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# Certification Docket for the Remedial Action Performed at the Middlesex Municipal Landfill in Middlesex, New Jersey in 1984 and 1986

Department of Energy
Technical Services Division
Oak Ridge Operations Office

May 1989

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# CERTIFICATION DOCKET FOR THE REMEDIAL ACTION PERFORMED AT THE MIDDLESEX MUNICIPAL LANDFILL IN MIDDLESEX, NEW JERSEY IN 1984 AND 1986

MAY 1989

Prepared for

UNITED STATES DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

Under Contract No. DE-AC05-81OR20722

By

Bechtel National, Inc.

Oak Ridge, Tennessee

Bechtel Job No. 14501

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INTRODUCTION TO THE
CERTIFICATION DOCKET FOR THE REMEDIAL ACTION
PERFORMED AT THE MIDDLESEX MUNICIPAL LANDFILL IN
MIDDLESEX, NEW JERSEY
IN 1984 AND 1986

## Description of the Formerly Utilized Sites Remedial Action Program at Middlesex, New Jersey

The U.S. Department of Energy (DOE), Office of Nuclear Energy, Office of Remedial Action and Waste Technology, Division of Facility and Site Decommissioning Projects (and/or the predecessor agency, offices, and divisions) has conducted a remedial action project at the Middlesex Municipal Landfill in Middlesex, New Jersey. The work is being administered by the Formerly Utilized Sites Remedial Action Program (FUSRAP) under the direction of the DOE Division of Facility and Site Decommissioning Projects. The United States Government initiated FUSRAP in 1974 to identify, 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 or from commercial operations causing conditions that Congress has mandated DOE to remedy (Ref. 1). The objectives of FUSRAP are to:

- Identify and assess sites formerly utilized to support early Manhattan Engineer District/Atomic Energy Commission (MED/AEC) nuclear work to determine whether further decontamination and/or control is needed
- Decontaminate and/or apply controls to these sites to permit conformance with currently applicable guidelines
- Dispose of and/or stabilize all generated residues in a radiologically and environmentally acceptable manner
- Accomplish all work in accordance with appropriate landowner agreements; local and state environmental and land use requirements to the extent permitted by Federal law; and applicable DOE orders, regulations, standards, policies, and procedures

- Certify, at the completion of remedial action, that the radiological conditions of sites comply with guidelines and are appropriate for future use.

FUSRAP is currently being managed by the DOE Oak Ridge Operations Office (ORO). As the Project Management Contractor (PMC) for FUSRAP, Bechtel National, Inc. (BNI) is the DOE representative for planning, managing, and implementing FUSRAP.

To support remedial action planning and define the locations and boundaries of contamination, DOE directed Oak Ridge National Laboratory (ORNL) to perform a radiological survey of the Middlesex Municipal Landfill 1978. This survey identified radioactively contaminated soil at the MML.

DOE developed a remedial action plan to remove the contamination from the MML. Remedial action was performed at the MML in 1984 and in 1986. The contaminated soil was removed from the MML and is being stored temporarily at the Middlesex Sampling Plant (MSP).

Executive Order 11991 empowered the Council on Environmental Quality (CEQ) to issue regulations to federal agencies for implementing those procedural provisions of the National Environmental Policy Act (NEPA) that are mandatory under law (Ref. 2). The CEQ issued the regulations containing guidance and specific requirements in June 1979 (Ref. 3). The DOE guidelines for implementing the NEPA process and satisfying the CEQ regulations were made effective on March 28, 1980 (Ref. 4).

The NEPA process requires FUSRAP decision-makers to identify and assess the environmental consequences of proposed actions prior to beginning remedial activities, developing disposal sites, or transporting and emplacing radioactive wastes. Documentation required by NEPA in support of remedial action is prepared by Argonne National Laboratory (ANL). Supporting documentation is provided by the FUSRAP PMC through the preparation of a series of

engineering studies and environmental reports to evaluate remedial action alternatives for the site under consideration. The action deemed appropriate by DOE based on the NEPA process evaluations is then implemented with consideration for public safety and in compliance with applicable federal, state, and local requirements.

For the site discussed in this report, the NEPA requirements were satisfied by the preparation of an Action Description Memorandum, which led to issuance of a Memorandum to File (MTF) documenting that the project had no significant impact on the environment (Refs. 5, 6).

Work performed under FUSRAP is governed by the provisions of the DOE quality assurance program plan for FUSRAP, which complies with DOE Order 5700.6 (Ref. 7). Work performed under FUSRAP by the PMC or by architect-engineers, construction and service subcontractors, and other project subcontractors is governed by the FUSRAP Quality Assurance Program Plan (Ref. 8). Effectiveness of implementation is appraised by the BNI quality assurance organization, and by DOE-ORO on a regular basis.

Remedial action was completed in 1986 at the properties identified in this docket. On April 7, 1989, DOE certified that the properties are in compliance with DOE decontamination criteria and standards developed to protect health, safety, and the environment. A Notice of Certification was published in the Federal Register on May 8, 1989.

## Purpose

The material in this docket consists of documents supporting the certification that the radiological conditions at the MML are in compliance with radiological guidelines and standards determined to

apply to the site and that use of these properties will not result in any measurable radiological hazard to the general public resulting from the activities of the Department of Energy predecessor agencies.

The certification docket contains only the material deemed most pertinent to the certification of these properties; the comprehensive package of records is available and will be archived by DOE through the Assistant Secretary for Management and Administration after certification. Copies of this docket will be available for public review between 8:00 a.m. and 4:00 p.m., Monday through Friday (except Federal holidays) at the DOE Public Reading Room located in Room 1E-190 of the Forrestal Building, 1000 Independence Avenue S.W., Washington, D.C. The certification docket will also be available in the Public Document Room, U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, Tennessee, and at the Middlesex Borough Library, Mountain Avenue, Middlesex, New Jersey.

## Property Identification

The properties that were decontaminated as part of the remedial action and are collectively referred to as the Middlesex Municipal Landfill are listed below. These properties are identified in Figure 19 of Exhibit III to this docket.

Parcel 1 located on 1190 Mountain Avenue, Borough of Middlesex, identified as Block 219, Lot 1 (owned by Middlesex Presbyterian Church).

Parcel 2 located on Mountain Avenue, Borough of Middlesex, identified as Block 219, Lot 2 (owned by the Borough of Middlesex).

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Exhibit I is a summary of remedial action activities at the subject properties. It provides a brief history of the origin of the

contamination at the MML, and summarizes the radiological characterizations conducted, the remedial action performed, and post-remedial action/verification activities.

The following documents contain the guidelines that determine the need for remedial action. The subject properties have been decontaminated to comply with these guidelines. The first document listed is included as Appendix A of Exhibit I; the second is included in Exhibit II (1).

U.S. Department of Energy. "U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites," Rev. 2, March 1987.

U.S. Department of Energy. Design Criteria for Formerly Utilized Sites Remedial Action Program (FUSRAP) and Surplus Facilities Management Program (SFMP), 14501-00-DC-01, Rev. 2, Oak Ridge, TN, March 1986.

The following documents authorized or designated the remedial action at the MML. A copy of each is included in Exhibit II (2).

Memorandum, Thomas G. Frangos, Director, Office of Environmental Compliance and Overview, Environmental Technology Control Division, Department of Energy, EV-13, to S. Meyers, Department of Energy, NE-90. "Notification of Need for Some Form of Remedial Action - Middlesex Municipal Landfill Site, Middlesex, New Jersey," April 14, 1980.

Memorandum, Stephen H. Greenleigh, Office of the General Counsel, Department of Energy, to Bill Snyder. "Legal Opinion - Authority to Decontaminate the Middlesex Municipal Landfill Site, Middlesex, New Jersey," May 30, 1980.

The following document describes radiological conditions at the subject properties before remedial action. It is referenced in Exhibit II (3) of this docket.

Oak Ridge National Laboratory. Radiological Survey of the Middlesex Municipal Landfill Site, Middlesex, New Jersey, DOE/EV-0005/20, Oak Ridge, TN, April 1980.

The documents listed below were prepared to fulfill the National Environmental Policy Act (NEPA) requirements for the subject properties. These documents are included in Exhibit II (4).

Argonne National Laboratory. Action Description Memorandum, Proposed 1984 Remedial Actions at Middlesex, New Jersey, Argonne, IL, April 27, 1984.

Memorandum, Franklin E. Coffman, Office of Terminal Waste Disposal and Remedial Action, Office of Nuclear Energy, Department of Energy, to File. "Action Description Memorandum (ADM) Review: Proposed 1984 Remedial Actions at Middlesex, New Jersey," September 7, 1984.

Exhibit II (5) includes the access agreements signed by the property owners and DOE before remedial action was initiated. The affected property owners are listed below.

Middlesex Presbyterian Church
Borough of Middlesex

The following report describes the extent of the remedial action and documents the successful decontamination of the two subject properties. This report is referenced in Exhibit II (6). In addition, Figures 1-18 in Exhibit III to this docket show the progression and extent of remedial action.

Bechtel National, Inc. Post-Remedial Action Report for the Middlesex Municipal Landfill Site, Middlesex, New Jersey, DOE/OR/20722-135, Oak Ridge, TN, February 1987.

The following documents document the successful decontamination of the subject properties. Both documents are included in Exhibit II (7) to this docket.

Letter, J.D. Berger, Oak Ridge Associated Universities, to J.J. Fiore, Director, Division of Facility and Site Decommissioning, Office of Nuclear Energy, Department of Energy Headquarters. "Verification of Remedial Actions at the MML," March 16, 1987.

Oak Ridge Associated Universities. Verification of Remedial Action, Middlesex Municipal Landfill, Middlesex, New Jersey, Oak Ridge, Tennessee, September 1987.

Before remedial action was conducted, a Memorandum of Understanding between the Borough of Middlesex, NJDEP, and DOE was agreed to and signed. Copies of this document and the letters transmitting it to the Borough of Middlesex and NJDEP are included in Exhibit II (8) of the docket. In addition, during remedial action activities, DOE and its contractors worked closely with NJDEP representatives. Following the completion of remedial action, a copy of the post-remedial action report was transmitted to the Borough of Middlesex and to NJDEP. A copy of the transmittal letter is included in Exhibit II (8).

The information in Exhibit II (9) states that following the completion of remedial action at the Middlesex Municipal Landfill under the auspices of FUSRAP and verification that the properties were successfully decontaminated, DOE has not imposed any restrictions on the use of the properties.

The Federal Register Notice informs the public of DOE's intent to certify that the subject properties are in compliance with applicable criteria and guidelines. The text of the Federal Register Notice is included in Exhibit II (10).

Baublitz, J.E. Acting Director, Office of Remedial Action and Waste Technology, Office of Nuclear Energy, Department of Energy Headquarters. Federal Register Notice: "Department of Energy, Office of Nuclear Energy, "Certification of the Radiological Condition of Middlesex Municipal Landfill in Middlesex, New Jersey," May 8, 1989.

The documents listed below validate the final certification of the subject properties and are included in Exhibit II (11).

Memorandum, J.J. Fiore, Director, Division of Facility and Site Decommissioning, Office of Nuclear Energy, Department of Energy, to J.E. Baublitz, Acting Director, Office of Remedial Action and Waste Technology, Office of Nuclear Energy, Department of Energy Headquarters. "Recommendation for Certification of Remedial Action at the Properties Comprising the Middlesex Municipal Landfill in Middlesex, New Jersey," April 20, 1989.

Bryan D. Walker, Acting Director, Technical Services Division, Oak Ridge Operations Office, Department of Energy, "Statement of Certification: Remedial Action at the Property Forming a Part of the Middlesex Municipal Landfill," April 7, 1989 (one statement for each property).

Cost data and waste volumes associated with the remedial action performed at the subject properties are included in Exhibit I of this docket.

## *Exhibit I* *Summary of Remedial Action Activities*

# EXHIBIT I

# SUMMARY OF REMEDIAL ACTION ACTIVITIES

MAY 1989

Prepared for

UNITED STATES DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

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## ABBREVIATIONS

| | |
|---|---|
| cm | centimeter |
| $cm^2$ | square centimeter |
| dpm | disintegrations per minute |
| ft | foot |
| m | meter |
| $m^2$ | square meter |
| uR/h | microroentgens per hour |
| MeV | million electron volts |
| mrad/h | millirad per hour |
| mrem | millirem |
| mrem/yr | millirem per year |
| pCi/g | picocuries per gram |
| WL | working level |

## LIST OF ACRONYMS

| | |
|---|---|
| AEC | Atomic Energy Commission |
| ANL | Argonne National Laboratory |
| BNI | Bechtel National, Inc. |
| CEQ | Council on Environmental Quality |
| DOE | Department of Energy |
| FUSRAP | Formerly Utilized Sites Remedial Action Program |
| IVC | Independent Verification Contractor |
| MED | Manhattan Engineer District |
| MML | Middlesex Municipal Landfill |
| MSP | Middlesex Sampling Plant |
| NEPA | National Environmental Policy Act |
| NJDEP | New Jersey Department of Environmental Protection |
| ORNL | Oak Ridge National Laboratory |
| ORO | Oak Ridge Operations |
| PIC | Pressurized Ionization Chamber |
| PMC | Project Management Contractor |

# 1.0 INTRODUCTION

Exhibit I summarizes the activities culminating in the certification that radiological conditions at the property discussed in this docket are in compliance with applicable guidelines and that use of the property will result in no radiological exposure above DOE criteria and standards established to protect members of the general public and occupants of the site. These activities were conducted under the Formerly Utilized Sites Remedial Action Program (FUSRAP) (Ref. 1). This summary includes a discussion of the remedial action process at this property: characterization of its radiological status, designation of the property as requiring remedial action, performance of the remedial action, and verification that the radioactivity has been removed. Further detail on each activity can be found in the referenced documents, most of which are included in the docket.

The property addressed in this docket is the Middlesex Municipal Landfill (MML) in Middlesex, New Jersey. The location of the MML is shown in Figure 1-1. The MML comprises two separate parcels, one of which is owned by the Borough of Middlesex, and one of which is owned by Middlesex Presbyterian Church. Figure 1-2 shows the property respective property lines.

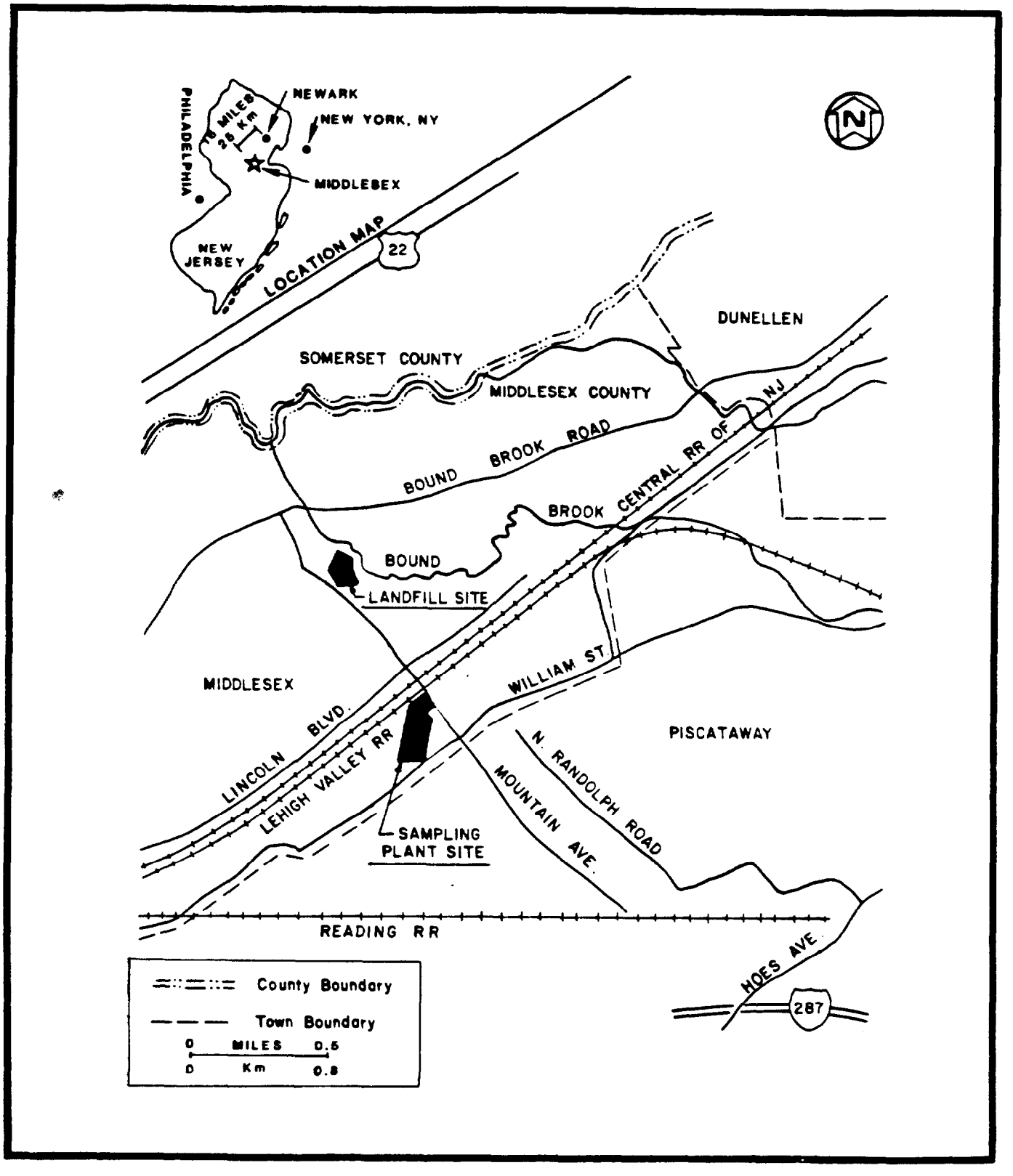


FIGURE 1-1 LOCATION OF THE MIDDLESEX MUNICIPAL LANDFILL (MML) SITE

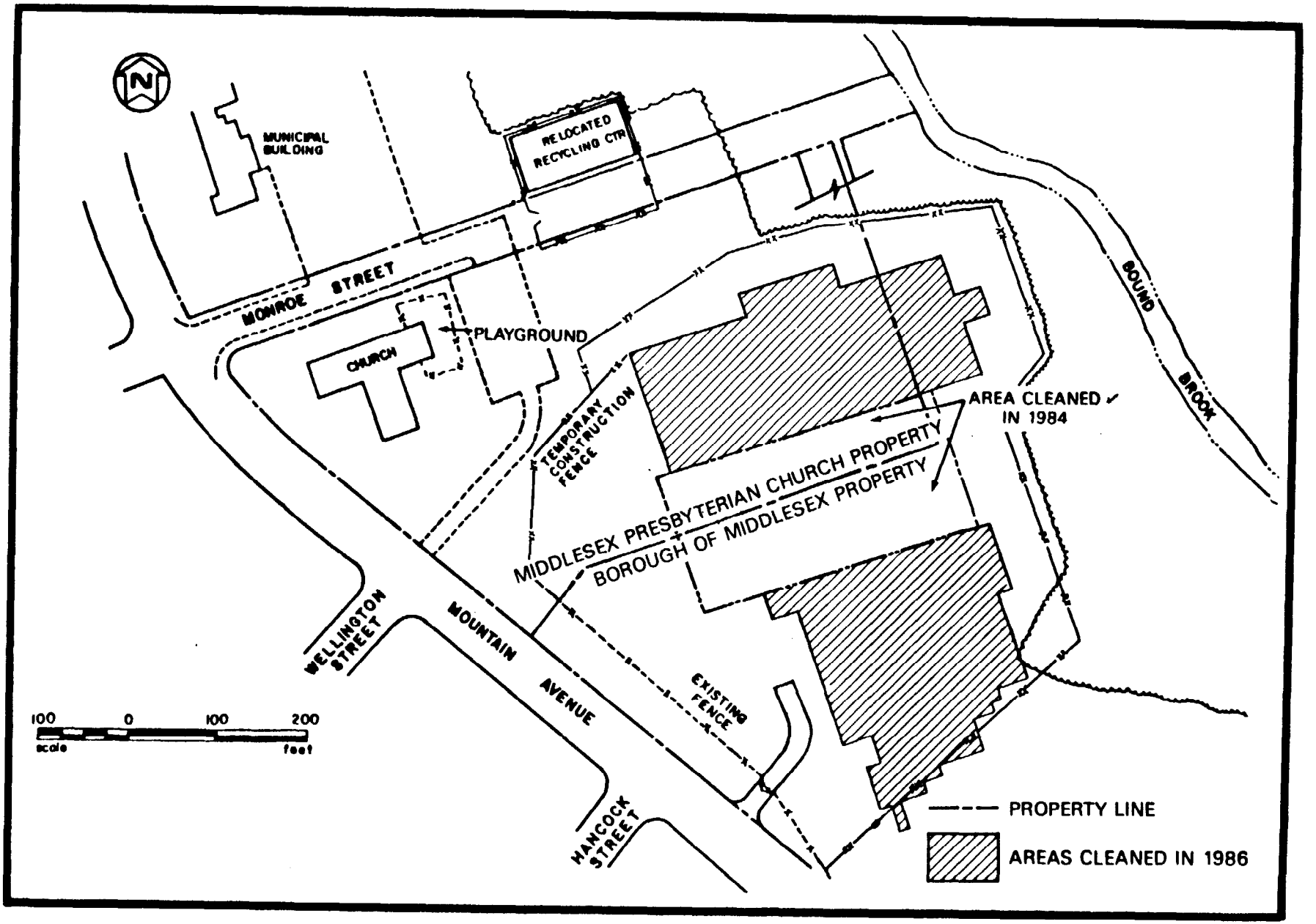


FIGURE 1-2 MAP OF THE MIDDLESEX MUNICIPAL LANDFILL AND VICINITY SHOWING LAND OWNERSHIP

## 2.0 SITE HISTORY

Although the MML and the Middlesex Sampling Plant (MSP) are two separate sites designated for remedial action under FUSRAP, their interrelationship dictates that the following brief history address both the MML and the MSP.

The MED established the MSP in 1943 as a facility for the sampling, storage, and/or shipment of uranium, thorium, and beryllium ores. All ores received at the facility were subsequently packaged, weighed, and shipped to processing facilities (Ref. 9).

In 1948, the AEC decided that the pitchblende (high-grade uranium ore) storage area at MSP should be paved. The area was graded smooth before it was covered with asphalt. The excess soil from the grading operation was transported to the MML. This soil, contaminated by previous ore spillage, was dispersed over approximately 5 acres of the MML and was used as fill or cover material for sanitary landfill operations (Ref. 9).

In 1960, elevated gamma radiation levels were detected on this site by civil defense monitors during a local civil defense exercise. A radiological survey of the site was conducted at that time by the AEC, and it was found that external gamma radiation levels over an area of approximately 1/2 acre were 20 to 50 times the background levels found in the surrounding area. The elevated gamma radiation could be directly attributed to contamination in the soil transported from the MSP. After discussions with Borough of Middlesex officials, the AEC removed the portion of the contaminated material nearest to the surface (approximately 650 $yd^3$ of material) and covered the area with about 2 ft of uncontaminated dirt. This action reportedly lowered the external gamma radiation levels to no more than 50 uR/h. The contaminated material was removed to the AEC New Brunswick Laboratory Site in New Brunswick, New Jersey.

In 1963, a parcel of approximately 5 acres of the landfill site was sold by the Borough of Middlesex to the Middlesex Presbyterian Church, and a church was subsequently constructed on that parcel. It was determined from discussions with local people that both the church and the Middlesex Municipal Building were constructed on "nonfill" or solid ground.

No further action was taken until 1974, when a radiological survey of the site was conducted by the AEC. The fact that the church and municipal building were constructed on solid ground was confirmed. In 1978, a radiological survey of the site was conducted by Oak Ridge National Laboratory (ORNL) to provide additional data and to provide a basis for evaluating changes in site conditions over the 4-year span since the AEC survey (Ref. 9).

A portion of the MML site is presently being used for can, bottle, and paper recycling operations. The site has not been used for solid waste disposal since 1974. Prior to the remedial action conducted in 1984 and 1986, no decontamination of the site had taken place since 1961.

## 3.0 SITE DESCRIPTION

The MML site is located in Middlesex County, New Jersey, approximately 16 mi southwest of Newark, New Jersey. The site, which lies within the municipal limits of the Borough of Middlesex, is east of Mountain Avenue, south of Monroe Street, and west of Bound Brook. The MML lies 0.5 mi north-northwest of the MSP.

The radioactively contaminated portion of the site covered approximately 3 acres of a formerly active municipal landfill. Approximately two-thirds of the portion of the site that required remedial action is owned by the Borough of Middlesex; the remainder is owned by the Middlesex Presbyterian Church. The land around the site is primarily public and/or undeveloped.

# 4.0 RADIOLOGICAL HISTORY AND STATUS

The radiological history presented below covers the period from 1979 to the completion of remedial action. Details of the 1961 AEC decontamination activities are not addressed.

## 4.1 RADIOLOGICAL CHARACTERIZATIONS

The first indication that additional radioactive material was present at the MML came in 1974. At the request of the Division of Operational Safety, AEC Headquarters, a radiological survey of certain adjoining properties belonging to the Borough of Middlesex and the Middlesex Presbyterian Church was performed during the period of March 25 to April 4, 1974. Survey results confirmed the existence of a contaminated area lying between and bordering on two properties: the grounds of the Middlesex Presbyterian Church, and property owned by the Borough of Middlesex. An area of approximately 3 acres was found to contain subsurface deposits of radioactivity ranging from about 3 to 60 times naturally occurring gamma background levels. The deposits were found to exist at depths ranging from less than 1 ft to 18 ft. Analysis results indicated the presence of above-background concentrations of radium and uranium. The average concentration of radium over the 3-acre area was found to be approximately 11 pCi/g, with localized concentrations of up to 140 pCi/g (Ref. 9).

In 1978, another radiological survey of the MML was conducted by ORNL to provide additional data and to provide a basis for evaluating changes in site conditions since 1974 (Ref. 9).

## 4.2 REMEDIAL ACTION GUIDELINES

The radioactive contamination on these properties consisted primarily of radium-226, with lesser amounts of uranium-238. A summary of DOE guidelines for the cleanup of residual contamination is contained in Table 4-1; the complete guidelines are provided in

TABLE 4-1

SUMMARY OF RESIDUAL CONTAMINATION GUIDELINES AT MML



BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 100 mrem/yr.

SOIL (LAND) GUIDELINES (MAXIMUM LIMITS)

| Radionuclide | Soil Concentration (pCi/g) above background[a,b,c] |
|---|---|
| Radium-226<br>Radium-228<br>Thorium-230<br>Thorium-232 | 5 pCi/g, 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. |
| Other radionuclides | Soil guidelines will be calculated on a site-specific basis using the DOE manual developed for this use. |

STRUCTURE GUIDELINES (MAXIMUM LIMITS)

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 has no radiological restrictions on its 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.[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 uR/h.

Indoor/Outdoor Structure Surface Contamination

| | Allowable Residual Surface Contamination[e] (dpm/100 $cm^2$) | | |
|---|---|---|---|
| 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 | 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 |

TABLE 4-1

(continued)



Indoor/Outdoor Structure Surface Contamination (continued)

| Radionuclide[f] | Allowable Residual Surface Contamination[e] (dpm/100 $cm^2$) Average[g,h] | Maximum[h,i] | Removable[h,j] |
|---|---|---|---|
| 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]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 concentrations of individual radionuclides shall be reduced so that the dose for the mixtures will not exceed the basic dose limit.

[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]Localized concentrations in excess of these limits are allowable provided that the average concentration over a 100-$m^2$ area does not exceed these limits.

[d]A working level (WL) is any combination of short-lived radon decay products in 1 liter of air that will result in the ultimate emission of $1.3 \times 10^5$ MeV 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 observed 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 more than 1 $m^2$. For objects of less surface area, the average shall be derived for each such object.

[h]The average and maximum radiation levels 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.

[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 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.

Appendix A. DOE used the radium-226 limit listed in Table 4-1 to determine the need for remedial action at the MML. DOE implemented these guidelines on the basis of their compatibility with the criteria used by the Environmental Protection Agency (Ref. 10). The design criteria document for FUSRAP contains additional information regarding applicable federal regulations (Ref. 11).

## 4.3 POST-REMEDIAL ACTION STATUS

As shown in the post-remedial action report for the MML, there is no area where radioactive contamination exceeds DOE guidelines (Ref. 12). An independent review of the remedial action performed on the parcels discussed in this report has been conducted by an independent verification contractor (IVC), the Radiological Site Assessment Group of Oak Ridge Associated Universities. The purpose of its assessment was to verify the data supporting the adequacy of the remedial action performed by BNI and to confirm the site's compliance with remedial action guidelines.

Based on all data collected, these parcels conform to all applicable DOE radiological guidelines established for release of these properties for future use (Refs. 13, 14).

# 5.0 SUMMARY OF REMEDIAL ACTION

The following subsections briefly describe the remedial action process and measures taken to protect the public and the environment.

## 5.1 PRE-REMEDIAL ACTION ACTIVITIES

Based on the radiological survey results, DOE "designated" the MML for remedial action; i.e., when radionuclide concentrations exceeded the guidelines listed in Table 4-1, contamination was to be removed from the property until the concentrations were within guideline values.

Alternatives to the remedial action and methods for performing the remedial action were then considered. For the MML, five alternatives were evaluated (Ref. 5).

One alternative was to take no action. This would require continued restrictions regarding the use of the landfill.

A second alternative was to release the landfill with no restrictions on its future use. This alternative would require extensive hydrological characterization of the landfill and a pathways analysis.

A third alternative was minimal excavation. This would involve excavating materials found within the upper 4.5 ft of the landfill. A pathways analysis would be required for the material at depths greater than 4.5 ft to determine if the site could be released for future use.

A fourth alternative was to stabilize the radioactive material in place. This would involve construction of a cutoff wall and cap to prevent infiltration of water into the material.

A fifth alternative was to excavate the contaminated soil and transport it, as well as any other contaminated materials, from the landfill. This alternative was chosen (Ref. 5).

Prior to the start of remedial action, representatives of DOE and BNI met with the Middlesex mayor, health officer, and chief of police to discuss the work. Agreement was reached on transportation routes and relocation of the Borough's recycling center, which was near the area to be excavated.

DOE and BNI also met with the pastor of the Middlesex Presbyterian Church and the director of the church's day-care center. Information was provided about safety measures to be taken during the remedial action, and DOE agreed to relocate the church's playground away from the excavation area.

Notification to the public was accomplished with an announcement by the mayor at a Borough Council meeting, which was reported in the Middlesex Chronicle on May 24, 1984. During the remedial action, BNI responded to media inquiries from the Middlesex Chronicle, the Bound Brook Chronicle, and the Bridgewater Courier News, all of which published articles about the project.

In addition, before BNI performed the remedial action, an access agreement had to be obtained from each of the property owners authorizing entry to the property and granting permission to do the work. The agreement, designated a Memo Agreement, granted DOE and its contractors the right to perform the remedial action. It also stated the scope of work, DOE responsibilities, and the plan to restore the properties to an "as was" condition. Concurrently, BNI began engineering design work and related activities to hire local subcontractors to perform the cleanup work (Refs. 15, 16).

## 5.2 DECONTAMINATION ACTIVITIES

After the access agreements had been obtained, the design work completed, and a subcontract awarded, the local subcontractor began

work. Under the supervision of BNI, the subcontractor excavated the property based on drawings showing the extent of the contamination on each property. Soil was then removed as indicated in the drawings, deposited in dump trucks, and transported to an interim storage pile at the MSP. The MSP is an engineered storage facility developed to store the contaminated material from the MML until a permanent disposal site is selected. An environmental monitoring program is in effect for the facility; all potential release pathways from the facility are monitored. An environmental monitoring report is issued each year by DOE. Environmental monitoring results were reported for both MSP and MML prior to the 1988 monitoring year; however, since environmental monitoring by DOE at the MML was discontinued at the end of calendar year 1987, environmental monitoring reports for 1988 and subsequent years will include only MSP.

Remedial action at the MML was conducted in two phases, in 1984 and 1986. Excavation of contaminated soil from the landfill began during the summer of 1984, and by November of that year approximately 15,000 $yd^3$ had been removed. Subsurface data gathered during the excavation showed the extent of contamination to be greater than that originally estimated. Excavation was halted in November 1984 and backfilling was completed. Excavation resumed in May 1986 and was completed in July of that year. The amount of material excavated during 1986 was approximately 16,000 $yd^3$ bringing the total amount of contaminated soil excavated from the landfill to approximately 31,000 $yd^3$. In addition, during 1986 backfilling of the landfill was completed, turf was established, and demobilization and general site cleanup were completed.

Before the excavation began, the radioactively contaminated area was staked and separated into five 30-ft-wide strips. Incremental 1-ft cuts (lifts) and side slopes of 2 horizontal:1 vertical were utilized for excavation of each strip. The 1-ft depth for the lifts was deemed necessary as a safety precaution, and was determined to be a depth that was reasonable for pre-screening and monitoring of radioactive material prior to excavation. Each strip was

radiologically tested before each lift was excavated and was classified as either radioactively contaminated waste or radioactively clean soil. Augered holes were installed in the excavation area to release any landfill gases before excavation. At the end of each work day and when work was not in progress, the excavated areas were sprayed with a masking agent to control objectionable odors.

During the cleanup, several procedures were implemented to control the radioactive materials being removed from the properties. These procedures were designed to minimize the exposure of workers and residents.

The primary pathway by which residents could be exposed to radiation was from dust released during the excavation. To minimize this potential, the subcontractor was required to keep all excavations and work areas free from dust by keeping the soil moistened. Air sampling was performed at the perimeter of the excavation areas to demonstrate compliance with DOE and New Jersey Department of Environmental Protection (NJDEP) standards for airborne radioactivity. These samples are collected by pulling large quantities of air through a filter. Airborne dust, which could potentially contain radioactive materials, was captured by the filter. The filters were then removed and analyzed for radioactivity. Because the amount of air drawn through the filter was known, the concentration of radioactivity in the air could be calculated. None of the measured radioactivity concentrations in air exceeded the applicable DOE guidelines and NJDEP standards.

To keep uncontaminated areas clean during excavation work, trucks were draped with tarpaulins before they were filled. This prevented the contaminated dirt from getting on the truck exterior and later falling onto uncontaminated property. If trucks were to be loaded on an uncontaminated area, the ground was covered with a tarpaulin before the truck pulled onto it for loading. If contaminated soil was spilled during the loading of the truck, this tarpaulin prevented the contamination of clean ground. Finally, all trucks

hauling radioactively contaminated soil were loaded only to about 80 percent of their capacity and truck beds were covered before moving. This too prevented soil from falling or being blown out of the truck onto uncontaminated ground or roadways while being transported.

After the trucks had dumped the contaminated soil at the MSP, they were decontaminated before being permitted on any public road. This procedure ensured that no contamination was brought back onto roads or to the MML.

Using this combination of procedures, the spreading of contaminated materials was effectively controlled.

## 5.3 POST-REMEDIAL ACTION SAMPLING

After the soil containing the radioactive contaminants was removed, another radiological survey was conducted to ensure that the property was clean (no radionuclide concentrations in excess of DOE guidelines). This survey used the techniques outlined below.

### 5.3.1 Surface Gamma Radiation Scans

Two types of gamma radiation scans were conducted to determine whether all radioactively contaminated soil had been removed. The first was a "walkover" scan. In this type of survey, the technician holds an unshielded gamma scintillation radiation detector a few inches above the surface and moves it slowly from side to side as he walks over the excavated area. The purpose of a walkover scan is to quickly detect areas of residual contamination. The advantage of this type of survey is that the detector quickly scans the area as the excavation proceeds.

The second gamma radiation scan was performed after all contamination detected by the walkover scan was removed. A lead-shielded gamma scintillation radiation detector was used for this survey to ensure that the only radiation detected was coming

from the ground under the detector. Measurements were made on each property at 7.5-ft intervals to ensure that the property had been cleaned of radioactively contaminated soil.

### 5.3.2 Soil Sampling

The primary method of ensuring compliance with DOE cleanup guidelines was to take soil samples. These samples were analyzed in a laboratory to determine the concentrations of radium-226, thorium-232, and uranium-238.

### 5.3.3 Exposure Rate Measurements

Pressurized ionization chamber (PIC) readings were taken to measure the gamma radiation exposure rate after removal of the contamination. The PIC measurements were taken at various locations on the properties.

Measured gamma radiation exposure rates were used to calculate annual doses assuming a conservative period of exposure at the point of measurement. A background radiation contribution of 100 mrem/yr was subtracted from the calculated dose. For comparison, the DOE radiation protection standard is 100 mrem/yr above the background level. None of the PIC readings exceeded this level.

## 5.4 VERIFICATION ACTIVITIES

The independent verification contractor (IVC) is responsible for preparing a generic plan outlining the procedures to be used during verification activities. The IVC conducted two types of verification reviews (Types A and B) for MML. Type A verification reviews included a review of the remedial action and radiological contractors' data and the analysis of some samples. Type B verification reviews included an on-site visit and survey involving direct measurements and sampling.

In addition to the surveys that have been performed on behalf of DOE (see Subsection 4.3), measures were taken by NJDEP to monitor remedial action activities. During the 1984 and 1986 remedial action activities, NJDEP representatives made weekly visits to the sites. They observed construction procedures and techniques and compared them to previously published descriptions (Refs. 15, 16). DOE and its contractors worked closely with NJDEP representatives. Additionally, a copy of the post-remedial action report was transmitted to the NJDEP.

## 5.5 PUBLIC AND OCCUPATIONAL EXPOSURES

### 5.5.1 Public Exposure

As shown in the post-remedial action report for the MML, the radiological exposure to the public following remedial action is less than 100 mrem/yr above the background level (Ref. 12). This is true for the total dose from all pathways.

### 5.5.2 Occupational Exposure

A health physics program was conducted during remedial action; it comprised control of contamination, management of occupational exposures, and radiological monitoring of construction.

#### Exposure to External Gamma Radiation

Eighty-six remedial action workers were monitored for external gamma exposure while remedial action was in progress at the MML. Of these workers, 73 (or 85 percent) exhibited no exposure at all; 13 persons (or approximately 15 percent) received exposures ranging from 9 to 223 mrem/yr. Monitoring results are shown in Table 5-1. All exposures were below the DOE standard of 5000 mrem/yr. Even the highest annual dose (223 mrem/yr) was only 5 percent of the radiation protection standard.

TABLE 5-1

MONITORING RESULTS FOR EXTERNAL

GAMMA RADIATION AT THE MML

| Number of Personnel Monitored | Number of Personnel Exposed | Exposure Range (mrem/yr) | | |
|---|---|---|---|---|
| | | 1 - 50 | 50 - 100 | 100 - 223 |
| 86 | 13 | 12 | 0 | 1 |

### Internal Exposure

During the remedial action at the MML, 435 bioanalyses were performed to monitor the potential exposure of personnel to the intake of airborne radionuclides such as radium-226, natural uranium, lead-210, and thorium-230. These results are summarized in Table 5-2. None of the samples indicated radionuclide concentrations that exceeded the minimum action level and would warrant re-sampling. Post-remedial action air particulate monitoring data are summarized in Table 5-3.

## 5.6 COST

The final subcontract bid item quantities and costs for the remedial action performed at the MML are given in Tables 5-4 and 5-5.

TABLE 5-2

MONITORING RESULTS FOR OCCUPATIONAL INTERNAL EXPOSURE AT THE MML

| Radionuclide | Number of Bioanalyses | Action Level Exceeded* |
|---|---|---|
| Radium-226 | 216 | None |
| Natural uranium | 215 | None |
| Thorium-230 | 2 | None |
| Lead-210 | 2 | None |
| Total | 435 | |

*The action levels are 0.7 pCi/l for radium-226, 0.1 pCi/l for natural uranium, and 15 mg/l for thorium-230.

TABLE 5-3

POST-REMEDIAL ACTION AIR MONITORING SUMMARY

| Parameter | Number of Measure-ments | Gross Alpha Measurement ($10^{-14}$ μCi/ml)* | |
|---|---|---|---|
| | | Average | Range |
| Air particulates | 84 | 1.3 | <0.05-10.8 |

*The DOE guideline for insoluble thorium-230 in air is $5 \times 10^{-14}$ μCi/ml (Ref. 17). The average value for the MML is below this guideline.

TABLE 5-4

REMEDIAL ACTION COSTS AT THE MIDDLESEX MUNICIPAL LANDFILL

FOR THE 1984 WORK



| Description | Final Quantity | Unit Price ($) | Final Amount ($) |
|---|---|---|---|
| Mobilization | ls | 10,288.00 | 10,288.00 |
| Rehabilitation of MML washdown facility structure | ls | 2,500.00 | 2,500.00 |
| MML washdown facility equipment installation and operation | ls | 2,500.00 | 2,500.00 |
| MSP washdown facility equipment installation and operation | ls | 2,500.00 | 2,500.00 |
| MML flexible holding tank | ls | 2,500.00 | 2,500.00 |
| Well closure | ls | 1,000.00 | 1,000.00 |
| Sandbag | ls | 500.00 | 500.00 |
| Site restoration | ls | 2,500.00 | 2,500.00 |
| Demobilization | ls | 2,500.00 | 2,500.00 |
| MML Excavation and segregation | 40,000 $yd^3$ | 10.00 | 400,000.00 |
| Transporting and placing contaminated material | 15,589 $yd^3$ | 15.00 | 233,835.00 |
| Herbicide | 1.4 AC | 100.00 | 140.00 |
| MSP geomembrane cover | 8,892 $yd^2$ | 1.00 | 8,892.00 |
| MSP geotextile fabric | 6,882 $yd^2$ | 0.10 | 688.20 |
| Backfill of uncontaminated MML materials | 22,000 $yd^3$ | 0.25 | 5,500.00 |
| Clean fill | 15,589 $yd^3$ | 8.00 | 124,712.00 |
| Turf establishment | 5.9 $yd^3$ | 500.00 | 2,950.00 |
| Medical exams | Allowance | Allowance | 7,682.50 |
| Concrete wall around MSP storage pile | 180 lf | 5.05 | 909.00 |

TABLE 5-4

(continued)



| Description | Final Quantity | Unit Price ($) | Final Amount ($) |
|---|---|---|---|
| Additional MML excavation and segregation | 15,823 $yd^3$ | 10.00 | 158,230.00 |
| Additional backfill of uncontaminated MML materials | 18,235 $yd^3$ | 0.25 | 4,558.50 |
| Two-man survey crew | 142.5 h | 60.00 | 8,550.00 |
| Three-man survey crew | 7 h | 73.00 | 525.00 |
| Office work | 371 h | 38.00 | 14,098.00 |
| Travel time two-man crew | 31 trips | 45.00 | 1,395.00 |
| Travel time 3-man crew | 2 trips | 65.00 | 130.00 |
| Medical exams | Allowance | Allowance | 2,439.00 |
| Medical exam (manhours) | 35 h | 25.00 | 875.00 |
| | | TOTAL | $1,002,897.20 |

[a]Lump sum is abbreviated as "ls."

TABLE 5-5

REMEDIAL ACTION COSTS AT THE MIDDLESEX MUNICIPAL LANDFILL FOR THE 1986 WORK



| Description | Final Quantity | Unit Price ($) | Final Amount ($) |
|---|---|---|---|
| Mobilization | ls[a] | 31,000.00 | 31,000.00 |
| Clearing | ls | 10,000.00 | 10,000.00 |
| Relocating Recycle Center | ls | 15,000.00 | 15,000.00 |
| Decontamination Facility (Landfill) | ls | 55,000.00 | 55,000.00 |
| Fence Removal | ls | 1,000.00 | 1,000.00 |
| Upgrading Existing Fence | ls | 1,500.00 | 1,500.00 |
| Additional Security Fence | ls | 22,000.00 | 22,000.00 |
| Haul Road | ls | 20,000.00 | 20,000.00 |
| Decontamination Facility (Sampling Plant) | ls | 12,000.00 | 12,000.00 |
| Water Supply | ls | 7,000.00 | 7,000.00 |
| Trailer Setup | ls | 3,000.00 | 3,000.00 |
| Electrical Supply | ls | 15,000.00 | 15,000.00 |
| Demobilization | ls | 1,500.00 | 1,500.00 |
| Relocate Playground | ls | 8,000.00 | 8,000.00 |
| Portable Trash Pump | ls | 205.00 | 205.00 |
| Temporary Security Fence | ls | 6,875.00 | 6,875.00 |
| Mobilization | ls | 4,730.00 | 4,730.00 |
| Well Removal | ls | 500.00 | 500.00 |

TABLE 5-5

(continued)



| Description | Final Quantity | Unit Price ($) | Final Amount ($) |
|---|---|---|---|
| Operating Decontamination | ls | 11,890.00 | 11,890.00 |
| Contamination Control | ls | 6,580.00 | 6,580.00 |
| Waste Storage Facility | ls | 81,620.00 | 81,620.00 |
| Turf Establishment | ls | 4,700.00 | 4,700.00 |
| Site Restoration | ls | 3,140.00 | 3,140.00 |
| Demobilization | ls | 2,000.00 | 2,000.00 |
| Gas Venting | 1,830 lf | 3.00 | 5,490.00 |
| Landfill Excavation | 18,500 $yd^3$ | .56 | 10,360.00 |
| Backfill | 6,479 $yd^3$ | .22 | 1,425.38 |
| Borrow Backfill | 6,200 $yd^3$ | 6.40 | 39,680.00 |
| Transporting | 6,200 $yd^3$ | 43.54 | 269,948.00 |
| Consolidation | ls | 1,500.00 | 1,500.00 |
| Masking Agent Initial Cost | ls | 603.33 | 603.33 |
| Spraying (Straight Time) | 4 h | 25.77 | 103.08 |
| Spraying (Overtime) | 6 h | 36.74 | 220.44 |
| Masking Agent | 2 drums | 1,580.69 | 3,161.38 |
| Laborers | 51 h | 25.77 | 1,314.27 |
| Backhoe 350H | 17 h | 292.22 | 4,964.00 |
| Waste Storage Facility | 99 lf | 604.60 | 59,855.40 |
| Additional Excavation | 2,840 $yd^3$ | .56 | 1,590.40 |
| Additional Transporting | 6,000 $yd^3$ | 40.00 | 240,000.00 |
| Additional Gas Venting | 800 lf | 3.00 | 2,400.00 |

TABLE 5-5

(continued)



| Description | Final Quantity | Unit Price ($) | Final Amount ($) |
|---|---|---|---|
| Borrow Fill | 6,000 $yd^3$ | 6.40 | 38,400.00 |
| Operating Decontamination Facility | 6,000 $yd^3$ | 1.92 | 11,520.00 |
| Soil Sterilization | 26,200 $ft^2$ | .15 | 3,930.00 |
| Additional Transporting | 2,661 $yd^3$ | 40.00 | 106,440.00 |
| Additional Borrow Fill | 1,328 $yd^3$ | 6.40 | 8,499.20 |
| 6-in. Diameter Pin | ls | 1,500.00 | 1,500.00 |
| Vent Holes | 585 lf | 3.00 | 1,755.00 |
| Plastic Cover | ls | 1,325.00 | 1,325.00 |
| Additional Soil | 17,034 $ft^2$ | .15 | 2,555.10 |
| Property Survey | ls | 2,700.00 | 2,700.00 |
| 2-Man Survey Crew | 25.5 h | 50.00 | 1,275.00 |
| 3-Man Survey Crew | 15 h | 65.00 | 975.00 |
| Office Work | 37 h | 35.00 | 1,295.00 |
| | | Total: | $1,151,776.08 |

[a]Lump sum is abbreviated as "ls."

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## GLOSSARY

**Alpha-emitting** - See radiation.

**Background Radiation** - Background radiation refers to naturally occurring radiation emitted from either cosmic (e.g., from the sun) or terrestrial (e.g., from the earth) sources. Exposure to this type of radiation is unavoidable and its level varies greatly depending on geographic location; e.g., New Jersey typically receives 100 mrem/yr, Colorado receives about 300 mrem/yr, and some areas in South America receive up to 7000 mrem/yr. Naturally occurring terrestrial radionuclides include uranium, radium, potassium, thorium, etc. These dose levels do not include the concentrations of naturally occurring radon inside buildings.

**Beta-gamma-emitting** - See radiation.

**Contamination** - Contamination is used generally to mean a concentration of radioactive materials in the soil exceeding naturally occurring levels. Contamination may or may not exceed DOE remedial action guidelines.

**Counts per minute** - A count is the unit of measurement registered by a radiation detection instrument when radiation imparts its energy within the sensitive range of the detector probe. The number of counts registered per minute can be related to the number of disintegrations per minute occurring from a radioactive material.

**Disintegrations per minute** - Disintegrations per minute is the measurement indicating the amount of radiation being released from a substance per minute. See the definition of picocurie.

**Dose** - Dose as used in this report is actually dose equivalent and is used to relate absorbed dose (mrad) to an effect on the body. Dose is measured in mrem. Examples of dose are: a dose of 500,000 mrem to the whole body in a short 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 results in an annual dose of about 100 mrem; DOE radiation protection standards limit the dose to members of the general public to 100 mrem/yr above background levels; living in a brick house results in a dose of about 75 mrem/yr above background.

**Exposure rate** - Exposure rate is the rate at which radiation imparts energy to the air. Exposure is typically measured in microroentgens (uR) and the exposure rate is typically given as uR/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 uR/h for 168 hours per week (continuous exposure) for 52 weeks per year, the whole-body dose would be 170 mrem.

**Gamma Radiation** - See radiation.

**Gram** - A gram is a metric unit for weight. It takes 454 grams to make 1 pound; 1 ounce equals 28 grams.

**Meter** - A meter is a metric unit of measurement for length; 1 meter is equal to approximately 39 inches.

**Microcurie** - A microcurie is 1,000,000 picocuries (see picocuries for additional explanation).

**Microroentgen** - A microroentgen (uR) is a unit used to measure radiation exposure. For further information, see the definition of exposure rate.

**Milliliter** - A milliliter is a unit of measure for volume. There are 3785 ml in 1 gallon.

**Millirad** - Millirad is a measure of the amount of energy imparted by radiation to a unit of mass. An absorbed dose rate is expressed in terms of mrad/h.

**Millirem** - millirem is the unit used to measure radiation doses to man. The DOE limit is 100 mrem above background radiation levels for members of the general public in any one year. Naturally occurring radioactive substances in the ground result in a yearly exposure to everyone of about 100 mrem. To date, no difference can be detected in the health of population groups exposed to 100 mrem/yr above background and in the health of groups who are not exposed.

**Picocurie** - A picocurie is the unit of measure for radioactivity just as an ounce is a unit to measure weight. One picocurie means that one radioactive particle is released on the average of every 27 seconds.

**Radium-226** - Radium-226 is a naturally occurring, radioactive material that spontaneously emits alpha radiation.

**Radiation** - There are three primary types of radiation: alpha, beta, and gamma. Alpha radiation travels less than an inch in air before it stops. Alpha radiation cannot penetrate the outer layer of skin on the body. Beta radiation can penetrate the outer layers of skin, but cannot reach the internal organs of the body. Gamma radiation is the most penetrating type and can usually reach the internal organs.

**Radionuclide** - A radionuclide is another word meaning a particular radioactive element. For example, uranium-235 is a radionuclide, uranium-238 is another, thorium-232 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 can be released for future use as uncontaminated. In practice, this may mean removing grass and soil, cutting trees, removing asphalt, etc. Remedial action also includes restoring remediated properties to their original conditions, to the extent that this is possible.

**Thorium** - Thorium is a naturally occurring element which is recovered from monazite for commercial purposes. Monazite contains from 3 to 9 percent thorium oxide. The principal use of thorium to date has been in the manufacture of gas lantern mantles because thorium oxide burns with a brilliant white light. Thorium oxide is also commonly found in high quality glasses and camera lenses because of its optical properties.

**Uranium** - Uranium is a naturally occurring, radioactive element. The principal use of uranium -- when refined -- is for the production of fuel for nuclear reactors. Uranium in its natural form is not suitable for use as a fuel source.

**Working Level** - Working level is a unit to measure the energy expended in air by radon or its radioactive decay products. The term was derived to measure radon progeny concentrations to which uranium miners were exposed.

# APPENDIX A

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

# 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-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 |

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 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. 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

# *Exhibit II* *Documents Supporting Certification of the Remedial Action at the Middlesex Municipal Landfill in Middlesex, New Jersey*

EXHIBIT II

DOCUMENTS SUPPORTING THE CERTIFICATION OF THE

REMEDIAL ACTION PERFORMED AT THE

MIDDLESEX MUNICIPAL LANDFILL IN

MIDDLESEX, NEW JERSEY, IN 1984 AND 1986

# PREFACE

For the convenience of the reader, Exhibit II is paginated continuously. Each page number begins with the designator "II-" to distinguish the numbering system used for Exhibit II from the individual numbering systems used in the documents comprising Exhibit II. The Exhibit II page numbers on which the individual documents begin are given on pages ii and II-iii of this docket. These page numbers are also listed on the title page introducing each subpart of Exhibit II.

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Exhibit II (1) - Decontamination or Stabilization Criteria

The following documents contain the guidelines that determine the need for remedial action. The subject properties have been decontaminated to comply with these guidelines. The first document listed is included as Appendix A of Exhibit I; the second is included on the following pages.


Page

U.S. Department of Energy. "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.

U.S. Department of Energy. Design Criteria for Formerly Utilized Sites Remedial Action Program (FUSRAP) and Surplus Facilities Management Program (SFMP), 14501-00-DC-01, Revision 2, Oak Ridge, TN, March 1986. II-2

ADVANCED TECHNOLOGY DIVISION

35271

REVISION NOTICE NO. 3

DESIGN CRITERIA

PAGE 1 OF 1

DEPARTMENT OF ENERGY
FORMERLY UTILIZED SITES
REMEDIAL ACTION PROGRAM
BECHTEL JOB 14501 (FUSRAP)

ISSUE DATE: 03/07/86

TO: Tech Writer MANUAL NUMBER 15

Please replace Table of Contents, Rev. 2 in your Design Criteria for Formerly Utilized Sites Remedial Action Program (FUSRAP) and Surplus Facilities Management Program (SFMP) which has a typographical error and format change, with the attached corrected Table of Contents, Rev. 2.

Please sign this revision notice in duplicate, retaining one copy for the front of your folder, returning one copy to the address indicated below:

PLEASE NOTE: As indicated on Table of Contents, Appendicies A, B, and D are still at Rev. 0.

PLEASE SIGN, DATE, AND RETURN THIS ENTIRE SHEET TO:

Bechtel National, Inc.
800 Oak Ridge Turnpike
Oak Ridge, TN 37830 ATTN: B. WOOD

ACKNOWLEDGEMENT:

MY COPY HAS BEEN BROUGHT TO CURRENT STATUS AND SUPERSEDED MATERIAL HAS BEEN REMOVED AND DESTROYED

☒ MY ADDRESS IS THE SAME

☐ MY ADDRESS IS AS FOLLOWS

SIGNATURE Jeannette M. Hoffman DATE 4/3/86 MANUAL NO. 15 VERIFY

14501-00-DC-01
REV. 1

# DESIGN CRITERIA FOR FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM (FUSRAP) AND SURPLUS FACILITIES MANAGEMENT PROGRAM (SFMP)

FEBRUARY 1986

NOTE: The remedial action guidelines contained in Appendix C to this report have been superseded by those contained in Appendix A to Exhibit I of the certification docket.

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 FUSPAP 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.

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# 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. |

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| 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. |

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| 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. |

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| 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. |

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

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| 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. |

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| 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). |

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

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| 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

| WBS 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 | Bayo Canyon | NM | Strontium-90 | 1,520* | - | - | FB&DU 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 | |
| 153 | St. Louis Airport | MO | Radium-226 | 86,000 | 30 | 3.8 | DOE/EV-0005/16 | |

APPENDIX B (Cont'd)

FUSRAP SITES

| WBS 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 Cylops | 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>2.88<br>$2.0 \times 10^{-2}$ | DOE/EV-0005/5<br>PB&DU 409-323 | |
| 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 | | 638,650 | | | | |

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.

NOTE: The guidelines contained herein have been superseded by those contained in Appendix A to Exhibit I of the certification docket.



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 $cm^2$)†[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 $m^2$. 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.

## 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.

Exhibit II (2) - Designation or Authorization Documentation

The following documents authorized or designated the two subject properties of the landfill for remedial action. A copy of each follows.


| | Page |
|---|---|
| Memorandum, Thomas G. Frangos, Director, Office of Environmental Compliance and Overview, Environmental Technology Control Division, Department of Energy, EV-13,to S. Meyers, Department of Energy, NE-90. "Notification of Need for Some Form of Remedial Action - Middlesex Municipal Landfill Site, Middlesex, New Jersey," April 14, 1980. | II-46 |
| Memorandum, Stephen H. Greenleigh, Office of the General Counsel, Department of Energy, to Bill Snyder. "Legal Opinion - Authority to Decontaminate the Middlesex Municipal Landfill Site, Middlesex, New Jersey," May 30, 1980. | II-48 |

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EV-13

Notification of Need for Some Form of Remedial Action - Middlesex Municipal Landfill Site, Middlesex, New Jersey

S. Meyers, NE-90

EV/ECT has determined portions of the Middlesex Municipal Landfill to be contaminated with low level residual radioactive material resulting from activities of the Manhattan Engineer District and Atomic Energy Commission. We consider this site to be of high priority. In support of these findings we have previously transmitted the radiological survey report for the Middlesex Municipal Landfill Site and the engineering and environmental analysis of remedial action options for the site. The site summary for the Middlesex Municipal Landfill is attached.

The Office of General Counsel has determined, following a survey of all available records, that DOE would have the existing authority under the Atomic Energy Act of 1954 to perform remedial measures on this site to remove low level residual radioactive material derived from the Middlesex Sampling Plant, where such removal is required to protect public health and safety.

Please keep us informed of the status of this project in order that EV may fulfill our overview responsibility for FUSRAP.

/s/
Thomas G. Frangos, Director
Office of Environmental
Compliance and Overview

Attachment

bcc: S. Miller, GC-34, w/attachment
Aerospace, w/attach
EV-10, w/attach
A. Whitman, w/attach

EV-131:AWhitman:mas:353-5439:3/26/80
REWRITTEN by S. Miller:4/7/80 - (See attached yellow for concurrence)*

CONCURRENCES

| SYM. | INITIALS/SIG. | DATE |
|---|---|---|
| EV-131 | Whitman | 4/10/80 |
| EV-13 | Counts | 4/10/80 |
| EV-13 | Mott | 4/7/80 |
| GC-34 | Miller | 4/7/80 |
| EV-10 | Frangos | 4/14/80 |



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EV-131

Notification of Need of Some Form of Remedial Action - Middlesex Municipal Landfill, Middlesex, New Jersey

Robert W. Ramsey, NE-30

In our memorandum to you dated April 14, 1980, we indicated that the priority for remedial action at the Middlesex Municipal Landfill was high. This designation was in error and should be changed to low (based on the health evaluation in the final radiological survey report). Please change your records to reflect this designation change.

Original signed by:

William E. Mott, Director
Environmental Control
Technology Division
Office of Environment

bcc: Aerospace

DIST
Subject
EV-1/RF
EV-10/RF
EV-13(2)/RF
EV Mailroom
AWhitman/RF

EV-131:AWhitman:mas:353-5439:5/8/80:DF-58

CONCURRENCES
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Department of Energy
Washington, D.C. 20585

MAY 30 1980

NOTE FOR BILL SNYDER

FROM: STEPHEN M. GREENLEIGH

SUBJ: LEGAL OPINION - AUTHORITY TO DECONTAMINATE THE MIDDLESEX MUNICIPAL LANDFILL SITE, MIDDLESEX, NEW JERSEY

I am transmitting a legal memorandum on the authority to decontaminate the Middlesex Municipal Landfill site, Middlesex, New Jersey.

This opinion is based upon an earlier opinion by Lynn Coleman on the authority to decontaminate the Middlesex Sampling Plant and adjacent private properties, issued on June 19, 1978, a copy of which is attached.

I would be pleased to discuss this matter further should you so desire.

Attachment
As stated

Department of Energy
Washington, D.C. 20585

MAY 30 1980

MEMORANDUM FOR BILL SNYDER

FROM: STEPHEN H. GREENLEIGH

SUBJ: LEGAL OPINION - AUTHORITY TO DECONTAMINATE THE MIDDLESEX MUNICIPAL LANDFILL SITE, MIDDLESEX, NEW JERSEY

## I. CONCLUSION

You have asked for an opinion of this Office as to whether the Department of Energy (DOE) has the authority to undertake a remedial action at a former landfill site in Middlesex, New Jersey which site contains low-level residual source material derived from the government-owned former Middlesex Sampling Plant.

It is the opinion of this Office that DOE would have the requisite authority to perform a remedial action at the Middlesex Landfill site to acquire and remove, or stabilize low-level residual source material derived from the Middlesex Sampling Plant if such acquisition and removal, or stabilization is required in order to protect public health and safety.

## II. DISCUSSION

In 1942, a sampling plant was built on government-owned land by the Manhattan Engineer District (MED) of the War Department to sample pitchblende ores purchased from foreign sources for use ultimately in the production of atomic weapons. As part of its Middlesex Sampling Plant operations, the MED, beginning in the mid 1940's disposed of low-level residual source material from the plant site, at a vacant dump site in Middlesex (now referred to as the Middlesex Municipal Landfill). In 1946, MED was abolished and its functions were transferred to the Atomic Energy Commission (AEC)[1] which continued to operate the Sampling Plant and to dispose of low-level residual source material at the Landfill (under authority of section 5(b)(5) and 6(a)(2) of the Atomic Energy Act of 1946, as amended, and sections 66 and 91(a)(2) of the Atomic Energy Act of 1954, as amended). The Sampling Plant operations, which ceased in 1967, resulted in extensive radioactive

[1] Executive Order 9816 of December 31, 1946 (46 FR 22112) transferred the Middlesex Sampling Plant to AEC.

[illegible]ination of the plant site and private properties adjacent to and in the vicinity of that site, including the Middlesex Landfill.

In 1967, the AEC conducted a decontamination effort at the plant site and subsequently excessed the property to the General Services Administration for unlicensed and unrestricted use. It was later transferred to the U.S. Navy and is currently used as a Marine Corps Training Center. The radiological condition existing during the 1967 survey of the Sampling Plant was not documented by the AEC nor is there any record of decontamination efforts on the private property adjacent to the plant site. In 1976, the plant site and surrounding private properties including the Landfill were surveyed by AEC's operational successor--the Energy Research and Development Administration (ERDA)[2]--and were found to be radioactively contaminated. The DOE assumed the responsibilities of ERDA on October 1, 1977[3]. In conducting the sampling operations on its property the AEC had the responsibility in accordance with sections (2)(d) and (e) of the Atomic Energy Act of 1954, as amended, to assure that the public health and safety would be adequately protected. This responsibility was recognized by the AEC when it undertook to decontaminate the plant site in connection with its cessation of operations at the Plant and its excessing the property to GSA to be disposed of for unrestricted use.

Consequently, it would follow that the Department of Energy (which had succeeded to all of the responsibilities and functions of the Atomic Energy Commission) has the implied authority under sections 2(d), 2(e), 66 and 91(a)(2) of the Atomic Energy Act of 1954, as amended, to decontaminate the Plant site and surrounding areas including the Landfill and to acquire source material from the Landfill if such actions are needed to protect public health and safety from potentially injurious radioactive contamination caused by its predecessor agency's operation of the sampling facility, and disposal of low-level residual source material at the Landfill.

The Assistant Secretary for Environment has confirmed that the Landfill site contains residual radioactive material derived from the Middlesex Sampling Plant and that remedial action would be required in order to protect public health and safety. Should the low-level source material buried on the site be exposed due to erosion or excavation or migrate off-site, or should buildings or other structures be constructed on the site, Middlesex residents could be subjected to a health risk. The Borough of Middlesex has expressed a desire to develop the property for low income public housing. Remedial action would be required before any such development would take place.

[2]Section 104 of the Energy Reorganization Act of 1974 abolished the AEC and transferred to ERDA all functions and responsibilities not specifically assigned to the Nuclear Regulatory Commission.

[3]Section 641 of the Department of Energy Organization Act of 1977 transferred all responsibilities of ERDA to DOE.

The Assistant Secretary for Nuclear Energy is planning to conduct a survey of the Landfill site to determine the extent of source material that would need to be removed from the Landfill in order to protect public health and safety.

A question has been raised as to whether the Borough of Middlesex might have voluntarily accepted legal responsibility for the material disposed of at the Landfill. A search for all available records has failed to uncover any documentary evidence of such an acceptance.

In order to protect DOE's legal rights in this matter, in the event such records or other evidence indicating responsibility on the part of the Borough are subsequently discovered, we suggest that any agreements between the DOE and the Borough for the undertaking of remedial action at the Landfill include at least the following provisions:

1. A provision whereby the Borough agrees to post security and to indemnify the United States from all claims, including those grounded in nuisance, negligence or strict liability, due to emissions of radiation from the site which are filed against the United States.

2. A provision releasing the United States from all responsibility to the Borough in connection with the remedial action.

3. A provision preserving DOE's rights to seek reimbursement from the Borough for any costs incurred by DOE in undertaking the remedial action.

A question has also been raised as to whether DOE, by undertaking a remedial action at the Landfill, may become responsible for hazardous non-radioactive and other solid waste disposed of there. DOE would have no authority under the Atomic Energy Act of 1954, as amended, to remove such material from the site. To protect DOE's rights in this regard (e.g., from inadvertent representations by Department programmatic personnel) we suggest that any remedial action agreement between DOE and the Borough also include estoppel and disclaimer clauses indicating that DOE's undertaking of remedial action at the Landfill is limited to the removal of residual radioactive material derived from the Sampling Plant, and does not in any way constitute an agreement by DOE to remove other wastes from the site.

Consistent with these recommendations and per the request of the Assistant Secretary for Nuclear Energy, this Office will prepare a draft Agreement between the DOE and the Borough of Middlesex for execution by the parties prior to the undertaking of a remedial action at the Landfill. A copy of this Agreement will be sent to you for your review and comment.

cc: John Gilbert, NE
William E. Mott, EM

Department of Energy
Washington, D.C. 20585

JUL 19 1978

Doc: E. Fygi, GC
H. Yohalem, GC
C. Mathews, GC
B. Brown, GC
T. Miller, GC
S. Faulkner, GC
W. Mott, EV
R. Ramsay, EV
R. Allen, EV

MEMORANDUM

TO: DALE D. MYERS

FROM: LYNN R. COLEMAN s/ LYNN R. COLEMAN

SUBJECT: LEGAL OPINION - AUTHORITY TO DECONTAMINATE MIDDLESEX SAMPLING PLANT SITE AND ADJACENT PRIVATE PROPERTIES

You have asked for an opinion of this Office as to whether the Department of Energy (DOE) has authority to decontaminate the site of a former government-owned sampling plant at Middlesex, New Jersey, and private properties adjacent to that site--all of which were radioactively contaminated as a result of past government actions at the site.

It is the opinion of this Office that DOE has the requisite authority to decontaminate the plant site and adjacent private properties.

As I understand it, a sampling plant was built in 1942 on government-owned land by the Manhattan Engineer District (MED) of the War Department to sample pitchblende ores purchased from foreign sources as part of the national defense effort. In 1946, MED was abolished and its functions were transferred to the Atomic Energy Commission (AEC)[1] which continued to operate the sampling plant until 1967 under authority of section 5(b)(5) and 6(a)(2) of the Atomic Energy Act of 1946, as amended, and sections 66 and 91(a)(2) of the Atomic Energy Act of 1954, as amended. The sampling plant operations resulted in extensive radioactive contamination of the plant site and private property adjacent to that site.

[1]Executive Order 9816 of December 31, 1946 (46 F.R. 22112) transferred the Middlesex sampling plant to AEC.

In 1967, the AEC conducted a decontamination effort at the plant site and subsequently excessed the property to the General Services Administration for unlicensed and unrestricted use. It was later transferred to the U.S. Navy and is currently used as a Marine Corps Training Center. The radiological condition existing during the 1967 survey of the sampling plant was not documented by the AEC nor is there any record of decontamination efforts on the private property adjacent to the plant site. In 1976, the plant site and surrounding private properties were surveyed by AEC's operational successor--the Energy Research and Development Administration (ERDA)[2]--and were found to be radioactively contaminated. The DOE assumed the responsibilities of ERDA on October 1, 1977[3]

In conducting the sampling operations on its property, the AEC had the responsibility in accordance with sections 2(d) and (c) of the Atomic Energy Act of 1954, as amended, to assure that the public health and safety would be adequately protected. Likewise, when the AEC ceased operations at the plant and excessed the property to GSA to be disposed of for unrestricted use, the AEC had an obligation to assure that such actions would not endanger the public health and safety. This responsibility was recognized by the AEC when it undertook to decontaminate the plant site prior to its release to GSA. However, the AEC failed to fulfill its responsibility and released the plant in a contaminated condition that has been shown to be potentially injurious to the public health and safety at the plant site as well as at adjacent private property. Consequently, it would appear to follow that DOE has the implied authority under sections 66 and 91(a)(2) of the Atomic Energy Act of 1954, as amended, to decontaminate the plant site and surrounding areas to protect the public health and safety from radioactive contamination caused by its predecessor agency's operation of the sampling facility.

cc: J. L. Liverman, EV

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[2]Section 104 of the Energy Reorganization Act of 1974 abolished the AEC and transferred to ERDA all functions and responsibiliti not specifically assigned to the Nuclear Regulatory Commission.

[3]Section 641 of the Department of Energy Organization Act of 1977 transferred all responsibilities of ERDA to DOE..

Exhibit II (3) - Radiological Characterization Report

The document listed below addresses the pre-remedial action status of the two subject properties; it is included in this exhibit.


| | Page |
|---|---|
| Oak Ridge National Laboratory. Radiological Survey of the Middlesex Municipal Landfill Site, Middlesex, New Jersey, DOE/EV-0005/20, Oak Ridge, TN, April 1980. | II-55 |

# Formerly Utilized MED/AEC Sites Remedial Action Program

## Radiological Survey of the Middlesex Municipal Landfill, Middlesex, New Jersey

**April 1980**

**Final Report**

Prepared for

**U.S. Department of Energy**
Assistant Secretary for Environment
Office of Environmental Compliance and Overview
Division of Environmental Control Technology

NOTE: The remedial action guidelines contained in Appendix IV to this report have been superseded by those contained in Appendix A to Exhibit I of the certification docket.

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# PREFACE

This series of reports results from a program initiated in 1974 by the Atomic Energy Commission (AEC) for determination of the condition of sites formerly utilized by the Manhattan Engineer District (MED) and the AEC for work involving the handling of radioactive materials. Since the early 1940's, the control of over 100 sites that were no longer required for nuclear programs has been returned to private industry or the public for unrestricted use. A search of MED and AEC records indicated that for some of these sites, documentation was insufficient to determine whether or not the decontamination work done at the time nuclear activities ceased is adequate by current guidelines.

This report contains the results of a survey of the current radiological condition of the Middlesex Municipal Landfill, Middlesex, New Jersey. Based upon the findings of the survey, there are low levels of radioactivity at various locations at this site and some type of remedial measures should be considered to preclude any future concern of inadvertent radiation exposure to people.

The work reported in this document was conducted by the following members of the Health and Safety Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee:

| | | |
|---|---|---|
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# RADIOLOGICAL SURVEY OF THE MIDDLESEX MUNICIPAL LANDFILL, MIDDLESEX, NEW JERSEY*

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## ABSTRACT

A radiological survey was conducted at the Middlesex Municipal Landfill in Middlesex, New Jersey. In 1948, dirt contaminated with pitchblende ores was brought to this site from a former ore sampling plant in Middlesex. This survey was conducted in order to characterize the present radiological condition of the site and to determine the extent to which contamination is being transported from the site by natural means such as by drainage. The survey included measurement of (1) radionuclide concentrations in surface and subsurface soil on the site; (2) radionuclide concentrations in surface and subsurface water on the site and in Bound Brook; (3) beta-gamma dose rates and external gamma radiation levels on and near the site; and (4) the rate of $^{222}Rn$ emanation from the soil on the site.

It was found that most of the contamination on the site is in the top 14 ft of soil; however, there is little contamination of surface soil on the site. Average radon emanation rates, average external gamma radiation levels, and average beta-gamma dose rates on the site do not appear to be significantly higher than background levels. Furthermore, radionuclide concentrations in water taken from Bound Brook near the site were far below guide values stated in federal guidelines.

