evaluated in the risk assessment. If radon at the site is consistent with background, it need not be evaluated in the risk characterization. (See ORS Comment # 1 for additional information on background.) The other issues raised in ORS' comment # 12 are mainly for clarification purposes. | As noted previously in the response to comment 5, the revised analysis assumes that no clean fill material is present above the soil containing residual radioactive materials at the exposure point concentration discussed above. Therefore, this issue is now moot. |

## Comment Responsiveness Summary - Continued
## Characterization of Radiation Dose and Risk Following Remediation of the Ventron Site

| M. Harvey Comment | Alexander/Johnson Clarification | FUSRAP Response |
|---|---|---|
| 12. Continued<br><br>contamination below DOE's cleanup limits will be covered with clean fill. DOE should assume that exposure to contamination at depth occurs unless it can be demonstrated that exposure to soil at depth is restricted and will remain so into the future.<br><br>• It appears that risks from exposure to radon from uranium contamination at the site were not included in the cancer risk estimates presented in Table 3. In accordance with the MCP requirement to evaluate cumulative risks to receptors from all exposure pathways, radon risks should be included.<br><br>• Based on review of the RESRAD data files, it appears that DOE used an exposure duration of 30 years in the risk calculations. However, this is not clearly stated in the Report. The Risk Characterization Report should clearly state the exposure duration assumed.<br><br>• Review of the RESRAD data files indicates that a value different from the default RESRAD consumption rate for fruit, vegetables, and grains was used. However, Appendix A states that the default value was used. The Report should correct this inconsistency and should provide the source of the value.<br><br>• The following parameters were used in the RESRAD calculations but are not included in Appendix A. DOE should add these parameters (and their values) to Appendix A: cover erosion rate, and inhalation shielding factor. | | Regarding consideration of the inhalation of radon and its decay products, FUSRAP does not agree that the radiation dose and risk from this exposure pathway should be considered jointly with other pathways. Rather, radon represents a very special case, as recognized throughout the radiation protection community and acknowledged by the development of specific concentration limits for radon decay products in indoor air. FUSRAP protocols require that potential exposure to radon decay products should be evaluated by comparison to the appropriate concentration limits (e.g., 0.02 working level). However, in deference to the DEP request, the radon pathway is included in the revised analysis in this instance only and for DEP information only. In this case, however, this pathway is a negligible contributor to dose and risk.<br><br>As indicated in the comment, the exposure durations assumed for the original and revised analyses were 30 years for the residential scenario and 25 years for the occupational scenario. These assumptions are more clearly stated in the revised report.<br><br>RESRAD default values have been used for these parameters in the revised analysis. However, the value for the fraction of total fruits and vegetables intake produced in a home garden is taken from the revised EPA Exposure Factors Handbook (August 1996), which recommends values for the Northeast Region as 0.005 for fruits and 0.038 for vegetables (Table 12-71), for a total of 0.043 for homegrown produce.<br><br>The cover erosion rate parameter values was inadvertently omitted from the draft report; since no cover is assumed in the revised analysis, the cover erosion rate is no longer applicable. The "inhalation shielding factor" is labeled in Appendix A of the draft report as the "fraction of outdoor dust present indoors". Pertinent exposure parameter values used in the revised analysis are tabulated in Appendix B of the revised report. |

## Comment Responsiveness Summary - Continued
## Characterization of Radiation Dose and Risk Following Remediation of the Ventron Site

| M. Harvey Comment | Alexander/Johnson Clarification | FUSRAP Response |
|---|---|---|
| Concluding Comment:<br><br>ORS notes that the Risk Characterization Report prepared by DOE is based on an estimate of soil concentrations that will exist after remediation occurs. Thus, this risk characterization is not a valid basis for a RAO until cleanup occurs and sufficient post-remediation sampling is performed to confirm that the estimated soil concentrations have been reached. | As ORS pointed out in the last paragraph of their memo, the issues raised in this letter and in the ORS memo are in response to the DOE risk characterization of the proposed cleanup concentrations only. Once the remediation and confirmatory sampling are completed, the results should be forwarded to DEP's Northeast Region. Any preliminary results from the post-remediation sampling which can be incorporated into a Risk Characterization Addendum will be useful for demonstrating that certain exposure pathways (discussed above) have been eliminated. | While the original submittal of the Risk Characterization Report (May 1996) was based on predicted values of post-remedial radionuclide concentrations in site soils and sediments, the revised report is based entirely on the actual post-remediation sampling results. Thus, the revised report represents a highly conservative analysis of the actual post-remediation site conditions, and no subsequent analysis should be required.<br><br>As noted in the previous comment responses, the exposure point concentration for residual uranium was taken to be the area-weighted arithmetic average of the post-remediation sampling results for all remediated areas. While the area-weighted average was considered to be the most representative value for this analysis due to the differing data densities collected within different remediated areas, the conclusions of the analysis would be unchanged if the simple arithmetic average of all sampling results was used. The exposure point concentrations for residual uranium are considered to be highly conservative, since all areas of the site identified to exceed approximately twice the background radiation levels were remediated; therefore, the non-remediated portion of the site could be assumed to contain uranium concentrations between one and two times the background levels, thus reducing the site-wide average concentration of uranium. In addition, the post-remediation sampling data represents the concentrations measured at the final excavation depth (i.e., at the "bottom of the hole"), and does not consider the placement of clean fill material to restore the excavated areas to grade; consideration of this fill material would lead to further reductions in the average site-wide concentration of residual uranium.<br><br>Based on the analysis presented in the revised Risk Characterization Report, the very low levels of residual uranium present at the Ventron site clearly present no significant risk of harm to human health, safety, public welfare, or the environment. |

**Department of Energy**

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831— 8723

140242

March 15, 1996

Ms. Lisa Alexander
Massachusetts Department of
Environmental Protection
10 Commerce Way
Woburn, Massachusetts 01801

Mr. Thomas F. O'Connell
Massachusetts Department of
Health/Radiation Control Program
305 South Street
Jamaica Plain, Massachusetts 02130

Dear Ms. Alexander and Mr. O'Connell:

**VENTRON SITE - TRANSMITTAL OF DOSE CALCULATION AND REMEDIAL ACTION APPROACH**

The purpose of this letter is to transmit the dose calculation and request your concurrence with the remedial action approach for Buildings A and A-1 at the Ventron site, Beverly, Massachusetts. The enclosed dose assessment evaluates the potential one-time dose to a hypothetical site worker involved in all phases of demolition of Buildings A and A-1, and a one-time dose to a hypothetical recycling worker involved in the smelting of steel beams and pipes from Buildings A and A-1. This analysis indicates that these buildings present no significant radiological risk, and can be demolished without any radiological decontamination efforts along with the other buildings on site.

The Ventron site in Beverly, Massachusetts was designated for inclusion into the Department of Energy's Formerly Utilized Sites Remedial Action Program (FUSRAP) in December 1985. The Ventron Corporation, formerly Metal Hydrides Corporation, was under contract to the U.S. Army Corps of Engineers Manhattan Engineer District (MED) from 1942 to 1947 to convert uranium oxide to uranium metal powder. In 1982, Ventron became a division of Morton Thiokol, Inc., which was renamed Morton International in 1990. Prior to and subsequent to MED-related activities, independent commercial work was performed by Morton at the Ventron site until 1986. The data used in the calculation was obtained from characterization efforts performed in 1992 and February 1996. The effort in 1996 was to fill data gaps in the 1992 survey. The data has shown that radioactive contamination on the steel, wood, and masonry surfaces is primarily fixed with very little transferable contamination. The combined data from the 1992 and 1996 surveys provided enough data to complete the enclosed dose calculations. This dose calculation was performed to determine the level of remedial action required on buildings A and A-1. We have found that the dose from residual radioactivity in Buildings A and A-1 is so low that no remedial action is necessary prior to demolition.

All site operations have ceased, and the owner is currently in the process of demolishing the on-site buildings. Based upon discussions with the property owner, Buildings A and A-1 will be demolished during the current year. All masonry material will be crushed with a portion used as on-site backfill and the rest disposed of in a construction landfill. All steel will be recycled, and all other materials will be sent to a construction landfill. The floor slabs will be left and removed by DOE during the subsurface remedial action. There are no plans to occupy or utilize the structure in the interim.

Radiation dose limits for members of the general public are outlined in DOE Order 5400.5 The maximum allowable annual dose to a member of the general public from all sources and pathways is 100 millirem (mrem) above background. DOE also requires that all radiation exposures must be reduced as low as reasonably achievable, taking into account technical, economic, and social considerations. EPA and NRC also invoke the 100 mrem per year (mrem/yr) dose limit for all sources and pathways, and also provide additional limits for specific sources. NRC proposed regulations for decommissioning radiologically contaminated facilities would establish a dose limit of 15 mrem/yr above background, and draft EPA regulations would also establish a similar requirement. Current Massachusetts State regulations under 105 CMR 120.291 impose an even lower dose limit of 10 mrem/year.

The enclosed analyses demonstrate that DOE's proposed approach for the Ventron site would satisfy all of the above requirements. Soil (volumetric) guidelines for uranium are site specific, based upon site characteristics and use. The site specific uranium soil guideline for the Ventron site is 100 picoCuries per gram (pCi/g) for total uranium.

As shown in the calculation, contamination on the walls, overheads, and floors of Buildings A and A-1 will not result in a radiation dose above 10 mrem to any member of the general public. The maximum dose to a hypothetical demolition worker is estimated to be about 2.5 mrem, and off-site exposure to the general public would be much less. Of the 2.5 mrem, approximately 1.8 mrem is attributable to removal of pipes from Buildings A and A-1. The maximum dose to a hypothetical recycling worker is estimated to be 5.0 mrem. Given the low radiation dose calculated to result from wall, overhead, and floor contamination (and the fact that these calculations were very conservative and likely over-estimate the dose), no remedial action needs to be performed. Also, calculations were performed for the use of the slag from the steel recycling as roadbed material and the disposal of the concrete estimated at 0.33 mrem/yr and the landfill disposal rubble and wood in a

landfill. Both calculations assumed a person in the proximity for 1 hour per day, 7 days a week. The dose from the slag was at $7.7 \times 10^{-4}$ mrem/yr. In addition to the dose calculations, a calculation was generated to determine the average radioactive concentration that would be present in the crushed masonry material. The concentration was calculated to be 2.31 pCi/g which is well below the site specific guideline of 100 pCi/g for total uranium, and also within the range of typical background concentrations for uranium in soil and building materials.

Prior to releasing the buildings to Morton for demolition, DOE will either remove or decontaminate to below DOE Order 5400.5 guidelines, all remaining non-structural equipment which includes a leach tank, lathe, drill press and various other pieces of equipment. After the buildings are demolished, DOE will then mobilize to excavate and transport to a licensed disposal facility all soil exceeding DOE guidelines.

As Morton is in the process of demolishing other buildings on the site and will proceed to buildings A and A-1 after completion of the other buildings, if at all possible your concurrence with this approach is requested by the end of March 1996.

We believe this is an appropriate approach given site conditions and the final disposition of Buildings A and A-1. Please contact me at (423) 576-9441 with any questions you may have regarding this data or the proposed approach.

Sincerely,

James D. Kopotic

James D. Kopotic, Site Manager
Former Sites Restoration Division

cc: Alicia Raddatz, Morton, Inc.

**Bechtel**

*Oak Ridge Corporate Center*
*151 Lafayette Drive*
*P.O. Box 350*
*Oak Ridge, Tennessee 37831-0350*

*Telephone: (423) 220-2000*

140242

Job No. 14501, FUSRAP Project
DOE Contract No. DE-AC05-91OR21919
Code: 5080/WBS: 127

Former Sites Restoration Division
Oak Ridge Operations Office
P.O. Box 6974
Oak Ridge, TN 37831-6974

Attention: Jim Kopotic
Site Manager - Ventron
Former Sites Restoration Division

Subject: Records Release

Calculation No. 127-CV-006
Title: Dose Assessment for Ventron Buildings A and A-1

Dear Mr. Kopotic:

In accordance with your request, a copy of the identified calculation is forwarded herewith.

Use of these calculations by persons without access to the pertinent factors and without proper regard for their purpose could lead to erroneous conclusions.

Should it become necessary to use this calculation in your work in the future, it is suggested that the calculation be reviewed with authorized Bechtel personnel to ensure that the purposes, assumptions, judgments and limitations are thoroughly understood. Bechtel cannot assume responsibility for the use of this calculation not under our direct control.

Sincerely,

James C. McCague
Project Engineering Manager - FUSRAP

JCM:sew:ET-0151

Enclosure: Calculation 127-CV-006

140210

# CALCULATION COVER SHEET

Bechtel National, Inc.

Project FUSRAP

Job No. 14501

Discipline Engineering and Technology Calc. No. 127-CV-~~001~~ 006 RAR

Subject Dose Assessment for Ventron Buildings A and A-1

Computer Program _____ Program No. _____

Committed Calculation [X] Preliminary [ ] Superseded [ ]

| Rev | Shts | Originator | Checker | Reviewer | Approval | Date |
|---|---|---|---|---|---|---|
| 0 | 49 | Andrea K. George 3/12/96 | 3/12/96 Timothy M. Kay | Timothy M. Kay for Melissa Queen | | 3/12/96 |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Summary of Revision

| Microfilmed: | Rev | Date | Spool Number | Rev | Date | Spool Number |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |

4.67 5159.1

## PURPOSE

This calculation estimates doses from Ventron Buildings A and A-1 if the buildings are demolished. Data used for this calculation can be found in the "Characterization Report for the Ventron Site" (DOE 1995) and the data packages D-24215 and D-24216. Data contained in D-24215 and D-24216 was collected in February 1996; a technical memorandum will be issued presenting the results.

The basis for this assessment is:

- Contamination at the Ventron site is found only on limited portions of Buildings A and A-1. The total curie content of all affected building components is approximately 5.02 mCi.
- Buildings A and A-1 will be demolished by a civilian demolition firm.
- The site owner has indicated that all masonry material will be crushed with a portion used as backfill and the rest disposed of in a construction landfill. All steel will be recycled and all other materials will be sent to a construction landfill.

## REFERENCES

DOE, 1983. "Pathways Analysis and Radiation Dose Estimates for Radioactive Residues at Formerly Utilized MED/AEC Sites", ORO-832, Oak Ridge, Tenn. (March).

DOE, 1989. "A Manual for Implementing Residual Radioactive Material Guidelines", DOE/CH/8901 (June).

DOE, 1990. Order 5400.5, "Radiation Protection of the Public and Environment", (June).

DOE, 1995. "Characterization Report for the Ventron Site" , DOE/OR/21950-1011, Oak Ridge, Tenn. (December).

NRC, 1990. "Residual Radioactive Contamination from Decomissioning, Technical basis for translating contamination levels to annual dose", Draft report for comment, NUREG/CR-5512, PNL-7212, (January).

Paustenbach, Dennis J., 1989. *The Risk Assessment of Environmental Hazards*, John Wiley & Sons, Inc. New York, New York.

RESRAD computer code, Version 5.61, Released 8/28/95.

Schleien, Bernard, ed., 1992. *The Health Physics and Radiological Health Handbook*, Scinta, Inc. Silver Spring, Maryland.

Waier, Philip R., Senior. Ed. *Means Building Construction Cost Data*, R.S. Means Company, 1996.

## ASSUMPTIONS

1. Bldgs. A and A-1 at the Ventron site are contaminated with processed uranium metal. U-238, U-234, and U-235 are present in their natural activity ratio of 1:1:0.046 (data supporting this ratio are contained in data package D-23904). It is conservatively assumed that all radiation detected during beta/gamma surveys is attributable to U-238. The survey instruments are calibrated to detect a 2.2 MeV gamma ray emitted from a strontium-90/yttrium-90 calibration source. The strontium-90/yttrium-90 emission is essentially the same energy as the 2.28 MeV primary beta emission from the short-lived U-238 decay product, protactinium-234m.

2. Among the principle exposure pathways - inhalation, ingestion, and external radiation exposure - the dose from inhalation far exceeds the contribution from the other pathways. Therefore, except for overhead demolition, only the dose from inhalation is calculated. The highest amount of hand contact with contaminated material is expected in the case of overhead demolition and the dose has been calculated to illustrate that, in the worst case, the dose from subsequent ingestion from hand contact with the overheads is well below 1 mrem.

3. Dose conversion factors for inhaled and ingested radioactivity are taken from the RESRAD computer code version 5.61. Dose calculations incorporate the dose from short-lived decay products of U-238 and U-235.

4. Bldgs. A and A-1 will be demolished by a civilian demolition firm. The maximally exposed individual as a result of residual radioactivity would be a hypothetical demolition worker who participates in all phases of the demolition or a hypothetical recycling worker who participates in all phases of metal recycling. A separate firm performs the recycling so the workers would not be the same.

5. The breathing rate for the exposed worker is conservatively assumed to be 20 $m^3$ per 8 hr shift.

6. Mass loading assumptions are based on the following:

   When dust is produced during normal construction activities, such as handling building rubble, a mass loading factor of 600 $\mu g\ m^{-3}$ is employed (DOE 1983). It is conservatively assumed that 100% of the dust is radioactively contaminated and that 30% of the dust is respirable (Paustenbach 1989). Thus, the respirable mass loading factor is 180 $\mu g/m^3$.

   When a recycling worker is exposed to slag after the steel beams and pipes have been smelted, the mass loading factor is assumed to be 100 $\mu g/m^3$ (NRC 1990) because the slag is a solid mass.

Thus, the respirable mass loading factor is 30 $\mu g/m^3$.

7. The respirable airborne contaminant particulates are assumed to have a size of 1 $\mu m$ activity median aerodynamic diameter (AMAD).

8. The dose calculations are presented for each phase of a hypothetical demolition in order to highlight the maximum exposure associated with each building component. This approach is conservative in that the likely scenario would entail rapid, mechanical, destruction of the structure (i.e. without individual phases) and subsequent removal of the debris. The latter tactic would to some extent quench potential airborne contamination as the structure is dropped.

The hypothetical demolition phases representing each of the building components and significant conditions/assumptions are as follows.

**Wall Demolition**: Contamination is on the surface of some walls within buildings A and A-1. Smear samples for removable surface activity were all below DOE 5400.5 guidelines. Walls are constructed of a variety of materials with large bays of windows. Demolition rates are taken from Waier 1996 and assume a crew of 8 laborers, two jackhammers, and a front-end loader. This crew is designated as B-5 in Waier 1996.

In addition to the initial plume, contaminated dust would be resuspended as rubble is removed. The duration of exposure will depend on the volume of rubble to be removed and the rate it is removed. A work crew with a front loader with a 1.25 $m^3$ capacity can load 80 $m^3$ per hour (Waier 1996). Because of the irregular sizing of the building rubble, it is plausible that the work may go slower and a conservative value of 40 $m^3$ per hour is used.

Since buildings A and A-1 have numerous rooms, a simplifying assumption was made to determine surface contamination levels. On each wall that showed any contamination above DOE Order 5400.5 guidelines, all surface contamination readings were averaged. The maximum of these averages was assumed to be present over the entire surface area of all contaminated walls. This is a very conservative assumption because the radiological contamination in buildings A and A-1 is spotty.

**Pipe and Overhead Demolition**: Contamination is assumed to be on the upper horizontal surfaces of the overhead metal and wood structure and iron pipes in building A. Building A-1 contains piping but does not contain any steel or wood beams. The ceiling in building A-1 is made entirely of concrete. Thus, a separate calculation for the pipes in building A-1 was not performed and the dose from the pipes in building A-1 is included in the dose from the overhead components in building A.

Demolition of these buildings will include salvage of the pipes and steel beams. The metal will be recycled by smelting while the wood will be disposed of in a construction landfill.

All contaminated pipes are assumed to be contaminated at levels equivalent to the average survey reading found on pipes which was 9,970 dpm/100 $cm^2$. All horizontal surfaces on contaminated steel beams are considered to be contaminated at the average survey reading found on steel beams which was 3,901 dpm/100 $cm^2$. All horizontal surfaces on contaminated wood beams and window sills are considered to be contaminated at the average survey reading found on wood which was 5,065 dpm/100 $cm^2$. The contamination is from deposited dust which is assumed to be 0.1 in. thick.

The primary exposure pathways are inhalation and ingestion. The activity generating the most airborne contamination will entail toppling the supporting beams and allowing the beams to fall to the ground where they will subsequently be sized for transport by cutting. Airborne contamination will be released as: (1) the beams fall to the ground; (2) the beams are cut for transport; and, (3) the beams are removed. Assuming all beams are felled in a very short time frame, the contaminated plume from any one beam falling will not have dissipated when the next beam is dropped; thus, the plume of airborne contamination will embody all the contamination present on the beams.

Personal contamination (and subsequent ingestion) will occur as the beams are handled during cutting and removal.

**Metal Recycling**: Potential exposures from recycling of the steel beams and pipes were considered for two activities:

- sand blasting of the metal to remove paint so the smelter will accept the metal
- exposure from the discarded slag after melting.

The same breathing rate used for demolition (20 $m^3$ per 8 hours) is used for the recycling worker. The sandblasting scenario assumes a dust loading of 180 $\mu g/m^3$; however, common construction practice for sandblasting is to wear a respirator.

The maximum exposure to the waste slag would occur if the slag was dumped on the ground in a waste area. This exposure scenario includes the inhalation, ingestion, and external pathways. The mass loading factor for inhalation exposure to slag after melting is 30 $\mu g/m^3$ because the slag is primarily a solid mass. Actually, slag is often used as roadbed material which is usually under at least 6 inches of gravel and asphalt. The resulting exposure scenario includes only the external pathway because the material is no longer available for inhalation or ingestion. A dose estimate for the roadbed exposure scenario is also included in this calculation.

**Floor Demolition**: Contamination is on the surface of portions of the floors within buildings A and A-1. Smear samples for removable surface activity were all below DOE 5400.5 guidelines. Floors are constructed of 4 in. concrete slabs. Demolition rates are taken from Waier 1996 and assume a crew of 8 laborers, two jackhammers, and a front-end loader. This crew is designated as B-5 in Waier 1996. In addition to the initial plume, contaminated dust would be resuspended

as rubble is removed.