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*Research sponsored by the Division of Environmental Control Technology, U.S. Department of Energy, under contract W-7405-eng-26 with the Union Carbide Corporation.

# SECTION I

# 1978 RADIOLOGICAL SURVEY OF THE MIDDLESEX MUNICIPAL LANDFILL

## INTRODUCTION

At the request of the Department of Energy (DOE), a radiological survey was conducted at the Middlesex Municipal Landfill in Middlesex, New Jersey. The surveyed area included the outdoor region shown in Fig. 1, as well as points located along Bound Brook both upstream and downstream from this region.

During the 1940s, a poorly drained field on the grounds of the Middlesex Sampling Plant had been used as an ore storage area. Drums and ore containers were stored on this open ground. Occasionally, handling and transfer operations would result in spillage of small amounts of ore. Consequently, this area became contaminated by small pieces of pitchblende interspersed with the muddy soil. Recovery of this small amount of ore was not feasible under the conditions that existed.

In 1948, the Atomic Energy Commission (AEC) decided that this storage area should be paved. The area was graded smooth prior to black topping. The excess soil from the grading operation was transported to the Middlesex Municipal Landfill. This soil, contaminated by previous ore spillage, was dispersed over approximately 5 acres of the landfill and was used as fill or cover material for sanitary landfill operations.

In 1960, elevated gamma radiation levels were detected on this site by civil defense monitors during a local civil defense exercise. A radiological survey of the site was made at that time by the AEC, and it was found that external gamma radiation levels over an area of approximately 1/2 acre were 20 to 50 times the background levels found in the surrounding area. The elevated gamma radiation could be directly attributed to contamination in the soil transported from the Sampling Plant. After discussions with Borough of Middlesex officials, the AEC removed approximately 650 $yd^3$ of the contaminated material nearest the surface and covered the area with about 2 ft of uncontaminated dirt. This action reportedly lowered the external gamma radiation levels to no

more than 50 μR/hr. The contaminated material was redeposited at an AEC-owned site in New Brunswick, New Jersey.

In 1963, a parcel of approximately 5 acres of the landfill site (originally owned by the Borough of Middlesex) was sold to the Middlesex Presbyterian Church; a church was subsequently constructed on that parcel. It was determined from discussions with local people that both the church and the Middlesex Municipal Building were constructed on "nonfill" or solid ground. This fact was confirmed during a survey of the landfill by the AEC in 1974 (results of this 1974 survey are presented in Section II of this report). The landfill site is surrounded by residences which approach to within 1/4 mile to the south and west and to the edge of Bound Brook on the eastern and northern edges. Results of the 1974 AEC survey indicate that contamination remaining on the property was in an area (See Fig. 1) of approximately 3 acres centered 400 ft northeast of the church.

The present radiological survey was conducted during June, 1978, by members of the Health and Safety Research Division of the Oak Ridge National Laboratory (ORNL). The survey was designed to provide additional data needed to supplement the 1974 survey and to provide a basis for comparison between site conditions in 1974 and the present. The survey included the following measurements: (1) beta-gamma dose rates at 1 cm from the surface and external gamma radiation levels at the surface and at 1 m above the surface throughout the site; (2) concentrations of $^{226}Ra$ and $^{238}U$ in surface and subsurface soil on the site; (3) concentrations of $^{226}Ra$, $^{238}U$, $^{230}Th$, and $^{210}Pb$ in surface and groundwater on the site and in Bound Brook; (4) gamma radiation levels at various depths in auger holes drilled on the site as a means of estimating the $^{226}Ra$ concentrations at these locations; and (5) rate of emanation of $^{222}Rn$ from the ground surface.

# SURVEY METHODS

## Instrumentation

### Measurement of Beta-Gamma Dose Rates and External Gamma Radiation Levels

Beta-gamma dose rates were measured with Geiger-Mueller (G-M) survey meters described in Appendix I. The meters were calibrated at ORNL using sealed isotopic sources and by comparison with a Victoreen Model 440 portable ionization chamber. It was determined that, for surfaces contaminated with $^{226}Ra$ in approximate equilibrium with $^{238}U$ and other radionuclides in the $^{238}U$ chain, an open-window reading of 2000 cpm is equivalent to approximately 1 mrad/hr.

Beta radiation cannot penetrate the closed window on the G-M probe; hence, only gamma radiation levels can be measured with the window closed. A significant difference in the open-window and closed-window readings on the G-M survey meter at some point indicates the presence of beta-emitting surface contamination, since most beta particles can penetrate only a few millimeters of dense materials such as soil.

External gamma radiation levels were measured with closed-window G-M survey meters, with the NaI scintillation meters described in Appendix I, and with the Phil gamma-ray dosimeter.[1] The scintillation detectors were standardized daily on the site through the use of sealed isotopic sources. The observed meter responses were standardized by comparison with the closed-window G-M survey meters at gamma radiation levels high enough that the rate meters on the instruments could be read accurately.

## Methods Used to Analyze Samples

Samples of soil collected on the site were packed in plastic bags and returned to ORNL, where they were dried for 24 hr at 110°C and then pulverized to a particle size no greater than 500 μm diam (35 mesh). Next, aliquots from each sample were transferred to plastic bottles, weighed, and counted using a Ge(Li) detection system to obtain the $^{226}Ra$ concentration. This system is coupled with a multichannel analyzer,

which sorts pulses corresponding to different gamma-ray energies. The $^{226}Ra$ concentration is obtained through the use of a computer program which integrates under photon peaks corresponding to 352, 609, 1120, and 1764 keV; these are gamma-ray energies associated with daughters of $^{226}Ra$. Because these photopeaks are used, counting is normally done about 30 days after grinding to allow equilibration of radon with $^{226}Ra$. These estimates of $^{226}Ra$ concentrations are presented in this report. A description of the Ge(Li) detector and soil counting techniques is given in Appendix II.

A measurement of the $^{238}U$ concentration in each sample was obtained by neutron absorption analysis techniques.[2]

Water and sediment samples collected on and near the site were analyzed by the Analytical Chemistry Division of ORNL for $^{210}Pb$, $^{226}Ra$, and $^{230}Th$, using techniques described in Appendices to the ORNL Master Manual. The samples were analyzed for $^{238}U$ using the neutron absorption techniques previously mentioned.[2] The activity reported for each radionuclide (except $^{238}U$) in the water sediment samples represents only that percentage of the activity (normally between 50 and 100%) available by hot $HNO_3$ leaching.

All direct survey meter readings reported in this document represent gross readings; background radiation levels have not been subtracted. Similarly, background levels have not been subtracted from radionuclide concentrations measured in environmental samples.

## Survey Procedures

An area considered large enough to encompass all of the radioactive material on the site was divided into 100 ft x 100 ft "survey blocks" by the rectangular grid system shown in Fig. 1. Next, the area was subdivided into 50 ft x 50 ft survey blocks by dividing each 100 ft x 100 ft survey block in this area into four equal parts. At each grid point (i.e., at the intersection of mutually perpendicular grid lines) open- and closed-window G-M survey meter readings were taken at 1 cm from the surface, and a gamma scintillation survey meter reading was taken at 1 m above the surface. Then, each survey block in the area of suspected

contamination was scanned with a gamma scintillation survey meter held near the surface. The maximum observed gamma radiation level in the block was recorded; and at the maximum gamma point, open- and closed-window G-M measurements were taken at 1 cm from the surface.

Holes were drilled with a motorized rig equipped with an 8-in.-diam auger, usually to depths of 10 to 20 ft., at the locations shown in Fig. 2. (Holes 1 through 9 were drilled and tested by ORNL in February, 1978, in conjunction with an engineering assessment of the site made by Ford, Bacon and Davis Utah.) A plastic pipe with a 4-in. inside diam 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 narrow collimating slot on the side. This arrangement allowed measurements of gamma radiation intensities resulting from contamination within small fractions of the hole depth. Measurements were usually made at 6-in. or 1-ft intervals. This "logging" of the core holes was done in order to define the profile of radioactivity underground and as a first step in determining the extent of subsurface contamination at each location. Moreover, the loggings were used to estimate the $^{226}$Ra concentration in contaminated regions. The procedure used for these estimates is described in Appendix III. For each hole showing elevated gamma levels, a sample of the potentially contaminated material brought up by the auger was collected for analysis of $^{226}$Ra and $^{238}$U.

The results of auger hole loggings were used to select locations where further soil sampling would be useful. At points as close as practical to selected auger holes, a split-spoon sampler was used to collect soil at intervals of 6 in. throughout the contaminated zone. The concentrations of $^{226}$Ra and $^{238}$U were determined for these samples.

Surface samples were collected at the locations shown in Fig. 3. Most of the surface sampling locations (as well as the drilling locations) were chosen to provide random and representative sampling. However, those locations labeled "B" in Fig. 3 are "biased" in that they were chosen for sampling because of high radiation levels at these points.

Water samples were taken from each auger hole in which water was found. In addition, water samples were taken from Bound Brook at the

locations described in Table 1. Most samples were analyzed for $^{226}Ra$, $^{238}U$, $^{230}Th$, and $^{210}Pb$.

### Measurement of the Flux of $^{222}Rn$

Since activated charcoal readily adsorbs $^{222}Rn$, an estimate of the radon flux from ground surfaces was obtained by placing canisters containing charcoal in direct contact with the ground (see Ref. 3). After a period of exposure which ranged from 1 to 2 days, the canisters were removed, and the radon daughters were allowed to achieve equilibrium. The amount of radon adsorbed on the activated charcoal canister was determined by counting the gamma emissions from $^{214}Pb$ and $^{214}Bi$ using a 3 x 3-in. NaI scintillation detector coupled to a multichannel pulse height analyzer.

The canisters were distributed uniformly over the site. These modified U.S. Army M-11 gas mask canisters were twisted into the soil to a depth of 1 cm and sealed with additional soil. A total of 41 canisters was used (see Fig. 4). These individual readings were then used to estimate the average rate of emanation of $^{222}Rn$ over the entire site.

## SURVEY RESULTS

### Background Measurements

Background external gamma radiation levels at 1 m above the ground in the Middlesex vicinity range from 5 to 10 μR/hr; the average rate is 8 μR/hr. Concentrations of $^{226}Ra$ and $^{238}U$ in background soil in the Middlesex area are typically near 1 pCi/g. Background beta-gamma dose rates, as measured with the G-M survey meters used on the site, average approximately 0.01 or 0.02 mrad/hr.

### Measurement of Beta-Gamma Dose Rates and External Gamma Radiation Levels

Grid point measurements of gamma radiation levels at 1 m are shown in Fig. 5. The value shown in each 100 x 100-ft survey block is the average of nine measurements taken at points uniformly spaced over the

block. This same reporting scheme is used in Fig. 6, which shows the average measurements of the beta-gamma dose rate at 1 cm from the ground. It appears from these results that the area designated by the 1974 AEC survey as containing the bulk of the contamination did not display average radiation exposures which are significantly higher than the rest of the landfill site. However, there are isolated spots in this area which do show elevated levels of radiation exposure. The results of a scan of the area thought to be contaminated are shown in Fig. 7. Highly elevated readings were obtained in only three of the 50 ft x 50 ft survey blocks. The highest readings (1.1 mR/hr gamma ray only and 7.3 mrad/hr beta plus gamma ray) were taken directly on the surface and were associated with a small rock which was subsequently removed from the soil and returned to ORNL for analysis. Removal of this rock resulted in only a slight reduction in the gamma-ray exposure rate at the surface.

It should be emphasized that this radiation profile reflects only average external gamma radiation levels at 1 m and should not be interpreted as showing point-by-point radiation levels. It should also be pointed out that since the highest background external gamma radiation level measured in the vicinity of the site was 10 μR/hr, all measurements of 10 μR/hr and below should not be used to indicate contamination. As may be noted from Fig. 5, all survey blocks had average gamma radiation levels less than 10 μR/hr. Thus, the data indicate that the site has an average external gamma exposure rate which cannot be distinguished from the background level.

Only one area had external gamma radiation levels which exceeded the limits of background. This area of approximately 500 $ft^2$, located near grid point 4+0, 200R, shows an average external gamma exposure level at 1 m of 30 μR/hr.

According to Nuclear Regulatory Commission (NRC) guidelines given in Appendix IV for the release of property for unrestricted use, average and maximum beta-gamma dose rates measured at 1 cm should not exceed 0.2 mrad/hr and 1.0 mrad/hr, respectively. Only one reading on the site, in the general area of the maximum external gamma area mentioned above, exceeded this NRC limit. This elevated beta-gamma reading was

associated with the previously mentioned rock which was removed for analysis. All other beta-gamma readings obtained on site were below NRC guidelines.

## Results of Surface Soil Sample Analyses

Surface soil samples were collected at various points throughout the site. As discussed earlier, most sampling locations were chosen according to a scheme devised to provide random, unbiased sampling. Those samples which were taken at spots chosen because of high radiation levels are "biased" and are labeled with a "B" in Table 2. Concentrations of $^{226}Ra$ and $^{238}U$ in random surface samples are also listed in Table 2. Radium-226 concentrations in these random samples ranged up to 1.8 pCi/g, and $^{238}U$ concentrations ranged up to 2.3 pCi/g. The average concentration of $^{226}Ra$ and $^{238}U$ for all random surface samples was less than 1.0 pCi/g and 1.22 pCi/g, respectively. These values may be considered to be "background." The biased sample taken at location B2 (Fig. 3) showed a $^{226}Ra$ concentration of 150 pCi/g; this location coincided with the maximum observed gamma and beta-gamma radiation levels mentioned above. A small rock taken at location B4B (Fig. 3) a few inches beneath the surface showed a $^{238}U$ concentration of 1100 pCi/g.

## Results of Subsurface Soil Sample Analyses

Holes were augered to depths of up to 25 ft at the locations shown in Fig. 2. At most of these locations, the material brought up by the auger was probed with an open-window G-M survey meter, and a sample of material showing elevated readings (or a sample taken at random, if no elevated readings were observed) was taken for analysis of $^{226}Ra$ and $^{238}U$. The concentrations of these radionuclides in the "grab" samples are shown in Table 3.

At locations 12, 17, and 29, holes were "cored" rather than "augered." That is, a split-spoon sampler was used to collect subsurface samples at known depths. Concentrations of $^{226}Ra$ and $^{238}U$ in these core samples are shown in Table 3, along with results for "composite" samples (those for which the depth was not determined). It was impossible to take

samples at certain depths due to the presence of buried tires, rags, and other rubbish.

Each of the auger holes and core holes was logged with a gamma scintillation probe as described in the section "Survey Methods." By comparison of the subsurface gamma radiation levels and the $^{226}Ra$ concentrations at the core hole locations, a procedure for estimating $^{226}Ra$ concentrations in subsurface soil from auger hole "loggings" was developed (see Appendix III). Estimates concerning the extent of the contaminated soil, as determined by the auger hole logging, are given in Table 4.

The general region in which the bulk of the subsurface contamination was found agrees with the region designated by the AEC report as containing the bulk of the contamination. This region is indicated in Fig. 8, along with a larger region where there is some scattered subsurface contamination or low-level contamination possibly due to leaching of radioactive materials. While the contaminated material appears to be very nonuniformly distributed, some generalizations concerning the extent of the contaminated material are indicated in Fig. 9.

## Results of Radon Emanation Study

The rate of emanation of $^{222}Rn$ was measured by the technique described in the section "Survey Methods." Canister locations and results of radon emanation measurements are indicated in Fig. 4. It may be seen from these results that the average rate of emanation for the landfill site is approximately 0.23 pCi/m$^2$ per sec. The highest values were located in the area that has been designated in previous sections as containing the bulk of the contamination. In addition, some higher-than-average readings were obtained near the banks of the former path of Bound Brook. The rate at which $^{222}Rn$ emanates from soils containing background concentrations of $^{226}Ra$ has been measured by other investigators, and these values may be compared with the average rate found here. Wilkening[4] found $^{222}Rn$ emanation rates which averaged 0.42 pCi/m$^2$ per sec. Furthermore, background radon flux measurements previously taken in the Middlesex area[5] averaged 0.45 pCi/m$^2$ per sec. Thus, radon emanation from the landfill is less than the average rate found at background locations in the Middlesex area.

## Radon and Radon Daughters

The results of the radon emanation studies at this site were used to estimate the probable maximum concentration of radon and radon daughters in air on the site. It is estimated that the maximum $^{222}Rn$ concentration at the site is less than 0.01 pCi/liter above the background concentration in the Middlesex area. This estimate employs an empirical relation developed by Schiager[6] and assumes conservative meteorological conditions. Furthermore, the radon concentration measured[7] on the roof of the Middlesex Municipal Building averaged 0.04 pCi/liter. The average concentration measured at two other Middlesex locations which could be considered as background was 0.06 pCi/liter.[7] It may be stated that the concentration of $^{222}Rn$ resulting from contamination at the site is indistinguishable from background.

The concentration of short-lived $^{222}Rn$ daughters is estimated to be less than 0.0001 working level.* The average radon daughter concentration measured in the parking lot of the Middlesex Municipal Building[7] was less than 0.001 working level. This may be compared with the average radon daughter concentration in the Middlesex area, which is typically 0.002 working level.[5]

## Results of Water Sample Analyses

Concentrations of $^{210}Pb$, $^{230}Th$, $^{226}Ra$, and $^{238}U$ in water samples taken from streams near the site that receive water from the site (directly or indirectly) are given in Table 1. In all cases, concentrations of these radionuclides were well below the concentration guides for water ($RCG_w$) stated in 10 CFR 20, Appendix B.[8] These radionuclide concentrations appear to be reasonably typical of background values.

Samples of groundwater which was encountered in drilling were taken from 11 holes. The results of analyses are found in Table 5. It may be noted that no sample had $^{226}Ra$ or $^{238}U$ concentrations which exceeded the concentration guides of 10 CFR 20.[8] The low concentrations of these

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*A working level is defined as 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 alpha particle energy.

radionuclides indicate that leaching into groundwater and subsequent migration may not be very extensive at this site.

## SUMMARY

In 1948, dirt contaminated with pitchblende ore was dumped on this site. A combination of analysis of subsurface soil samples and gamma scintillation probe "loggings" of 18 holes augered on this site to depths of 25 ft reveal the general location of the bulk of this contamination (see Figs. 8 and 9). Most of the contamination is in the top 14 ft of soil in an area covering 400 x 300 ft in the center of the site. There is little contamination in the surface soil. Average radon emanation rates, average external gamma radiation levels, and average beta-gamma dose rates do not appear to be significantly different from background levels. There may be some leaching of subsurface contaminants toward Bound Brook (see Fig. 8 and 9). However, available data indicate that the amount of leached material is very small at present. Furthermore, the spread of scattered activity into these areas may be attributable to previous landfill operations. Concentrations of $^{210}Pb$, $^{230}Th$, $^{226}Ra$, and $^{238}U$ in water samples taken from Bound Brook near the site were far below guide values stated in 10 CFR 20, Appendix B, and were within the normal range of background concentrations.

An evaluation has been made of current radiation exposures at the Middlesex Municipal Landfill and is presented in Appendix V (page 67) of this report. The purpose of this evaluation is to present information which will permit the reader to compare current radiation exposures from the site to normal background exposures for that part of New Jersey, as well as to scientifically based guideline values established for the protection of radiation workers and members of the general public.

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8. Code of Federal Regulations, Title 10, Part 20.2, "Standards for Protection Against Radiation," Appendix B.

ORNL-DWG 78-20830

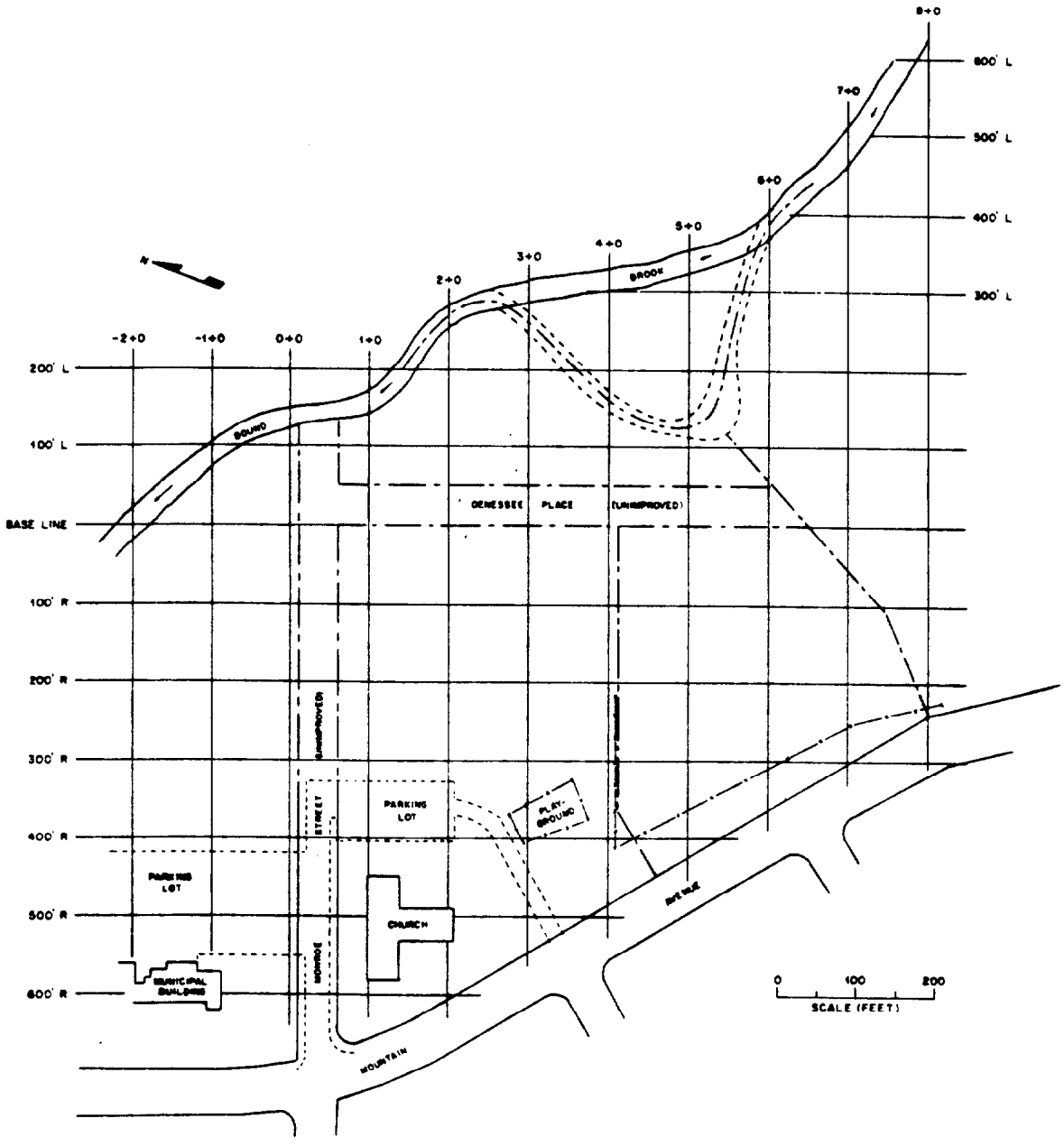


Fig. 1. Scaled drawing of surveyed area and grid systems needed for survey.

ORNL-DWG 78-20831

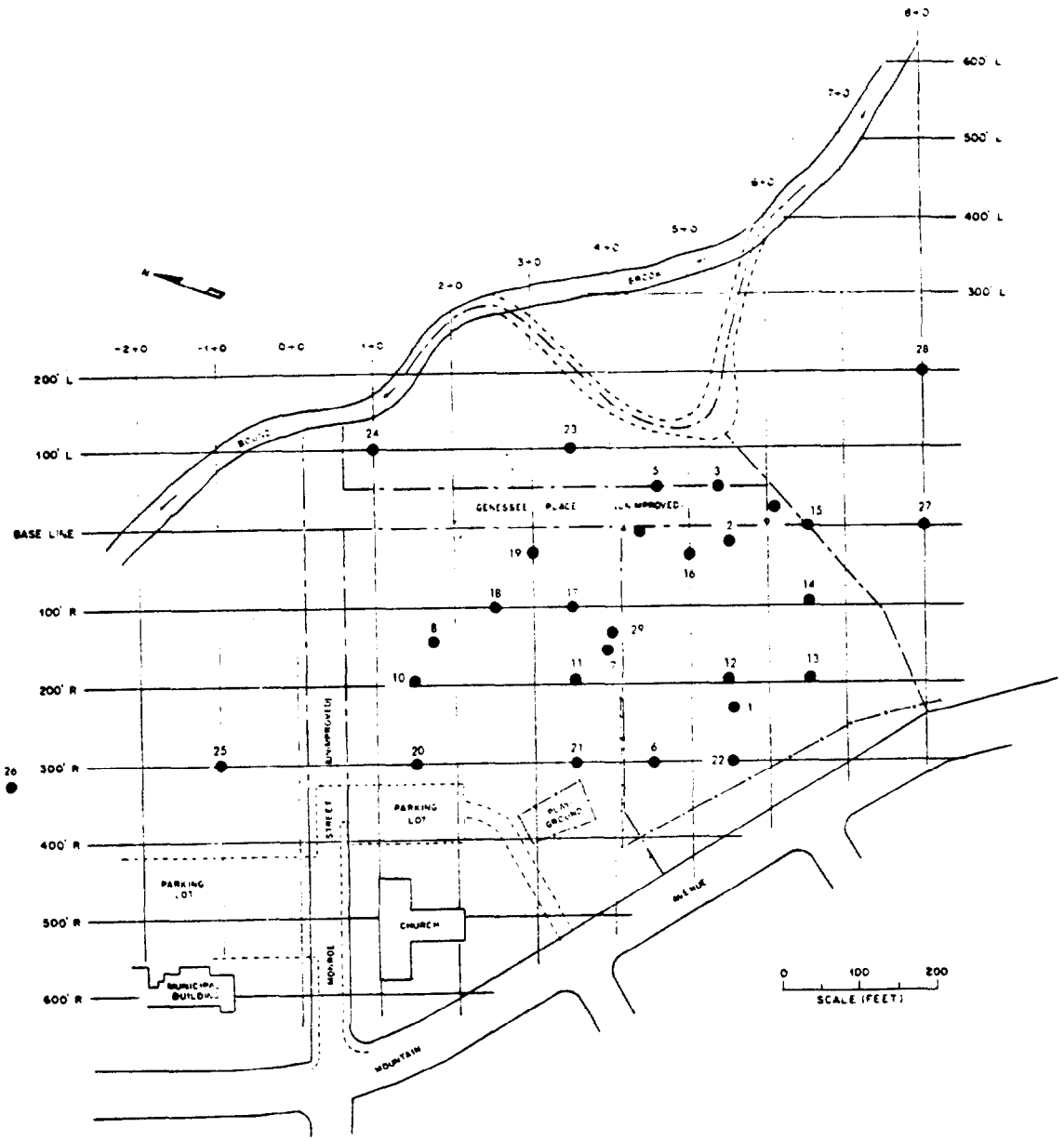


Fig. 2. Drill hole locations.

ORNL-DWG 78-20832

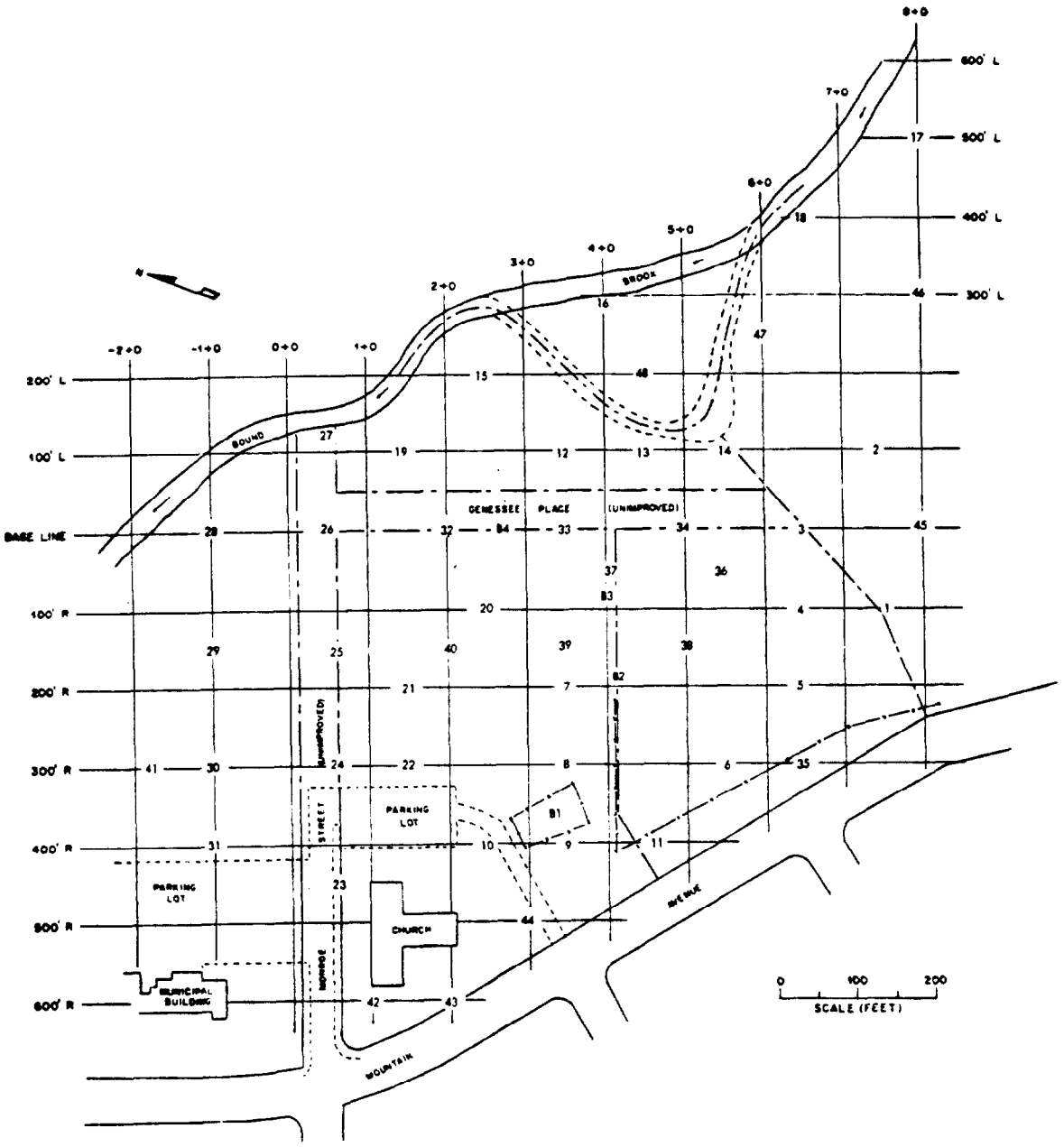


Fig. 3. Surface soil sampling locations.

ORNL-DWG 78-20833

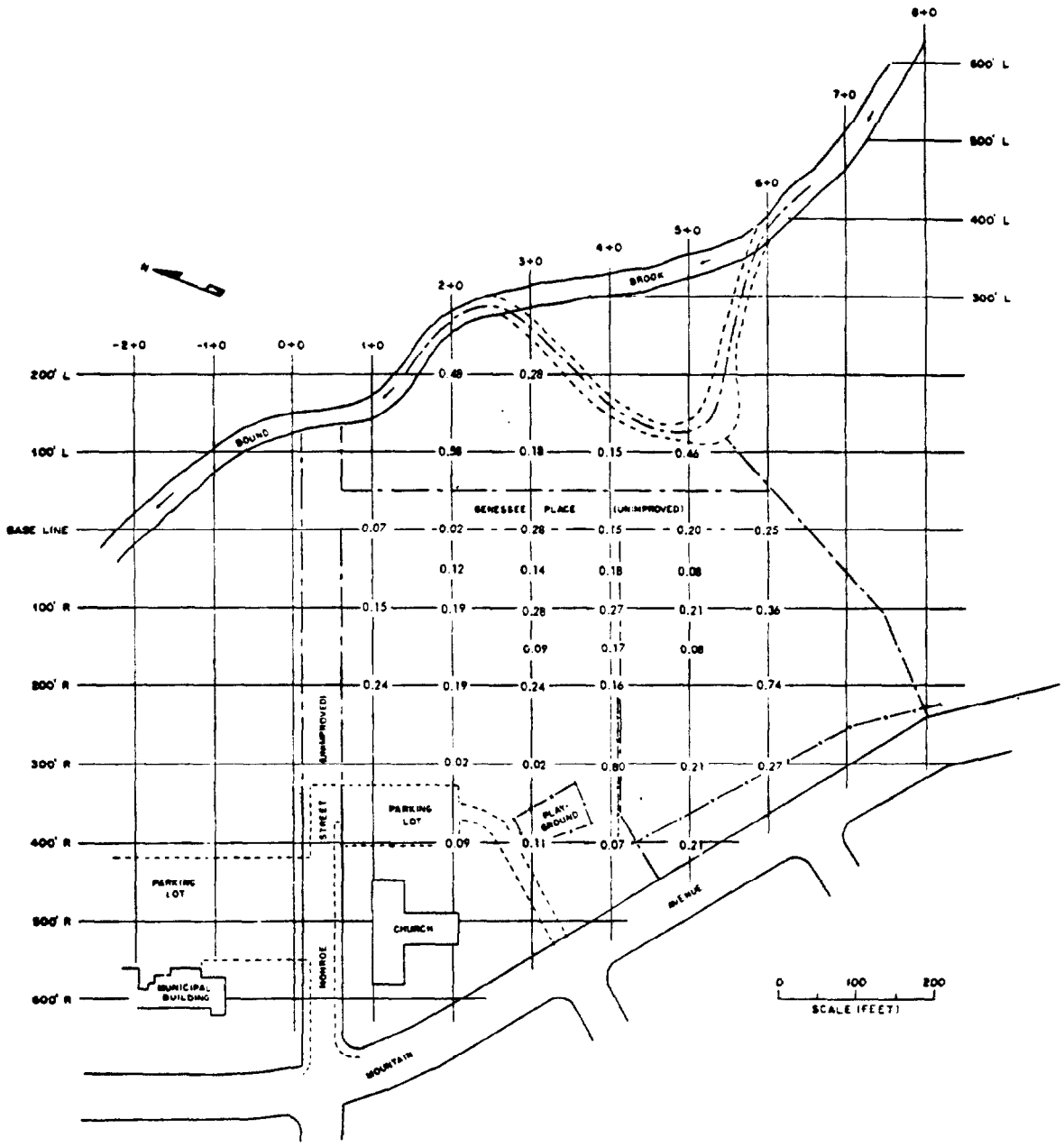


Fig. 4. Radon emanation rates (pCi/m$^2$ per sec) measured on the site.

ORNL-DWG 78-20834

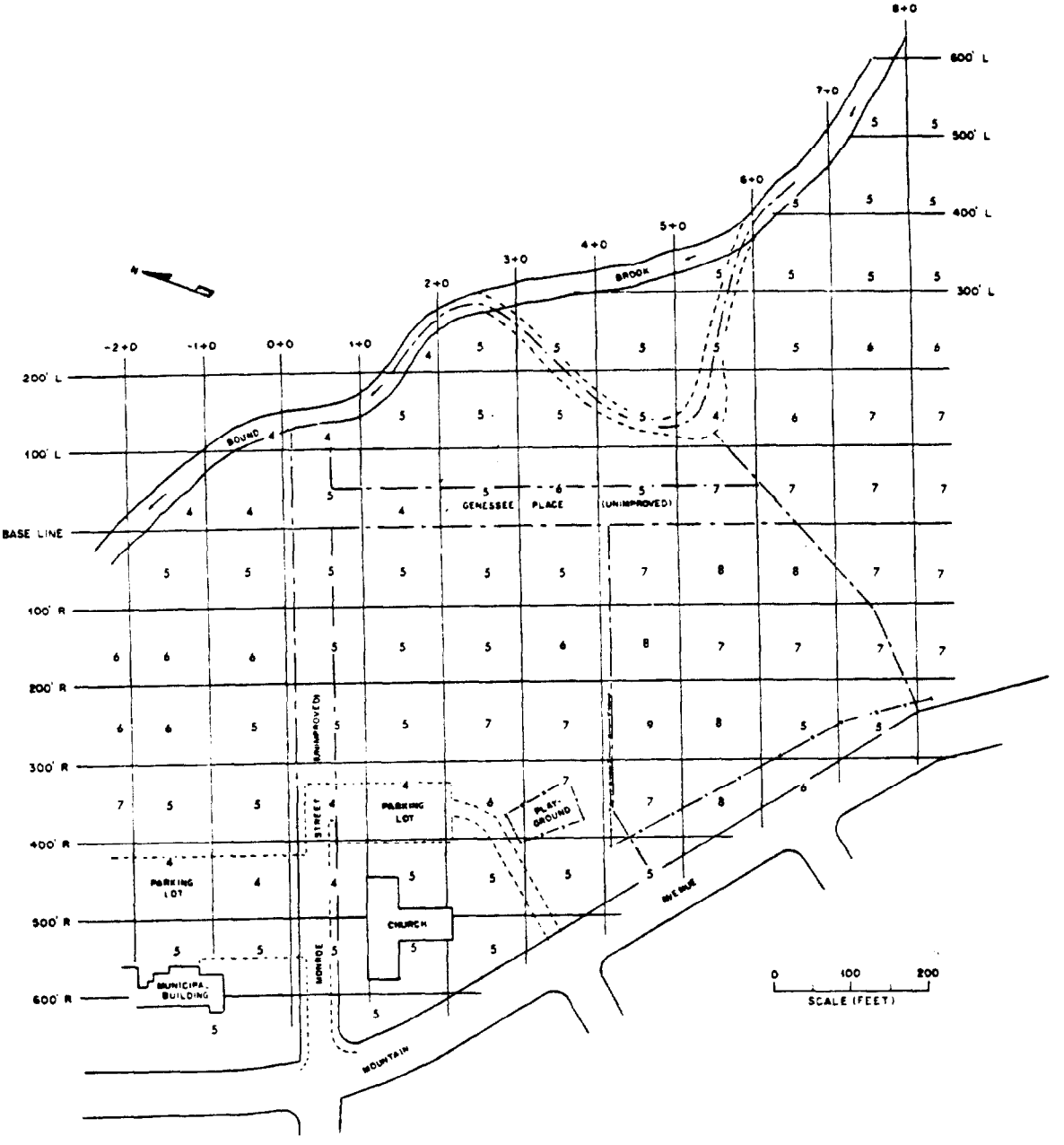


Fig. 5. Average external gamma radiation levels (μR/hr) in survey blocks.

ORNL-DWG 78-21412

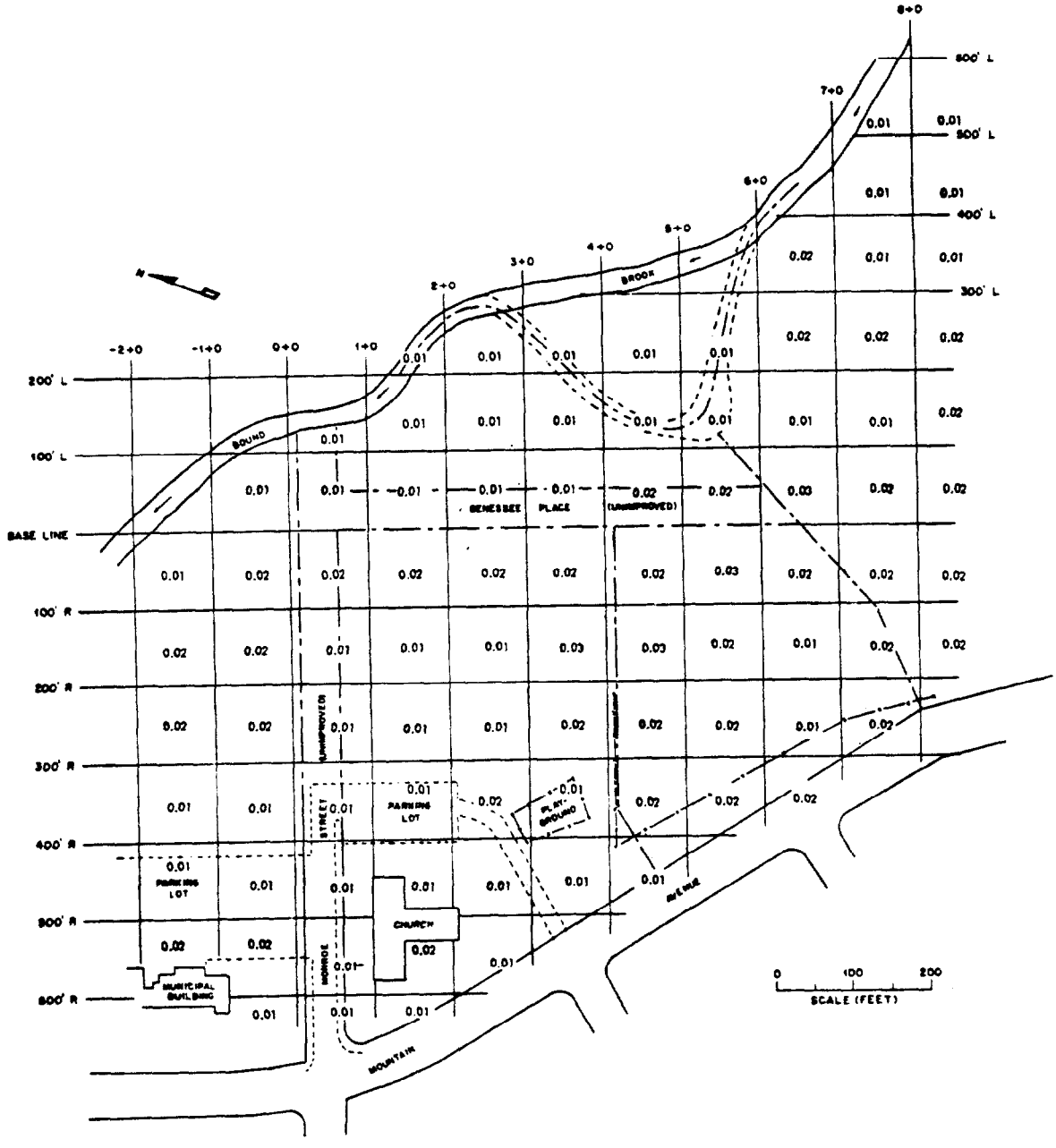


Fig. 6. Average beta-gamma dose rates (mrad/hr) at 1 cm in survey blocks.

ORNL-DWG 78-21413

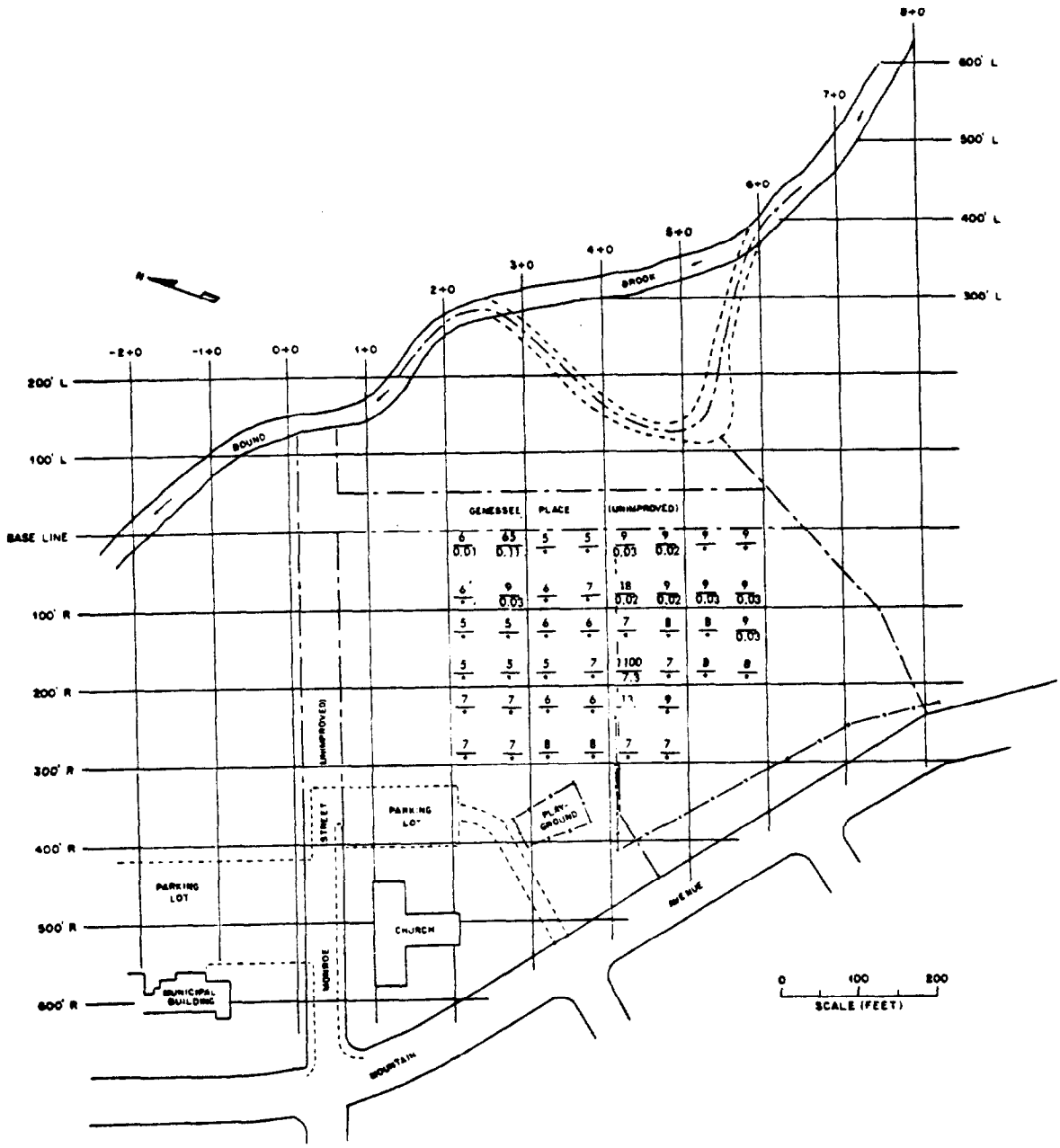


Fig. 7. Maximum measured external gamma radiation levels at surface (numerator, in μR/hr) and beta-gamma dose rate at 1 cm (denominator, in mrad/hr) in 50 ft x 50 ft survey blocks, with asterisks indicating uniform readings (see Fig. 6 for the uniform reading).

ORNL-DWG 78-21414

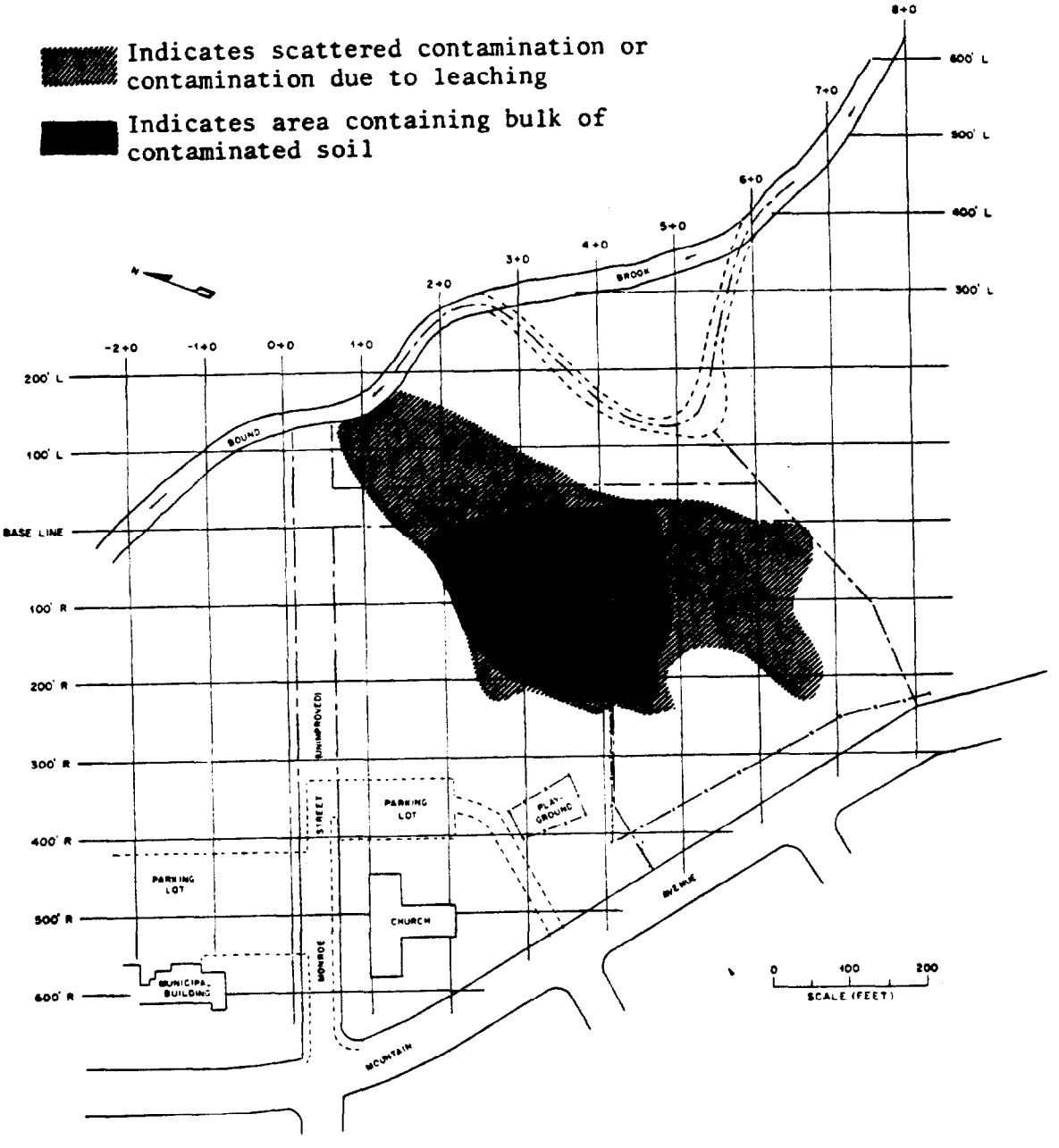


Fig. 8. Area containing contaminated soil.

ORNL-DWG 78-21415

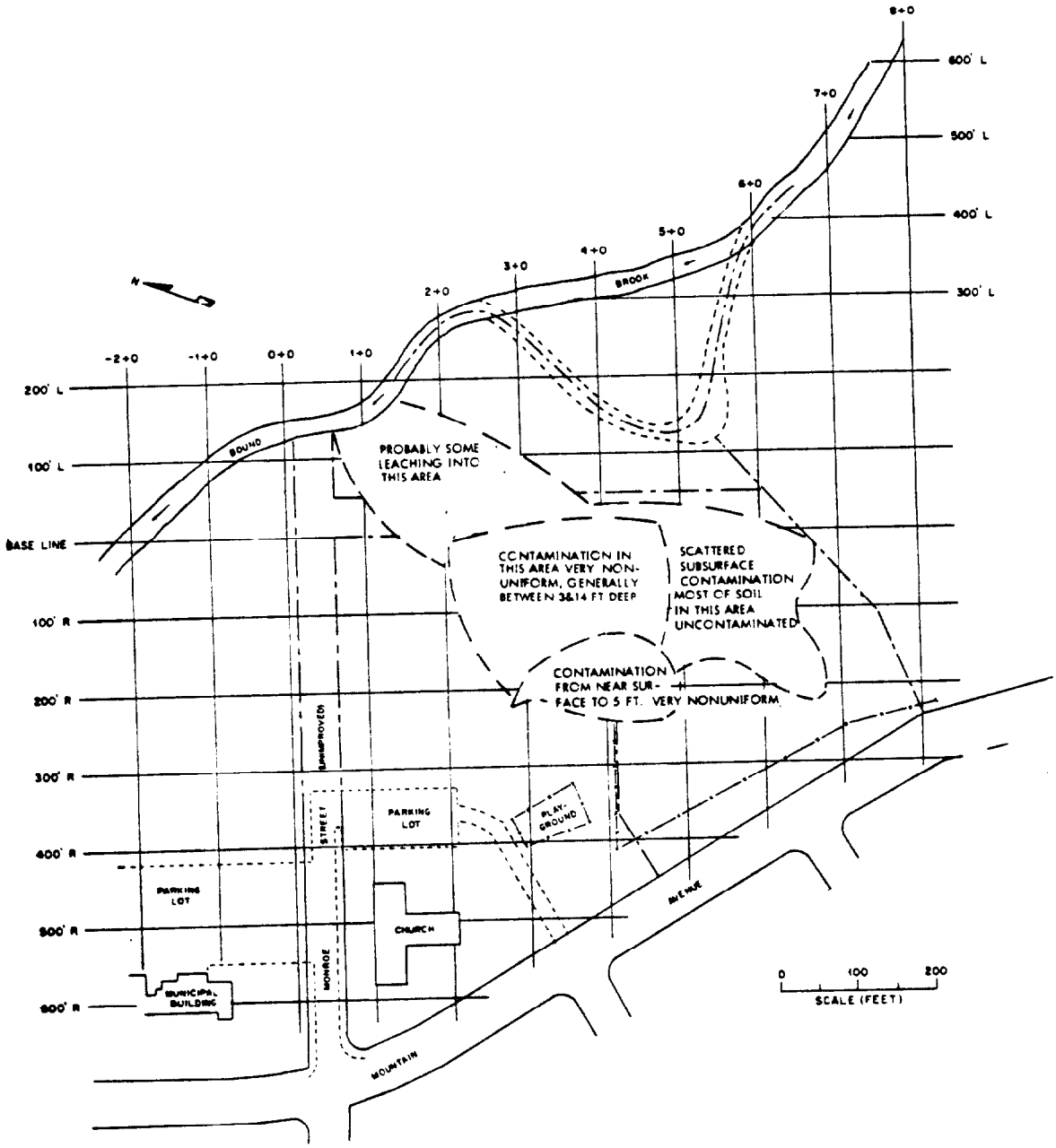


Fig. 9. Possible extent of contamination in various areas.

Table 1. Concentrations of $^{210}Pb$, $^{230}Th$, $^{226}Ra$, and $^{238}U$ (pCi/ml) in water samples from streams receiving water from site

| Sample designation | Location | $^{210}Pb$ | $^{230}Th$ | $^{226}Ra$ | $^{238}U$ |
|---|---|---|---|---|---|
| MOW20 | Ambrose Brook at Raritan Avenue | <0.005 | <0.0005 | <0.0005 | Background[a] |
| MOW21 | Bound Brook at Union Avenue | <0.003 | <0.0005 | <0.0005 | 0.002 |
| MOW22 | Bound Brook at Bound Brook Road | <0.004 | <0.0005 | <0.0005 | 0.002 |
| MOW23 | Bound Brook 450 ft downstream from grid line 0+0 (Fig. 1) | <0.003 | <0.001 | <0.0005 | 0.004 |
| MOW24 | Bound Brook at grid line -1+0 (Fig. 1) | <0.004 | <0.001 | <0.0005 | 0.017 |
| MOW25 | Bound Brook at grid line 1+0 (Fig. 1) | <0.003 | <0.0005 | <0.0005 | Background |
| MOW26 | Bound Brook at grid line 3+0 (Fig. 1) | <0.003 | <0.0005 | <0.0005 | 0.0003 |
| MOW27 | Bound Brook at grid line 5+0 (Fig. 1) | <0.003 | <0.0005 | <0.0005 | Background |
| MOW28 | Bound Brook at grid line 7+0 (Fig. 1) | <0.004 | <0.0005 | <0.0005 | 0.0005 |
| MOW29 | Bound Brook at South Lincoln Avenue | <0.004 | <0.0005 | <0.0005 | 0.003 |
| $RCG_w$ (soluble)[b] | | 0.1 | 2 | 0.03 | 40 |

[a]"Background" is less than 0.02 ppm.

[b]10 CFR 20, Appendix B.

Table 2. Concentrations of $^{226}Ra$ and $^{238}U$ (pCi/g) in surface soil samples

| Sample location shown in Fig. 3 | $^{226}Ra$ | $^{238}U$ |
|---|---|---|
| 1 | 0.9 | 1.1 |
| 2 | 1.2 | 1.4 |
| 3 | 1.0 | 1.2 |
| 4 | 0.9 | 1.2 |
| 5 | 0.2 | 0.2 |
| 6 | 0.8 | 1.1 |
| 7 | 0.7 | 0.9 |
| 8 | 0.7 | 1.6 |
| 9 | 0.9 | 0.9 |
| 10 | 0.6 | 0.6 |
| 11 | 1.1 | 1.3 |
| 12 | 1.4 | 1.1 |
| 13 | 0.8 | 1.1 |
| 14 | 0.3 | 0.4 |
| 15 | 0.7 | 1.5 |
| 16 | 1.0 | 1.7 |
| 17 | 0.9 | 1.0 |
| 18 | 0.5 | 0.9 |
| 19 | 1.0 | 1.3 |
| 20 | 0.4 | 0.6 |
| 21 | 0.9 | 0.6 |
| 22 | 0.6 | 0.7 |
| 23 | 0.7 | 0.9 |
| 24 | 1.4 | 1.8 |
| 25 | 0.8 | 1.1 |
| 26 | 1.2 | 2.3 |
| 27 | 0.5 | 0.9 |
| 28 | 0.6 | 1.0 |
| 29 | 0.6 | 0.7 |
| 30 | 0.9 | 1.3 |
| 31 | 0.5 | 0.7 |
| 32 | 0.7 | 0.9 |
| 33 | 0.4 | 0.6 |
| 34 | 1.0 | 1.2 |
| 35 | 0.7 | 0.7 |
| 36 | 0.7 | 1.0 |
| 37 | 0.6 | 0.8 |
| 38 | 0.4 | 0.5 |
| 39 | 0.9 | 1.3 |
| 40 | 0.8 | 0.7 |
| 41 | 0.8 | 1.3 |
| 42 | 0.5 | 1.2 |
| 43 | 0.6 | 0.6 |
| 44 | 0.6 | 0.4 |
| 45 | 0.7 | 1.0 |

Table 2 (cont.). Concentrations of $^{226}Ra$ and $^{238}U$ (pCi/g) in surface soil samples

| Sample location shown in Fig. 3 | $^{226}Ra$ | $^{238}U$ |
|---|---|---|
| 46 | 0.7 | 1.1 |
| 47 | 0.5 | 0.8 |
| 48 | 0.8 | 2.0 |
| B1 | 0.6 | 1.0 |
| B2 | 150 | 93 |
| B3 | 1.1 | 1.6 |
| B4A | 3.6 | 1.0 |
| B2B[a] | -- | 1100 |

[a]This sample was actually a small rock taken a few inches beneath the surface; not enough sample was present for $^{226}Ra$ determination.

Table 3. Concentrations of $^{226}Ra$ and $^{238}U$ (pCi/g) in subsurface soil on the landfill site

| Sample designation[a] | Depth (ft) | $^{226}Ra$ | $^{238}U$ |
|---|---|---|---|
| MCD1 | --[b] | 0.7 | 1.0 |
| 1A | 0 - 2.0 | 1.0 | 1.2 |
| 1C | 5.0- 7.0 | 0.8 | 0.9 |
| 1E | 10.0-12.0 | 2.9 | 3.0 |
| MCD2 | -- | 0.6 | 0.7 |
| 2A | 0 - 2.0 | 0.6 | 0.6 |
| MCD3 | -- | 1.5 | 2.0 |
| 3A | 1.0- 2.0 | 2.8 | 2.4 |
| 3B | 3.0- 5.0 | 1.0 | 2.5 |
| 3C | 5.0- 7.0 | 0.7 | 1.5 |
| 3D | 7.0- 9.0 | 0.7 | 0.7 |
| MCD4 | -- | 1.8 | 2.5 |
| MCD5 | -- | 1.1 | 2.8 |
| 5A | 9.0-11.0 | 0.4 | 0.7 |
| MCD6 | -- | 0.6 | 0.6 |
| 6A | 0 - 2.0 | 0.9 | 1.2 |
| 6C | 5.0- 6.0 | 0.8 | 0.8 |
| 6D | 6.0- 8.0 | 0.6 | 0.6 |
| 6E | 8.0-10.0 | 0.6 | 0.6 |
| 6F | 10.0-12.0 | 0.5 | 0.5 |
| 6G | 12.0-14.0 | 0.5 | 0.8 |
| MCD7 | -- | 2.7 | 3.7 |
| 7A | 0 - 2.0 | 12 | 0.7 |
| 7B | 2.0- 3.0 | 1.5 | 1.2 |
| 7C | 3.0- 4.0 | 5.5 | 5.5 |
| MCD8 | -- | 1.2 | 1.4 |
| MCD9 | -- | 0.7 | 0.9 |
| 9A | 15.0-17.0 | 0.5 | 0.9 |
| 9B | 20.0-22.0 | 1.0 | 1.0 |
| MCD10 | -- | 3.2 | 1.1 |
| MCD11 | -- | 2.2 | 2.3 |
| MCD12 | -- | 7.0 | 1.0 |
| 12A | 0 - 1.0 | 0.9 | 1.2 |
| 12B | 1.0- 2.0 | 1.0 | 1.3 |
| 12C | 2.0- 3.0 | 0.9 | 1.2 |
| 12D | 3.0- 4.0 | 0.7 | 1.0 |
| 12E | 4.0- 5.0 | 0.6 | 1.3 |
| 12F | 5.0- 6.0 | 0.6 | 0.7 |
| 12G | 6.0- 7.0 | 0.6 | 0.9 |
| 12H | 7.0- 7.5 | 0.5 | 0.7 |
| 12K | 10.0-11.0 | 0.5 | 0.8 |
| 12L | 11.0-12.0 | 0.6 | 0.7 |
| 12M | 12.0-13.0 | 0.5 | 0.6 |
| 12N | 13.0-14.0 | 0.4 | 0.5 |
| MCD13 | -- | 1.2 | 0.6 |

Table 3 (cont.). Concentrations of $^{226}Ra$ and $^{238}U$ (pCi/g) in subsurface soil on the landfill site

| Sample designation[a] | Depth (ft) | $^{226}Ra$ | $^{238}U$ |
|---|---|---|---|
| MCD14 | -- | 1.9 | 1.7 |
| MCD15 | -- | 170 | 140 |
| MCD16 | -- | 2.0 | 2.3 |
| 16A | 0 - 1.0 | 0.8 | 1.1 |
| 16B | 1.0- 2.0 | 0.8 | 1.3 |
| MCD17 | -- | 1000 | 630 |
| 17A | 0 - 1.0 | 0.6 | 0.8 |
| 17B | 1.0- 2.0 | 0.5 | 0.7 |
| 17C | 2.0- 4.0 | 1.1 | 1.4 |
| 17E | 4.0- 5.0 | 4.8 | 7.1 |
| 17F | 5.0- 6.0 | 25 | 28 |
| 17G | 6.0- 7.0 | 19 | 19 |
| 17H | 7.0- 8.0 | 6.2 | 8.2 |
| 17I | 8.0- 9.0 | 6.1 | 4.1 |
| 17J | 9.0-10.0 | 2.0 | 2.1 |
| MCD18 | -- | 9.4 | 8.4 |
| MCD19 | -- | 12 | 11 |
| MCD20 | -- | 1.5 | 2.5 |
| MCD21 | -- | 0.7 | 1.1 |
| MCD22 | -- | 0.7 | 0.8 |
| MCD23 | -- | 1.4 | 2.3 |
| MCD24 | -- | 1.1 | 1.7 |
| MCD25 | -- | 1.6 | 1.4 |
| MCD26 | -- | 1.1 | 1.1 |
| MCD27 | -- | 1.1 | 1.1 |
| MCD29A[c] | 0 - 1.0 | 1.1 | 1.2 |
| 29B | 1.0- 2.0 | 5.8 | 8.8 |
| 29C | 2.0- 3.0 | 54 | 58 |
| 29D | 3.0- 4.0 | 40 | 49 |
| 29F | 5.0- 6.0 | 16 | 22 |
| 29G | 6.0- 7.0 | 1.0 | 1.4 |
| 29J | 8.0-10.0 | 2.0 | 3.0 |

[a]Number refers to hole locations as shown in Fig. 2.

[b]Samples for which no depth is given were taken from auger turnings while the hole was being drilled.

[c]Hole 28 collapsed before any samples could be taken.

Table 4. Estimated[a] concentrations of $^{226}Ra$ (pCi/g) in subsurface soil on the landfill site

| Location shown in Fig. 2 | Depth (ft) | $^{226}Ra$ |
|---|---|---|
| 10 | 0 -19.0 | <1.0 |
| 11 | 0 | 9.0 |
| | 1.0 | 10 |
| | 2.0 | 21 |
| | 3.0 | 11 |
| | 4.0 | 9.0 |
| | 5.0 | 6.0 |
| | 6.0 | 7.0 |
| | 7.0 | 6.0 |
| | 8.0 | 5.0 |
| | 9.0 | 5.0 |
| | 10.0-12.0 | <1.0 |
| 13 | 0 | <1.0 |
| | 1.0 | <1.0 |
| | 2.0 | 2.0 |
| | 3.0 | <1.0 |
| | 4.0 | 4.0 |
| | 5.0 | 3.0 |
| | 6.0 | 4.0 |
| | 7.0 | 5.0 |
| | 8.0 | 4.0 |
| | 9.0 | 3.0 |
| | 10.0 | 4.0 |
| | 11.0 | 4.0 |
| | 12.0 | 5.0 |
| | 13.0 | 9.0 |
| | 14.0 | 10 |
| | 15.0 | 12 |
| | 16.0 | 4.0 |
| | 17.0 | 1.0 |
| 14 | 0-25.0 | <1.0 |
| 15 | 0- 6.0 | <1.0 |
| | 7.0 | 2.0 |
| | 8.0 | 3.0 |
| | 9.0 | 3.0 |
| | 10.0 | 5.0 |
| | 11.0 | 5.0 |
| | 12.0 | 5.0 |
| | 13.0 | 9.0 |
| | 14.0 | 27 |
| | 15.0 | 16 |
| | 16.0 | 6.0 |
| | 17.0 | 4.0 |
| | 18.0 | 3.0 |

Table 4 (cont.). Estimated[a] concentrations of $^{226}Ra$ (pCi/g) in subsurface soil on the landfill site

| Location shown in Fig. 2 | Depth (ft) | $^{226}Ra$ |
|---|---|---|
| 16 | 0-22.0 | <1.0 |
| 18 | 0- 5.0 | <1.0 |
| | 6.0 | 4.0 |
| | 7.0 | 12 |
| | 8.0 | 2 |
| | 9.0 | <1.0 |
| | 10.0 | 2.0 |
| | 11.0-19.0 | <1.0 |
| 19 | 0- 4.0 | <1.0 |
| | 5.0 | 9.0 |
| | 6.0 | 21 |
| | 7.0 | 9.0 |
| | 8.0 | 47 |
| | 9.0 | 36 |
| | 10.0 | 8.0 |
| | 11.0 | 8.0 |
| 20 | 0-17.0 | <1.0 |
| 21 | 0-18.0 | <1.0 |
| 22 | hole fell in | |
| 23 | 0-10.0 | <1.0 |
| 24 | 0-12.0 | <1.0 |
| | 12.0-19.0 | 4.0 |
| 25 | 0-13.0 | <1.0 |
| 26 | 0-12.0 | <1.0 |
| 27 | 0-22.0 | <1.0 |
| 28 | hole fell in; no log | |

[a]Estimated from gamma radiation intensities in auger holes.

Table 5. Concentrations of radionuclides in groundwater samples

| Sample no.[a] | $^{226}Ra$ (pCi/liter) | $^{238}U$ (pCi/liter) |
|---|---|---|
| MCD10 | <0.5 | 0.3 |
| MCD15 | 0.9 | 4.1 |
| MCD16 | <0.5 | <3[b] |
| MCD17 | 1.4 | 11 |
| MCD18 | <0.5 | <3[b] |
| MCD20 | 1.4 | <3[b] |
| MCD23 | <0.5 | 10 |
| MCD24 | <0.5 | 3.2 |
| MCD25 | <0.5 | <3[b] |
| MCD26 | <0.5 | 5.0 |
| MCD27 | 5.5 | 0.05 |

[a]Identification numbers refer to augered hole locations shown in Fig. 2

[b]For these samples, 3 pCi/liter of $^{238}U$ was the minimum measurable activity.

# APPENDIX I

## DESCRIPTION OF RADIATION SURVEY METERS

## RADIATION SURVEY METERS

### Beta-Gamma Survey Meter

A portable Geiger-Mueller (G-M) survey meter is the primary instrument for measuring beta-gamma radioactivity. The G-M tube is a halogen-quenched stainless steel tube having a 30 mg/cm$^2$ wall thickness and presenting a cross-sectional area of approximately 10 cm$^2$. Since the G-M tube is sensitive to both beta and gamma radiation, measurements are taken in both an open-window and a closed-window configuration. Beta radiation cannot penetrate the closed window, and thus the beta reading can be determined by taking the difference between the open- and closed-window readings. This meter is shown in Fig. I-A.

The G-M survey meters were calibrated by comparison with a precalibrated Victoreen Model 440 ionization chamber (Fig. I-B). The open-window calibration factor was found to be 2000 cpm per mrad/hr for surfaces contaminated with $^{226}$Ra in equilibrium with $^{238}$U and 2300 cpm per mrad/hr for surfaces contaminated with initially pure uranium. The closed-window (gamma) calibration factor, determined by use of a National Bureau of Standards (NBS) standard $^{226}$Ra source, was 3200 cpm per mrad/hr.

### Gamma Scintillation Survey Meter

A portable survey meter using a NaI scintillation probe is used to measure low-level gamma radiation exposure. The scintillation probe is a 3.2 x 3.8-cm NaI crystal coupled to a photomultiplier tube. This probe is connected to a Victoreen Model Thyac III ratemeter (see Fig. I-C). This unit is capable of measuring radiation levels from a few μR/hr to several hundred μR/hr. This instrument is calibrated at ORNL with an NBS standard $^{226}$Ra source. Typical calibration factors are of the order of 300 cpm/μR per hr.

The mobile laboratories shown in Fig. I-D are used during each formal survey to serve as a control center and to house instruments and other equipment needed during the survey. Each lab is equipped with its own electric generator and mobile radio-telephone as well as its own set of calibrated survey instruments. One of the mobile labs has its own microcomputer for data reduction in remote locations.

ORNL-Photo 6704-76

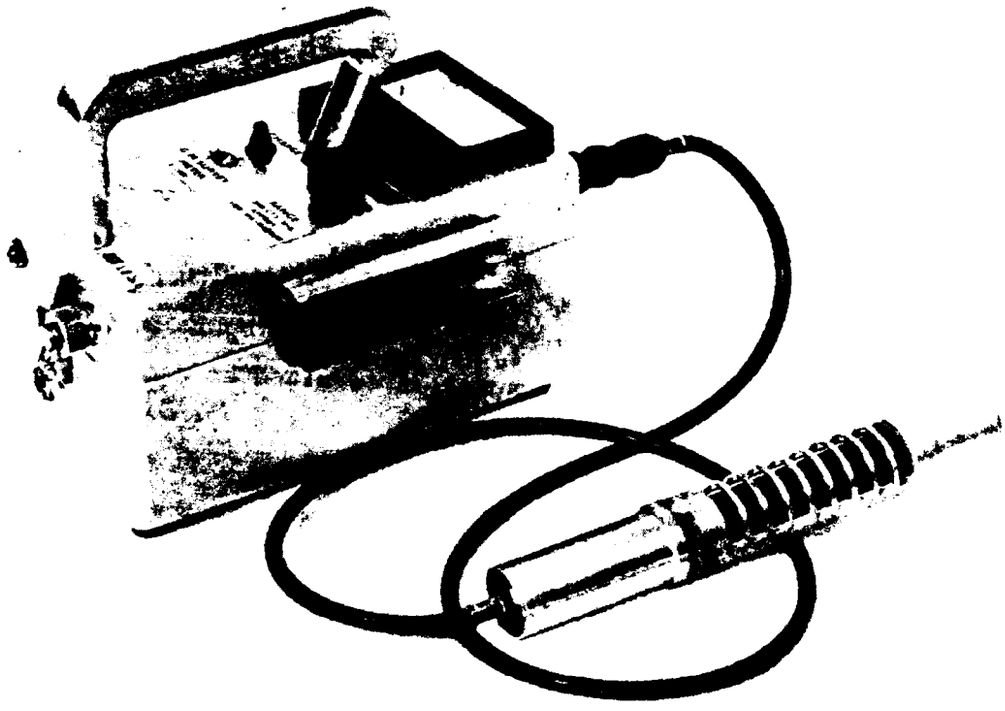

Fig. I-A. Geiger-Mueller survey meter.