Since buildings A and A-1 have numerous rooms, a simplifying assumption was made to determine surface contamination levels. Within each room that showed any contamination above DOE Order 5400.5 guidelines, all surface contamination readings on the floor were averaged. The maximum of these averages was assumed to be present over the entire surface area of all contaminated floors. This is a very conservative assumption because the radiological contamination in buildings A and A-1 is spotty.

**Crusher operations:** A portion of concrete rubble from the demolition of buildings A and A-1 will be crushed and used as backfill on site. The remainder will be disposed of in a construction landfill. It is unknown at this time how much of the material will be crushed; therefore, the conservative assumption was made for the purposes of this calculation that all concrete rubble will be crushed. The processing rate of the crusher was developed from BNI experience with crushing operations.

**Landfill disposal:** The site owner has indicated that wood and any masonry rubble that is not used as backfill will go to a construction landfill for disposal. A calculation was performed assuming all wood and masonry material is disposed of in a landfill. This assumption is more conservative than assuming that the masonry material is used as backfill and left on-site because the landfill will have a minimum daily soil cover of only 6" whereas the backfill used on-site will probably have at least 6" of soil in order to grow grass or will have a building with a concrete slab built on top of the backfill.

Dose from the material disposed of in a landfill is estimated by using the RESRAD computer code, Version 5.61.

9. The actual calculations were done in Microsoft EXCEL, except for the landfill disposal, and printouts are attached. Example calculations for each phase will be shown below.

## CALCULATION

### Wall Demolition

Since buildings A and A-1 have numerous rooms, a simplifying assumption was made to determine surface contamination levels. On each wall that showed any contamination above DOE Order 5400.5 guidelines, all surface contamination readings were averaged. The maximum of these averages was assumed to be present over the entire surface area of all contaminated walls in both buildings, which was 24,434 dpm/100 $cm^2$. This is a very conservative assumption because the radiological contamination in buildings A and A-1 is spotty.

EXCEL printouts for the wall demolition of building A are contained in Attachment A and for building A-1 in Attachment B. The dose for demolition of all walls in building A and removal of the associated rubble is estimated to be 0.07 mrem. The total amount of U-238 activity present on the walls in building A is estimated to be 0.819 mCi. The dose for wall demolition and rubble removal of Building A-1 is estimated to be 0.02 mrem with a total U-238 activity of 0.586 mCi. A mass loading factor of 180 $\mu g/m^3$ was assumed for all demolition activities.

The following example explains step-by-step the calculations in Attachments A and B.

**Building A sheet rock walls:**

Thickness: 0.5 inches (1.27 cm)
Effective density: 1.8 $g/cm^3$
Mass under 100 $cm^2$ survey area: 229 g
Average activity in survey area: 24,434 dpm/100 $cm^2$ (11,106 pCi/100 $cm^2$)

Average concentration:

$$(24{,}434 \text{ dpm}/100 \text{ cm}^2)(\text{pCi} / 2.2 \text{ dpm})(100 \text{ cm}^2 / 229 \text{ g})$$
$$= 48.58 \text{ pCi/g}$$

The mass loading factor is 180 $\mu g/m^3$; therefore the initial airborne concentration is:

$$(48.58 \text{ pCi/g})(180 \ \mu g/m^3) = 8.75 \times 10^{-3} \text{ pCi/m}^3$$

The dose to the hypothetical maximally exposed individual will depend on the duration of exposure. The duration of exposure will depend on the amount of wall to be removed and the rate it is removed. A work crew with a front loader can demolish sheet rock walls at a rate of 1000 $ft^2$ per day (p.38 Waier 1996). The total area of sheet rock wall in building A is 1011 $ft^2$.

The duration of the demolition of the sheet rock walls is:

$$((1011 \text{ ft}^2)/(1000 \text{ ft}^2 /\text{day}))\ (8 \text{ hr/day}) = 8.09 \text{ hrs}$$

The inhalation intake is:

$$(0.00875 \text{ pCi/m}^3)(2.5 \text{ m}^3 /\text{hr})(8 \text{ hr}) \quad = 0.177 \text{ pCi}$$

And the dose is:

U-234 = (0.177 pCi)(0.13 mrem/pCi) = 0.0230 mrem
U-235+D = 0.046(0.177 pCi)(0.12 mrem/pCi) = 9.76 x $10^{-4}$ mrem
U-238+D = (0.177 pCi)(0.12 mrem/ pCi) = 0.0212 mrem

The total dose from demolition of the sheet rock walls in building A is 0.0452 mrem.

**Building A**

| | |
|---|---|
| Dose from Sheet Rock Wall Demolition = | 0.0452 mrem |
| Dose from 4" Cinder Block Wall Demolition = | 0.000843 mrem |
| Dose from 8" Cinder Block Wall Demolition = | 0.00337 mrem |
| Dose from 12" Solid Block Walls Demolition = | 0.00249 mrem |
| Dose from 4" Block Window Demolition = | 0.000490 mrem |
| Dose from Pane Window Demolition = | 0.0118 mrem |
| Dose from Rubble Removal = | 0.00102 mrem |
| **Total Dose for Bldg. A Wall Demolition =** | **0.07 mrem.** |

**Building A-1**

| | |
|---|---|
| Dose from Sheet Rock Wall Demolition = | 0.00496 mrem |
| Dose from 4" Cinder Block Wall Demolition = | 0.000565 mrem |
| Dose from 8" Cinder Block Wall Demolition = | 0.000328 mrem |
| Dose from 12" Solid Block Wall Demolition = | 0.00142 mrem |
| Dose from 4" Block Window Demolition = | 0.000146 mrem |
| Dose from Pane Window Demolition = | 0.00949 mrem |
| Dose from 6" Solid Block Wall Demolition = | 0.00219 mrem |
| Dose from Rubble Removal = | 0.000704 mrem |
| **Total Dose for Bldg. A-1 Wall Demolition =** | **0.02 mrem.** |

**The dose to a demolition worker present when all building A and A-1 walls are demolished and removed is 0.09 mrem.**

## Pipe and Overhead Demolition

EXCEL printouts for the overhead demolition of both building A and A-1 are contained in Attachment C. Building A-1 has a concrete ceiling that is uncontaminated. Only the pipes in building A-1 are contaminated and are included in this calculation. The dose for demolition of all overheads in building A and the pipes in both buildings is estimated to be 2.31 mrem. The total amount of U-238 activity present on the overheads in both buildings is estimated to be 0.105 mCi. The dose for cutting the steel beams and pipes for transport to the recycling facility is estimated to be 0.05 mrem. A mass loading factor of 180 $\mu g/m^3$ was assumed for modeling the inhalation pathway for all demolition activities. An ingestion rate of 480 mg/day (DOE 1989) was assumed for modeling the ingestion pathway.

All contaminated pipes are assumed to be covered in contamination equivalent to the average survey reading found on pipes which was 9,970 dpm/100 $cm^2$. All horizontal surfaces on contaminated steel beams are considered to be contaminated at the average survey reading found on steel beams which was 3,901 dpm/100 $cm^2$. All horizontal surfaces on contaminated wood beams and window sills are considered to be contaminated at the average survey reading found on wood which was 5,065 dpm/100 $cm^2$. The contamination is assumed to be from deposited dust which is assumed to be 0.1 in. (0.254 cm) thick.

The following example explains step-by-step the calculations in Attachment C.

**Steel beam demolition:**

1. The average fixed contamination was measured to be:

   3901 dpm/100 $cm^2$ = 1773 pCi/100 $cm^2$

2. The contamination on the steel is from settled dust. Assuming the dust is 0.1 in. thick and has a density similar to soil, i.e. ~1.6 g /$cm^3$. The concentration of the contamination is:

   (17.73 pCi/$cm^2$)/(0.254 cm)/(1.6 g/$cm^3$) = 43.6 pCi/g

3. The intake of radioactivity will depend on the duration of exposure and the concentration of contaminant. An engineering appraisal of the building plans for Building A have disclosed that there is approximately 3,877 linear feet of over head supporting steel. A removal rate of 400 linear feet/day was reported in Waier 1996. For this quantity of structural steel, salvage operations will take approximately 9.7 eight- hour shifts.

   A conservative mass loading factor of 180 μg/$m^3$ (DOE 1983) for construction activities would result in the following inhalation intake of U-238.

   (43.6 pCi/g)(1.8 x $10^{-4}$ g/$m^3$)(2.5 $m^3$/hr)(77.5 hrs) = 1.52 pCi

4. The resultant dose is:

   U-234 = (1.52 pCi)(0.13 mrem/pCi) = 0.198 mrem
   U-235+D = 0.046(1.52 pCi)(0.12 mrem/pCi) = 0.0084 mrem
   U-238+D = (1.52 pCi)(0.12 mrem/ pCi) = 0.183 mrem

   Dose from inhalation during steel beam demolition = 0.39 mrem

5. The intake of uranium by ingestion can be estimated by assuming a worker will ingest 480 mg of dust and dirt per day (8 hour shift).

The resultant radioactivity intake is thus:

(43.6 pCi/ g)(9.7 days)(480 mg/day) = 203 pCi

6. The resultant dose is:

U-234 = (203 pCi)(2.8 x $10^{-4}$ mrem/ pCi) = 0.0568 mrem
U-235+D = 0.046(203 pCi)(2.7 x $10^{-4}$ mrem/ pCi) = 0.0025 mrem
U-238+D = (203 pCi)(2.7 x $10^{-4}$ mrem/ pCi) = 0.0548 mrem

Dose from ingestion during steel beam demolition = 0.114 mrem

7. Total dose from steel beam demolition in bldg A = 0.503 mrem
Total dose from wood beam demolition in bldg A= 0.0384 mrem
Total dose from pipe demolition in bldgs. A and A-1 = 1.77 mrem

8. **The total dose to a demolition worker from demolishing contaminated beams and piping in building A and removing the contaminated piping in building A-1 is 2.31 mrem.**

**Steel and Pipe Cutting:**

1. The total linear feet of both steel and pipe in buildings A and A-1which requires cutting is 5,877 ft, of which 3,877 ft is steel and 2,000 ft is pipe. The fraction of time spent cutting steel and pipe is:

(3,877 ft steel)/(5,877 ft total) = 0.66

(2,000 ft pipe)/(5,877 ft total) = 0.34

The weighted average fixed contamination:

(0.66[3901 dpm/100 $cm^2$ ]) + (0.34[9970 dpm/100 $cm^2$]) = 5,966 dpm/100 $cm^2$
= 2,711 pCi/100 $cm^2$.

2. The contamination on the steel and pipes is from settled dust. Assuming the dust is 0.1 in. (0.254 cm) thick and has a density similar to soil, i.e. 1.6 g/$cm^3$. The concentration of the contamination is:

(27.11 pCi/$cm^2$)/(0.254 cm)/(1.6 g /$cm^3$) = 66.7 pCi/g

3. The intake of radioactivity will depend on the duration of exposure and the concentration of contaminant. An engineering appraisal of the building plans for Building A have disclosed that there is approximately 3,877 linear feet of over head supporting steel and buildings A and A-1 have approximately 2,000 linear feet of pipe. If it assumed that the metal was cut into 15 ft lengths and that a cut takes 1 min, the cutting operation would last approximately 6.5 hours.

   A conservative mass loading factor of 180 $\mu g/m^3$ would result in the following intake of U-238.

   $$(66.7\ pCi/g)(180\ \mu g/m^3)(2.5\ m^3/hr)(6.5\ hrs) = 0.196\ pCi$$

4. The resultant dose is:

   U-234 = (0.196 pCi)(0.13 mrem/ pCi) = 0.0255 mrem
   U-235+D = 0.046(0.196 pCi)(0.12 mrem/ pCi) = 0.00108 mrem
   U-238+D = (0.196 pCi)(0.12 mrem/ pCi) = 0.0235 mrem

   **Dose from inhalation during steel beam and pipe cutting = 0.05 mrem**

**The total dose to a demolition worker from all overhead demolition and cutting is estimated to be 2.36 mrem.**

**Overhead Recycling**

EXCEL printouts for the overhead recycling of both building A and A-1 steel beams and pipes are contained in Attachment D. The dose for recycling of all steel beams and pipes in both buildings is estimated to be 5.0 mrem.

Two exposure scenarios were identified for recycling of the metal beams and pipes. These were sandblasting of the metal (to remove paint), and exposure to slag after melting.

The calculations presented in Attachment D are summarized below.

1. **Sand blasting of metal to remove paint**

   The weighted average surface contamination of the beams and pipes = 5966 dpm/100 $cm^2$.
   Sandblasting production rate = 1352 $ft^2$ /day (p.149, Waier 1996)
   Surface area of contaminated metal = 3910 $ft^2$

   The contamination on the metal is from fixed dust. Assuming the dust is 0.1 in. thick and has a density similar to soil, i.e. 1.6 g/ $cm^3$. The concentration of the contamination is:

$(59.66\ dpm/cm^2)(pCi/2.2\ dpm)/(0.254\ cm)/(1.6\ g/cm^3) = 66.7\ pCi/g$

Time to sandblast metal = $(3910\ ft^2)/(1352\ ft^2/day)$ = 23 hours or 2.9 shifts

Assume dust loading of 180 $\mu g/m^3$ and that 100% of the nuisance dust is radioactively contaminated at the concentrations calculated in the demolition section.

The inhalation dose is calculated to be:

U-234 = $(2.5\ m^3/hr)(23\ hr)(66.73\ pCi/g)(180\ \mu g/m^3)(0.13\ mrem/pCi) = 0.0903$ mrem
U-235+D = $0.046(2.5\ m^3/hr)(23\ hr)(66.73\ pCi/g)(180\ \mu g/m^3)(0.12\ mrem/pCi)=0.00383$ mrem
U-238+D = $(2.5\ m^3/hr)(23\ hr)(66.73\ pCi/g)(180\ \mu g/m^3)(0.12\ mrem/pCi) = 0.0834$ mrem

Total dose = 0.178 mrem

2. **Slag from melting recycled metal**

An engineering appraisal of building A indicates that there is 111 $ft^3$ of steel beam present. The volume of steel was determined by estimating the linear feet of each type of I-beam and multiplying by the cross-sectional area of each type of I-beam. (see Attachment D) Uranium contamination in steel tends to be concentrated in the slag when the steel is melted. SEG personnel indicated from their experience in melting uranium contaminated steel, 99% of the uranium and 3% of the metal end up in the slag. The slag is often used as roadbed material which is usually under at least 6 inches of gravel and asphalt. Higher exposure would result from slag dumped on the ground in a waste area.

Total U-238 activity in the metal = $(5966\ dpm/100\ cm^2)(3910\ ft^2)(pCi/2.2\ dpm) = 98.5\ \mu Ci$
Mass of steel = $(111\ ft^3)(7.86\ g/cm^3) = 2.47 \times 10^7$ g of steel
Mass of pipe = (10.79 lb/ft of 4" pipe)(2000 ft) = $9.80 \times 10^6$ g of pipe
Mass of metal present = $3.45 \times 10^7$ g

The concentration of U-238 in the slag is:

$$(98.5\ \mu Ci)(0.99) / (3.45 \times 10^7\ g) / (0.03) = 94.21\ pCi/gm$$

Density of slag is assumed to be 1/2 that of steel = $(7.86\ gm/cm^3) / 2 = 3.93\ gm/cm^2$
Since the slag is primarily a solid mass, the mass loading is assumed to be 30 $\mu g/m^3$
A worker is expected to be exposed to the waste slag approximately 10% of the time

The inhalation dose is

U-234 = $(2.5\ m^3/hr)(0.1\ yr)(30\ \mu g/m^3)(94.21\ pCi/g)(0.13\ mrem/pCi) = 0.257$ mrem
U-235+D = $0.046(2.5\ m^3/hr)(0.1\ yr)(30\ \mu g/m^3)(94.21\ pCi/g)(0.12\ mrem/pCi) = 0.0109$ mrem
U-238+D = $(2.5\ m^3/hr)(0.1\ yr)(30\ \mu g/m^3)(94.21\ pCi/g)(0.12\ mrem/pCi) = 0.237$ mrem

The ingestion dose is, using an ingestion rate of 480 mg/day:

U-234 = (480 mg/day)(0.1 yr)(94.21 pCi/g)($2.8 \times 10^{-4}$ mrem/pCi) = 0.443 mrem
U-235+D = 0.046(480 mg/day)(0.1 yr)(94.21 pCi/g)( $2.7 \times 10^{-4}$ mrem/pCi) = 0.0197 mrem
U-238+D = (480 mg/day)(0.1 yr)(94.21 pCi/g)( $2.7 \times 10^{-4}$ mrem/pCi) = 0.427 mrem

The external dose is

U-234 = (0.1 yr)(3.93 g/cm$^3$)(94.21 pCi/g)($6.97 \times 10^{-4}$ mrem/yr / pCi/cm$^3$) = 0.0258 mrem
U-235+D = 0.046(0.1 yr)(3.93 g/cm$^3$)(94.21 pCi/g)($4.90 \times 10^{-1}$ mrem/yr / pCi/cm$^3$) = 0.835 mrem
U-238+D = (0.1 yr)(3.93 g/cm$^3$)(94.21 pCi/g)(($6.97 \times 10^{-2}$ mrem/yr / pCi/cm$^3$) =2.58 mrem

The total exposure is 4.84 mrem to slag dumped on the ground in a waste area.

**The total dose to the recycling worker from sandblasting and slag exposure is 5.0 mrem.**

Typically, waste slag is used as roadbed material which is then covered with at least 6" of gravel and asphalt. In this situation, the inhalation and ingestion pathways are no longer applicable. It is also reasonable to assume that a maximum exposure duration for a member of the general public driving on the road would be 1 hr per day, 7days per week . Therefore, the external dose to a member of the general public from driving on a roadbed of waste slag is decreased by 90% (RESRAD 1990) to 0.33 mrem.

## Floor Demolition

Since buildings A and A-1 have numerous rooms, a simplifying assumption was made to determine surface contamination levels. On each floor that showed any contamination above DOE Order 5400.5 guidelines, all surface contamination readings were averaged. The maximum of these averages was assumed to be present over the entire surface area of all contaminated floors in each building. For building A, the average was 7,410 dpm/100 cm$^2$. For building A-1, the average was 34,096 dpm/100 cm$^2$. This is a very conservative assumption because the radiological contamination in buildings A and A-1 is spotty.

EXCEL printouts for the floor demolitions of both buildings A and A-1 are contained in Attachment E. The dose for demolition of all floors in building A and removal of the associated rubble is estimated to be 0.0059 mrem. The total amount of U-238 activity present on the floors in building A is estimated to be 0.357 mCi. The dose for floor demolition and rubble removal of Building A-1 is estimated to be 0.0098 mrem with a total U-238 activity of 0.591 mCi.

The following example explains step-by-step the calculations in Attachment E.

**Building A Floors:**

The concentration of U-238 in floor components is calculated as follows:

Thickness: 4 inches (10.16 cm)
Effective density: 2.4 g/cm$^3$
Mass under 100 cm$^2$ survey area: 2438.4 g
Average activity in survey area: 7,410 dpm/100 cm$^2$ (3368 pCi/100 cm$^2$)

Average U-238 concentration:

(7410 dpm/100 cm$^2$)(pCi / 2.2 dpm)(100 cm$^2$ / 2438 g)
= 1.38 pCi/g

The initial airborne concentration is:

$$(1.38 \text{ pCi/g})(180 \ \mu\text{g/ m}^3) = 2.49 \times 10^{-4} \text{ pCi/ m}^3$$

The dose to the hypothetical maximally exposed individual will depend on the duration of exposure. The duration of exposure will depend on the amount of floor to be removed and the rate it is removed. A work crew with a front loader can demolish 4 in. concrete slabs at a rate of 3.1 m$^3$ per hour (p.30 Waier 1996). The total volume of contaminated concrete floor in building A is 108 m$^3$.

The duration of the demolition of the floor is:

$$(108 \text{ m}^3) / (3.1 \text{ m}^3 \text{/hr}) = 34.78 \text{ hrs}$$

The inhalation intake is:

$$(2.49 \times 10^{-4} \text{ pCi/ m}^3)(2.5 \text{ m}^3 \text{/hr})(34.78 \text{ hrs}) = 0.0216 \text{ pCi}$$

And the dose is:

U-234 = (0.0216 pCi)(0.13 mrem/ pCi) = 0.00281 mrem
U-235+D = 0.046(0.0216 pCi)(0.12 mrem/ pCi) = 1.19 x 10$^{-4}$ mrem
U-238+D = (0.0216 pCi)(0.12 mrem/ pCi) = 0.00259 mrem

Dose from Building A Floor Demolition = 0.00552 mrem

**Dose from Complete Floor Demolition and Removal of Both Buildings = 0.016 mrem.**

**Contamination in Building Rubble**

To estimate the total radioactive contamination expected in the building rubble that would be crushed and disposed of following demolition, the total activity assumed to be in the concrete rubble is dispersed throughout the entire concrete rubble mass of the building (both contaminated and uncontaminated). The concentration of radioactivity in all concrete building rubble is the result of an EXCEL spreadsheet that is shown in Attachment F.

U-234 radioactivity in concrete = $2.35 \times 10^9$ pCi = 2.35 mCi
U-235+D radioactivity in concrete = $0.046(2.35 \times 10^9$ pCi) = 0.11 mCi
U-238+D radioactivity in concrete = $2.35 \times 10^9$ pCi = 2.35 mCi

The average concentration of total uranium for the building rubble is calculated as:

$4.81 \times 10^9$ pCi / $2.08 \times 10^9$ g = 2.31 pCi/g

The spreadsheet shown in Attachment F shows that the uranium activity in the dust on the wood beams is so much lower than the activity in the concrete rubble that it does not affect the average concentration in building rubble. The average concentration of 2.31 pCi/g calculated for concrete rubble is assumed for the average concentration of total uranium for all building rubble.

This concentration is well below the uranium soil contamination guideline of 100 pCi per gram established for the Ventron site. In addition, it is comparable to the natural radioactivity found in many common building materials. Attachment G contains a table which lists the natural radioactivity concentrations found in common building materials.

The values of the individual uranium isotopes would therefore be:

U-234 = 2.35 mCi
U-235 = 0.11 mCi
U-238 = 2.35 mCi

These values are well below the EPA's Reportable Quantities (RQs) for U-234, U-235, and U-238 specified in 40 CFR 302.

Using the specific activity of the uranium isotopes, the mass of the uranium present is

U-234 = (2.35 mCi)/(6.19 mCi/g) = 0.38 g
U-235 = (0.11 mCi)/($2.14 \times 10^{-3}$ mCi/g) = 50.6 g
U-238 = (2.35 mCi)/($3.33 \times 10^{-4}$ mCi/g) = 7066 g

The total mass of uranium is:

$$U = 7117 \text{ g} = 15.7 \text{ lbs}$$

This value is well below EPA's RQ values for uranium compounds (uranyl acetate, uranyl nitrate) with respect to chemical hazards.

## Crusher Operations

A portion of concrete rubble from the demolition of buildings A and A-1 will be crushed and used as backfill on site. The remainder will be disposed of in a construction landfill. It is unknown at this time how much of the material will be crushed; therefore, the conservative assumption was made for the purposes of this calculation that all concrete rubble will be crushed. The processing rate of 20 $yd^3$/hr was developed from BNI experience with crushing operations. An EXCEL printout for the crusher operation is contained in Attachment F. The dose for crushing the associated rubble is estimated to be 0.015 mrem. A mass loading factor of 180 $\mu g/m^3$ was assumed for all crusher activities.

The following explains step-by-step the calculation in Attachment F.

The concentration of total uranium in the concrete was given above as 2.31 pCi/g.

The airborne concentration is:

$$(2.31 \text{ pCi/ g})(180 \ \mu\text{g/ m}^3) = 4.16 \times 10^{-4} \text{ pCi/ m}^3$$

The dose to the hypothetical maximally exposed demolition worker will depend on the duration of exposure. The duration of exposure will depend on the production rate of the crusher. The crusher has an assumed production rate of 20 $yd^3$ per hour. The total volume of contaminated concrete is 1135 $yd^3$.

The duration of the crushing operation is:

$$(1135 \text{ yd}^3) / (20 \text{ yd}^3 \text{ /hr}) = 56.76 \text{ hrs}$$

The inhalation intake is:

$$(4.16 \times 10^{-4} \text{ pCi/ m}^3)(2.5 \text{ m}^3 \text{ /hr})(56.76 \text{ hrs}) = 0.059 \text{ pCi}$$

And the dose is:

U-234 = 0.489(0.059 pCi)(0.13 mrem/ pCi) = 0.0038 mrem
U-235+D = 0.022(0.059 pCi)(0.12 mrem/ pCi) = 0.00016 mrem
U-238+D = 0.489(0.059 pCi)(0.12 mrem/ pCi) = 0.0035 mrem

**Dose to demolition worker from crusher operation is 0.0074 mrem.**

## Landfill Disposal

The site owner has indicated that wood and any masonry rubble that is not used as backfill will go to a construction landfill for disposal. A calculation was performed assuming all wood and masonry material is disposed of in a landfill. This assumption is more conservative than assuming that the masonry material is used as backfill and left on-site because the landfill will have a minimum daily soil cover of only 6" whereas the backfill used on-site will probably have at least 6" of soil in order to grow grass or will have a building with a concrete slab built on top of the backfill.

Dose from the material disposed of in a landfill is estimated by using the RESRAD computer code, Version 5.61. The summary result page is given in Attachment F. An estimated 17.3 $yd^3$ of wood and 1135 $yd^3$ of masonry material will be generated from the demolition of buildings A and A-1. If this volume of material was spread in a 1' thick layer, it would occupy 289 $m^2$ in a landfill. The material is assumed to contain 2.31 pCi/g of total uranium as determined above. If it is assumed that a landfill worker spends 1 hr per day standing directly over the burial area, the resulting dose is $7.7 \times 10^{-4}$ mrem/yr.

## CONCLUSIONS

Contamination on the walls, overheads, and floors of Buildings A and A-1 will not result in a radiation dose above 100 mrem to any member of the general public. The maximum dose to a hypothetical demolition worker is estimated to be 2.5 mrem, and offsite exposure to the general public would be much less. Of the 2.5 mrem, 1.8 mrem is attributable to the removal of pipes in buildings A and A-1. The maximum dose to a hypothetical recycling worker is estimated to be 5.0 mrem. Concrete rubble is expected to contain 2.31 pCi/g of total uranium. Given the low radiation dose calculated to result from wall, overhead, and floor contamination (and the fact that these calculations were very conservative and likely over-estimated the dose) and the expectation that the concrete rubble will contain activity concentrations equivalent to background, no remedial action need be performed.

Exposure to member of the general public could occur through disposal of the building materials. Waste slag from metal smelting is typically used as roadbed material with at least 6" of gravel

and asphalt cover. A person spending 1 hr per day, 7 days per week, exposed to the covered roadbed material would receive an estimated 0.33 mrem/yr. If all masonry material and wood is disposed of in a construction landfill, a landfill worker spending 1 hr per day exposed to the material buried under a 6" clean soil cover would received an estimated dose of $7.7 \times 10^{-4}$ mrem/yr. These doses are indistinguishable from typical background doses.

# ATTACHMENT A

## Wall Demolition
## Building A

# Calculation Sheet

Originator Andrea George Date 03/08/96 Calc. No. 127-CV-0026 Rev. No. 0
Project FUSRAP Job No. 14501 Checked Date 3/11/96
Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 19 of 49

14021 0

Bechtel

## Wall Demolition
## Building A

Maximum Average from Room 29, West Wall = 24434 dpm/100 cm$^2$

Contaminated Walls

| Room | Wall | Area (ft$^2$) | Block Window Area (ft$^2$) | Pane Window Area (ft$^2$) | Type |
|---|---|---|---|---|---|
| 9 | East | 84 | 0 | 0 | Wood frame and sheet rock |
| 13 | West | 294 | 0 | 0 | Wood frame and sheet rock |
| 27 | West | 104 | 0 | 36 | Wood Frame and Sheet Rock |
| 29 | North | 184 | 0 | 6 | 1/2 Wood/sheet rock and 1/2 12" concrete |
| 29 | South | 184 | 0 | 6 | 1/2 Wood/sheet rock and 1/2 12" concrete |
| 29 | West | 161 | 0 | 9 | 1/2 Wood/sheet rock and 1/2 12" concrete |
| 19 | North | 266 | 0 | 0 | 4" Cinder Block |
| 19 | South | 266 | 0 | 0 | 4" Cinder Block |
| 28 | East | 132 | 0 | 8 | 4" Cinder Block |
| 19 | East | 420 | 0 | 0 | 8" Cinder block |
| 20 | East | 776 | 36 | 0 | 8" Cinder block |
| 27 | South | 276 | 0 | 4 | 8" Cinder block |
| 30 | West | 1184 | 192 | 24 | 8" cinder block |
| 29 | North | 184 | 0 | 6 | 1/2 Wood/sheet rock and 1/2 12" concrete |
| 29 | South | 184 | 0 | 6 | 1/2 Wood/sheet rock and 1/2 12" concrete |
| 29 | West | 161 | 0 | 9 | 1/2 Wood/sheet rock and 1/2 12" concrete |
| 29 | East | 170 | 0 | 0 | 12" Concrete |
| B-1 | North | 490 | 0 | 0 | 12" concrete |
| B-1 | East | 259 | 0 | 0 | 12" concrete |
| B-2 | South | 242 | 0 | 38 | 12" concrete |
| B-3 | North | 252 | 0 | 0 | 12" concrete |
| B-3 | South | 232 | 0 | 20 | 12" concrete |
| B-3 | West | 518 | 0 | 0 | 12" concrete |
| B-3 | East | 518 | 0 | 0 | 12" concrete |

# Calculation Sheet

Originator Andrea George Date 03/08/96 Calc. No. 127-CV-0016 Rev. No. 0
Project FUSRAP Job No. 14501 Checked Date 3/11/96
Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 20 of 49

Bechtel

140210

## Wall Demolition
## Building A

### Sheet Rock Walls

| | | |
|---|---|---|
| Total area: | 1011 | $ft^2$ contaminated |
| Total pCi: | 1.04E+08 | pCi present |
| Total Vol: | 42 | $ft^3$ contaminated |
| | 1.56 | $yd^3$ contaminated |
| | 1.19 | $m^3$ contaminated |
| Thickness: | 0.5 | in |
| | 1.27 | cm |
| Density: | 1.8 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 228.6 | g |
| Average conc.: | 48.58 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 1000 | $ft^2$/day (p.38 Waier 1996) |
| Removal Time: | 8.09 | hr |
| Airborne conc: | 8.75E-03 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 1.77E-01 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 2.30E-02 | mrem |
| U-235 dose: | 9.76E-04 | mrem |
| U-238 dose: | 2.12E-02 | mrem |
| **Total Dose =** | **4.52E-02** | **mrem** |

### 4" Cinder Block Walls

| | | |
|---|---|---|
| Total area: | 664 | $ft^2$ contaminated |
| Total pCi: | 6.85E+07 | pCi present |
| Total Vol: | 111 | $ft^3$ contaminated |
| | 4.10 | $yd^3$ contaminated |
| | 3.13 | $m^3$ contaminated |
| Thickness: | 2 | in |
| | 5.08 | cm |
| Density: | 2.4 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 1219.2 | g |
| Average conc.: | 9.11 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 6600 | $ft^2$/day (p.29 Waier 1996) |
| Removal Time: | 0.80 | hr |
| Airborne conc: | 1.64E-03 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 3.30E-03 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 4.29E-04 | mrem |
| U-235 dose: | 1.82E-05 | mrem |
| U-238 dose: | 3.96E-04 | mrem |
| **Total Dose =** | **8.43E-04** | **mrem** |

HAZ-A.XLS

# Calculation Sheet

Originator Andrea George Date 03/08/96 Calc. No. 127-CV-0016 Rev. No. 0
Project FUSRAP Job No. 14501 Checked Date 3/11/96
Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 21 of 49

140210

bechtel

## Wall Demolition
## Building A

### 8" Cinder Block Walls

| | | |
|---|---|---|
| Total area: | 2656 | $ft^2$ contaminated |
| Total pCi: | 2.74E+08 | pCi present |
| Total Vol: | 885 | $ft^3$ contaminated |
| | 32.79 | $yd^3$ contaminated |
| | 25.07 | $m^3$ contaminated |
| Thickness: | 4 | in |
| | 10.16 | cm |
| Density: | 2.4 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 2438.4 | g |
| Average conc.: | 4.55 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 3300 | $ft^2$/day (p.29 Waier 1996) |
| Removal Time: | 6.44 | hr |
| Airborne conc: | 8.20E-04 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 1.32E-02 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 1.72E-03 | mrem |
| U-235 dose: | 7.28E-05 | mrem |
| U-238 dose: | 1.58E-03 | mrem |
| **Total Dose =** | **3.37E-03** | **mrem** |

### 12" Solid Block Walls

| | | |
|---|---|---|
| Total area: | 3210 | $ft^2$ contaminated |
| Total pCi: | 3.31E+08 | pCi present |
| Total Vol: | 3210 | $ft^3$ contaminated |
| | 118.89 | $yd^3$ contaminated |
| | 90.90 | $m^3$ contaminated |
| Thickness: | 12 | in |
| | 30.48 | cm |
| Density: | 2.4 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 7315.2 | g |
| Average conc.: | 1.52 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 1800 | $ft^2$/day (p.29 Waier 1996) |
| Removal Time: | 14.27 | hr |
| Airborne conc: | 2.73E-04 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 9.75E-03 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 1.27E-03 | mrem |
| U-235 dose: | 5.38E-05 | mrem |
| U-238 dose: | 1.17E-03 | mrem |
| **Total Dose =** | **2.49E-03** | **mrem** |

# Calculation Sheet

Originator Andrea George Date 03/08/96 Calc. No. 127-CV-0026 Rev. No. 0
Project FUSRAP Job No. 14501 Checked Date 3/11/96
Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 22 of 49

140210

Bechtel

## Wall Demolition
## Building A

### 4" Block Windows

| | | |
|---|---|---|
| Total area: | 228 | $ft^2$ contaminated |
| Total pCi: | 2.35E+07 | pCi present |
| Total Vol: | 76 | $ft^3$ contaminated |
| | 2.81 | $yd^3$ contaminated |
| | 2.15 | $m^3$ contaminated |
| Thickness: | 4 | in |
| | 10.16 | cm |
| Density: | 2.6 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 2641.6 | g |
| Average conc.: | 4.20 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 1800 | $ft^2$/day (p.29 Waier 1996) |
| Removal Time: | 1.01 | hr |
| Airborne conc: | 7.57E-04 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 1.92E-03 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 2.49E-04 | mrem |
| U-235 dose: | 1.06E-05 | mrem |
| U-238 dose: | 2.30E-04 | mrem |
| **Total Dose =** | **4.90E-04** | **mrem** |

### Pane Windows

| | | |
|---|---|---|
| Total area: | 172 | $ft^2$ contaminated |
| Total pCi: | 1.77E+07 | pCi present |
| Total Vol: | 2 | $ft^3$ contaminated |
| | 0.07 | $yd^3$ contaminated |
| | 0.05 | $m^3$ contaminated |
| Thickness: | 0.125 | in |
| | 0.3175 | cm |
| Density: | 2.6 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 82.55 | g |
| Average conc.: | 134.54 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 1800 | $ft^2$/day (p.29 Waier 1996) |
| Removal Time: | 0.76 | hr |
| Airborne conc: | 2.42E-02 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 4.63E-02 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 6.02E-03 | mrem |
| U-235 dose: | 2.55E-04 | mrem |
| U-238 dose: | 5.55E-03 | mrem |
| **Total Dose =** | **1.18E-02** | **mrem** |

**Wall Demolition**
**Building A**

| Rubble Removal | | |
|---|---|---|
| Total Vol: | 4326 | $ft^3$ contaminated |
| | 160 | $yd^3$ contaminated |
| | 122 | $m^3$ contaminated |
| Weighted Average conc.: | 2.89 | pCi/g |
| Mass loading | | |
| Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 40 | $m^3$/hr (p.30 Waier 1996) |
| Removal Time: | 3.06 | hr |
| Airborne conc: | 5.21E-04 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 3.99E-03 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 5.19E-04 | mrem |
| U-235 dose: | 2.20E-05 | mrem |
| U-238 dose: | 4.79E-04 | mrem |
| **Total Dose =** | **1.02E-03** | **mrem** |

**Total pCi = 8.19E+08 pCi**

**Total Dose for Wall Demolition = 0.07 mrem**

# ATTACHMENT B

## Wall Demolition
## Building A-1

# Calculation Sheet

Originator Andrea George Date 03/08/96 Calc. No. 127-CV-0076 Rev. No. 0
Project FUSRAP Job No. 14501 Checked Date 3/11/96
Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 25 of 49

140210

DECLASSIFIED

## Wall Demolition
## Building A-1

a:\ven-ha.doc

Maximum Average from Room 29, West Wall = 24434 dpm/100 cm$^2$

Contaminated Walls

| Room | Wall | Area (ft$^2$) | Block Window Area (ft$^2$) | Pane Window Area (ft$^2$) | Type |
|---|---|---|---|---|---|
| 1 | East | 111 | 0 | 36 | Wood frame and sheet rock |
| 5 | East | 445 | 16 | 36 | 4" Cinder Block |
| 5 | North | 258 | 36 | 0 | 8" Cinder block |
| 1 | West | 131 | 16 | 0 | 6" concrete |
| 6 | West | 875 | 0 | 0 | 6" concrete |
| 7 | North | 301 | 0 | 0 | 6" concrete |
| 7 | South | 301 | 0 | 0 | 6" concrete |
| 7 | West | 280 | 0 | 0 | 6" concrete |
| 7 | East | 280 | 0 | 0 | 6" concrete |
| 10 | South | 448 | 0 | 0 | 6" concrete |
| B-1 | North | 84 | 0 | 0 | 6" concrete |
| B-1 | West | 122 | 0 | 0 | 6" concrete |
| 2 | South | 278 | 0 | 30 | 12" Concrete |
| 6 | North | 402 | 0 | 30 | 12" concrete |
| 10 | North | 448 | 0 | 0 | 12" concrete |
| 10 | West | 196 | 0 | 0 | 12" concrete |
| B-1 | South | 78 | 0 | 6 | 12" concrete |
| B-1 | East | 126 | 0 | 0 | 12" concrete |
| B-4 | North | 308 | 0 | 0 | 12" concrete |

# Calculation Sheet

Originator Andrea George Date 03/08/96 Calc. No. 127-CV-0026 Rev. No. 0
Project FUSRAP Job No. 14501 Checked Date 3/11/96
Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 26 of 49

14021 0

Bechtel

## Wall Demolition
## Building A-1

### Sheet Rock Walls

| | | |
|---|---|---|
| Total area: | 111 | $ft^2$ contaminated |
| Total pCi: | 1.15E+07 | pCi present |
| Total Vol: | 5 | $ft^3$ contaminated |
| | 0.17 | $yd^3$ contaminated |
| | 0.13 | $m^3$ contaminated |
| Thickness: | 0.5 | in |
| | 1.27 | cm |
| Density: | 1.8 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 228.6 | g |
| Average conc.: | 48.58 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 1000 | $ft^2$/day (p.38 Waier 1996) |
| Removal Time: | 0.89 | hr |
| Airborne conc: | 8.75E-03 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 1.94E-02 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 2.52E-03 | mrem |
| U-235 dose: | 1.07E-04 | mrem |
| U-238 dose: | 2.33E-03 | mrem |
| **Total Dose =** | **4.96E-03** | **mrem** |

### 4" Cinder Block Walls

| | | |
|---|---|---|
| Total area: | 445 | $ft^2$ contaminated |
| Total pCi: | 4.59E+07 | pCi present |
| Total Vol: | 74 | $ft^3$ contaminated |
| | 2.75 | $yd^3$ contaminated |
| | 2.10 | $m^3$ contaminated |
| Thickness: | 2 | in |
| | 5.08 | cm |
| Density: | 2.4 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 1219.2 | g |
| Average conc.: | 9.11 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 6600 | $ft^2$/day (p.29 Waier 1996) |
| Removal Time: | 0.54 | hr |
| Airborne conc: | 1.64E-03 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 2.21E-03 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 2.87E-04 | mrem |
| U-235 dose: | 1.22E-05 | mrem |
| U-238 dose: | 2.65E-04 | mrem |
| **Total Dose =** | **5.65E-04** | **mrem** |

# Calculation Sheet

Originator Andrea George Date 03/08/96 Calc. No. 127-CV-0016 Rev. No. 0

Project FUSRAP Job No. 14501 Checked Date 3/11/96

Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 27 of 49

140210

Bechtel

## Wall Demolition
## Building A-1

### 8" Cinder Block Walls

| | |
|---|---|
| Total area: | 258 $ft^2$ contaminated |
| Total pCi: | 2.66E+07 pCi present |
| Total Vol: | 86 $ft^3$ contaminated |
| | 3.19 $yd^3$ contaminated |
| | 2.44 $m^3$ contaminated |
| Thickness: | 4 in |
| | 10.16 cm |
| Density: | 2.4 $g/cm^3$ |
| Mass under 100 $cm^2$: | 2438.4 g |
| Average conc.: | 4.55 pCi/g |
| Mass loading Factor: | 1.80E-04 $g/m^3$ |
| Removal Rate: | 3300 $ft^2$/day (p.29 Waier 1996) |
| Removal Time: | 0.63 hr |
| Airborne conc: | 8.20E-04 $pCi/m^3$ |
| Inhalation Rate: | 2.5 $m^3$/hr |
| Intake: | 1.28E-03 pCi |
| U-234 DCF: | 0.13 mrem/pCi |
| U-235 DCF: | 0.12 mrem/pCi |
| U-238 DCF: | 0.12 mrem/pCi |
| U-234 dose: | 1.67E-04 mrem |
| U-235 dose: | 7.08E-06 mrem |
| U-238 dose: | 1.54E-04 mrem |
| **Total Dose =** | **3.28E-04 mrem** |

### 12" Solid Block Walls

| | |
|---|---|
| Total area: | 1836 $ft^2$ contaminated |
| Total pCi: | 1.89E+08 pCi present |
| Total Vol: | 1836 $ft^3$ contaminated |
| | 68.00 $yd^3$ contaminated |
| | 51.99 $m^3$ contaminated |
| Thickness: | 12 in |
| | 30.48 cm |
| Density: | 2.4 $g/cm^3$ |
| Mass under 100 $cm^2$: | 7315.2 g |
| Average conc.: | 1.52 pCi/g |
| Mass loading Factor: | 1.80E-04 $g/m^3$ |
| Removal Rate: | 1800 $ft^2$/day (p.29 Waier 1996) |
| Removal Time: | 8.16 hr |
| Airborne conc: | 2.73E-04 $pCi/m^3$ |
| Inhalation Rate: | 2.5 $m^3$/hr |
| Intake: | 5.58E-03 pCi |
| U-234 DCF: | 0.13 mrem/pCi |
| U-235 DCF: | 0.12 mrem/pCi |
| U-238 DCF: | 0.12 mrem/pCi |
| U-234 dose: | 7.25E-04 mrem |
| U-235 dose: | 3.08E-05 mrem |
| U-238 dose: | 6.69E-04 mrem |
| **Total Dose =** | **1.42E-03 mrem** |

# Calculation Sheet

Originator Andrea George Date 03/08/96 Calc. No. 127-CV-0026 Rev. No. 0
Project FUSRAP Job No. 14501 Checked YMH Date 3/11/96
Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 28 of 49

Bechtel

140210

## Wall Demolition
## Building A-1

### 4" Block Windows

| | | |
|---|---|---|
| Total area: | 68 | $ft^2$ contaminated |
| Total pCi: | 7.02E+06 | pCi present |
| Total Vol: | 23 | $ft^3$ contaminated |
| | 0.84 | $yd^3$ contaminated |
| | 0.64 | $m^3$ contaminated |
| Thickness: | 4 | in |
| | 10.16 | cm |
| Density: | 2.6 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 2641.6 | g |
| Average conc.: | 4.20 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 1800 | $ft^2$/day (p.29 Waier 1996) |
| Removal Time: | 0.30 | hr |
| Airborne conc: | 7.57E-04 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 5.72E-04 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 7.43E-05 | mrem |
| U-235 dose: | 3.16E-06 | mrem |
| U-238 dose: | 6.86E-05 | mrem |
| **Total Dose =** | **1.46E-04** | **mrem** |