ORNL-Photo 6710-76

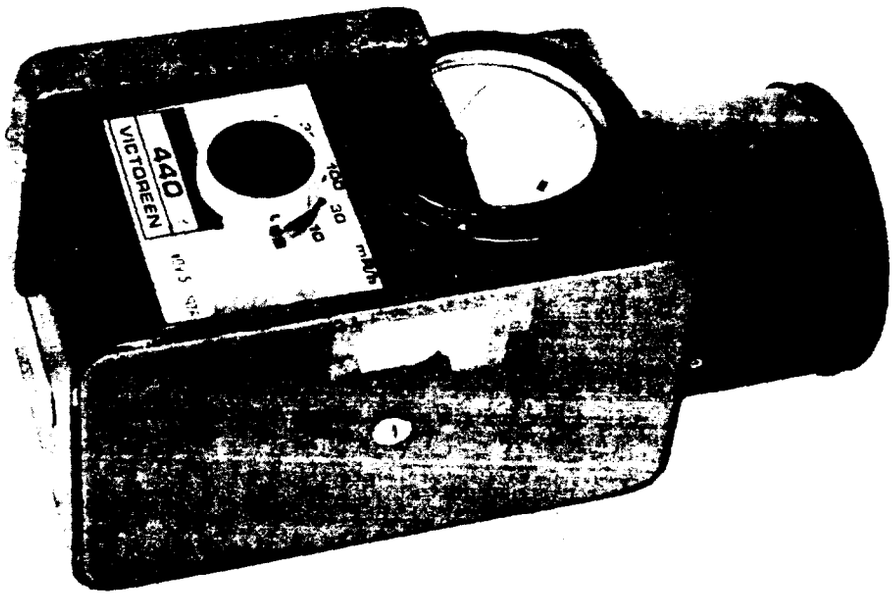


Fig. I-B. Victoreen Model 440 ionization chamber.

ORNL-Photo 6707-76

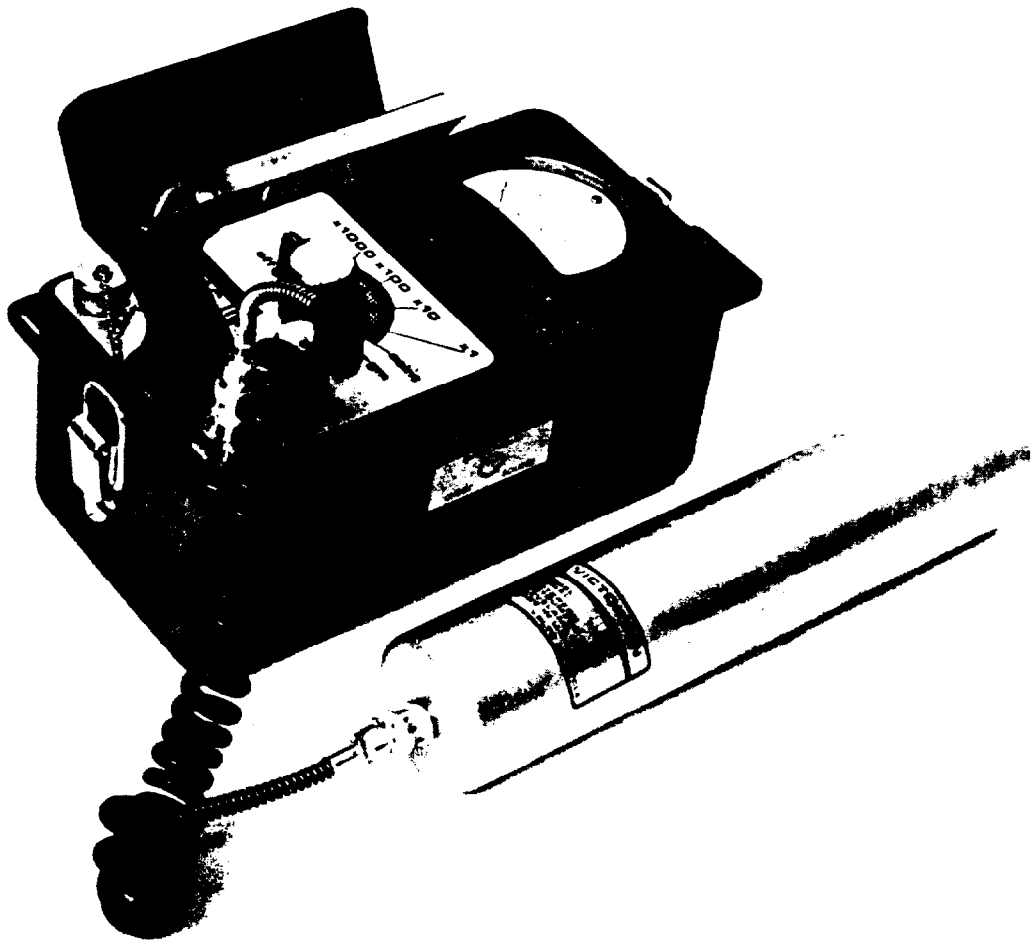

Fig. I-C. Gamma scintillation survey meter.

ORNL-Photo 1068-78

Fig. I-D. Mobile labs used for logistic support during surveys.

# APPENDIX II

## DESCRIPTION OF GE(LI) DETECTOR AND SOIL COUNTING PROCEDURES

## DESCRIPTION OF Ge(Li) DETECTOR SYSTEM

A holder for twelve 30-$cm^3$ polyethylene bottles (standard containers for liquid scintillation samples) and a background shield have been designed for use with a 50-$cm^3$ Ge(Li) detector system (see Fig. II-A). During counting of the samples, the holder is used to position ten of the sample bottles around the cylindrical surface of the detector, parallel to and symmetric about its axis, and two additional bottles across the end surface of the detector, perpendicular to and symmetric with its axis. With a 300-$cm^3$ sample and a graded shield developed for use with the system, it is possible to measure 1 pCi/g of $^{232}Th$ or $^{226}Ra$ with an error of ±10% or less.

Pulses are sorted by a 4096-channel analyzer (see Fig. II-B), stored on magnetic tape, and subsequently entered into a computer program which uses an iterative least-squares method to identify radionuclides corresponding to those gamma-ray lines found in the sample. The program, which is accessible through a remote terminal, relies on a library of radioisotopes which contains approximately 700 isotopes and 2500 gamma rays and which runs continuously on the IBM-360 system at ORNL. In identifying and quantifying $^{226}Ra$, six principal gamma-ray lines are analyzed. Most of these are from $^{214}Bi$ and correspond to 295, 352, 609, 1120, 1765, and 2204 keV. An estimate of the concentration of $^{238}U$ is obtained from an analysis of the 93 keV line from its daughter $^{234}Th$.

ORNL-Photo 2172-75

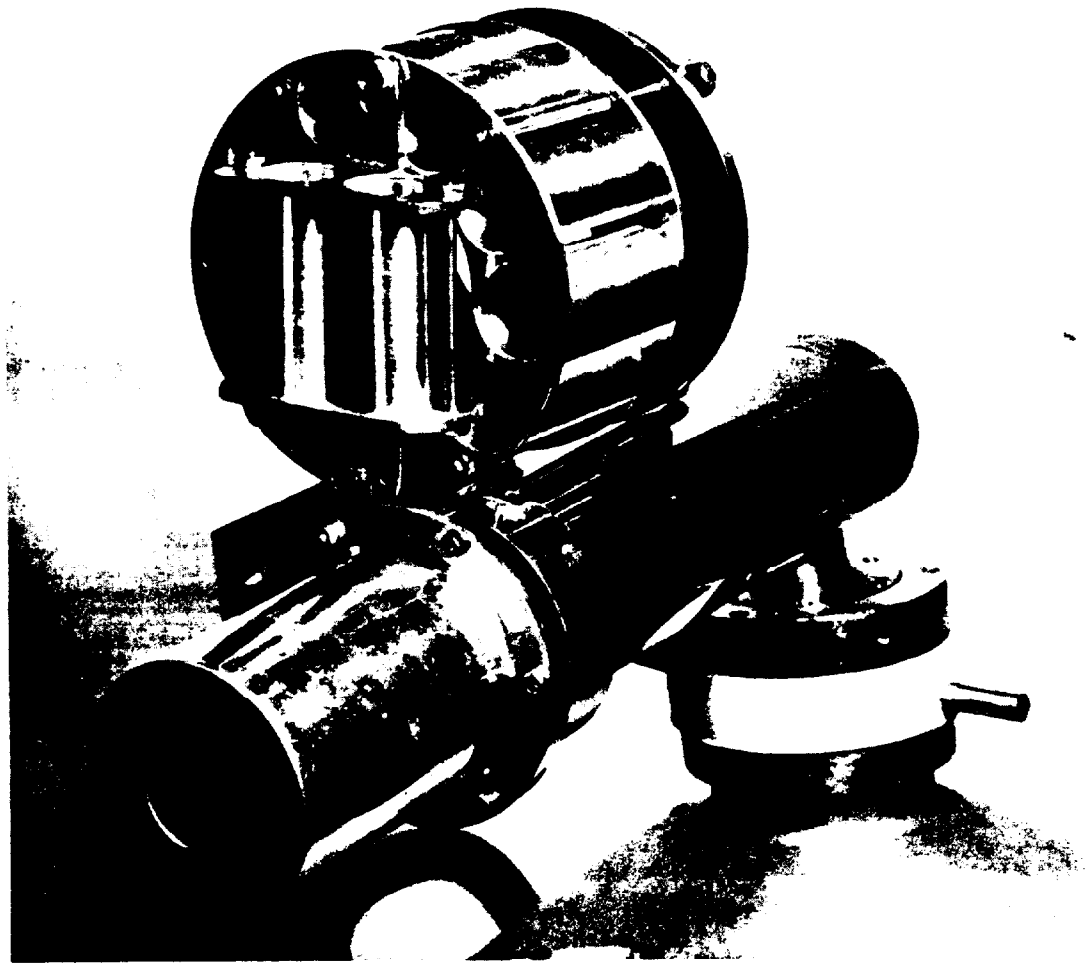

Fig. II-A. Holder for Ge(Li) detector system.

ORNL-Photo 6719-76

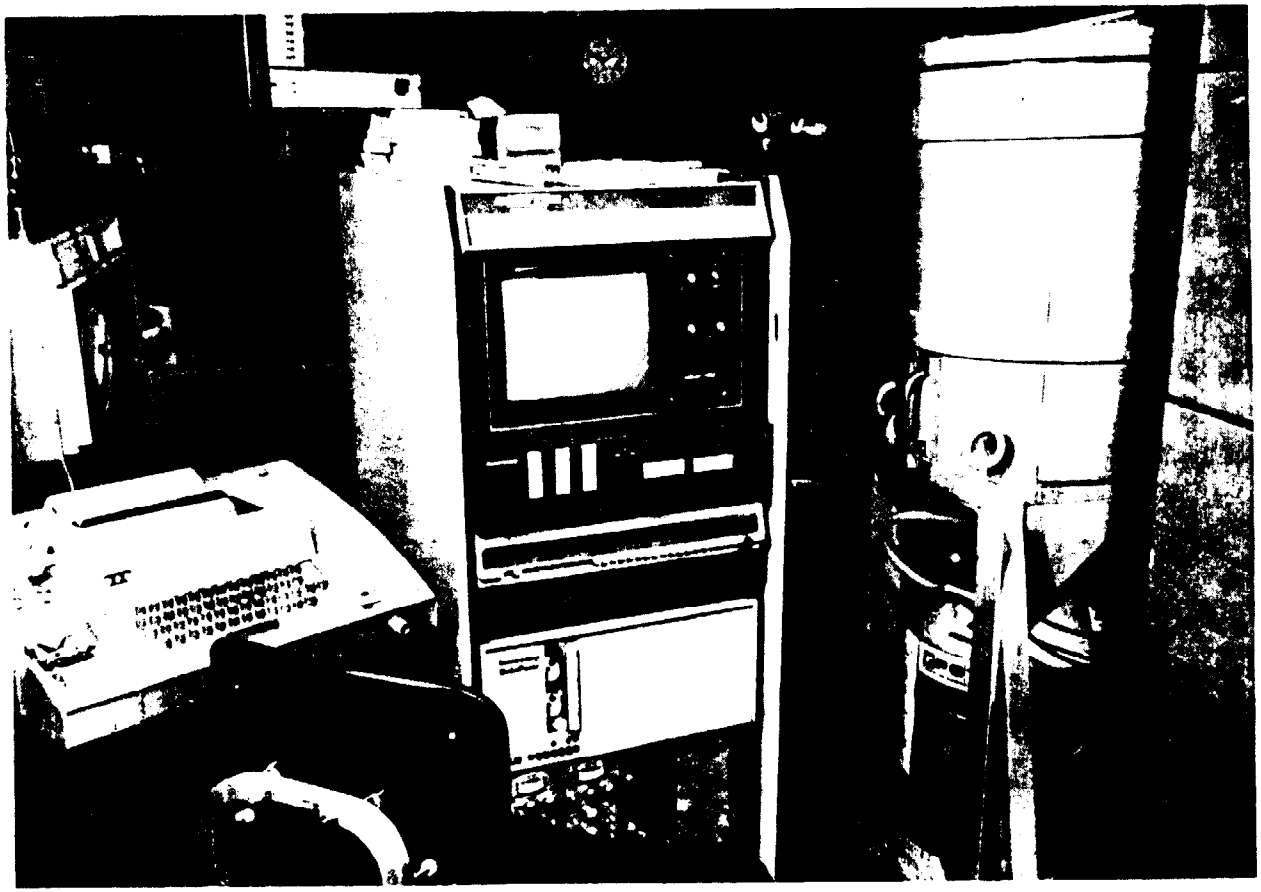

Fig. II-B. Computer-based multichannel analyzer and one of three Ge(Li) counting systems.

# APPENDIX III

## PROCEDURE FOR ESTIMATING $^{226}$RA CONCENTRATIONS FROM GAMMA SCINTILLATION PROBE LOGGINGS

Since the gamma radiation intensity of subsurface soil contaminated with $^{226}Ra$ and other radionuclides from the $^{238}U$ chain depends chiefly on the concentrations of $^{226}Ra$ and daughters present, gamma scintillation probe loggings in auger holes can be used to estimate $^{226}Ra$ concentrations in subsurface soil. In the case of the Middlesex site, 29 auger holes were logged. At two of these holes, soil samples were extracted at intervals of approximately 6 in. By comparison with scintillation probe readings at corresponding depths, a "best-fitting" curve, $y = 11x - 12.8$, was obtained, where $y$ is the $^{226}Ra$ concentration in pCi/g and $x$ is the meter reading in thousand counts per min. Using this conversion, the $^{226}Ra$ concentration was estimated from gamma radiation levels measured in auger holes.

NOTE: The guidelines contained herein have been superseded by those contained in Appendix A to Exhibit I of the certification docket.

# APPENDIX IV

## PERTINENT RADIOLOGICAL REGULATIONS, STANDARDS, AND GUIDELINES

# 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

U.S. Nuclear Regulatory Commission
Division of Fuel Cycle and Material Safety
Washington, D.C. 20555

November 1976

The instructions in this guide in conjunction with Table IV-1 specify the radioactivity and radiation exposure rate limits which should be used in accomplishing the decontamination and survey of surfaces or premises and equipment prior to abandonment or release for unrestricted use. The limits in Table IV-1 do not apply to premises, equipment, or scrap containing induced radioactivity for which the radiological considerations pertinent to their use may be different. The release of such facilities or items from regulatory control will be considered on a case-by-case basis.

1. The licensee shall make a reasonable effort to eliminate residual contamination.
2. Radioactivity on equipment or surfaces shall not be covered by paint, plating, or other covering material unless contamination levels, as determined by a survey and documented, are below the limits specified in Table IV-1 prior to applying the covering. A reasonable effort must be made to minimize the contamination prior to use of any covering.
3. The radioactivity on the interior surfaces of pipes, drain lines, or ductwork shall be determined by making measurements at all traps, and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or ductwork. Surfaces of premises, equipment, or scrap which are likely to be contaminated but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement shall be presumed to be contaminated in excess of the limits.
4. Upon request, the Commission may authorize a licensee to relinquish possession or control of premises, equipment, or scrap having surfaces contaminated with material in excess of the limits specified. This may include, but would not be limited to, special circumstances such as razing of buildings, transfer or premises to another organization continuing work with radioactive materials, or conversion of facilities to a long-term storage or standby status. Such request must:

a. Provide detailed, specific information describing the premises, equipment or scrap, radioactive contaminants, and the nature, extent, and degree of residual surface contamination.

b. Provide a detailed health and safety analysis which reflects that the residual amounts of material on surface areas, together with other considerations such as prospective use of the premises, equipment or scrap, are unlikely to result in an unreasonable risk to the health and safety of the public.

5. Prior to release of premises for unrestricted use, the licensee shall make a comprehensive radiation survey which establishes that contamination is within the limits specified in Table IV-1. A copy of the survey report shall be filed with the Division of Fuel Cycle and Material Safety, USNRC, Washington, D.C. 20555, and also with the Director of the Regional Office of the Office of Inspection and Enforcement, USNRC, having jurisdiction. The report should be filed at least 30 days prior to the planned date of abandonment. The survey report shall:

a. Identify the premises.

b. Show that reasonable effort has been made to eliminate residual contamination.

c. Describe the scope of the survey and general procedures followed.

d. State the findings of the survey in units specified in the instruction.

Following review of the report, the NRC will consider visiting the facilities to confirm the survey.

Table IV-1. Acceptable surface contamination levels

| Nuclides[a] | Average[b,c,f] | Maximum[b,d,f] | Removable[b,e,f] |
|---|---|---|---|
| U-nat, U-235, U-238, and associated decay products | 5,000 dpm $\alpha$/100 $cm^2$ | 15,000 dpm $\alpha$/100 $cm^2$ | 1,000 dpm $\alpha$/100 $cm^2$ |
| Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129 | 100 dpm/100 $cm^2$ | 300 dpm/100 $cm^2$ | 20 dpm/100 $cm^2$ |
| Th-nat, Th-232, Sr-90 Ra-223, Ra-224, U-232, I-126, I-131, I-133 | 1,000 dpm/100 $cm^2$ | 3,000 dpm/100 $cm^2$ | 200 dpm/100 $cm^2$ |
| Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and other noted above. | 5,000 dpm $\beta\gamma$/100 $cm^2$ | 15,000 dpm $\beta\gamma$/100 $cm^2$ | 1,000 dpm $\beta\gamma$/100 $cm^2$ |

[a]Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides 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 observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c]Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

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

[e]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 assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

[f]The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

Excerpts from
Proposed
ANSI N328-197

Proposed American National Standard

# Control of Radioactive Surface Contamination on Materials, Equipment, and Facilities to be Released for Uncontrolled Use

Secretariat
Health Physics Society

Property shall not be released for uncontrolled use unless documented measurements show the total and removable contamination levels to be no greater than the values in Table IV-2 or Table IV-3. (Table IV-3 is easier to apply when the contaminants cannot be individually identified.)

Where potentially contaminated surfaces are not accessible for measurement (as in some pipes, drains, and ductwork), such property shall not be released pursuant to this standard, but made the subject of case-by-case evaluation. Credit shall not be taken for coatings over contamination.

Table IV-2. Surface contamination limits

The levels may be averaged[a] over the 1 $m^2$ provided the maximum activity in any area of 100 $cm^2$ is less than 3 times the limit value.

| Nuclide | Limit (activity) dpm/100 $cm^2$ | |
|---|---|---|
| | Total | Removable |
| Group 1: Nuclides for which the nonoccupational $MPC_a$[b] is $2 \times 10^{-13}$ $Ci/m^3$ or less or for which the nonoccupational $MPC_w$[c] is $2 \times 10^{-7}$ $Ci/m^3$ or less; includes Ac-227; Am-241; -242m, -243; Cf-249; -250, -251, -252; Cm-243, -244, -245, -246, -247, -248; I-125, -129; Np-237; Pa-231; Pb-210; Pu-238, -239, -240, -242, -244; Ra-226, -228; Th-228, -238.[d] | 100 | 20 |
| Group 2: Those nuclides not in Group 1 for which the nonoccupational $MPC_a$[b] is $1 \times 10^{-12}$ $Ci/m^3$ or less or for which the nonoccupational $MPC_w$[c] is $1 \times 10^{-6}$ $Ci/m^3$ or less; includes Es-254; Fm-256; I-126, -131, -133; Po-210; Ra-223; Sr-90; Th-232; U-232.[d] | 1000 | 200 |
| Group 3: Those nuclides not in Group 1 or Group 2. | 5000 | 1000 |

[a]See note following table on applications of limits.

[b]$MPC_a$: Maximum Permissible Concentration in Air applicable to continuous exposure of members of the public as published by or derived from an authoritative source such as NCRP, ICRP, or NRC (10 CFR 20, Appendix B, Table 2, Column 1).

[c]$MPC_w$: Maximum Permissible Concentration in Water applicable to members of the public.

[d]Values presented here are obtained from 10 CFR Part 20. The most limiting of all given MPC values (e.g., soluble vs. insoluble) are to be used. In the event of the occurrence of a mixture of radionuclides, the fraction contributed by each constituent of its own limit shall be determined and the sum of the fractions must be less than one.

Table IV-3. Alternate surface contamination limits

(All alpha emitters, except U-nat and Th-nat are considered as a group.) The levels may be averaged over 1 $m^2$[a] provided the maximum activity in any area of 100 $cm^2$ is less than 3 times the limit value.

| Nuclide | Limit (activity) dpm/100 $cm^2$ | |
|---|---|---|
| | Total | Removable |
| If the contaminant cannot be identified; or if alpha emitters other than U-nat and Th-nat are present; or if the beta emitters comprise Ac-227, Ra-226, Ra-228, I-125, and I-129. | 100 | 20 |
| If it is known that all alpha emitters are generated from U-nat and Th-nat; and beta emitters are present which, while not identified, do not include Ac-227, I-125, I-129, Ra-226, and Ra-228. | 1000 | 200 |
| If it is known that alpha emitters are generated only from U-nat and Th-nat; and the beta emitters, while not identified, do not include Ac-227, I-125, I-129, Sr-90, Ra-223, Ra-228, I-126, I-131, and I-133. | 5000 | 1000 |

[a]Note on application of Tables IV-2 and IV-3 to isolated spots or activity:

For purposes of averaging, any $m^2$ of surface shall be considered to be contaminated above the limit, L, applicable to 100 $cm^2$ if:

a. From measurements of a representative number, n, of sections, it is determined that $1/n \sum_{n} Si \geq L$, where Si is the dpm/100 $cm^2$ determined from measurement of section i; or

b. On surfaces less than 1 $m^2$, it is determined that $1/n \sum_{n} Si \geq AL$, where A is the area of the surface in units of $m^2$; or

c. It is determined that the activity of all isolated spots or particles in any area less than 100 $cm^2$ exceeds 3L.

SURGEON GENERAL'S GUIDELINES
Part 712
Grand Junction Remedial Action Criteria

*Federal Register*, Vol. 41, No. 253, pp. 56777-8, Thursday, December 30, 1976

## PART 712 - GRAND JUNCTION REMEDIAL ACTION CRITERIA

### 712.1 Purpose

(a) The regulations in this part establish the criteria for determination by ERDA of the need for, priority of, and selection of appropriate remedial action to limit the exposure of individuals in the area of Grand Junction, Colo., to radiation emanating from uranium mill tailings which have been used as construction-related material.

(b) The regulations in this part are issued pursuant to Publ. L. 92-314 (86 Stat. 222) of June 16, 1972.

### 712.2 Scope

The regulations in this part apply to all structures in the area of Grand Junction, Colo., under or adjacent to which uranium mill tailings have been used as a construction-related material between January 1, 1951, and June 16, 1972, inclusive.

### 712.3 Definitions

As used in this part:

(a) "Administrator" means the Administrator of the Energy Research and Development Administration or his duly authorized representative.

(b) "Area of Grand Junction, Colo.," means Mesa County, Colo.

(c) "Background" means radiation arising from cosmic rays and radioactive material other than uranium mill tailings.

(d) "ERDA" means the Energy Research and Development Administration or duly authorized representative thereof.

(e) "Construction-related material" means any material used in the construction of a structure.

(f) "External gamma radiation level" means the average gamma radiation exposure rate for the habitable area of a structure as measured near floor level.

(g) "Indoor radon daughter concentration level" means that concentration of radon daughters determined by: (1) averaging the results of 6 air samples, each of at least 100 hours duration, and taken at a minimum of 4-week intervals throughout the year in a habitable area of a structure, or (2) utilizing some other procedure approved by the Commission.

(h) "MilliRoentgen" (mR) means a unit equal to one-thousandth (1/1000) of a Roentgen which Roentgen is defined as an exposure dose of X or gamma radiation such that the associated corpuscular emission per 0.001293 gram of air produces, in air, ions carrying one electrostatic unit of quantity of electricity of either sign.

(i) "Radiation" means the electromagnetic energy (gamma) and the particulate radiation (alpha and beta) which emanate from the radioactive decay of radium and its daughter products.

(j) "Radon daughters" means the consecutive decay products of radon-222. Generally these include Radium A (polonium-218), Radium B (lead-218), Radium C (bismuth-214), and Radium C′ (polonium-214).

(k) "Remedial action" means any action taken with a reasonable expectation of reducing the radiation exposure resulting from uranium mill tailings which have been used as construction-related material in and around structures in the area of Grand Junction, Colo.

(l) "Surgeon General's guidelines" means radiation guidelines related to uranium mill tailings prepared and released by the Office of the U.S. Surgeon General, Department of Health, Education and Welfare on July 27, 1970.

(m) "Uranium mill tailings" means tailings from a uranium mill operation involved in the federal uranium procurement program.

(n) "Working Level" (WL) means any combination of short-lived radon daughter products in 1 liter of air that will result in the ultimate emission of $1.3 \times 10^5$ MeV of potential alpha energy.

712.4 Interpretations

Except as specifically authorized by the Administrator in writing, no interpretation of the meaning of the regulations in this part by an officer or employee of ERDA other than a written interpretation by the General Counsel will be recognized to be binding upon ERDA.

712.5 Communications

Except where otherwise specified in this part, all communications concerning the regulations in this part should be addressed to the Director, Division of Safety, Standards, and Compliance, U.S. Energy Research and Development Administration, Washington, D.C. 20545.

712.6 General radiation exposure level criteria for remedial action

The basis for undertaking remedial action shall be the applicable guidelines published by the Surgeon General of the United States. These guidelines recommend the following graded action levels for remedial action in terms of external gamma radiation level (EGR) and indoor radon daughter concentration level (RDC) above background found within dwellings constructed on or with uranium mill tailings:

| EGR | RDC | Recommendation |
|---|---|---|
| Greater than 0.1 mR/hr | Greater than 0.05 WL | Remedial action indicated |
| From 0.05 to 0.1 mR/hr | From 0.01 to 0.05 WL | Remedial action may be suggested |
| Less than 0.05 mR/hr | Less than 0.01 WL | No remedial action indicated |

712.7 Criteria for determination of possible need for remedial action

Once it is determined that a possible need for remedial action exists, the record owner of a structure shall be notified of that structure's eligibility for an engineering assessment to confirm the need for remedial action and to ascertain the most appropriate remedial

measure, if any. A determination of possible need will be made if as a result of the presence of uranium mill tailings under or adjacent to the structure, one of the following criteria is met:

(a) Where ERDA approved data on indoor radon daughter concentration levels are available:

(1) For dwellings and schoolrooms: An indoor radon daughter concentration level of 0.01 WL or greater above background.

(2) For other structures: An indoor radon daughter concentration level of 0.03 WL or greater above background.

(b) Where ERDA approved data on indoor radon daughter concentration levels are not available:

(1) For dwellings and schoolrooms:

(i) An external gamma radiation level of 0.05 mR/hr or greater above background.

(ii) An indoor radon daughter concentration level of 0.01 WL or greater above background (presumed).

(A) It may be presumed that if the external gamma radiation level is equal to or exceeds 0.02 mR/hr above background, the indoor radon daughter concentration level equals or exceeds 0.01 WL above background.

(B) It should be presumed that if the external gamma radiation level is less than 0.001 mR/hr above background, the indoor radon daughter concentration level is less than 0.01 WL above background and no possible need for remedial action exists.

(C) If the external gamma radiation level is equal to or greater than 0.001 mR/hr above background but is less than 0.02 mR/hr above background, measurements will be required to ascertain the indoor radon daughter concentration level.

(2) For other structures:

(i) An external gamma radiation level of 0.15 mR/hr above background averaged on a room-by-room basis.

(ii) No presumptions shall be made on the external gamma radiation level/indoor radon daughter concentration level relationship. Decisions will be made in individual cases based upon the results of actual measurements.

712.8 Determination of possible need for remedial action where criteria have not been met

The possible need for remedial action may be determined where the criteria in 712.7 have not been met if various other factors are present. Such factors include, but are not necessarily limited to, size of the affected area, distribution of radiation levels in the affected area, amount of tailings, age of individuals occupying affected area, occupancy time, and use of the affected area.

712.9 Factors to be considered in determination of order or priority for remedial action

In determining the order or priority for execution of remedial action, consideration shall be given, but not necessarily limited to, the following factors:

(a) Classification of structure. Dwellings and schools shall be considered first.

(b) Availability of data. Those structures for which data on indoor radon daughter concentration levels and/or external gamma radiation levels are available when the program starts and which meet the criteria in 712.7 will be considered first.

(c) Order of application. Insofar as feasible remedial action will be taken in the order which the application is received.

(d) Magnitude of radiation level. In general, those structures with the highest radiation levels will be given primary consideration.

(e) Geographical location of structures. A group of structures located in the same immediate geographical vicinity may be given priority consideration particularly where they involve similar remedial efforts.

(f) Availability of structures. An attempt will be made to schedule remedial action during those periods when remedial action can be taken with minimum interference.

(g) Climatic conditions. Climatic conditions or other seasonable considerations may affect the scheduling of certain remedial measures.

712.10 Selection of appropriate remedial action

(a) Tailings will be removed from those structures where the appropriately averaged external gamma radiation level is equal to or greater than 0.05 mR/hr above background in the case of dwellings and schools and 0.15 mR/hr above background in the case of other structures.

(b) Where the criterion in paragraph (a) of this section is not met, other remedial action techniques, including but not limited to sealants, ventilation, and shielding, may be considered in addition to that of tailings removal. ERDA shall select the remedial action technique or combination of techniques, which it determined to be the most appropriate under the circumstances.

ENVIRONMENTAL PROTECTION AGENCY
Title 40, Part 141

Drinking Water Regulations--Radionuclides

Interim Primary Drinking Water Regulations
Promulgation of Regulations on Radionuclides
*Federal Register*, Vol. 41, No. 133, pp. 28402-9, Friday, July 9, 1976

Part 141.15 *Federal Register*
Vol. 41, No. 133, p. 28404, Friday, July 9, 1976

Maximum contamination levels for $^{226}Ra$, $^{228}Ra$, and gross alpha particle radioactivity.

(a) Combined $^{226}Ra$ and $^{228}Ra$ - 5 pCi/liter.

(b) Gross alpha particle activity (including $^{226}Ra$ but excluding radon and uranium) - 15 pCi/liter.

# APPENDIX V

## EVALUATION OF RADIATION EXPOSURES AT THE MIDDLESEX MUNICIPAL LANDFILL, MIDDLESEX, NEW JERSEY

# EVALUATION OF RADIATION EXPOSURES AT THE MIDDLESEX MUNICIPAL LANDFILL, MIDDLESEX, NEW JERSEY

The U.S. Department of Energy (DOE) has determined that the Middlesex Municipal Landfill in Middlesex, New Jersey, is presently contaminated with naturally occurring radioactive residues. In 1948, this 23-acre site was used to deposit about 6000 cubic yards of soil contaminated with pitchblende ore (a naturally occurring mineral containing a high percentage of uranium). This contaminated soil had been moved to the landfill from the former Middlesex Sampling Plant by an authorized contractor. Results of an Atomic Energy Commission (AEC) survey in 1960 revealed some higher-than-normal external gamma radiation levels over an area of approximately 1/2 acre. This finding resulted in the removal of about 600 cubic yards of contaminated material. This cleaned area was subsequently covered with about 2 feet of clean fill dirt, thus lowering the external gamma radiation to approximately normal levels.

During the period between 1960 and 1974, a tract of land of approximately 5 acres was sold to the Middlesex Presbyterian Church and a building was constructed on the land. During weekdays, part of the building and grounds is currently used as a day care center for local children. The church and the Middlesex Municipal Building are located on the western edge of the site, and Bound Brook forms a border along the northern and northeastern edges of the site. The closest residence to the center of the area where contaminated material exists is approximately 500 feet toward the south.

Contamination at the Middlesex Municipal Landfill is due to underground deposits of naturally occurring radionuclides, principally uranium-238 and its decay products including, but not limited to, thorium-230 and radium-226. This contamination could result in slight radiation exposures to persons playing or working on the site. The area containing most of the contamination is not occupied at present; also, it is located at least 100 feet from both the church playground and a group of waste bins used by the local population for the disposal of refuse. Future plans for the site include its possible use as a municipal park. At the present time, approximately 15 children and several adults

use the church building and playground for about 30 hours per week. On Sunday, this building is occupied by approximately 100 persons for about 3 hours. The municipal building, located on the western edge of the site, has an occupancy of approximately 600 man-hours per week by city employees.

Radiation exposures to temporary occupants of the site result from two primary sources: inhalation of radon gas and its decay products which exist in air and gamma radiation emitted by the contamination in the soil. Additional exposures from ingestion (e.g., eating or drinking while occupying one of the contaminated areas) are relatively small as compared with inhalation and direct gamma radiation. However, the presence of small pieces of uranium-bearing ore at or near the ground surface could pose a potential for direct ingestion by small children.

The radionuclides which comprise the contamination at the landfill site are present in minute quantities throughout our environment. Concentrations of these radionuclides in normal soils, air, water, food, etc., are referred to as background concentrations. Radiation exposures resulting from this environmental radioactivity are referred to as background exposures. These background exposures are not caused by any human activity and, to a large extent, can be controlled only through man's moving to areas with lower background exposures. Each and every human receives some background exposure daily.

The use of radioactive materials for scientific, industrial, or medical purposes may cause radiation exposures above the background level to be received by workers in the industry and, to a lesser extent, by members of the general public. Scientifically based guidelines have been developed to place an upper limit on these additional exposures. Limits established for exposure to the general public are much lower than the limits established for workers in the nuclear industry.

Temporary occupants of the church and municipal building on the strip of land which borders the Middlesex Municipal Landfill are receiving radiation exposures which are indistinguishable from background exposures. In no case would an exposure in this area approach guidelines for limiting exposure to the general public. Present exposures are summarized and are compared numerically with guidelines and background radiation in the accompanying Table V-1.

Uranium-238 is believed to have been created when the earth was formed. It is still present today because it takes a very long time to decay. The half-life is a measure of the time required for decay; for uranium-238 it is 4.5 billion years. Thus, if you begin with one curie* of uranium-238, one-half curie will remain after 4.5 billion years. After 9 billion years, this would only be one-quarter curie of uranium-238, etc. As the uranium-238 decays, it changes into another substance--thorium-234. Thorium-234 is called the "daughter" of uranium-238. In turn, thorium-234 is the "parent" of protactinium-234. Radioactive decay started by uranium-238 continues as shown in Table V-2 until stable lead is formed. The "decay product" listed in this table is the radiation produced as the parent decays.

## Exposure to External Gamma Radiation

As may be seen in Table V-2, several of the daughters of uranium-238 emit gamma radiation. (Gamma rays are penetrating radiation like X-rays.) Hence, the contaminated areas represent sources of external gamma radiation exposure. Gamma exposure rates measured at 1 meter above the ground ranged from 4 to 32 microRoentgens† per hour. One small area (approximately 500 square feet), located in the center of the site, shows an average external gamma radiation level of 30 microRoentgens per hour at 1 meter above the ground. If this small area were to be occupied for 2000 hours per year (normal working hours), the resulting exposure would be equivalent to 60,000 microRoentgens. For comparison, a typical chest X-ray (according to Department of Health, Education, and Welfare data) might yield an exposure of about 27,000 microRoentgens. The background exposure rate in the Middlesex area ranges from 5 to 10 microRoentgens per hour with an average background

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*A curie is a unit defined for expressing the amount of radioactivity present in a substance; one curie represents 37 billion radioactive disintegrations per second.

†The Roentgen is a unit which is defined for radiation protection purposes for people exposed to penetrating gamma radiation. A microRoentgen is one-millionth of a Roentgen.

rate of 8 microRoentgens per hour. The average exposure rate measured at the Middlesex Municipal Landfill was about 5 microRoentgens per hour.

The National Council on Radiation Protection and Measurements (NCRP) has recommended a maximum annual whole body exposure rate of 500,000 microRoentgens per year to an individual continually exposed in the general population; this corresponds to an exposure rate of 250 microRoentgens per hour for 2000 exposure hours. At the present time, there are no exposures at this site which exceed this guideline value. For an individual in the general public, this guideline is ten times lower than guidelines established for a worker in the nuclear industry.

## Inhalation of Radionuclides

Radon-222, the daughter of radium-226 (as shown in Table V-2) is an inert gas which may leave the soil and enter the atmosphere. The average daily concentration of radon-222 was 0.04 picocurie* per liter of air measured at the municipal building over a 7-day period in May, 1978. At approximately the same time, the average daily concentration of radon-222 was 0.06 picocurie per liter of air measured at the Parker School. The Parker School is reasonably representative of area background. Thus, radon-222 concentrations attributable to the landfill site are comparable to those caused by background radioactivity.

Radioactive decay of radon-222 is rapid (days) and its decay gives rise to short-lived daughters as shown in Table V-2. Background concentrations of radon daughters both inside and outside structures are typically less than 0.01 working level† (WL). The average concentration of short-lived radon-222 daughters in air measured at the parking lot of the municipal building was less than 0.001 working level. Consequently, exposures to radon-222 and its daughters (due to material buried at this site) are insignificant as long as use of the site does not change.

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*One picocurie is one million-millionth of a curie, previously defined.

†The working level is a unit which is defined for radiation protection purposes for uranium miners. It represents a specific level of energy emitted by the short-lived daughters of radon.

It is further estimated that radon levels in the air of a structure (concrete slab or with crawl space) built directly over soil containing the bulk of the contamination could approach 0.8 picocuries per liter which is similar to indoor levels of background radon-222. This level would be expected to yield radon daughter concentrations of about 0.004 working level. If structures with basements were built in the same contaminated area, resulting radon daughter concentrations could be significantly greater. Although no such structures exist at the present and none are planned for the immediate future, nothing definitive can be said at this time regarding long-range land-use plans.

Studies of the health of uranium and other hard-rock miners have established that inhalation of large quantities of radon daughters over long periods of time increases an individual's risk of contracting lung cancer. The present federal guide value for uranium mine workers (given by the Environmental Protection Agency [EPA]), when translated to the units discussed here, would limit mine workers to an exposure of 0.33 working level throughout the normal work period of 2000 hours per year. This guide value is significantly lower than the exposures received by most of the miners included in the health studies mentioned above.

## Other Considerations of Exposure

Both groundwater and water from Bound Brook were sampled and analyzed for a variety of radionuclides. All samples had radionuclide concentrations well below the recommended values set forth in 10 CFR 20* for water consumed by the general public.

Radiation measurements and soil samples taken along Bound Brook on the site indicate that small amounts of contaminated material may have migrated toward the brook from the area containing the highest levels of contamination.

While no crops are currently grown on this site, use of the contaminated soil for such a purpose could produce additional human exposure

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*Title 10, Code of Federal Regulations, Part 20, is a regulatory document published by the Nuclear Regulatory Commission and may be found in the *Federal Register*.

through consumption of crops which have incorporated radioactive materials (e.g., radium-226). Actions which involve considerable scraping or tilling of dry soil could lead to human exposure through inhalation of airborne radioactive dust.

Use of this site or its residues for residential construction could result in continuous exposures to radon daughters which are in excess of guideline values.

## Risk and Radiation Exposures

Risks resulting from radiation exposures should be considered within the context of other risks incurred in normal living. For simplicity, risks to health may be classified in four categories:

1. Unacceptable--problems with risk so high as to require immediate action, such as severe diseases where medical treatment is required to save a life.
2. Concerned--problems where people are willing to spend time and money to reduce potential hazards. Examples of this include the maintenance of public highways and signs, signals, fire departments, and rescue squads.
3. Recognized--problems where people may accept some inconvenience to avoid certain activities such as flying in airplanes, swimming alone, etc.
4. No great concern--problems with a low frequency of occurrence. There is an awareness of potential hazard but an accompanying feeling that these problems occur only to other people.

An individual may be exposed to risks over which he can exercise some control (voluntary), and risks over which he feels he has no personal control or choice (involuntary).

Daily, an individual is confronted with decisions about risk which have an associated benefit--for example, driving a car. This can serve as an illustration that a voluntary, concerned risk may be deemed appropriate due to the desirable perceived benefit. As another example, an individual who smokes cigarettes has subjected himself to a risk of lung cancer which is about ten times higher than that for a nonsmoker.

For purposes of radiation protection, all radiation exposures are assumed to be capable of increasing an individual's risk of contracting cancer. A precise numerical value cannot be assigned with any certainty to a given individual's increase in risk attributable to radiation exposure. The reasons for this are numerous; they include the individual's personal habits and state of health, previous or concurrent exposure to other cancer-causing agents, and the individual's family medical history. Because of these variables, large uncertainties would exist in any estimates of the number of increased cancers in the relatively small population being exposed at the Middlesex Landfill site.

The normal annual death rate from lung cancer for all population groups in Middlesex County (as of 1970) was 29.4 deaths per 100,000 population; in Somerset County (as of 1970), the rate was 26.0 deaths per 100,000 population. At the same time, the annual death rates from lung cancer for all population groups in the United States and the state of New Jersey were 21.1 and 25.7 deaths per 100,000 population, respectively. A one-year exposure to the guideline value for uranium miners (0.33 working level for 2000 hours) might increase the risk of death due to lung cancer by approximately four percent.

The annual death rate from all types of cancer among all population groups in Middlesex County (as of 1970) was 184 deaths per 100,000 population; in Somerset County (as of 1970), the rate was 160 deaths per 100,000 population. At the same time, the death rates from all types of cancer for all population groups in the United States and in the state of New Jersey were 151 and 175 per 100,000 population, respectively. A one-year exposure to penetrating gamma radiation of 500,000 microRoentgens might increase the risk of death due to all types of cancer by about one-tenth of a percent. Exposures in excess of these guideline values would be expected to result in proportionately higher increases in risk. Consequently, any action taken to reduce either the rate or the duration of radiation exposures would also reduce the risk attendant to that exposure.

## Remedial Measures

The small radiation exposures at the Middlesex Municipal Landfill are attributable to the presence of contaminated soil and materials buried within the soil. Contamination on the surface appears to be confined to a small area of approximately 500 square feet. The small exposures which presently exist, as well as more serious potential exposures, could be alleviated by removal of the contaminated material or by covering the contaminated area with several feet of uncontaminated soil. The DOE is now actively evaluating alternatives under a priority program designed to assure adequate public protection.

## Summary

The Middlesex Municipal Landfill is contaminated with buried materials containing naturally occurring uranium-238, radium-226, and their daughters. Current radiation exposures are not appreciably different from background exposures. However, the underground contamination poses the potential for producing elevated levels of human exposure if future activities at the site were to uncover pieces of uranium ore at or near the ground surface, or result in the construction of buildings over the contaminated area. The DOE has developed a coordinated plan which addresses the specific problems at the Middlesex Landfill site and other formerly utilized MED/AEC sites. Currently, work is underway to implement the elements of this plan.

Table V-1. Summary of exposure data at the Middlesex Municipal Landfill, Middlesex, New Jersey

| Exposure source | Background levels | Guideline value for general public | Guideline value for radiation workers | Average levels at Middlesex Municipal Landfill |
|---|---|---|---|---|
| Radon in air | Less than one picocurie[a] per liter of air | Continuous exposure to 3 picocuries per liter of air | Exposure for 40 hours per week and 50 weeks per year to 30 picocuries per liter of air | Average daytime concentration measured on roof of Municipal Building was 0.04 picocurie per liter of air |
| Radon daughters in air | Less than 0.01 working level[b] | 0.01 working level for residences and school rooms, and 0.03 working level for other structures | 0.33 working level for uranium miners exposed for 40 hours per week and 50 weeks per year | Average concentration measured on parking lot of Municipal Building was less than 0.001 working level |
| Gamma radiation from decay products of radium and uranium contamination | 8 microRoentgens[c] per hour in the Middlesex area | 250 microRoentgens per hour above natural background for 40 hours per week and 50 weeks per year for an individual in the general public. This is equivalent to 0.5 Roentgen per year | 2500 microRoentgens per hour for 40 hours per week and 50 weeks per year. This is equivalent to 5 Roentgens per year | Average gamma radiation level 1 meter above the ground was about 5 microRoentgens per hour. One small area averaged 30 microRoentgens per hour |

[a]The picocurie is a unit which was defined for expressing the amount of radioactivity present in a substance.

[b]The working level is a unit which was defined for radiation protection purposes for uranium miners. It represents a specific level of energy emitted by the short-lived daughters of radon.

[c]The Roentgen is a unit which was defined for radiation protection purposes for people exposed to penetrating gamma radiation. A microRoentgen is one-millionth of a Roentgen.

Table V-2. Uranium-238 decay series

| Parent | Half-life | Decay products | Daughter |
|---|---|---|---|
| uranium-238 | 4.5 billion years | alpha | thorium-234 |
| thorium-234 | 24 days | beta, gamma | protactinium-234 |
| protactinium-234 | 1.2 minutes | beta, gamma | uranium-234 |
| uranium-234 | 250 thousand years | alpha | thorium-230 |
| thorium-230 | 80 thousand years | alpha | radium-226 |
| radium-226 | 1600 years | alpha | radon-222 |
| radon-222 | 3.8 days | alpha | polonium-218 |
| polonium-218[a] | 3 minutes | alpha | lead-214 |
| lead-214[a] | 27 minutes | beta, gamma | bismuth-214 |
| bismuth-214[a] | 20 minutes | beta, gamma | polonium-214 |
| polonium-214[a] | $\frac{2}{10,000}$ second | alpha | lead-210 |
| lead-210 | 22 years | beta | bismuth-210 |
| bismuth-210 | 5 days | beta | polonium-210 |
| polonium-210 | 140 days | alpha | lead-206 |
| lead-206 | stable | none | none |

[a]Short-lived radon daughters.

# SECTION II

## U.S. ATOMIC ENERGY COMMISSION RADIATION SURVEY REPORT FOR THE BOROUGH OF MIDDLESEX MUNICIPAL LANDFILL SITE JUNE, 1974

### PREFACE

This radiological survey was conducted by the Atomic Energy Commission (AEC) in 1974, and a limited number of copies were distributed. This printing represents a second edition for wider distribution. This effort was a prelude to the current Department of Energy program for determination of the radiological condition of sites formerly utilized by the Manhattan Engineer District (MED) and the AEC for work involving the handling, storage, or disposal of radioactive materials.

In 1974, the findings of the AEC survey indicated the presence of radioactivity in the landfill site; however, it represented no measurable radiation health or safety problem as the property was being utilized at that time. Major excavation or development of the site in the future could pose a potential for radiation exposure that could, under certain circumstances, exceed radiation protection standards for the general public. Such potential for radiation exposure would be of a low level and could be dealt with at the time of planning and development without risk to the public health or undue interference in development activities. From that long-range point of view, the AEC suggested to the Borough of Middlesex that the property record be appropriately flagged to provide assurance in the future that these considerations are recognized and evaluated in connection with requests for building permits or other possible real property zoning and land use.

# SECTION II

## U.S. ATOMIC ENERGY COMMISSION RADIATION SURVEY REPORT FOR THE BOROUGH OF MIDDLESEX MUNICIPAL LANDFILL SITE JUNE, 1974

### INTRODUCTION AND SUMMARY

At the request of the Division of Operational Safety, Atomic Energy Commission (AEC) Headquarters, a radiological survey of certain adjoining properties belonging to the Borough of Middlesex, New Jersey, and the Middlesex Presbyterian Church was made during the period March 25 to April 4, 1974. The historical background leading to the requested survey is discussed in a later section of the report. An area of approximately 3 acres was found to contain subsurface deposits of radioactivity ranging from about 3 to 60 times naturally occurring gamma background levels. This area is approximately half on Borough property and half on church property. The deposits were found to exist at depths ranging from less than 1 ft to 18 ft. Over 100 soil samples from 39 core holes were taken and analyzed for radium, uranium, and thorium at the New Brunswick Laboratory. An average radium concentration over the 3-acre area was found to be about 11 pCi/g with localized maximum levels up to 140 pCi/g.

Surface gamma measurements were found to be within the range of normal background variations except in a small area (<100 $ft^2$) where the contaminated residual is located near the surface. This area is on Borough property presently used as a sanitary landfill.

Radon samples were taken over the suspect area and inside the church building and compared with background radon levels from off-site areas. Only those samples taken in the area having elevated surface gamma readings were significantly above background levels (i.e., about an order of magnitude higher). No evidence of elevated radon was found inside the church building.

Preliminary survey findings were discussed by AEC representatives with the Mayor of Middlesex Borough at the time of the on-site survey. No such discussion was held with church representatives. Representatives

from the *Middlesex Chronicle* newspaper and radio-TV station *WCTC*, New Brunswick, made inquiries during the initial phases of the on-site survey. In response, it was indicated that survey findings would be made public when the analytical work was completed.

## CONCLUSIONS

Findings of this survey appear to support the following conclusions:

1. 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.
2. The exposure of individuals at or exceeding AEC 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.

## HISTORICAL BACKGROUND

In 1948, dirt contaminated with pitchblende ore was removed from the Middlesex Sampling Plant site to the Middlesex Municipal Landfill by a contractor during construction of an asphalt pad.

In May, 1960, during a local civil defense (CD) exercise, CD monitors detected elevated radiation levels in the landfill and questioned the source of the radioactive material. 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 likely 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 1/2 acre.

Meetings were held with local officials in November, 1960, to discuss the significance of survey findings and to offer remedial assistance. The AEC subsequently removed the part of the material

nearest the surface (about 650 $yd^3$) and covered the area with about 2 ft of clean dirt--sufficient to reduce surface radiation levels to about 50 μR/hr. Upon assurance by the AEC that no health hazard existed, Borough officials agreed the situation was satisfactory. No official record of the residual contamination exists in available Borough records.

On January 30, 1974, a meeting was again held with Middlesex Borough officials to request permission to resurvey the involved area to permit reevaluation of current conditions. It was learned that about 5 acres previously a part of the landfill had been sold to the Middlesex Presbyterian Church and a church building erected thereon. Location of the suspect area, as recollected by "old timers" at the Borough, was near the boundary between church and dump properties. The accuracy of this information has been subsequently confirmed by survey data. At this meeting, the press was informed of AEC survey plans and briefed on the history surrounding the suspected contamination.

## Description of the Area Surveyed

The area bounded by Mountain Avenue, Pershing Avenue, Westminister Street, and Bound Brook is shown in Fig. 1. In 1948, the time when it is suspected that contaminated soil was disposed of at the landfill, essentially all of the area was designated as a landfill site for the Borough of Middlesex.

Subsequent to the 1961 AEC cleanup action, a 5-acre plot was sold to the Middlesex Presbyterian Church and a building constructed. It was understood from discussions with local people familiar with the history of the site that the church and municipal building were constructed on "nonfill" or solid ground.

In 1948, the landfill area was essentially a gully from the brook to within 100 to 200 ft of Mountain Avenue. The area is now, for the most part, level to within about 100 ft of the brook--indicating the amount of fill which has been deposited. Bound Brook flood plain elevation is about 15 ft below Mountain Avenue. The surface of the landfill has reportedly risen 8 to 10 ft since 1961. Findings from the gamma scanning of core holes confirm the presence of contaminated material at successively greater depths as one goes away from Mountain Avenue toward the brook.

The current landfill site lies to the south and southeast of the Presbyterian Church property and is expected to reach final elevations and terminate operation in 1974. Borough plans for the site are reportedly contingent on the availability of federal funds. If funds become available, a park-recreation area may be developed in the present landfill area.

## SURVEY FINDINGS

### Surface Gamma Survey

Figure 2 shows a schematic of the area covered by systematic traverses of areas presently or formerly used for landfill disposal. Other areas around the buildings and parking lots which were not amenable to such systematic traverses were surveyed and found to be generally in the background range of 9 to 11 μR/hr. Asphalt parking areas tended to measure somewhat lower (i.e., 7 to 9 μR/hr).

Core holes 1, 2, and 6 (see Fig. 3) were drilled to explore areas with elevated gamma readings (i.e., 80 μR/hr, 17 μR/hr, and 30 μR/hr, respectively). Drillings confirmed the presence of contaminated material near the surface. Core hole 34 was drilled at the other location of elevated reading (i.e., 20 μR/hr), and no significant subsurface contamination was found. Core holes 7 and 20, with normal background readings at the surface, revealed substantial deposits of radioactive materials at depths from 2 to 4 ft. Hence, it is apparent that surface readings are not a conclusive measurement unless the deposit is very near the surface.

### Radon Survey

Radon surveys were conducted by the AEC Health and Safety Laboratory (HASL). The intended purpose of the radon survey was to assist in identifying the location of contaminated material in the dump site. As with the surface gamma survey, the radon data are not conclusively indicative for deeper deposits. Extension of the interpretation of radon survey data for other purposes such as the estimation of potential radon sources affecting future construction in the area is not attempted.

Background radon emanation within a few miles of the dump site as measured by HASL revealed fluctuations up to a factor of six. These measurements are made by sealing a "flux can" to the ground and, after a sampling period of 30 min, transferring the trapped air from the can to a radon scintillation chamber. Radon emanation rate may then be calculated in curies per unit area per unit time. Comparison with similar type measurements made in the suspect area showed some samples to be above the reference off-site background range. All but one of the elevated samples are in the small area with surface radiation levels of 20 to 30 μR/hr and are about 10 to 20 times concurrent off-site radon levels. The other elevated sample, which showed an emanation rate about twice the maximum background levels, was from an area with surface gamma readings of 14 to 15 μR/hr.

Radon and radon daugher measurements made in the church building were indistinguishable from naturally occurring levels.

## Subsurface Survey

Thirty-nine core holes were drilled as shown in Fig. 3. Each hole was scanned with a shielded Geiger-Mueller (G-M) probe, and gamma radiation readings are tabulated in Table 1. The maximum radiation level detected was about 0.6 mR/hr. Contaminated material was detected over an area of about 3 acres as shown by the shaded area on Fig. 1. Contamination was found to exist over this area in a layer generally 3 to 5 ft in thickness and at depths from less than 1 ft to about 18 ft. Two typical cross sections through the contaminated area are illustrated in Figs. 4 and 5. It is roughly estimated that between 15-20,000 $yd^3$ of contaminated material may exist in this area. If so, an obvious dilution of the remaining 6000 $yd^3$ hauled here in 1948 has occurred. It should be pointed out that in this report "contaminated" refers to areas where gamma radiation readings in core holes exceed 50 cpm. This represents about three times observed background levels in the core holes (i.e., 20 μR/hr). Selection of this criterion is based solely on the fact that the level is sufficiently above field instrument sensitivity and beyond the range of background fluctuations to allow some degree of confidence that the suspect radioactive material is present. The

criterion is not selected to suggest that higher levels represent a health hazard.

Soil samples were analyzed by the New Brunswick Laboratory for uranium, thorium, and radium concentrations.

Table 2 is a compilation by core hole of the analytical results. It is noted that radium concentrations over the 3-acre area average about 11 pCi/g with the maximum observed to be 140 pCi/g. Naturally occurring radium in area soil is about 1 pCi/g (NYO-1521). Uranium levels up to 280 ppm were found. This compares with the 10 CFR 40 *de minimus* concentration of 500 ppm. Uranium concentrations appear to track consistently with radium concentrations as one would expect. Thorium concentrations are not appreciably different from general background levels reported to EPA (ORP/SID 72-1).

Soil samples were collected along the brook to assess any run off from the contaminated residual. Grass was also collected in the vicinity of core hole 20 for analysis. These analytical data are included in Table 2.

## Evaluation of Data

Two conditions require evaluation to permit an understanding of the health and safety implications of radioactive material remaining in the landfill site.

- Case 1 - What is the potential for radiation exposure to individuals assuming the area remains undeveloped or otherwise undisturbed by excavation below the existing surface?
- Case 2 - What is the potential radiation exposure to individuals if the area is developed and subsurface deposits are disturbed and/or exposed?

Case 1 suggests a situation which may exist at the site for at most a few years. The present landfill site is expected to terminate operation in the immediate future. The part of the church property which contains radioactive material will likely have a development potential independent of that of the Borough Landfill but equally as unpredictable at this time.

It is clear, however, that for as long as Case 1 conditions exist the credible potential for gamma radiation or radon exposure approaching a fraction of the AEC population guides is negligible. Certainly no health hazard attributable to the radioactive deposit can be imagined for Case 1.

For the conditions anticipated for Case 2, one must consider the additive exposure effect of gamma radiation levels existing at the site and the radon concentrations which emanate from residual radium deposits.

Projected external gamma exposure from maximum residual radiation levels (0.6 mR/hr) could be on the order of 5 rem/year if one assumed continuous occupancy and ignored the practicalities of geometry, attenuation, and radiation field averaging. One may allow at least a factor of 0.1 reduction to account for these parameters and retain some margin of conservatism. Thus, exposure at the 0.5 rem/year level may be considered possible under very limited circumstances. Further reduction of this projected exposure rate is probably possible; however, since no radiological control exists over the use of the site, it is considered inadvisable to rule out those circumstances which are, in fact, theoretically possible.

Projected radon exposure becomes significant only if buildings are constructed in the contaminated area causing a concentration or buildup inside the structures. The following section provides a computation of radon buildup in a house assuming soil concentrations on the order of 100 pCi/g. Based on soil analyses in Table 2, this level must be considered credible.

## THEORETICAL IMPACT OF RADIATION RESIDUAL ON RADON LEVELS IN FUTURE CONSTRUCTION AT THE MIDDLESEX MUNICIPAL LANDFILL SITE

### Statement of Problem

This section develops a theoretical calculation of the radon levels that would be expected in the baseline of a house constructed on the Middlesex Borough Municipal Landfill site and subject to the effects of a residual concentration such as that which remains in the 3-acre area identified by the 1974 AEC-OR survey of the landfill.

Statement of Basic Assumptions

1. Regarding the prevailing radium concentration: Soil analyses over the 3-acre area containing residual pitchblende contamination indicates an average radium concentration of about 11 pCi/g. This compares to a naturally occurring background level of 1 pCi/g. For this calculation, to assure conservatism, the five highest soil samples have been averaged yielding a radium concentration of about 100 pCi/g. It is assumed that a house could be exposed to soil containing such a radium level.
2. Regarding the hypothetical future house construction: It is assumed that the floor of the baseline is 8 ft below grade and dimensions of the basement are 60 x 30 ft. It is assumed that backfill around the basement wall extends 2 ft in the perpendicular direction out from the four basement walls. The backfill is assumed contaminated to a level of 100 pCi of radium per gram of soil.

Utilizing these basic assumptions, the following calculation is made to attempt to predict radon levels in future housing which might be constructed on the landfill site.

The source, $S$, of the radon will be the inventory of radium in the volume, $V_b$, of backfill:

$$S = V_b \text{ (100 pCi/g)}$$
$$V_b = (60' \times 8' \times 2') \text{ 2 walls} + (30' \times 8' \times 2') \text{ 2 walls} = 3 \times 10^3 \text{ ft}^3 \qquad (1)$$
$$\rho = 100 \text{ lbs/ft}^3 = \text{density of backfill}$$
$$S = 3 \times 10^3 \text{ ft}^3 \times 100 \text{ lbs/ft}^3 \times 450 \text{ g/lb} \times 100 \text{ pCi/g} = 13.5 \text{ mCi.}$$

Assuming the radon to be in equilibrium with the radium, there would be a total of 13.5 mCi of radon produced in the backfill. It is crudely estimated from geometrical considerations that about one-third of the radon produced or 4.5 mCi would enter the basement.

Now the question becomes what is the maximum concentration of radon which will occur in the house assuming a minimum ventilation rate of one-half the building volume per hour. This ventilation rate is reported

by ORNL to be the lowest observed in their feasibility studies [illegible] contaminated natural gas usage in connection with Project Gasbuggy.

Let

$N$ = the number of radon atoms at time, $t$,

$C_1$ = a constant source of radon atoms,

= $4.5 \times 10^{-3}$ Ci $\times$ $3.7 \times 10^{10}$ atoms/sec = $1.7 \times 10^{8}$ atoms/sec,

$C_2$ = a rate at which radon atoms are removed via ventilation

= 0.5/hr = $1.4 \times 10^{-4}$/sec.

Therefore,

$$\frac{dN}{dt} = C_1 - \lambda N - C_2 N. \tag{2}$$

Where $\lambda$ is the radon decay constant,

$$\lambda = \frac{0.693}{3.8 \text{ days} \times 24 \text{ hr/day} \times 3600 \text{ sec/hr}} = 2.1 \times 10^{-6}/\text{sec}.$$

Since $\lambda$ is much less than $C_2$, for purposes of this calculation, the radiological decay of radon will be neglected and the $\lambda N$ term in equation (2) drops out leaving

$$\frac{dN}{dt} = C_1 - C_2 N. \tag{3}$$

Integrating equation (3) and solving for $N$ gives

$$N = \frac{C_1}{C_2}\left[1 - \exp(-C_2 t)\right]. \tag{4}$$

Let $t \to \infty$ to represent an equilibrium condition

$$N = \frac{C_1}{C_2} \text{ at equilibrium} \tag{5}$$

$$= \frac{1.7 \times 18^{8} \text{ atoms/sec}}{1.4 \times 10^{-4}/\text{sec}} = 1.2 \times 10^{12} \text{ atoms of radon.}$$

The radon activity at equilibrium in the house will be

$$N = \frac{1.3 \times 10^{12} \text{ atoms} \times 2.1 \times 10^{-6}/\text{sec}}{3.7 \times 10^{10} \text{ atoms/sec - Ci}} = 7 \times 10^{-5} \text{ Ci.} \tag{6}$$

The equilibrium radon concentration, $X$, in the basement due to the radium inventory in the backfill is therefore

$$X = \frac{70 \text{ Ci}}{\text{volume of basement}} = 1.4 \times 10^{-7} \text{ Ci/cc.}$$

This equals a working level concentration of 1.3 WL.

It should be pointed out that, if the house were built without a basement upon a concrete slab on top of ground contaminated at the 10 pCi/g concentration, the radon levels in the house may be two to three times below this level.

In the above calculations, no credit is taken for the attenuation of radon as it diffuses through the walls of the structure.

ORNL-DWG 80-8232C

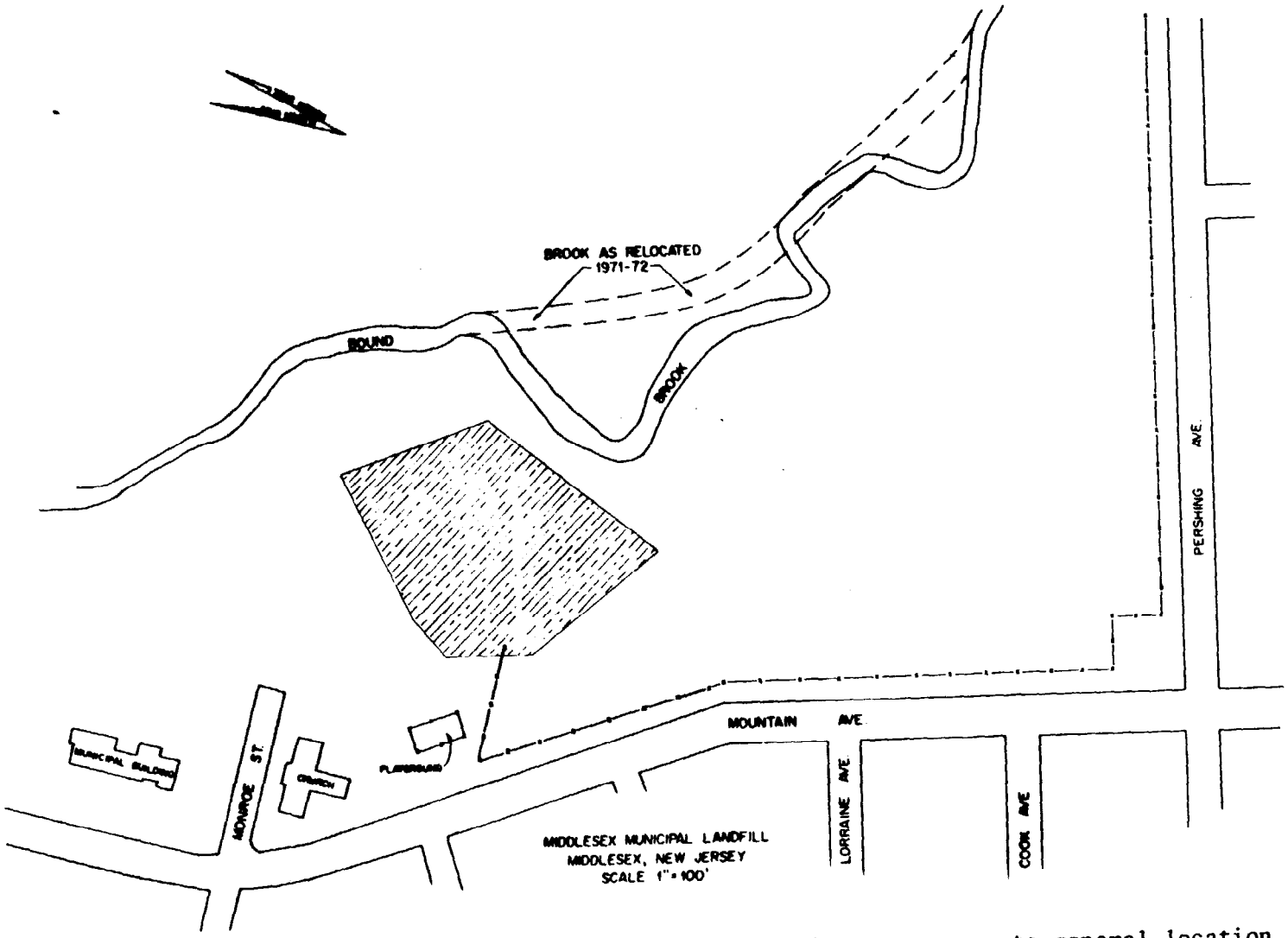


Fig. 1. Middlesex Municipal Landfill site. (Shaded area represents general location where contaminated material was found during the 1974 survey.)

ORNL-DWG 80-8232B

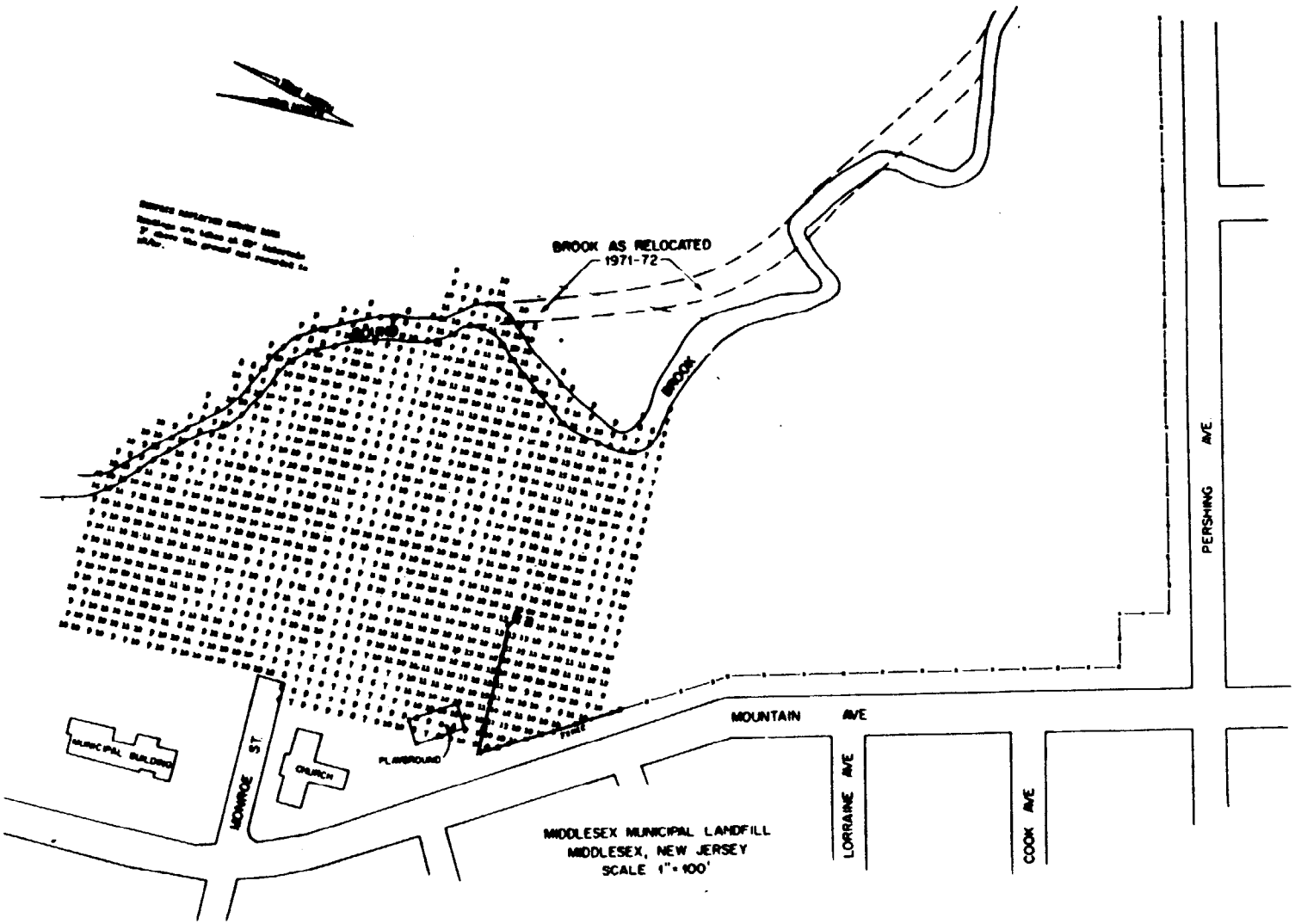


Fig. 2. Gamma radiation traverse of Middlesex Municipal Landfill taken during 1974 survey.