### Pane Windows

| | | |
|---|---|---|
| Total area: | 138 | $ft^2$ contaminated |
| Total pCi: | 1.42E+07 | pCi present |
| Total Vol: | 1.44 | $ft^3$ contaminated |
| | 0.05 | $yd^3$ contaminated |
| | 0.04 | $m^3$ contaminated |
| Thickness: | 0.125 | in |
| | 0.3175 | cm |
| Density: | 2.6 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 82.55 | g |
| Average conc.: | 134.54 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 1800 | $ft^2$/day (p.29 Waier 1996) |
| Removal Time: | 0.61 | hr |
| Airborne conc: | 2.42E-02 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 3.71E-02 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 4.83E-03 | mrem |
| U-235 dose: | 2.05E-04 | mrem |
| U-238 dose: | 4.46E-03 | mrem |
| **Total Dose =** | **9.49E-03** | **mrem** |

# Calculation Sheet

Originator Andrea George Date 03/08/96 Calc. No. 127-CV-0026 Rev. 1
Project FUSRAP Job No. 14501 Checked Date 3/11/96
Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 29 of 49

140210

Bechtel

## Wall Demolition
## Building A-1

### 6" Solid Block Walls

| | | |
|---|---|---|
| Total area: | 2822 | $ft^2$ contaminated |
| Total pCi: | 2.91E+08 | pCi present |
| Total Vol: | 1411 | $ft^3$ contaminated |
| | 52.26 | $yd^3$ contaminated |
| | 39.96 | $m^3$ contaminated |
| Thickness: | 6 | in |
| | 15.24 | cm |
| Density: | 2.4 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 3657.6 | g |
| Average conc.: | 3.04 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 3600 | $ft^2$/day (p.29 Waier 1996) |
| Removal Time: | 6.27 | hr |
| Airborne conc: | 5.47E-04 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 8.57E-03 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 1.11E-03 | mrem |
| U-235 dose: | 4.73E-05 | mrem |
| U-238 dose: | 1.03E-03 | mrem |
| **Total Dose =** | **2.19E-03** | **mrem** |

### Rubble Removal

| | | |
|---|---|---|
| Total Vol: | 3436 | $ft^3$ contaminated |
| | 127.26 | $yd^3$ contaminated |
| | 97.29 | $m^3$ contaminated |
| Weighted Average conc.: | 2.52 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 40 | $m^3$/hr (p.30 Waier 1996) |
| Removal Time: | 2.43 | hr |
| Airborne conc: | 4.53E-04 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 2.76E-03 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 3.58E-04 | mrem |
| U-235 dose: | 1.52E-05 | mrem |
| U-238 dose: | 3.31E-04 | mrem |
| **Total Dose =** | **7.04E-04** | **mrem** |

**Total Dose from Wall Demolition** **0.02 mrem**
**Total pCi =** **5.86E+08 pCi**

HAZ-A1.XLS

a:\ven-ha.doc

# ATTACHMENT C

## Overhead Demolition
## Buildings A and A-1

# Calculation Sheet

Originator Andrea George AG Date 03/08/96 Calc. No. 127-CV-0026 Rev. No. 0

Project FUSRAP Job No. 14501 Checked CYM Date 3/11/96

Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 31 of 49

140210

Bechtel

## Overhead Demolition
## Buildings A and A-1

| Building | Room | Total Linear Feet | Total Surface Area ($ft^2$) | Total Volume ($ft^3$) | Material |
|---|---|---|---|---|---|
| A | 20 | 76 | 76 | 4 | Steel Beam |
| A | 20 | 57 | 38 | 2 | Steel Beam |
| A | 30 | 1080 | 270 | 21 | Steel Angles |
| A | 30 | 1080 | 180 | 10 | Steel Angles |
| A | 30 | 400 | 667 | 24 | Steel Beam |
| A | 30 | 540 | 1258 | 42 | Steel Beam |
| A | 30 | 104 | 104 | 3 | Steel Beam |
| A | 30 | 540 | 270 | 5 | Steel Plates |
| A | Entire bldg. | 1500 | 785 | | 4" iron piping |
| A-1 | Entire bldg. | 500 | 262 | | 4" iron piping |
| A | 19 | 38 | 6 | 6 | Wood |
| A | 20 | 114 | 19 | 19 | Wood |
| A | 20 | 200 | 33 | 22 | Wood |
| A | 20 | 174 | 29 | 19 | Wood |
| A | 30 | 420 | 70 | 70 | Wood |
| A | 30 | 1200 | 200 | 132 | Wood |
| A | 30 | 400 | 67 | 44 | Wood |
| A | High Bays | 1425 | 237 | 156 | Wood |

# Calculation Sheet

Originator Andrea George Date 03/08/96 Calc. No. 127-CV-0026 Rev. No. 0
Project FUSRAP Job No. 14501 Checked Date 3/11/96
Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 32 of 49

140210

Bechtel

## Overhead Demolition
## Buildings A and A-1

### Wood Demolition
### Inhalation

| | | |
|---|---|---|
| Avg. survey reading: | 5,065 | dpm/100 $cm^2$ |
| Total linear feet: | 3,971 | linear ft contaminated |
| Total area: | 661 | $ft^2$ contaminated |
| **Total pCi:** | **1.41E+07** | **pCi present** |
| Thickness: | 0.1 | in |
| | 0.254 | cm |
| Density: | 1.6 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 40.64 | g |
| Average conc.: | 56.65 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 1160 | $ft^2$/day (p.37 Waier 1996) |
| Removal Time: | 4.56 | hr |
| Airborne conc: | 1.02E-02 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 1.16E-01 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 1.51E-02 | mrem |
| U-235 dose: | 6.41E-04 | mrem |
| U-238 dose: | 1.39E-02 | mrem |
| **Total Dose =** | **2.97E-02** | **mrem** |

### Wood Demolition
### Ingestion

| | | |
|---|---|---|
| Avg. survey reading: | 5,065 | dpm/100 $cm^2$ |
| Total linear feet: | 3,971 | linear ft contaminated |
| Total area: | 661 | $ft^2$ contaminated |
| Thickness: | 0.1 | in |
| | 0.254 | cm |
| Density: | 1.6 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 40.64 | g |
| Average conc.: | 56.65 | pCi/g |
| Removal Rate: | 1160 | $ft^2$/day (p.37 Waier 1996) |
| Removal Time: | 4.56 | hr |
| Ingestion Rate: | 480 | mg/day |
| Intake: | 1.55E+01 | pCi |
| U-234 DCF: | 2.80E-04 | mrem/pCi |
| U-235 DCF: | 2.70E-04 | mrem/pCi |
| U-238 DCF: | 2.70E-04 | mrem/pCi |
| U-234 dose: | 4.34E-03 | mrem |
| U-235 dose: | 1.92E-04 | mrem |
| U-238 dose: | 4.18E-03 | mrem |
| **Total Dose =** | **8.71E-03** | **mrem** |

**Demolition worker dose from wood = 3.84E-02 mrem**

# Calculation Sheet

Bechtel

140210

Originator Andrea George Date 03/08/96 Calc. No. 127-CV-0016 Rev. No. 0

Project FUSRAP Job No. 14501 Checked Date 3/11/96

Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 33 of 49

## Overhead Demolition
## Buildings A and A-1

### Steel Demolition
### Inhalation

| | | |
|---|---|---|
| Avg. survey reading: | 3,901 | dpm/100 cm$^2$ |
| Total linear feet: | 3,877 | linear ft contaminated |
| Total area: | 2863 | ft$^2$ contaminated |
| **Total pCi:** | **4.72E+07** | **pCi present** |
| Thickness: | 0.1 | in |
| | 0.254 | cm |
| Density: | 1.6 | g/cm$^3$ |
| Mass under 100 cm$^2$: | 40.64 | g |
| Average conc.: | 43.63 | pCi/g |
| Mass loading Factor: | 1.80E-04 | g/m$^3$ |
| Removal Rate: | 400 | LF/day (p.34 Waier 1996) |
| Removal Time: | 77.54 | hr |
| Airborne conc: | 7.85E-03 | pCi/m$^3$ |
| Inhalation Rate: | 2.5 | m$^3$/hr |
| Intake: | 1.52E+00 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 1.98E-01 | mrem |
| U-235 dose: | 8.40E-03 | mrem |
| U-238 dose: | 1.83E-01 | mrem |
| **Total Dose =** | **3.89E-01** | **mrem** |

### Steel Demolition
### Ingestion

| | | |
|---|---|---|
| Avg. survey reading: | 3,901 | dpm/100 cm$^2$ |
| Total linear feet: | 3,877 | linear ft contaminated |
| Total area: | 2863 | ft$^2$ contaminated |
| Thickness: | 0.1 | in |
| | 0.254 | cm |
| Density: | 1.6 | g/cm$^3$ |
| Mass under 100 cm$^2$: | 40.64 | g |
| Average conc.: | 43.63 | pCi/g |
| Removal Rate: | 400 | LF/day (p.34 Waier 1996) |
| Removal Time: | 77.54 | hr |
| Ingestion Rate: | 480 | mg/day |
| Intake: | 2.03E+02 | pCi |
| U-234 DCF: | 2.80E-04 | mrem/pCi |
| U-235 DCF: | 2.70E-04 | mrem/pCi |
| U-238 DCF: | 2.70E-04 | mrem/pCi |
| U-234 dose: | 5.68E-02 | mrem |
| U-235 dose: | 2.52E-03 | mrem |
| U-238 dose: | 5.48E-02 | mrem |
| **Total Dose =** | **1.14E-01** | **mrem** |

**Demolition worker dose from steel = 5.03E-01 mrem**

# Calculation Sheet

Originator Andrea George Date 03/08/96 Calc. No. 127-CV-0016 Rev. No. 0
Project FUSRAP Job No. 14501 Checked Date 3/11/96
Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 34 of 49

140210

## Overhead Demolition
## Buildings A and A-1

### Pipe Demolition
### Inhalation

| | | |
|---|---|---|
| Avg. survey reading: | 9,970 | dpm/100 cm$^2$ |
| Total linear feet: | 2,000 | linear ft contaminated |
| Total area: | 1047 | ft$^2$ contaminated |
| **Total pCi:** | **4.41E+07** | **pCi present** |
| Thickness: | 0.1 | in |
| | 0.254 | cm |
| Density: | 1.6 | g/cm$^3$ |
| Mass under 100 cm$^2$: | 40.64 | g |
| Average conc.: | 111.51 | pCi/g |
| Mass loading Factor: | 1.80E-04 | g/m$^3$ |
| Removal Rate: | 150 | LF/day (p.37 Waier 1996) |
| Removal Time: | 106.67 | hr |
| Airborne conc: | 2.01E-02 | pCi/m$^3$ |
| Inhalation Rate: | 2.5 | m$^3$/hr |
| Intake: | 5.35E+00 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 6.96E-01 | mrem |
| U-235 dose: | 2.95E-02 | mrem |
| U-238 dose: | 6.42E-01 | mrem |
| **Total Dose =** | **1.37E+00** | **mrem** |

### Pipe Demolition
### Ingestion

| | | |
|---|---|---|
| Avg. survey reading: | 9,970 | dpm/100 cm$^2$ |
| Total linear feet: | 2,000 | linear ft contaminated |
| Total area: | 1047 | ft$^2$ contaminated |
| Thickness: | 0.1 | in |
| | 0.254 | cm |
| Density: | 1.6 | g/cm$^3$ |
| Mass under 100 cm$^2$: | 40.64 | g |
| Average conc.: | 111.51 | pCi/g |
| Removal Rate: | 150 | LF/day (p.37 Waier 1996) |
| Removal Time: | 106.67 | hr |
| Ingestion Rate: | 480 | mg/day |
| Intake: | 7.14E+02 | pCi |
| U-234 DCF: | 2.80E-04 | mrem/pCi |
| U-235 DCF: | 2.70E-04 | mrem/pCi |
| U-238 DCF: | 2.70E-04 | mrem/pCi |
| U-234 dose: | 2.00E-01 | mrem |
| U-235 dose: | 8.86E-03 | mrem |
| U-238 dose: | 1.93E-01 | mrem |
| **Total Dose =** | **4.01E-01** | **mrem** |

**Demolition worker dose from pipes = 1.77E+00 mrem**

# Calculation Sheet

Originator Andrea George Date 03/08/96 Calc. No. 127-CV-0076 Rev. No. 0
Project FUSRAP Job No. 14501 Checked Date 3/11/96
Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 35 of 49

14021 Bechtel

## Overhead Demolition
## Buildings A and A-1

| Steel and Pipe Cutting Inhalation | | |
|---|---|---|
| Weighted avg. | 5,966 | dpm/100 $cm^2$ |
| Total linear feet: | 5,877 | linear ft contaminated |
| Total area: | 3910 | $ft^2$ contaminated |
| Thickness: | 0.1 | in |
| | 0.254 | cm |
| Density: | 1.6 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 40.64 | g |
| Average conc.: | 66.73 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Frequency of Cuts: | 15 | ft |
| Time to make a cut: | 1.00 | min |
| Cutting Time: | 6.53 | hrs |
| Airborne conc: | 1.20E-02 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3/hr$ |
| Intake: | 1.96E-01 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 2.55E-02 | mrem |
| U-235 dose: | 1.08E-03 | mrem |
| U-238 dose: | 2.35E-02 | mrem |
| **Total Dose =** | **5.01E-02** | **mrem** |

**Total Dose from Overhead Demolition = 2.36 mrem**

**Total pCi = 1.05E+08 pCi**

a:\ven-ha.doc

HAZ-MISC.XLS

# ATTACHMENT D

## Overhead Recycling Buildings A and A-1

# Calculation Sheet

Bechtel

140210

Originator Andrea George AG Date 03/08/96 Calc. No. 127-CV-0076 Rev. No. 0

Project FUSRAP Job No. 14501 Checked [illegible] Date 3/11/96

Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 37 of 49

## Overhead Recycling
## Building A and A-1

| Building | Room | Total Linear Feet | Total Surface Area ($ft^2$) | Total Volume ($ft^3$) | Material |
|---|---|---|---|---|---|
| A | 20 | 76 | 76 | 4 | Steel Beam |
| A | 20 | 57 | 38 | 2 | Steel Beam |
| A | 30 | 1080 | 270 | 21 | Steel Angles |
| A | 30 | 1080 | 180 | 10 | Steel Angles |
| A | 30 | 400 | 667 | 24 | Steel Beam |
| A | 30 | 540 | 1258 | 42 | Steel Beam |
| A | 30 | 104 | 104 | 3 | Steel Beam |
| A | 30 | 540 | 270 | 5 | Steel Plates |
| A | Entire bldg. | 1500 | 785 | | 4" iron piping |
| A-1 | Entire bldg. | 500 | 262 | | 4" iron piping |
| A | 19 | 38 | 6 | 6 | Wood |
| A | 20 | 114 | 19 | 19 | Wood |
| A | 20 | 200 | 33 | 22 | Wood |
| A | 20 | 174 | 29 | 19 | Wood |
| A | 30 | 420 | 70 | 70 | Wood |
| A | 30 | 1200 | 200 | 132 | Wood |
| A | 30 | 400 | 67 | 44 | Wood |
| A | High Bays | 1425 | 237 | 156 | Wood |

# Calculation Sheet

Originator Andrea George Date 03/08/96 Calc. No. 127-CV-0026 Rev. No. 0
Project FUSRAP Job No. 14501 Checked Date 3/11/96
Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 38 of 49

Bechtel

140210

## Overhead Recycling
## Building A and A-1

### Slag from Melting Steel and Pipes
### Ingestion

| | | |
|---|---|---|
| Weighted avg. | 5,966 | dpm/100 cm$^2$ |
| Total linear feet: | 5,877 | linear ft contaminated |
| Total area: | 3910 | ft$^2$ contaminated |
| Total activity: | 9.85E+07 | pCi |
| Vol. of steel: | 111 | ft$^3$ |
| Fraction of U in slag: | 0.99 | |
| Fraction of metal in slag: | 0.03 | |
| Density of steel: | 7.86 | g/cm$^3$ |
| Mass of steel beams: | 2.47E+07 | g |
| Weight of pipe: | 10.79 | lb/ft of pipe |
| Mass of pipes: | 9.80E+06 | g |
| Density of slag: | 3.93 | g/cm$^3$ |
| Conc. in slag: | 94.21 | pCi/g |
| Ingestion Rate: | 480 | mg/day |
| Exposure time: | 0.1 | yr |
| Intake: | 1.58E+03 | pCi |
| U-234 DCF: | 2.80E-04 | mrem/pCi |
| U-235 DCF: | 2.70E-04 | mrem/pCi |
| U-238 DCF: | 2.70E-04 | mrem/pCi |
| U-234 dose: | 4.43E-01 | mrem |
| U-235 dose: | 1.97E-02 | mrem |
| U-238 dose: | 4.27E-01 | mrem |
| **Total Dose =** | **8.90E-01** | **mrem** |

### Slag from Melting Steel and Pipes
### External Dose

| | | |
|---|---|---|
| Weighted avg. | 5,966 | dpm/100 cm$^2$ |
| Total linear feet: | 5,877 | linear ft contaminated |
| Total area: | 3910 | ft$^2$ contaminated |
| Total activity: | 9.85E+07 | pCi |
| Vol. of steel: | 111 | ft$^3$ |
| Fraction of U in slag: | 0.99 | |
| Fraction of metal in slag: | 0.03 | |
| Density of steel: | 7.86 | g/cm$^3$ |
| Mass of steel beams: | 2.47E+07 | g |
| Weight of pipe: | 10.79 | lb/ft of pipe |
| Mass of pipes: | 9.80E+06 | g |
| Density of slag: | 3.93 | g/cm$^3$ |
| Conc. in slag: | 94.21 | pCi/g |
| Exposure time: | 0.1 | yr |
| U-234 DCF: | 6.97E-04 | mrem/yr/pCi/cm$^3$ |
| U-235 DCF: | 4.90E-01 | mrem/yr/pCi/cm$^3$ |
| U-238 DCF: | 6.97E-02 | mrem/yr/pCi/cm$^3$ |
| U-234 dose: | 2.58E-02 | mrem |
| U-235 dose: | 8.35E-01 | mrem |
| U-238 dose: | 2.58E+00 | mrem |
| **Total Dose =** | **3.44E+00** | **mrem** |

**Total dose to recycling worker = 5.01 mrem**

# Calculation Sheet

Originator Andrea George Date 03/08/96 Calc. No. 127-CV-0026 Rev. No. 0
Project FUSRAP Job No. 14501 Checked Date 3/11/96
Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 39 of 49

140210

Bechtel

## Overhead Recycling Building A and A-1

### Sandblasting of Steel and Pipes Inhalation

| | | |
|---|---|---|
| Weighted avg. | 5,966 | dpm/100 cm$^2$ |
| Total linear feet: | 5,877 | linear ft contaminated |
| Total area: | 3910 | ft$^2$ contaminated |
| Thickness: | 0.1 | in |
| | 0.254 | cm |
| Density: | 1.6 | g/cm$^3$ |
| Mass under 100 cm$^2$: | 40.64 | g |
| Average conc.: | 66.73 | pCi/g |
| Mass loading Factor: | 1.80E-04 | g/m$^3$ |
| Removal Rate: | 1352 | ft$^2$/day (p.149 Waier 1996) |
| Removal Time: | 23.13 | hr |
| Airborne conc: | 1.20E-02 | pCi/m$^3$ |
| Inhalation Rate: | 2.5 | m$^3$/hr |
| Intake: | 6.95E-01 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 9.03E-02 | mrem |
| U-235 dose: | 3.83E-03 | mrem |
| U-238 dose: | 8.34E-02 | mrem |
| **Total Dose =** | **1.78E-01** | **mrem** |

### Slag from Melting Steel and Pipes Inhalation

| | | |
|---|---|---|
| Weighted avg. | 5,966 | dpm/100 cm$^2$ |
| Total linear feet: | 5,877 | linear ft contaminated |
| Total area: | 3910 | ft$^2$ contaminated |
| Total activity: | 9.85E+07 | pCi |
| Vol. of steel: | 111 | ft$^3$ |
| Fraction of U in slag: | 0.99 | |
| Fraction of metal in slag: | 0.03 | |
| Density of steel: | 7.86 | g/cm$^3$ |
| Mass of steel beams: | 2.47E+07 | g |
| Weight of pipe: | 10.79 | lb/ft of pipe |
| Mass of pipes: | 9.80E+06 | g |
| Density of slag: | 3.93 | g/cm$^3$ |
| Conc. in slag: | 94.21 | pCi/g |
| Mass loading Factor: | 3.00E-05 | g/m$^3$ |
| Exposure time: | 0.1 | yr |
| Airborne conc: | 2.83E-03 | pCi/m$^3$ |
| Inhalation Rate: | 2.5 | m$^3$/hr |
| Intake: | 1.98E+00 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 2.57E-01 | mrem |
| U-235 dose: | 1.09E-02 | mrem |
| U-238 dose: | 2.37E-01 | mrem |
| **Total Dose =** | **5.06E-01** | **mrem** |

# ATTACHMENT E

## Floor Demolition
## Buildings A and A-1

# Calculation Sheet

**Bechtel**

140210

Originator Andrea George AG Date 03/08/96 Calc. No. 127-CV-00X6 Rev. No. 0

Project FUSRAP Job No. 14501 Checked CMH Date 3/11/96

Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 41 of 49

## Floor Demolition
## Building A

Maximum Average from Room 29 = 7410 dpm/100 $cm^2$

Contaminated Rooms

| Room | Area ($ft^2$) | Type |
|---|---|---|
| 19 | 530 | 4" concrete |
| 20 | 3102 | " |
| 25 | 207 | " |
| 26 | 132 | 4" concrete, asbestos tile, and carpet |
| 27 | 200 | 4" concrete |
| 28 | 390 | " |
| 29 | 323 | " |
| 30 | 6008.5 | " |
| 33 | 529.5 | " |