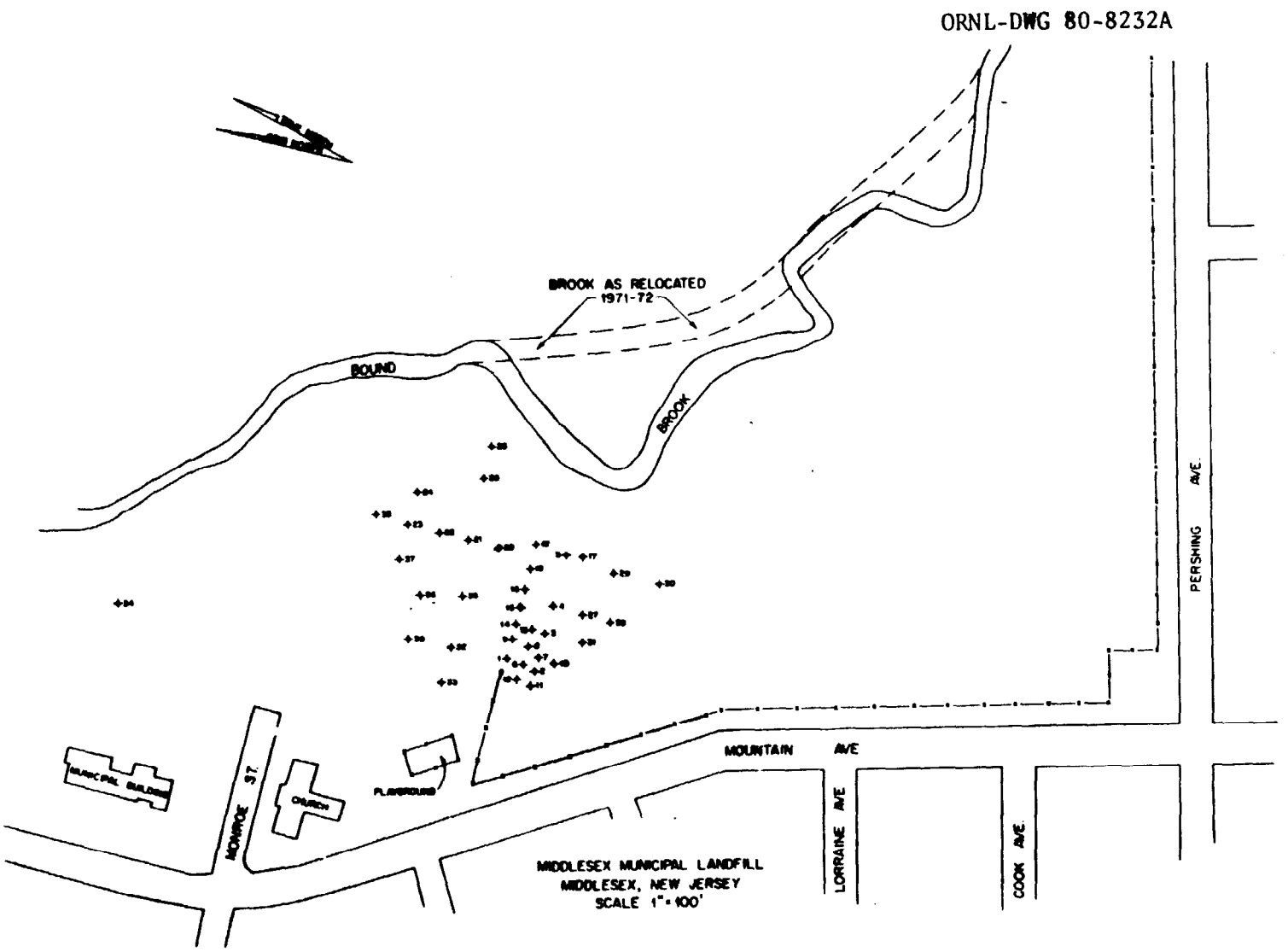


Fig. 3. Location of auger holes during the 1974 survey of the Middlesex Municipal Landfill.

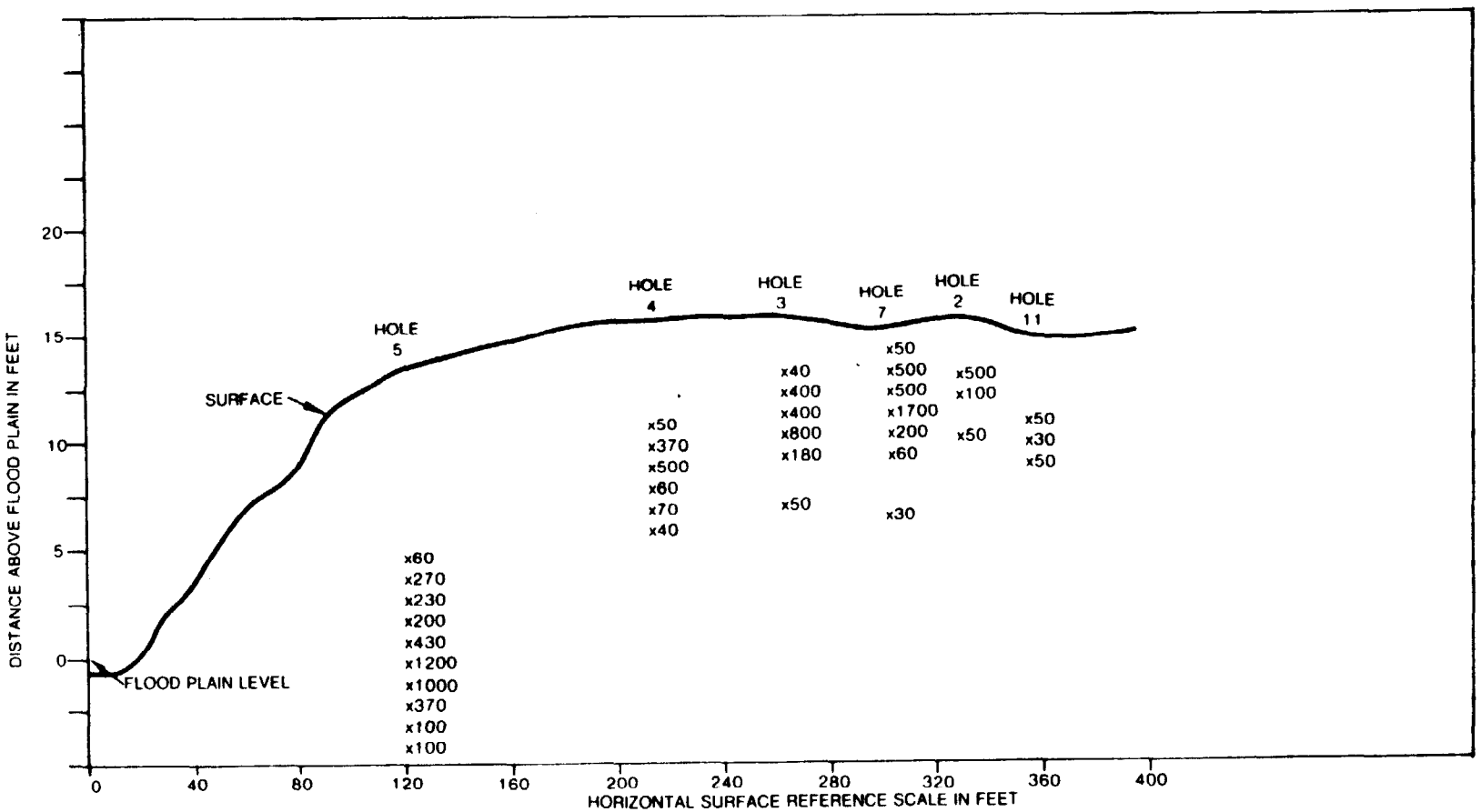


Fig. 4. Surface cross section measurements for holes 5, 4, 3, 7, 2, and 11 (counts/min). (Source: U.S. Atomic Energy Commission, *Radiation Survey Report of the Middlesex Landfill Site*, June, 1974.)

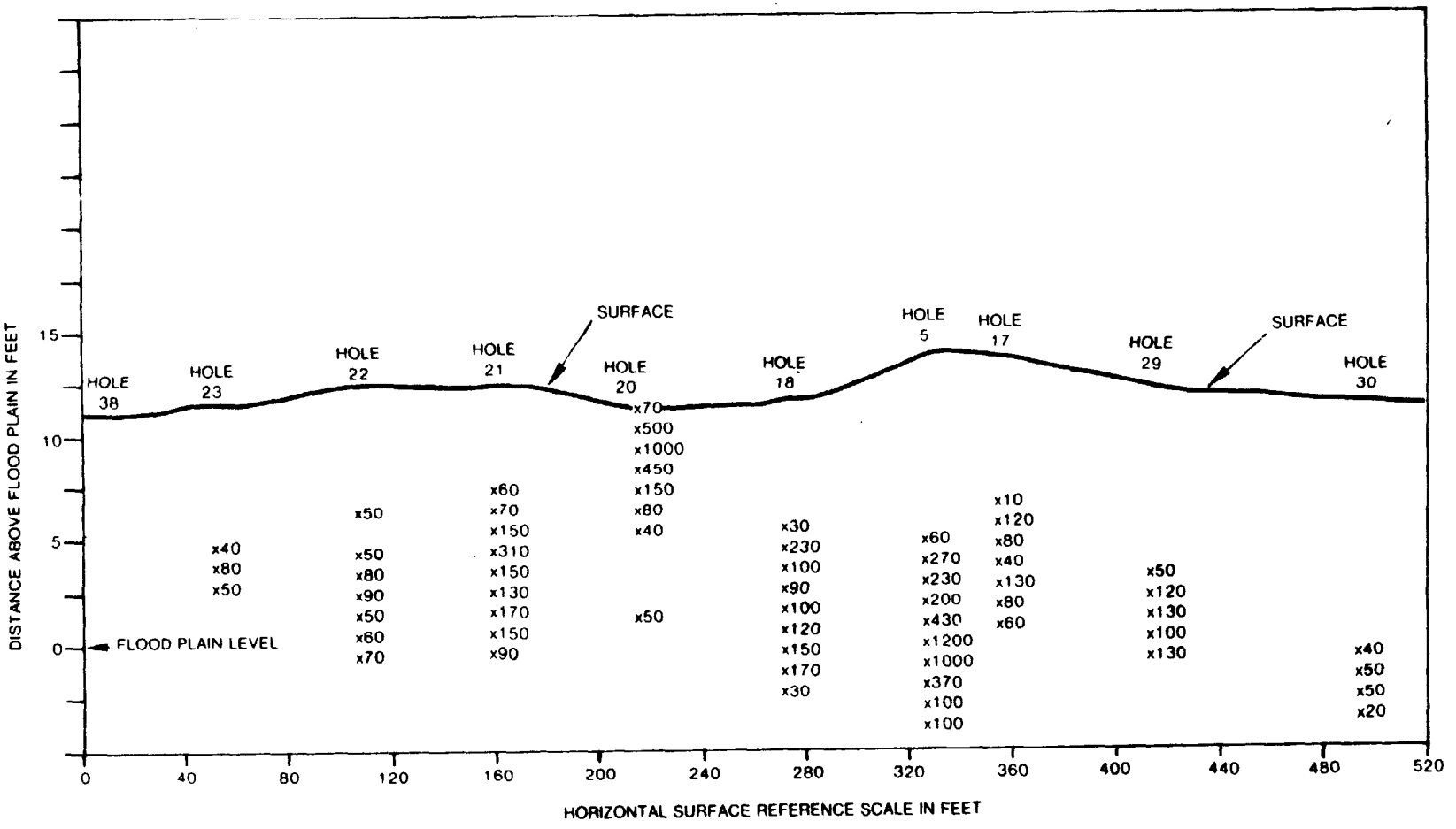


Fig. 5. Cross section and measurements from holes 38, 23, 22, 21, 20, 18, 5, 17, 29, and 30 (counts/min). (Source: U.S. Atomic Energy Commission, *Radiation Survey Report of the Middlesex Landfill Site*, June, 1974.)

Table 1. Radiation profile of core holes, readings in counts per minute (CPM)
2.6 CPM ≈ 1 μR/hr

| Hole no. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface elevation above the floodplain in ft | 14.50 | 15.24 | 16.26 | 16.19 | 14.06 | 16.25 | 15.65 | 15.16 | 14.17 | 14.98 | 15.08 | 15.00 | 15.23 | 14.35 | 13.44 | 14.44 | 13.81 |
| Gamma level, μR/hr, at 3 ft above hole | 80 | 17 | 13 | 8 | 11 | 30 | 11 | 15 | 10 | 11 | 10 | 12 | 9 | 9 | 9 | 9 | 11 |
| Hole - depth in ft | | | | | | | | | | | | | | | | | |
| 0 | 700 | | | 20 | 30 | 60 | 50 | 20 | 20 | 30 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| 1 | | | | 30 | 20 | 170 | 50 | | | 20 | 20 | 40 | 30 | 10 | 40 | 20 | 20 |
| 2 | 270 | 500 | 40 | 10 | 20 | | 500 | 150 | 90 | 20 | 40 | 40 | 80 | 70 | 30 | 40 | 10 |
| 3 | 70 | 100 | 400 | 10 | 10 | 70 | 500 | 110 | 100 | 20 | 20 | 20 | 100 | 60 | 50 | 240 | 10 |
| 4 | | | 400 | 10 | 10 | | 1700 | | 100 | 50 | 50 | 10 | 220 | 150 | 50 | 800 | 10 |
| 5 | | | 800 | 50 | 10 | | 200 | 110 | 40 | 20 | 30 | 30 | 120 | 170 | 370 | 480 | 20 |
| 6 | 40 | 50 | 180 | 370 | 10 | 40 | 60 | | 40 | 20 | 50 | 40 | 60 | 70 | 130 | 120 | 20 |
| 7 | | | | 500 | 10 | | | | 50 | 30 | 30 | 50 | 20 | 30 | 60 | 110 | 10 |
| 8 | | | | 60 | 10 | | | 30 | 70 | 10 | 30 | 30 | 10 | 20 | 40 | 120 | 120 |
| 9 | 25 | 50 | 50 | 70 | 60 | 30 | 30 | | 50 | 20 | 30 | 40 | 30 | 20 | 50 | 110 | 80 |
| 10 | | | 50 | 40 | 270 | | | | 30 | 10 | 20 | 20 | 20 | 10 | 40 | 90 | 40 |
| 11 | 40 | 30 | | 40 | 230 | | | 30 | 40 | 10 | 20 | 20 | 30 | 10 | 30 | 100 | 130 |
| 12 | | | | 50 | 200 | 30 | 30 | | 30 | | 20 | | 30 | 20 | 40 | 70 | 80 |
| 13 | | | | 50 | 430 | | | 30 | | | 20 | | | | 40 | 20 | 60 |
| 14 | | | | | 1200 | | 30 | | | | 30 | | | | | 10 | |
| 15 | | | | | 1000 | 20 | | | | | 30 | | | | | 20 | |
| 16 | | | | | 370 | 30 | | | | | 20 | | | | | | |
| 17 | | | | | 100 | | | | | | 20 | | | | | | |
| 18 | | | | | 100 | | | | | | 20 | | | | | | |

Table 1. Radiation profile of core holes, readings in counts per minute (CPM) 2.6 CPM ≈ 1 μR/hr (cont.)

| Hole no. | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface elevation above the floodplain in ft | 11.70 | 12.55 | 11.40 | 12.56 | 12.34 | 11.67 | 10.34 | 9.91 | 7.39 | 16.38 | 16.99 | 12.39 | 12.10 | 15.96 | 14.06 | 14.77 | 5.55 |
| Gamma level, μR/hr, at 3 ft above hole | 10 | 10 | 10 | 9 | 8 | 9 | 10 | 11 | 10 | 8 | 9 | 8 | 9 | 9 | 12 | 12 | 20 |
| Hole - depth in ft | | | | | | | | | | | | | | | | | |
| 0 | 20 | 20 | 70 | 10 | 10 | 20 | 20 | 30 | 20 | 20 | 30 | 20 | 20 | 10 | 20 | 20 | 20 |
| 1 | 30 | 40 | 500 | 10 | 20 | 10 | 30 | 20 | 10 | 20 | 20 | 20 | 20 | 10 | 20 | 20 | 40 |
| 2 | 20 | 40 | 1000 | 20 | 20 | 30 | 20 | 20 | 20 | 10 | 20 | 20 | 10 | 10 | 40 | 30 | 30 |
| 3 | 10 | 20 | 450 | 30 | 10 | 30 | 30 | 20 | 20 | 20 | 30 | 20 | 10 | 10 | 40 | 50 | 30 |
| 4 | 30 | 30 | 150 | 20 | 10 | 20 | 20 | 20 | 10 | 10 | 20 | 10 | 10 | 20 | 50 | 20 | 20 |
| 5 | 20 | 120 | 80 | 60 | 10 | 20 | 20 | 20 | 10 | 10 | 20 | 10 | 20 | 10 | 50 | 30 | 20 |
| 6 | 30 | 270 | 40 | 70 | 50 | 20 | 30 | 20 | 30 | 10 | 20 | 20 | 20 | 60 | 30 | 40 | 30 |
| 7 | 230 | 70 | | 150 | 20 | 40 | 70 | 80 | 40 | 50 | 10 | 20 | 10 | 50 | 30 | 30 | 10 |
| 8 | 100 | 70 | | 310 | 50 | 80 | 70 | 90 | 30 | 120 | 10 | 20 | 10 | 40 | 30 | 30 | 20 |
| 9 | 90 | 50 | | 150 | 80 | 50 | 50 | 90 | 30 | 60 | 60 | 50 | 10 | 20 | 30 | 30 | |
| 10 | 100 | 50 | 50 | 130 | 90 | 20 | 50 | 80 | 10 | 40 | 50 | 120 | 20 | 30 | 20 | 20 | |
| 11 | 120 | 30 | | 170 | 50 | 20 | | 80 | 20 | 40 | 40 | 130 | 10 | 30 | 20 | 20 | |
| 12 | 150 | 20 | | 150 | 60 | 20 | | | | 50 | 40 | 100 | 40 | | 30 | 20 | |
| 13 | 170 | | | 90 | 70 | 30 | | | | 50 | | 130 | 50 | | | | |
| 14 | 30 | | | | | | | | | | | | 50 | | | | |
| 15 | | | | | | | | | | | | | 20 | | | | |

Table 1. Radiation profile of core holes, readings in counts per minute (CPM) 2.6 CPM ≈ 1 μR/hr (cont.)

| Hole no. | 35 | 36 | 37 | 38 | 39 |
|---|---|---|---|---|---|
| Surface elevation above the floodplain in ft | 13.23 | 13.20 | 12.83 | 11.18 | 13.61 |
| Gamma level, μR/hr, at 3 ft above hole | 10 | 10 | 10 | 10 | 10 |
| Hole - depth in ft | | | | | |
| 0 | 20 | 10 | 10 | 10 | 10 |
| 1 | 30 | 10 | 10 | 10 | 40 |
| 2 | 20 | 10 | 20 | 10 | 30 |
| 3 | 30 | 20 | 30 | 10 | 60 |
| 4 | 60 | 100 | 20 | 10 | 40 |
| 5 | 50 | 230 | 20 | 20 | 70 |
| 6 | 60 | 110 | 10 | 20 | 40 |
| 7 | 180 | 60 | 20 | 30 | 30 |
| 8 | 180 | 50 | 40 | 30 | 20 |
| 9 | 120 | 40 | 40 | 10 | 20 |
| 10 | 50 | | | 30 | 20 |
| 11 | 30 | | | 20 | 20 |
| 12 | | | | 20 | 30 |
| 13 | | | | 20 | |

Table 2. Core hole soil samples

| Sample Location | Ra pCi/g | μg U/g[a] | μg Th/g[a] |
|---|---|---|---|
| **Hole 1** | | | |
| 0- 1 ft | 23 | 40 | 5 |
| 6- 8 ft | 7 | 6 | 7 |
| 10-12 ft | 3.9 | 3 | 8 |
| **Hole 2** | | | |
| 3- 5 ft | 5.4 | 5 | 11 |
| 6- 8 ft | 1.2 | 2 | 8 |
| 9-11 ft | 0.5 | 3 | 7 |
| 11-12 ft | 0.1 | 19 | 9 |
| **Hole 3** | | | |
| 6- 8 ft | 140 | 280 | 9 |
| 9-11 ft | 28 | 40 | 9 |
| 11-13 ft | 6 | 11 | 11 |
| 13-18 ft | 3 | 7 | 11 |
| **Hole 4** | | | |
| 6- 8 ft | 97 | 130 | 10 |
| 12 ft | 13 | 15 | 10 |
| **Hole 5** | | | |
| 13-20 ft | 26 | 90 | 6 |
| **Hole 6** | | | |
| 0- 2 ft | 13 | 40 | 8 |
| 2- 5 ft | 15 | 70 | 6 |
| 8-13 ft | 5 | 6 | 7 |
| 13-18 ft | 7.1 | 4 | 9 |
| 18-20 ft | 2.5 | 3 | 7 |
| **Hole 7** | | | |
| 0- 2 ft | 0.3 | 3 | 9 |
| 2- 5 ft | 60 | 60 | 8 |
| 13-20 ft | 13 | 4 | 8 |
| **Hole 8** | | | |
| 0- 2 ft[b] | 33 | 80 | 11 |
| 1- 5 ft | 23 | 40 | 18 |
| 5- 8 ft | 9.5 | 12 | 10 |
| 8-13 ft | 4.8 | 8 | 19 |
| **Hole 9** | | | |
| 0- 2 ft | 24 | 14 | 7 |
| 2- 5 ft | 19 | 30 | 12 |
| 5- 8 ft | 3.6 | 6 | 14 |
| 8-13 ft | 4.7 | 10 | 25 |
| **Hole 10** | | | |
| 0- 2 ft | <0.1 | 4 | 11 |
| 2- 5 ft | 5.8 | 3 | 6 |
| 5- 8 ft | 5.7 | 3 | 5 |
| 8-13 ft | 1.5 | 1 | 5 |
| **Hole 11** | | | |
| 0- 2 ft | 2.4 | 3 | 7 |
| 5-13 ft | 8.0 | 3 | 8 |
| **Hole 12** | | | |
| 0- 2 ft | 7.6 | 3 | 8 |
| 2- 8 ft | 1.8 | 3 | 7 |
| 8-13 ft | 2 | 4 | 11 |
| **Hole 13** | | | |
| 0- 2 ft | 1 | 3 | 7 |
| 2- 5 ft | 6 | 40 | 14 |
| 5- 8 ft | 10 | 17 | 20 |
| **Hole 14** | | | |
| 0- 2 ft | 4.1 | 3 | 7 |
| 2- 5 ft | 9.9 | 17 | 25 |
| 5-10 ft | 3.7 | 6 | 20 |
| 10-12 ft | 3.6 | 3 | 6 |
| **Hole 15** | | | |
| 0- 2 ft | 6.2 | 8 | 13 |
| 2- 5 ft | 9.0 | 12 | 10 |
| 5- 8 ft | 25 | 30 | 15 |
| **Hole 16** | | | |
| 0- 2 ft | 6 | 3 | 10 |
| 8-12 ft | 12 | 22 | 9 |
| 18-20 ft | 8.7 | 9 | 8 |
| **Hole 17** | | | |
| 0- 1 ft[b] | <1.0 | 4 | 12 |
| 0- 8 ft | 2.8 | 3 | 10 |
| 8-20 ft | 7.3 | 14 | 5 |
| **Hole 18** | | | |
| 0- 2 ft | 3.7 | 3 | 12 |
| 10-15 ft | 4 | 8 | 7 |
| 15-20 ft | 9.3 | 12 | 5 |
| **Hole 19** | | | |
| 0- 3 ft | 7.7 | 3 | 13 |
| 3- 8 ft | 4.2 | 20 | 7 |
| 8-13 ft | 6.1 | 7 | 15 |
| 13-18 ft | 1.2 | 5 | 8 |
| **Hole 20** | | | |
| 0- 3 ft | 4 | 6 | 9 |
| 3- 8 ft | 112 | 200 | 8 |
| 8-13 ft | 5.8 | 8 | 9 |
| **Hole 21** | | | |
| 0- 5 ft | 2.9 | 4 | 7 |
| 5- 8 ft | 5 | 3 | 4 |
| 8-13 ft | 10 | 15 | 7 |
| 13-18 ft | 3.3 | 7 | 6 |
| **Hole 22** | | | |
| 0- 3 ft | 3.5 | 1.5 | 3 |
| 3- 7 ft | 3.4 | 1.5 | 5 |

Table 2. Core hole soil samples (cont.)

| Sample Location | Ra pCi/g | μg U/g[a] | μg Th/g[a] |
|---|---|---|---|
| **Hole 23** | | | |
| 0- 3 ft | <1.0 | 2 | 5 |
| 3- 8 ft | 10 | 7 | 5 |
| 8-13 ft | 8.3 | 4 | 6 |
| **Hole 24** | | | |
| 0- 3 ft | 5.0 | 2 | 4 |
| 3- 8 ft | 5.6 | 2 | 4 |
| **Hole 25** | | | |
| 0- 3 ft | 4.0 | 4 | 7 |
| 3- 8 ft | 4.2 | 3 | 6 |
| 8-11 ft | 4.4 | 2 | 5 |
| **Hole 26** | | | |
| 0- 3 ft | 3.3 | 5 | 6 |
| **Hole 27** | | | |
| 0- 3 ft | 2.9 | 3 | 7 |
| 3- 8 ft | 4.4 | 9 | 9 |
| **Hole 28** | | | |
| 0- 3 ft | 3.4 | 2 | 5 |
| 3- 8 ft | 0.5 | 1 | 9 |
| 8-13 ft | 5 | 7 | 6 |
| **Hole 29** | | | |
| 0- 3 ft | 4.5 | 1.5 | 4 |
| 8-13 ft | 4 | 5 | 3 |
| 13-18 ft | 19 | 25 | 7 |
| **Hole 30** | | | |
| 0- 3 ft | 2.8 | 3 | 5 |
| 3- 8 ft | 1.7 | 2 | 5 |
| 8-13 ft | 7 | 3 | 5 |
| 13-18 ft | 3.3 | 2 | 4 |
| **Hole 31** | | | |
| 0- 3 ft | 6.7 | 3 | 6 |
| 3- 8 ft | <0.1 | 11 | 11 |
| 8-13 ft | 2.8 | 3 | 5 |
| **Hole 32** | | | |
| 0- 3 ft | 3 | 4 | 6 |
| 3- 8 ft | <0.1 | 4 | 15 |
| 8-13 ft | 4.7 | 2 | 7 |
| **Hole 33** | | | |
| 0- 3 ft | 8.7 | 4 | 8 |
| 3- 8 ft | 3.7 | 2 | 6 |
| 8-13 ft | 5.2 | 2 | 6 |
| **Hole 34** | | | |
| 0- 3 ft | 5.1 | 4 | 11 |
| 3- 8 ft | <1.0 | 4 | 7 |
| 8-13 ft | 2.4 | 4 | 10 |
| **Hole 35** | | | |
| 0- 3 ft | 3.9 | 2 | 7 |
| 3- 8 ft | 11 | 16 | 8 |
| 8-13 ft | 5.3 | 9 | 5 |
| **Hole 36** | | | |
| 0- 3 ft | 3.1 | 4 | 5 |
| 3- 8 ft | 7.6 | 17 | 7 |
| 8-13 ft | 11 | 16 | 10 |
| **Hole 37** | | | |
| 0- 3 ft | 3.5 | 2 | 4 |
| 3- 8 ft | 5.8 | 2 | 5 |
| 8-13 ft | 0.8 | 2 | 5 |
| **Hole 38** | | | |
| 0- 7 ft | <0.1 | 2 | 6 |
| 7-13 ft | 4.1 | 5 | 5 |
| **Hole 39** | | | |
| 0- 8 ft | 1.5 | 3 | 7 |
| 8-13 ft | 9.5 | 4 | 7 |
| **Creek 1** | | | |
| On flood-plane N of hole 38 | 3.1 | 1.5 | 4 |
| **Creek 2** | | | |
| On flood-plane N of hole 38 | 3.5 | 1.5 | 3 |
| **Creek 3** | | | |
| On flood-plane E of hole 26 | 4.0 | 2 | 5 |
| **Creek 4** | | | |
| On flood-plane E of hole 5 | 4.6 | 1.5 | 4 |
| Grass at hole 20 | 3.4 | 0.4 | 1.5 |

[a]Accuracy of these values is estimated to be ±20%.

[b]Sample from the original hole which could not be drilled beyond this depth.

*U.S. GOVERNMENT PRINTING OFFICE : 1980 0-310-912/1017

Exhibit II (4) - NEPA Documents

The documents listed below fulfill the NEPA requirements for the subject properties. They are included in this section of the docket.


| | Page |
|---|---|
| Argonne National Laboratory. Action Description Memorandum, Proposed 1984 Remedial Actions at Middlesex, New Jersey, Argonne, IL, April 27, 1984. | II-153 |
| Memorandum, Franklin E. Coffman, Office of Terminal Waste Disposal and Remedial Action, Office of Nuclear Energy, Department of Energy, to File. "Action Description Memorandum (ADM) Review: Proposed 1984 Remedial Actions at Middlesex, New Jersey," September 7, 1984. | II-209 |

# ACTION DESCRIPTION MEMORANDUM

## PROPOSED 1984 REMEDIAL ACTIONS AT MIDDLESEX, NEW JERSEY

Prepared by

Environmental Research Division
Argonne National Laboratory
Argonne, Illinois

Draft: April 12, 1984
Final: April 27, 1984

NOTE: The remedial action guidelines contained in Appendix A to this report have been superseded by those contained in Appendix A to Exhibit I of the certification docket.

Prepared for

U.S. Department of Energy
Oak Ridge Operations
Technical Services Division
Oak Ridge, Tennessee

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## 1. SUMMARY OF PROPOSED ACTIONS AND RELATED ACTIVITIES

Under the Formerly Utilized Sites Remedial Action Program (FUSRAP), the U.S. Department of Energy (DOE) proposes to carry out some remedial actions during 1984 at two sites in Middlesex, New Jersey (Figures 1.1 and 1.2). The proposed 1984 remedial actions include cleanup of radioactively contaminated materials located at the Middlesex Landfill and interim storage of these contaminated materials at DOE's Middlesex Sampling Plant site. The major proposed actions include:

- Excavation of approximately 14,000 $m^3$ (18,000 $yd^3$)* of landfill materials, of which about one-third (4,600 $m^3$ [6,000 $yd^3$])* is expected to be radioactively contaminated. (These wastes are expected to be co-contaminated with hazardous chemicals.**)

- Transport of the 4,600 $m^3$ (6,000 $yd^3$)* of radioactively contaminated wastes to the Sampling Plant site and placement of these materials in a new interim-storage pile on the existing asphalt storage pad.

- Backfilling of the excavated area at the Landfill with the 9,200 $m^3$ (12,000 $yd^3$)* of excavated wastes that have radionuclide concentrations below the cleanup criteria, supplemented with approximately 4,600 $m^3$ (6,000 $yd^3$)* of clean fill materials to restore the Landfill to the original grade.

- Construction of support facilities at the Landfill, including an access road, a vehicle decontamination area, and an area for stockpiling and drying excavated materials (as necessary) prior to transport.

Details of the various proposed activities are given in Section 4 (Proposed Action and Alternatives).

The radioactively contaminated materials will be removed from the Landfill according to DOE's radiological guidelines for residual radionuclide concentrations in soil at FUSRAP sites (Appendix A). Following removal of the

---

*These volumes are being revised as detailed engineering progresses. As of April 24, 1984, the estimated total volume to be excavated has been reduced to 13,000 $m^3$ (16,000 $yd^3$), of which 4,200 $m^3$ (5,500 $yd^3$) is expected to be radioactively contaminated.

**Because of the chemical contamination, the proposed actions are being coordinated with the U.S. Environmental Protection Agency (EPA) under a Memorandum of Understanding between DOE and EPA regarding hazardous wastes (see Section 5.2.1).

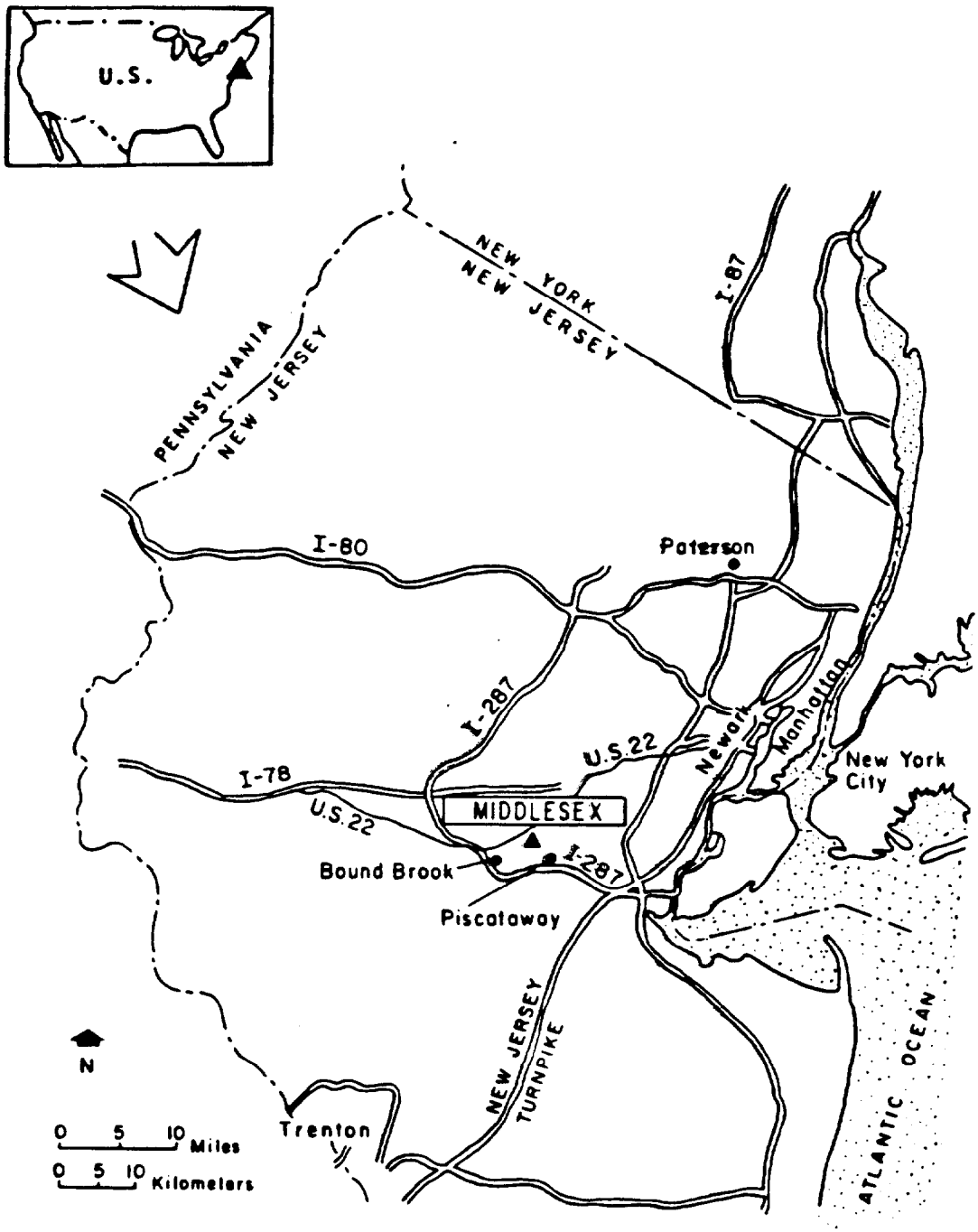



Figure 1.1. Location of Middlesex, New Jersey.

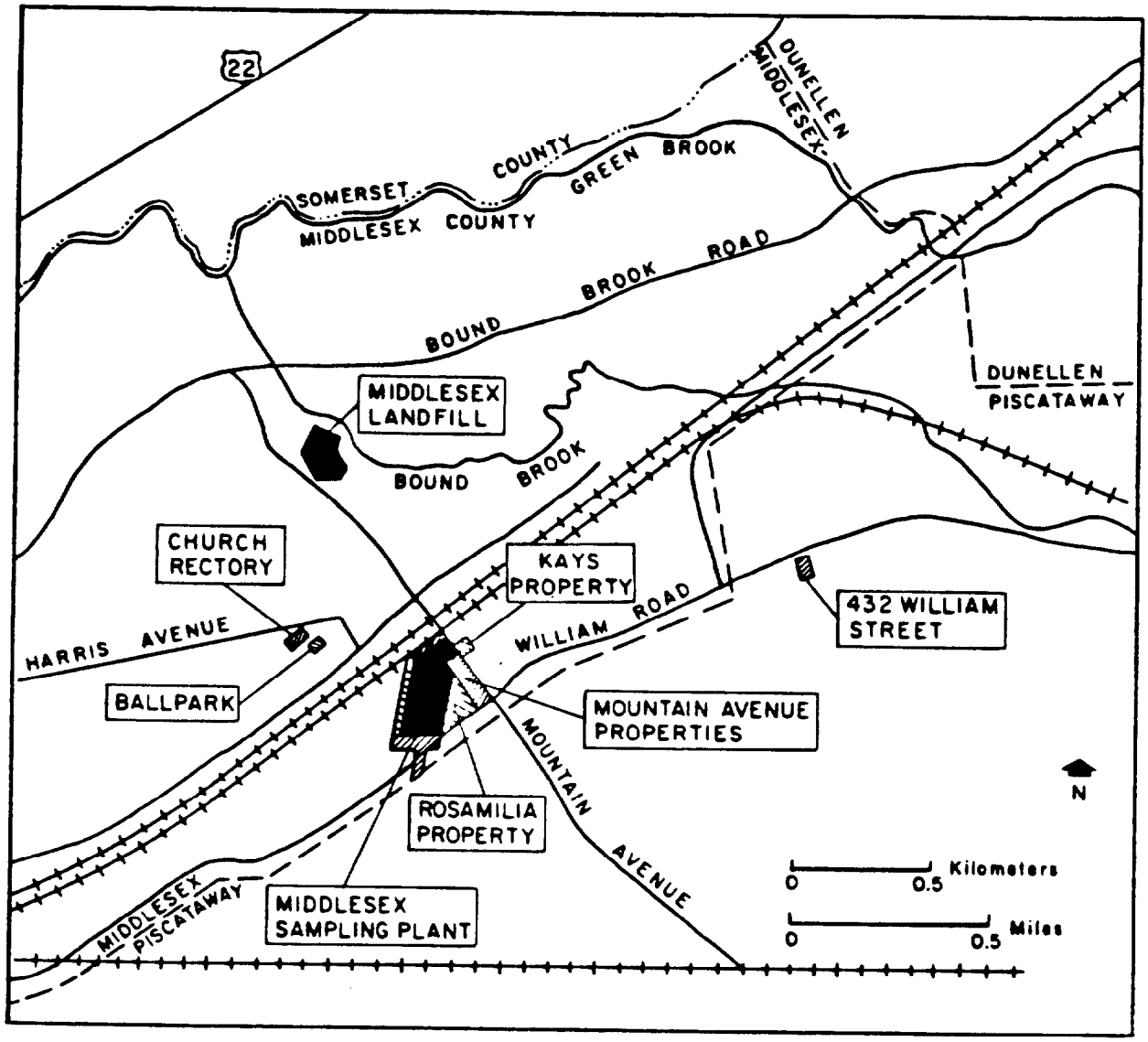



Figure 1.2. Location of the Middlesex Landfill, DOE Middlesex Sampling Plant Site, and Previously Contaminated Properties.

radioactively contaminated materials, DOE will make another decision regarding release of the Landfill for unrestricted use relative to the radioactive condition of the site. A decision on future use of the Landfill relative to chemical contamination is not within DOE's jurisdiction. The U.S. Environmental Protection Agency (EPA) and state and local governments have jurisdiction with respect to hazardous chemicals in the Landfill and will determine the need for further remedial actions, if any.

The proposed 1984 remedial actions are a continuation of remedial actions involving cleanup of the Sampling Plant site and several vicinity properties (see Section 2.1). The decisions to be made now are whether to carry out the proposed 1984 work and, if so, in what manner. Depending on future funding (determined by the yearly Congressional appropriations), there will be separate future decisions on additional remedial actions. Because a permanent storage or disposal site is not now available, current plans call for interim storage at the Sampling Plant site. Another future decision will be made relative to permanent disposition of the contaminated materials.

Separate environmental analyses will be prepared to support future decisions on additional remedial actions, permanent disposition of the contaminated materials, and release of sites for unrestricted use after cleanup.

# 2. HISTORY AND NEED FOR ACTION

## 2.1 GENERAL SETTING

Middlesex, New Jersey, is located in an urban area about 35 km (22 mi) southwest of downtown Manhattan (New York City), 29 km (18 mi) southwest of Newark, New Jersey, and 48 km (30 mi) northeast of Trenton, New Jersey (Figure 1.1). There are several properties in the Borough of Middlesex and Township of Piscataway (both in Middlesex County) that have been identified as being radioactively contaminated as a result of work that was carried out on various uranium, thorium, and beryllium ores at the Middlesex Sampling Plant (Figure 1.2). Most of the contaminated properties have been cleaned up and the contaminated materials placed in a large interim-storage pile at the Sampling Plant site. These properties and their current status are listed below:

| | |
|---|---|
| <u>Phase I Remedial Actions</u> (5 properties) | |
| 432 William Street<br>Church rectory<br>Playground<br>Rosamilia property<br>Kays property | Cleaned up in 1980; certified and released for unrestricted use (U.S. Dep. Energy 1983a) |
| <u>Phase II Remedial Actions</u> (28 properties) | |
| Mountain Avenue properties<br>Area south of Sampling Plant site and ditch to Main Stream<br>Periphery of Sampling Plant site<br>Road on north side of Sampling Plant site | Cleaned up in 1981 and 1982; not yet certified |
| <u>Middlesex Landfill Remedial Actions</u> | Proposed for cleanup in 1984 |
| <u>Phase III Remedial Actions</u> | |
| Sampling Plant site, including old processing building and interim-storage piles | To be decided in the future |

## 2.2 HISTORY

The history of the Middlesex Sampling Plant, the Middlesex Landfill, and the other properties can be found in reports by Bechtel National (1984a, 1984c), Boyer et al. (1982), Ford, Bacon & Davis (1978, 1979), and U.S. Department of Energy (1979, 1980a, 1980b). Following is a brief summary.

From 1943 to 1955, the Middlesex Sampling Plant was used to thaw, crush, dry, screen, sample, weigh, assay, store, package, and/or ship various types of uranium, thorium, and beryllium ores. This work was originally carried out under the auspices of the Manhattan Engineer District (MED) of the U.S. Army Corps of Engineers during development of the atomic bomb. The MED was succeeded by the U.S. Atomic Energy Commission (AEC), the U.S. Energy Research and Development Administration (ERDA), and finally (for certain functions) by DOE. Some of the radioactively contaminated wastes resulting from the sampling operations were containerized and disposed at sea by the U.S. Navy. From 1955 to 1967, the Sampling Plant was used mainly for storage and some sampling of thorium residues. In 1967, onsite structures were decontaminated and the site was certified and released for unrestricted use. The U.S. General Services Administration transferred the property in 1969 to the U.S. Marine Corps, who used the site for a reserve training center until 1979. Through an agreement established in 1978, DOE became custodian of the site. Currently, DOE uses the site for interim storage of radioactively contaminated materials that have been cleaned up from nearby vicinity properties and areas adjacent to the Sampling Plant site. Except for an onsite custodian, the buildings are unoccupied and the site is fenced.

The Middlesex Landfill has been in use for over 25 years. In 1948, the landfill area was a gully that extended from within 30-61 m (100-200 ft) of Mountain Avenue to Bound Brook. By 1974, the area was level to within about 30 m (100 ft) of the brook. The surface of the Landfill reportedly rose about 2.4-3.0 m (8-10 ft) from 1961 until it was closed in 1974. The Landfill is currently used as a collection point for recycling of cans, bottles, and paper.

In 1948 during some renovations at the Middlesex Sampling Plant, about 4,600 $m^3$ (6,000 $yd^3$) of excess soil contaminated with uranium ore was transported and disposed at the Middlesex Landfill. Contaminated soil was also apparently taken to the church rectory site and the 432 William Street property (Figure 1.2) for use as fill material.

In May 1960 during a civil defense drill, elevated radiation levels were detected at the Landfill. These elevated radiation levels were confined to an area of less than 0.24 ha (0.6 acre). In 1961, the AEC removed 500 $m^3$ (650 $yd^3$) of near-surface radioactively contaminated material and covered the area with 0.6 m (2 ft) of clean soil. The contaminated soil was removed to the AEC New Brunswick Laboratory in New Brunswick, New Jersey. Since the 1961 remedial action, about 2 ha (5 acres) of the northern portion of the Landfill site has been sold to the Middlesex Presbyterian Church and a church building has been erected.

Beginning in 1980, DOE conducted remedial actions designed to cleanup radioactively contaminated properties and to place the contaminated materials in a large storage pile at the Sampling Plant site. All vicinity properties except the Landfill have been cleaned up (see Section 2.1). About 27,000 $m^3$ (35,000 $yd^3$) of contaminated soils are now stored on an asphalt pad under a synthetic-rubber (EPDM) cover at the southern end of the Sampling Plant site.

## 2.3 RADIOLOGICAL CONTAMINATION AND NEED FOR ACTION

The Middlesex Landfill has been surveyed several times. The two most recent and comprehensive surveys were made in 1974 and 1978.

The results of the 1974 survey (U.S. At. Energy Comm. 1974) indicated that surface gamma readings were generally in the background range of 9-11 μR/h. At points of higher gamma readings, core samples confirmed the presence of radioactivity near the surface. Some core samples from areas that had normal background readings at the surface revealed some elevated levels of radioactivity at 0.6-1.2 m (2-4 ft) below the surface. Based on the 1974 survey, it was concluded that the radioactivity represented no measurable radiation health or safety problem relative to the use of the property at that time. If any excavation or other development at the Landfill was proposed in the future, the radiological conditions would need to be reevaluated to ensure that there was no undue risk to the public. The AEC suggested that the property record be appropriately flagged so that these limitations would be recognized in any future proposed use of the land.

The 1978 survey (U.S. Dep. Energy 1980b) was conducted to further characterize the current radiological condition of the site. Both surface and subsurface measurements were taken. This survey confirmed that there is little contamination of surface soil on the site. Average radon emanation rates, average external gamma radiation levels, and average beta-gamma dose rates on the site are near background levels. Radionuclide concentrations in water taken from Bound Brook near the site were far below allowable Nuclear Regulatory Commission limits (30,000 pCi/L for uranium and 30 pCi/L for radium-226 [10 CFR 20]). Background is reported as 0.29 pCi/L; all results in the 1978 study were reported as being <0.5 pCi/L and more recent results (Bechtel Natl. 1984a) were reported as being slightly less than background.

The 1978 measurements contain only two borings within the proposed excavation area. Several borings were taken in this area in the 1974 survey (Figure 2.1). Based on the 1974 and 1978 survey data, the concentration of radium-226 is plotted as a function of depth in the vicinity of the proposed excavation area (Figure 2.2). Based on the 1974 and 1978 survey data, the following observations can be made:

- The distribution of contaminated materials within the Landfill is very spotty, both vertically and horizontally.

- There is little or no correlation between surface radiation levels and subsurface radionuclide concentrations.

- The closely grouped samples that had concentrations in excess of DOE radiological guidelines are in the proposed excavation area, although most of the samples had radium-226 concentrations below 15 pCi/g. At the 0- to 15-cm depth, nine samples had radium concentrations above the 5 pCi/g radiological guideline (Table 2.1 and Appendix A). The 15 pCi/g guideline for radium concentration at the 15-cm to 1.5-m depth was exceeded in five cases, including two that were taken at the 0- to 15-cm depth. Radium-226 contamination below 1.5 m is not covered by existing guidelines and has to be considered on a site-specific basis. (No site-specific analysis has been conducted of contamination below 1.5 m at the Landfill.)

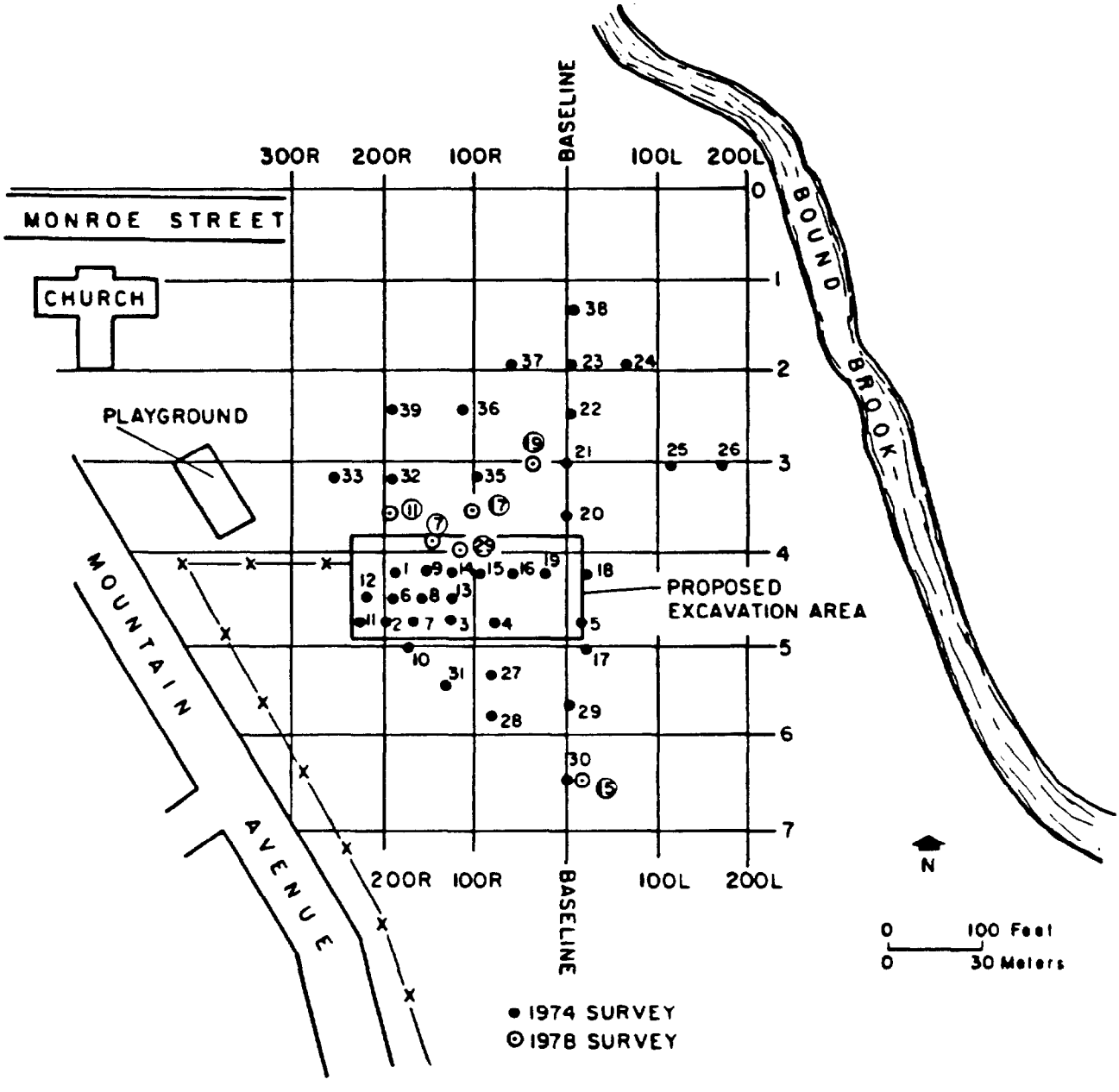
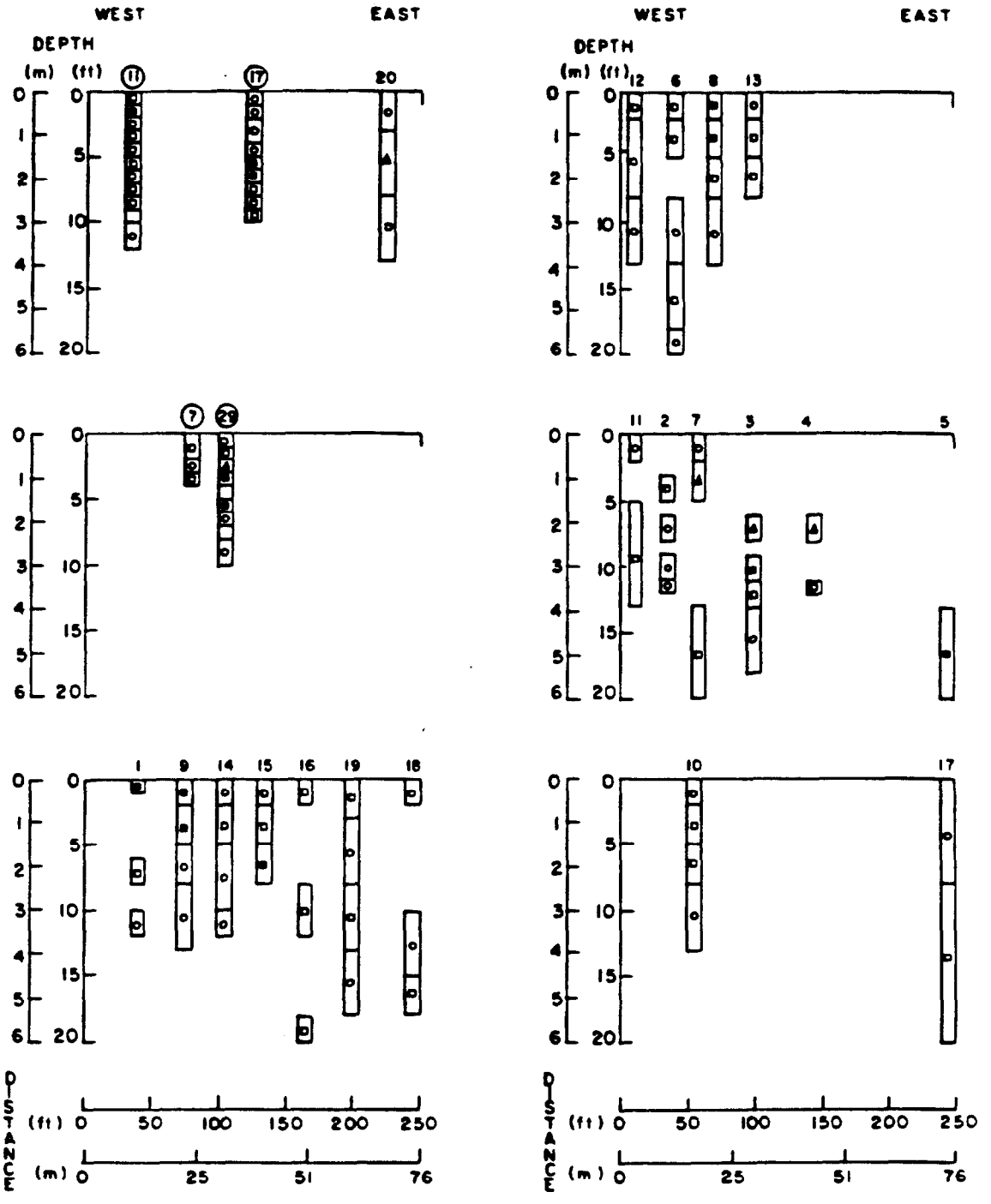



Figure 2.1. Locations of 1974 and 1978 Core Samples Relative to the Proposed Excavation Area. Source: Adapted from U.S. Atomic Energy Commission (1974).




LEGEND:

BOREHOLE NUMBERS CORRESPOND TO BOREHOLE LOCATIONS ON FIGURE 2.1.

RADIUM-226 CONCENTRATION:

- ○ <5pCi/g
- □ 5-15pCi/g
- ■ 15-50pCi/g
- ▲ >50pCi/g

Figure 2.2. Contamination of the Middlesex Municipal Landfill as a Function of Depth Below Surface. Based on data presented in reports of the U.S. Atomic Energy Commission (1974) and U.S. Department of Energy (1980b).

Table 2.1. DOE Radiological Guidelines for Residual Radionuclide Concentrations in Soil at FUSRAP Sites

| Radionuclide | Allowable Concentration Above Background (pCi/g) |
|---|---|
| U-natural†[1] | 75 |
| U-238†[2] | 150 |
| Th-232 | 15 |
| Ra-226 | 5/15†[3] |

†[1] One curie of natural uranium means the sum of $3.7 \times 10^{10}$ disintegrations/second (dis/s) over any 15-cm-thick layer from U-238 plus $3.7 \times 10^{10}$ dis/s from U-234 plus $1.7 \times 10^{9}$ dis/s from U-235.

†[2] Assumes no other uranium isotopes are present.

†[3] 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 and less than 1.5 m below the surface.

- Except for one sample at a depth of 3.6 m in Borehole 5, only two-thirds of the proposed excavation area had samples above radiological guidelines.
- There were several boreholes outside the proposed excavation area that had concentrations above guidelines: Boreholes 11, 15, 17, and 19 from the 1978 survey; and Borehole 20 from the 1974 survey.
- Based on the borehole data, it is conservatively estimated that the average concentration in the 4,600 $m^3$ (6,000 $yd^3$) to be removed to the storage pile is about 15 pCi/g. Therefore, the total amount of radium-226 to be removed from the proposed excavation area is about 0.093 Ci.
- Assays of surface soils indicated that only one area--centered around coordinates 4 and 200R (Figure 2.1)--exceeded the uranium-238 guideline of 150 pCi/g.

Although it was determined earlier that the radioactive contamination in the Middlesex Landfill presents no immediate public health concern, local and state authorities have expressed concerns about the contamination at the Landfill. DOE therefore proposes to remove the slightly contaminated materials to the Sampling Plant site for storage until permanent disposition of the materials can be determined.

# 3. AFFECTED ENVIRONMENT

## 3.1 GEOLOGY AND HYDROLOGY

### 3.1.1 Middlesex Landfill Site

The Middlesex Landfill is located within the Piedmont Province of central New Jersey (Barksdale et al. 1943). The ground surface at the Landfill ranges from 11 m (35 ft) MSL near Bound Brook to about 16 m (53 ft) MSL near Mountain Avenue (Figure 3.1). Before landfill operations began in the mid 1940s, the area was a gully that extended from within 30 to 61 m (100 to 200 ft) of Mountain Avenue to the brook. As a result of filling activities, the area is now mostly level out to a steep slope within about 33 m (100 ft) of the brook.

Surface runoff flows east towards Bound Brook, which in turn flows northwest and discharges into Green Brook (Figure 3.2). Green Brook discharges into the Raritan River about 3.0 km (1.9 mi) southwest of the site (Figure 3.2). The nearest potable surface water supply (4.4 $m^3/s$ [100 mgd]) is drawn from the Raritan River at the confluence with the Millstone River, about 4.2 km (2.6 mi) upstream of the confluence of Green Brook (Cesanek 1984). A private industry (Union Carbide Corporation) withdraws a very small amount of water (0.2 $m^3/s$ [5 mgd]) from the Raritan River about 0.8 km (0.5 mi) downstream from the confluence with Green Brook.

The 100-year flood level at the Landfill is about 13 m (44 ft) MSL. Therefore, during the 100-year flood, the eastern edge of the site would be flooded about two-thirds of the way up the slope (Figure 3.1). The discharge associated with the 100-year flood is estimated to be about 115 $m^3/s$ (4050 $ft^3/s$) at the Landfill (Swanson 1984). Based on drainage areas and stream-flow measurements on Bound Brook and Cedar Brook at South Plainfield (see gauging stations on Figure 3.2), it is estimated that the low flow of Bound Brook at the Landfill is about 0.2 $m^3/s$ (8.8 $ft^3/s$) during the month of August (U.S. Geol. Surv. 1983).

Groundwater at the Landfill is found in both the unconsolidated overburden deposits and in the bedrock. The overburden is about 3.4 to 10 m (11 to 34 ft) thick, of which the upper 0 to 6.1 m (0 to 20 ft) consists of fill material (Ford, Bacon & Davis 1979; Bechtel Natl. 1984b). Underlying the fill material are sedimentary units of sandy clay, silt, and sand. The upper aquifer in the overburden material (including the lower part of the fill materials) is separated from the lower bedrock aquifer by a layer of lower-permeability ($6.5 \times 10^{-6}$ to $7.0 \times 10^{-7}$ cm/s) clay formed from weathered shale bedrock. The lower aquifer, which is the major reservoir in the region, occurs in the fractured upper surface of the Brunswick Shale Formation.

It is not known to what extent the upper and lower aquifers may be interconnected. Because the permeability of the clay layer is not extremely low and both aquifers have the same groundwater level, it is possible that the

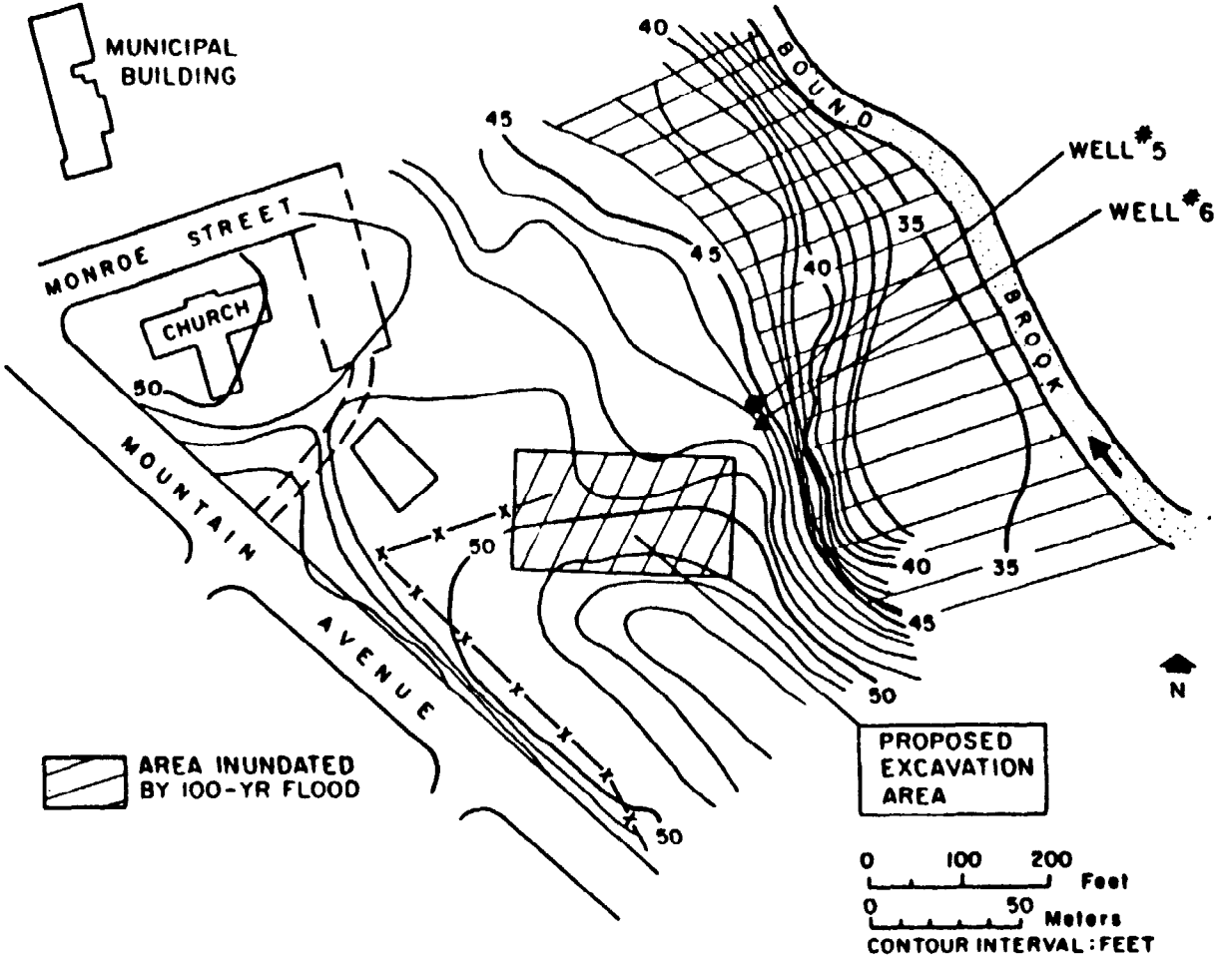



Figure 3.1. Topographic Map of the Middlesex Landfill Site. Source: Adapted from Bechtel National (1984c--Figure 2-4).

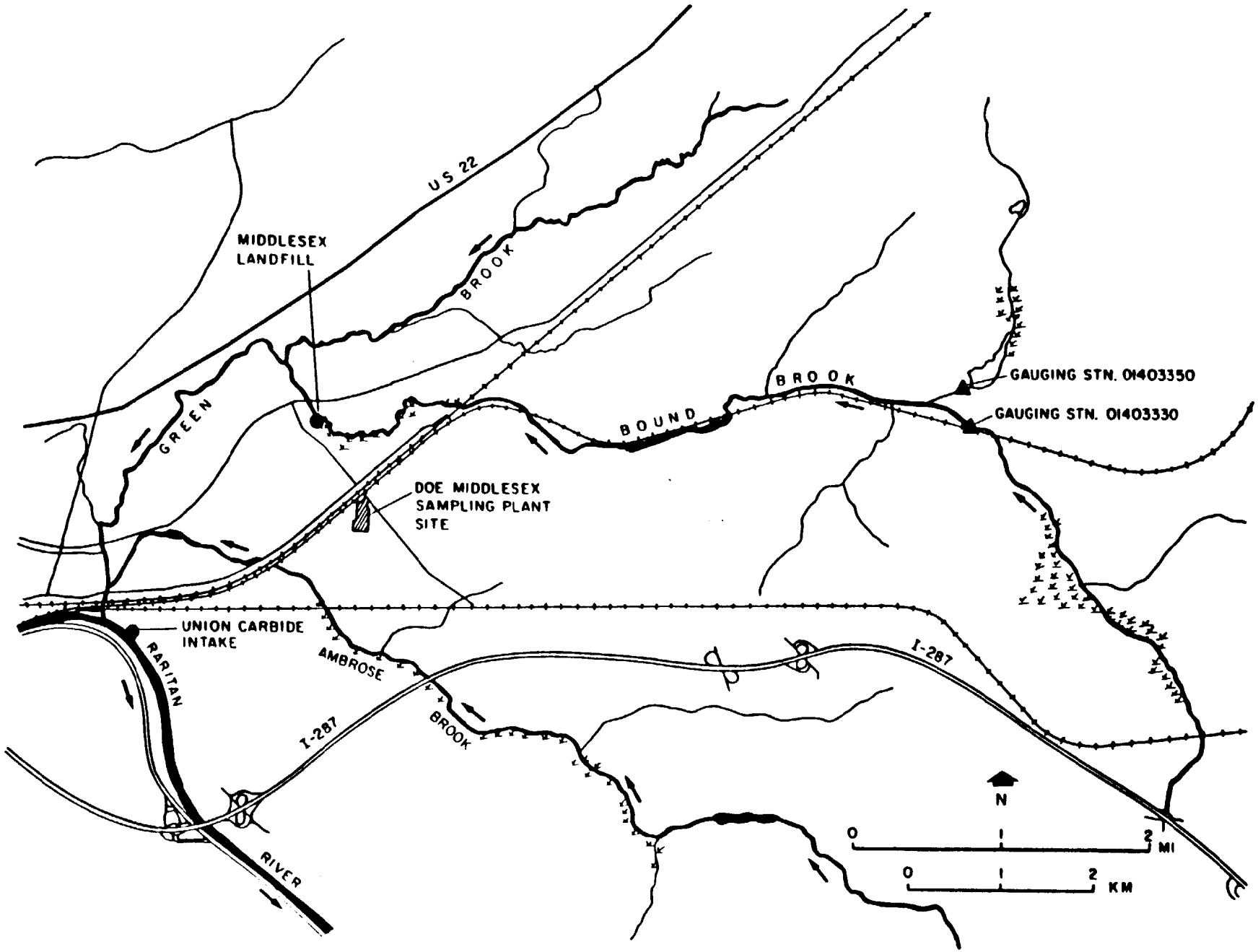



Figure 3.2. Surface Water Drainage Near the Middlesex Landfill and Sampling Plant Sites.
Source: Adapted from U.S. Geological Survey (1981).

aquifers may be partially connected. On the other hand, the limited water quality data that are available for comparing the upper and lower aquifers at the Landfill (Bechtel Natl. 1984b) indicate that there may not be much exchange between the two aquifers. Comparative water temperature data are not available.

The groundwater table varies seasonally (Table 3.1). It has been reported as high as 12 m (40 ft) MSL at two wells located near the eastern edge of the proposed excavation area (Figure 3.1). Thus, groundwater may be found about 3 m (10 ft) below the surface of the Landfill in the proposed excavation area. If the groundwater table follows surface contours, water may be encountered 1.6 m (5.4 ft) below the surface in the excavation area. The general direction of groundwater flow at the Landfill is east-northeast toward Bound Brook.

Table 3.1. Selected Groundwater Elevations in Two Wells Near the Eastern Edge of the Proposed Excavation Area

| Well No. | Aquifer | Surface Elevation | | Date | Groundwater Elevation | | Groundwater Depth | |
|---|---|---|---|---|---|---|---|---|
| | | m MSL | ft MSL | | m MSL | ft MSL | m | ft |
| 5 | Upper (overburden) | 13.7 | 45.6 | 12/17/81 | 9.8 | 32.6 | 3.9 | 13.0 |
| | | | | 2/24/82 | 12.1 | 40.2 | 1.6 | 5.4 |
| | | | | 11/24/82 | 8.7 | 29.1 | 5.0 | 16.5 |
| | | | | 7/13/83 | 10.4 | 34.6 | 3.3 | 11.0 |
| 6 | Lower (bedrock) | 13.5 | 45.1 | 12/17/81 | 10.5 | 35.0 | 3.0 | 10.1 |
| | | | | 2/24/82 | 11.9 | 39.7 | 1.6 | 5.4 |
| | | | | 11/24/82 | 12.8 | 42.7†[1] | 0.7 | 2.4†[1] |
| | | | | 7/13/83 | 10.7 | 35.7 | 2.8 | 9.4 |

†[1] Results suspect.

Source: Bechtel National (1984b).

In a recent analysis of water samples from onsite wells (Eberline 1983), only one sample had a radium-226 concentration elevated above the EPA Interim Primary and Secondary Drinking Water Standard of 5 pCi/L. Total uranium concentrations were all below the EPA recommended level of 10 pCi/L. Four samples had slightly elevated concentrations of chromium, lead, and selenium (Eberline 1983; Princeton Test. Lab. 1983a). (See further discussion in Section 3.6.)

### 3.1.2 Middlesex Sampling Plant Site

The Middlesex Sampling Plant site is generally flat, with an elevation ranging from 15 to 19 m (50 to 61 ft) MSL. The dominant soil types are silty

to sandy loams with a thickness of 0.5 to 2.4 m (1.5 to 8 ft). Underlying these deposits are the shales of the Brunswick Formation (U.S. Soil Conserv. Serv. 1976).

Surface runoff from the existing storage pad (see Figure 4.3) is collected in several drains that empty into a large settling basin through an underground drainage system and then into a drainage easement ditch south of the site which runs 180 m (600 ft) south to Main Stream (Figure 3.3). Main Stream empties into Ambrose Brook, and Ambrose Brook flows into Green Brook near the confluence with the Raritan River (Figure 3.2). Neither Main Stream nor Ambrose Brook are used for water supplies.

Groundwater at the Sampling Plant site is available in surficial stratified glacial drift deposits and in the shale bedrock aquifer. The shallow unconfined groundwater in the surficial deposits flows southwest to Main Stream.

Surface water samples collected at the outfall of the settling basin and in Main Stream (Figure 3.3) during 1980, 1981, and 1982 had average uranium and radium-226 concentrations well below the DOE guidelines for uncontrolled areas (Bechtel Natl. 1984a). For soluble radium-226, only 2 of 42 samples collected at the plant outfall exceeded the DOE guideline. This was during 1980 when the pile was exposed during cleanup actions at vicinity properties. Groundwater samples taken from several wells located on the site indicated that the maximum uranium concentrations ranged from 0.005 to 0.34 mg/L, and maximum radium-226 concentrations ranged from 0.2 to 2.3 pCi/L--all within the DOE guidelines for uncontrolled areas (Bechtel Natl. 1984a).

## 3.2 METEOROLOGY

New Jersey averages about 120 days of precipitation per year, and the mean annual precipitation is about 120 cm (48 in.). August is the wettest month, with an average of 12 cm (4.8 in.) of precipitation measured at Somerville, New Jersey, about 13 km [7.8 mi] west of Middlesex (Gale Res. Co. 1980). The highest amount of precipitation recorded for a single day is 23 cm (8.9 in.), and the highest monthly total is 37 cm (14 in.). Floods accompany heavy rains, which in turn are sometimes associated with storms of tropical origin. Short droughts occur during the growing season, but prolonged droughts are rare--generally occurring only once every 15 years (Gale Res. Co. 1980). The prevailing winds are from the northwest during October through April and from the southwest during the summer months.

## 3.3 ECOLOGY

Middlesex is located within the glaciated area of the Appalachian oak forest section of the eastern deciduous forest (Bailey 1978). This forest section is characterized by oak, hickory, maple, basswood, elm, and ash--with alder, willow, ash, elm, and hygrophytic shrubs common in moist (poorly drained) habitats. However, because the Landfill is located within an urban setting and was used for disposal of wastes, little forest habitat is present.