# Calculation Sheet

Originator Andrea George Date 03/08/96 Calc. No. 127-CV-0026 Rev. No. 0
Project FUSRAP Job No. 14501 Checked CMK Date 3/11/96
Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 42 of 49

140210

Bechtel

## Floor Demolition
## Building A

### Floor Demolition

| | | |
|---|---|---|
| Total area: | 11422 | $ft^2$ contaminated |
| Total pCi: | 3.57E+08 | pCi present |
| Total Vol: | 3807 | $ft^3$ contaminated |
| | 141.01 | $yd^3$ contaminated |
| | 107.81 | $m^3$ contaminated |
| Thickness: | 4 | in |
| | 10.16 | cm |
| Density: | 2.4 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 2438.4 | g |
| Average conc.: | 1.38 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 3.1 | $m^3$/hr (p.30 Waier 1996) |
| Removal Time: | 34.78 | hr |
| Airborne conc: | 2.49E-04 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 2.16E-02 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 2.81E-03 | mrem |
| U-235 dose: | 1.19E-04 | mrem |
| U-238 dose: | 2.59E-03 | mrem |
| **Total Dose =** | **5.52E-03** | **mrem** |

### Rubble Removal

| | | |
|---|---|---|
| Total area: | 11422 | $ft^2$ contaminated |
| Total Vol: | 3807 | $ft^3$ contaminated |
| | 141.01 | $yd^3$ contaminated |
| | 107.81 | $m^3$ contaminated |
| Thickness: | 4 | in |
| | 10.16 | cm |
| Density: | 2.4 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 2438.4 | g |
| Average conc.: | 1.38 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 40 | $m^3$/hr (p.30 Waier 1996) |
| Removal Time: | 2.70 | hr |
| Airborne conc: | 2.49E-04 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 1.68E-03 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 2.18E-04 | mrem |
| U-235 dose: | 9.25E-06 | mrem |
| U-238 dose: | 2.01E-04 | mrem |
| **Total Dose =** | **4.28E-04** | **mrem** |

# Calculation Sheet

Originator Andrea George AG Date 03/08/96 Calc. No. 127-CV-0026 Rev. No. 0

Project FUSRAP Job No. 14501 Checked CMM Date 3/11/96

Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 43 of 49

140210

DEWITT

## Floor Demolition
## Building A-1

Maximum Average from Room 8 = 34096 dpm/100 $cm^2$

Contaminated Rooms

| Room | Area ($ft^2$) | Type |
|---|---|---|
| 1 | 205 | 4" concrete |
| 2 | 264 | " |
| 4 | 483.75 | " |
| 5 | 635.5 | " |
| 6 | 1723 | " |
| 8 | 344 | " |
| 10 | 448 | " |

# Calculation Sheet

Originator Andrea George Date 03/08/96 Calc. No. 127-CV-0076 Rev. No. 0
Project FUSRAP Job No. 14501 Checked Date 3/11/96
Subject Dose Assessment for Ventron Buildings A and A-1 Sheet No. 44 of 49

Bechtel

140210

## Floor Demolition
## Building A-1

### Floor Demolition

| | | |
|---|---|---|
| Total area: | 4103.25 | $ft^2$ contaminated |
| Total pCi: | 5.91E+08 | pCi present |
| Total Vol: | 1368 | $ft^3$ contaminated |
| | 50.66 | $yd^3$ contaminated |
| | 38.73 | $m^3$ contaminated |
| Thickness: | 4 | in |
| | 10.16 | cm |
| Density: | 2.4 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 2438.4 | g |
| Average conc.: | 6.36 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 3.1 | $m^3$/hr (p.30 Waier 1996) |
| Removal Time: | 12.49 | hr |
| Airborne conc: | 1.14E-03 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 3.57E-02 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 4.65E-03 | mrem |
| U-235 dose: | 1.97E-04 | mrem |
| U-238 dose: | 4.29E-03 | mrem |
| **Total Dose =** | **9.13E-03** | **mrem** |

### Rubble Removal

| | | |
|---|---|---|
| Total area: | 4103.25 | $ft^2$ contaminated |
| Total Vol: | 1368 | $ft^3$ contaminated |
| | 50.66 | $yd^3$ contaminated |
| | 38.73 | $m^3$ contaminated |
| Thickness: | 4 | in |
| | 10.16 | cm |
| Density: | 2.4 | $g/cm^3$ |
| Mass under 100 $cm^2$: | 2438.4 | g |
| Average conc.: | 6.36 | pCi/g |
| Mass loading Factor: | 1.80E-04 | $g/m^3$ |
| Removal Rate: | 40 | $m^3$/hr (p.30 Waier 1996) |
| Removal Time: | 0.97 | hr |
| Airborne conc: | 1.14E-03 | $pCi/m^3$ |
| Inhalation Rate: | 2.5 | $m^3$/hr |
| Intake: | 2.77E-03 | pCi |
| U-234 DCF: | 0.13 | mrem/pCi |
| U-235 DCF: | 0.12 | mrem/pCi |
| U-238 DCF: | 0.12 | mrem/pCi |
| U-234 dose: | 3.60E-04 | mrem |
| U-235 dose: | 1.53E-05 | mrem |
| U-238 dose: | 3.32E-04 | mrem |
| **Total Dose =** | **7.08E-04** | **mrem** |

# ATTACHMENT F

## Contamination in Building Rubble
## Crusher Operations
## Landfill Operations

## Summary of Rubble Volumes

| Bldg | Section | Description | Mass (g) | U-238 Activity (pCi) |
|---|---|---|---|---|
| A-1 | Floor | 4" Concrete | 2.20E+08 | 5.91E+08 |
| A-1 | Walls | 4" Cinder block<br>8" cinder block<br>12" Solid block<br>6" solid block | 8.08E+08 | 5.86E+08 |
| A | Floor | 4" concrete | 4.15E+08 | 3.57E+08 |
| A | Walls | 4" Cinder block<br>8" cinder block<br>12" Solid block | 6.40E+08 | 8.19E+08 |
| | | **Totals =** | 2.08E+09 | 2.35E+09 |

Avg. conc. in masonry rubble = 2.31 pCi/g of total uranium

**Masonry Rubble**

| | | |
|---|---|---|
| U-234 total activity = | 2.35 | mCi |
| U-235 total activity = | 0.11 | mCi |
| U-238 total activity = | 2.35 | mCi |
| Total Activity = | 4.81 | mCi |

**Wood and masonry rubble**

| | | |
|---|---|---|
| Mass of wood = | 2.12E+07 | g |
| U-238 activity in dust on wood = | 1.41E+07 | pCi |
| Avg. conc. in building rubble = | 2.30 | pCi/g |

| | | | | | |
|---|---|---|---|---|---|
| U-234 specific activity = | 6.19 | mCi/g | Mass of U-234 = | 0.38 | g |
| U-235 specific activity= | 2.14E-03 | mCi/g | Mass of U-235 = | 50.58 | g |
| U-238 specific activity= | 3.33E-04 | mCi/g | Mass of U-238 = | 7066.07 | g |

Total mass of U = 7117.02 g
15.6763 lbs

## Concrete Crusher

| | | |
|---|---|---|
| Production Rate = | 20 | $yd^3/hr$ |
| Concrete to be Processed = | 1135.186 | $yd^3$ |
| Processing time = | 56.7593 | hrs |
| Mass loading factor= | 0.00018 | $g/m^3$ |
| Airborne conc = | 0.000416 | $pCi/m^3$ |
| Inhalation rate = | 2.5 | $m^3/hr$ |
| Intake = | 0.059032 | pCi |
| U-234 DCF = | 0.13 | mrem/pCi |
| U-235 DCF = | 0.12 | mrem/pCi |
| U-238 DCF = | 0.12 | mrem/pCi |
| U-234 dose = | 0.003753 | mrem |
| U-235 dose = | 0.000156 | mrem |
| U-238 dose = | 0.003464 | mrem |
| **Total dose =** | **0.007373** | **mrem** |

RESRAD, Version 5.61 T½ Limit = 0.5 year 03/08/96 17:35 Page 9
Summary : RESRAD default data File: VENLAND.DAT

| Contaminated Zone Dimensions | | Initial Soil Concentrations, pCi/g | |
|---|---|---|---|
| Area: | 289.00 square meters | U-234 | 1.130E+00 |
| Thickness: | 0.30 meters | U-235 | 5.100E-02 |
| Cover Depth: | 0.15 meters | U-238 | 1.130E+00 |

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 30 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

| t (years): | 0.000E+00 | 1.000E+00 | 3.000E+00 | 1.000E+01 | 3.000E+01 | 1.000E+02 | 3.000E+02 | 1.000E+03 |
|---|---|---|---|---|---|---|---|---|
| TDOSE(t): | 7.731E-04 | 7.631E-04 | 7.436E-04 | 6.790E-04 | 5.238E-04 | 2.118E-04 | 1.797E-05 | 4.292E-06 |
| M(t): | 2.577E-05 | 2.544E-05 | 2.479E-05 | 2.263E-05 | 1.746E-05 | 7.059E-06 | 5.991E-07 | 1.431E-07 |

Maximum TDOSE(t): 7.731E-04 mrem/yr at t = 0.000E+00 years

Attachment G

## Naturally Occurring Radiation in Building Materials and Solid Waste

| Material | | U-238 (pCi/g) | Ra-226 (pCi/g) | Th-232 (pCi/g) | Reference |
|---|---|---|---|---|---|
| Red Brick | | 1.2 | | 1.8 | A |
| Concrete | | 0.9 | | | A |
| Clay Brick | | 3.0 | 14 | 1.2 | A |
| Silicate Brick | | 0.2 | 0.2 | 0.1 | A |
| Granite | | 6.0 | 2.4 | 2.2 | A |
| Natural Gypsum | | 0.4 | 0.6 | 0.2 | A |
| Manufactured Gypsum | C | | 30 - 40 | | B |
| Concrete Block (Fly Ash) | C | 1 - 12 | 0.2 - 4.0 | 1.0 - 1.2 | A |
| Cement | | 1.1 | | 0.4 | A |
| Silica Sand | | 0.3 | | 0.5 | A |
| Photo Materials | C | 0.07 - .34 | | | A |
| Coal | C | 0.07 - 8.4 | | 0.21 - 19 | A |
| Fly Ash - Anthracite | | 3.0 | | | B |
| Fly Ash - Eastern Bituminous | | 12.7 | | | B |
| Fly Ash - Western Bituminous | | 5.4 | | | B |
| Fly Ash - Lignite | | 7.4 | | | B |
| Fertilizer | | D | 5 - 6 | | A |

A Eisenbud, Merril (1987), "Environmental Radioactivity From Natural, Industrial, and Military Sources," Academic Press, Inc.., New York.

B National Council on Radiation Protection and Measurements, "Exposure From the Uranium Series with Emphasis on Radon and its Daughters," NCRP Report 77, 1983.

C Values shown are ranges

D Reference does not give activities but does state that in 1974 about 26 million tons of ore (phosphate rock) mined for fertilizer production contained about 1,000 Ci of radium-226 in equilibrium with uranium-238 and 3,000 Ci of potassium-40 are added to the soil during fertilizer application in the US annually.

142718

96-288

# Department of Energy

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831—8723

May 30, 1996

Ms. Lisa Alexander
Massachusetts Department of
Environmental Protection
10 Commerce Way
Woburn, Massachusetts 01801

Mr. Thomas F. O'Connell
Massachusetts Department of
Health, Radiation Control Program
305 South Street
Jamaica Plain, Massachusetts 02130

Dear Ms. Alexander and Mr. O'Connell:

**VENTRON SITE - FINAL TRANSMITTAL OF REQUESTED INFORMATION**

In response to our meeting on March 27, 1996, I have enclosed supplemental information regarding the Department of Energy's (DOE) proposed removal action at the Ventron Site in Beverly, Massachusetts.

Dose calculations for the demolition of Buildings A and A-1 were transmitted to you on March 15, 1996, prior to our meeting. The first enclosure is the DOE Headquarters approval for the proposed approach for these buildings. The supplemental limits granted in this approval are based on the characterization data for the site and reference the dose calculations. As discussed in our meeting, measurements of levels of radioactivity present in the demolition debris will be performed prior to release of this material to the site owner. These measurements will ensure compliance with the parameters used in the dose calculations. As requested at the meeting, we have also developed estimates of the potential risk associated with the demolition of Buildings A and A-1, which is included as a second enclosure. The maximum risks associated with these activities range from $10^{-9}$ to $10^{-7}$, well below the target risk range established by the U.S. EPA and the target risk of $10^{-5}$ established by Massachusetts DEP.

The uranium guideline derivation report was also transmitted to you prior to our meeting. This derivation was performed to determine a soil uranium activity concentration that would limit the potential radiation doses to current and future receptors to less than 100 mrem/yr. The 100 mrem/yr dose limit is a consensus standard, recognized by virtually all national and international radiation protection authorities, including DOE, the U.S. Environmental Protection Agency (EPA), the Nuclear Regulatory Commission (NRC), the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP). The soil concentration limit derived in this report, 230 pCi/g for uranium-238, was subsequently lowered to 100 pCi/g in order to implement DOE's as-low as-reasonably-achievable (ALARA) policy. DOE's soil criteria for the secondary contaminants of concern, radium-226 and thorium-232, are specified in DOE Order 5400.5, and are equivalent to those specified in EPA regulation 40 CFR 192 for cleanup of uranium mill tailings. These criteria have been successfully applied at over 5000 contaminated properties throughout the United States.

As you requested at our meeting, I have also enclosed an analysis of the potential radiation dose and health risk associated with the site conditions following the removal action. Following completion of the proposed removal action, the dose to future occupants of the site is predicted to range from less than 1 mrem/yr to an upper bound of 3 mrem/yr; these dose estimates are well below DOE guidelines and Massachusetts regulations for radioactive materials (i.e., 105 CMR 120 limits the dose from a remediated property not to exceed 10 mrem/yr above background for unrestricted use). The potential health risk to future site occupants is also estimated to meet EPA and Massachusetts DEP guidelines. In addition, a final dose assessment will also be performed following completion of the removal action, using actual post-remediation sampling results.

This completes the deliverables that we committed to provide to you during our March meeting. Mobilization is scheduled to begin mid-June with the completion of remedial action scheduled for early September 1996. After completing the remedial action, the site will be released to DOE's independent verification contractor (IVC). The IVC will verify that the remedial action meets the established criteria. A Post-Remedial Action Report, Federal Register Notice, and a Certification Docket will be completed for the site. The Certification Docket is the final certification that the property meets all applicable criteria.

The enclosed documents demonstrate that the proposed cleanup action will restore the site to a condition that presents no significant risk of harm to human health, safety, public welfare, or the environment. Also enclosed is a copy of the final Engineering Evaluation/Cost Analysis (EE/CA). If you have any questions, please contact me at (423) 576-9441.

Sincerely,

James D. Kopotic

James D. Kopotic, Site Manager
Former Sites Restoration Division

Enclosures: As stated

cc w/o enclosures:
Stephen M. Johnson, MA-DEP
Alicia Raddatz, Morton, Inc.

# DISCUSSION POINTS: DOE CLEANUP APPROACH FOR THE VENTRON SITE

Remediation of residual radioactive materials exceeding DOE criteria is being conducted under DOE's Formerly Utilized Sites Remedial Action Program. The cleanup is being pursued as a removal action, as documented in the *Ventron Engineering Evaluation/Cost Analysis (EE/CA)* (DOE, May 1996). In addition to the EE/CA, other pertinent documents include the *Site Characterization Report for the Ventron Site* (December 1995), *Derivation of Uranium Residual Radioactive Material Guidelines for the Ventron Site* (ANL, March 1992), and *Uranium Guideline for the Ventron Site* (Memo from J. Wagoner to L. Price, DOE, November 6, 1992). These documents were all developed in accordance with DOE requirements and guidelines to derive site-specific cleanup limits for those contaminants for which DOE has responsibility and authority. In a meeting on March 27, 1996, between DOE, Morton, MADEP and MADPH-RCP personnel, DOE was made aware of recent risk characterization guidance (MADEP, July 1995) developed in support of the Massachusetts Contingency Plan (MCP). After reviewing this guidance, DOE has conducted additional analyses (*Characterization of Radiation Dose and Human Health Risk Following Remediation of the Ventron Site*, May 1996; and *Risk Assessment for Ventron Buildings A and A-1 Demolition*, May 1996) which indicate that the remediation approach proposed by DOE meets the MADEP risk objectives, as well as all applicable DOE requirements. DOE's proposed response action will remediate levels of residual radioactive materials at the site to a condition that presents no significant risk of harm to human health, safety, public welfare, or the environment. Key findings and highlights of DOE's proposed approach for the Ventron site are summarized below:

- Contaminants of concern: DOE has authority only for remediation of radioactive contamination resulting from operations formerly conducted under contract with the Atomic Energy Commission (AEC) and Manhattan Engineer District (MED). Uranium is the primary radioactive contaminant for which DOE has responsibility; radium-226 and thorium-232, and their associated decay products, are also present, but generally at lower levels. Therefore, DOE's analysis is limited exclusively to remediation of these contaminants for which DOE has authority to address. Remediation of chemical contaminants and any non-DOE radioactive contaminants is being conducted separately by Morton.

- Cleanup criteria: DOE Order 5400.5 specifies cleanup criteria for radium-226 and thorium-232 in soil. These criteria limit concentrations of these radionuclides in soil to 5 pCi/g in the top 15-cm layer of soil, and 15 pCi/g in any subsequent 15-cm layer, averaged over any 100 $m^2$ area. These guidelines, which are generally applicable to any DOE remedial actions involving these radionuclides, are adopted from EPA regulation 40 CFR 192 for cleanup of uranium mill tailings. These criteria have been successfully applied at over 5000 contaminated properties throughout the United States. For uranium, DOE policy requires derivation of site-specific guidelines; values for the Ventron site are documented in the 1992 ANL report and DOE memorandum. DOE's analysis indicates that radiation doses and health risk from residual concentrations of radioactive materials following completion of the proposed cleanup would be indistinguishable from natural background exposures.

- Risk characterization: The DOE cleanup criteria for uranium were derived to limit potential radiation doses to current and future receptors to less than 100 mrem/yr; as indicated in the

report *Characterization of Radiation Dose and Human Health Risk Following Remediation of the Ventron Site* (DOE, May 1996), current estimates of post-remediation dose are much lower, with a maximum estimated dose of approximately 3 mrem/yr under worst-case conditions and less than 1 mrem/yr under expected conditions. Noncancer effects were not explicitly considered in the derivation of the DOE criteria; however, noncancer effects of uranium have been evaluated in the report, and determined to be well within acceptable levels (Hazard Quotient = 0.001). The MADEP comments also recommend that cumulative risks of all contaminants should be evaluated; however, as discussed above, DOE has authority only for specific radioactive contaminants of concern, and has no authority or jurisdiction for evaluation of other contaminants.

- Background data: Background data for the radioactive contaminants of concern (uranium, radium, and thorium) are well documented throughout the U.S. These radionuclides are natural constituents of the earth's mantle, and occur naturally in soil and rock at relatively consistent concentrations. Given the small variability in background concentrations for these radionuclides within a given geographic region, DOE experience indicates that the available background samples provide sufficient data to characterize site-specific background conditions, and additional investigation of background is not warranted.

- Evaluation of residential properties: Properties in the immediate vicinity of the Ventron site were evaluated by DOE during initial investigations of the site. A review of the radiological survey reports for the 24 properties indicates that none of the samples exceeded the site-specific uranium guideline of 50 pCi/g for U-238. Only three samples exceeded 50% of the guideline:

  - 24 pCi/g U-238 in sample S2 from 14 Cliff St. (ORNL/RASA-91/25), taken from the face of the rock cliff, approximately 5 ft above the high water line;

  - 34 pCi/g U-238 in sample B1 from 9 and 11 Congress St. (ORNL/RASA-91/13), taken from a small area of less than 1 $m^2$ at the rain gutter downspout outfall; and

  - 40 pCi/g U-238 in sample S9B from 18 Cliff St. (ORNL/RASA-91/26), taken from the bay floor (harbor flat area), approximately 53 ft from the base of the cliff.

  None of the vicinity properties were designated for consideration under FUSRAP, due to the low levels of radioactive materials identified. Consequently, DOE has no authority to conduct investigations or evaluations for these properties.

- Additional characterization data needs for hazardous chemicals: As noted above, DOE has responsibility and authority only for specific radioactive contaminants at this site (uranium, radium, and thorium at concentrations above authorized limits). Therefore, DOE has no authority to expend resources for further characterization of hazardous chemical contaminants at the site. DOE characterization of chemical contamination is limited to data required to determine proper disposition of the remediation wastes (e.g., whether specific waste streams would be classified as mixed wastes vs radioactive wastes).

- Dose & risk estimates:

| | mrem/yr | Cancer risk |
|---|---|---|
| - Remediation worker from Bldg A/A-1 demolition: | 2.5 | 1.5E-7 |
| - Recylcing worker from Bldg A/A-1 demolition: | 5.0 | 2.2E-7 |
| - Landfill worker from Bldg A/A-1 demolition: | 0.0008 | 1E-8 |
| - Future Ventron site resident: | < 1 - 3.5 | 9E-7 - 3E-5 |
| - Future Ventron site worker: | < 1 | 1E-9 - 8E-6 |

144842 96-379

# Department of Energy

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831—8723

July 31, 1996

Ms. Meg Harvey
Office of Research and Standards
Massachusetts Department of Environmental Protection
One Winter Street
Boston, Massachusetts 02108

Dear Ms. Harvey:

**VENTRON SITE - TRANSMITTAL OF RESRAD DATA FILES**

Enclosed is a computer disk containing the RESRAD data files used to derive the dose and risk estimates presented in the report "Characterization of Radiation Dose and Human Health Risk Following Remediation of the Ventron Site". Also enclosed is a second disk containing the RESRAD source code (Version 5.61) for your convenience. These materials may be useful in your review of this report.

The enclosed table indicates the names of each of the RESRAD data files and output reports that correspond to the calculations presented in the report. In preparing this material for you we identified a minor error in the report which does not materially impact the conclusions of the evaluation. In Table 3 of the report the upper bound dose estimates should be reported as 3.8 mrem/yr for the resident and 1.2 mrem/yr for the worker; these maximum values occur 1000 years following completion of the remedial action. The values reported in the report (3.5 mrem/yr and 0.86 mrem/yr, respectively) represent the dose estimates immediately following completion of the remedial action (i.e., time zero). The risk estimates are not changed to one significant digit. A corrected copy of Table 3 is enclosed.

I hope that these files will assist you in completing your review of the DOE assessment. Based on this evaluation, the proposed cleanup action will restore the site to a condition that presents no significant risk of harm to human health, safety, public welfare, or the environment. If you have any questions, please call me at (423) 576-9441.

Sincerely,

James Kopotic

James D. Kopotic, Site Manager
Former Sites Restoration Division

Enclosures: As stated

cc w/o enclosures:
Steve Johnson - MDEP
Lisa Alexander - MDEP
Suzanne Condon - MDPH
Tom O'Connell - MDPH
Alicia Raddatz - Morton, Inc.

RESRAD Data File Names and Output Reports for the Ventron Site, Estimated Post-RA Conditions

| Scenario | Data File | Output Files |
|---|---|---|
| Resident - Best Estimate (excludes radon pathway) | VENTRON.BER | **VENBER.SUM (dose estimates)**<br>**VENBER.RSK (risk estimates)** |
| Resident - Upper Bound (excludes radon pathway) | VENTRON.UBR | VENUBR.SUM (dose estimates)<br>VENUBR.RSK (risk estimates) |
| Resident - Radon Pathway | VENTRON.RNR (best estimate)<br>VENTRON.RNX (upper bound) | VENRNW.DET (radon conc estimates)<br>VENRNX.DET (radon conc estimates) |
| Worker - Best Estimate (excludes radon pathway) | VENTRON.BEW | **VENBEW.SUM (dose estimates)**<br>**VENBEW.RSK (risk estimates)** |
| Worker - Upper Bound (excludes radon pathway) | VENTRON.UBW | VENUBW.SUM (dose estimates)<br>VENUBW.RSK (risk estimates) |
| Worker - Radon Pathway | VENTRON.RNW (best estimate)<br>VENTRON.RNX (upper bound) | VENRNW.DET (radon conc estimates)<br>VENRNX.DET (radon conc estimates) |

Note: DOE dose limits explicitly exclude radon pathway exposures; the radon exposure pathway is, therefore, evaluated separately from other exposure pathways by comparison to specific radon concentration limits for indoor air (pCi/L) and radon decay product concentrations in indoor air (Working Level).

Table 3. Estimates of Potential Radiation Dose and Risk for Future Exposure Scenarios Following Remediation of the Ventron Site (Revised).

| Scenario | Dose (mrem/yr) | Cancer Risk | Radon Conc. (pCi/L) | Radon Decay Product Conc. (WL) |
|---|---|---|---|---|
| Resident | | | | |
| Best Estimate | 0.24 | $9 \times 10^{-7}$ | 0.078 | 0.0004 |
| Upper Bound | 3.8 | $3 \times 10^{-5}$ | 0.17 | 0.0009 |
| Commercial/Industrial Employee | | | | |
| Best Estimate | 0.00036 | $1 \times 10^{-9}$ | 0.078 | 0.0004 |
| Upper Bound | 1.2 | $8 \times 10^{-6}$ | 0.17 | 0.0009 |

143840


# The Commonwealth of Massachusetts

Executive Office of Health and Human Services
Department of Public Health
Radiation Control Program
305 South Street, Jamaica Plain, MA 02130
(617) 727-6214 · FAX (617) 727-2098

WILLIAM F. WELD
Governor

ARGEO PAUL CELLUCCI
Lieutenant Governor

GERALD WHITBURN
Secretary

DAVID H. MULLIGAN
Commissioner


JUL 3 1 04 PM '96

June 21, 1996

James Kopotic
Site Manager
United States Department of Energy
Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831-8723

Re: Ventron Site, Beverly, MA

Dear Mr. Kopotic,

The MA Radiation Control Program (RCP) is in receipt of your documentation which describes the United States Department of Energy's (DOE) proposed plan for the remediation of radioactive materials at the Ventron site located in Beverly, MA.

The Ventron site has been designated by DOE as a part of the Formerly Utilized Site Remedial Action Program (FUSRAP). The site is currently owed by Morton International, Inc. The site was previously owed by Metal Hydrides Corporation and subsequently the Ventron Corporation.

In the 1940s the site was under contract with the Manhattan Engineering District and the Atomic Energy Commission. Under these contracts, the company performed operations involving the use of uranium. Thorium and radium have also been used in past operational activities at the Ventron site.

There have not been any operational activities at the Ventron site since November of 1994.

The RCP has reviewed the proposed remediation plan documentation. This documentation included the results of previous radiological surveys performed on soil, aquatic media and building surfaces for DOE; descriptions of the extent of radiological contamination at the site; proposed radiological cleanup options; and, dose/risk assessment methodologies.

143840



The proposed radiological remediation plan was evaluated against 105 CMR 120.000 of the Massachusetts Regulations for the Control of Radiation (MRCR). The proposed remediation plan, as submitted, appears to met the requirements of 105 CMR 120.291: Vacating Premises.

Therefore, the RCP approves of the remediation plan which has been submitted by the US DOE based on the documentation and information currently available on the radiological conditions at the Ventron site.

If the radiological remediation activities described in the submitted plan change and/or there are additional activities performed at the site which did not appear in the proposed plan, then the RCP must be notified of these changes.

If you have any questions, please do not hesitate to contact our office at 617-727-6214.

Sincerely,

Thomas F. O'Connell

Thomas F. O'Connell
Radiation Scientist
Radiation Control Program

cc: R. Hallisey, Dir.-MA RCP
L. Alexander, MA DEP
A. Raddatz, Morton International

143797

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
METROPOLITAN BOSTON - NORTHEAST REGIONAL OFFICE

JUL 1 1 47 PM '96

WILLIAM F. WELD
Governor

ARGEO PAUL CELLUCCI
Lt. Governor

TRUDY COXE
Secretary

DAVID B. STRUHS
Commissioner

JUN 21 1996

Department of Energy
Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, TN 37831-8723

Attention: Jim Kopotic

RE: BEVERLY - Former
Ventron Site
10-12 Congress Street
**Demolition of Building A & A-1;**
**Risk Characterization Report**
**RTN 3-2887**

Dear Mr. Kopotic,

The Massachusetts Department of Environmental Protection's (MDEP's) Bureau of Waste Site Cleanup (BWSC) has completed its review of the Department of Energy's (DOE) recent submittal. The package, comprised of materials requested during a March 29, 1996 site visit, included (1) information on the DOE's Supplemental Regulations and the justification for the remediation approach regarding Buildings A and A-1; (2) additional calculations addressing risk to workers who would be involved with building demolition and/or transport and disposal of materials from the site; and, (3) the final report entitled "Ventron Engineering Evaluation/Cost Analysis (EE/CA)". This material provided additional documentation for the remedial action approach originally proposed by DOE and Morton International, Inc. (Morton) for demolition and removal of buildings.

The package also included the "Characterization of Radiation Dose and Human Health Risk Following Remediation of the Ventron Site" dated May 1996, prepared by the DOE's Sites Restoration Division. These reports were received on May 31, 1996 by MDEP BWSC (Northeast Regional Office) and during the first week of June by Meg Harvey at the MDEP's Office of Research and Standards (ORS, Boston office). This Characterization report is the critical piece of information that ORS needs to determine whether the DOE's cleanup criteria will meet the Massachusetts Contingency Plan (MCP) requirements for complying with the MCP risk limits. Unlike previously submitted material which back-calculates a site specific cleanup concentration based on an allowable dose, the Characterization report estimates the risk in terms of cancer slope factors and also in terms of non-cancer risks (specifically from uranium's effects on kidneys) which are required by the MCP.

Based on submittals we have received, the MDEP has no objection to the proposed building demolition. It is MDEP's understanding that

the building rubble is going to remain onsite until the final disposal option has been determined. DOE will provide health physics support for radiological screening during demolition, and material will be sorted for disposal based on radionuclide concentrations. Material with radiological concentrations exceeding DOE's guidelines will be disposed at a DOE facility for radiological waste. Morton is currently investigating options for the final disposal of the material which will not be handled by DOE. It is MDEP's understanding that Morton is still investigating various options, including off-site disposal of the wood and metal. Morton has also been investigating various options for disposal of the concrete rubble, including possibly backfilling rubble with radiological concentrations below the site cleanup guidelines. In previous discussions, it had been indicated that this material might be sent to a construction and demolition landfill pending acceptance at such a facility. Prior to transporting the demolition debris off-site, MDEP must be provided with a copy of the approval for this material from the agency that regulates the receiving facility.

Regarding the site specific clean up guidelines and excavation of the radiologically contaminated soils, it is MDEP's understanding that the remedial response action as proposed is scheduled to begin this summer. You have indicated that it would take at least three months to complete the excavation and that DOE would prefer to do so before the onset of winter. As discussed with you on June 19, 1996, the MDEP has no objection to DOE mobilizing to the site to initiate the soil and sediment excavation; however, as we have indicated, MDEP's ORS will not be able to review the Characterization report to provide MDEP's comments to DOE regarding the assumptions and risk calculations with respect to the MCP until mid to late July.

If you have any questions regarding this matter, please contact DEP's Lisa Alexander at (617) 932-7722.

Very Truly Yours,

Lisa M. Alexander
Environmental Engineer

Stephen M. Johnson
Section Chief
Bureau of Waste Site Cleanup

cc: Alicia Raddatz, Morton International, 150 Andover Street, Danvers, MA 01923-1480

143797

Former Morton/Ventron
RTN 3-2887

Michael Redmon, Bechtel National, Inc., 151 Lafayette Drive, P.O. Box 350, Oak Ridge, TN 37831-0350
Tom O'Connell, Department of Public Health, Radiation Control Progam, 305 South St., Jamaica Plain, MA 02130
Elaine Kreuger, Department of Public Health, 150 Tremont St., Boston, MA 02111
Joseph Walsh, Jr., CHO, Director, Beverly - BOH, P.O. Box 441, Beverly, MA 01915
Beverly Conservation Commission, DPW Office, 191 Cabot St., Beverly, MA 01915
Jake Condon, 19 Wellman St., Beverly, MA 01915
Beverly Public Library, 32 Essex St., Beverly, MA 01915
DEP, Office of Research and Standards, Attn: Meg Harvey
DEP Data Entry/File

143180

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
METROPOLITAN BOSTON - NORTHEAST REGIONAL OFFICE

JUN 12 1 48 PM '96

WILLIAM F. WELD
Governor

ARGEO PAUL CELLUCCI
Lt. Governor

TRUDY COXE
Secretary

DAVID B. STRUHS
Commissioner

Department of Energy
Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831-8723

JUN 05 1996

Attention: Jim Kopotic

RE: BEVERLY - Former
Ventron Site
10-12 Congress Street
Review of DOE's December 1995
Site Characterization Report
for the Former Ventron Site
**RTN 3-2887**

Dear Mr. Kopotic,

The Department of Environmental Protection's (DEP's) Office of Research and Standards (ORS) has completed its review of the Department of Energy's (DOE) December 1995 "Site Characterization Report for the Ventron Site" and several related documents. Enclosed with this letter is a Memorandum prepared by Meg Harvey of ORS, dated May 9, 1995. As discussed in our recent telephone conversations, this memo has been enclosed to provide guidance regarding the fulfillment of DEP's Risk Assessment requirements under the Massachusetts Contingency Plan, 310 CMR 40.0000. The memo summarizes ORS' conclusions, recommendations and concerns with respect to the risk assessment and characterization information thus far presented by DOE.

One point of clarification needs to be made regarding the wording in ORS' comment No. 2 on Page 4 of the memo. Ms. Harvey indicates that "at nearly every property, radionuclide concentrations... are elevated above background concentrations in the Beverly area." Background was determined to be 0.7 to 1.0 picocuries per gram (pCi/g) based on values obtained from three soil samples from various locations in the Beverly area near the Ventron site. The memo goes on to state that "uranium concentrations [at four properties] were significantly elevated above background but were not elevated above DOE guidelines" of 35 to 40 picocuries per gram. The writer spoke with Ms. Harvey on June 3, 1996 regarding this comment. Ms. Harvey indicated that, while radionuclide concentrations were low in all cases, they are, technically, above background under the strict definition of the Massachusetts Contingency Plan (MCP). Therefore the risk assessment must discuss in more detail why the detected levels are not inconsistent with the MCP's definition of "background" and do not require further assessment or remediation.

Former Morton/Ventron
RTN 3-2887

DOE provided an explanation in the residential radiation survey reports that radionuclide concentrations at the four residential properties that seemed elevated can still be classified as background. Following review of the DOE's residential radiation surveys, it appears that residential samples exhibiting the elevated radionuclide concentrations were taken either from areas where granite and certain other building and/or fill materials (e.g., concrete, brick and coal ash) are present or from areas in soil near driplines or drainspouts. DOE notes that materials such as granite, concrete and coal ash typically have higher concentrations of radionuclides than soils and were observed at many of the residences. These materials may explain the radionuclide results, in concentrations above 0.7 to 1.0 up to about 10-15 pCi/g. The DOE reports also noted that other apparently elevated results were associated with drainspouts and roof driplines. According to information in some of the residential surveys, dry deposition from airborne particles is often concentrated at driplines and outfalls receiving runoff from roofs and platforms.

The risk characterization should include information such as that provided in the residential radiation survey reports and may provide additional details about the likely sources of the radionuclides at the residential properties. Furthermore, additional background characterization should be performed to more accurately determine what "background" might be with more consideration given to materials other than soils in the Beverly area, i.e., conducting additional sampling in locations where granite, concrete and coal ash are present but could not be associated with the former Morton/Ventron site in any way.

Please note that until DEP has the information requested by ORS, DEP cannot consider the risk assessment/risk characterization complete for this site. It is DEP's understanding that Morton will address all non-radionuclide contamination at the site and that DOE will provide the required information on the radionuclide contamination.

If you have any questions regarding this matter, please contact DEP's Lisa Alexander at (617) 932-7722 or Meg Harvey at (617) 292-5513.

Very Truly Yours,

Lisa M. Alexander

Lisa M. Alexander
Environmental Engineer

Stephen M. Johnson

Stephen M. Johnson
Section Chief
Bureau of Waste Site Cleanup

143180

Former Morton/Ventron
RTN 3-2887

cc: Joseph Walsh, Jr., CHO, Director, Beverly - BOH, P.O. Box 441, Beverly, MA 01915
Beverly Conservation Commission, DPW Office, 191 Cabot St., Beverly, MA 01915
Jake Condon, 19 Wellman St., Beverly, MA 01915
Beverly Public Library, 32 Essex St., Beverly, MA 01915
Elaine Kreuger, Department of Public Health, 150 Tremont St., Boston, MA 02111
Tom O'Connell, Department of Public Health, Radiation Control, 305 South St., Jamaica Plain, MA 02130
DEP, Office of Research and Standards, Attn: Meg Harvey
DEP Data Entry/File

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
ONE WINTER STREET, BOSTON MA 02108 (617) 292-5500

3-2887

WILLIAM F. WELD
Governor

ARGEO PAUL CELLUCCI
Lt. Governor

TRUDY COXE
Secretary

DAVID B. STRUHS
Commissioner

143180

# MEMORANDUM

TO: Lisa Alexander, Site Management Branch, BWSC, NERO

FROM: Meg Harvey, Office of Research and Standards, BSPT MEH

THROUGH: Carol Rowan West, Director, Office of Research and Standards, BSPT CRW
Nancy Bettinger, Office of Research and Standards, BSPT NB

SUBJECT: Review of Site Characterization Report for the Ventron Site, Beverly, MA (DEP Site Number 3-2887)

DATE: May 9, 1995

As requested in your Work Order dated February 12, 1996, ORS has reviewed the document entitled *Site Characterization Report for the Ventron Site*, prepared by the U.S. Department of Energy in December 1995. In accordance with your Work Order, the purpose of ORS' review was to evaluate the radionuclide remediation guidelines established by the U.S. Department of Energy (DOE) for consistency with the risk limits in the Massachusetts Contingency Plan (MCP). Supplementary documents related to derivation of the remedial guidelines were also reviewed by ORS (*Derivation of Uranium Residual Radioactive Material Guidelines For The Ventron Site*, Argonne National Laboratory, March 1992; *Ventron Site - Uranium Cleanup Guideline Recommendation*, Memorandum from L. Price, U.S. DOE to J. Wagoner II, U.S. DOE, October 12, 1995; *Uranium Guideline for the Ventron Site, Beverly, Massachusetts*, Memorandum from J. Wagoner II, U.S. DOE to L. Price, U.S. DOE, November 6, 1995).

## BACKGROUND

The Ventron site is approximately 3 acres in size and is located in Beverly, on Massachusetts Bay, at the confluence of the Bass and Danvers Rivers. Ventron Corporation (formerly Metal Hydrides Corporation) began operations involving uranium material in the early 1940s under contract to the U.S. Army Corps of Engineers Manhattan Engineer District (MED). Ventron continued handling uranium and thorium materials independently of MED until the mid-1980s. Hazardous chemicals were also used at the site by Ventron for non-MED-related activities. DOE designated Ventron as a Formerly Utilized Sites Remedial Action Program (FUSRAP) site in 1986. FUSRAP is managed by DOE to identify and cleanup or otherwise control sites with residual radioactive materials from the early years of the nation's atomic energy program. Under FUSRAP, DOE has authority to

Printed on Recycled Paper

remediate MED-related materials at the site. Morton International, Inc. (the current owner/operator of the site), is responsible for all non-MED-related materials at the site. The site is listed as a Tier 1A site under the MCP.

## SUMMARY OF DOE SITE CHARACTERIZATION REPORT FOR THE VENTRON SITE

The objective of the Characterization Report, as stated by DOE, is to present the results of radiological and chemical characterization of the site and to identify areas where remediation of uranium by DOE may be required. Characterization studies have identified the following radionuclides of concern at the Ventron Site: Uranium-238, Radium-226, and Thorium-232. DOE has derived a remedial objective for Uranium-238 in soils of 50 pCi/g above background levels. Limited characterization studies for chemicals indicate that possible chemical contaminants of concern include polychlorinated biphenyls, mercury, and total petroleum hydrocarbons.

The Characterization Report identifies preliminary remediation objectives in soil for the radiological contaminants at the site. Remedial action guidelines for Radium-226 and Thorium-232 are as follows:

- 5 pCi/g above background, averaged vertically over the first 15 centimeters of soil and horizontally over any 100 $m^2$ area; and

- 15 pCi/g above background, averaged vertically over 15-centimeter-thick layers of soil at depths greater than 15 centimeters below the surface and horizontally over any 100 $m^2$ area.

The basis for these guidelines is not provided; the report simply states that they are contained in DOE Order 5400.5.

The Characterization Report also identifies a remedial objective for Uranium-238 in soil of 50 pCi/g above background levels. DOE has derived this level based on a dose assessment and application of the "as low as reasonably achievable" (ALARA) principle. DOE's dose assessment evaluated three exposure scenarios; industrial worker, recreational use, and residential farming use. Estimated doses for each of these scenarios are well below DOE's dose guideline of 100 millirem per year, which must be met under all plausible, worst case scenarios. The Site Characterization Report identifies areas at the site where soil concentrations exceed the remedial objective for Uranium-238 of 50 pCi/g.

The approach DOE has used to derive a remedial guideline for Uranium-238 differs from the MCP approach to risk characterization. The DOE procedure involves a comparison of site concentrations with a regulatory guideline developed based on dose limits. This approach does not include an evaluation of noncancer effects from exposure to uranium. In addition, the DOE approach does not estimate cancer risks in a way that allows such risks to be compared with MCP risk limits. In contrast, the MCP approach involves estimating cumulative cancer and noncancer risks from multiple contaminants at the site and multiple exposure routes at the site and comparing such risks with MCP cumulative site cancer and noncancer risk limits.

## CONCLUSIONS

The Site Characterization Report was prepared by DOE to meet requirements in DOE regulations rather than to meet requirements in the MCP. The information presented in the DOE Report does not document compliance with risk management criteria in the MCP. Based on the information presented in the Report, it is not possible for ORS to conclude whether the remedial objective DOE has derived for Uranium-238, or the remedial objectives in DOE Order 5400.5 for Radium-226 and Thorium-232 meet a level of No Significant Risk as defined in the MCP.

## RECOMMENDATIONS

Based on its review, ORS offers the following recommendations.

- To meet the requirements of the MCP, a Risk Characterization report should be prepared which consists of a characterization of potential risks to human health, public welfare, safety and the environment from all contaminants (chemical and radiological) at the Ventron site. Such an evaluation must be prepared in accordance with the MCP and should consider appropriate DEP and EPA policy and guidance. For radionuclides at the site, cancer risks should be quantified using cancer slope factors published by the U.S. Environmental Protection Agency (EPA) in the Health Effects Assessment Summary Tables (HEAST). Since uranium has been shown to be toxic to the kidney (IRIS, 1996), noncancer risks from the chemical toxicity of uranium should be evaluated in addition to cancer risks from its radioactive nature.

  As stated previously, cumulative noncancer risks for all site contaminants (chemical and radionuclide) should be calculated and compared with the MCP noncancer risk limit. Cancer risks from chemicals and radionuclides should be calculated and compared separately with the MCP cancer risk limit.

- Prior to preparing the risk characterization report, a Scope of Work for the human health risk characterization and for the ecological risk characterization should be submitted to DEP for review and approval. The Scopes of Work should describe the approach that will be taken to characterize risks at the site.