No site-specific ecological surveys have been made at either the Landfill or the Sampling Plant Site. The following discussion is based on a site visit in March 1984 and on general literature information for the region. The flora

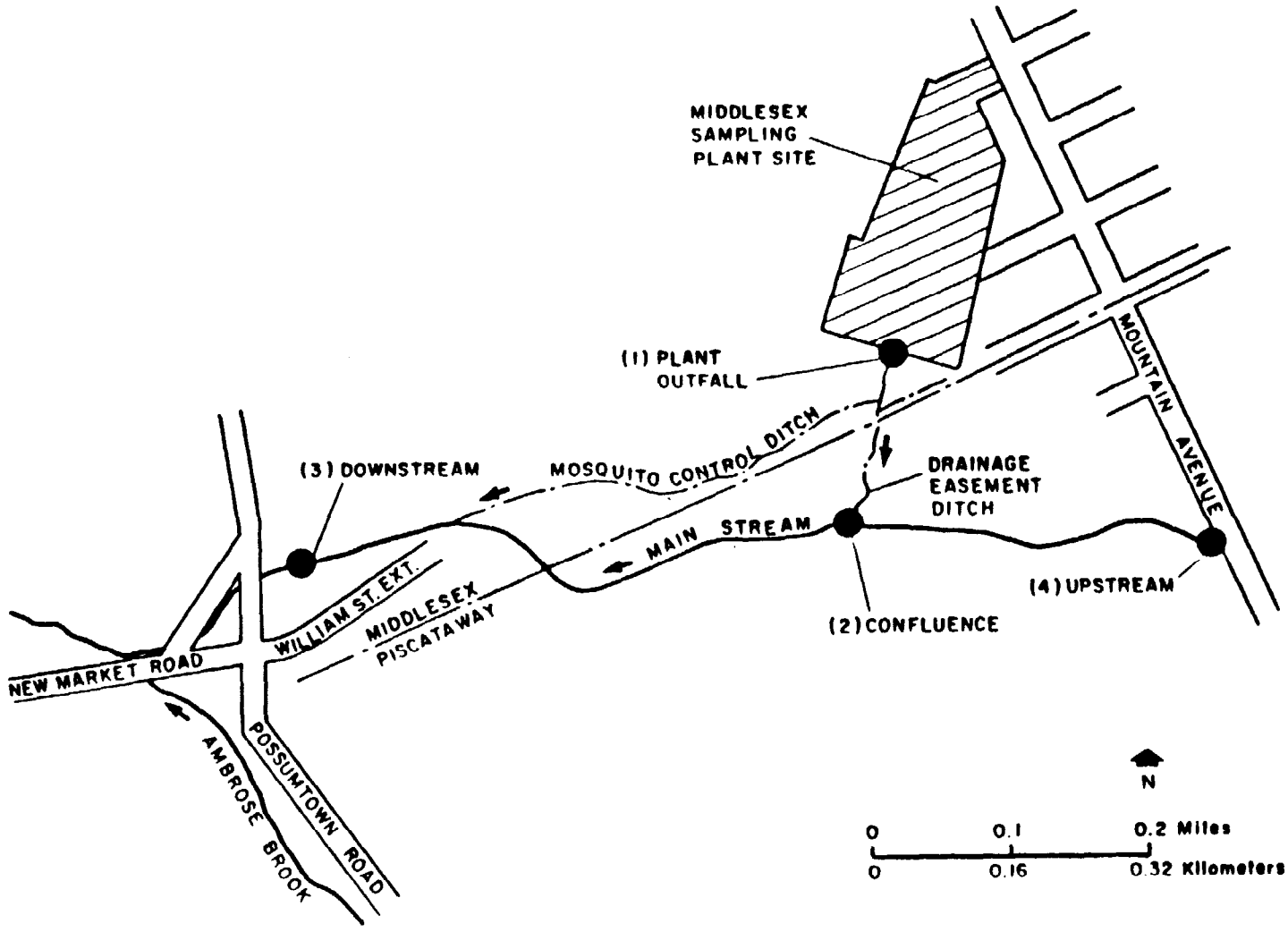



Figure 3.3. Surface Drainage Map of the Middlesex Sampling Plant Site.
Source: Adapted from Bechtel National (1984a).

of the Landfill site is dominated by early successional species. These include grasses and forbs (e.g., aster, fescue, plantain, goldenrod, panic-grass, clover, dandelion, smartweed, yarrow, thistle, and wild carrot) and shrubs and small trees (e.g., maple, aspen, willow, elm, cherry, and cottonwood). Mature trees are common in the floodplain of Bound Brook. The reed phragmites (Phragmites communis) is also common on the site, especially in the floodplain area, and occurs in small stands on the upper portion of the fill material. Phragmites is indicative of poorly drained or moist soils (e.g., marshes, pond margins, and ditches) (Galvin 1979).

The fauna is probably limited due to a lack of suitable habitat. Commonly encountered species are those that have adapted to surburban/urban encroachment. Birds include the house sparrow, starling, rock dove (pigeon), red-winged blackbird, common crow, and robin. Mammals include the Norway rat, racoon, opossum, woodchuck, house mouse, meadow vole, white-footed mouse, deer mouse, eastern mole, eastern cottontail rabbit, striped skunk, eastern gray squirrel, and shorttail shrew. A few species of reptiles such as the eastern garter snake and American toad have partially adapted to urban habitats and can be expected to occur in the area.

Aquatic habitat is limited to Bound Brook and a pond formed by a former channel of the brook. Plant communities of Bound Brook and permanently moist areas are dominated by cattails and marsh grasses. Mosquito and midge larvae, aquatic beetles and bugs, and other aquatic invertebrates capable of rapid colonization and/or short life cycles are probably typical inhabitants of temporary water bodies found in the vicinity. Species typical of small, generally degraded streams are probably found in Bound Brook (e.g., aquatic worms, midges, snails, blackflies, beetles, bugs, minnows, and suckers).

Minimal biotic resources occur on the Middlesex Sampling Plant site because most of the site is paved. Pigeons, sparrows, rats, and mice may occur on the site, and some aquatic insects (mostly dipterans) and frogs may occur in the sedimentation basin.

Because of the highly disturbed nature of both the Landfill and Sampling Plant sites, the occurrence of any rare or endangered species on these sites is extremely unlikely.

## 3.4 LAND USE

The Middlesex Landfill site is located on property that is jointly owned by the Borough of Middlesex and the Middlesex Presbyterian Church. Until 1974, the Landfill was used for disposal of municipal wastes from other landfills, businesses, and streets. The Landfill site is no longer in active use except for a can, bottle, and paper recycling operation located near the entrance. The areas immediately east and south of the Landfill are undeveloped. The Middlesex Presbyterian Church is adjacent to the northwest side of the Landfill, and the Middlesex Municipal Building is located northwest of the church property (Figure 3.1). Mountain Avenue and residential properties are located on the west side of the Landfill.

The Landfill and adjacent properties on the north, east, and south are zoned for single-family and planned residential options (Cross Assoc. 1976). One property west of the site (across from Mountain Avenue) is mostly zoned

for a municipal center. Similar zoning--plus zoning for single-family, apartment, general business, two-family, commercial/light manufacturing/wholesale, and industrial/industrial park--are also located within several kilometers of the site.

The Middlesex Sampling Plant site currently contains abandoned buildings and a large interim-storage pile. The site is bordered to the north by the Central Railroad of New Jersey and the Lehigh Valley Railroad, to the east by an empty lot (Rosamilia property) and residential properties on Mountain Avenue, to the south by a vacant field, and to the west by industry. During the day, there is frequent heavy-truck traffic entering and leaving the access road off Mountain Avenue between the railroad and the north end of the Sampling Plant site. The site and adjacent property are zoned for industrial/industrial park, although single-family residences are located just east and southeast of the Sampling Plant site. Zoning within several kilometers of the site is similar to that previously mentioned for the Landfill.

The current land use surrounding both sites is a mosaic of residential, commercial, industrial, public, and vacant land (Ford, Bacon & Davis 1979). With the completion of Interstate 287, the area has become increasingly more attractive for development. Future activity probably will include the development of residential areas south and southeast of the site and the development of industrially zoned land from about 0.8 to 1.6 km (0.5 to 1 mi) to the south and southwest (Ford, Bacon & Davis 1979).

Future land use is not expected to change greatly from current plans and usage. The Middlesex 1976 Master Plan (Ford, Bacon & Davis 1979) calls for creating a homogeneous industrial zone along South Avenue and Lincoln Boulevard, replacing nursery and greenhouse properties with residential areas and developing vacant lands outside the flood-control areas. Moreover, plans to extend William Street across the southern portion of the site have been under consideration for many years. Such action would allow development of a large area in Piscataway.

## 3.5 SOCIOECONOMICS

Both the Landfill and Sampling Plant sites are accessible to railroad and interstate transportation systems (Figure 3.4). Several schools, hospitals, and other institutional facilities are located within 3.2 km (2 mi) of the contaminated properties (Raritan Valley Regional Chamber of Commerce, undated; League of Women Voters 1980). However, except for the Middlesex Presbyterian Church located on the north side of the Landfill, no other institutional facilities occur near the two sites or along Mountain Avenue between the sites.

There are about 15 million people residing within 80 km (50 mi) of Middlesex. The 1980 populations for Middlesex and Piscataway were 13,480 and 42,223, respectively--a change from the 1974 populations of 14,004 and 37,132 (U.S. Bur. Census 1982b; Raritan Valley Regional Chamber of Commerce, undated). Populations in both communities are projected to increase over the next 10 to 15 years (Raritan Valley Regional Chamber of Commerce, undated). Little unimproved or vacant land is available for residential development in Middlesex. However, there are several hundred acres of vacant land to the south of the Sampling Plant site in Piscataway. The Township of Piscataway recently passed

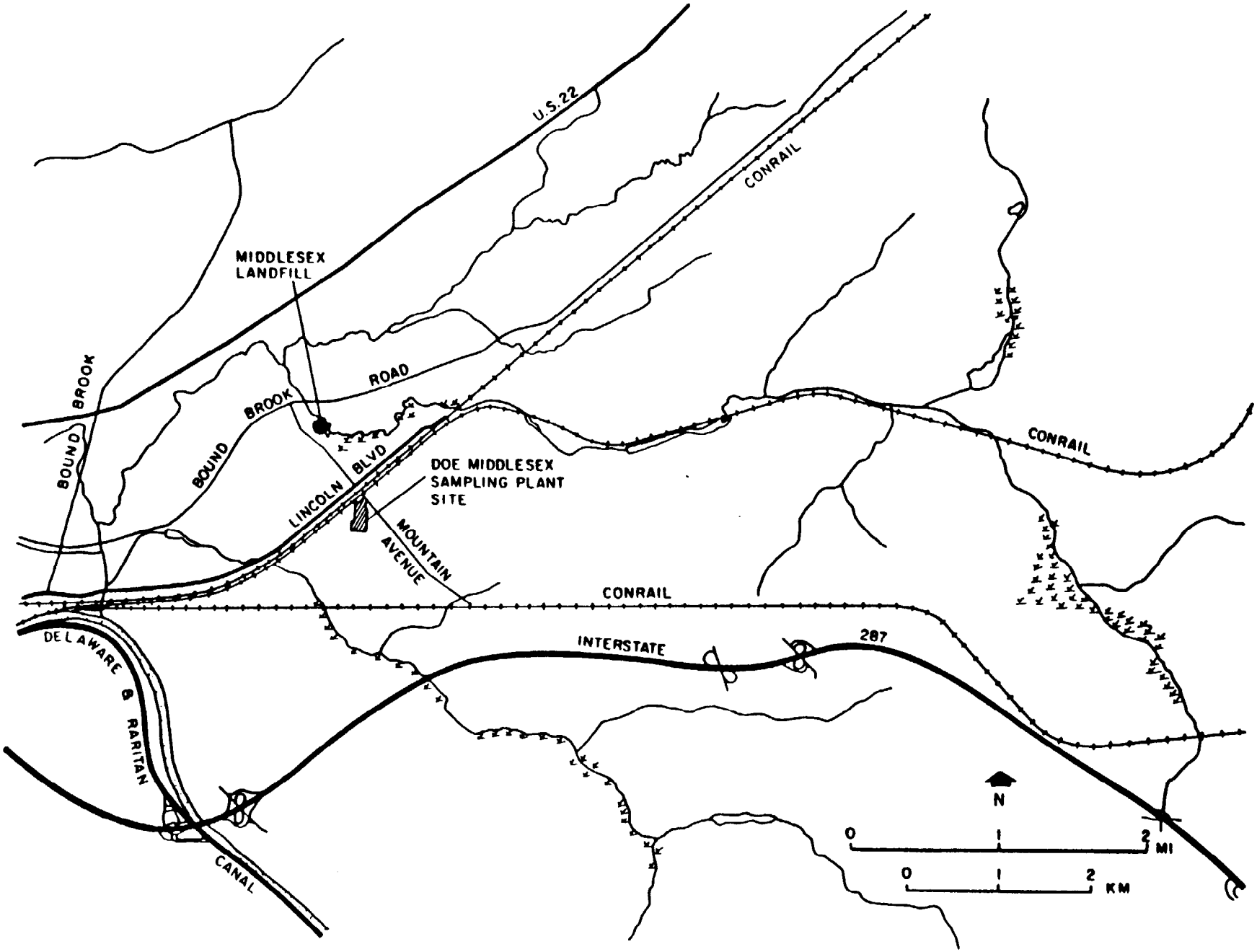



Figure 3.4. Transportation System Near Middlesex, New Jersey.
Source: Adapted from U.S. Geological Survey (1981).

a new master plan calling for the development of several residential areas on sections of this vacant land (Ford, Bacon & Davis 1979). If the plan is followed, the population in Piscataway within 1.6 km (1 mi) of the Sampling Plant site could increase by as much as 12,000 people.

The 1980 housing characteristics in the communities of Middlesex and Piscataway are similar. Median home values were $60,300 for Middlesex and $63,100 for Piscataway (U.S. Bureau of Census 1982a). Vacancy rates for home owners and rental properties were very low when compared to the patterns recorded in many other New Jersey communities.

Both Middlesex and Piscataway are comprised predominantely of white, married-couple families having a median family income in 1979 of $25,000 to $26,000 (U.S. Bur. Census 1982b). In 1982, the average household size for the communities of Middlesex and Piscataway was 2.94 and 2.93, respectively, a number that has steadily declined since 1960 (Middlesex Co. Plan. Board 1983). The most prevalent occupations in these communities are manufacturing, professional and related services, and retail trade (U.S. Bur. Census 1982b).

Middlesex and Piscataway are located in the central subregion of Middlesex County, which attracted over 60% of the county's 1980 daily in-commuters (Middlesex Co. Plan. Board 1983). Based on 1980 census information (U.S. Bur. Census 1982b), commuting by private vehicles appears to be the preferred mode of transportation in both communities. Therefore, many of the workers who are employed within 1.6 km (1 mi) of the sites are expected to be commuting into this area from outside the county by private vehicle.

The radioactive contamination in the project area has produced some effects on the current socioeconomic setting because of local health and safety perceptions. The presence of radioactive materials on the DOE Sampling Plant site has had a bearing on the demand for the use of surrounding properties (Ford, Bacon & Davis 1978). It is not known whether or not a similar situation may also be associated with properties around the Landfill site.

## 3.6 CHEMICAL

### 3.6.1 Landfill Materials

There is evidence which indicates that appreciable quantities of non-radiological hazardous wastes may be present in the Landfill. High concentrations of arsenic, chromium, and lead were detected in a composite soil sample analyzed from a borehole drilled in 1983 about 120 m (400 ft) north of the Landfill. Cyanide and some organics were also present (Bechtel Natl. 1984b; Fisk Assoc. 1984).

Six boreholes were drilled in January 1984 in the area to be excavated (Fisk Assoc. 1984). The presence of appreciable amounts of methane hampered drilling operations and limited sample collection. High concentrations of chromium, arsenic, and lead were found along with hazardous organics such as PCBs, benzo(a)pyrene, and naphthalene (Rudolph 1984; Keller 1984). Details of the results for all borehole analyses are given in Table 3.2. It should be emphasized that the estimated average concentrations are based on samples from only six boreholes. Based on the average concentrations, it is estimated that thousands of kilograms of chemicals may be transported to the Sampling Plant

Table 3.2. Concentrations of Hazardous Materials in Borehole Samples from the Middlesex Landfill†[1]

| Parameter | Concentrations (ppm) Well 83-22 | 1984 Boreholes Average†[2] | 1984 Boreholes Range†[2] | Number of Positive Results†[2] | Detection Limits (ppm) Well 83-22 | Detection Limits (ppm) 1984 Boreholes |
|---|---|---|---|---|---|---|
| Arsenic | 330 | 38 | 0.86 - 179 | 6 | | |
| Beryllium | 0.2 | 0.75 | 0.25 - 1.25 | 6 | | |
| Cadmium | 27.4 | 5.9 | 0.65 - 29 | 6 | | |
| Chromium | 155 | 79 | 18 - 71 | 6 | | |
| Copper | 53 | 130 | 56 - 251 | 6 | | |
| Lead | 742 | 367 | 61 - 938 | 6 | | |
| Mercury | 0.8 | 0.25 | 0.06 - 0.52 | 6 | | |
| Nickel | 21.5 | 26 | 18 - 36 | 6 | | |
| Selenium | 0.4 | -†[3] | -†[3] | 0 | | 0.5 |
| Silver | 1.1 | 3.2 | 2.5 - 4.5 | 6 | | |
| Thallium | 23 | - | - | 0 | | 5 |
| Zinc | 1,100 | 456 | 60 - 1,800 | 6 | | 1 |
| Cyanide | 3.8 | 1.7 | 1.3 - 3.6 | 1 | 0.1 | 1.3 |
| Phenols | 0.4 | - | - | 0 | 0.1 | 0.4 |
| Methylene chloride | 0.243 | - | - | 0 | 0.001 | 0.05 |
| Trichlorofluoromethane | 0.053 | - | - | 0 | 0.001 | 0.05 |
| 1,1,1-Trichloroethane | 0.085 | - | - | 0 | 0.001 | 0.02 |
| Trichloroethene | 0.335 | - | - | 0 | 0.001 | 0.02 |
| Chlorobenzene | 0.020 | - | - | 0 | 0.001 | 0.01 |
| Benzene | 0.005 | - | - | 0 | 0.001 | 0.01 |
| Toluene | 0.304 | - | - | 0 | 0.001 | 0.01 |
| Ethylbenzene | 0.161 | - | - | 0 | 0.001 | 0.01 |
| 2,4,D; methoxyclor | 0.021 | - | - | 0 | | |
| Acenaphthene | -†[3] | 0.28 | 0.2 - 0.76 | 3 | 0.01 | 0.2 |
| Anthracene | - | 2.5 | 0.2 - 5.6 | 5 | 0.01 | 0.2 |
| Benzo(a)anthracene | - | 4.4 | 0.26 - 6.8 | 6 | 0.01 | 0.2 |
| Benzo(a)pyrene | - | 3.8 | 0.2 - 7.3 | 5 | 0.01 | 0.2 |
| Benzo(ghi)perylene | - | 0.6 | 0.2 - 1.4 | 4 | 0.01 | 0.5 |
| Benzo(k)fluoranthene | - | 3.4 | 0.2 - 6.2 | 5 | 0.01 | 0.2 |
| Bis(2-ethylhexyl)phthalate | - | 2.3 | 0.2 - 5.6 | 4 | 0.01 | 0.2 |
| Dibenzo(a,h)anthracene | - | 0.57 | 0.19 - 1.2 | 3 | 0.01 | 0.5 |
| 1,4 Dichlorobenzene | - | 0.18 | 0.1 - 0.2 | 1 | 0.01 | 0.2 |
| Di-n-butyl phthalate | - | 0.98 | 0.2 - 2.1 | 5 | 0.01 | 0.2 |
| Fluoranthene | - | 2.7 | 0.2 - 5.9 | 5 | 0.01 | 0.2 |
| Fluorene | - | 0.38 | 0.2 - 0.73 | 3 | 0.01 | 0.2 |
| Ideno(1,2,3-cd)pyrene | - | 0.53 | 0.2 - 1.1 | 4 | 0.01 | 0.5 |
| Naphthalene | - | 0.57 | 0.2 - 1.5 | 4 | 0.01 | 0.2 |
| Pyrene | - | 2.3 | 0.2 - 4.9 | 5 | 0.01 | 0.2 |
| Phenol | - | 0.65 | 0.5 - 1.4 | 1 | 0.01 | 0.5 |
| 4,4 DDT | - | 0.07 | 0.02 - 0.20 | 1 | 0.001 | 0.02 |
| 4,4 DDE | - | 0.06 | 0.02 - 0.20 | 1 | 0.001 | 0.02 |
| 4,4 DDD | - | 0.06 | 0.02 - 0.20 | 1 | 0.001 | 0.02 |
| PCB 1254 | - | 2.4 | 0.5 - 12.0 | 1 | 0.001 | 0.5 |

†[1] Based on Rudolph (1984) and Bechtel National (1984a--Appendix D). Only those parameters are listed for which at least one positive result was obtained.

†[2] Averages and ranges were computed using detection limits as the results for those samples with negative results.

†[3] A dash means no positive results obtained.

site for storage. For example, 280 kg arsenic, 580 kg chromium, 950 kg copper, 2,700 kg lead, 3,300 kg zinc, 28 kg benzo(α)pyrene, 17 kg pyrene, and 18 kg PCB may be stored. Approximately twice as much will be placed back into the Landfill. In some respects, these amounts may be overestimates--e.g., average concentrations were estimated using detection limits at the lower end of the range in some cases; however, in other respects, the amounts may be underestimates--e.g., concentrations varied widely and the contents of any buried containers were not sampled.

Prior to drilling the boreholes, a ground penetrating radar survey was carried out to locate buried metal objects. The boreholes were then drilled to avoid known metal objects. It is not known if the objects are metal drums or containers. The presence of drums is suspected because some drums can be seen protruding from the landfill slope (Merry-Libby 1984; Glenn 1984a).

Although the available data indicate the presence of hazardous chemical substances in the Landfill, additonal data are needed to sufficiently characterize the chemical condition of the Landfill (particularly in the area to be excavated) with respect to predicting potential impacts of excavation, storage, and long-term disposal of landfill materials. The 1983 borehole sample was not located in the area to be excavated, and the results of the organics analyses of the 1984 samples are quite different from those of the 1983 sample. One problem is the high detection limits associated with the 1984 data. Also, the lack of 1984 data for volatile organics is highly suspect for landfill samples, indicating possible problems with sample preservation or analytical methods. Furthermore, spatial heterogeneities may not be adequately accounted for because the 1984 boreholes are located quite far from one another (15 to 24 m [50 to 80 ft]). Finally, there may be buried drums or other containers and their contents are not known.

### 3.6.2 Groundwater

Analyses of groundwater samples taken from seven wells drilled into the upper (overburden) aquifer at the Landfill showed low levels of metals (Table 3.3). Pesticides and PCBs were not detectable at a level of 2 ppb (5 ppb for PCBs). Several other organics were detected, and concentrations in some samples exceeded regulatory limits. Those chemicals for which analysis of water samples from one or more wells gave positive results are listed in Table 3.3. Several of the chemicals (chromium, lead, and naphthalene) were close to, but below, the regulatory limits. Only selenium had an average concentration slightly above the regulatory limit.

It is difficult to know if the values given in Table 3.3 are representative of average upper aquifer concentrations. For one thing, these values refer to water samples drawn at one time in 1983. For at least part of the year the groundwater level in some of the wells sampled extends into the Landfill (Section 3.1) and concentrations of hazardous materials in the landfill materials appear to be appreciable (Section 3.6.1).

Except for chloride, sulfate, total dissolved solids (TDS), and hardness, no analyses were performed on well-water samples drawn from the bedrock aquifer. The lower bedrock and upper overburden aquifers may or may not be appreciably interconnected at the Landfill (Section 3.1).

## Table 3.3. Concentrations of Chemicals in Wellwater from the Upper (Overburden) Aquifer†[1]

| Parameter | Concentration (ppb) Average†[2] | Range†[2] | Detection Limit | Number of Positive Results | Regulatory Limits |
|---|---|---|---|---|---|
| Chloride | 80†[3] | 20 - 150†[3] | - | 7 | |
| Sulfate | 36†[3] | 10 - 100†[3] | - | 7 | |
| TDS | 1,400†[3] | 680 - 4,600†[3] | - | 7 | |
| Hardness | 380†[3] | 250 - 600†[3] | - | 7 | |
| Chromium | 36 | 20 - 87 | 20 | 3 | 50†[4] |
| Copper | 20 | 20 - 22 | 20 | 1 | bkgd†[4] |
| Lead | 41 | 24 - 56 | - | 7 | 50†[4] |
| Zinc | 40 | 14 - 120 | - | 7 | bkgd†[4] |
| Arsenic | 15 | 10 - 50 | 10 | 2 | 50†[4] |
| Silver | 13 | 10 - 24 | 10 | 3 | 50†[4] |
| Selenium | 12 | 10 - 40 | 10 | 3 | 10†[4] |
| Uranium | 6.3 | 5 - 13 | 5 | 2 | bkgd†[4] |
| Cyanide | 10 | 10 - 12 | 10 | 2 | bkgd†[4] |
| Phenols | 100 | 100 | 100 | 1 | bkgd†[4] |
| 1,4 Dichlorobenzene | 11 | 7 - 18 | 10 | 2 | bkgd†[4] |
| Naphthalene | 11 | 4 - 25 | 10 | 3 | 13†[5] |
| Benzene | 2.5 | 1 - 5 | 1 | 5 | bkgd†[4] |
| Chlorobenzene | 77 | 1 - 430 | 1 | 4 | 400†[5] |
| Chloroform | 5 | 2 - 20 | 2 | 1 | bkgd†[4] |
| 1,1 dichloroethane | 3 | 1 - 10 | 1 | 1 | bkgd†[4] |
| Ethylbenzene | 3 | 1 - 10 | 1 | 1 | 1,400†[5] |
| Toluene | 2 | 1 - 6 | 1 | 3 | bkgd†[4] |

†[1] Based on Bechtel National (1984b), Princeton Testing Lab (1983b), and Haywood (1983).

†[2] The seven values, one for each well into the overburden aquifer, were averaged together. The detection limit was taken as the sample value for those wells for which the presence of a parameter was not detectable. Where appropriate, this limit was included in determining the range of values.

†[3] Concentrations given in ppm.

†[4] 40 CFR 264 groundwater limits for operators of hazardous waste sites. The abbreviation "bkgd" denotes background concentrations.

†[5] New Jersey Pollutant Discharge Elimination System (NJPDES) limits in effluents for toxicity protection of potable water supplies.

# 4. PROPOSED REMEDIAL ACTIONS AND ALTERNATIVES

## 4.1 PROPOSED 1984 ACTIONS

### 4.1.1 Middlesex Landfill

The proposed actions for 1984 involve cleanup of the Middlesex Landfill and placement of radioactively contaminated materials in an interim-storage pile on the Middlesex Sampling Plant site. It is expected that approximately 14,000 $m^3$ (18,000 $yd^3$)* of landfill materials will be excavated, of which about one-third (4,600 $m^3$) [6,000 $yd^3$])* is expected to be radioactively contaminated. The proposed excavation area is shown in Figure 4.1.

Support facilities will be constructed at the Landfill prior to excavation. Small trees and shrubs and other vegetation will be removed. A gravel access road will be constructed from the main gate off Mountain Avenue to the proposed excavation area (Figure 4.1). Because some of the excavated materials will probably be wet (see further discussion in Section 5.2), a synthetic liner will be placed on the ground north of the excavation area (Figure 4.1). This area will be used to stockpile wet wastes, allowing them to drain back into the excavation area and partially dry prior to being loaded onto trucks for transport to the Sampling Plant site.

A decontamination facility, consisting of a gravel-filled pit with a wooden ramp over the pit, will be constructed south of the excavation area (Figure 4.1). Steam and high-pressure water will be used to clean construction vehicles and any large buried objects that need to be decontaminated (see below). After collecting in the pit, the water will flow to a standpipe and will be recirculated through a sand filter to remove particulates. It is expected that the sand filters will have to be replaced about every two days; used filters will be disposed on the interim-storage pile. When the water becomes too contaminated and can no longer be recirculated, it will be transferred to a 3,800-L (1,000-gal) stationary bladder tank and will be used for dust control at the Landfill.

Excavation will be carried out similar to a strip mining operation, with minimal exposure of the open cut and backfilling completed as soon as excavation depth allows. The wastes will be excavated in strips 9-m (30-ft) wide and 34-m (110-ft) long in 0.3-m (1-ft) depth increments (Figure 4.2). The layer to be excavated will be radiologically surveyed, and materials that are

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*These volumes are being revised as detailed engineering progresses. As of April 24, 1984, the estimated total volume to be excavated has been reduced to 13,000 $m^3$ (16,000 $yd^3$), of which 4,200 $m^3$ (5,500 $yd^3$) is expected to be radioactively contaminated.

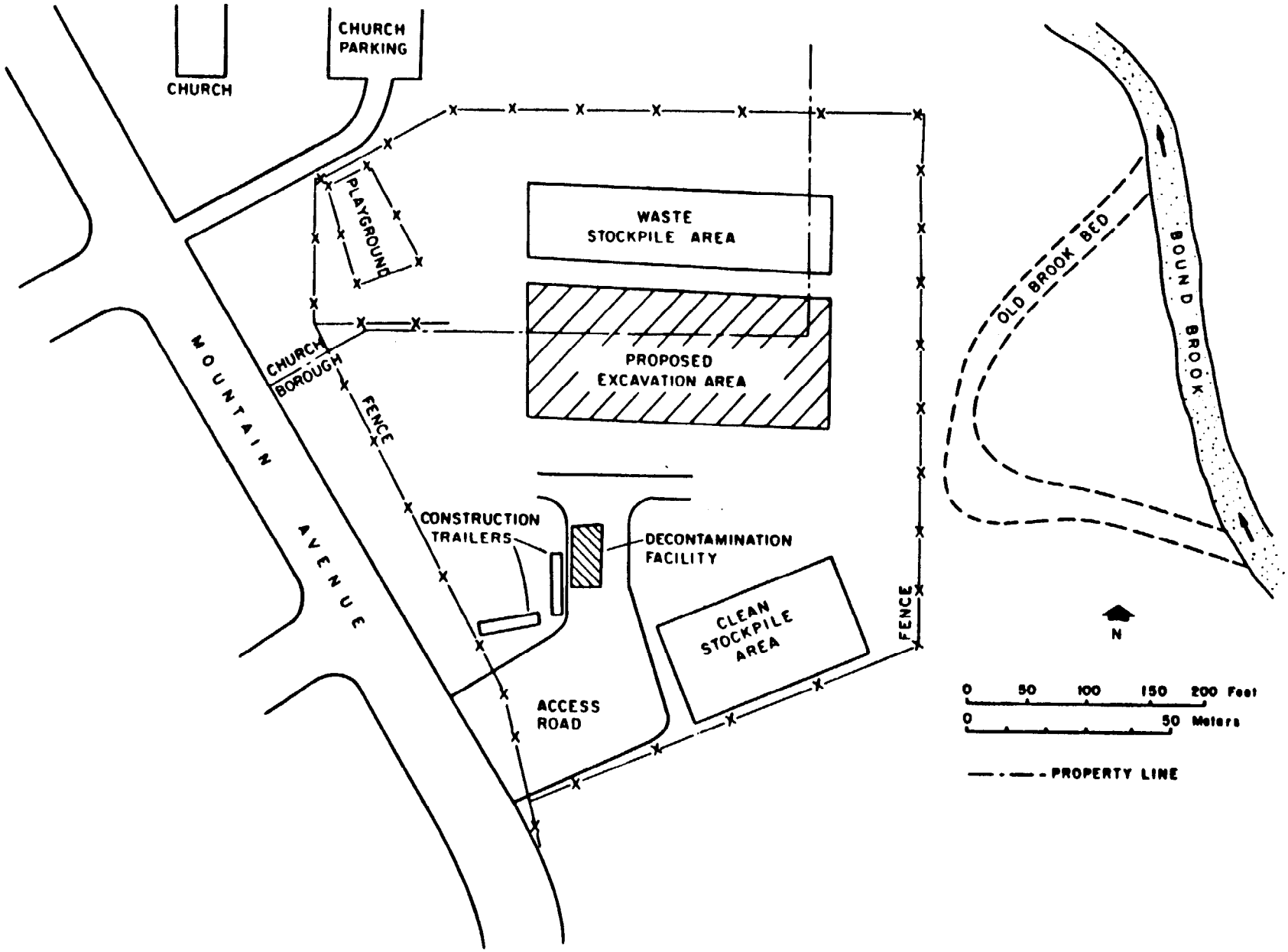



Figure 4.1. Middlesex Landfill--Proposed Cleanup Plan. Source: Preliminary drawing (1984) by Bechtel National.

radioactively contaminated will be excavated and loaded onto trucks for delivery to the Sampling Plant site for interim storage. For the first cut, landfill material that is not radioactively contaminated will be placed in the stockpile area on the north side of the excavation area. For subsequent cuts, such material will be backfilled into the previously excavated cut.

Buried metal objects and other large pieces of wastes will be decontaminated and returned to the excavation area. Decontamination will be accomplished by mechanical cleaning (e.g., rigorously shaking off loose soil at the excavation area and, if necessary, taking the object to the onsite decontamination pad for washing down). Any objects that cannot be sufficiently decontaminated will be taken to the Sampling Plant site.

The transport distance to the Sampling Plant site is approximately 0.8 km (0.5 mi) along Mountain Avenue. The dump trucks transporting the radioactive materials will be covered with tarpaulins. The capacity of the trucks will be restricted by the applicable load limits of the roads and a railroad bridge that must be traversed. Using 10-$yd^3$ trucks and assuming an excavation time of 40 workdays, about 600 truckloads, or 15 truckloads per day, will be required.

### 4.1.2 Sampling Plant

The northern part of the existing asphalt storage pad at the Sampling Plant site will be used for storage of the landfill wastes (Figure 4.3). In addition to the existing large pile on the south storage pad area, there is a small existing pile on the north pad area containing contaminated ashes resulting from incineration of trees and other organic matter removed from other properties during previous remedial actions. This ash pile is covered with a synthetic liner (EPDM). This pile and the area to be covered by the new storage pile (Figure 4.3) will be covered with a synthetic liner and the landfill wastes will then be placed on the liner to form one continuous new storage pile. Wastes will be laid down in layers and dried or wetted, as necessary, so that they can be compacted by a bulldozer. The pile will eventually reach a height of about 3 m (10 ft), cover an area of 1,800 $m^2$ (20,000 $ft^2$), and have 3:1 side slopes.* Any large objects that are removed from the Landfill and cannot be adequately decontaminated will be stored in a separate section of the pile.

It will take about 3 months to complete the pile and cover it with a synthetic cover. The synthetic liner and cover have not yet been specified. The material will be resistant to degradation by the chemical substances, particularly organics, in the landfill wastes. Both Hypalon and EPDM are currently being considered. (See further discussion in Section 5.2.)

The trucks will dump the wastes from a ramp at the storage pile in order to minimize decontamination requirements. After depositing each load at the storage pile, the trucks will be surveyed for radioactivity and decontaminated, as necessary, at the existing decontamination area in the northeast corner of

*The pile dimensions may change slightly if waste volumes change.

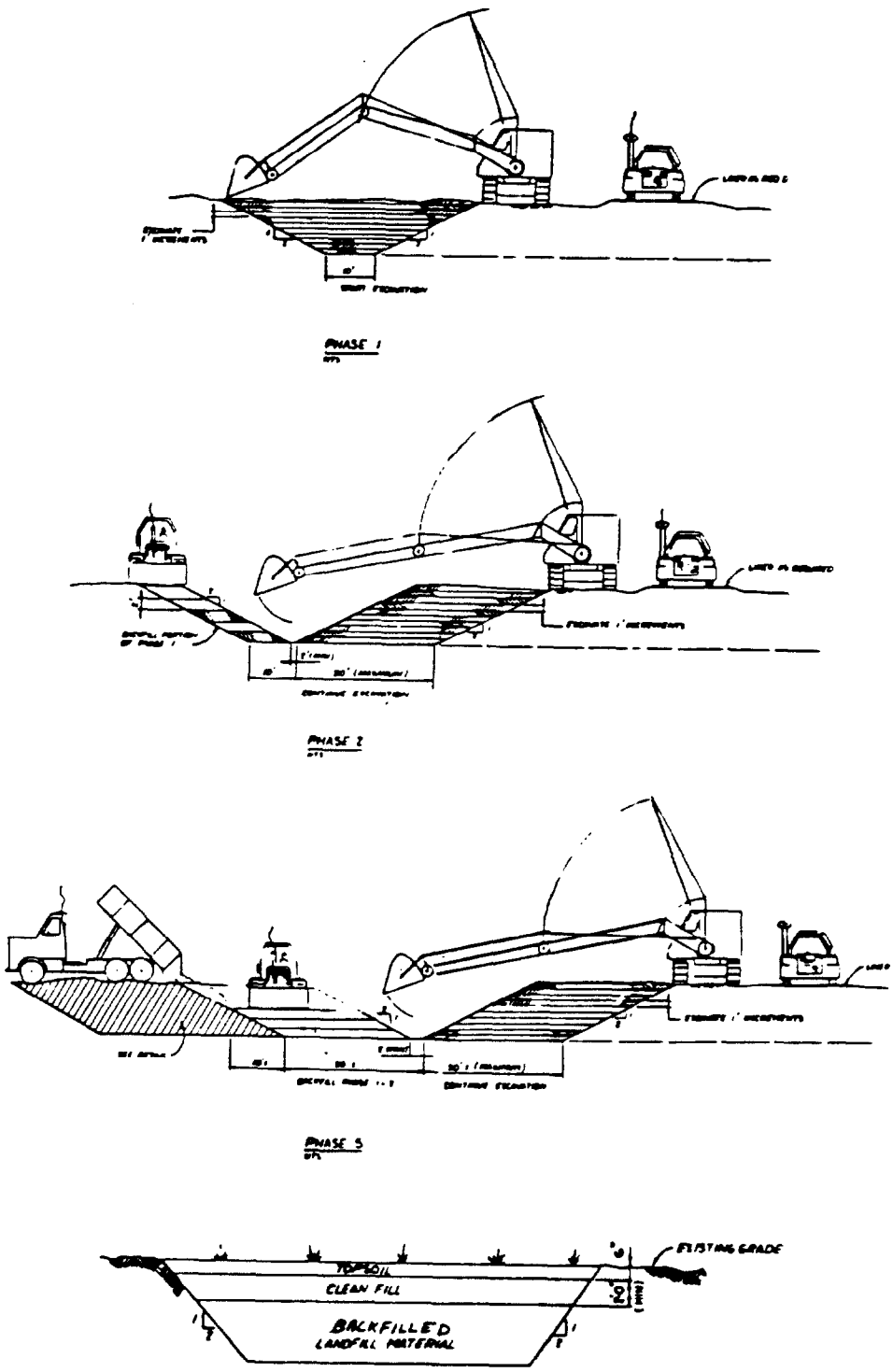



Figure 4.2. Middlesex Landfill--Sequence of Proposed Excavation and Backfill Activities. Source: Preliminary drawing (1984) by Bechtel National.

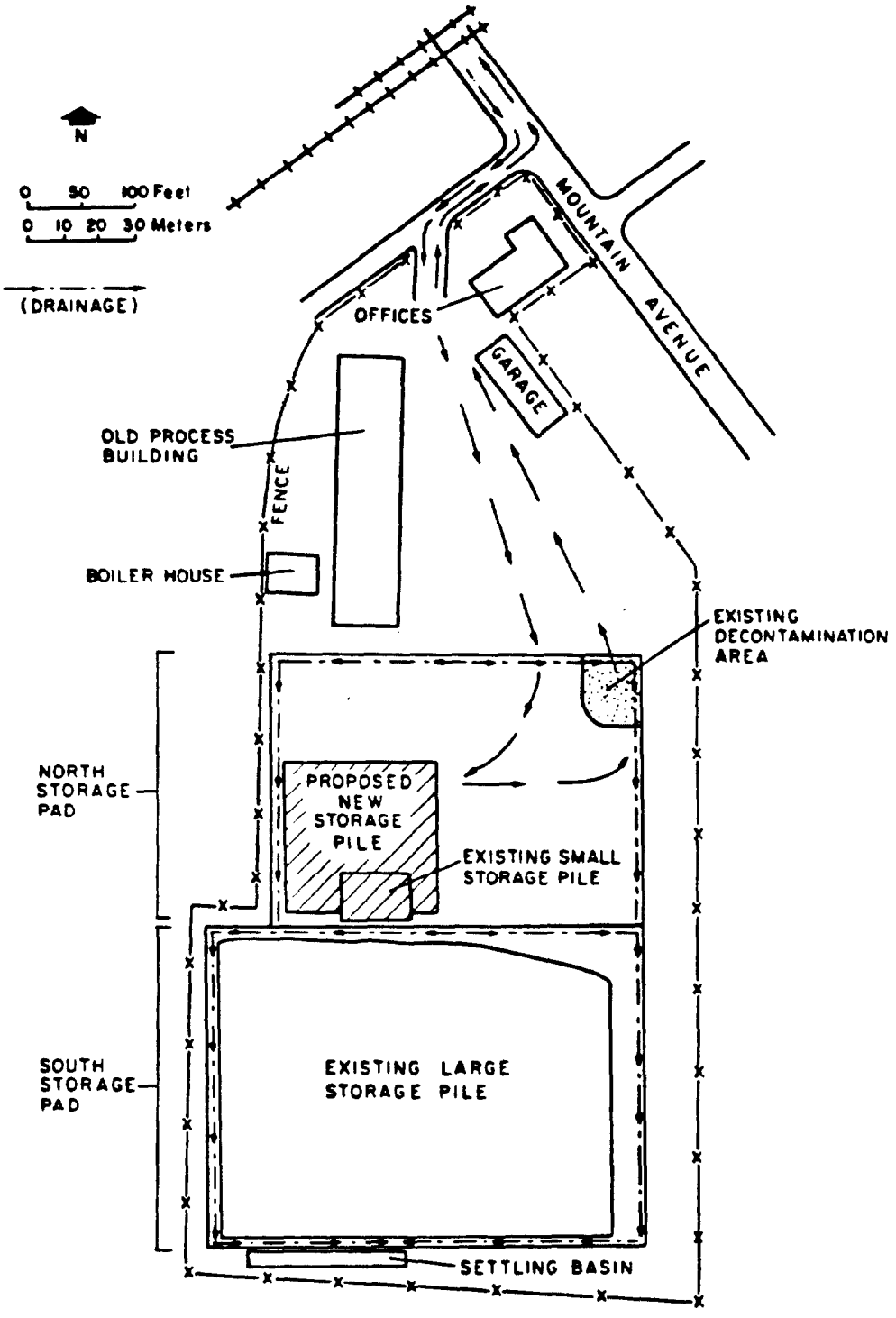



Figure 4.3. Middlesex Sampling Plant Site--Proposed Location of New Storage Pile. Source: Preliminary drawing (1984) by Bechtel National.

storage pad. This will be accomplished using a fire hose. The drainage system of the north pad area (which currently empties into the south pad drainage system and then to the settling basin and ditch) will be modified to separately collect all runoff from the north pad. The collected water will be analyzed for both radiological and chemical contaminants. If determined to be within acceptable limits, it will be released to the ditch. If contaminated, the water will be placed in storage tanks and hauled offsite to a licensed facility for treatment and disposal.

A summary of the measures to mitigate and monitor potential impacts that will be a part of the proposed actions is given in Table 4.1. Additional measures that are being considered are discussed in Section 5.

## 4.2 ALTERNATIVES TO THE PROPOSED ACTION

Alternatives to the proposed action include:

1. TAKE NO ACTION AND CONTINUE RESTRICTIONS REGARDING USE OF THE LANDFILL. This may require formal implementation of legal and other institutional controls, such as putting restrictive covenants on deeds.

2. RELEASE THE LANDFILL FOR UNRESTRICTED USE WITH RESPECT TO RADIOLOGICAL CONDITIONS. This would require more extensive hydrological characterization of the Landfill and a pathway analysis of potential exposure of humans to the radioactivity under possible land- and water-use scenarios. The release of the Landfill with respect to hazardous chemical conditions is not under DOE's jurisdiction.

3. EXCAVATE AND STORE ONLY THE RADIOACTIVELY CONTAMINATED MATERIALS FOUND WITHIN THE UPPER 1.5 m OF THE LANDFILL. "Hot spots" would also be excavated. This would require a pathway analysis of radioactivity below 1.5 m to determine whether, after cleanup, the site could be released for unrestricted use after cleanup with respect to radiological conditions.

4. STABILIZE THE RADIOACTIVE MATERIALS IN PLACE. Such measures might include construction of a cap over the Landfill to reduce radon emissions and reduce infiltration into and subsequent seepage from the Landfill. Restrictions on future use of the Landfill may also be necessary.

5. DELAY REMEDIAL ACTION UNTIL THE CHEMICAL CONDITION OF THE LANDFILL CAN BE MORE ADEQUATELY CHARACTERIZED. If necessary, more mitigative measures could be planned with respect to hazardous chemicals. Such measures might include coordination with EPA and other authorities to either stabilize both the hazardous chemical and radioactive wastes in place or to remove both kinds of wastes together to a treatment and/or permanent disposal facility.

6. MOVE THE RADIOACTIVELY AND/OR CHEMICALLY CONTAMINATED MATERIALS DIRECTLY TO ANOTHER SITE(S) FOR LONG-TERM MANAGEMENT OR PERMANENT DISPOSAL. This alternative offers the advantage of moving the contaminated materials only once. However, a permanent disposal site has not yet been identified, and funds are currently available for excavation and interim storage.

Table 4.1. Summary of Measures to Mitigate and Monitor Potential Adverse Impacts That Will Be Part of the Proposed 1984 Actions

- Controls over possible spread of radiological and chemical contamination, including: worker monitoring; decontamination of vehicles; control of runoff from the excavation and storage areas; and use of a cover and liner at the storage pile to inhibit infiltration into and seepage from the stored wastes.
- Careful radiological surveys of each 0.3-m (1-ft) excavation layer to minimize the amount of material that has to be treated as being radioactively contaminated.
- Erosion and dust controls, including: staged, prompt restoration/revegetation of disturbed areas and completion of work before end of growing season; temporary cover over storage pile, as necessary; watering of disturbed areas and unpaved truck routes; covering truckloads of contaminated material with tarpaulins; and spraying collected contaminated water on the storage pile during construction of the pile.
- Drilling of ventholes and excavation in 0.3-m (1-ft) increments to allow methane gas to dissipate; provision of anti-spark devices on trucks and other construction equipment; monitoring for methane and other volatile gases.
- Use of protective clothing and masks if hazardous chemicals are encountered.
- Water quality monitoring, including: radiological monitoring of wells around the storage area and radiological and chemical monitoring of runoff water collected from the north storage pad area.
- Air monitoring for radioactive gases and dust.
- Noise mitigation, including: periodic checks of mufflers, compressors, etc.; work between 8:00 a.m. and 8:00 p.m. to minimize nuisance to nearby residents.
- Construction of a new fence around the excavation area; prompt restoration of the original grade at the Landfill.
- Scheduling of truck movements and provision of traffic directors, as necessary, to minimize traffic congestion.
- Temporary relocation of the recycling center to an area behind the municipal building during the Landfill cleanup.
- Consultation, cooperation, and coordination with local authorities and concerned citizens throughout the entire period of the action, including: regular information/coordination/planning meetings during both the cleanup and storage phases and designation of an onsite public liaison person for the cleanup phase.
- Periodic monitoring and surveillance of the interim-storage pile, with maintenance of the cover and a pest (rodent and plant) control program, as necessary, to ensure the integrity of the pile and minimize potential offsite movement of contaminants.

7. REMOVE THE CONTAMINATED MATERIALS TO THE MIDDLESEX SAMPLING PLANT FOR LONG-TERM MANAGEMENT OR PERMANENT DISPOSAL. This would require additional site characterization and design engineering. In addition, such disposal would most reasonably be considered in conjunction with disposal of the wastes that are already stored in the existing interim-storage piles on the Sampling Plant site. Funds are currently not available for consideration of a permanent site. Moreover, local authorities have taken the position that they do not want the Middlesex Sampling Plant site used for permanent disposal of either radioactive materials or chemically co-contaminated materials.

8. DISPOSE OF THE LANDFILL WASTES IN THE OCEAN. This has previously been considered for the wastes that are already stored at the Sampling Plant site. However, this alternative has received much public opposition and the regulatory framework for taking such an action is not yet in place. Furthermore, the presence of hazardous chemicals in the Landfill wastes may preclude their disposal in the ocean.

# 5. ENVIRONMENTAL CONSEQUENCES AND MITIGATION

## 5.1 RADIOLOGICAL

A major potential issue associated with the proposed remedial actions is the radiological impacts. The predominant pathways by which radionuclides could reach nearby workers and members of the general public during the proposed actions are: (1) internal dose from inhalation of radioactive products such as those from decay of radon gas (radon-222)--a radionuclide in the decay chain of uranium-238, which is found at the Middlesex Landfill site (Figure 5.1), (2) internal dose from inhalation of contaminated dust particles, (3) external dose from submersion in a cloud of contaminated dust, and (4) external dose from radioactive particles deposited on the ground. Based on analysis of similar activities (Argonne Natl. Lab. 1982), it is expected that the internal dose from ingesting contaminated food or water will be relatively insignificant.

The analysis of potential doses to nearby individuals and to the general public within an 80-km (50-mi) radius of the Landfill is based on the following:

- Radionuclides in the uranium-238 decay chain (Figures 5.1) are assumed to be present in equilibrium with the parent radionuclide.

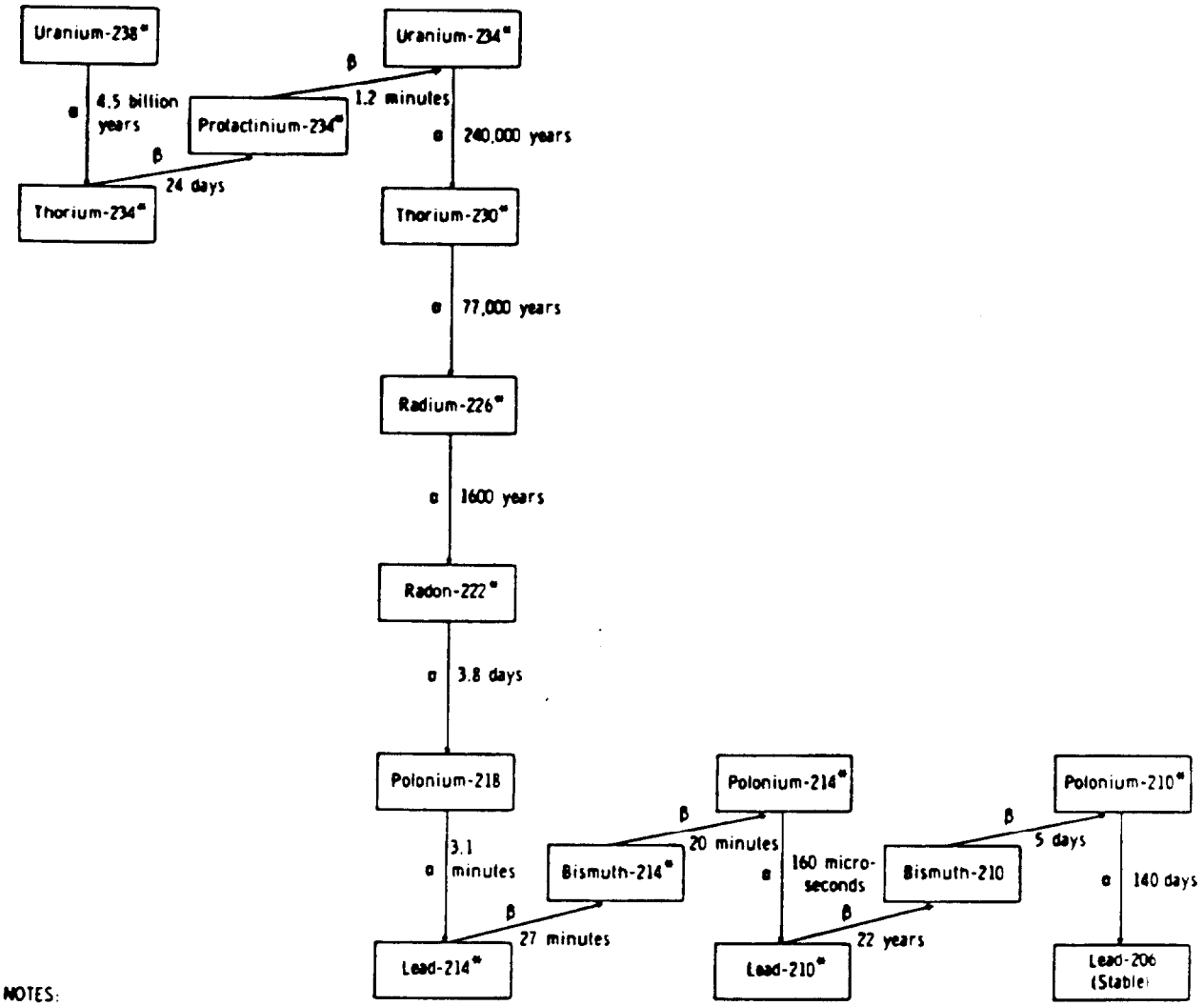
- The average concentration of each of the radionuclides in the contaminated materials to be excavated and stored is 15 pCi/g (Section 2.3).

- The duration of the activities involving cleanup and construction of the interim-storage pile will be 3 months.

- Both gaseous and particulate releases will occur while the material is being excavated and placed on the storage pile (for 3 months), but only gaseous releases will occur thereafter because the storage pile will be covered and maintained.

- Particulate releases from the excavation activities and exposed storage pile (during the 3 months of pile construction) are assumed to be 0.14 $kg/m^2/mo$ (0.6 ton/acre/mo), which is half the rate reported for general construction activities (U.S. Environ. Prot. Agency 1977; Argonne Natl. Lab. 1982). It is expected that much of the excavated material will be wet, and dust-control measures will be used at the storage pile. Estimated radioactive particulate releases are therefore 0.000012 Ci for each of the radionuclides in the uranium-238 decay chain.

- Radon gas releases will include both "puff" releases when the contaminated materials are disturbed during excavation and "steady" releases from the storage pile. Puff releases are assumed to be 20% of the radon gas inventory (the other 80% remains trapped within the contaminated particles). Steady releases account for most of the releases and are calculated based on the assumptions that the stored material will: (a) be an average of




NOTES:

Only the dominant decay mode is shown.
The times shown are half-lives.
The symbols α and β indicate alpha and beta decay.
An asterisk indicates that the isotope is also a gamma emitter.

Figure 5.1. Uranium-238 Radioactive Decay Chain.

2.5 m (8.3 ft) in depth, (b) cover an area of 1800 $m^2$ (20,000 $ft^2$), (c) have an average moisture content of about 13%, and (d) have a gaseous diffusion coefficient of 0.0036 $cm^2/s$. For continued releases during interim storage, no credit is taken for retardation of radon gas by the cover. Radon fluxes are estimated to be 3.1 $pCi/m^2/s$. These fluxes are calculated according to the method of analysis given in a report of the U.S. Nuclear Regulatory Commission (1983). Radon releases are estimated to be 0.044 Ci during the 3-month action period and 0.18 Ci/yr thereafter.

- The population distribution for the 15 million people within 80 km (50 mi) of Middlesex is estimated based on 1980 county census data.

- Meteorological conditions at Middlesex are assumed to be similar to those at Newark, New Jersey, for which meteorological data are available.

- Doses are evaluated in terms of the 100-year environmental dose commitment (EDC). The 100-year EDC is the integrated dose over 100 years resulting from continued exposure to the radionuclides released either during the 3 months of remedial actions or during each subsequent year from the storage pile.

Assuming that the mitigative measures discussed in Table 4.1 are implemented, potential doses to nearby individuals are estimated to be small (Table 5.1). The predicted whole-body doses are similar in magnitude to doses received while spending 2 minutes on a jet plane at high altitudes or spending 3 months (the time required to complete the remedial actions) at an altitude that is 2.6-m (8.7-ft) higher (Table 5.2). Specific organ doses (e.g., bone and lung) are lower than doses received from natural sources (Table 5.2).

Table 5.1. Estimated Radiological Doses to Nearby Individuals As a Result of Releases During the Proposed 1984 Remedial Actions†[1]

| Individual/Location | Distance and Direction from Center of Storage Pile | Dose (mrem) | | | |
|---|---|---|---|---|---|
| | | Whole Body | Bone | Average Lung | Bronchial Epithelium |
| Worker at Salvage Yard | 50 m W | 0.0083 | 0.22 | 0.24 | 0.29 |
| Resident on Mountain Avenue | 140 m ENE | 0.011 | 0.29 | 0.32 | 0.39 |
| Resident on William Street | 200 m SE | 0.0023 | 0.063 | 0.068 | 0.083 |

†[1] Bases for radiological analysis are given in the text.

Table 5.2. Comparison of Doses to Maximally Exposed Individual to Doses from Natural Background Sources

| Dose from Remedial Action (values from Table 5.1) | Comparable Dose |
|---|---|
| 0.011 mrem (whole body) | Equal to dose from riding about 2 minutes in a jet plane at 10,000 m (33,000 ft) because of increase in cosmic radiation with altitude,†[1] or<br><br>Equal to dose from staying for the same amount of time as the remedial action (3 months) at 2.6-m (8.7-ft) higher altitude†[1] |
| 0.29 mrem (bone) | 30 mrem received from natural radiation sources (background) over the same period of time†[1] |
| 0.32 mrem (average lung) | 45 mrem received from natural background radiation over the same period of time†[1] |
| 0.39 mrem (bronchial epithelium) | 83 to 150 mrem received from radon from natural background radiation over the same period of time†[2] |

†[1] Conversion factors are given in reports of Argonne National Laboratory (1982) and National Council on Radiation Protection and Measurements (1975).

†[2] Based on 320 to 600 mrem/yr, assuming an outdoor radon-222 concentration of 0.3 pCi/L (Moses et al. 1963), an indoor concentration of 1 pCi/L (U.N. Sci. Comm. At. Radiat. 1977), and dose conversion factors for radon-222 of 1000 mrem/yr per pCi/L for outdoor background conditions (infinite source) and 625 mrem/yr per pCi/L for indoor conditions (50% equilibrium of radon daughters) (U.S. Nucl. Reg. Comm. 1980).

The estimated doses to several organs and the whole body for the general public are presented in Table 5.3. The general public is considered to be the population of about 15 million people (1980 census) residing within 80 km (50 mi) of the site. This population will receive doses resulting from releases during the remedial actions; and, after the remedial actions have been completed, this population will continue to be exposed to radioactive releases from the storage pile (e.g., radon gas). These doses will all be negligible compared to doses the same population will receive from natural background sources of radiation (Table 5.3).

Table 5.3. Estimated Doses to the General Public As a Result of the Proposed 1984 Remedial Actions

| Tissue or Organ | Dose†[1] (person- or organ-rem) From Releases During the 3 Months of Remedial Actions | From Natural Background Radiation During the 3 Months of Remedial Actions | Dose from Releases as Percentage of Background |
|---|---|---|---|
| Whole body | 0.054 | 380,000 | 0.000014% |
| Bone | 0.30 | 450,000 | 0.000067% |
| Average lung | 0.30 | 680,000 | 0.000044% |
| Bronchial epithelium | 0.12 | 400,000 - 2,300,000 | 0.0000052 - 0.000030% |

| Tissue or Organ | Dose†[1] (person- or organ-rem/yr) From Continuing Gaseous Releases from the Storage Pile | From Continuing Natural Background Radiation | Dose from Releases as Percentage of Background |
|---|---|---|---|
| Whole body | 0.0052 | 1,500,000 | 0.00000035% |
| Bone | 0.016 | 1,800,000 | 0.00000089% |
| Average lung | 0.0046 | 2,700,000 | 0.00000017% |
| Bronchial epithelium | 0.48 | 4,800,000 - 9,000,000 | 0.0000053 - 0.000010% |

†[1] Reported as the 100-year environmental dose commitment to the population within 80 km (50 mi) of the Middlesex Sampling Plant site.

Doses to workers will be controlled and limited to less than those specified by DOE regulations for occupational doses (e.g., whole-body doses of 3000 mrem/quarter or 5000 mrem/year). Workers will be trained with regard to radiation risks and proper health-physics procedures.

Another potential radiological issue is whether the decontamination guidelines for the contaminated areas are considered sufficient (see Appendix A). The guidelines to be used are based on recent detailed studies (U.S. Dep. Energy 1983b; Gilbert et al. 1983). DOE believes that these guidelines are conservatively low for considering potential adverse health effects that might occur in the future from any residual contamination. All remedial actions will be conducted in a manner to minimize radiation doses to the general public and to workers in accordance with DOE's as-low-as-reasonably-achievable (ALARA) philosophy. Release of the Landfill for unrestricted use is not part of the proposed remedial actions. Such release will be subject to a separate DOE decision in the future.

## 5.2 CHEMICAL, PHYSICAL, AND BIOLOGICAL

### 5.2.1 Chemical

#### 5.2.1.1 Landfill

There are two pathways for potential chemical impacts resulting from activities at the Landfill: (1) atmospheric transport of hazardous dusts and organic vapors, and (2) leachate and runoff entering surface water or groundwater. Atmospheric transport of hazardous dusts and organic vapors may impact people living within about one hundred meters (a few hundred feet) of the Landfill. Besides being potentially hazardous, airborne chemicals may have objectionable odors. Also, the release of methane gas may cause a potential explosion hazard. Mitigative measures will be taken, including: use of anti-spark devices on vehicles and equipment, use of an air quality monitor for volatile gases, keeping exposed surfaces moist to minimize dust generation, restricting activities when it is very windy, and following procedures to minimize the rupture of drums and containers. Workers at the Landfill will be exposed to much higher concentrations of hazardous materials than will people living nearby. Therefore, workers will wear protective clothing and masks, as necessary, and activities will be carried out in a manner that will serve to protect their health.

The activities at the Landfill may adversely impact surface water and groundwater both during and after the remedial actions. Although there currently seems to be little movement of radioactive or chemical contaminants (Sections 3.1 and 3.6), disruption of the landfill materials could result in mobilization of the hazardous chemicals. This could occur in several ways. First, it is expected that groundwater will be encountered during excavation, and the excavation itself may temporarily change local upper aquifer flow patterns so that more groundwater flows into the excavation hole from all sides. This will especially be the case if Bound Brook is at flood stage. Wet wastes excavated from the Landfill will be placed alongside the excavation and contaminated leachate will drain back into the excavation. The physical disruption and mixing of contaminants and the presence of large amounts of contaminated water may possibly increase contaminant migration into groundwater, particularly in the overburden aquifer. Contaminated surface runoff and groundwater may also reach Bound Brook, especially if a severe (e.g., 100-year) flood occurs during excavation.

There should be no little or impacts from atmospheric transport of hazardous chemicals after closure of the Landfill because the backfilled wastes will be completely covered with clean backfill. The potential impacts on surface water should also be somewhat less because of the cover. However, depending on the degree of disruption and mixing of backfilled waste material, the chemical impact on groundwater could be worse than before the excavation.

Mitigative measures at the Landfill include minimizing the amounts of contaminated leachate and wastewater generated during the activities. This can be accomplished primarily by not excavating when the groundwater level is high, usually during the summer. Besides minimizing the rupture of drums or containers, another mitigative measure that could be considered is containing and removing the contents of any ruptured drums from the landfill area for safe disposal.

A possible mitigative factor results from the fact that the total amount of backfilled contaminated material will be less than the original amount of excavated material; thus the total amount of chemical contaminants in the Landfill will be less than it was prior to the excavation activities. However, this may be partially counteracted by any increased contaminant mobilization caused by the excavation activities.

Another mitigative factor is that the overburden aquifer is not used for drinking water, at least near the site, and Bound Brook and other downstream waters are not used as a source of potable water (Section 3.1). However, the degree of interconnection between the overburden aquifer and bedrock aquifer (which is used as a public water supply) is not known (Section 3.1).

A reasonable precautionary measure that could be considered is to carry out a program of sampling and analysis for chemical parameters in both the wastes to be transported and backfilled, as well as in the water that collects in the excavated area.* Also, further chemical characterization of the landfill materials will serve to more clearly delineate the potential for contamination of surface water, groundwater, and air and may help to define other mitigative measures.

5.2.1.2 Transportation

There should be minimal potential chemical impacts from the trucks transporting the wastes from the Landfill to the Sampling Plant site. The trucks will have a water-tight bed, will be gasketed, and will be covered with tarpaulins (Bechtel Natl. 1983). Little or no releases of contaminated dust or leachate are expected during the 0.8-km (0.5-mi) trip. Also, the wastes will be drained prior to loading onto the trucks (Section 4.1.1). U.S. Environmental Protection Agency (EPA) and U.S. Department of Transportation (DOT) shipping regulations for hazardous wastes (40 CFR 263 and 49 CFR 177) require that, for shipment in hopper or dump trucks, the trucks must be free from leaks and discharge openings must be securely closed during transportation (49 CFR 173.510).

5.2.1.3 Sampling Plant

The impact of dust and organic vapors entering the atmosphere from the wastes at the Sampling Plant site should be similar to those at the Landfill because dumping and forming the wastes into a pile should generate emissions in amounts similar to those generated during excavation activites. Although less material will be dumped at the Sampling Plant site than is excavated at the Landfill, the material at the Sampling Plant site will be exposed in an above-ground pile for about 3 months until it is covered.

There may be impacts on surface water and groundwater at the Sampling Plant site due to the presence of hazardous chemicals. During construction of the storage pile and during storage, all runoff from the north storage pad

*It is currently planned to take only 20 samples of the wastes to be transported for chemical analysis (Glenn 1984b). This corresponds to about one sample for every 30 truckloads.

area will be collected, analyzed for both radiological and chemical contaminants, and treated if necessary (Section 4.1.2). Based on a peak average monthly precipitation of 37 cm (15 in.), it is estimated that up to 27,000 L (7,000 gal) could be collected in one month.

During the storage period, there may be contamination of both surface water and groundwater if the liner and cover are seriously degraded, thereby allowing release of chemicals. Liners such as Hypalon or EPDM, which have been used previously for storage of wastes having similar radioactive contamination, are not recommended for materials containing petroleum solvents or aromatic or halogenated hydrocarbons (EPDM) or oils (Hypalon) (U.S. Environ. Prot. Agency 1980). Therefore, the selection of the special liner and cover material is being studied relative to the known chemical contaminants. Also, the wastes will be sampled during construction of the pile and analyzed relative to organics that may damage the liner and cover. There will be periodic inspection of the cover, with maintenance or replacement of the cover, as necessary. As long as the cover is maintained, infiltration into and seepage or runoff from the pile will be minimized. A mitigatve measure that could be considered is periodic analysis of samples taken from the existing onsite monitoring wells for chemicals that are expected to be most mobile and/or hazardous.

#### 5.2.1.4 Regulations

According to DOE Order 5408.2 and a Memorandum of Understanding between DOE and the EPA (signed on February 22, 1984), activities at both the Landfill and the Sampling Plant site are governed by EPA requirements for hazardous waste sites. Of particular relevance are those requirements contained in 40 CFR 260-265. The specifics of any requirements relative to EPA regulations are being worked out during ongoing consultation and coordination with the EPA and the New Jersey Department of Environmental Protection.

The redeposition of nonradioactive wastes back into the Landfill may be subject to New Jersey nonhazardous waste management regulations (N.J. Dep. Environ. Prot. 1983). According to these regulations, the redeposition of all solid waste resulting from a landfill excavation shall be in conformity with all requirements for landfills. One requirement is that in order for a landfill to receive and deposit wastes, it must have a system in place for interception, collection, and treatment of any and all leachate generated at the facility. Proper approvals for such a system and for a monitoring program are also required. Such a system and monitoring program are not currently planned for the redeposited material at the Landfill. This issue will be resolved during planned coordination with the EPA and the New Jersey Department of Environmental Protection relative to the proposed remedial actions.

### 5.2.2 Physical

Disturbed areas at the Landfill will be subject to wind and water erosion, with subsequent potential increases in turbidity, sedimentation, and dissolved solids in Bound Brook. The greatest potential for such impact will occur in the summer months during the thunderstorm season. The magnitude of this impact will depend primarily on the timing of construction and the amount of material exposed. However, because Bound Brook is located in an urbanized area and receives a number of point and nonpoint discharges, no noticeable

change in suspended solids is expected. Runoff from the storage pad at the Sampling Plant is not expected to be high in suspended solids because only the actual storage pile will be barren soil; the remainder of the site is paved with asphalt or gravel. Furthermore, a temporary cover will be placed over the pile when heavy rains are predicted, and all runoff from the north storage pad area will be collected and treated, as necessary.

Another issue may be the durability of the interim-storage pile. Frost penetrates to a depth of about 38 cm (15 in.) in the Middlesex area. Frost heave could cause the cover to rupture--resulting in infiltration of snowmelt and rainwater, saturation of the pile, and leaching to groundwater. This may be exacerbated by the relatively steep side slopes (3:1) that may lead to slumping of the stored material. However, measures will be taken to minimize this potential impact, including: compaction of the stored materials, periodic surveillance to check on the integrity of the pile and its cover, and repairs (as necessary).

Water from the local public supply system (estimated to be less than 38,000 L [10,000 gal]) will be used for equipment decontamination at both the Landfill and Sampling Plant sites. At the Landfill, a steam/high-pressure water system will be used to minimize water use, and water will be recirculated through filters as much as possible. The amount of water to be used is small relative to the available resources and local demands in Middlesex.

Construction of the access roads will require consumption of timber, sand, and gravel resources. These resources are generally available locally, and supplies will not be unduly strained by the demands of the proposed project.

### 5.2.3 Biological

Implementation of the proposed action will have only a minimal effect on the terrestrial biota in the project area. Mammals and birds currently inhabiting the area to be disturbed at the Landfill will be dispossessed (larger and/or mobile species) or destroyed (smaller, less mobile species). The vegetation will be destroyed temporarily. After backfilling is complete, disturbed areas will be seeded and vegetation should become reestablished quickly. The area is expected to be dominated by early successional species similar to those present prior to the remedial actions. The adverse effects of dust, noise, and traffic during the period of excavation and storage will be minimal due to (1) the paucity of wildlife, (2) the fact that the sites are located in an urban area where such impacts currently exist, and (3) the implementation of mitigative measures (i.e., dust suppression). No impacts to endangered or threatened biota are anticipated from the proposed actions because their habitats do not correspond to those found on the affected sites.

During the interim-storage period (designed for 25 years), animals and plants could adversely affect the durability of the interim-storage pile. Burrowing animals such as the woodchucks may invade the pile--resulting in excavation of the contaminated soils, increased water infiltration, and decreased stability of the pile (Arthur and Markham 1983). Plant roots may also intrude into the storage pile (Cline and Uresk 1979; Yamamoto 1982)--especially species that produce suckers, such as the tree-of-heaven. However, the storage pile will be located on the asphalt storage pad, which will deter

animals from inhabiting it. Also, during the interim-storage period, the cover will be maintained and a pest-control program will be implemented, if necessary (Table 4.1).

## 5.3 SOCIOECONOMIC IMPACTS

At the county and community levels, the settlement pattern should not be impacted by the proposed action. Following cleanup of contaminated soils at the Landfill site, current public and residential land uses could continue (subject to local zoning ordinances). Borough of Middlesex plans for the Landfill site are reportedly contingent on the availability of federal funds. If funds become available, a park-recreation area might be developed in the present location (U.S. Dep. Energy 1980b).

As long as the interim-storage pile remains at the Sampling Plant, the land cannot be used for other kinds of development. The federal government will maintain the storage pile. If the radioactive materials are removed from the site in the future, the assessed value of this property may increase approximately 10 times (see Ford, Bacon & Davis 1979), especially if the property is used for industrial or commercial purposes.