## COMMENTS

The following comments address specific issues that ORS believes are particularly important for DOE to address in the MCP risk assessment. DOE should refer to the MCP and to DEP's *Guidance for Disposal Site Risk Characterization* (July 1995) for additional information and guidance about preparing a risk characterization in accordance with the MCP. Since DEP guidance does not contain guidance specific to radiological risk characterizations, DOE should also refer to the procedures contained in EPA guidance (*Risk Assessment Guidance for Superfund, Volume 1 Part A*, December 1989; *Risk Assessment Guidance for Superfund, Volume 1 Part B*, December 1991).

1. The background data that has been collected is not adequate to characterize background conditions at the site. DOE should refer to DEP Guidance (July 1995) for information on

characterizing site background conditions. In particular, DOE should address the following issues related to characterizing background conditions at the site.

- One of the background soil samples was composited over 0 to 4 feet. The other two background soil samples were surficial samples (depth of these samples was not provided). Background samples should be taken at depth intervals comparable to those from which site samples were collected. In addition, three samples is probably an inadequate number of samples to adequately characterize soil background conditions at this site.

- Detection limits for soil and mussel analyses are higher than concentrations of concern, or levels that could pose a significant risk for many of the chemicals and for uranium-238.

- The Site Characterization Report states that a radiological analysis of lobster tissue was performed which indicated no significant difference in radionuclide concentrations between lobsters taken from near the site and a background location. These data must be presented in the risk assessment.

2. DOE has concluded, based on radiological investigations of residential housing adjacent to the Ventron site, that no detectable radiological constituents have migrated into the adjacent properties and no further investigation is warranted. However, at nearly every property, radionuclide concentrations (particularly uranium-238) are elevated above background concentrations in the Beverly area. At four properties, uranium-238 concentrations were significantly elevated above background but were not elevated above DOE guidelines (stated to be 35-40 pCi/g). In accordance with the MCP, all residential properties with radionuclide concentrations above background must be evaluated in the risk assessment.

3. Much of the radionuclide data presented in the Site Characterization Report is presented in terms of whether levels exceed DOE's cleanup guidelines. To determine whether a contaminant exceeds MCP risk management criteria, the cancer and non-cancer risks must be quantified in the risk assessment. Each detected contaminant should be included in the risk assessment unless one of the following conditions are met.

   - The chemical is present at a low frequency of detection and in low concentration relative to the detection limit.

   - The chemical is present at a level which is consistent with background concentration for the area and there is no evidence that its presence is related to activities at the site.

   - The chemical is a field or laboratory contaminant.

4. Additional sampling and analysis will be necessary in order to fully characterize the nature and extent of hazardous chemical waste at the site. It is likely that further sampling and analysis will also be necessary to fully characterize the nature and extent of radiological waste at the site. In developing a plan for additional data collection, human health and ecological risk assessment needs should be considered. For the human health risk

assessment, the type and locations of sampling and the analytical methods used should be determined based on the exposure points and activity patterns at the site so that the data will be usable for exposure evaluation. The ecological risk assessment will have different biological and chemical data requirements which will depend on the fate and transport characteristics of the contaminants and the exposure pathways and receptors of concern.

If you have any questions about information presented in this memorandum, please contact me at 292-5513.

cc: Helen Waldorf

# REFERENCES

DEP 1995. *Guidance For Disposal Site Risk Characterization, In Support of the Massachusetts Contingency Plan*, Massachusetts Department of Environmental Protection, Bureau of Waste Site Cleanup and Office of Research and Standards, Interim Final Policy BWSC/ORS-95-141, July 1995.

IRIS 1996. U.S. Environmental Protection Agency Integrated Risk Information System, 1996.

EPA 1989. *Risk Assessment Guidance for Superfund: Volume 1-Human Health Evaluation Manual (Part A)*, Interim Final. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. EPA/540/1-89/002, December 1989.

EPA 1991. *Risk Assessment Guidance for Superfund: Volume 1-Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)*, Interim Final. U.S. Environmental Protection Agency, December 1991.

148853

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
METROPOLITAN BOSTON - NORTHEAST REGIONAL OFFICE

Nov 25 2 11 PM '96

WILLIAM F. WELD
Governor

ARGEO PAUL CELLUCCI
Lt. Governor

TRUDY COXE
Secretary

DAVID B. STRUHS
Commissioner

Department of Energy
Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831-8723

NOV 18 1996

Attention: Jim Kopotic

RE: BEVERLY - Former Ventron Site
10-12 Congress Street
Review of DOE's May 1996
Characterization of Radiation
Dose and Human Health Risk
Following Remediation of the
Ventron Site
**RTN 3-2887**

Dear Mr. Kopotic,

The Department of Environmental Protection's (DEP's) Office of Research and Standards (ORS) has completed its review of the Department of Energy's (DOE's) May 1996 submittal, "Characterization of Radiation Dose and Human Health Risk Following Remediation of the Ventron Site". DOE's submittal was intended to provide additional background and risk based justification for the previously proposed site-specific cleanup guidelines for uranium at the former Ventron site. These cleanup guidelines, 50 picocuries per gram (pCi/g) of uranium isotope 238 (U-238) and 100 pCi/g total uranium, are based on both prior risk characterization for the site and application of the DOE's "as low as reasonably achievable" (ALARA) policy.

ORS has reviewed the exposure assumptions and risk calculations provided by DOE and compared the DOE submittal with ORS's own guidance for conducting risk assessments. A number of areas were flagged by ORS where DOE's risk assessment methodology and assumptions varied from the Massachusetts DEP/ORS guidance. Enclosed with this letter is a September 9, 1996 Memorandum prepared by Meg Harvey of DEP/ORS, which provides comments on the DOE's May 1996 report. This cover letter is intended to provide additional discussion/clarification about the comments in the ORS memo. In general, under the Massachusetts Contingency Plan (MCP), 310 CMR 40.0000, persons submitting risk characterizations and assessments to DEP may either follow the ORS guidance or use technically defensible alternatives. Rather than revise the entire submittal, DOE may submit an addendum to the May 1996

report to address the issues raised in this letter and the attached memo.

Please refer to the ORS memo for the original comments; the discussions/clarifications are provided below.

1. The Risk Characterization report indicated that background levels of radionuclides had been subtracted from the exposure point concentrations (EPCs). (See page 5, paragraph 3 of the DOE Characterization report). It was not clear whether the report used site-specific background values or national values. Although subtraction of the background concentrations is a common way to deal with background levels of radiation in dose assessments, it is inconsistent with the way background is addressed under the MCP. Therefore, DOE must either recalculate the EPCs to include the background concentrations of uranium, thorium and radium or provide a technically defensible argument for not doing so.

2. DOE's Risk Characterization report identifies several exposure pathways and calculates a cumulative cancer risk from those pathways but "may not represent cumulative site risk" since some other potential exposure pathways were not evaluated. ORS' comment refers specifically to incidental ingestion or dermal contact with sediments from the tidal flats. ORS also indicates that DOE should evaluate whether exposure to groundwater is likely to occur. In general, if an exposure pathway does not exist it does not need to be evaluated. However, in some cases, for example, exposures to groundwater, the risk assessment should explicitly state why such exposures are not expected to occur and therefore, not evaluated. As will be specified below, there are some other exposure assumptions and pathways that may still need to be evaluated.

3&4. It is DEP's understanding that all contaminated storm sewers and utility lines are currently being excavated from the site. Likewise, it is DEP's understanding that all buildings, foundations and contamination from beneath the buildings are currently being excavated and will be removed from the site. If these potential exposures no longer exist then they do not need to be evaluated in a Risk Characterization Addendum. However, it would be helpful if an Addendum detailed the available post-demolition/cleanup conditions and contaminant concentrations on the site.

5. Comment #5 raises two issues: non-cancer risks via ingestion of produce from an on-site garden and "all other

soil exposure pathways". ORS has several self-explanatory comments (see Memo) which DOE must address.

At issue here is DOE's assertion that all other soil exposure pathways (e.g., dermal contact, incidental ingestion) would be incomplete because residual radioactive materials would remain below a surface layer of clean fill. DOE had indicated that fill would be placed at the site at depths of 0.15 to 0.8 meters, or approximately 6 to 32 inches. It is not clear from the Risk Characterization report whether the clean fill will only be placed as backfill in areas where excavation is expected to occur or if it will also be placed as cover over the entire site. This should be explicitly stated. Based on a telephone conversation subsequent to the receipt of the Risk Characterization report, it is DEP's current understanding that clean fill will only be placed in excavated areas and that there will likely be areas where surface soils have radiological contamination at or near the maximum cleanup guidelines. Since the issue here is whether these guidelines represent "no significant risk" under the MCP, the related exposure pathways (i.e., dermal contact, incidental ingestion) must be evaluated. Even if a minimum of 6 inches of backfill were to cover the entire site, this depth is not beyond the planting depth requirement of most plants, shrubs and trees and is well within the depth of root vegetables and flowering bulbs. Therefore, it is not unrealistic to expect exposures to occur in any type of onsite gardening or landscaping, particularly in the shallower areas of backfill.

In addition to this, it is DEP's understanding that there is a substantial body of research indicating that under certain conditions related to soil mineralogy and pH, some plants will selectively take up uranium and other radionuclides from both soil and groundwater, thereby concentrating them in the body of the plant. While this has evidently been useful at some sites as a remediation strategy, it suggests another potential exposure pathway that should be evaluated. If a level of "no significant risk" cannot be assured, an Activity and Use Limitation may have to be placed on the property following the cleanup, restricting the agricultural/gardening activities that might otherwise take place. Since it is DEP's understanding that a Class A Response Action Outcome with no Activity and Use Limitation is desired by the property owner, the final site-wide risk assessment must ultimately evaluate all potential exposure scenarios.

**Beverly - Former Ventron**
**RTN 3-2887**

6. This item in ORS' memo is self explanatory; it may be addressed in a Risk Characterization Addendum.

7&8. These items in ORS' memo are clarifications for the record and do not require an amendment.

9. This item in ORS' memo is self explanatory; DOE may provide additional clarification in an addendum.

10. Since the maximum radionuclide concentration at the site following the remediation will be within the site specific cleanup guidelines, it does not appear that there will be any "hotspots" as defined in the MCP.

11. It appears that DOE's use of EPA risk guidance and use of the upper bound estimate of risk may in fact be more conservative than the MCP requires. No amendment is required in this regard. ORS also commented that DOE "must demonstrate that assumptions used to generate the best estimate (of risk) are consistent with DEP's regulations and guidelines". Specifically, if the changes outlined in ORS' memo and in this letter are adequately addressed, DEP will accept those changes as sufficient demonstration that the evaluation of risk from radiological materials at this site is consistent with DEP's regulations and guidance.

12. Comment #12 also raises several issues. The first issue, regarding the site being covered with clean fill, was already discussed above in item 5. The issue of radon is raised next. Regarding radon, if it has come to be located at the site as a result of the Manhattan Engineering District activities which DOE is under authority to remediate, then it needs to be evaluated in the risk assessment. If radon at the site is consistent with background, it need not be evaluated in the risk characterization. (See ORS Comment #1 for additional information on background). The other issues raised in ORS' comment #12 are mainly for clarification purposes.

As ORS pointed out in the last paragraph of their memo, the issues raised in this letter and in the ORS memo are in response to the DOE risk characterization of the proposed cleanup concentrations only. Once the remediation and confirmatory sampling are completed, the results should be forwarded to DEP's Northeast Region. Any preliminary results from the post-remediation sampling which can be incorporated into a Risk Characterization Addendum will be useful for demonstrating that certain exposure pathways (discussed above) have been eliminated.

**Beverly - Former Ventron**
**RTN 3-2887**

In the interim, a Risk Characterization Addendum which addresses the above comments is needed in order for DEP to grant final approval of the cleanup guidelines for uranium proposed by DOE. We understand that DEP's final approval is desired prior to DOE's completion of the ongoing remediation.

As a separate - but related - point, please note that an MCP Phase II Risk Characterization of the site must be completed after the Comprehensive Site Assessment of all Oil and Hazardous Materials (radiological and non-radiological) has been completed. It is our understanding that Morton International will perform this work. If the post-remediation sampling of the radionuclide cleanup demonstrates that residual uranium concentrations are within the MCP risk limits, then the DOE's May 1996 Risk Characterization and Addendum may be used in fulfilling that portion of the Phase II Risk Characterization that applies to radiological risks.

If you have any questions regarding this matter, please contact DEP's Lisa Alexander at (617) 932-7722 or Meg Harvey at (413) 784-1100.

Very Truly Yours,

Lisa M. Alexander
Environmental Engineer

Stephen M. Johnson
Section Chief
Bureau of Waste Site Cleanup

cc: Morton International, 150 Andover Street, Danvers, MA 01923-1480; Attention: Alicia Raddatz
Joseph Walsh, Jr., CHO, Director, Beverly - BOH, P.O. Box 441, Beverly, MA 01915
Beverly Conservation Commission, DPW Office, 191 Cabot St., Beverly, MA 01915
Jake Condon, 19 Wellman St., Beverly, MA 01915
Beverly Public Library, 32 Essex St., Beverly, MA 01915
Elaine Kreuger, Department of Public Health, 150 Tremont St., Boston, MA 02111
Tom O'Connell, Department of Public Health, Radiation Control, 305 South St., Jamaica Plain, MA 02130
DEP, Office of Research and Standards, WERO, Attn: Meg Harvey
DEP Data Entry/File

148853 Beverly 10-12 Congress St 3-2887

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
ONE WINTER STREET, BOSTON, MA 02108 617-292-5500

WILLIAM F. WELD
Governor

ARGEO PAUL CELLUCCI
Lt. Governor

TRUDY COXE
Secretary

DAVID B. STRUHS
Commissioner

# MEMORANDUM

TO: Lisa Alexander, Site Management Branch, BWSC, NERO

FROM: Meg Harvey, Office of Research and Standards, BSPT MH

THROUGH: Carol Rowan West, Director, Office of Research and Standards, BSPT CRW
Nancy Bettinger, Office of Research and Standards, BSPT NB

SUBJECT: Review of Risk Assessment for Radiological Contamination at the Ventron Site, Beverly, MA (DEP Site Number 3-2887)

DATE: September 9, 1996

As requested, ORS has reviewed the document entitled *Characterization of Radiation Dose and Human Health Risk Following Remediation of the Ventron Site*, prepared by the U.S. Department of Energy (DOE) in May 1996. The purpose of ORS' review was to determine whether the risk assessment for radiological contamination at the Ventron Site meets the requirements of the Massachusetts Contingency Plan (MCP) and is consistent with Massachusetts Department of Environmental Protection (DEP) risk assessment policy, guidance and practice.

In addition, ORS reviewed RESRAD data files used to derive risk estimates, which were provided by DOE on July 31, 1996.

## SITE HISTORY

The Ventron site is approximately 3 acres in size and is located in Beverly, on Massachusetts Bay, at the confluence of the Bass and Danvers Rivers. Ventron Corporation (formerly Metal Hydrides Corporation) began operations involving uranium material in the early 1940s under contract to the U.S. Army Corps of Engineers Manhattan Engineer District (MED). Ventron continued handling uranium and thorium materials independently of MED until the mid-1980s. Hazardous chemicals were also used at the site by Ventron for non-MED-related activities. DOE designated Ventron as a Formerly Utilized Sites Remedial Action Program (FUSRAP) site in 1986. FUSRAP is managed by DOE to identify and cleanup or otherwise control sites with residual radioactive materials from the early years of the nation's atomic energy program. Under FUSRAP, DOE has authority to remediate MED-related materials at the site. Morton International, Inc. (the current owner/operator of the site), is responsible for all non-MED-related materials at the site. The site is listed as a Tier 1A site under the Massachusetts Contingency Plan (MCP).

The Risk Characterization Report was prepared by DOE to demonstrate that DOE's proposed remedial action for radionuclides at the Ventron site will meet DEP's risk management criteria in

Printed on Recycled Paper

the MCP. As stated in the Risk Characterization Report (and the Ventron Engineering Evaluation/Cost Analysis Report (May 1996)), DOE's proposed remedial action calls for removal of soils and sediments containing concentrations of total uranium above DOE's site-specific cleanup limit of 100 pCi/g. Soils and sediments exceeding the cleanup limit will be removed and excavated areas will be backfilled with clean soil.

## CONCLUSIONS

Based on its review, ORS concludes that the Risk Characterization Report for radioactive materials at the Ventron site needs revision in several key areas in order for it to be consistent with the requirements of the Massachusetts Contingency Plan and with DEP risk assessment policy, guidance and practice. Key areas that need revision are as follows:

- background levels of radionuclides have not been treated in a manner consistent with the MCP;
- the Report has not addressed cumulative cancer risks from radionuclide contamination at the site; and
- many of the exposure assumptions used in the Report are not consistent with the MCP and with DEP risk assessment policy, guidance and practice.

## RECOMMENDATIONS

ORS recommends against approval of the Risk Characterization Report for radiological materials at the Ventron site until all the items raised in this memorandum have been addressed.

## COMMENTS

1. In accordance with the MCP, chemicals which are present at levels consistent with background are removed from the risk assessment process because, by definition, they pose a level of No Significant Risk. In order to eliminate a chemical from the risk assessment based on background, it must be demonstrated that levels of a chemical at the site are consistent with background levels of the chemical. Such background comparisons are conducted medium-by-medium. If such a determination can be made, the chemical need not be evaluated in the risk assessment. However, if site levels of a chemical are not consistent with background, exposures to the concentrations present at the site must be evaluated in the risk assessment. In the Risk Characterization Report for the Ventron site, background levels of radionuclides were subtracted from the Exposure Point Concentrations. This is inconsistent with the MCP. EPCs should represent the average concentration to which a receptor is being exposed over time and should not have background levels subtracted. DOE should recalculate the EPCs to include background levels.

   ORS notes that it has stated previously in comments on the Site Characterization Plan (Memorandum dated May 9, 1996) that the background data presented in the Site Characterization Plan are not adequate to characterize background conditions.

2. The risks calculated in the Risk Characterization Report may not represent cumulative site risks to a residential receptor because the Risk Characterization Report has not addressed potential exposures to radioactive contaminants in all contaminated media at the site. The Risk Characterization Report only evaluates five exposure pathways (direct external exposure to soil, soil ingestion, radon inhalation, dust inhalation and ingestion of produce). Other potential exposure pathways such as external exposure to sediment and incidental ingestion of sediment have not been evaluated. In addition, the Report should evaluate whether exposure to groundwater is likely to occur. Under the MCP, a risk characterization must estimate cumulative site risks to appropriate receptor groups. Cumulative risks account for exposures that a receptor may receive from multiple chemicals in multiple media by multiple exposure routes. The Risk Characterization Report should identify all contaminated media at the site and should evaluate all exposures to such media, as appropriate.

   On a related point, the Report states that sampling data have identified no elevated concentrations of radionuclides in seafoods and therefore, this pathway was found to be insignificant. The Risk Characterization Report should fully describe the sampling program and data on which this statement is based. The Report should also present a compelling justification for eliminating ingestion of seafoods as a exposure route in the risk characterization.

3. The Risk Characterization Report does not evaluate exposures to radioactive contamination in storm sewers and underground utility lines. The Risk Characterization Report should evaluate direct exposure and ingestion exposure to a worker who could potentially come into contact with contamination in storm sewers or utility lines at or near the facility.

4. The Risk Characterization Report does not evaluate the transport of contaminated onsite soil to surface water from erosion. Such potential impacts should be evaluated in the Risk Assessment Report. In particular, the Report should evaluate the potential for soil erosion from under buildings which may be removed under a future site use scenario.

5. The Risk Characterization Report includes an evaluation of noncancer risks from exposure to uranium via ingestion of produce from an onsite garden. The Risk Characterization Report states that all other soil exposure pathways would be incomplete because it is assumed that all residual radioactive materials would remain below a surface layer of clean soil backfill. ORS has several comments on this point.

   - DOE's statement that all residual radioactive materials would remain below a layer of clean soil must be supported by additional information. As described above, DOE's proposed remedial action for soils and sediment involves only excavation of areas exceeding DOE's cleanup limit for uranium. Given this, it appears unlikely that all areas with contamination below DOE's cleanup limits will be covered with clean fill. However, even if DOE can support its assumption with additional information, the MCP requires that exposures to contamination at depth (up to 15 feet) be evaluated because of the possibility that future excavation could bring contaminated soils to the surface where exposure could occur.

- The evaluation of noncancer risks from uranium exposure only considers ingestion of uranium via soil ingestion and produce consumption. The evaluation of noncancer risks should also include dermal contact with soil.

- Noncancer risks from exposure to uranium should be considered in DOE's risk assessment in addition to the risk assessment that will be done at a later date for chemical contamination at the Ventron site. As stated previously, the MCP requires an evaluation of cumulative cancer and noncancer risks at a site. Therefore, the evaluation of noncancer risks should include the contribution from both chemical and radiological contaminants. ORS notes that for cancer risks, it is not appropriate to add cancer risks from chemicals with radionuclides (EPA 1991). Therefore, cancer risks from radionuclides are compared with MCP risk limits separately from cancer risks from chemicals.

6. As stated in the exposure scenario section, a resident was assumed to spend 16 hours per day indoors and 0.5 hours per day outdoors. The sources for this assumption are EPA's Exposure Factors Handbook and EPA's Supplemental Guidance: Standard Default Exposure Factors. Based on a review of these documents, ORS cannot find a reference to 0.5 hours per day.

   For the purposes of risk characterizations performed under the MCP, the receptor group of concern should be characterized by those individuals whose activities (described by the frequency and duration of the activities) represent a *full and unrestricted use* of the site. ORS believes that assuming that a resident spends only 0.5 hours per day outdoors in his or her yard does not represent "full use" of the yard. ORS believes that 3 hours per day is an assumption that is more consistent with "full use" of a backyard. This assumption is documented in a Memorandum from M. Harvey to C. Rowan West dated September 4, 1996. DOE could use an alternative assumption if there were reasons to believe that residents spend less time outdoors at this site than at other areas. However, such an argument may not be plausible given the nature of the site.

7. The report correctly states that DEP's default exposure frequency for residential exposures is approximately 150 days per year (5 days per year from April through October). However, such exposure frequency is for outdoor exposure. For the record, DEP, notes that it also has a default exposure frequency of 212 days per year (7 days per week from October through April) for indoor exposures to a young child aged 1 to 6.