Cleanup activities involving excavation, movement, restoration, and storage of the contaminated soils at the Landfill could cause some localized impacts. Transport of soils to the Sampling Plant site will increase truck traffic on Mountain Avenue (about 15 trucks per day). Additional traffic may also result from movement of equipment to the job sites, transport of clean backfill materials to the Landfill, and the small work force that is expected to commute to these sites in private vehicles (Section 3.5). Transportation impacts are expected to be short-term and are likely to be associated with increased traffic congestion. It is expected that the increased traffic associated with the proposed remedial actions will be negligible compared to the traffic (including heavy trucks) that already occurs during the day on Mountain Avenue. Truck movements will be scheduled and traffic directors will be provided, as necessary.

Excavation, loading, unloading, pile construction, and site restoration activities--as well as increased traffic--are expected to temporarily increase local noise levels around both the Landfill and Sampling Plant sites. Some individuals that use the municipal building and church near the Landfill and residents on Mountain Avenue and William Street near the Sampling Plant may be annoyed. Background noise at the Sampling Plant is relatively higher than at the Landfill because of other industrial activities on nearby properties. In order to minimize noise impacts at both locations, mufflers and compressors, etc., will be periodically checked and work will be carried out only between 8:00 a.m. and 8:00 p.m. An additional mitigative measure that could be considered is scheduling work after services at the adjacent church if work at the Landfill site occurs on a Sunday.

Demographic changes from the influx of workers or the outmigration of local residents is expected to be insignificant. Some local subcontractors will be hired and a few work force in-movers with families are anticipated. Following cleanup of the Landfill, local health concerns should be reduced. Consequently, future home sales, outmovement of residents, and/or land-use changes at and near the Landfill are not anticipated at this time. However,

some degree of public concern may continue until decisions are made regarding: (1) permanent disposition of the contaminated materials to be stored on the Sampling Plant site, and (2) release of the decontaminated sites for unrestricted use.

Another potential adverse impact is noxious odors from the excavated Landfill materials. The mitigative measures discussed previously (Section 5.2.1) should help minimize this impact to nearby residents.

Other socioeconomic impacts, such as demands on local goods and services or effects on the local economy, are expected to be minimal for a project of this size (Argonne Natl. Lab. 1982).

In an analysis of previous remedial actions at Middlesex (Ford, Bacon & Davis 1979), the following conclusions were reached: (1) workers are likely to be drawn from both the local area and outside the vicinity, (2) the influx of workers would not stress local services, and (3) a storage pile as high as 3 m (10 ft) above ground level on the Sampling Plant site may be aesthetically displeasing. These same conclusions are also applicable to the proposed 1984 remedial actions.

Through proper planning and coordination, adverse socioeconomic impacts can be minimized. Dissemination of information to the public is an important activity needed during remedial actions (Ford, Bacon & Davis 1979; Argonne Natl. Lab. 1982). Nonradiological health and safety concerns associated with excavating and loading activities at the Landfill will be lessened by construction of a fence (Section 4.1.2) and other security measures. Radiological concerns may be lessened by providing the public with information regarding the cleanup schedule and planned monitoring procedures.

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NOTE: The guidelines contained herein have been superseded by those contained in Appendix A to Exhibit I of the certification docket.

# APPENDIX A. U.S. DEPARTMENT OF ENERGY INTERIM RESIDUAL CONTAMINATION AND WASTE-CONTROL GUIDELINES FOR FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM (FUSRAP) AND REMOTE SURPLUS FACILITIES MANAGEMENT PROGRAM (SFMP) SITES

March 5, 1984
(Review Within DOE Continuing)

Presented here are the residual contamination cleanup and waste-control guidelines of general applicability to the FUSRAP project and remote SFMP sites.* A site-specific analysis will be prepared for each FUSRAP and remote SFMP site prior to determining residual contamination guidelines for a specific site. In addition, it is policy of the DOE to decontaminate sites in a manner consistent with DOE's as-low-as-reasonably-achievable (ALARA) policy. ALARA will be considered in reducing levels of residual contamination below applicable dose limits. ALARA will be implemented using cost/benefit considerations, and applied on a site-specific basis.

The soil residual contamination criteria were developed on the basis of limiting maximum individual radiation exposure to DOE limits specified in DOE Order 5480.1A, exclusive of exposure from natural background radiation or medical procedures. The radium-226 and thorium-230 guidelines include an additional limitation for builup of radon-222 decay products in buildings. The aggregate of the contribution from all major pathways, based on scenarios for permanent intrusion--e.g., establishing residences on the site, was assumed. In most circumstances, the probability is low that such an intrusion will occur. Also, conservative assumptions were used in deriving these criteria to ensure that a particular dose limit would not be exceeded. Use of these guidelines is additionally conservative because the pathways considered in the derivation of the criteria assume all water intake and most food intake is from the site. Also, the FUSRAP and remote SFMP sites often have limited agricultural capability and the contamination is generally not homogeneous. The combined effect of these factors is such that the probable radiation exposure to the average population on, or in the vicinity of, FUSRAP or remote SFMP sites decontaminated to these criteria guidelines will not be appreciably different from that normally received from natural background radiation.

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*A remote SFMP site is one that is excess to DOE programmatic needs and is located outside a major operating DOE Research and Development (R&D) or production area. Remote sites are more likely to be released to the public or excessed to other government agencies after decontamination than are sites located within major R&D or production areas.

The residual contamination guidelines for surface contamination of structures were developed from the proposed ANSI standard (proposed ANSI N13.12--an adaptation to be applied, as appropriate) modified as appropriate to be consistent with DOE Order 5480.1A and the specific needs of FUSRAP for cost-effective, workable guidelines that provide an adequate safety margin. The very conservative nature of these guidelines and the possible need to adjust them in the future will continue to receive attention by DOE. The waste-control guidelines are consistent with DOE Orders and EPA regulations for inactive uranium milling sites, 40 CFR Part 192.

## A. RESIDUAL CONTAMINATION GUIDELINES FOR FORMERLY UTILIZED SITES AND REMOTE SURPLUS FACILITIES MANAGEMENT PROGRAM SITES

The following guidelines represent the maximum residual contamination limits for unrestricted use of land and structures contaminated with radionuclides related to the nuclear fuel cycle at FUSRAP and remote SFMP sites. A site-specific analysis will be prepared for each site prior to determining residual contamination guidelines for a specific site. It is the policy of DOE to decontaminate sites to contamination levels at or below the limits and in a manner consistent with DOE's as-low-as-is-reasonably-achievable (ALARA) policy on a site-specific basis. Site-specific guidelines and ALARA policy will be determined by DOE on a site-specific basis and an ALARA report filed on completion of remedial action at a site. Existing state and federal standards will be applied for water protection. Residual contamination limits for other nuclides will be developed when required using the same methodology as was used for those represented here [described in ORO-831 (U.S. Dep. Energy 1983) and ORO-832 (Gilbert et al. 1983)].

### 1. Soil (Land) Guidelines (Maximum Limits for Unrestricted Use)

| Radionuclide | Soil Criteria†[1],†[2],†[3] (pCi/g above background) |
|---|---|
| U-Natural†[4] | 75 |
| U-238†[5] | 150 |
| U-234†[5] | 150 |
| Th-230†[6] | 15 |
| Ra-226 | 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 and less than 1.5 m below the surface. |
| U-235†[5] | 140 |
| Pa-231 | 40 |
| Ac-227 | 190 |
| Th-232 | 15 |

| | |
|---|---|
| Am-241 | 60 |
| Pu-241†[7] | 2400 |
| Pu-238, -239, -240 | 300 |
| Cs-137 | 80 |
| Sr-90 | 300 |
| H-3 (pCi/mL soil moisture) | 5,200 |

†[1] In the event of occurrence of mixtures of radionuclides, the fraction contributed by each radionuclide to its guideline shall be determined, and the sum of these fractions shall not exceed 1. There are two special cases for which this rule must be modified:

(a) If Ra-226 is present, then the fraction for Ra-226 should not be included in the sum if the Ra-226 concentration is less than or equal to the Th-230 concentration. If the Ra-226 concentration exceeds the Th-230 concentration, then the sum shall be evaluated by replacing the Ra-226 concentration by the difference between the Ra-226 and Th-230 concentrations.

(b) If Ac-227 is present, then the same rule given in (a) for Ra-226 relative to Th-230 applies for Ac-227 relative to Pa-231.

†[2] Except for Ra-226, these guidelines represent unrestricted-use residual concentrations above background averaged across any 15-cm-thick layer to any depth and over any contiguous 100-$m^2$ surface area. The same conditions prevail for Ra-226 except for soil layers beneath 1.5 m; beneath 1.5 m, the allowable Ra-226 concentration may be affected by site-specific conditions and must be evaluated accordingly.

†[3] Localized concentrations in excess of these guidelines are allowable provided that the average over 100 $m^2$ is not exceeded. However, DOE ALARA policy will be considered on a site-specific basis when dealing with elevated localized concentrations.

†[4] One curie of natural uranium means the sum of $3.7 \times 10^{10}$ disintegrations per second (dis/s) over any 15-cm-thick layers from U-238 plus $3.7 \times 10^{10}$ dis/s from U-234 plus $1.7 \times 10^{9}$ dis/s from U-235. One curie of natural uranium is equivalent to 3,000 kilograms or 6,600 pounds of natural uranium.

†[5] Assumes no other uranium isotopes are present.

†[6] The Th-230 guideline is 15 pCi/g to account for ingrowth of Ra-226 as Th-230 decays. Ra-226 is a limiting radionuclide because its decay product is Rn-222 gas.

†[7] The Pu-241 criterion was derived from the Am-241 concentration.

2. Structure Guidelines (Maximum Limits for Unrestricted Use

a. Indoor Radon Decay Products

A structure located on private property and intended for unrestricted use shall be subject to remedial action as necessary to ensure the annual average concentration of radon decay products is less than 0.03 WL within the structure.

b. Indoor Gamma Radiation

The indoor gamma radiation after decontamination shall not exceed 20 microroentgen per hour (20 μR/h) above background in any occupied or habitable building.

c. Indoor/Outdoor Structure Surface Contamination

| Radionuclides | Allowable Surface Residual Contamination (dpm/100 $cm^2$)†1 Total | Removable |
|---|---|---|
| Group 1: Radionuclides for which the uncontrolled area concentration guide in air above background†2 is $2 \times 10^{-13}$ Ci/$m^3$ or less or for which the uncontrolled area concentration guide in water above background†2 is $2 \times 10^{-7}$ Ci/$m^3$ or less; includes Pa-231, Th-228, Th-230, Ac-227, Ra-226, Ra-228, and Pb-210. | 100 | 20 |
| Group 2: Radionuclides not in Group 1 for which the uncontrolled area concentration guide in air above background†2 is $1 \times 10^{-12}$ Ci/$m^3$ or less or for which the uncontrolled area concentration guide in water above background†2 is $1 \times 10^{-6}$ Ci/$m^3$ or less; includes U-232, U-238, Th-232, Ra-223, and Po-210. | 1,000 | 200 |
| Group 3: Those radionuclides not in Group 1 or Group 2; includes U-234, U-235, Ra-224, and all other beta-gamma emitters. | 5,000 | 1,000 |

†1 The levels may be averaged over 1 $m^2$ provided the maximum activity in any area of 100 $cm^2$ is less than 3 times the limit value; dpm = disintegrations per minute. In the event of occurrence of mixtures of radionuclides, the fraction contributed by each radionuclide to its limit shall be determined, and the sum of these fractions shall not exceed 1.

†2 Given in Attachment 1 to Chapter XI, Table II, DOE Order 5480.1A, the most limiting of all given concentration guide values (e.g., soluble versus insoluble) are to be used.

## B. CONTROL OF RADIOACTIVE WASTES AND RESIDUES FROM FUSRAP AND REMOTE SFMP SITES

Specified here are the control requirements for radioactive wastes and residues related to the nuclear fuel cycle at FUSRAP and remote SFMP sites. It is the policy of DOE to store radioactive wastes in a manner representing sound engineering practices consistent with DOE's ALARA policy.

### 1. Interim Storage

All operational and control requirements specified in the following DOE Orders shall apply:

a. 5480.1A, Environmental Protection, Safety, and Health Protection Program for DOE Operations.

b. 5480.2, Hazardous and Radioactive Mixed Waste Management.

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

d. 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Rquirements.

e. 5484.2, Unusual Occurrence Reporting System.

f. 5820, Radioactive Waste Management.

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

h. Rn-222 concentrations in the atmosphere above facility surfaces or openings shall not (1) exceed 100 pCi/L at any given point, or an average concentration of 30 pCi/L for the facility site, or (2) exceed an average Rn-222 concentration at or above any location outside the facility site of 3.0 pCi/L (above background).

i. For water protection, use existing state and federal standards; apply site-specific measures where needed.

### 2. Long-Term Management

a. All operational requirements specified for Interim Storage Facilities (B.1) will apply.

b. Control and stabilization features will be designed to ensure, to the extent reasonably achievable, an effective life of 1,000 years and, in any case, at least 200 years. Other disposal site design features shall conform with 40 CFR Part 192 performance guidelines/requirements.

c. Rn-222 emanation to the atmosphere from facility surfaces or openings shall not (1) exceed an average release rate of 20 pCi/m$^2$/s, or (2) increase the annual average Rn-222 concentration at or above any location outside the facility site by more than 0.5 pCi/L.

d. For water protection, use existing state and federal standards; apply site-specific measures where needed.

e. Prior to placement of any potentially biodegradable contaminated wastes in a Long-Term Management Facility, such wastes will be properly conditioned to (1) ensure that the generation and escape of biogenic gases will not cause the requirement in paragraph 2.c. to be exceeded, and (2) ensure that biodegradation within the facility will not result in premature structural failure not in accordance with the requirements in paragraph 2.b. If biodegradable wastes are conditioned by incineration, incineration operations will be carried out in compliance with all applicable federal, state, and local air emission standards and requirements, including any standards for radionuclides established pursuant to 40 CFR Part 61, National Emission Standards for Hazardous Air Pollutants (NESHAPS).

C. Exceptions

1. Procedure--Analysis of site-specific conditions.

2. Applicability--Where health and safety would be endangered, or where cost clearly outweighs benefits.

D. Guideline Sources

| Criteria | Source |
|---|---|
| Residual Contamination Guidelines†[1] | |
| Soil Guideline | DOE Order 5480.1A, 40 CFR Part 192†[2] |
| Structure Guideline | 40 CFR Part 192, proposed ANSI N13.12 |
| Control of Radioactive Wastes and Residues | |
| Interim Storage | DOE Order 5480.1A |
| Long-Term Management | 40 CFR Part 192 |
| Exceptions | |
| Procedure | 40 CFR Part 192 |
| Applicability | 40 CFR Part 192 |

†[1] The bases of the residual contamination guidelines are developed in ORO-831 (U.S. Dep. Energy 1983) and ORO-832 (Gilbert et al. 1983).

†[2] Based on limiting the concentration of Rn-222 decay products to 0.03 WL within structures.

REFERENCES (Appendix A)

Gilbert, T.L., P.C. Chee, M.J. Knight, J.M. Peterson, C.J. Roberts, J.E. Robinson, S.Y.H. Tsai, and Y.C. Yuan. 1983. Pathways Analysis and Radiation Dose Estimates for Radioactive Residues at Formerly Utilized MED/AEC Sites. ORO-832. Prepared for the Formerly Utilized Sites Remedial Action Program, U.S. Department of Energy, Oak Ridge, TN, by the Division of Environmental Impact Studies, Argonne National Laboratory, Argonne, IL. March 1983.

U.S. Department of Energy. 1983. Radiological Guidelines for Application to DOE's Formerly Utilized Sites Remedial Action Program. ORO-831. Oak Ridge Operations, Oak Ridge, TN. March 1983.

## LIST OF CONTRIBUTORS

This Action Description Memorandum has been prepared by the U.S. Department of Energy (DOE) with contractual assistance from Argonne National Laboratory (ANL). Staff members of the DOE Oak Ridge Operations Office and Bechtel National, Inc., have reviewed the document. The following staff members of the ANL Environmental Research Division contributed to the preparation of this report.

| Name | Education/Expertise | EIS Contribution |
|---|---|---|
| Pamela Merry-Libby | B.S. Biology<br>12 yr experience in environmental assessment of energy-related projects | Project Leader |
| Paul A. Benioff | Ph.D. Chemistry<br>6 yr experience in environmental impact assessment;<br>16 yr experience in chemistry | Description of chemical wastes and impacts |
| Sue Ann Curtis | Ph.D. Anthropology<br>9 yr experience in socioeconomic and cultural resources assessment;<br>10 yr experience in archaeology | Description of existing socio-economic environment and impacts |
| John M. Peterson | M.S., P.E. Nuclear Engineering<br>9 yr experience in nuclear programs, including 5 yr in environmental assessment | Review of engineering and radio-logical analyses |
| William S. Vinikour | M.S. Biology (environmental emphasis)<br>10 yr experience in environmental impact assessment and aquatic research | Description of existing ecologi-cal environment and impacts |
| Robert W. Vocke | Ph.D. Water Resources/Botany<br>6 yr experience in environmental impact assessment | FUSRAP Program Manager, review |
| Seymour Vogler | B.S. Chemistry<br>37 yr experience in nuclear fuel reprocessing and waste management | Description of engineering and existing radiological environment |
| John Hsiao-Chung Wang | M.S. Environmental Health Engineering<br>Ph.D. (candidate) Health Physics<br>2 yr experience in health physics | Description of radiological impacts |
| Dimis J. Wyman | M.S. Botany, M.A. Library Science<br>8 yr experience in technical editing | Technical editing |
| Jing-Yea Yang | Ph.D. Environmental Engineering<br>11 yr experience in hydrology and water resources analysis | Description of hydrological and geological existing environment and impacts |

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(5-83)

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NJ.5

United States Government | Department of Energy

# memorandum

DATE: SEP 7 1984

REPLY TO
ATTN OF: NE-20

SUBJECT: Action Description Memorandum (ADM) Review: Proposed 1984 Remedial Actions at Middlesex, New Jersey

TO: File

Department of Energy (DOE) proposes to carry out some remedial actions during 1984 at two sites in Middlesex, New Jersey. The proposed 1984 remedial actions include cleanup of radioactively contaminated materials located at the Middlesex Landfill and interim storage of these contaminated materials at DOE's Middlesex Sampling Plant site. The major proposed actions include:

- Excavation of approximately 14,000 $m^3$ (18,000 $yd^3$)* of landfill materials, of which about one-third (4,600 $m^3$ (6,000 $yd^3$)).* is expected to be radioactively contaminated. (These wastes are expected to be co-contaminated with hazardous chemicals.**

- Transport of the 4,600 $m^3$ (6,000 $yd^3$)* of radioactively contaminated wastes to the Sampling Plant site and placement of these materials in a new interim-storage pile on the existing asphalt storage pad.

- Backfilling of the excavated area at the Landfill with the 9,200 $m^3$ (12,000 $yd^3$)* of excavated wastes that have radionuclide concentrations below the cleanup criteria, supplemented with approximately 4,600 $m^3$ (6,000 $yd^3$)* of clean fill materials to restore the Landfill to the original grade.

- Construction of support facilities at the Landfill, including an access road, a vehicle decontamination area, and an area for stockpiling and drying excavated materials (as necessary) prior to transport.

The radioactively contaminated materials will be removed from the Landfill according to DOE's radiological guidelines for residual radionuclide concentrations in soil at FUSRAP sites. Following removal

---

* These volumes are being revised as detailed engineering progresses. As of April 24, 1984, the estimated total volume to be excavated has been reduced to 13,000 $m^3$ (16,000 $yd^3$), of which 4,200 $m^3$ (5,500 $yd^3$) is expected to be radioactively contaminated.

** Because of the chemical contamination, the proposed actions have been coordinated with the U.S. Environmental Protection Agency (Attachment 1).

of the radioactively contaminated materials, DOE will make a decision regarding the future use of the property relative to the final radiological condition of the site. A decision on future use of the Landfill relative to chemical contamination is not within DOE's jurisdiction. The U.S. Environmental Protection Agency (EPA) and State and local governments have jurisdiction with respect to hazardous chemical in the Landfill and will determine the need for further remedial actions, if any.

Details and impact analysis for the activities are given in the attached ADM (Action Description Memorandum "Proposed 1984 Remedial Actions at Middlesex, New Jersey" - Attachment 2).

The proposed 1984 remedial actions are a continuation of remedial actions involving the former Middlesex Sampling Plant and vicinity properties. The current status of the Middlesex remedial action is noted in Section 2 "General Setting" on page 2-1 of the attached ADM.

After reviewing all of the pertinent facts including the attached ADM, I have determined that the remedial action described in the subject ADM is an action which in and of itself will have a clearly insignificant impact on the quality of the human environment within the meaning of the National Environmental Policy Act (NEPA), 42 U.S.C. 4321 et seq.

Separate environmental reviews will be prepared to support future decisions on remedial action at Middlesex, New Jersey, including permanent disposition of the contaminated materials or other remedial actions that may impact the quality of the human environment within the meaning of the NEPA, 42 U.S.C. 4321 et seq.

Franklin E. Coffman, Director
Office of Terminal Waste Disposal
and Remedial Action
Office of Nuclear Energy

2 Attachments*

cc: w/attachs.
S. Miller, GC-11
S. Woodbury, PE-252

*Note: The second attachment referenced herein precedes this memorandum as part of Exhibit II(4).

A. Whitman

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION II
26 FEDERAL PLAZA
NEW YORK, NEW YORK 10278

JUL 20 1984

Mr. E.L. Keller, Director
Technical Services Division
U.S. Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, Tennessee 37831

Dear Mr. Keller:

The purpose of this letter is a follow-up to my letter of June 25, 1984 concerning the proposed remedial action at the Middlesex Landfill (ML) by the U.S. Department of Energy (DOE) under its Formerly Utilized Sites Remedial Action Program (FUSRAP).

Based on the E.P. toxicity data received from DOE for samples taken in the portion of the Middlesex Landfill subject to the proposed remedial action we concur that the material is apparently not subject to the Resource Conservation and Recovery Act (RCRA) as hazardous waste. Additionally, a review of the sampling program utilized by DOE to obtain these data was done by the U.S. Environmental Protection Agency 's (EPA) Region II Office. This review did show some deficiencies in the monitoring program, specifically: 1. the lack of a sampling plan, 2. a cleaning method for split spoon core samples which is inconsistent with EPA Region II Standand Operating Procedures, and 3. the use of biased instead of random sampling. However, these deficiencies would tend to lead to more conservative results or a worst case situation.

Considering the DOE's time frame for this proposed remedial action and the fact that the data appear to support the conclusion that the material subject to the remedial action is not a RCRA hazardous waste, the EPA has no objection to the implementation of the remedial action plan as proposed by DOE in the "Work Plan For the Middlesex Municipal Landfill Site" (ORO-846).

Hopefully, this satisfies your original request of June 5, 1984.

Sincerely yours,

Shelley Erlich Hoffman

for Conrad Simon, Director
Air & Waste Management Division



So 22159

DOE-ORO COMMCTR NO.024 002

Exhibit II (5) - Access Agreements

Page

Access agreements were obtained from Middlesex Presbyterian Church and the Borough of Middlesex before remedial action activities began. Copies of both access agreements are provided in this section. II-213

21038

Bechtel National, Inc.
Engineers — Constructors

Oak Ridge Office
Jackson Plaza Tower
800 Oak Ridge Turnpike
Oak Ridge Tennessee
Mail Address P O Box 350 Oak Ridge TN 37830

AUG 3 1984

Rev. Kirk Orr
Middlesex Presbyterian Church
1190 Mountain Avenue
Middlesex, New Jersey 08846

Dear Mr. Orr:

Enclosed for your records is a fully executed copy of the access agreement between you and the U. S. Department of Energy for remedial action on your property. We believe that all the changes you requested, if any, have been made in the restoration schedules. If there are any problems with the agreement, please call John Schlatter collect at (615) 576-5034.

We are in the final stages of awarding contracts to perform this work, and we will notify you as soon as we have a schedule for work on your property. Thank you for your assistance.

Very truly yours,

Robert L. Rudolph
Project Manager - FUSRAP

JFS:mgo
Enclosure: As Stated

~~19210~~ ~~18999~~

~~19321~~

21038

DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE
P. O. BOX E
OAK RIDGE, TENNESSEE 37830

CONTRACT NO. DE-AC05-81OR20722

AGREEMENT

THIS AGREEMENT, entered into this 31st day of May, 1984, effective as of the 31st day of May 1984, between THE UNITED STATES OF AMERICA (hereinafter called the "Government"), acting through the DEPARTMENT OF ENERGY (hereinafter called the "DOE"), and the TRUSTEES OF THE MIDDLESEX PRESBYTERIAN CHURCH (hereinafter called the "CHURCH"), with a mailing address of 1190 Mountain Avenue, Middlesex, New Jersey, 08846.

WITNESSETH THAT:

WHEREAS, the DOE through its contractor, Bechtel National, Inc., is conducting a low-level radioactive waste remedial action program in the environs of the former Middlesex uranium ore sampling plant; and

WHEREAS, the Church owns real property (hereinafter referred to as the "PROPERTY"), described in the Addendum hereto, which requires remedial action; and

WHEREAS, the Church has agreed to such remedial action under the terms set forth below and in the attached Addendum:

NOW THEREFORE, in consideration of the mutual promises, the parties hereto agree as follows:

1. The Church hereby grants to the DOE or its designees a permit giving: (a) the right to enter upon the property for the purpose of removing low-level radioactive material from such property; and (b) the right to enter upon the property to take soil samples, perform radiological surveys, and to perform or take any other reasonable action consistent with the expeditious completion of the subject remedial action; and (c) the right to restrict access to such parts of the property, as may be necessary, to facilitate remedial action; and (d) the right to periodically enter upon the property after completion of the remedial action for the purpose of conducting follow-up radiological surveys.

2. The Government shall be responsible for any loss or destruction of or damage to the Church's real or personal property caused by the activities of the DOE or its designees in exercising any of the rights given in this Agreement. This responsibility shall be limited to the cost of restoring the property to a condition comparable to its original condition by techniques of backfilling, seeding, repair or replacement, and such other methods as may be agreed to between the parties at the time of restoration work in accordance with the terms and conditions of this Agreement. Effective upon completion of the restoration work in accordance with the terms and conditions of this Agreement and upon certification by the DOE that the Church's property meets all applicable radiological criteria, the Church will release the Government, its contractors, and the officers, employees, servants, and agents of either of them from all further responsibility related to the radioactive contamination and the remedial action covered by this agreement.

3. The Church will notify the DOE in writing if the property is, or at any time during the term of this Agreement shall become, leased, sold or otherwise transferred to another party. The Church will also give written notice to any purchaser, lessee, or transferee of the applicability of the rights contained in this Agreement when such purchase, lease, or transfer takes place during the term of this Agreement. The Church hereby consents to any Lessee of the property entering into a suitable agreement with the Government to cover any part of the remedial action that may affect such Lessee.

4. No member of or delegate to Congress, or Resident Commissioner, shall be admitted to any share or part of this Agreement, or to any benefit that may arise therefrom; but this provision shall be construed to extend to this Agreement if made with a corporation for its general benefit.

5. The Church warrants that no person or selling agency has been employed or retained to solicit or secure that Agreement upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees and bona fide established commercial or selling agencies maintained by the Church for the purpose of securing business. For breach or violation of this warranty, the Government shall have the right to annul this Agreement without liability or in its discretion to deduct from the Agreement price or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

6. To the extent that provisions of this Agreement call for the expenditure of appropriated funds in fiscal years subsequent to Fiscal Year 1984, such provisions shall be subject to the availability of funds appropriated by the Congress which the DOE may legally spend for such purposes.

7. This Agreement shall terminate upon completion of the restoration work in accordance with the terms and conditions of this Agreement and upon certification by the DOE that the Church's property meets applicable radiological criteria to the maximum extent practicable.

8. The Government and the DOE agree to indemnify and save harmless the Church for any damages or claims for damages arising out of or in connection with said remedial action plan described in this agreement.

IN WITNESS WHEREOF, the parties have executed this Agreement in several counterparts.

| MIDDLESEX PRESBYTERIAN CHURCH | THE UNITED STATES OF AMERICA |
| --- | --- |
| | BY: DEPARTMENT OF ENERGY |
| BY: Norma H. Stroter | BY: Vincent Karhan |
| TITLE: President, Board of Trustees | TITLE: Contracting Officer |

0157x

# ADDENDUM
## Middlesex Presbyterian Church

The "Property" referenced in this agreement is described as Lot 1, Block 219, Middlesex County, New Jersey, within the corporate limits of the Borough of Middlesex.

Surveys have shown that low-level radioactive contamination exists on this property. In order to meet criteria established for contaminated properties associated with the former Middlesex Sampling Plant, it will be necessary to remove contaminated soil on the affected areas as shown on Bechtel Drawing No. 17-DD08-C-01 (Revision 1), a copy of which is attached and made part of this agreement. (NOTE: These are estimates based upon preliminary radiological surveys, and the exact amounts of property affected and the scope of work will be determined at the time of excavation.)

Following removal of contaminated material and field verification that the property meets applicable radiological criteria, the property will be restored as nearly as reasonably practical to its condition at the start of the remedial action.

On this property it is anticipated that restoration will consist of returning the property to its original contour and seeding to restore grass cover.

The following sequence of remedial action operations is anticipated on this property:

A. Installation of a safety/security fence around the excavation site.

B. Excavation of contaminated soil from the affected areas. Dust control measures during digging and loading will minimize airborne contaminants. Continuous radiological monitoring of the excavated surface will reveal when sufficient material has been removed. Covered dump trucks will transport the contaminated topsoil to the former Middlesex Sampling Plant.

C. Removal of vegetation as required from the affected areas.

D. Radiological sampling and analysis of the excavation for verification that contamination has been removed. It is anticipated that time required for analysis prior to backfilling is one week.

E. Backfilling to return the area to its original contour and planting to establish grass cover.

CCN NO. 20732

COM. TYPE 2/2/L

# ADVANCED TECHNOLOGY DIVISION
# COMMUNICATION DISTRIBUTION
# FUSRAP PROJECT

COM. REF. NO. _____

COM. DATE 7-20 PROCESS DATE 7-23

FROM J. Schlatter TO Dist

SUBJECT signed original of the access agreement with Brough or MDSK

FILE NO. 120 WBS 118-K AFF. DOC. NO. 19004 19544

## DISTRIBUTION

| | | | W/A | | | | W/A |
|---|---|---|---|---|---|---|---|
| PROJECT MANAGER | PM | | | OPERATIONS | OP | | |
| DEPUTY PROJ. MANAGER | DP | | | PROJ. QUALITY ASSURANCE | QA | | |
| TECHNICAL MANAGER | TM | | | PROJECT ADMINISTRATION | PA | | |
| PROJECT ENGINEER | PE | | | PUBLIC RELATIONS | PR | 1 | 1 |
| FACILITIES ENGINEER | FE | | | NIAGARA FALLS SITE | NF | | |
| SAFETY & LICENSING | RS | | | EBERLINE | E | | |
| ENVIRONMENTAL | ES | | | PDCC | PD | orig | |
| TECHNICAL REPORTS | TR | | | D. Adair | | 1 | 1 |
| PLANNING & CONTROL | PC | | | | | | |
| PROCUREMENT | PO | | | | | | |
| FIELD CONSTRUCTION | FC | | | | | | |
| TASK MANAGER | TS | | | | | | |

RETURN TO PDCC FOR CORRECTION

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~~19544~~

20722

DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE
P. O. BOX E
OAK RIDGE, TENNESSEE 37830

CONTRACT NO. DE-AC05-81OR20722

AGREEMENT

THIS AGREEMENT, entered into this 18th day of July, 1984, effective as of the 18th day of July, between THE UNITED STATES OF AMERICA (hereinafter called the "Government"), acting through the DEPARTMENT OF ENERGY (hereinafter called the "DOE"), and the BOROUGH OF MIDDLESEX, NEW JERSEY (hereinafter called the "BOROUGH"), a body politic, created, operating and existing under and by virtue of the laws of the State of New Jersey, with a mailing address of 1200 Mountain Avenue, Middlesex, New Jersey, 08846.

WITNESSETH THAT:

WHEREAS, the DOE through its contractor, Bechtel National, Inc., is conducting a low-level radioactive waste remedial action program in the environs of the former Middlesex uranium ore sampling plant; and

WHEREAS, the DOE and the Borough entered into a Memorandum of Understanding dated November 20, 1979, agreeing to cooperate in said remedial action program; and

WHEREAS, the Mayor and the Borough Clerk were directed and authorized to execute agreements covering remedial action on Borough-owned property by a resolution of the Borough Council dated April 21, 1981; and

WHEREAS, the Borough owns real property (hereinafter referred to as the "PROPERTY"), described in the attached Addendum, which requires remedial action; and

WHEREAS, the Borough has agreed to such remedial action under the terms set forth below and in the attached Addendum:

NOW THEREFORE, in consideration of the mutual promises, the parties hereto agree as follows:

1. The Borough hereby grants to the DOE or its designees a permit giving: (a) the right to enter upon the property for the purpose of removing low-level radioactive material from such property; and (b) the right to enter upon the property to take soil samples, perform radiological surveys, and to perform or take any other reasonable action consistent with the expeditious completion of the subject remedial action; and (c) the right to restrict access to such parts of the property, as may be necessary, to facilitate remedial action; and (d) the right to periodically enter upon the property after completion of the remedial action for the purpose of conducting follow-up radiological surveys.

2. The Government shall be responsible for any loss or destruction of or damage to the Borough's real or personal property caused by the activities of the DOE or its designees in exercising any of the rights given in this Agreement. This responsibility shall be limited to the cost of restoring the property to a condition comparable to its original condition by techniques of backfilling, seeding, repair or replacement, and such other methods as may be agreed to between the parties at the time of restoration work in accordance with the terms and conditions of this Agreement. Effective upon completion of the restoration work in accordance with the terms and conditions of this Agreement and upon certification by the DOE that the Borough's property meets all applicable radiological criteria, the Borough will release the Government, its contractors, and the officers, employees, servants, and agents of either of them from all further responsibility related to the radioactive contamination and the remedial action covered by this agreement.

3. The Borough will notify the DOE in writing if the property is, or at any time during the term of this Agreement shall become, leased, sold or otherwise transferred to another party. The Borough will also give written notice to any purchaser, lessee, or transferee of the applicability of the rights contained in this Agreement when such purchase, lease, or transfer takes place during the term of this Agreement. The Borough hereby consents to any Lessee of the property entering into a suitable agreement with the Government to cover any part of the remedial action that may affect such Lessee.

4. No member of or delegate to Congress, or Resident Commissioner, shall be admitted to any share or part of this Agreement, or to any benefit that may arise therefrom; but this provision shall be construed to extend to this Agreement if made with a corporation for its general benefit.

5. The Borough warrants that no person or selling agency has been employed or retained to solicit or secure that Agreement upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees and bona fide established commercial or selling agencies maintained by the Borough for the purpose of securing business. For breach or violation of this warranty, the Government shall have the right to annul this Agreement without liability or in its discretion to deduct from the Agreement price or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

6. To the extent that provisions of this Agreement call for the expenditure of appropriated funds in fiscal years subsequent to Fiscal Year 1984, such provisions shall be subject to the availability of funds appropriated by the Congress which the DOE may legally spend for such purposes.

7. This Agreement shall terminate upon completion of the restoration work in accordance with the terms and conditions of this Agreement and upon certification by the DOE that the Borough's property meets applicable radiological criteria to the maximum extent practicable.

8. The Government and the DOE agree to indemnify and save harmless the Borough for any damages or claims for damages arising out of or in connection with said remedial action plan described in this agreement.

9. The United States Department of Energy agrees to indemnify and hold harmless the Borough of Middlesex for any claims, demands, suits, and legal fees, Court costs, expenses, etc., made and/or filed against the Borough of Middlesex by the Department of Energy personnel or personnel of its contractors, subcontractors, and/or their officers, employees, servants or agents, if either of them or any of them suffer any injuries while on the Borough's property or for any property damage sustained by such persons, unless such injury and/or property damage is caused by the willful or wanton acts of the Borough precipitating such injury or damage.

IN WITNESS WHEREOF, the parties have executed this Agreement in several counterparts.

BOROUGH OF MIDDLESEX

BY: Ronald S Dobies
MAYOR

Margaret Hanania
CLERK

THE UNITED STATES OF AMERICA

BY: DEPARATMENT OF ENERGY

BY: [signature]

TITLE: CONTRACTING OFFICER

RECEIVED
JUL 20 1984
FUSRAP PDCC

0156x; 4/12/84

ADDENDUM
Borough of Middlesex

The "Property" referenced in this agreement is described as Lot 2, Block 219, Middlesex County, New Jersey, within the corporate limits of the Borough of Middlesex.

Surveys have shown that low-level radioactive contamination exists on this property. In order to meet criteria established for contaminated properties associated with the former Middlesex Sampling Plant, it will be necessary to remove contaminated soil on the affected areas as shown on Bechtel Drawing No. 17-DD08-C-01 (Revision 1), a copy of which is attached and made part of this agreement. (NOTE: These are estimates based upon preliminary radiological surveys, and the exact amounts of property affected and the scope of work will be determined at the time of excavation.)

Following removal of contaminated material and field verification that the property meets applicable radiological criteria, the property will be restored as nearly as reasonably practical to its condition at the start of the remedial action.

On this property it is anticipated that restoration will consist of returning the property to its original contour and seeding to restore grass cover. Recycling center located near the site will be relocated by DOE contractors, at no cost to the Borough, to a site acceptable to the Borough for the duration of remedial action.

The following sequence of remedial action operations is anticipated on this property:

A. Installation of a safety/security fence around the excavation site.

B. Excavation of contaminated soil from the affected areas. Dust control measures during digging and loading will minimize airborne contaminants. Continuous radiological monitoring of the excavated surface will reveal when sufficient material has been removed. Covered dump trucks will transport the contaminated topsoil to the former Middlesex Sampling Plant. Traffic flow will be coordinated with the Middlesex Chief of Police.

C. Removal of vegetation as required from the affected areas.

D. Radiological sampling and analysis of the excavation for verification that contamination has been removed. It is anticipated that time required for analysis prior to backfilling is one week.

E. Backfilling to return the area to its original contour and planting to establish grass cover.

0156x;

Exhibit II (6) - Post-Remedial Action Report

The following report documents remedial action activities performed at the MML and the radiological status of the MML following the completion of remedial action. The post-remedial action report is included in this section of the docket.


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|---|---|
| Bechtel National, Inc. Post-Remedial Action Report for the Middlesex Municipal Landfill Site, Middlesex, New Jersey, DOE/OR/20722-135, Oak Ridge, TN, February 1987. | II-226 |

DOE/OR/20722-135

Formerly Utilized Sites Remedial Action Program (FUSRAP)
Contract No. DE-AC05-81OR20722

# POST-REMEDIAL ACTION REPORT FOR THE MIDDLESEX MUNICIPAL LANDFILL SITE

## Middlesex, New Jersey

February 1987

NOTE: The remedial action guidelines in Table 1 of this report have been superseded by those given in Appendix A to Exhibit I of the certification docket.

Bechtel National, Inc.

DOE/OR/20722-135

# POST-REMEDIAL ACTION REPORT
# FOR THE
# MIDDLESEX MUNICIPAL LANDFILL SITE
# MIDDLESEX, NEW JERSEY

FEBRUARY 1987

Prepared for

UNITED STATES DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE
Under Contract No. DE-AC05-81OR20722

By

K. A. Davis, C. P. Leichtweis,
M. E. Kaye, and A. M. Feldman
Bechtel National, Inc.
Oak Ridge, Tennessee

Bechtel Job No. 14501

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## ABBREVIATIONS

| | |
|---|---|
| cm | centimeter |
| dpm | **disintegrations per minute** |
| ft | foot |
| g | **gram** |
| h | hour |
| µR | **microroentgen** |
| µR/h | microroentgens per hour |
| µCi/ml | **microcuries per milliliter** |
| m | meter |
| mi | mile |
| mrem | **millirem** |
| mrem/yr | millirem per year |
| urem | **microrem** |
| pCi | **picocuries** |
| pCi/g | picocuries per gram |
| WL | **Working Level** |
| $yd^3$ | cubic yards |
| yr | year |

*Words appearing in boldfaced print are explained in the glossary.

## 1.0 INTRODUCTION

The purpose of this report is to document post-remedial action sampling performed by Bechtel National, Inc. (BNI) on the Middlesex Municipal Landfill (MML) in Middlesex, New Jersey. The MML site is located in the Borough of Middlesex, Middlesex County, New Jersey, approximately 18 mi southwest of Newark (Figure 1). The Middlesex Sampling Plant (MSP) is located about 0.5 mi southeast of the landfill. Remedial action was conducted at the MML from 1984 through 1986 under the Formerly Utilized Sites Remedial Action Program (FUSRAP), a U.S. Department of Energy (DOE) effort to identify, decontaminate, or otherwise control sites where low-level radioactive contamination (exceeding current guidelines) remains from the early days of the nation's atomic energy program. FUSRAP is currently managed by DOE's Oak Ridge Operations Office. As the Project Management Contractor, BNI acts as DOE's representative in the planning, management, and implementation of FUSRAP.

This report briefly describes the origin of the radioactive contamination on the MML property, the method used to determine its extent, and the type of remedial action performed. It also provides the guidelines used in performing the remedial action, summarizes the data on the current radiological status of the property, and presents final excavation limits and depths.

### Background

The MSP was used for the assaying of uranium and thorium ores between 1943 and 1955. During the operation of the MSP, some radioactively contaminated soil containing pitchblende (a naturally occurring uranium ore) was shipped to the MML. Although there is no documentation to indicate when the contamination of the landfill occurred, a review of MSP files

documenting operations conducted from 1946 to 1966 indicates the contaminated soil was probably shipped to the landfill between November 1947 and October 1948 (Ref. 1). Construction of a drainage ditch and paved storage area at the sampling plant took place during this period; it is believed that some of the material deposited at the landfill may have resulted from these construction activities. During landfill operations conducted in subsequent years, layers of cover material of various thicknesses were placed on top of the contaminated materials. The landfill has not been used for solid waste disposal since 1974.

During a local civil defense exercise in May 1960, monitors detected elevated **radiation** levels in the landfill. A radiological survey was conducted, and the results confirmed elevated **gamma radiation** levels (several times background) over a fairly consolidated area covering less than a half acre.

In 1961 the Atomic Energy Commission (AEC) removed the top layer of material from the landfill and covered the area with a 2-ft layer of clean dirt. The contaminated soil (approximately 650 $yd^3$) was taken to the AEC laboratories in New Brunswick, New Jersey.

In 1974, the AEC conducted a radiological survey of the area (Ref. 2). Survey results confirmed the existence of a contaminated area lying between Middlesex Presbyterian Church and properties owned by the Borough of Middlesex. The Oak Ridge National Laboratory (ORNL) conducted another radiological survey in 1978 (Ref. 3).

Based on survey results and on the configuration and usage of the landfill, it was concluded that the MML did not present a significant potential radiation hazard to the public. However, it was further concluded that if the area were to be developed for residential or commercial purposes at some future date, exposure of workers or the public in excess of guideline levels

could result if remedial action were not taken.

An engineering evaluation of remedial action alternatives and an environmental assessment were performed by Ford, Bacon, and Davis in 1979 (Refs. 4, 5). Remedial action began at the MML in 1984 and was completed in 1986.

## 2.0 REMEDIAL ACTION GUIDELINES

The principal radionuclides of concern at the MML were radium-226, thorium-232, and uranium-238. Table 1 lists the DOE residual contamination guidelines governing the release of the property for **unrestricted use** (Ref. 6). DOE implemented these guidelines on the basis of their compatibility with the criteria used for the same purpose by the Environmental Protection Agency (EPA) (Ref. 7). Since compliance with the remedial action guideline for radium ensures that the concentration of residual uranium is also acceptably low, a site-specific guideline for uranium was not calculated. However, if typical (as opposed to site-specific) values are used as the basis for calculating a guideline for uranium, this guideline would be approximately 75 pCi/g. Where the guidelines in Table 1 were exceeded, contaminated soil was removed from the property until radionuclide concentrations were within guidelines. On the basis that these guidelines have been met, the property can be released for unrestricted use.

## 3.0 REMEDIAL ACTION

After it was determined on the basis of radiological surveys that the MML was contaminated, DOE "designated" it for remedial action. This means that the landfill was found to be contaminated in excess of DOE guidelines and was therefore eligible for remedial action under FUSRAP. The Borough of Middlesex (owner of the landfill) was notified at this time, and BNI began the engineering design and related activities to hire local subcontractors to perform the cleanup work (Ref. 8).

## Cleanup/Decontamination Activities

When the design work had been completed and a local subcontractor hired, drawings showing the extent of the contamination in the soil on the property were given to the excavation subcontractor. Figure 2 shows the areas excavated in 1984 and 1986. The subcontractor removed the soil as indicated in the engineering drawings, placed it in dump trucks, and transported it to the storage pile at the MSP site, where it will be stored until a permanent disposal site is selected.

## Contamination Control During the Cleanup

During the cleanup, several measures were taken to control the radioactive materials being removed from the MML site. These measures were designed to keep nearby residents from being exposed to radiation in excess of applicable standards during remedial action. The primary pathway by which residents and workers could be exposed to radiation was from dust released during excavation. To prevent such exposure, the subcontractor was required to keep all excavations and work areas free from dust by keeping the soil moistened.

To keep uncontaminated areas clean during the course of excavation work, haul trucks were kept draped with tarpaulins before they were loaded. This kept contaminated dirt from getting on the exteriors of trucks and later falling off the trucks and onto clean property. If a truck was parked on a clean area while being loaded, the ground was also covered with a tarpaulin and the truck pulled onto it before being loaded. If contaminated soil was spilled during the loading of the truck, the tarpaulin prevented the contamination of clean ground. Measures were taken to prevent the leakage of contaminated material onto city streets; these measures included the installation of gaskets around the tailgates of the trucks.

To prevent soil from falling off the truck and onto clean ground or roadways, all trucks hauling contaminated soil were covered before leaving the site. The haul trucks were also monitored for removable surface contamination. Any truck found to contain surface contamination exceeding allowable limits was decontaminated in the vehicle washdown facility before leaving the site (Figure 2).

The combination of these measures effected control of the contamination and prevented its spread onto areas accessible to the general public. Continuous air sampling was performed along the perimeter of the site during excavation to monitor the presence of alpha-emitting radionuclides in the air. The average concentration of these radionuclides in the 84 air samples collected was less than $1.3 \times 10^{-14}$ $\mu$Ci/ml. The most restrictive DOE guideline for the radionuclides present at the site would be the thorium-230 guideline of $8 \times 10^{-14}$ $\mu$Ci/ml.

## 4.0 POST-REMEDIAL ACTION SAMPLING

The contaminated portion of the MML was found to cover an area of approximately 3 acres, with contamination extending from a depth of approximately 1 ft below the ground surface to a depth of about 18 ft. Surface contamination was found to be below guideline levels based on radiological surveys of the ground surface.

Remedial action was conducted at the MML in accordance with the sorting procedure shown in Figure 3 for separating contaminated materials from clean materials. The contaminated subsurface materials were excavated in distinct lifts, each of which was 30 ft wide and 1 ft deep. The lift extending from the surface to a depth of 1 ft is designated Lift 1; the lift extending from a depth of 1 ft to a depth of 2 ft is Lift 2, and so on. Lift 17 was the final lift to be excavated. Each lift was removed in two 15-ft strips. Each strip of each lift was radiologically surveyed prior to excavation and classified as either

contaminated or clean. The contaminated materials were transported to the contaminated waste storage pile at the MSP; the clean soil was stockpiled and used to backfill the excavation after remedial action was confirmed as complete.

After the contaminated soil was removed, the sides and bottoms of the excavations were radiologically surveyed and sampled to ensure that the property was indeed clean (exhibited no radionuclide concentrations in excess of the DOE guidelines).

Surface Gamma Radiation Scans

Following removal of each lift, two types of gamma radiation scans were conducted to determine whether all radioactively contaminated soil had been removed. First, a walkover scan was performed. In conducting this scan, the surveyor held the radiation detector a few inches above the ground surface and slowly moved it back and forth while walking over the excavated area. This type of survey was performed to detect areas of residual contamination exceeding DOE guidelines for subsurface areas. The advantage of the walkover survey is that the detector quickly scans the area as the excavation proceeds.

The second type of gamma radiation scan was performed after all contamination detected by the walkover scan was removed. In performing this scan, the surveyor used a detector with lead shielding around all portions of the detector except the surface parallel to the ground. The purpose of the lead shielding is to ensure that any radiation detected is emanating from the ground directly under the detector. At the MML, the surveyor took systematic measurements at intervals of approximately 7.5 ft in the excavated areas to ensure that the area had been cleaned of radioactively contaminated soils.

If either of these two types of gamma radiation scans revealed contamination at the MML in concentrations exceeding DOE

guidelines, additional soil was removed, and both types of scans were performed again. This process was repeated until DOE guidelines were met.

## Soil Sampling

An extensive soil sampling program was conducted in addition to the two types of gamma radiation scans described above. Post-remedial action sampling comprised the collection of 4,800 soil samples at 15-ft intervals. To ensure that the excavation was deep enough to remove contamination exceeding DOE guidelines, samples were collected from each lift following removal of the previous lift. For instance, after Lift 1 was removed, samples were collected at a depth of 1 to 2 ft. The processes of removing each lift and sampling the 1-ft soil layer below it were conducted alternately until the lower limit of contamination was reached. Two samples were collected at each 15-ft interval of each lift: one from the vertical midpoint of the lift, and one from the bottom of the lift. Sampling locations are shown in Figures 4-20. Figure 21 shows overall excavation depths.

The soil samples were analyzed to determine the concentrations of radium-226, thorium-232, and uranium-238. Results of these analyses are summarized below; individual results for each sampling location are contained in Reference 9. Of the 4,800 samples collected, only 32 samples exceeded the 15-pCi/g cleanup guideline. Each of these 32 samples was individually investigated. In accordance with DOE guidance, average concentrations were calculated for these samples and were found in all cases to fall within the 15-pCi/g limit for 100-$m^2$ areas (Table 1). Analysis results for radium-226 indicated concentrations ranging from 0.1 to 43.2 pCi/g, with an average concentration of 1.9 pCi/g. For thorium-232, concentrations ranged from 0.1 to 32.0 pCi/g, with an average concentration of 1.6 pCi/g. Uranium-238 concentrations ranged from 0.3 to 37.6 pCi/q, with an average concentration of 6.5 pCi/g.

Exposure Rate Measurements

Pressurized Ionization Chamber (PIC) readings were taken to measure the gamma radiation **exposure rate** after the contamination was removed and the excavation backfilled with clean material. The PIC was set up at the locations shown in Figure 22. As shown in Table 2, all exposure rates 1 m above the surface of the backfilled excavation were less than or equal to the background radiation level for the New Jersey area. The values in the table were calculated from measured exposure rates and assume continuous exposure.

## 5.0 POST-REMEDIAL ACTION STATUS

As shown in Table 2, gamma radiation exposure rate measurements taken after removing the radioactive materials show that there is no area in which radioactive contamination remains in concentrations sufficient to result in a dose in excess of the DOE radiation protection standard of 100 mrem/yr. An independent assessment of the remedial action conducted at the Middlesex Municipal Landfill site, Middlesex, New Jersey was performed by the Oak Ridge Associated Universities (ORAU) under the Radiological Site Assessment Program. The purpose of the assessment was to verify the BNI data supporting the adequacy of the remedial action and to confirm that radiological conditions at the landfill are in compliance with DOE remedial action guidelines.

In addition to the surveys performed on behalf of DOE, monitoring of remedial action activities was conducted by the New Jersey Department of Environmental Protection. This included observing on-site operations and procedures, and analyzing archived soil samples.

Based on all data collected, the Middlesex Municipal Landfill site conforms to all applicable DOE radiological guidelines established for release of this site for unrestricted use.

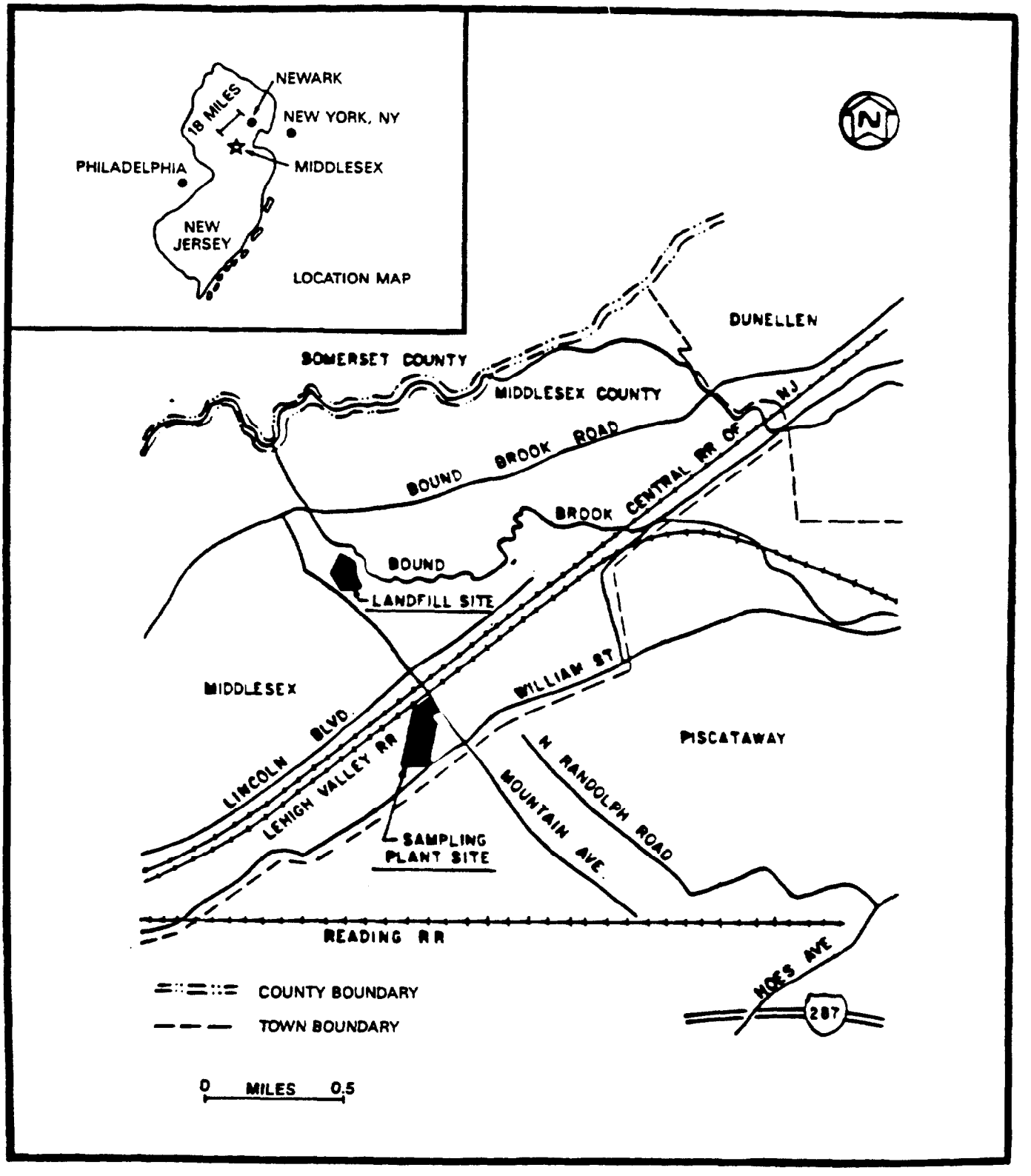


FIGURE 1 LOCATION OF THE MIDDLESEX MUNICIPAL LANDFILL SITE

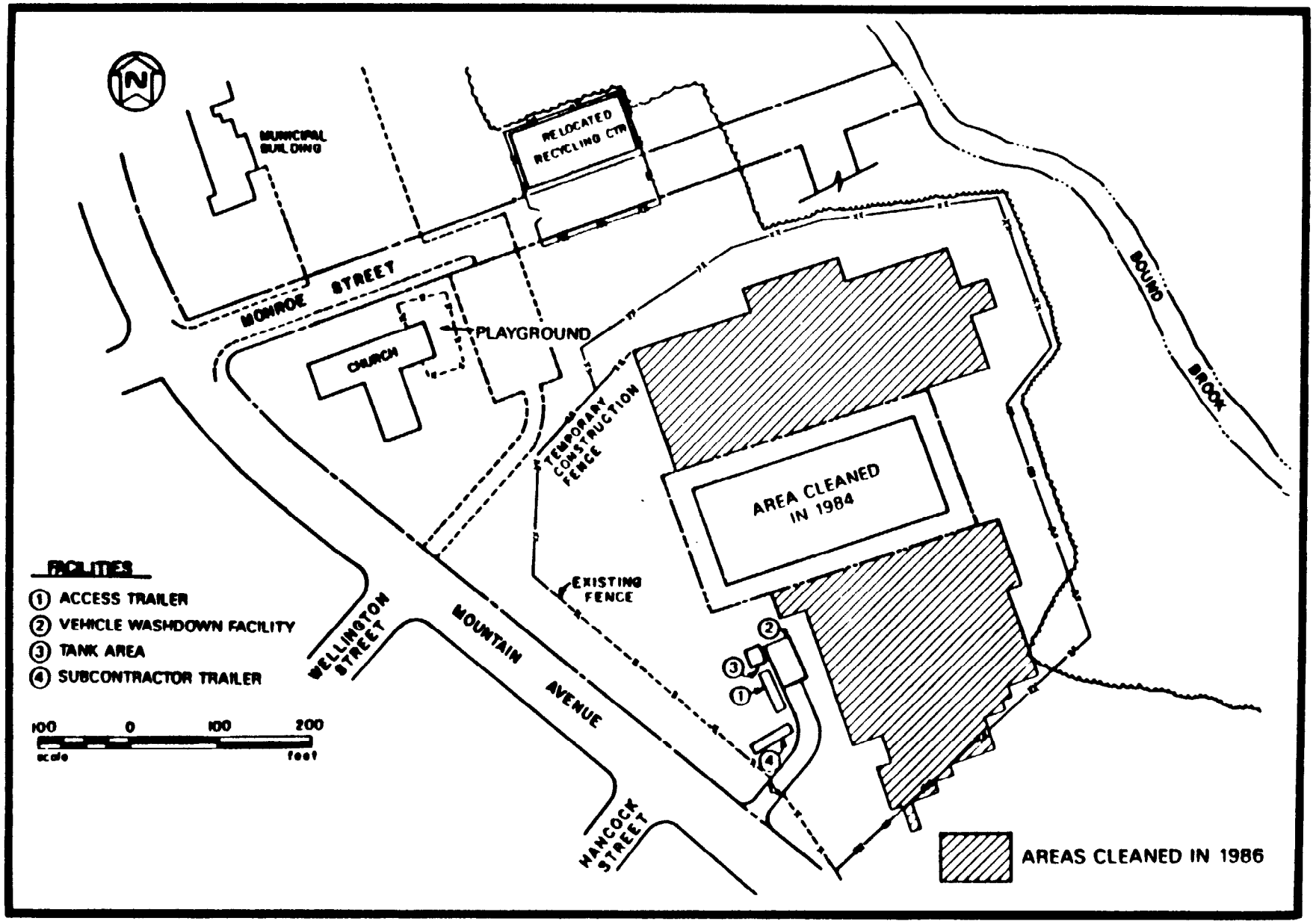


FIGURE 2 REMEDIAL ACTION AREAS AT THE MIDDLESEX MUNICIPAL LANDFILL

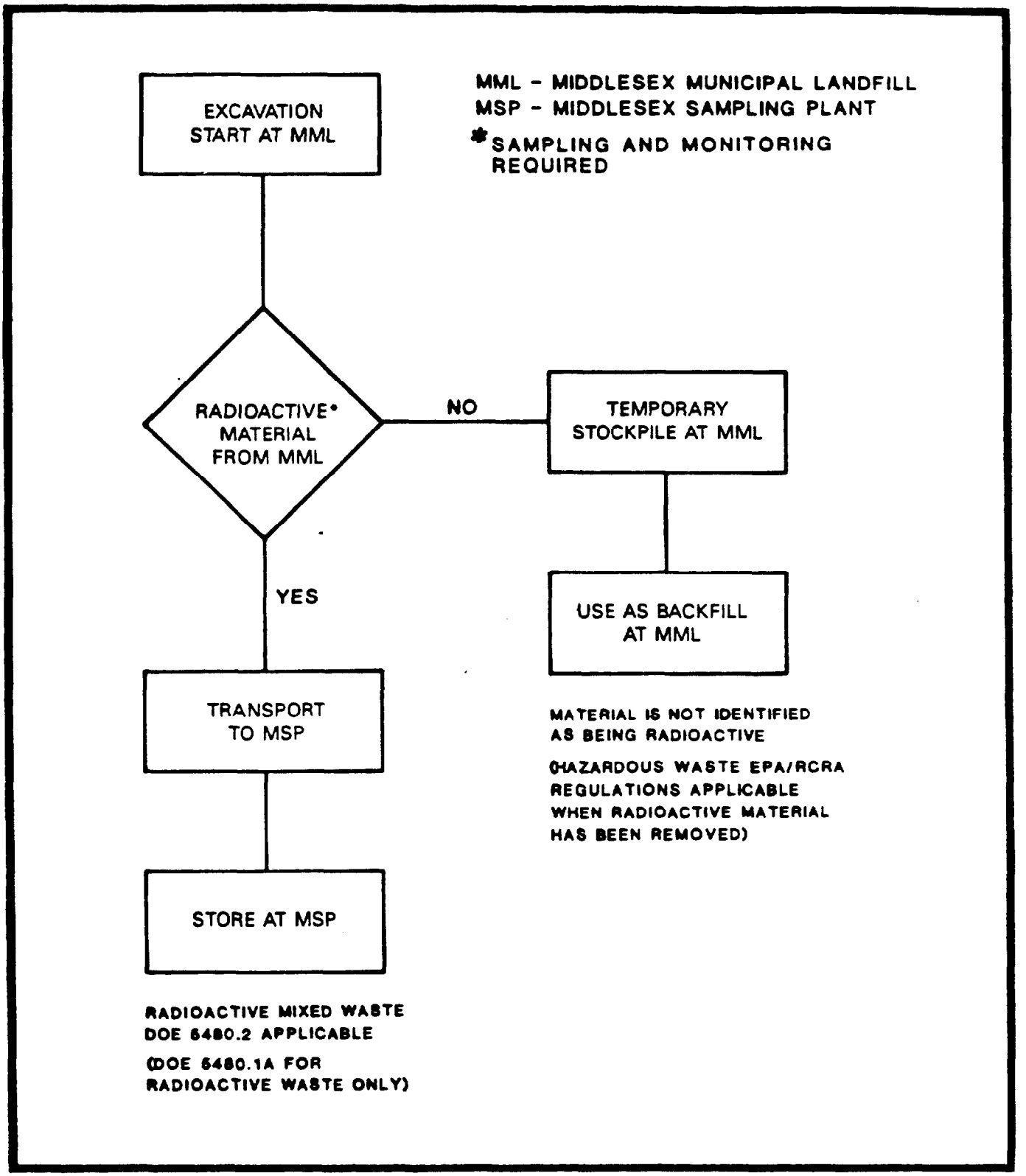


FIGURE 3 LOGIC DIAGRAM FOR SORTING MATERIALS EXCAVATED FROM MIDDLESEX MUNICIPAL LANDFILL

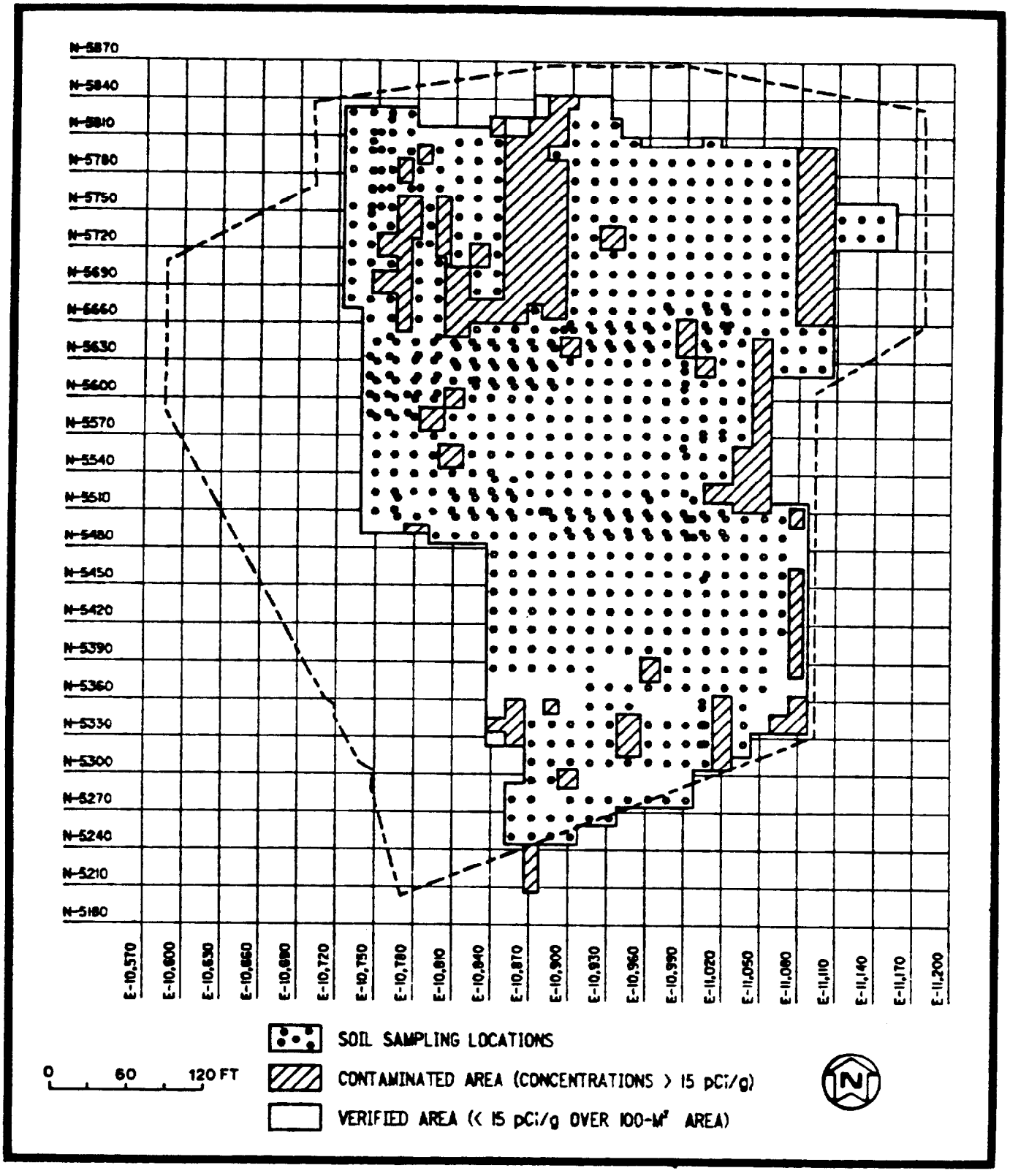


FIGURE 4 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 1

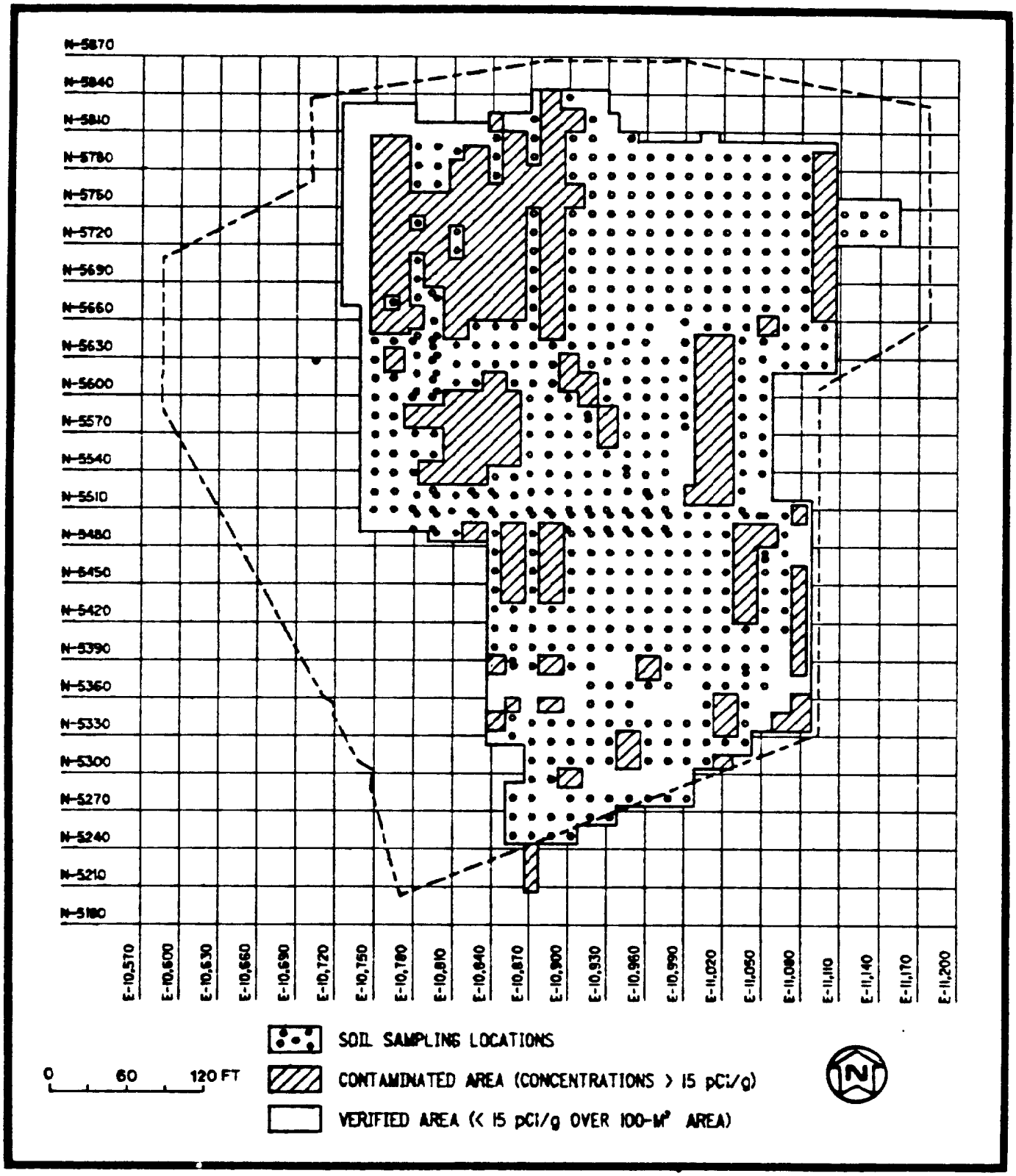


FIGURE 5 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 2

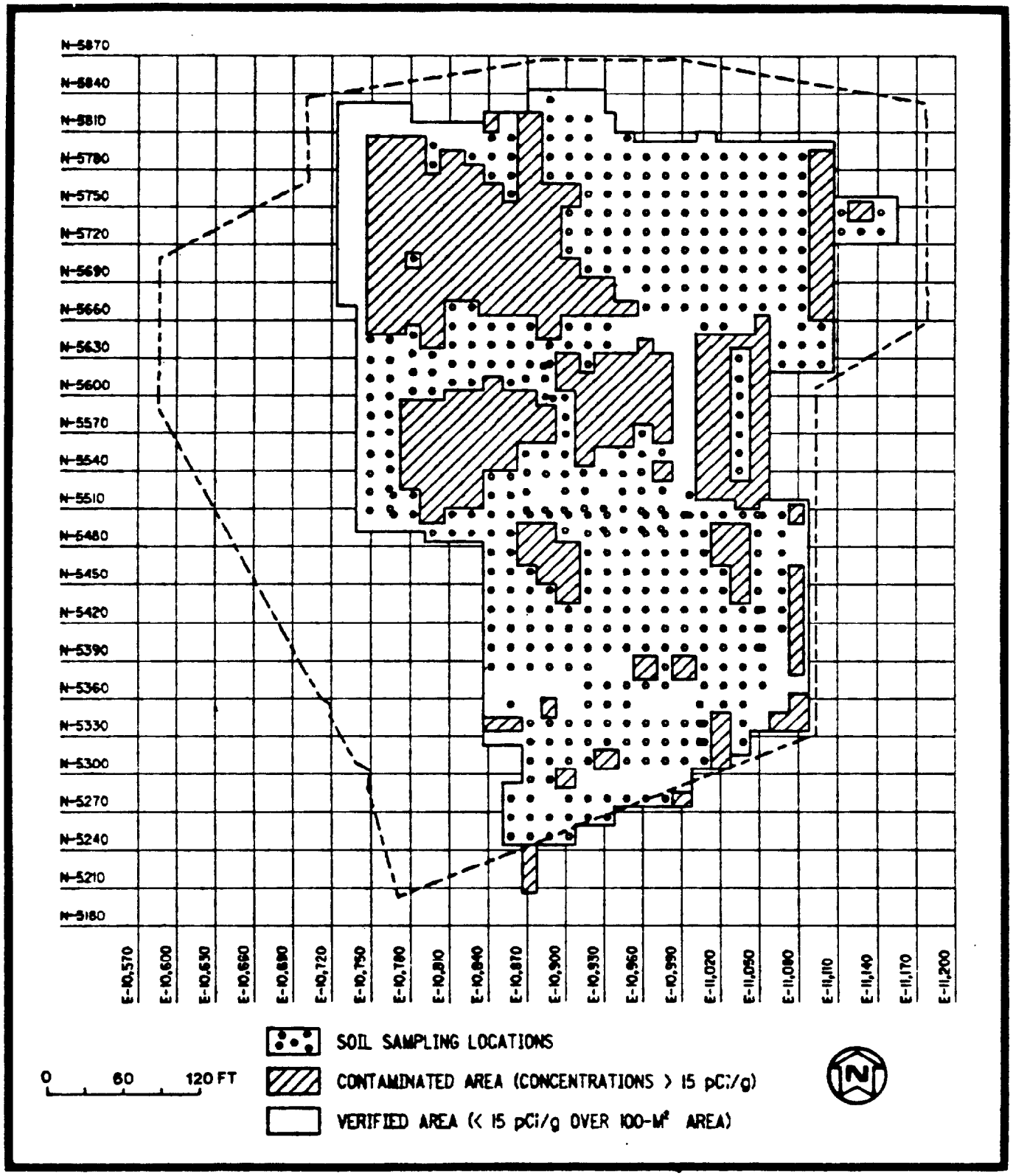


FIGURE 6 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 3

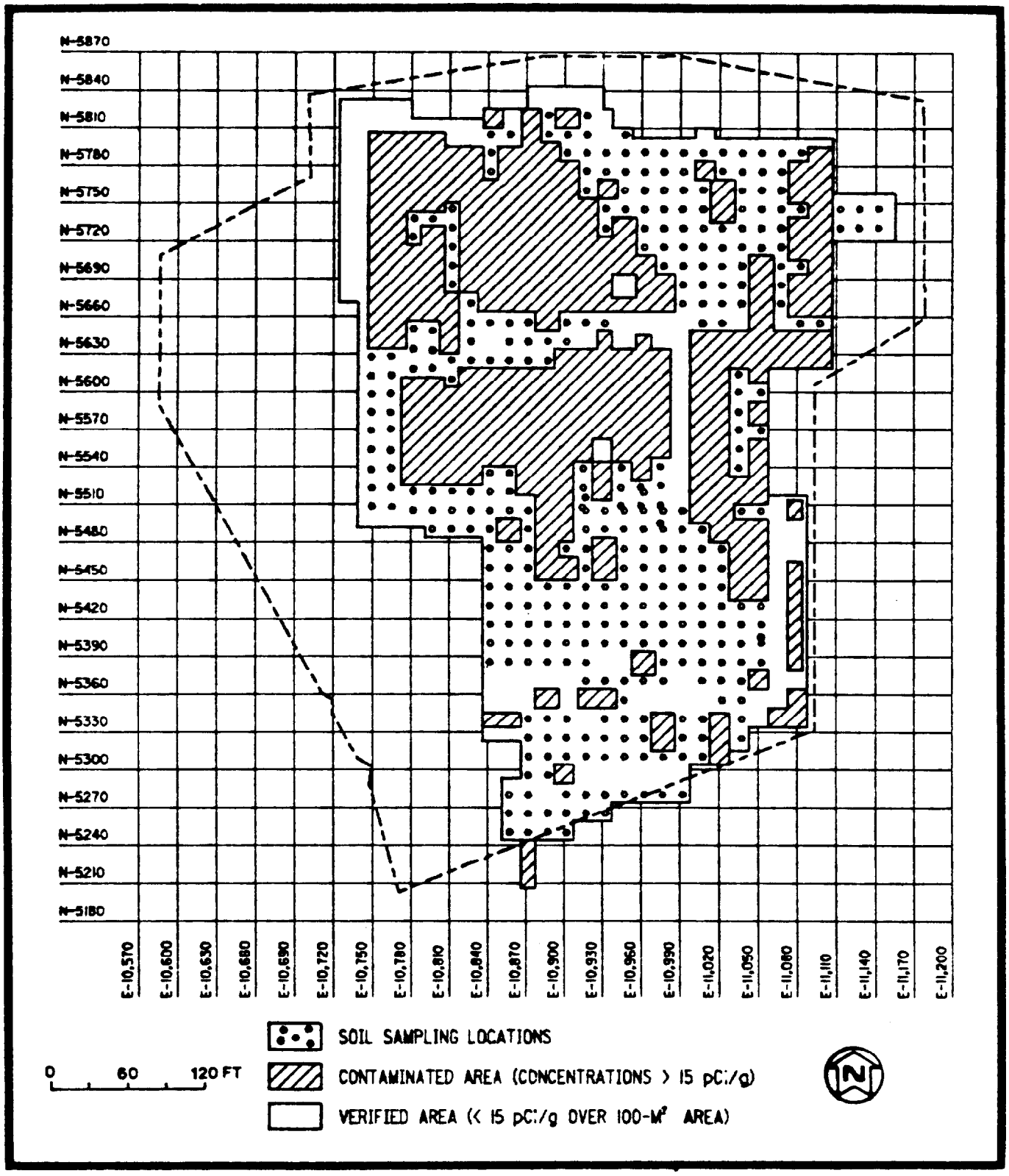


FIGURE 7 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 4

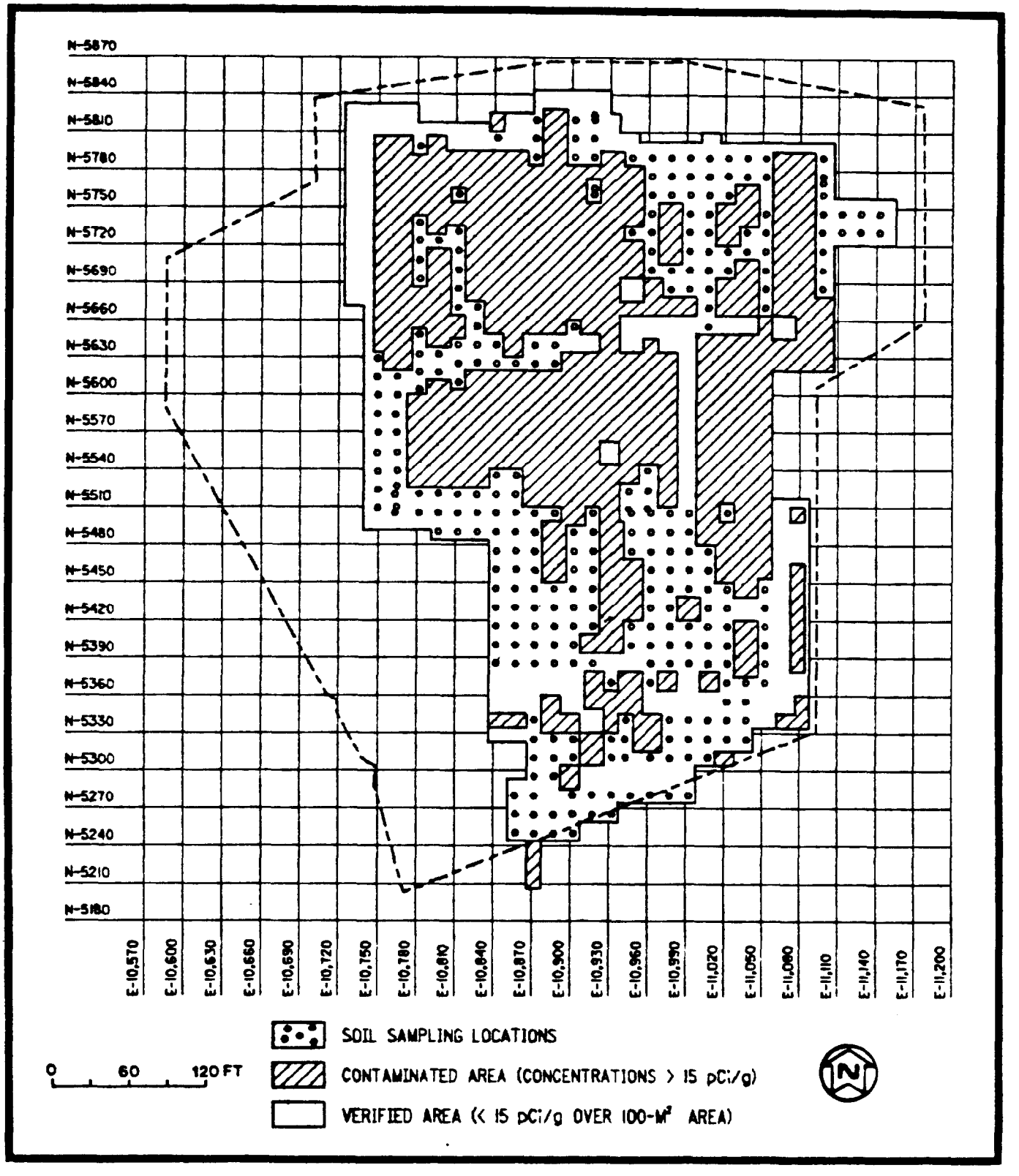


FIGURE 8 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 5

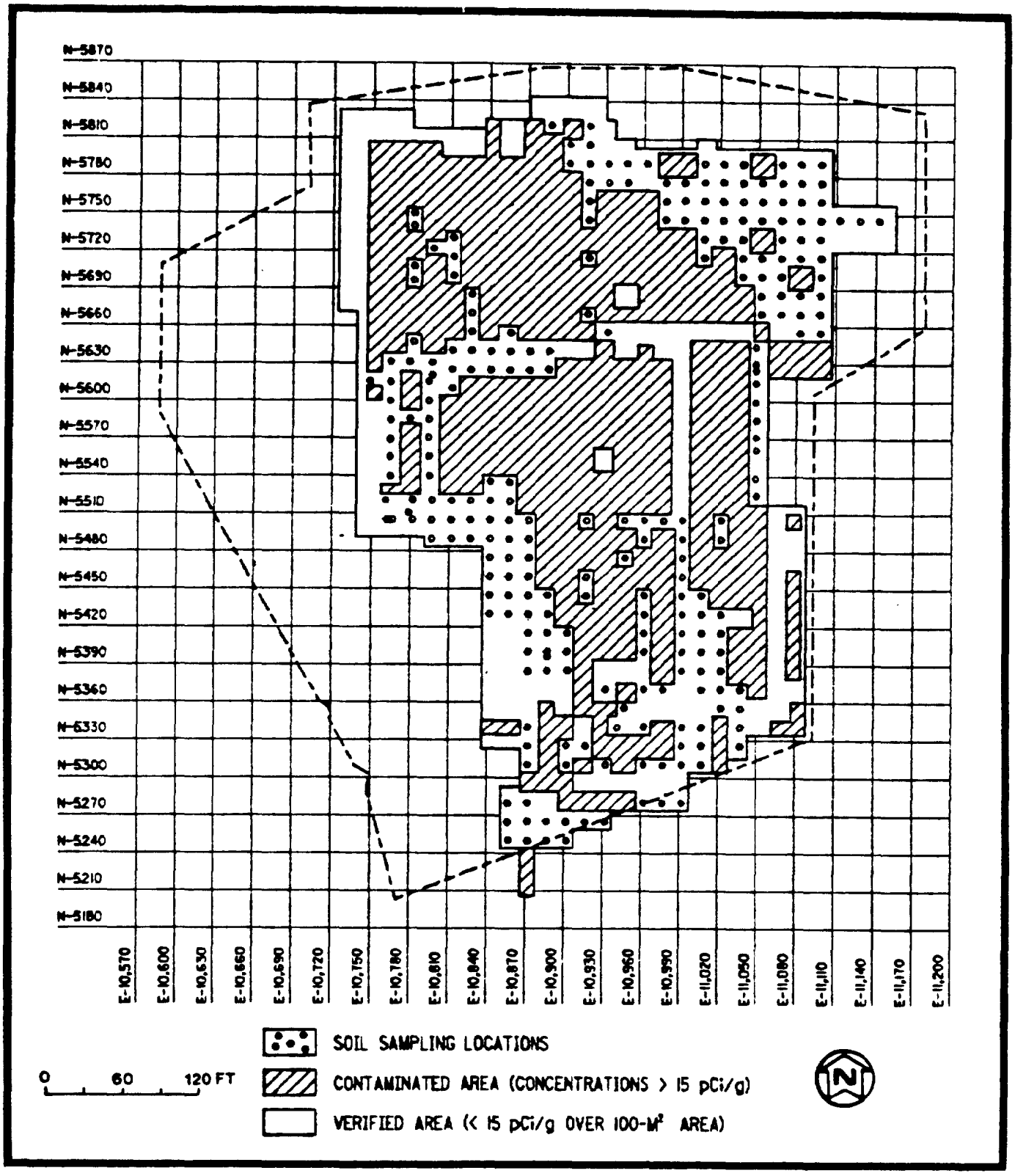


FIGURE 9 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 6

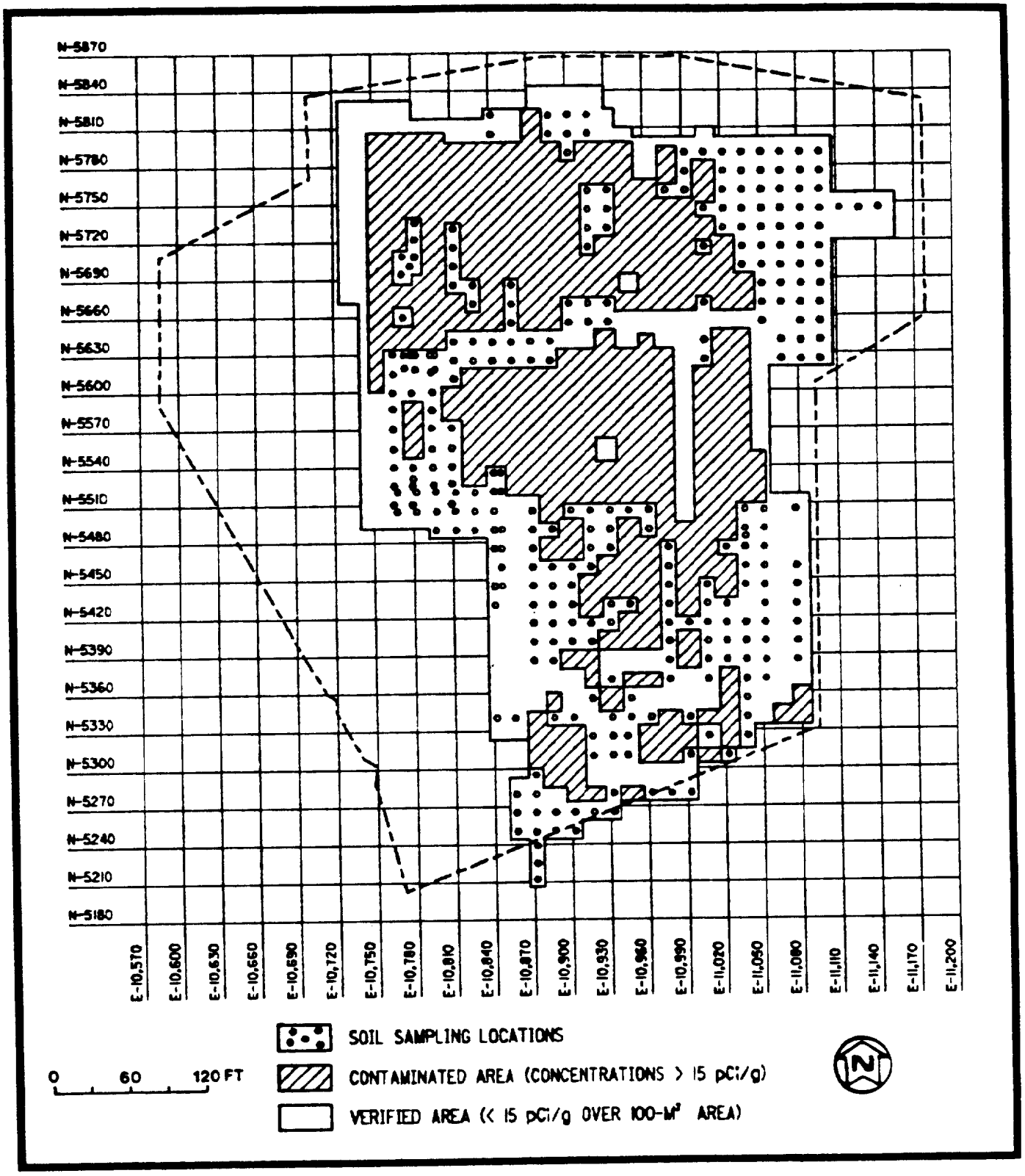


FIGURE 10 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 7

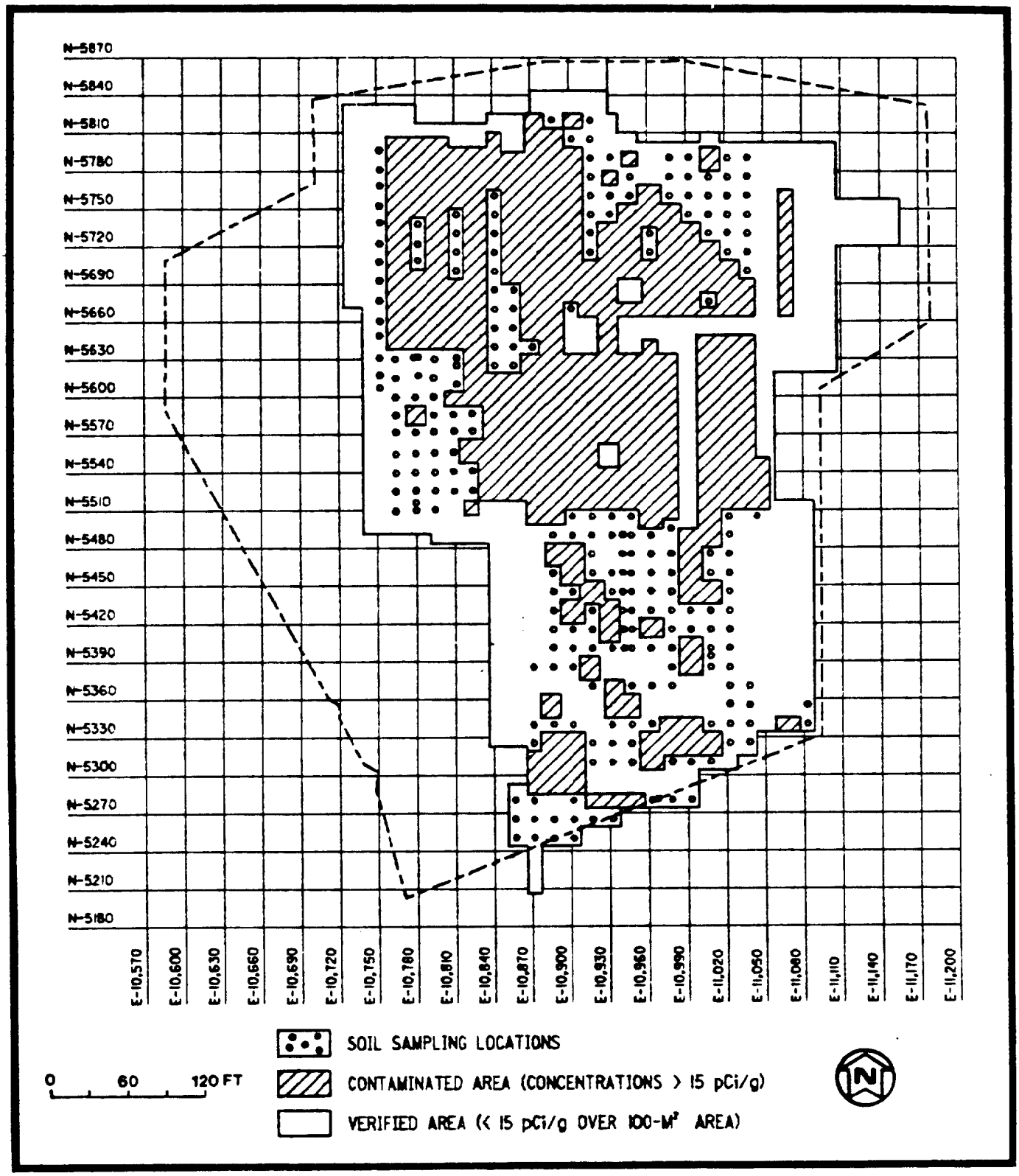


FIGURE 11 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 8

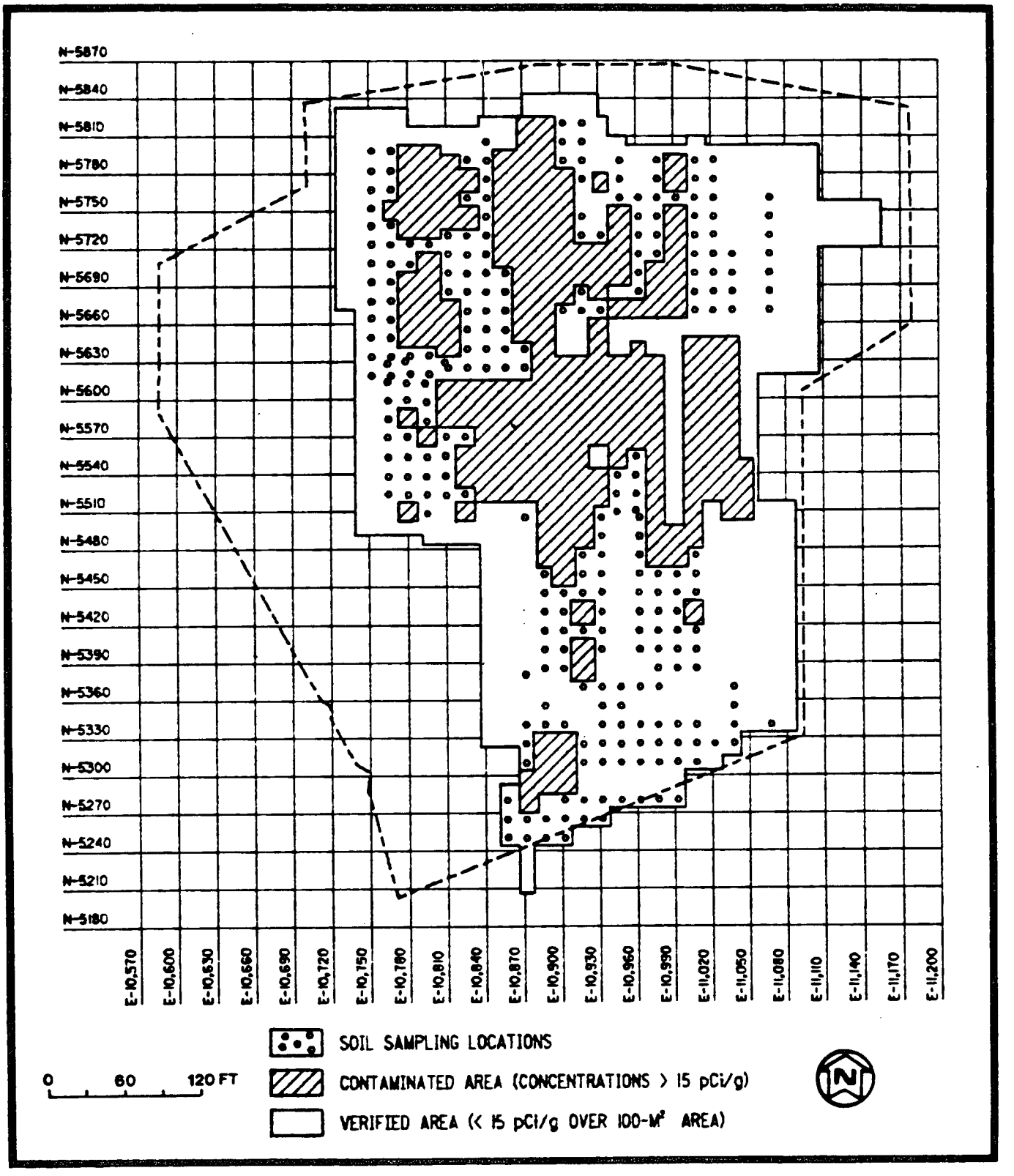


FIGURE 12 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 9

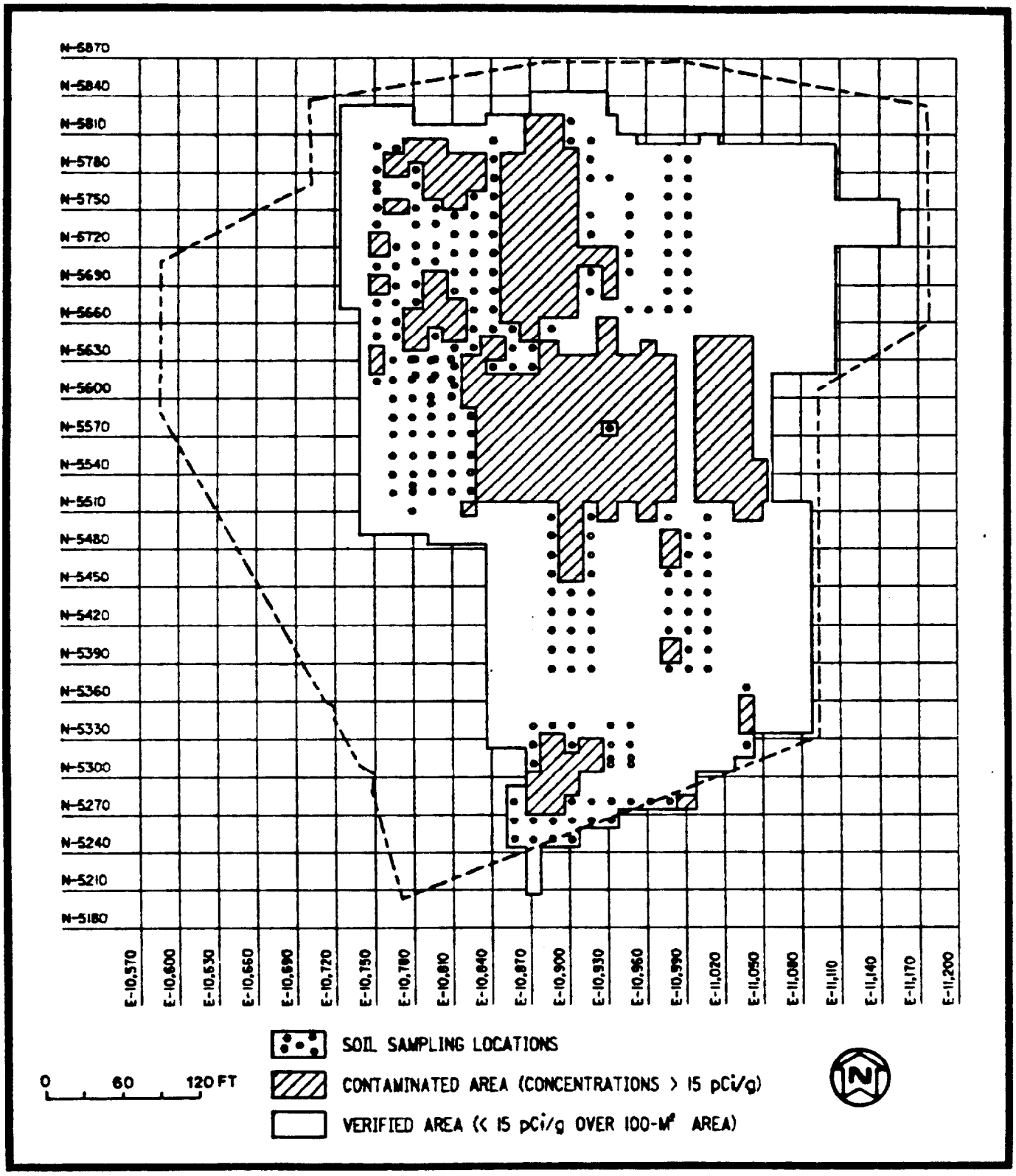


FIGURE 13 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 10

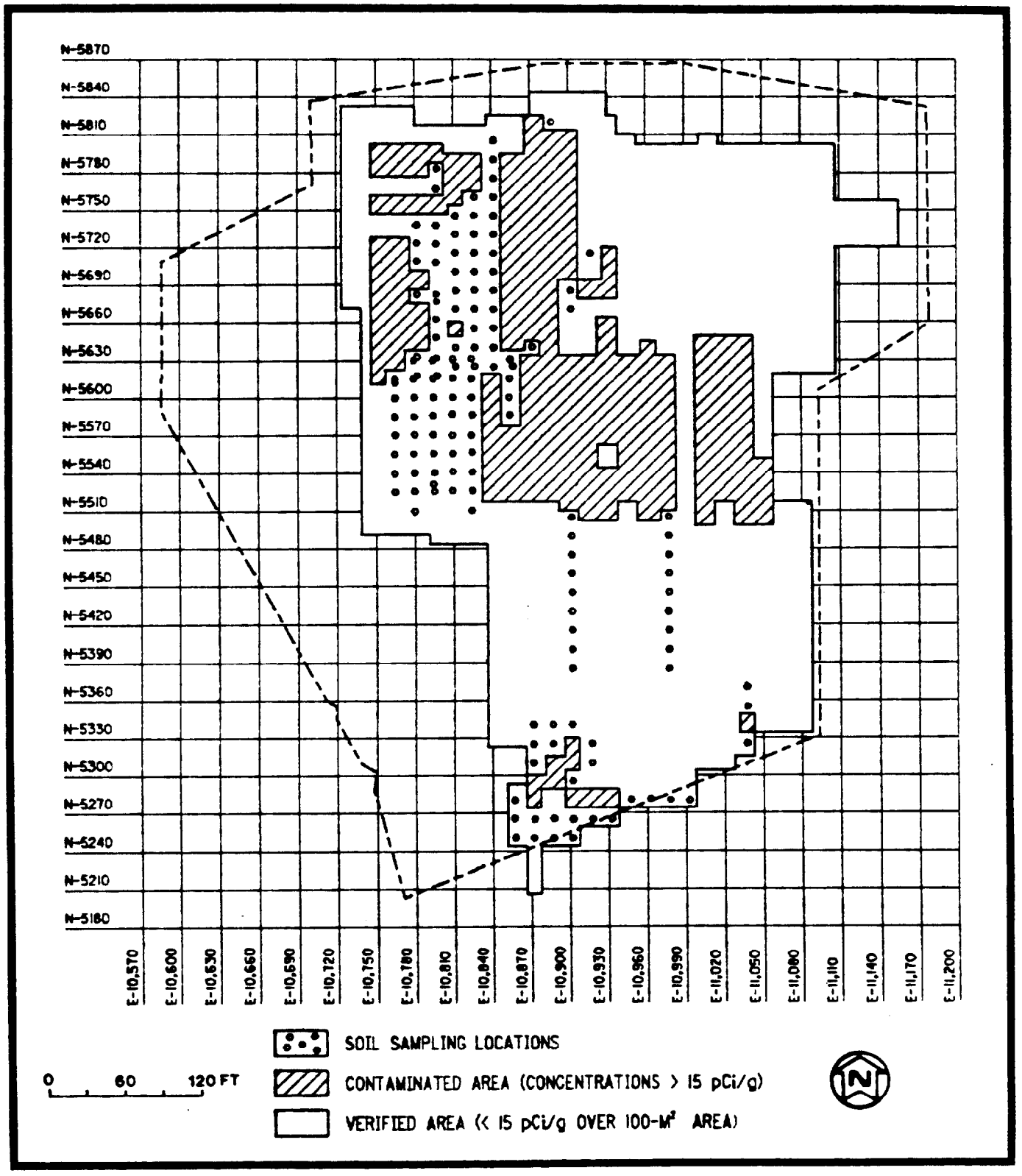


FIGURE 14 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 11

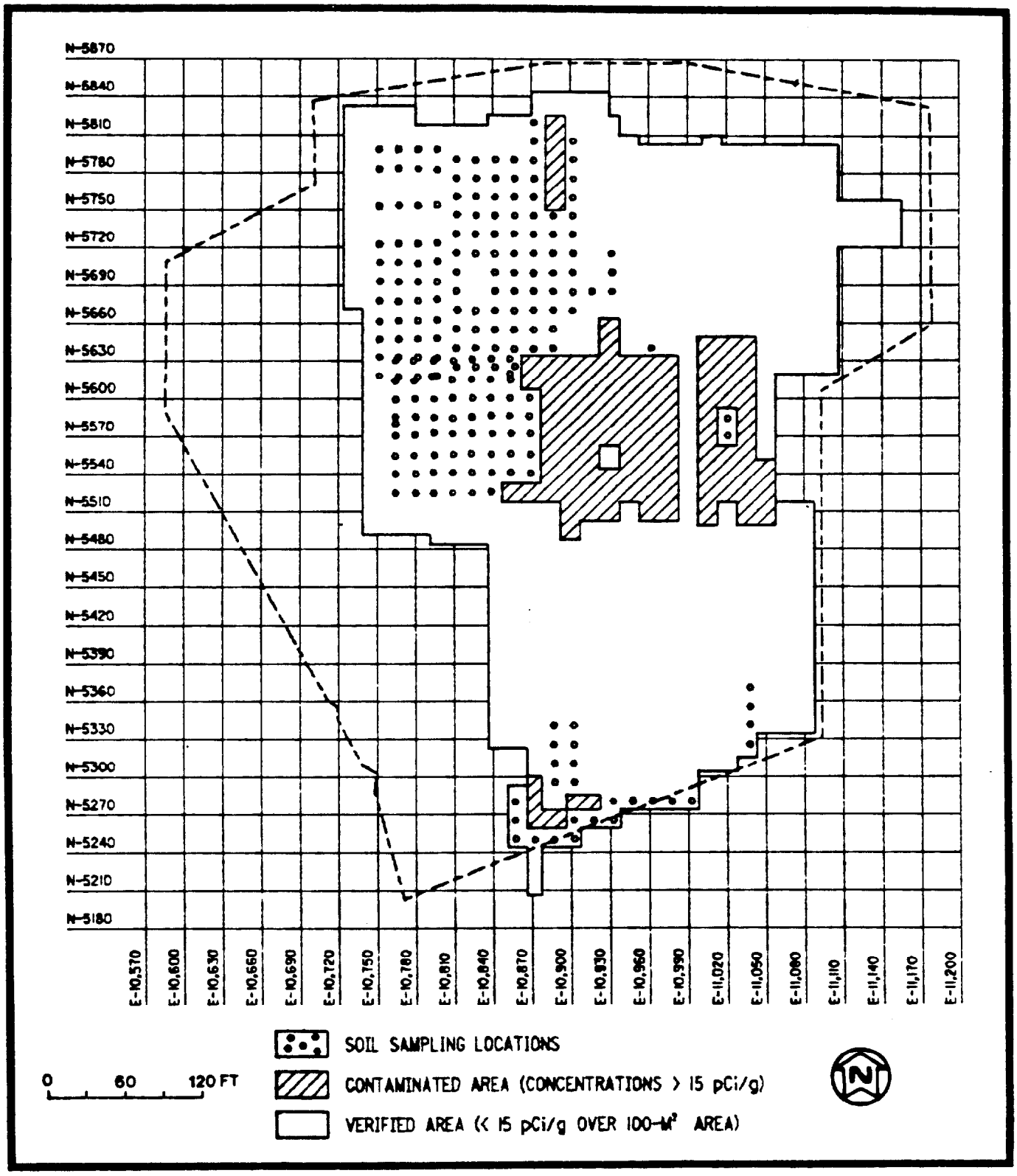


FIGURE 15 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 12

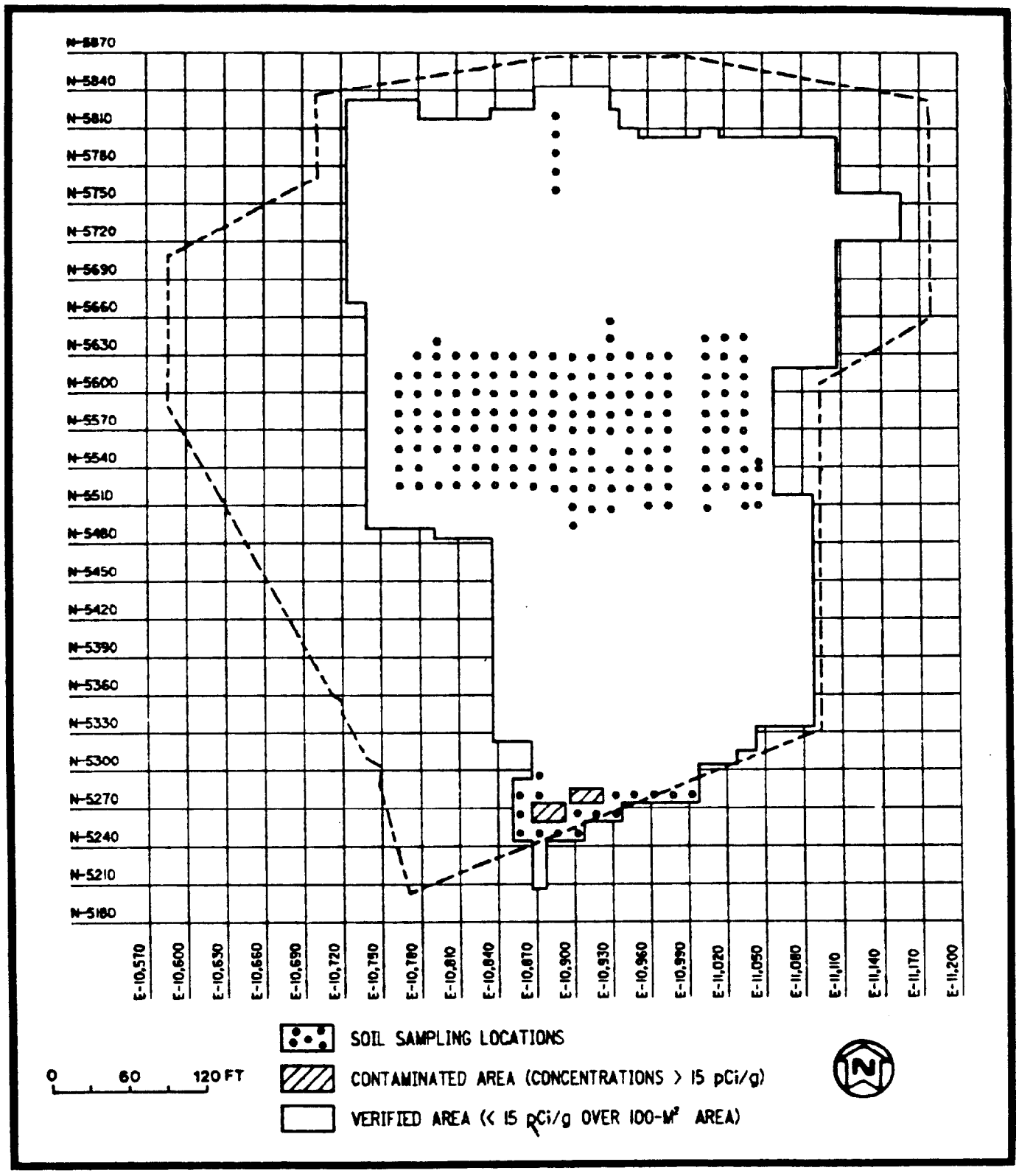


FIGURE 16 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 13

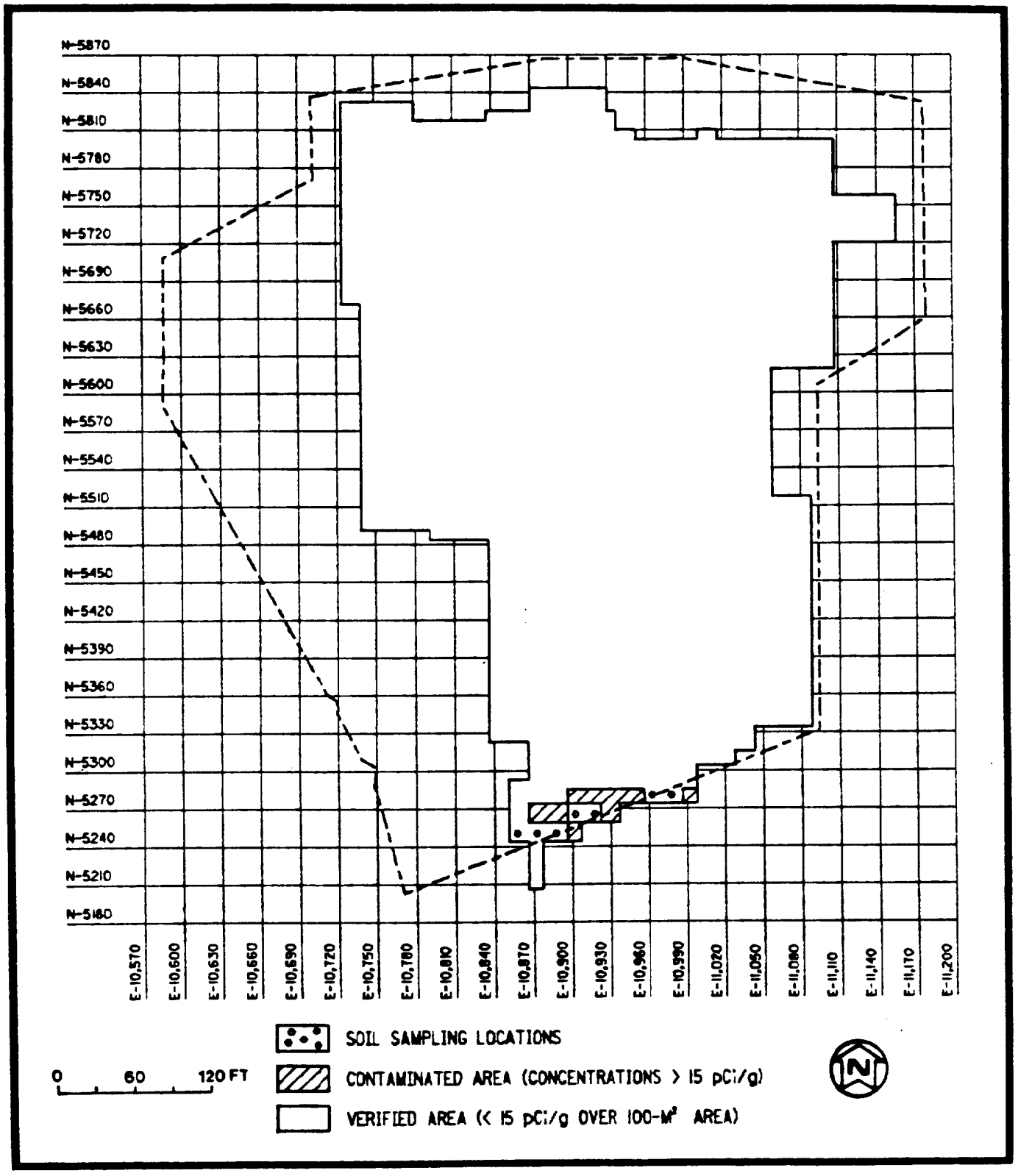


FIGURE 17 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 14

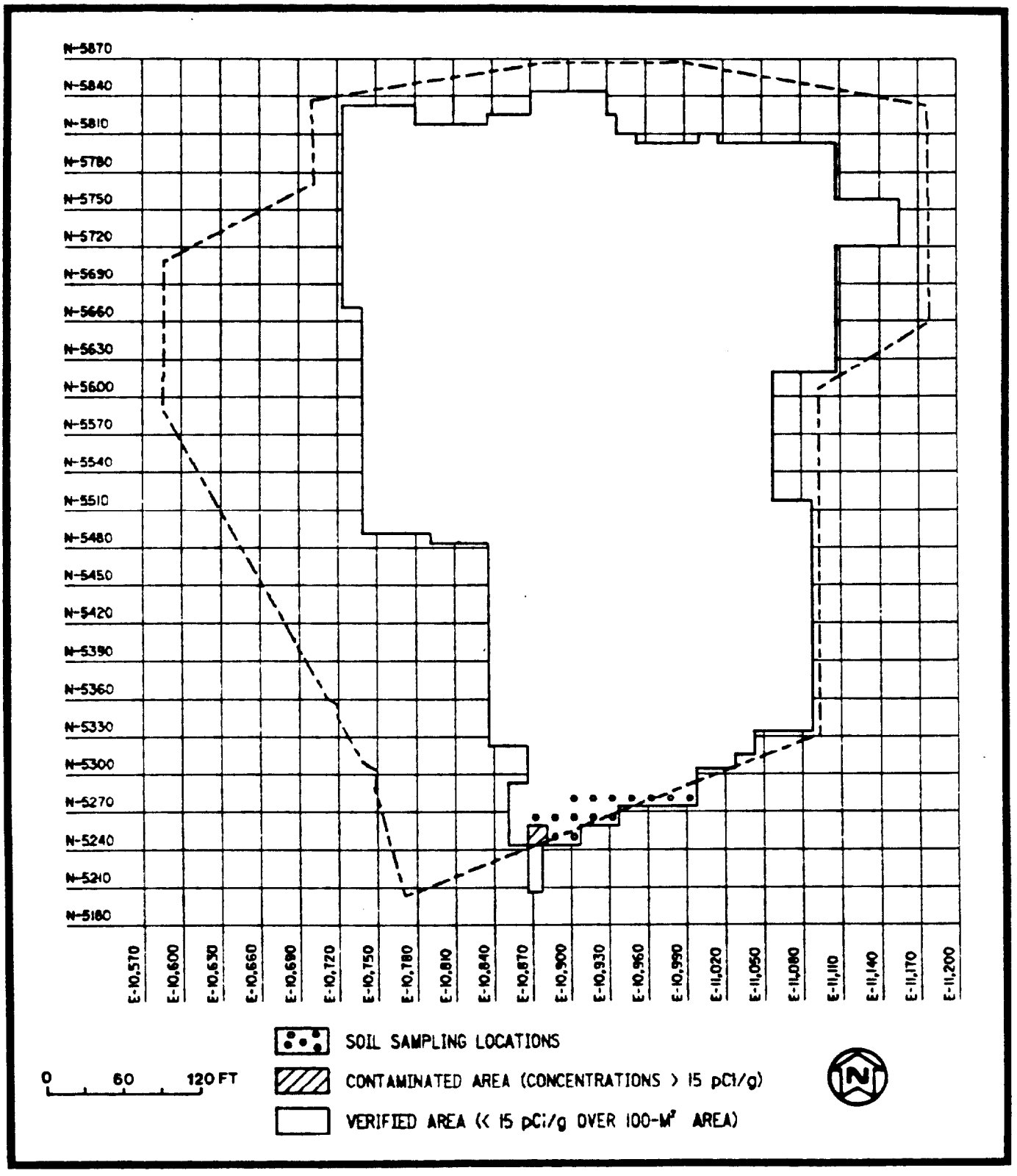


FIGURE 18 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 15

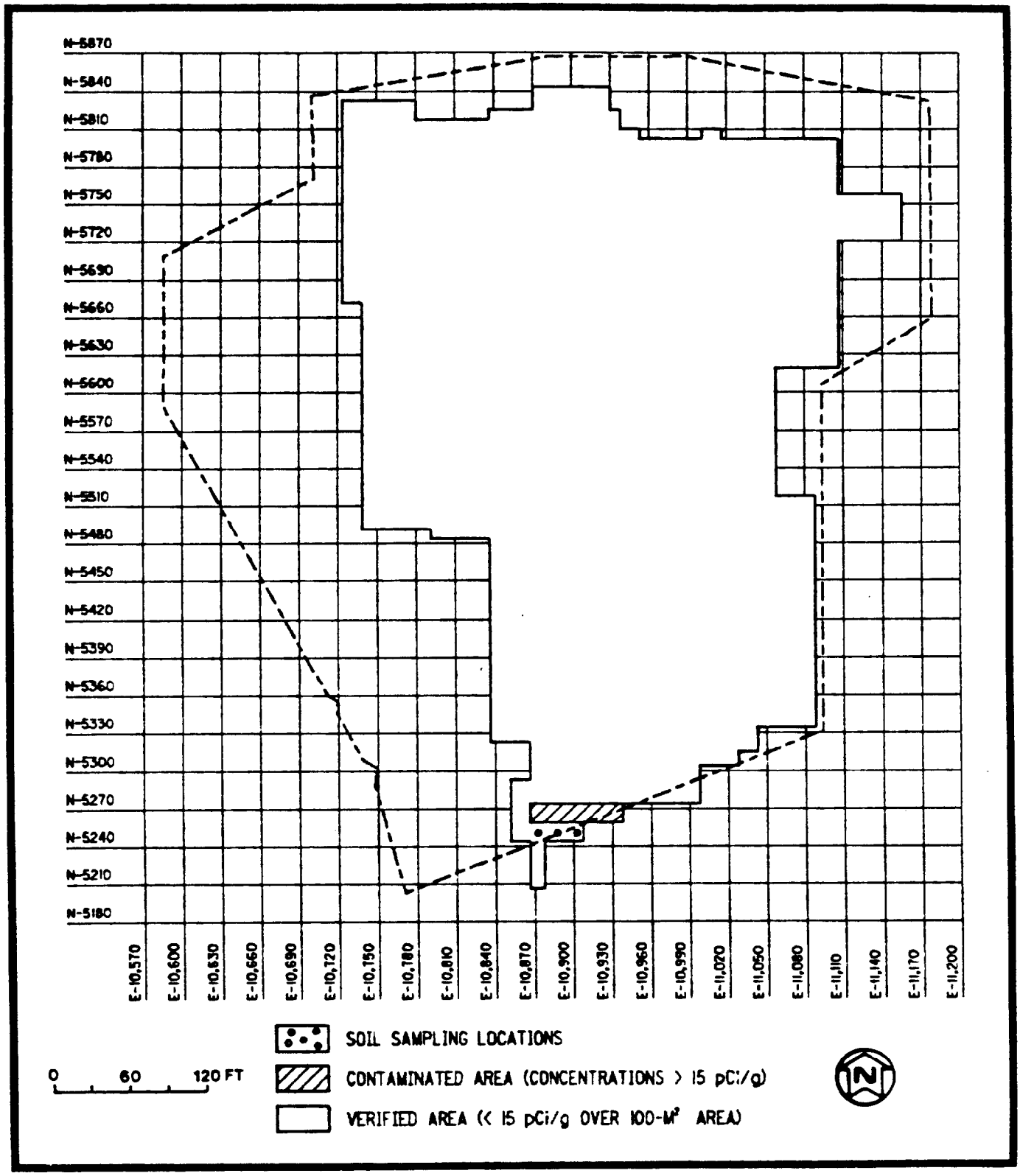


FIGURE 19 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 16

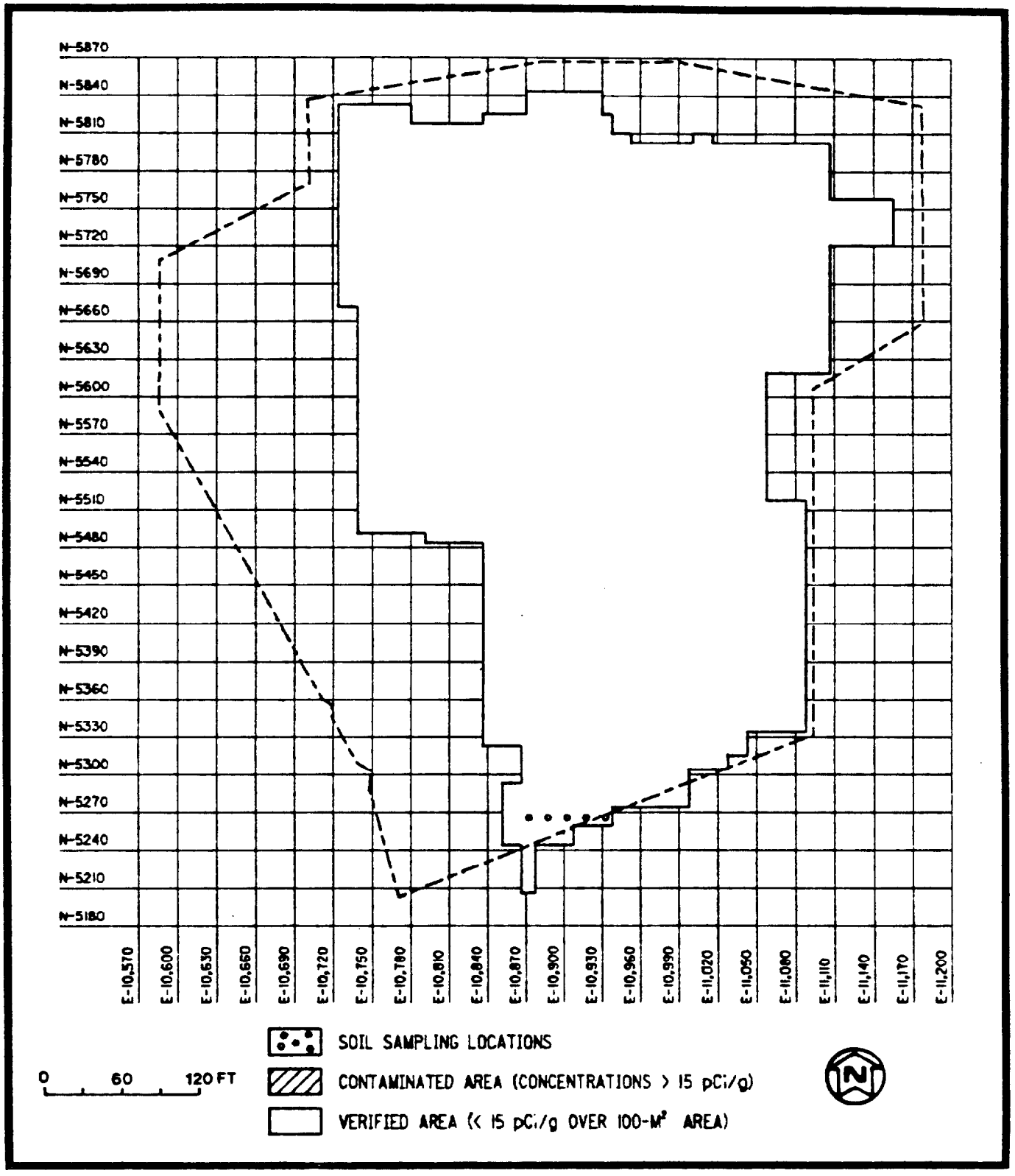


FIGURE 20 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 17

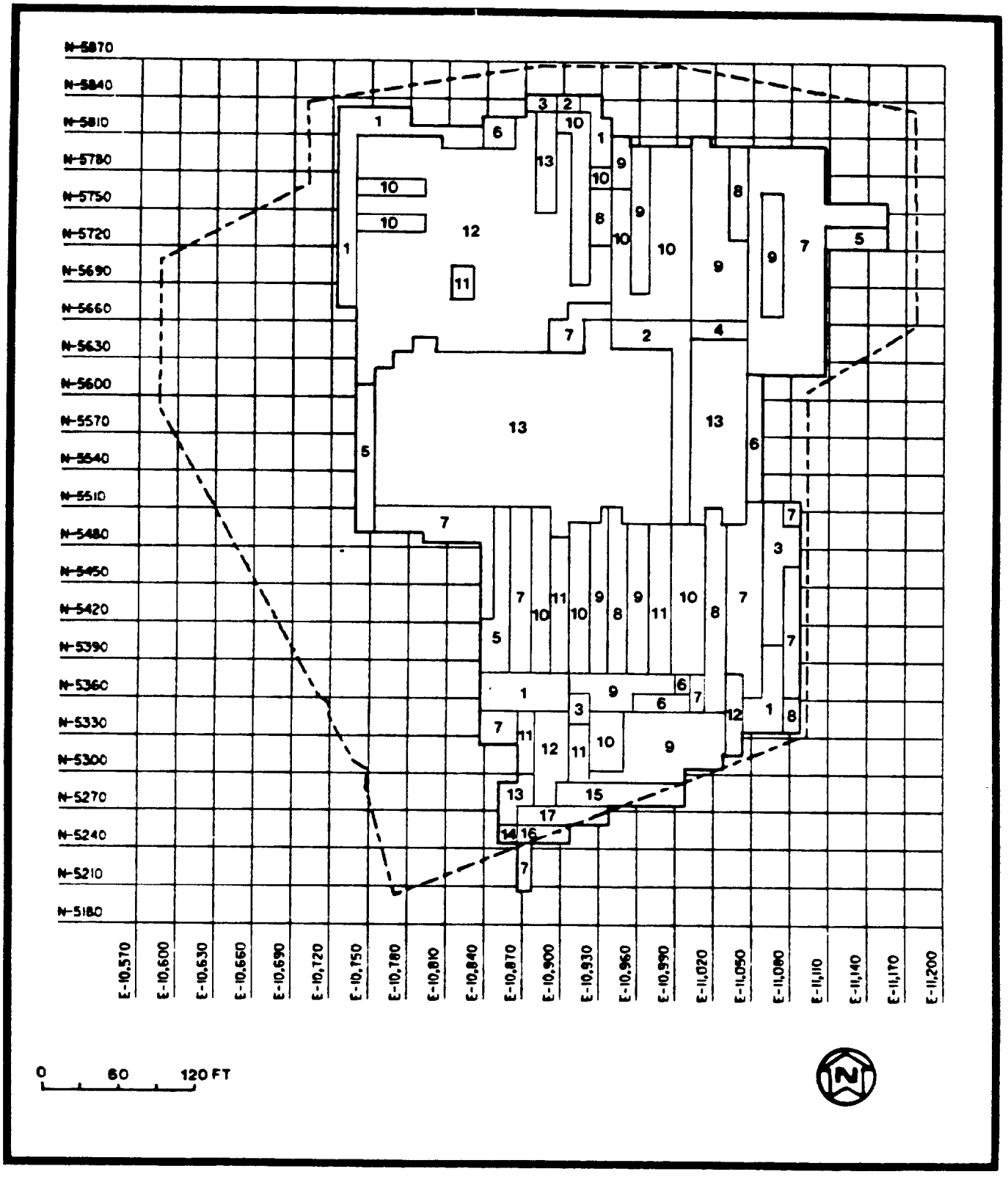


FIGURE 21 APPROXIMATE EXCAVATION DEPTHS (FT)

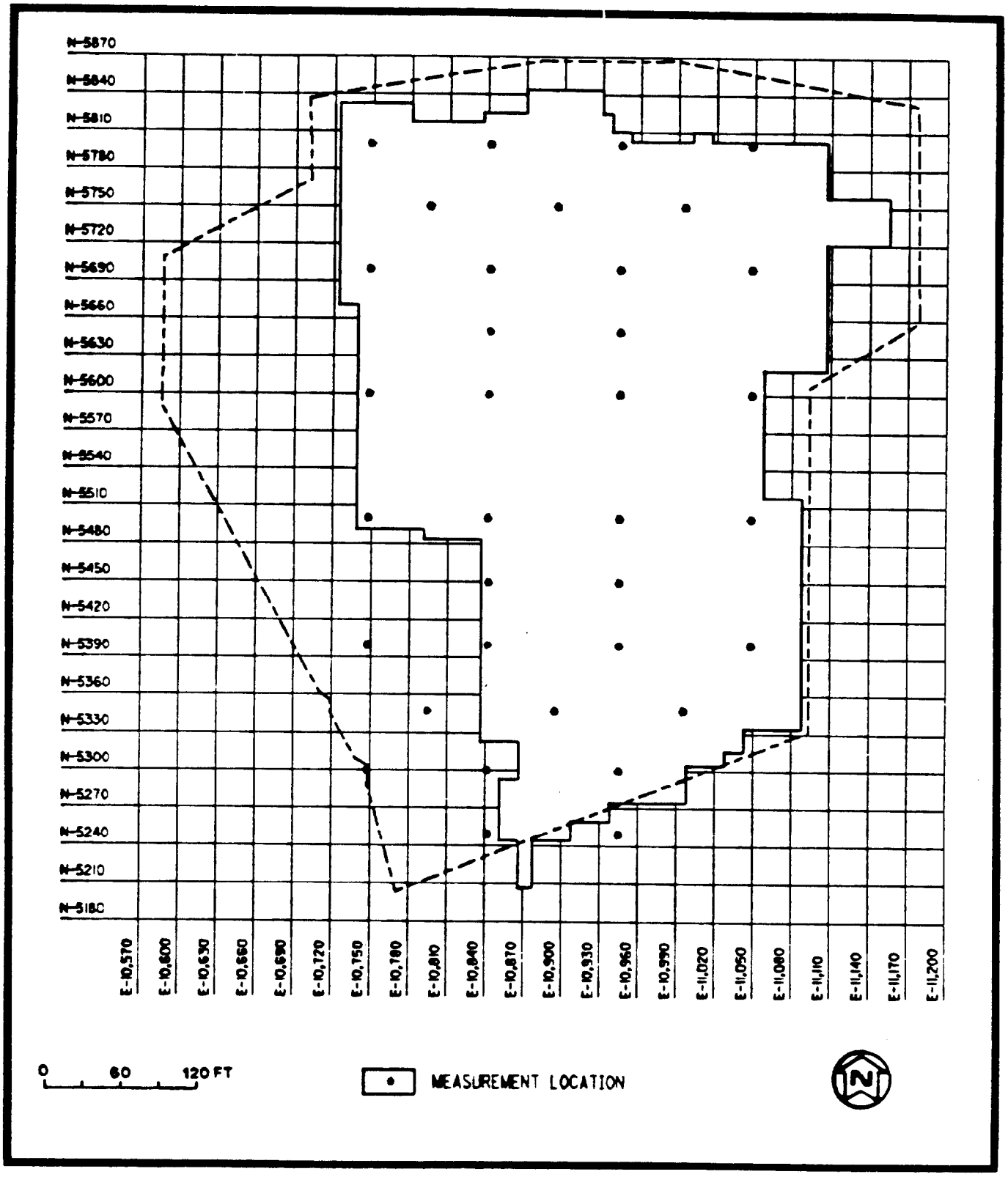


FIGURE 22 POST-REMEDIAL ACTION GAMMA RADIATION EXPOSURE RATE MEASUREMENT LOCATIONS

NOTE: The guidelines contained herein have been superseded by those contained in Appendix A to Exhibit I of the certification docket.

TABLE I

SUMMARY OF RESIDUAL CONTAMINATION GUIDELINES



BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 100 mrem/yr.

SOIL (LAND) GUIDELINES (MAXIMUM LIMITS FOR UNRESTRICTED USE)

| Radionuclide | Soil Concentration (pCi/g) above background[a,b,c] |
|---|---|
| Radium-226<br>Radium-228<br>Thorium-230<br>Thorium-232 | 5 pCi/g, 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. |
| Other radionuclides | Soil guidelines will be calculated on a site-specific basis using the DOE manual developed for this use. |

STRUCTURE GUIDELINES (MAXIMUM LIMITS FOR UNRESTRICTED USE)

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.[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 to be released for unrestricted use shall not exceed the background level by more than 20 μR/h.

Indoor/Outdoor Structure Surface Contamination

| Radionuclide[f] | Allowable Residual Surface Contamination[e] (dpm/100 cm$^2$) 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 | 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 |

TABLE I

(continued)



Indoor/Outdoor Structure Surface Contamination (continued)

| Radionuclide[f] | Allowable Residual Surface Contamination[e] (dpm/100 $cm^2$) Average[g,h] | Maximum[h,i] | Removable[h,j] |
|---|---|---|---|
| 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 | 5,000 $\beta-\gamma$ | 15,000 $\beta-\gamma$ | 1,000 $\beta-\gamma$ |

[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 concentrations of individual radionuclides shall be reduced so that the dose for the mixtures will not exceed the basic dose limit.

[b]These guidelines represent unrestricted-use residual concentrations above background averaged across any 15-cm-thick layer to any depth and over any contiguous 100-$m^2$ surface area.

[c]Localized concentrations in excess of these limits are allowable provided that the average concentration over a 100-$m^2$ area does not exceed these limits.

[d]A working level (WL) is any combination of short-lived radon decay products in 1 liter of air that will result in the ultimate emission of $1.3 \times 10^5$ MeV 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 observed 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 more than 1 $m^2$. For objects of less surface area, the average shall be derived for each such object.

[h]The average and maximum radiation levels 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.

[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 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.

TABLE 2

GAMMA RADIATION EXPOSURE RATE MEASUREMENTS

AT MIDDLESEX MUNICIPAL LANDFILL*

| Number of Measurements | Exposure Rate (mrem/yr)** | | DOE Radiation Protection Standard (mrem/yr)*** |
|---|---|---|---|
| | Average | Range | |
| 35 | 80 | 60-94 | 100 |

*Measurements were taken 1 m above the backfilled excavation.

**Converted to 100 mrem/yr from exposure rate measurements. Assumes continuous occupancy at point of measurement, and includes contribution from natural background.

***Above background.

## REFERENCES


1. U.S. Department of Energy. Description of the Formerly Utilized Sites Remedial Action Program, ORO-777, Oak Ridge, TN, September 1980 (as modified by DOE, October 1983).

2. U.S. Atomic Energy Commission. U.S. Atomic Energy Commission Radiation Survey Report of the Middlesex Landfill Site, March 25-April 4, 1974, Germantown, MD, June 1974.

3. Oak Ridge National Laboratory. Radiological Survey of the Middlesex Municipal Landfill Site, Middlesex, New Jersey, DOE/EV-005/20, Oak Ridge, TN, April 1980.

4. Ford, Bacon and Davis Utah, Inc. Engineering Evaluation of the Middlesex Municipal Landfill Site, Middlesex, New Jersey, FBDC 230-004, July 1979.

5. Ford, Bacon and Davis Utah, Inc. Environmental Analysis of the Middlesex Municipal Landfill Site, Middlesex, New Jersey, FBDU 230-008, July 1979.

6. Letter, John E. Baublitz, Jr. to E. L. Keller. "Guidelines for Residual Radioactivity at FUSRAP and Remote SFMP Sites" (Attachment: 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), July 22, 1985.

7. U.S. Code of Federal Regulations. 40 CFR 192, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," Washington, DC, July 1984.

8. U.S. Department of Energy. Remedial Action Work Plan for the Middlesex Municipal Landfill Site, ORO-846, Rev. 2, Oak Ridge, TN, February 1986.

9. Letter, J. R. Kannard, Bechtel National, Inc., to J. D. Berger, Oak Ridge Associated Universities. "Middlesex Landfill Post-Remedial Action Data," CCN 043207, February 13, 1987.

## GLOSSARY

**Background Radiation** - Background radiation refers to naturally occurring radiation emitted from either cosmic (e.g., from the sun) or terrestrial (e.g., from the earth) sources. Exposure to this type of radiation is unavoidable and its level varies greatly depending on geographic location; e.g., New Jersey typically receives 100 mrem/yr, Colorado receives about 300 mrem/yr, and some areas in South America receive up to 7000 mrem/yr. Naturally occurring terrestrial radionuclides include uranium, radium, potassium, and thorium.

**Contamination** - Contamination means a concentration of radioactive materials in the soil exceeding that permitted by DOE guidelines.

**Counts per minute** - A count is the unit of measurement registered by a radiation detection instrument when radiation imparts its energy within the sensitive range of the detector probe. The number of counts registered per minute can be related to the number of disintegrations per minute occurring from a radioactive material.

**Disintegrations per minute** - Disintegrations per minute is the measurement indicating the amount of radiation being released from a substance per minute. See the definition of picocurie for more information.

**Exposure rate** - Exposure rate is the rate at which radiation imparts energy to the air. Exposure is typically measured in microroentgens (μR) and the exposure rate is typically given 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 uR/h for 168 hours per week (continuous exposure) for 52 weeks per year, the whole-body dose would be 170 mrem.

**Gamma Radiation** - See radiation.

**Gram** - A gram is a metric unit for weight. It takes 454 grams to make 1 pound; 1 ounce equals 28 grams.

**Meter** - A meter is a metric unit of measurement for length; 1 meter is equal to approximately 39 inches.

**Microroentgen** - A microroentgen (uR) is a unit used to measure radiation exposure. For further information, see the definition of exposure rate.

**Millirem** - The millirem is the unit used to measure radiation doses to man. The DOE limit is 100 mrem above background radiation levels for members of the general public in any one year. For comparison, a typical chest x-ray is about 40 mrem. Naturally occurring radioactive substances in the ground result in a yearly exposure to everyone of about 100 mrem. To date, no difference can be detected in the health of population groups exposed to 100 mrem/yr above background and in the health of groups who are not exposed.

**Microrem** - The microrem is also a unit used to measure radiation doses to man. It is equal to one-thousandth of a millirem.

**Picocurie** - A picocurie is the unit of measure for radioactivity just as an ounce is a unit to measure weight. One picocurie means that one radioactive particle is released on the average of every 27 seconds.

**Pitchblende** - A black-to-brown ore mineral that is the chief source of uranium.

**Radium-226** - Radium-226 is a naturally occurring, radioactive material that spontaneously emits alpha radiation.

**Radiation** - There are three primary types of radiation: alpha, beta, and gamma. Alpha radiation travels less than an inch in air before it stops. Alpha radiation cannot penetrate the outer layer of skin on the body. Beta radiation can penetrate the outer layers of skin, but cannot reach the internal organs of the body. Gamma radiation is the most penetrating type and can usually reach the internal organs.

**Radionuclide** - A radionuclide is a specific radioactive element. For example, uranium-235 is a radionuclide, uranium-238 is another, thorium-232 another, and so on.

**Remedial Action** - Remedial action is a general term used to mean "cleanup of contamination." It refers to any action required so that a property can be released for unrestricted use as uncontaminated. In practice, this may mean removing grass and soil, cutting trees, removing asphalt, etc.

**Thorium** - Thorium is a naturally occurring element that is recovered from monazite for commercial purposes. Monazite contains from 3 to 9 percent thorium oxide. The principal use of thorium to date has been in the preparation of gas lantern mantles because thorium oxide burns with a brilliant white light. Thorium oxide is also commonly found in high quality glasses and camera lenses because of its good optical characteristics.

**Unrestricted Use** - Unrestricted use means that a property can be used for any purpose without regard to the radioactivity that used to be on the property. These uses could include anything -- farming, a residence, a playground, etc.

**Uranium** - Uranium is a naturally occurring, radioactive element. The principal use of uranium -- when refined -- is for the production of fuel for nuclear reactors. Uranium in its natural form is not suitable for use as a fuel source.

**Working level** - Working level is a unit of measurement for the energy expended in air by radon or its radioactive decay products. The term was derived for use with uranium mine workers and has become the accepted unit for environmental measurements.

## Exhibit II (7) - Interim Verification Letters to Property Owners and Verification Statements and Reports

The verification statement for the subject properties is listed below and included in this section. The verification report is also included in this section.


| | Page |
|---|---|
| Letter, J.D. Berger, Oak Ridge Associated Universities, to J.J. Fiore, Director, Division of Facility and Site Decommissioning, Office of Nuclear Energy, Department of Energy Headquarters. "Verification of Remedial Actions at the MML," March 16, 1987. | II-273 |
| Oak Ridge Associated Universities. Verification of Remedial Action, Middlesex Municipal Landfill, Middlesex, New Jersey, Oak Ridge, Tennessee, September 1987. | II-275 |

Oak Ridge
Associated Universities
Post Office Box 117
Oak Ridge, Tennessee 37831-0117

Manpower Education
Research and Training
Division

March 16, 1987

Mr. James J. Fiore, Director
Division of Facility and Site
Decommissioning Projects
Office of Nuclear Energy
U.S. Department of Energy
Washington, DC 20545

Subject: VERIFICATION OF REMEDIAL ACTIONS AT THE MIDDLESEX MUNICIPAL LANDFILL

Dear Mr. Fiore:

Oak Ridge Associated Universities (ORAU) has completed independent verification activities on the Middlesex Municipal Landfill site. Based on the results of document reviews, confirmatory sample analyses, and independent site surveys it is ORAU's opinion that the remedial actions have been effective in meeting the DOE radiological guidelines established for that property. A report, describing the verification activities and findings is being prepared.