8. Exposure Point Concentrations were calculated as the 95% percentile confidence limit of the mean ($UCL_{95}$). This is a standard EPA practice and DEP recognizes that a benefit of this practice is that it compensates for sampling uncertainty. However, it is DEP practice to calculate the EPC as the arithmetic mean. A benefit to using the arithmetic mean rather than the $UCL_{95}$ is that the arithmetic mean concentration used in the risk assessment can also be used to generate cleanup requirements.

9. The Risk Characterization Report does not clearly present the data that were used to calculate the EPC. The Risk Characterization should provide enough detail so that the EPC can be reproduced easily.

10. The MCP requires that separate EPCs be calculated for hotspots. Hotspots are specifically defined in the MCP at (310 CMR 40.0006). The Risk Characterization Report does not include an evaluation of whether there are any hotspots at the Ventron site. The Report should be revised to address hotspots if they exist.

11. Table 3 provides best estimates of cancer risk as well as upper bound estimates of cancer risk. The upper-bound estimate of cancer risk for the residential scenario slightly exceeds DEP's risk management criterion of $1 \times 10^{-5}$. ORS notes that "upper bound" and "best estimate" are EPA terms. In exposure assessments done under the MCP, ORS uses a mix of conservative and mid-range exposure parameters to produce a realistic upper-end exposure estimate which will be protective of people making full and unrestricted use of the site. Default exposure parameters are contained in DEP Risk Assessment Guidance (DEP, 1995).

    The Risk Characterization Report states that the upper-bound estimate is less plausible than the best estimate and is not considered to accurately reflect post-remediation conditions at the site. However, the Report does not clearly present the exposure assumptions used to generate the upper-bound estimate. If DOE believes that the best estimate rather than the upper-bound estimate is more reasonable for post-remediation conditions, it must demonstrate that assumptions used to generate the best estimate are consistent with DEP's regulations and guidance.

12. In an effort to relate DOE's dose limits to cancer risks from radionuclides, DOE used the RESRAD computer code, version 5.61 to calculate potential radiation doses and cancer risks to receptors. The RESRAD code calculates cancer risk using EPA-published cancer slope factors for individual radionuclides. ORS has the following comments on the RESRAD model.

    - The input parameters for the RESRAD code used to calculate risk include an assumption that radioactive contamination is covered by a depth of either 0.8 or 0.15 meters of clean soil. As stated in a previous comment, DOE's proposed remedial action for soils and sediment involves excavation only of areas exceeding DOE's cleanup limit for uranium. Given this, it appears unlikely that all areas with contamination below DOE's cleanup limits will be covered with clean fill. DOE should assume that exposure to contamination at depth occurs unless it can be demonstrated that exposure to soil at depth is restricted and will remain so into the future.

    - It appears that risks from exposure to radon from uranium contamination at the site were not included in the cancer risk estimates presented in Table 3. In accordance with the MCP requirement to evaluate cumulative risks to receptors from all exposure pathways, radon risks should be included.

    - Based on review of the RESRAD data files, it appears that DOE used an exposure duration of 30 years in the risk calculations. However, this is not clearly stated in the Report. The Risk Characterization Report should clearly state the exposure duration assumed.

- Review of the RESRAD data files indicates that a value different from the default RESRAD consumption rate for fruit, vegetable, and grains was used. However, Appendix A states that the default value was used. The Report should correct this inconsistency and should provide the source of the value.

- The following parameters were used in the RESRAD calculations but are not included in Appendix A. DOE should add these parameters (and their values) to Appendix A:

  - cover erosion rate; and
  - inhalation shielding factor.

ORS notes that the Risk Characterization Report prepared by DOE is based on an estimate of soil concentrations that will exist after remediation occurs. Thus, this risk characterization is not a valid basis for an RAO until cleanup occurs and sufficient post-remediation sampling is performed to confirm that the estimated soil concentrations have been reached.

If you have any questions about this review, please contact me at 413-784-1100 x 313.

cc: Helen Waldorf

# REFERENCES

EPA 1991. *Risk Assessment Guidance for Superfund: Volume 1-Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)*, Interim Final. U.S. Environmental Protection Agency, December 1991.

DEP 1995. *Guidance For Disposal Site Risk Characterization, In Support of the Massachusetts Contingency Plan*, Massachusetts Department of Environmental Protection, Bureau of Waste Site Cleanup and Office of Research and Standards, Interim Final Policy BWSC/ORS-95-141, July 1995.

148853

Massachusetts Department of Environmental Protection
Bureau of Waste Site Cleanup (BWSC)

# TIER I PERMIT

| For DEP Use Only |
|---|
| Effective Date: |
| Expiration Date: |

## This Permit is Issued to:

x One Permittee

☐ More than One Permittee*

*A list of all Permittees is attached.

One Permittee:

| | | | |
|---|---|---|---|
| Name of Organization: | **Largo Realty, Inc.** | | |
| Permittee Name: | **Largo Realty, Inc.** | | |
| Title or c/o: | **Mr. David Altschuler** | | |
| Street: | **220 Boylston Street** | | |
| City/Town: | **Chestnut Hill** | State: **MA** | Zip code: **02167-2005** |
| Telephone: | **(617) 332 - 2340** | | |

## DEP Finding Concerning Tier Classification

☐ Tier IA (BWSC01) x Tier IB (BWSC02) ☐ Tier IC (BWSC03) Permit No. **96591**

This permit authorizes the performance of comprehensive remedial response actions at:

| | | | |
|---|---|---|---|
| Disposal Site Number: | **3-0123** | | |
| Disposal Site Name: | **Gas Country Service Station (FMR)** | | |
| Street: | **100 Derby Street** | | |
| City/Town: | **Hingham** | State: **MA** | Zip code: **02043** |

Unless a request for an adjudicatory hearing is made pursuant to 310 CMR 40.0770, this permit shall be effective 21 days after the date of issuance by the Department and the receipt of the signed Permit Acceptance Statement, whichever is later. **The Permittee has 30 days from the date of issuance of this Tier I Permit to sign and submit the completed Permit Acceptance Statement to the Department.**

This permit shall expire 5 years from its effective date.

## Permit Conditions; Pursuant to 310 CMR 40.0740:

(1) The permittee(s) performing response actions pursuant to this Tier I Permit shall comply at all times with M.G.L. c. 21E, 310 CMR 40.0000, the terms and conditions of the permit and any other applicable federal, state or local law.

(2) In every proceeding, the burden shall be on the Permittee to demonstrate compliance with the terms and conditions of a permit at all times.

(3) Each Permittee shall comply with:

(a) submittal of a Class A, B or C Response Action Outcome Statement within five years of the effective date of the permit, unless otherwise provided in the permit;

(b) submittal of a copy of the signed and completed Permit Acceptance Statement required by 310 CMR 40.0750(2) to the Chief Municipal Officer(s) and the local boards of health for the communities where the disposal site is located, and to any member of the public identified in the Department's Statement of Basis.

(c) notification in writing to the Department:

1. as required in 310 CMR 40.0500;
2. upon gaining knowledge of any technical, financial or legal inability to perform any necessary response action, in accordance with 310 CMR 40.0172;
3. upon a decision by a permittee who is performing response actions as an Other Person to not proceed as required by the permit; and
4. of any change in the LSP of Record for the disposal site no later than ten days after the effective date of such change through the filing of a Minor Permit Modification by the permittee in accordance with 310 CMR 40.0725;

(d) compliance with:

1. all applicable submittal requirements, including but not limited to, scopes of work, Status Reports, Completion Statements, Phase Reports, and RAOs;
2. all requirements for record keeping and document retention, including but not limited to 310 CMR 40.0014, 310 CMR 40.0022 and 310 CMR 40.0023;
3. the Notification Regulations, 310 CMR 40.0300, in the event of discovery of new releases located at the disposal site, threat of release or Imminent Hazard;
4. the management procedures for excavated soils and wastes and requirements for remedial air emissions set forth in 310 CMR 40.0030 and 310 CMR 40.0040; and
5. all public involvement activities required by 310 CMR 40.1400 through 40.1406;

(e) inclusion of the Disposal Site Number and the permit number on documents submitted to the Department with respect to the disposal site;

(f) certification of documents submitted to the Department as required by 310 CMR 40.0009;

(g) evaluation of the need to perform Immediate Response Actions in accordance with 310 CMR 40.0400 as new or additional information about the disposal site is obtained;

(h) modification or cessation of any response action as necessary to maintain compliance with any permit condition or to prevent an actual or potential threat to health, safety, public welfare, or the environment;

(i) notification, orally or in writing, to the Department within seventy-two hours of obtaining knowledge of the need to modify or cease any response actions for the reasons in 310 CMR 40.0740(3)(h); provided that any such oral notification shall be confirmed by the permittee in writing within sixty days of such oral notice and any written notice shall include a Status Report prepared by an LSP; and timely remediation of any adverse impacts to health, safety, public welfare or the environment that result from the performance of response actions;

(j) at disposal sites where groundwater investigation is necessary, delineation of the vertical and horizontal extent of contamination, identification and confirmation of groundwater flow directions, identification of groundwater migration pathways, including but not limited to, the identification of possible partitioning of dissolved volatile organic compounds at the water table interface which may lead to vapor transport into subsurface structures, homes or other occupied or unoccupied buildings, and monitoring of groundwater wells, discharges and/or other monitoring points in a manner which provides for the timely development or representative information about conditions and changes in conditions at the disposal site;

(k) acquisition of all required federal, state and local permits;

(l) proper operation and maintenance of all treatment, storage, abatement or control systems and of all equipment required to continue or complete response actions;

(m) authorization for personnel and authorized agents of the Department to enter, at reasonable times and upon the presentation of credentials, any premises owned or controlled by the permittee for the purpose of investigating, sampling, or inspecting any records, conditions, equipment, practice or property relating to response actions at the disposal site, or protecting health, safety, public welfare, or the environment; and

(n) notification upon a change of the Primary representative as required by 310 CMR 40.0703(7), if one is designated.

(4) A Tier I Permit does not grant any property rights or exclusive privileges, nor does it authorize any injury to private property or invasion of property rights.

**Special Conditions; Pursuant to 310 CMR 40.0740(3)(o):**

Each permittee shall comply with all **Special Conditions** if attached to this permit in **Attachment A.** Special Conditions are included within this permit:

☐ Yes* x No

*Note: Pursuant to 310 CMR 40.0722(6)(c), a "Statement of Basis" for this permit decision has been prepared by DEP if special conditions are included with this Permit.

## DEP Authorization

Issued by the Department of Environmental Protection:

Name (Print):_____ Date of Issuance: _____

Signature _____

## Notice of Appeal Rights

Any person aggrieved by a decision of the Department with respect to any Tier I permit application may request an adjudicatory hearing before the Department in accordance with M.G.L. c. 21E and 310 CMR 40.0050 and 40.0770, within 21 days of the date of issuance of the Tier I permit, if:

a) the Department issues a permit for a classification higher than that stated in the LSP Tier Classification Opinion; or

b) the Department denies the applicant a permit, unless the Department notifies the applicant in the permit decision that the Department intends to undertake or arrange for the performance of necessary response actions at the disposal site; or

c) The Department imposes conditions pursuant to 310 CMR 40.0730(1)(h) and 40.0740(3)(o) without the applicant's consent.

# Permit Acceptance Statement and Certification of Submittal

**Note:** Each Permittee must complete this section and return the signed Permit Acceptance Statement and Certification of Submittal within 30 days of the date of issuance of this Permit decision. For disposal sites with more than one Permittee, make copies of this section, have each Permittee complete this information, and submit all copies to the Department along with the Acceptance Statement.

## Permit Acceptance Statement

I accept this permit and agree to conduct all response actions at this disposal site in accordance with this Permit and the provisions of 310 CMR 40.0000. I am aware of the requirements set forth in 310 CMR 40.0172 for notifying the Department in the event that I am unable to proceed with such response actions[1].

Largo Realty, Inc., by Neal M. Drawas, an LSP, working with Kroll Environmental Enterprises, Inc., under Power of Attorney dated: _____

Position or title: _____

Signature: _____

Date: _____

## Certification of Submittal (The above permittee must also sign the following certification)

I, _____, attest under the pains and penalties of perjury (i) that I have personally examined and am familiar with the information contained in this submittal, including any and all documents accompanying this submittal, (ii) that, based on my inquiry of those individuals immediately responsible for obtaining the information, the material information contained in this submittal is, to the best of my knowledge and belief, true, accurate and complete, and (iii) that I am fully authorized to make this attestation on behalf of the person or entity legally responsible for this submittal[1][1]. I/the person or entity on whose behalf this submittal is made am/is aware that there are significant penalties, including, but not limited to , possible fines and imprisonment, for willfully submitting false, inaccurate or incomplete information.

Largo Realty, Inc., by Neal M. Drawas, an LSP, working with Kroll Environmental Enterprises, Inc., under Power of Attorney dated: _____

Position or title: _____

Signature: _____

Date: _____

(1) Please Note:
If any person other than those who are legally responsible for this submittal are going to sign the above Acceptance Statement and the Certification of Submittal, a written authorization, from each person(s) or entity(ies) who is/are legally responsible for this submittal, must be attached to this permit.

**This Attachment will be completed by DEP**

**ATTACHMENT A TO PERMIT NO. 96591**

Each Permittee shall comply with the following special condition:

x Check here if not applicable to this permit.

148853

Massachusetts Department of Environmental Protection
Bureau of Waste Site Cleanup (BWSC)

# TIER I PERMIT

**For DEP Use Only**

Effective Date:
Expiration Date:

## This Permit is Issued to:

x One Permittee

☐ More than One Permittee*

*A list of all Permittees is attached.

One Permittee:

| | | | |
|---|---|---|---|
| Name of Organization: | **Largo Realty, Inc.** | | |
| Permittee Name: | **Largo Realty, Inc.** | | |
| Title or c/o: | **Mr. David Altschuler** | | |
| Street: | **220 Boylston Street** | | |
| City/Town: | **Chestnut Hill** | State: **MA** | Zip code: **02167-2005** |
| Telephone: | **(617) 332 - 2340** | | |

## DEP Finding Concerning Tier Classification

☐ Tier IA (BWSC01) x Tier IB (BWSC02) ☐ Tier IC (BWSC03) Permit No. **96591**

This permit authorizes the performance of comprehensive remedial response actions at:

| | | | |
|---|---|---|---|
| Disposal Site Number: | **3-0123** | | |
| Disposal Site Name: | **Gas Country Service Station (FMR)** | | |
| Street: | **100 Derby Street** | | |
| City/Town: | **Hingham** | State: **MA** | Zip code: **02043** |

Unless a request for an adjudicatory hearing is made pursuant to 310 CMR 40.0770, this permit shall be effective 21 days after the date of issuance by the Department and the receipt of the signed Permit Acceptance Statement, whichever is later. **The Permittee has 30 days from the date of issuance of this Tier I Permit to sign and submit the completed Permit Acceptance Statement to the Department.**

This permit shall expire 5 years from its effective date.

## Permit Conditions; Pursuant to 310 CMR 40.0740:

(1) The permittee(s) performing response actions pursuant to this Tier I Permit shall comply at all times with M.G.L. c. 21E, 310 CMR 40.0000, the terms and conditions of the permit and any other applicable federal, state or local law.

(2) In every proceeding, the burden shall be on the Permittee to demonstrate compliance with the terms and conditions of a permit at all times.

(3) Each Permittee shall comply with:

(a) submittal of a Class A, B or C Response Action Outcome Statement within five years of the effective date of the permit, unless otherwise provided in the permit;

(b) submittal of a copy of the signed and completed Permit Acceptance Statement required by 310 CMR 40.0750(2) to the Chief Municipal Officer(s) and the local boards of health for the communities where the disposal site is located, and to any member of the public identified in the Department's Statement of Basis.

(c) notification in writing to the Department:

1. as required in 310 CMR 40.0500;
2. upon gaining knowledge of any technical, financial or legal inability to perform any necessary response action, in accordance with 310 CMR 40.0172;
3. upon a decision by a permittee who is performing response actions as an Other Person to not proceed as required by the permit; and
4. of any change in the LSP of Record for the disposal site no later than ten days after the effective date of such change through the filing of a Minor Permit Modification by the permittee in accordance with 310 CMR 40.0725;

(d) compliance with:

1. all applicable submittal requirements, including but not limited to, scopes of work, Status Reports, Completion Statements, Phase Reports, and RAOs;
2. all requirements for record keeping and document retention, including but not limited to 310 CMR 40.0014, 310 CMR 40.0022 and 310 CMR 40.0023;
3. the Notification Regulations, 310 CMR 40.0300, in the event of discovery of new releases located at the disposal site, threat of release or Imminent Hazard;
4. the management procedures for excavated soils and wastes and requirements for remedial air emissions set forth in 310 CMR 40.0030 and 310 CMR 40.0040; and
5. all public involvement activities required by 310 CMR 40.1400 through 40.1406;

(e) inclusion of the Disposal Site Number and the permit number on documents submitted to the Department with respect to the disposal site;

(f) certification of documents submitted to the Department as required by 310 CMR 40.0009;

(g) evaluation of the need to perform Immediate Response Actions in accordance with 310 CMR 40.0400 as new or additional information about the disposal site is obtained;

(h) modification or cessation of any response action as necessary to maintain compliance with any permit condition or to prevent an actual or potential threat to health, safety, public welfare, or the environment;

(i) notification, orally or in writing, to the Department within seventy-two hours of obtaining knowledge of the need to modify or cease any response actions for the reasons in 310 CMR 40.0740(3)(h); provided that any such oral notification shall be confirmed by the permittee in writing within sixty days of such oral notice and any written notice shall include a Status Report prepared by an LSP; and timely remediation of any adverse impacts to health, safety, public welfare or the environment that result from the performance of response actions;

(j) at disposal sites where groundwater investigation is necessary, delineation of the vertical and horizontal extent of contamination, identification and confirmation of groundwater flow directions, identification of groundwater migration pathways, including but not limited to, the identification of possible partitioning of dissolved volatile organic compounds at the water table interface which may lead to vapor transport into subsurface structures, homes or other occupied or unoccupied buildings, and monitoring of groundwater wells, discharges and/or other monitoring points in a manner which provides for the timely development or representative information about conditions and changes in conditions at the disposal site;

(k) acquisition of all required federal, state and local permits;

(l) proper operation and maintenance of all treatment, storage, abatement or control systems and of all equipment required to continue or complete response actions;

(m) authorization for personnel and authorized agents of the Department to enter, at reasonable times and upon the presentation of credentials, any premises owned or controlled by the permittee for the purpose of investigating, sampling, or inspecting any records, conditions, equipment, practice or property relating to response actions at the disposal site, or protecting health, safety, public welfare, or the environment; and

(n) notification upon a change of the Primary representative as required by 310 CMR 40.0703(7), if one is designated.

(4) A Tier I Permit does not grant any property rights or exclusive privileges, nor does it authorize any injury to private property or invasion of property rights.

**Special Conditions; Pursuant to 310 CMR 40.0740(3)(o):**

Each permittee shall comply with all **Special Conditions** if attached to this permit in **Attachment A.** Special Conditions are included within this permit:

☐ Yes* x No

*Note: Pursuant to 310 CMR 40.0722(6)(c), a "Statement of Basis" for this permit decision has been prepared by DEP if special conditions are included with this Permit.

## DEP Authorization

Issued by the Department of Environmental Protection:

Name (Print):_____ Date of Issuance: _____

Signature _____

## Notice of Appeal Rights

Any person aggrieved by a decision of the Department with respect to any Tier I permit application may request an adjudicatory hearing before the Department in accordance with M.G.L. c. 21E and 310 CMR 40.0050 and 40.0770, within 21 days of the date of issuance of the Tier I permit, if:

a) the Department issues a permit for a classification higher than that stated in the LSP Tier Classification Opinion; or

b) the Department denies the applicant a permit, unless the Department notifies the applicant in the permit decision that the Department intends to undertake or arrange for the performance of necessary response actions at the disposal site; or

c) The Department imposes conditions pursuant to 310 CMR 40.0730(1)(h) and 40.0740(3)(o) without the applicant's consent.

# Permit Acceptance Statement and Certification of Submittal

Note: Each Permittee must complete this section and return the signed Permit Acceptance Statement and Certification of Submittal within 30 days of the date of issuance of this Permit decision. For disposal sites with more than one Permittee, make copies of this section, have each Permittee complete this information, and submit all copies to the Department along with the Acceptance Statement.

## Permit Acceptance Statement

I accept this permit and agree to conduct all response actions at this disposal site in accordance with this Permit and the provisions of 310 CMR 40.0000. I am aware of the requirements set forth in 310 CMR 40.0172 for notifying the Department in the event that I am unable to proceed with such response actions[1].

Largo Realty, Inc., by Neal M. Drawas, an LSP, working with Kroll Environmental Enterprises, Inc., under Power of Attorney dated: _____

Position or title: _____

Signature: _____

Date: _____

## Certification of Submittal (The above permittee must also sign the following certification)

I, _____, attest under the pains and penalties of perjury (i) that I have personally examined and am familiar with the information contained in this submittal, including any and all documents accompanying this submittal, (ii) that, based on my inquiry of those individuals immediately responsible for obtaining the information, the material information contained in this submittal is, to the best of my knowledge and belief, true, accurate and complete, and (iii) that I am fully authorized to make this attestation on behalf of the person or entity legally responsible for this submittal[1][1]. I/the person or entity on whose behalf this submittal is made am/is aware that there are significant penalties, including, but not limited to , possible fines and imprisonment, for willfully submitting false, inaccurate or incomplete information.

Largo Realty, Inc., by Neal M. Drawas, an LSP, working with Kroll Environmental Enterprises, Inc., under Power of Attorney dated: _____

Position or title: _____

Signature: _____

Date: _____

(1) Please Note:
If any person other than those who are legally responsible for this submittal are going to sign the above Acceptance Statement and the Certification of Submittal, a written authorization, from each person(s) or entity(ies) who is/are legally responsible for this submittal, must be attached to this permit.

**This Attachment will be completed by DEP**

**ATTACHMENT A TO PERMIT NO. 96591**

Each Permittee shall comply with the following special condition:

x Check here if not applicable to this permit.