Questions regarding this matter may be referred to me at FTS 626-3305.

Sincerely,

Glenn A. Murphy -for-
James D. Berger, Manager
Radiological Site Assessment Program

JDB:sjf

Enclosures

cc: A. Wallo, DOE/NE
S. Ahrends, DOE/ORO/TSD
J. Nemec, BNI
W. Borden, BNI
C. Leichtweis, BNI

Oak Ridge Associated Universities

848198

# Memorandum

Rebecca Kennedy for

**To** Luis E. Velazquez **From** James D. Berger

**Date** September 29, 1987 **Copies to** Boyle, Cloutier, File, List Below

**Subject** FINAL VERIFICATION REPORT - MIDDLESEX LANDFILL REMEDIAL ACTION

Enclosed are eight copies of the final verification survey report for Remedial Action on the Middlesex Municipal Landfill, Middlesex, New Jersey. This report should be forwarded to Mr. J. Fiore of DOE/NE's Division of Facility and Site Decommissioning Projects.

Questions may be referred to me at 576-3305.

JDB/sjf

cc: R. Atkin, DOE/OR/TSD
G. Hovey, BNI
A. Wallo, DOE/NE

G. K. HOVEY

Prepared by
Oak Ridge Associated
Universities

Prepared for
Division of
Facility and Site
Decommissioning
Projects

U.S. Department
of Energy

# VERIFICATION OF REMEDIAL ACTION MIDDLESEX MUNICIPAL LANDFILL MIDDLESEX, NEW JERSEY

**J. D. BERGER**

Radiological Site Assessment Program
Manpower Education, Research, and Training Division

FINAL REPORT
SEPTEMBER 1987

# VERIFICATION
# OF
# REMEDIAL ACTION
# MIDDLESEX MUNICIPAL LANDFILL
# MIDDLESEX, NEW JERSEY

Prepared by

J.D. Berger

Radiological Site Assessment Program
Manpower Education, Research, and Training Division
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Prepared For

U.S. Department of Energy
as part of the
Formerly Utilized Sites - Remedial Action Program

**FINAL REPORT**

September 1987

This report is based on work performed under contract number DE-AC05-76OR00033 with the U.S. Department of Energy.

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# VERIFICATION
# OF
# REMEDIAL ACTION
# MIDDLESEX MUNICIPAL LANDFILL
# MIDDLESEX, NEW JERSEY

## INTRODUCTION

Between 1943 and 1955, the Middlesex Sampling Plant in Middlesex, New Jersey, about 29 km southwest of Newark (Figure 1), was used by the Manhattan Engineer District and U.S. Atomic Energy Commission, predecessors of the U.S. Department of Energy, for the assay of uranium and thorium ores. Although no supporting documentation is available, it is believed that construction activities at the Sampling Plant, between November 1947 and October 1948, resulted in the placement of soils, contaminated with uranium ore, into the Middlesex Municipal Landfill, approximately 0.9 km northwest of the Sampling Plant. Landfill operations in subsequent years, resulted in dispersion of the contaminated soil throughout the landfill site and covering of the contaminated material with varying thicknesses of noncontaminated soil. Use of the landfill for municipal waste disposal was discontinued in 1974.

The presence of low-level contamination in the Middlesex Municipal Landfill was initially discovered in May 1960, during a local civil defense exercise. In 1961, the top layer of material was removed from the landfill by the Atomic Energy Commission (AEC) and replaced with a layer of clean soil. The AEC conducted a radiological survey of the area in 1974 and Oak Ridge National Laboratory (ORNL) conducted an additional survey in 1978 at the direction of the U.S. Department of Energy (DOE).[1,2] Ford, Bacon, and Davis performed an engineering evaluation of remedial action alternatives in 1979.[3]

Results of the surveys and engineering evaluation indicated that the Middlesex Municipal Landfill contained radiological contamination levels in excess of the DOE guidelines, and the site was designated for remedial action under DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP). From 1984 through 1986 Bechtel National, Inc. (BNI), the Project Management Contractor for FUSRAP, conducted additional characterization surveys, where necessary, to more accurately define the boundaries of the contamination and conducted remedial actions to remove the contaminated soil.

Remedial action was in accordance with an April 1984 action description memorandum and February 1986 work plan.[4,5] The remedial action consisted of removal of noncontaminated cover material, excavation of contaminated fill material, and transport of the contaminated material to the Middlesex Sampling Plant where it was placed in interim storage. Figure 2 is a plot plan of this landfill site, indicating the remedial action area. Following completion of excavations, BNI conducted surveys to demonstrate compliance with the cleanup guidelines, refilled the excavations, and restored the site surface. The remedial action and results of the followup surveys are described in a post-remedial action report and supporting data tables prepared by BNI.[6,7]

It is the policy of DOE to perform independent (third party) verifications of the effectiveness of remedial actions conducted within FUSRAP. The Radiological Site Assessment Program of Oak Ridge Associated Universities (ORAU) has been designated by DOE as the organization responsible for this task at the Middlesex Municipal Landfill. During May through July 1986, ORAU performed verification activities for the landfill site. This report describes the procedures and findings of that verification.

## PROCEDURES

### Objectives

The objectives of the verification were to confirm that the surveys, sampling, and analyses conducted prior to, during, and following remedial action and associated project documentation provide an accurate and complete description of the condition of the property and, thereby, confirm that remedial actions have been effective in meeting established criteria.

### Procedures

1. Radiological survey reports, engineering evaluations, work plans, and the post-remedial action reports (references 1-7) were reviewed. Data were evaluated to assure that areas exceeding criteria were identified and had undergone remedial action. Post-remedial action radionuclide

concentrations in soil and exposure-rate data were compared to criteria, and the post-remedial action report and data were reviewed for general thoroughness and accuracy.

2. Thirty soil samples, collected during the post-remedial action survey, were obtained from BNI and independently analyzed for Ra-226, U-238, and Th-232 by the ORAU laboratory to confirm the accuracy of BNI analyses.

3. Survey teams from ORAU visited the Middlesex area and performed visual inspections and limited independent gamma scans, exposure rate measurements, and soil sampling on representative portions of the excavated areas and restored landfill property. Dates of these independent surveys were May 29 and 30, 1986; June 20, 1986; June 30, 1986; and July 28, 1986.

Findings of the inspections and radiological surveys were compared with the post-remedial action report and the established Middlesex Municipal Landfill guidelines (Appendix A). Measurement and analytical equipment and procedures are described in further detail in Appendices B and C.

## FINDINGS AND RESULTS

### Document Review

Review of the AEC and ORNL survey reports and the interim data, developed by BNI during successive excavations, indicated appropriate decisions concerning requirements for remedial action. During remedial action, a narrow band of contaminated soil, not previously identified by the ORNL or BNI characterization surveys, was discovered on the south side of the landfill and was excavated. Visual ORAU inspections of selected areas of remedial action confirmed the extent of excavations as identified by BNI in the post-remedial action report. Several samples, reported in the BNI data tables, contain Ra-226 and/or Th-232 concentrations exceeding the guideline concentrations. However, these samples represent small, isolated regions and in combination

with other samples collected from adjacent excavated regions, the resulting average concentrations satisfy the guidelines, for contiguous areas of 100 $m^2$. In addition, many of the samples listed in the data tables were obtained at interim excavation depths for remedial action control monitoring. Because of the need for timely excavation decisions, such samples were not dried, pulverized, and held for radon ingrowth before analysis; the concentrations determined were, instead, multiplied by conservative factors to account for anticipated effects of standard preparation and analysis procedures. Based on previous additional analyses of such samples, this approach has been found to yield concentration levels, which are conservatively overestimated by up to a factor of 2 to 3, depending upon the radionuclides and soil characteristics. Therefore, some of the data values reported in the BNI tables over estimate the actual concentrations in soil at this site. It should also be noted that the concentrations reported in the BNI data tables include background contributions from naturally occurring materials.

## Confirmatory Sample Analyses

Table 1 presents the results of gamma spectrometry analyses, performed by ORAU and BNI, for 30 soil samples from the remediated areas. For the primary radionuclide of concern, Ra-226, data are in agreement within their respective $2\sigma$ confidence levels for 23 of the 30 samples and within $3\sigma$ confidence levels for 25 of the 30 samples. Only one sample (from grid coordinate N5760.5, E10917.5 in BNI data Table 17) indicated a substantial difference between ORAU and BNI analyses. The BNI value was 36.3 ± 2.2 pCi/g of Ra-226 as compared to the ORAU value of 4.8 ± 0.5 pCi/g; a reason for the discrepancy could not be identified. Analyses of variance on paired Ra-226 data yielded a correlation factor of 0.98. Thorium 232 and U-238 data pairs were within their respective $3\sigma$ confidence levels for 29 of 30 and 28 of 30 samples. On the basis of these findings, it is ORAU's opinion that the BNI data are accurate, within the statistical limitations of the analytical procedures.

## Verification Surveys

### Excavated Area

Figure 3 indicates the portions of the excavation which were independently surveyed by ORAU. Surface scans of the excavations identified six small,

isolated locations of elevated gamma radiation (Figure 4). The size of these locations, i.e. <1 $m^2$, and the associated radiation levels indicated that the average soil concentrations in the 100 $m^2$ areas surrounding these elevated locations would likely satisfy the DOE guidelines for the landfill site. However, each of these locations was investigated further to determine the source of the radiation and to assure that the guideline concentrations were satisfied. At three of the locations, the sources were identified as "nuggets" of uranium ore, approximately 1 cm in diameter. Removal of these pieces of ore reduced the radiation levels to the ambient background ranges. Another of these locations was a clod of soil, which had apparently fallen into the completed excavation from the adjacent area, still being remediated. This piece of material was removed, again reducing the gamma radiation level to the background range. Discrete sources could not be identified at the other two locations of elevated radiation. Soil samples, obtained from these two locations, contained radionuclide concentrations within the guideline levels (Table 2).

Gamma exposure rates, measured in the surveyed portions of the excavation are presented in Table 3. Levels ranged from 8 to 34 μR/h at contact and 7 to 64 μR/h at 1 m above the bottom of the excavation. The two highest contact and 1 m measurements were at grid coordinates N5380, E10927, and N5380, E10955. Both of these measurements were at the edge of an ongoing excavation. At all other measurement points the highest contact and 1 m exposure rates were 15 μR/h and 17 μR/h, respectively.

Soil samples (15 cm depth) were collected at locations of gamma measurements; radionuclide concentrations in these samples are summarized in Table 4. All soil concentration values include background levels. Three of these samples contained Ra-226 concentrations above the guideline level of 15 pCi/g. The highest concentration was 48.0 pCi/g at grid location N5308, E10927; this sampling location was at the edge of an active excavation and included loose contaminated soil which had fallen onto the previously excavated surface. Most other samples contained Ra-226 concentrations well below 15 pCi/g, and averaging over an area of 100 $m^2$ would result in levels below the 15 pCi/g (above background) guideline. Thorium 232 concentrations were generally lower than the Ra-226 concentrations. The maximum Th-232

concentration measured was 3.0 pCi/g - well below the 15 pCi/g guideline level. The highest U-238 concentration was 57.7 pCi/g; this was the sample that also contained the highest Ra-226 concentration.

These direct measurements and samples indicate that remedial actions were effective in removing radiologically contaminated material from the landfill and reducing residual radionuclide levels to within the guidelines established for this project.

Backfilled Areas

Walkover scans of the entire landfill site, conducted after backfilling of excavations, identified 11 small (<1 $m^2$) isolated locations and two larger areas (up to approximately 25 $m^2$) of elevated contact gamma radiation. These locations are shown on Figure 5. As was the case with the areas of elevated radiation identified in the excavations, the small size of most of these locations and the associated radiation levels indicated that the average soil concentrations over 100 $m^2$ areas would still satisfy the Ra-226 guideline level of 5 pCi/g above background. Further investigations at the small isolated locations resulted in identification and removal of small nuggets of uranium ore from ten locations; a discrete source could not be identified at the other location. A soil sample obtained from the point of highest contact radiation at this location contained a Ra-226 concentration of 1.4 pCi/g (Table 2).

The two larger areas of elevated contact radiation were adjacent to the excavated portion of the landfill. Based on their location and the surface nature of the contamination, it is believed that these areas may have resulted from spillage during earlier activities at the landfill, i.e. before the current remedial actions. BNI performed removal of the surface soil at these locations to a depth of 15-30 cm. Followup gamma scans of these areas indicated that the radioactive contamination had been effectively removed. Soil samples were collected from locations in each of these areas, where the highest contact gamma radiation level was measured. The analyses, presented in Table 2, indicated a maximum Ra-226 concentration of 14.3 pCi/g. Because these samples represented what would become a subsurface layer after backfilling, concentrations were within the DOE guideline level of 15 pCi/g above

background. Uranium and thorium concentrations in these samples were less than the Ra-226 levels.

Gamma exposure rate measurements at 50 foot (15.15 m) intervals throughout the site are presented in Table 5. These levels ranged from 5-8 μR/h at surface contact and from 6-8 μR/h at 1 m above the surface. These levels are comparable to typical background exposure rates in the Middlesex, New Jersey area.

Radionuclide concentrations in surface soil samples from 100 foot intervals are presented in Table 6. Concentration ranges were Ra-226, 0.3 to 2.6 pCi/g; Th-232, 0.4 to 2.0 pCi/g; and U-238, <0.4 to 4.5 pCi/g. All of these samples contained concentrations of Ra-226 and Th-232, which are within the DOE's guidelines for surface soil, and concentrations of U-238, which are below the guideline levels typically used for remedial actions at DOE FUSRAP sites.

On the basis of the direct measurements and soil sampling, performed as part of this survey, external radiation levels and radionuclide concentrations on the backfilled landfill property satisfy the DOE remedial action guidelines.

## CONCLUSIONS

Between May 1986 and May 1987, Oak Ridge Associated Universities' Radiological Site Assessment Program performed independent activities to verify the adequacy of remedial actions at the Middlesex Municipal Landfill and the accuracy of documentation supporting the remedial actions. The verification activities included document reviews, confirmatory laboratory analyses, and independent direct measurements and sample analysis. Based on the results and findings of these activities it is ORAU's opinion that the remedial action has been effective in satisfying the established DOE criteria. It is also ORAU's opinion that the documentation supporting the remedial action process is adequate and accurate. A verification letter, indicating these opinions, was provided to DOE in March 1987.[8]

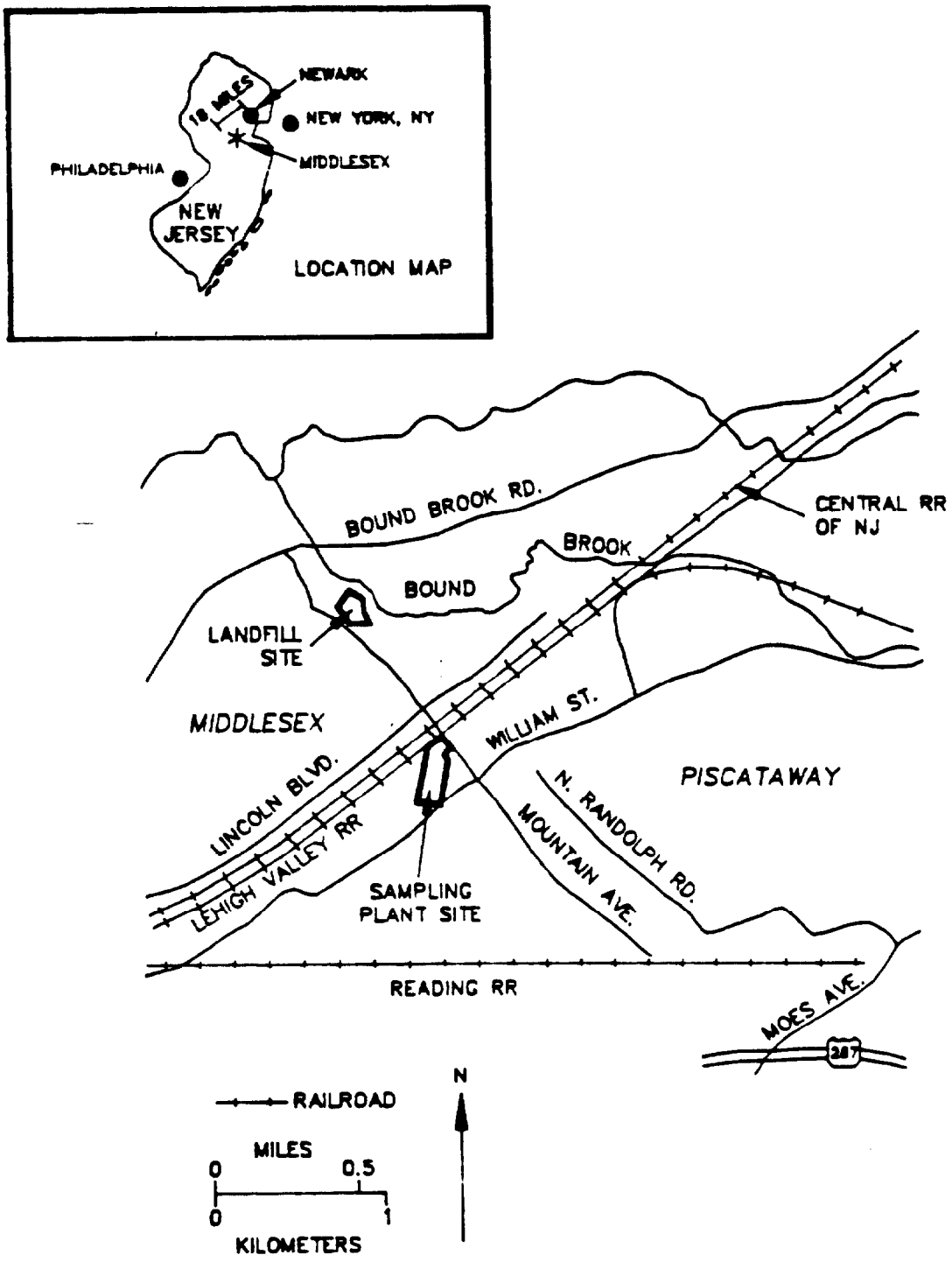


FIGURE 1: Location of the Middlesex Municipal Landfill Site

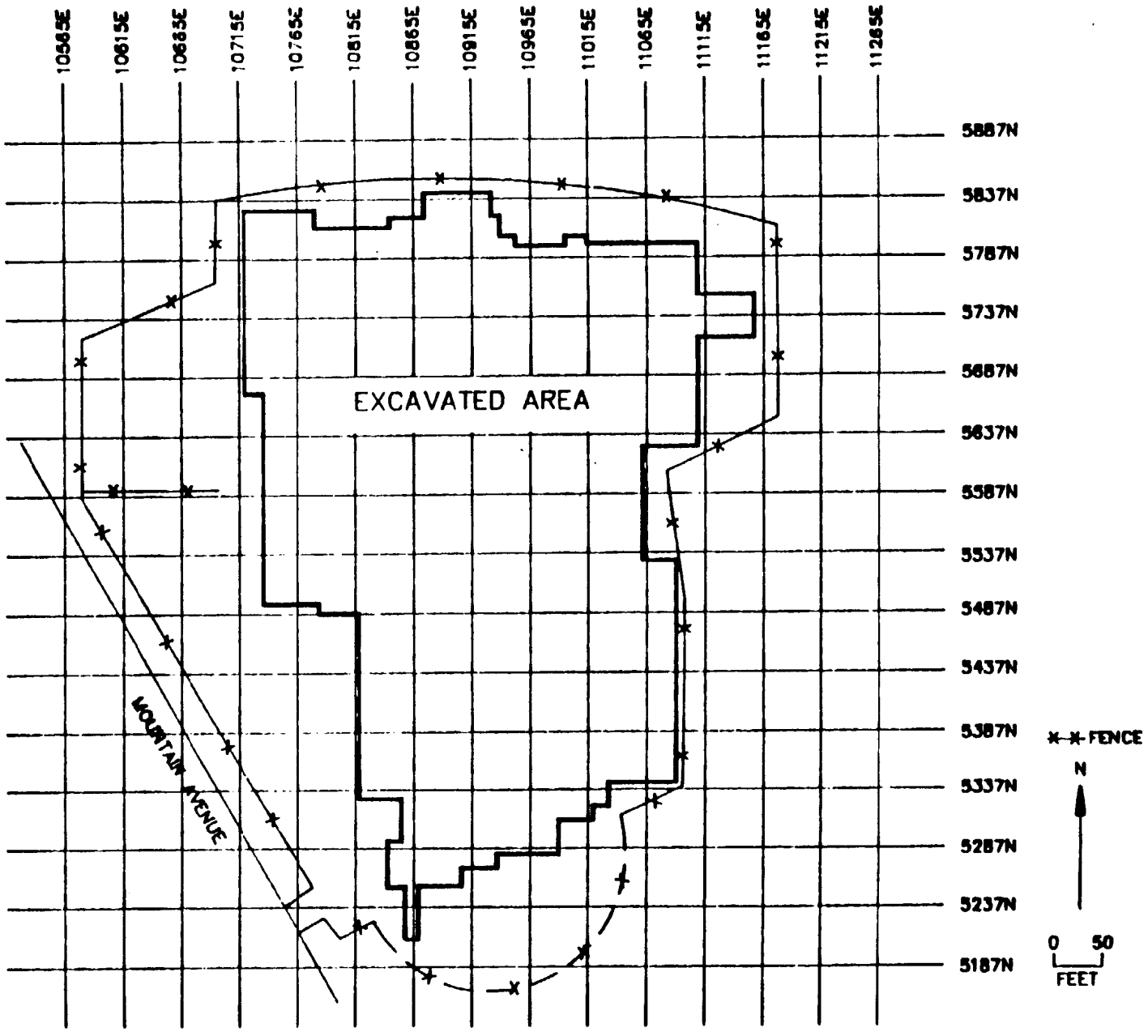


FIGURE 2: Middlesex Municipal Landfill Site Indicating Excavated Area and Grid System Established for Survey Reference

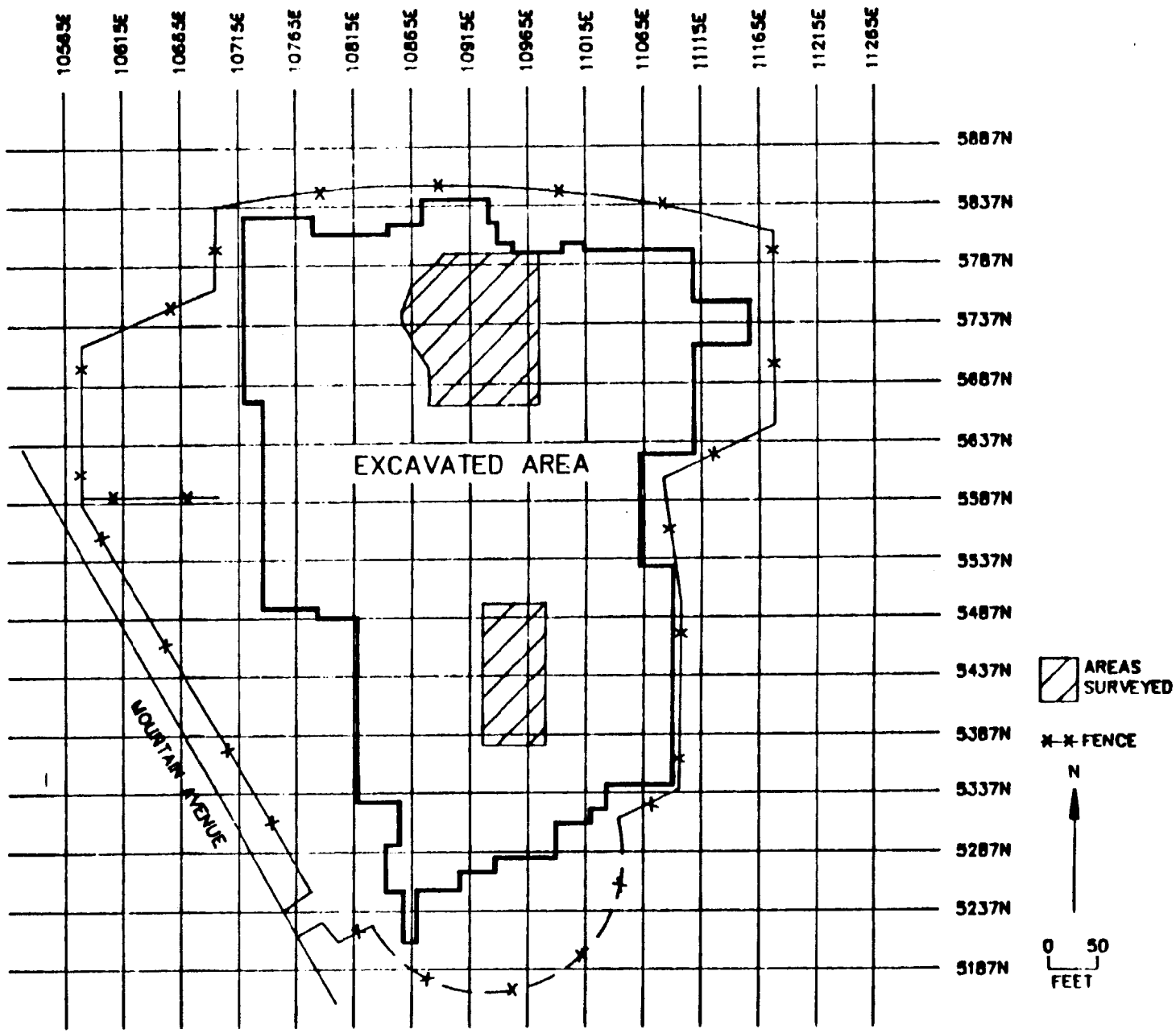


FIGURE 3: Portion of Excavated Area Included in Independent Survey

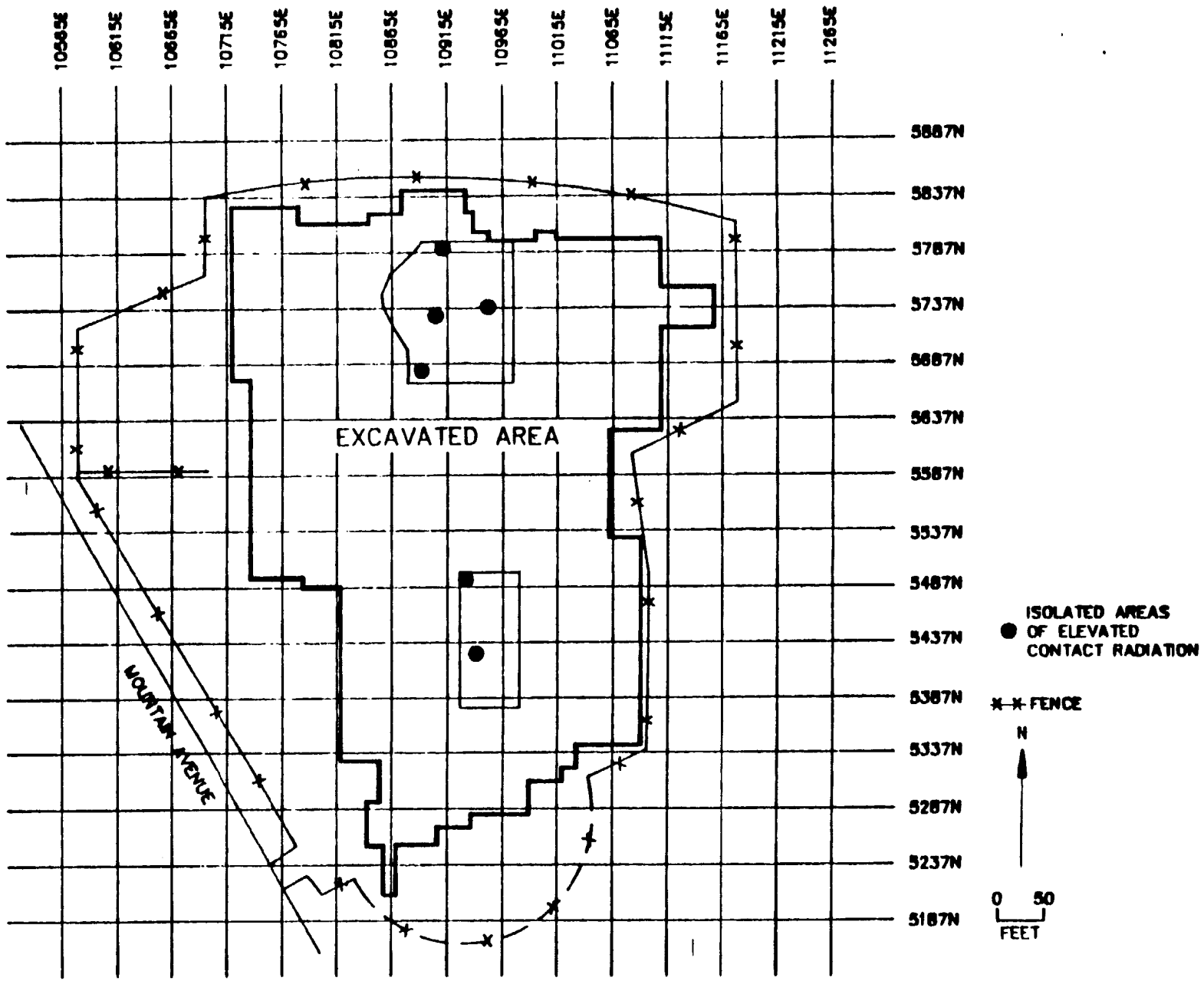


FIGURE 4: Locations of Elevated Contact Radiation Identified by Surface Scans

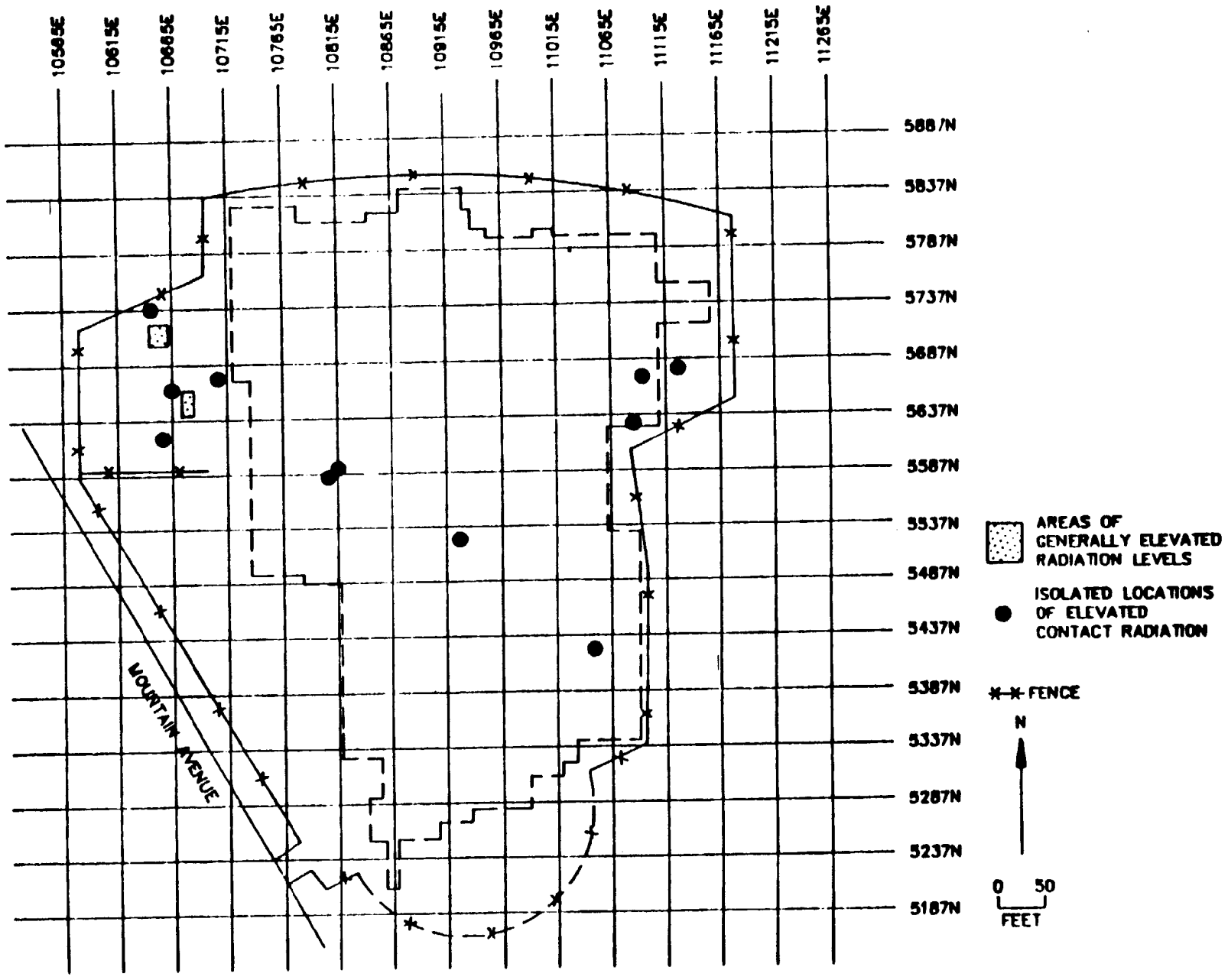


FIGURE 5: Locations of Elevated Contact Radiation Identified by Surface Scans of Site After Backfilling

TABLE 1

RESULTS OF CONFIRMATORY ANALYSES ON SOIL SAMPLES
FROM THE MIDDLESEX MUNICIPAL LANDFILL

| Sample Identification[a] | | | Analysis | Radionuclide Concentrations (pCi/g) | | |
|---|---|---|---|---|---|---|
| Table | Grid Coordinate N | Grid Coordinate E | By | Ra-226 | Th-232 | U-238 |
| 3 | 5655.5 | 10962.5 | BNI | 1.6 ± 0.4[c] | 0.7 ± 0.1 | <2.7 |
| | | | ORAU | 2.1 ± 0.3 | 1.4 ± 0.6 | 1.4 ± 2.8 |
| 10 | 5385.5 | 10857.5 | BNI | 5.2 ± 0.6 | 1.0 ± 0.3 | 6.7 ± 3.0 |
| | | | ORAU | 3.2 ± 0.3 | 1.5 ± 0.5 | 9.4 ± 1.7 |
| 11 | 5490.5 | 10857.5 | BNI | 7.2 ± 0.5 | <0.8 | 9.1 ± 1.7 |
| | | | ORAU | 8.3 ± 0.5 | 1.1 ± 0.5 | 11.8 ± 1.2 |
| | 5525.0 | 11050.0 | BNI | 1.2 ± 0.1 | 1.2 ± 0.3 | 2.5 ± 1.8 |
| | | | ORAU | 1.2 ± 0.3 | 1.5 ± 0.5 | 2.4 ± 2.6 |
| 13 | 5430.5 | 11037.5 | BNI | 23.6 ± 7.1 | <2.2 | 8.0 ± 1.4 |
| | | | ORAU | 29.7 ± 1.1 | 1.8 ± 1.0 | 20.2 ± 3.2 |
| | 5460.5 | 11037.5 | BNI | 14.2 ± 0.6 | 0.7 ± 0.3 | 12.0 ± 1.4 |
| | | | ORAU | 14.3 ± 0.8 | 2.4 ± 0.9 | 13.3 ± 2.4 |
| | 5745.5 | 11067.5 | BNI | 1.8 ± 0.2 | <0.8 | 4.2 ± 1.5 |
| | | | ORAU | 2.3 ± 0.3 | 2.2 ± 0.6 | 3.6 ± 1.1 |
| 15 | 5790.5 | 10932.5 | BNI | 11.4 ± 3.1 | 0.9 ± 0.5 | 11.7 ± 4.4 |
| | | | ORAU | 16.3 ± 0.8 | 0.7 ± 0.7 | 15.9 ± 2.3 |
| | 5370.5 | 11022.5 | BNI | 11.4 ± 0.7 | 1.4 ± 0.5 | 8.7 ± 3.3 |
| | | | ORAU | 12.9 ± 0.8 | 1.5 ± 0.7 | 5.7 ± 3.1 |
| | 5430.5 | 11022.5 | BNI | 10.6 ± 0.6 | 0.6 ± 0.4 | 9.0 ± 1.7 |
| | | | ORAU | 11.1 ± 0.8 | <0.5 | 14.8 |
| 17 | 5760.5 | 10917.5 | BNI | 36.3 ± 2.2 | 1.7 ± 0.9 | 26.0 ± 8.2 |
| | | | ORAU | 4.8 ± 0.5 | 1.2 ± 0.6 | 5.0 ± 2.4 |
| | 5670.5 | 10932.5 | BNI | 5.5 ± 0.6 | 1.0 ± 0.1 | 5.8 ± 3.1 |
| | | | ORAU | 6.0 ± 0.5 | 0.8 ± 0.3 | 6.2 ± 1.0 |
| | 5730.5 | 10932.5 | BNI | 11.1 ± 0.9 | 0.6 ± 0.7 | 16.4 ± 4.0 |
| | | | ORAU | 11.3 ± 0.8 | <0.4 | 12.5 ± 2.4 |
| 19 | 5700.5 | 10947.5 | BNI | 8.2 ± 0.7 | 1.0 ± 0.7 | 6.5 ± 0.3 |
| | | | ORAU | 9.1 ± 0.6 | 2.4 ± 0.7 | 11.0 ± 4.5 |

TABLE 1 (Continued)

RESULTS OF CONFIRMATORY ANALYSES ON SOIL SAMPLES
FROM THE MIDDLESEX MUNICIPAL LANDFILL

| Sample Identification | | | Analysis | Radionuclide Concentrations (pCi/g) | | |
|---|---|---|---|---|---|---|
| Table | Grid Coordinate N | Grid Coordinate E | By | Ra-226 | Th-232 | U-238 |
| 19 | 5670.5 | 10962.5 | BNI | 8.5 ± 0.5 | 1.0 ± 0.3 | 8.1 ± 4.0 |
| | | | ORAU | 8.8 ± 0.6 | 1.1 ± 0.6 | 9.4 ± 3.0 |
| 21 | 5475.5 | 10902.5 | BNI | 8.9 ± 1.0 | 1.3 ± 0.3 | 15.3 ± 2.8 |
| | | | ORAU | 12.6 ± 0.8 | 1.7 ± 0.7 | 8.9 ± 6.0 |
| | 5445.5 | 10977.5 | BNI | 1.6 ± 0.3 | 1.0 ± 0.5 | <6.3 |
| | | | ORAU | 2.1 ± 0.4 | 1.6 ± 0.6 | 9.9 ± 2.3 |
| | 5490.5 | 10977.5 | BNI | 3.7 ± 0.6 | 1.3 ± 0.5 | 3.7 ± 3.3 |
| | | | ORAU | 4.1 ± 0.4 | 1.3 ± 0.7 | 9.8 ± 2.6 |
| 23 | 5768.0 | 10782.5 | BNI | 0.6 ± 0.1 | 0.7 ± 0.2 | <5.4 |
| | | | ORAU | 0.8 ± 0.2 | 0.9 ± 0.4 | 1.7 ± 0.5 |
| | 5790.5 | 10902.5 | BNI | 6.4 ± 0.6 | 1.3 ± 5.2 | 4.9 ± 2.0 |
| | | | ORAU | 8.4 ± 0.7 | 2.1 ± 0.7 | 3.4 ± 4.9 |
| | 5700.5 | 10932.5 | BNI | 14.6 ± 0.6 | <0.9 | 9.9 ± 4.8 |
| | | | ORAU | 17.3 ± 1.0 | <0.5 | 14.2 ± 7.9 |
| 25 | 5805.5 | 10887.5 | BNI | 0.5 ± 0.2 | 0.7 ± 0.3 | 1.3 ± 0.6 |
| | | | ORAU | 1.0 ± 0.3 | 1.1 ± 0.4 | <1.1 |
| | 5615.0 | 10900.0 | BNI | 4.2 ± 0.2 | 1.3 ± 0.9 | 6.1 ± 2.4 |
| | | | ORAU | 4.6 ± 0.5 | 1.3 ± 0.6 | 5.5 ± 1.0 |
| | 5510.0 | 11005.0 | BNI | 11.5 ± 1.1 | 0.6 ± 0.5 | 16.8 ± 4.7 |
| | | | ORAU | 11.6 ± 0.9 | 1.4 ± 1.1 | 13.7 ± 5.3 |
| | 5555.0 | 11005.0 | BNI | 10.4 ± 0.8 | <1.1 | 9.5 ± 5.3 |
| | | | ORAU | 9.9 ± 0.7 | <0.6 | <15.1 |
| | 5645.0 | 11005.0 | BNI | 5.7 ± 0.6 | 1.9 ± 0.5 | 6.4 ± 2.0 |
| | | | ORAU | 6.3 ± 0.6 | 2.7 ± 0.7 | 6.1 ± 4.1 |
| 26 | 5570.0 | 10900.0 | BNI | 3.0 ± 0.3 | 2.0 ± 1.3 | 1.8 ± 0.3 |
| | | | ORAU | 3.5 ± 0.5 | 4.0 ± 1.0 | 3.0 ± 2.1 |
| 29 | 5280.5 | 10917.5 | BNI | 1.3 ± 0.2 | 0.9 ± 0.5 | 5.6 ± 1.3 |
| | | | ORAU | 1.6 ± 0.2 | 1.4 ± 0.6 | 5.0 ± 2.2 |

TABLE 1 (Continued)

RESULTS OF CONFIRMATORY ANALYSES ON SOIL SAMPLES
FROM THE MIDDLESEX MUNICIPAL LANDFILL

| Sample Identification | | | Analysis | Radionuclide Concentrations (pCi/g) | | |
|---|---|---|---|---|---|---|
| Table | Grid Coordinate N | E | By | Ra-226 | Th-232 | U-238 |
| 29 | 5280.5 | 10932.5 | BNI | 1.5 ± 0.3 | 1.3 ± 0.5 | 6.4 ± 1.5 |
| | | | ORAU | 1.3 ± 0.3 | 1.3 ± 0.4 | 5.2 ± 1.7 |
| | 5280.5 | 10977.5 | BNI | 1.7 ± 1.0 | 1.0 ± 0.5 | 5.4 ± 1.8 |
| | | | ORAU | 2.1 ± 0.4 | 1.5 ± 0.6 | 4.8 ± 3.9 |

[a]From Post-Remedial Action Report data tables.
[b]Concentrations include background contributions from naturally occurring radionuclides in soil.
[c]Uncertainties are 2σ based only on counting statistics: systematic ORAU laboratory uncertainties, estimated at ± 6 to 10%, are not included in the reported values for the ORAU analyses.

TABLE 2

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM LOCATIONS IDENTIFIED BY WALKOVER SCANS

| Grid Location | Radionuclide Concentrations (pCi/g)[a] | | |
|---|---|---|---|
| | Ra-226 | Th-232 | U-238 |
| **Excavated Area**[b] | | | |
| N5411, E10937 | 3.1 ± 0.9[d] | 2.1 ± 0.9 | 3.0 ± 2.0 |
| N5675, E10905 | 11.3 ± 0.9 | 2.0 ± 0.9 | 12.4 ± 4.6 |
| **Backfilled Area**[c] | | | |
| N5593, E10816 (hot spot) | 1.4 ± 0.3 | 1.3 ± 0.4 | 0.5 ± 0.8 |
| N5657, E10681 | 14.3 ± 0.7 | 10.7 ± 1.1 | 11.4 ± 4.3 |
| N5722, E10656 | 5.4 ± 0.5 | 5.4 ± 0.7 | 2.3 ± 4.0 |

[a]Concentrations include background contributions from naturally occurring radionuclides in soil.
[b]Refer to Figure 4.
[c]Refer to Figure 5.
[d]Uncertainties are 2σ based only on counting statistics; additional analytical uncertainties of ± 6 to 10% have not been propagated in these data.

## TABLE 3

## GAMMA EXPOSURE RATES MEASURED IN EXCAVATED AREAS

| Grid Location[a] | | Exposure Rate (μR/h)[b] | |
|---|---|---|---|
| N | E | Surface Contact | 1 m Above Surface |
| 5380 | 10927 | 34 | 64 |
| 5380 | 10955 | 16 | 20 |
| 5384 | 10980 | 10 | 8 |
| 5408 | 10927 | 10 | 10 |
| 5408 | 10955 | 14 | 14 |
| 5408 | 10975 | 9 | 9 |
| 5438 | 10927 | 15 | 17 |
| 5438 | 10955 | 14 | 14 |
| 5438 | 10975 | 8 | 8 |
| 5468 | 10926 | 12 | 10 |
| 5468 | 10955 | 14 | 15 |
| 5468 | 10970 | 8 | 8 |
| 5498 | 10925 | 10 | 10 |
| 5498 | 10955 | 8 | 8 |
| 5498 | 10970 | 7 | 7 |
| 5515 | 10970 | 8 | 10 |
| 5516 | 10927 | 10 | 12 |
| 5516 | 10955 | 13 | 10 |
| 5657 | 10913 | 8 | 12 |
| 5663 | 10925 | 10 | 10 |
| 5663 | 10925 | 14 | 10 |
| 5668 | 10985 | 14 | 12 |
| 5668 | 11007 | 14 | 14 |
| 5678 | 10913 | 8 | 10 |
| 5678 | 10923 | 8 | 8 |
| 5678 | 10955 | 14 | 12 |
| 5678 | 10985 | 12 | 14 |
| 5678 | 11007 | 14 | 17 |
| 5708 | 10910 | 12 | 14 |
| 5708 | 10925 | 10 | 10 |
| 5708 | 10955 | 10 | 10 |
| 5708 | 10985 | 10 | 10 |
| 5708 | 11008 | 14 | 15 |
| 5738 | 10906 | 14 | 10 |
| 5738 | 10925 | 12 | 12 |
| 5738 | 10955 | 10 | 10 |
| 5738 | 10985 | 10 | 10 |
| 5738 | 11008 | 10 | 12 |
| 5768 | 10908 | 10 | 10 |
| 5768 | 10925 | 12 | 12 |
| 5768 | 10955 | 10 | 10 |
| 5768 | 10985 | 10 | 10 |

TABLE 3 (Continued)

GAMMA EXPOSURE RATES MEASURED
IN EXCAVATED AREAS

| Grid Location | | Exposure Rate (μR/h) | |
|---|---|---|---|
| N | E | Surface Contact | 1 m Above Surface |
| 5768 | 11008 | 12 | 10 |
| 5798 | 10930 | 12 | 10 |
| 5798 | 10955 | 10 | 10 |
| 5798 | 10985 | 10 | 10 |
| 5798 | 11010 | 8 | 10 |

[a]Refer to Figure 3.
[b]Includes background exposure rate-typical range, 6 to 10 μR/h.

## TABLE 4

## RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES COLLECTED FROM EXCAVATED AREAS

| Grid Location[a] | | Radionuclide Concentrations (pCi/g)[b] | | |
|---|---|---|---|---|
| N | E | Ra-226 | Th-232 | U-238 |
| 5380 | 10927 | 48.0 ± 1.4[c] | 1.5 ± 0.7 | 57.7 ± 2.9 |
| 5380 | 10955 | 9.9 ± 0.8 | 0.8 ± 0.7 | 8.6 ± 3.6 |
| 5384 | 10980 | 3.6 ± 0.5 | 1.6 ± 0.5 | 2.3 ± 2.4 |
| 5408 | 10927 | 1.7 ± 0.5 | 1.4 ± 0.8 | 1.1 ± 1.2 |
| 5408 | 10955 | 2.2 ± 0.7 | 2.1 ± 0.9 | 3.3 ± 2.9 |
| 5408 | 10975 | 6.8 ± 0.9 | 3.0 ± 1.5 | 1.9 ± 2.2 |
| 5438 | 10927 | 1.7 ± 0.5 | 1.1 ± 0.8 | 2.8 ± 1.9 |
| 5438 | 10955 | 3.5 ± 0.8 | 2.5 ± 1.2 | 14.0 ± 3.1 |
| 5438 | 10975 | 1.7 ± 0.6 | 1.2 ± 0.9 | 5.5 ± 2.7 |
| 5468 | 10926 | 1.9 ± 0.5 | 1.2 ± 0.6 | <0.5 |
| 5468 | 10955 | 4.3 ± 1.3 | 2.1 ± 1.0 | 4.8 ± 1.9 |
| 5468 | 10970 | 3.0 ± 0.6 | 1.6 ± 0.6 | 3.0 ± 2.3 |
| 5498 | 10925 | 1.9 ± 0.7 | 1.4 ± 0.7 | 3.3 ± 1.5 |
| 5498 | 10955 | 1.2 ± 0.2 | 1.5 ± 0.4 | 0.5 ± 0.4 |
| 5498 | 10970 | 1.7 ± 0.8 | 1.5 ± 1.5 | 1.4 ± 1.7 |
| 5515 | 10970 | 1.2 ± 0.4 | 0.3 ± 0.4 | 2.1 ± 1.2 |
| 5516 | 10927 | 2.0 ± 0.6 | 1.5 ± 1.0 | 2.0 ± 2.9 |
| 5516 | 10955 | 3.7 ± 0.4 | 0.9 ± 0.6 | 2.5 ± 0.9 |
| 5657 | 10913 | 1.4 ± 0.3 | 1.2 ± 0.6 | 0.9 ± 2.3 |
| 5663 | 10925 | 5.3 ± 0.8 | 1.6 ± 0.8 | 3.8 ± 3.4 |
| 5663 | 10955 | 2.9 ± 0.5 | 1.3 ± 0.5 | 3.0 ± 3.0 |
| 5668 | 10985 | 1.0 ± 0.3 | 1.6 ± 0.4 | 1.7 ± 1.2 |
| 5668 | 11007 | 1.6 ± 0.4 | 1.8 ± 0.6 | 2.9 ± 2.4 |
| 5678 | 10913 | 2.2 ± 0.4 | 1.2 ± 0.5 | 3.7 ± 1.1 |
| 5678 | 10923 | 0.8 ± 0.3 | 0.5 ± 0.3 | 1.1 ± 1.6 |
| 5678 | 10955 | 3.2 ± 0.5 | 2.3 ± 1.1 | 5.2 ± 1.8 |
| 5678 | 10985 | 4.4 ± 0.5 | 1.5 ± 0.8 | 10.0 ± 1.5 |
| 5678 | 11007 | 24.5 ± 1.5 | <0.6 | 13.7 ± 6.3 |
| 5708 | 10910 | 1.6 ± 0.4 | 1.2 ± 0.6 | 2.6 ± 2.3 |
| 5708 | 10925 | 12.0 ± 0.8 | 1.1 ± 0.8 | 2.9 ± 1.3 |
| 5708 | 10955 | 0.8 ± 0.2 | 1.4 ± 0.5 | 4.1 ± 4.1 |

TABLE 4 (Continued)

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
COLLECTED FROM EXCAVATED AREAS

| Grid Location | | Radionuclide Concentrations (pCi/g) | | |
|---|---|---|---|---|
| N | E | Ra-226 | Th-232 | U-238 |
| 5708 | 10985 | 2.0 ± 0.5 | 1.3 ± 0.6 | 3.8 ± 3.0 |
| 5708 | 11008 | 14.5 ± 0.9 | 0.9 ± 1.3 | 6.5 ± 3.4 |
| 5738 | 10906 | 1.5 ± 0.4 | 1.2 ± 0.4 | 2.1 ± 2.5 |
| 5738 | 10925 | 6.1 ± 0.6 | 1.2 ± 0.4 | 3.2 ± 1.2 |
| 5738 | 10955 | 3.9 ± 0.6 | 1.0 ± 0.7 | 5.7 ± 4.3 |
| 5738 | 10985 | 2.3 ± 0.5 | 1.6 ± 0.7 | 2.5 ± 1.8 |
| 5738 | 11008 | 3.8 ± 0.5 | 2.1 ± 0.7 | 3.3 ± 1.8 |
| 5768 | 10908 | 1.5 ± 0.3 | 1.2 ± 0.4 | 0.6 ± 0.7 |
| 5768 | 10925 | 5.0 ± 0.8 | 2.4 ± 1.0 | 12.0 ± 4.1 |
| 5768 | 10955 | 6.3 ± 0.6 | 0.6 ± 0.4 | 4.8 ± 3.6 |
| 5768 | 10985 | 3.0 ± 0.5 | 1.2 ± 0.6 | 3.8 ± 1.0 |
| 5768 | 11008 | 6.0 ± 0.6 | 1.4 ± 0.5 | 6.9 ± 2.2 |
| 5798 | 10930 | 3.9 ± 0.7 | 1.1 ± 0.7 | 6.6 ± 2.4 |
| 5798 | 10955 | 1.6 ± 0.4 | 1.1 ± 0.7 | 5.0 ± 3.8 |
| 5798 | 10985 | 0.7 ± 0.3 | 0.7 ± 0.5 | 0.9 ± 2.0 |
| 5798 | 11010 | 0.8 ± 0.2 | 0.8 ± 0.4 | 0.9 ± 1.3 |

[a]Refer to Figure 3.
[b]Concentrations include background contributions from naturally occurring radionuclides in soil.
[c]Uncertainties are 2σ based only on counting statistics; additional analytical uncertainties of ± 6 to 10% have not been propagated in these data.

TABLE 5

EXPOSURE RATES MEASURED AT 50 FOOT GRID INTERVALS AFTER BACKFILLING OF REMEDIAL ACTION EXCAVATIONS

| Grid Location[a] | | Exposure Rate (μR/h)[b] | |
|---|---|---|---|
| N | E | Surface Contact | 1 m Above Surface |
| 5187 | 10865 | 8 | 8 |
| 5187 | 10915 | 7 | 7 |
| 5187 | 10965 | 7 | 7 |
| 5237 | 10815 | 6 | 6 |
| 5237 | 10865 | 6 | 6 |
| 5237 | 19915 | 6 | 6 |
| 5237 | 10965 | 7 | 7 |
| 5237 | 11015 | 6 | 6 |
| 5287 | 10745 | 6 | 6 |
| 5287 | 10765 | 6 | 6 |
| 5287 | 10815 | 6 | 6 |
| 5287 | 10865 | 7 | 7 |
| 5287 | 10915 | ---[c] | --- |
| 5287 | 10965 | --- | --- |
| 5287 | 11015 | --- | --- |
| 5337 | 10725 | 7 | 7 |
| 5337 | 10765 | 6 | 6 |
| 5337 | 10815 | 6 | 6 |
| 5337 | 10865 | --- | --- |
| 5337 | 10915 | 7 | 7 |
| 5337 | 10965 | 7 | 7 |
| 5337 | 11015 | 6 | 6 |
| 5337 | 11065 | 8 | 8 |
| 5337 | 11095 | 8 | 7 |
| 5387 | 10705 | 6 | 6 |
| 5387 | 10715 | 6 | 6 |
| 5387 | 10765 | 5 | 6 |
| 5387 | 10815 | 8 | 8 |
| 5387 | 10865 | 8 | 8 |
| 5387 | 10915 | 8 | 8 |
| 5387 | 10965 | 7 | 7 |
| 5387 | 11015 | 7 | 7 |
| 5387 | 11065 | 6 | 6 |
| 5387 | 11093 | 7 | 7 |
| 5437 | 10672 | 6 | 6 |
| 5437 | 10715 | 6 | 7 |
| 5437 | 10765 | 6 | 6 |
| 5437 | 10815 | 8 | 8 |
| 5437 | 10865 | 8 | 8 |
| 5437 | 10915 | 7 | 7 |
| 5437 | 10965 | 6 | 6 |
| 5437 | 11015 | 7 | 7 |

TABLE 5 (Continued)

EXPOSURE RATES MEASURED AT 50 FOOT GRID INTERVALS AFTER BACKFILLING OF REMEDIAL ACTION EXCAVATIONS

| Grid Location | | Exposure Rate (μR/h) | |
|---|---|---|---|
| N | E | Surface Contact | 1 m Above Surface |
| 5437 | 11065 | 7 | 8 |
| 5437 | 11095 | 7 | 7 |
| 5487 | 10644 | 7 | 7 |
| 5487 | 10665 | 8 | 8 |
| 5487 | 10715 | 7 | 7 |
| 5487 | 10765 | 7 | 7 |
| 5487 | 10815 | 8 | 8 |
| 5487 | 10865 | 8 | 8 |
| 5487 | 10915 | 7 | 7 |
| 5487 | 10965 | 7 | 7 |
| 5487 | 11015 | 8 | 7 |
| 5487 | 11065 | 7 | 7 |
| 5487 | 11100 | 7 | 7 |
| 5537 | 10616 | 7 | 7 |
| 5537 | 10665 | 8 | 8 |
| 5537 | 10715 | 7 | 7 |
| 5537 | 10765 | 7 | 7 |
| 5537 | 10815 | 7 | 7 |
| 5537 | 10865 | 7 | 7 |
| 5537 | 10915 | 8 | 8 |
| 5537 | 10965 | 8 | 7 |
| 5537 | 11015 | 8 | 7 |
| 5537 | 11065 | 7 | 7 |
| 5537 | 11095 | 7 | 6 |
| 5587 | 10585 | 7 | 6 |
| 5587 | 10615 | 7 | 7 |
| 5587 | 10665 | 8 | 8 |
| 5587 | 10715 | 6 | 6 |
| 5587 | 10765 | 7 | 7 |
| 5587 | 10815 | 7 | 8 |
| 5587 | 10865 | 7 | 7 |
| 5587 | 10915 | 7 | 7 |
| 5587 | 10965 | 7 | 7 |
| 5587 | 11015 | 8 | 7 |
| 5587 | 11065 | 7 | 7 |
| 5587 | 11086 | 7 | 7 |
| 5637 | 10585 | 6 | 6 |
| 5637 | 10615 | 6 | 6 |
| 5637 | 10665 | 7 | 7 |
| 5637 | 10715 | 7 | 6 |
| 5637 | 10765 | 6 | 6 |
| 5637 | 10815 | 7 | 7 |
| 5637 | 10865 | 7 | 7 |

TABLE 5 (Continued)

EXPOSURE RATES MEASURED AT 50 FOOT GRID INTERVALS AFTER BACKFILLING OF REMEDIAL ACTION EXCAVATIONS

| Grid Location | | Exposure Rate (μR/h) | |
|---|---|---|---|
| N | E | Surface Contact | 1 m Above Surface |
| 5637 | 10915 | 7 | 7 |
| 5637 | 10965 | 7 | 7 |
| 5637 | 11015 | 7 | 7 |
| 5637 | 11065 | 6 | 7 |
| 5637 | 11115 | 7 | 6 |
| 5637 | 11148 | 6 | 6 |
| 5687 | 10585 | 6 | 6 |
| 5687 | 10615 | 6 | 6 |
| 5687 | 10665 | 6 | 6 |
| 5687 | 10715 | 7 | 7 |
| 5687 | 10765 | 6 | 6 |
| 5687 | 10815 | 6 | 6 |
| 5687 | 10865 | 7 | 7 |
| 5687 | 10915 | 7 | 7 |
| 5687 | 10965 | 7 | 6 |
| 5687 | 11015 | 7 | 7 |
| 5687 | 11065 | 7 | 7 |
| 5687 | 11115 | 6 | 6 |
| 5687 | 11165 | 6 | 6 |
| 5737 | 10644 | 6 | 6 |
| 5737 | 10665 | 6 | 6 |
| 5736 | 10715 | 7 | 6 |
| 5737 | 10765 | 6 | 6 |
| 5737 | 10815 | 6 | 6 |
| 5737 | 10865 | 6 | 6 |
| 5737 | 10915 | 7 | 7 |
| 5737 | 10965 | 6 | 6 |
| 5737 | 11015 | 6 | 6 |
| 5737 | 11065 | 7 | 7 |
| 5737 | 11115 | 7 | 7 |
| 5737 | 11165 | 6 | 6 |
| 5787 | 10700 | 6 | 6 |
| 5787 | 10715 | 6 | 6 |
| 5787 | 10765 | 6 | 7 |
| 5787 | 10815 | 7 | 7 |
| 5787 | 10865 | 6 | 6 |
| 5787 | 10915 | 7 | 7 |
| 5787 | 10965 | 6 | 6 |
| 5787 | 11015 | 7 | 6 |
| 5787 | 11065 | 7 | 7 |
| 5787 | 11115 | 7 | 7 |
| 5787 | 11165 | 6 | 6 |

TABLE 5 (Continued)

EXPOSURE RATES MEASURED AT 50 FOOT GRID INTERVALS AFTER BACKFILLING OF REMEDIAL ACTION EXCAVATIONS

| Grid Location | | Exposure Rate (μR/h) | |
|---|---|---|---|
| N | E | Surface Contact | 1 m Above Surface |
| 5837 | 10715 | 6 | 6 |
| 5837 | 10765 | 6 | 6 |
| 5837 | 10815 | 7 | 6 |
| 5837 | 10865 | 6 | 6 |
| 5837 | 10915 | 7 | 6 |
| 5837 | 10965 | 6 | 6 |
| 5837 | 11015 | 6 | 6 |
| 5837 | 11065 | 5 | 6 |
| 5849 | 10815 | 6 | 6 |
| 5853 | 10856 | 6 | 6 |
| 5855 | 10965 | 6 | 6 |
| 5858 | 10915 | 6 | 6 |

[a]Refer to Figure 2.
[b]Includes background exposure rate-typical range, 6 to 10 μR/h.
[b]No measurement taken: excavated area had not been backfilled at time of survey.

## TABLE 6

## RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL FROM BACKFILLED AREAS FOLLOWING REMEDIAL ACTION

| Grid Coordinate[a] | | Radionuclide Concentrations (pCi/g)[b] | | |
|---|---|---|---|---|
| N | E | Ra-226 | Th-232 | U-238 |
| 5187 | 10865 | 0.9 ± 0.3[c] | 1.8 ± 0.8 | <0.8 |
| 5187 | 10965 | 0.5 ± 0.2 | 0.8 ± 0.4 | 0.9 ± 0.8 |
| 5237 | 10815 | 0.4 ± 0.1 | 0.8 ± 0.4 | 0.8 ± 1.0 |
| 5237 | 10865 | 0.5 ± 0.2 | 0.8 ± 0.4 | <0.4 |
| 5237 | 10915 | 0.7 ± 0.2 | 0.5 ± 0.5 | 1.0 ± 0.8 |
| 5237 | 10965 | 0.4 ± 0.2 | 0.9 ± 0.4 | <0.5 |
| 5237 | 11015 | 0.8 ± 0.3 | 1.2 ± 0.4 | 1.2 ± 0.9 |
| 5287 | 10765 | 0.3 ± 0.1 | 0.7 ± 0.4 | 0.8 ± 0.8 |
| 5337 | 10725 | 1.0 ± 0.3 | 1.8 ± 0.5 | 0.7 ± 1.0 |
| 5337 | 10815 | 0.5 ± 0.1 | 0.5 ± 0.4 | 0.9 ± 1.0 |
| 5337 | 10915 | 0.8 ± 0.2 | 1.0 ± 0.4 | <0.6 |
| 5337 | 11015 | 0.4 ± 0.1 | 0.9 ± 0.3 | 0.3 ± 0.3 |
| 5337 | 11095 | 0.7 ± 0.3 | 1.1 ± 0.8 | <0.9 |
| 5387 | 10705 | 0.7 ± 0.2 | 0.7 ± 0.3 | <0.8 |
| 5387 | 10765 | 0.8 ± 0.2 | 1.4 ± 0.4 | 2.0 ± 1.4 |
| 5387 | 10865 | 1.0 ± 0.2 | 1.4 ± 0.4 | 0.5 ± 0.4 |
| 5387 | 10965 | 1.6 ± 0.4 | 0.9 ± 0.6 | 1.7 ± 2.2 |
| 5387 | 11065 | 0.9 ± 0.2 | 1.0 ± 0.4 | 0.4 ± 1.6 |
| 5437 | 10715 | 0.4 ± 0.2 | 1.0 ± 0.6 | 1.2 ± 1.1 |
| 5437 | 10815 | 1.0 ± 0.2 | 1.5 ± 0.5 | 2.8 ± 0.8 |
| 5437 | 10915 | 1.0 ± 0.2 | 0.9 ± 0.3 | 1.7 ± 1.3 |
| 5437 | 11015 | 1.2 ± 0.2 | 1.4 ± 0.5 | 0.7 ± 1.3 |
| 5437 | 11095 | 0.9 ± 0.2 | 1.2 ± 0.4 | 0.5 ± 0.8 |
| 5487 | 10665 | 1.0 ± 0.2 | 1.5 ± 0.3 | 2.3 ± 0.7 |
| 5487 | 10765 | 1.6 ± 0.3 | 1.6 ± 0.4 | 4.4 ± 5.6 |
| 5487 | 10865 | 1.1 ± 0.2 | 1.4 ± 0.4 | 2.1 ± 1.2 |
| 5487 | 10965 | 0.8 ± 0.2 | 0.8 ± 0.3 | 0.8 ± 0.5 |
| 5487 | 11065 | 1.9 ± 0.4 | 1.2 ± 0.6 | 4.5 ± 2.6 |
| 5537 | 10616 | 0.8 ± 0.2 | 1.3 ± 0.4 | 1.7 ± 0.8 |
| 5537 | 10715 | 0.7 ± 0.3 | 1.0 ± 0.3 | 1.7 ± 2.0 |
| 5537 | 10815 | 1.0 ± 0.2 | 1.8 ± 0.5 | ± |
| 5537 | 10915 | 1.2 ± 0.2 | 1.3 ± 0.5 | 1.7 ± 0.8 |
| 5537 | 11015 | 1.3 ± 0.3 | 1.0 ± 0.4 | 1.1 ± 1.6 |
| 5537 | 11095 | 0.6 ± 0.3 | 0.6 ± 0.4 | 0.6 ± 1.2 |

TABLE 6 (Continued)

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL
FROM BACKFILLED AREAS FOLLOWING REMEDIAL ACTION

| Grid Coordinate | | Radionuclide Concentrations (pCi/g) | | |
|---|---|---|---|---|
| N | E | Ra-226 | Th-232 | U-238 |
| 5587 | 10585 | 1.1 ± 0.3 | 1.0 ± 0.5 | 1.1 ± 0.5 |
| 5587 | 10665 | 0.9 ± 0.4 | 1.8 ± 0.6 | <1.0 |
| 5587 | 10765 | 0.8 ± 0.2 | 1.7 ± 0.5 | <0.6 |
| 5587 | 10865 | 0.8 ± 0.2 | 1.5 ± 0.5 | 1.6 ± 0.8 |
| 5587 | 10965 | 1.2 ± 0.3 | 1.4 ± 0.5 | 3.9 ± 1.8 |
| 5587 | 11065 | 0.6 ± 0.2 | 1.4 ± 0.3 | 1.5 ± 0.7 |
| 5637 | 10615 | 1.1 ± 0.2 | 0.6 ± 0.3 | <0.8 |
| 5637 | 10715 | 0.9 ± 0.2 | 1.4 ± 0.4 | 1.0 ± 1.3 |
| 5637 | 10815 | 0.9 ± 0.2 | 1.7 ± 0.4 | 2.9 ± 0.7 |
| 5637 | 10915 | 2.0 ± 0.3 | 1.5 ± 0.5 | 1.9 ± 2.3 |
| 5637 | 11015 | 1.2 ± 0.3 | 1.5 ± 0.6 | 3.0 ± 2.0 |
| 5637 | 11115 | 1.5 ± 0.3 | 1.3 ± 0.5 | 1.3 ± 1.0 |
| 5637 | 11148 | 2.6 ± 0.4 | 1.0 ± 0.9 | 2.9 ± 2.3 |
| 5687 | 10585 | 0.5 ± 0.2 | 0.5 ± 0.5 | 0.9 ± 1.1 |
| 5687 | 10665 | 0.5 ± 0.1 | 0.7 ± 0.3 | 0.6 ± 1.0 |
| 5687 | 10765 | 0.9 ± 0.3 | 1.5 ± 0.5 | <0.8 |
| 5687 | 10865 | 0.8 ± 0.2 | 1.0 ± 0.5 | 0.9 ± 1.8 |
| 5687 | 10965 | 0.9 ± 0.2 | 1.2 ± 0.3 | 1.5 ± 0.6 |
| 5687 | 11065 | 1.1 ± 0.3 | 1.6 ± 0.6 | <0.9 |
| 5687 | 11165 | 0.7 ± 0.2 | 1.5 ± 0.4 | 1.6 ± 1.1 |
| 5737 | 10644 | 0.8 ± 0.2 | 0.8 ± 0.3 | 0.5 ± 0.8 |
| 5737 | 10715 | 0.8 ± 0.2 | 1.0 ± 0.4 | <0.8 |
| 5737 | 10815 | 1.0 ± 0.2 | 1.5 ± 0.5 | <0.7 |
| 5737 | 10915 | 1.0 ± 0.2 | 0.8 ± 0.4 | 1.3 ± 0.9 |
| 5737 | 11015 | 0.9 ± 0.2 | 1.2 ± 0.5 | <0.9 |
| 5737 | 11115 | 1.2 ± 0.3 | 1.2 ± 0.4 | 1.7 ± 1.0 |
| 5787 | 10700 | 0.6 ± 0.2 | 1.0 ± 0.6 | 0.4 ± 0.5 |
| 5787 | 10765 | 0.9 ± 0.3 | 1.4 ± 0.5 | <1.8 |
| 5787 | 10865 | 1.0 ± 0.2 | 1.5 ± 0.5 | 1.8 ± 0.8 |
| 5787 | 10965 | 0.7 ± 0.2 | 1.0 ± 0.4 | 1.6 ± 0.6 |
| 5787 | 11065 | 0.8 ± 0.3 | 1.3 ± 0.5 | <0.8 |
| 5787 | 11165 | 2.3 ± 0.4 | 1.1 ± 0.5 | 2.6 ± 1.5 |
| 5837 | 10715 | 0.7 ± 0.3 | 1.0 ± 0.4 | 1.1 ± 1.2 |
| 5837 | 10815 | 1.1 ± 0.4 | 1.9 ± 0.9 | 2.2 ± 2.5 |
| 5837 | 10915 | 1.0 ± 0.3 | 0.9 ± 1.6 | <1.0 |
| 5837 | 11015 | 0.8 ± 0.2 | 0.8 ± 0.3 | 2.6 ± 0.6 |

TABLE 6 (Continued)

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL
FROM BACKFILLED AREAS FOLLOWING REMEDIAL ACTION

| Grid Coordinate | | Radionuclide Concentrations (pCi/g) | | |
|---|---|---|---|---|
| N | E | Ra-226 | Th-232 | U-238 |
| 5853 | 10865 | 1.8 ± 0.4 | 2.0 ± 0.7 | 1.6 ± 0.9 |
| 5855 | 10965 | 1.0 ± 0.2 | 1.3 ± 0.5 | 1.4 ± 1.2 |

[a]Refer to Figure 2.
[b]Concentrations include background contributions from naturally occurring radionuclides in soil.
[c]Uncertainties are 2σ based only on counting statistics; additional analytical uncertainties of ± 6 to 10% have not been propagated in these data.

## REFERENCES


1. U.S. Atomic Energy Commission. U.S. Atomic Energy Commission Radiation Survey Report of the Middlesex Landfill Site, March 25-April 4, 1974, Germantown, MD, June 1974.

2. Oak Ridge National Laboratory. Radiological Survey of the Middlesex Municipal Landfill Site, Middlesex, New Jersey, DOE/EV-005/20, Oak Ridge, TN, April 1980.

3. Ford, Bacon and Davis Utah, Inc. Engineering Evaluation of the Middlesex Municipal Landfill Site, Middlesex, New Jersey, FBDC 230-004, July 1979.

4. Argonne National Laboratory. Action Description Memorandum, Proposed 1984 Remedial Actions at Middlesex, New Jersey, April 1984.

5. U.S. Department of Energy. Remedial Action Work Plan for the Middlesex Municipal Landfill Site, ORO-846, Rev. 2, Oak Ridge, TN, February 1986.

6. Bechtel National, Inc. Post-Remedial Action Report for the Middlesex Municipal Landfill Site, Middlesex, New Jersey, DOE/OR/20722-135, February 1987.

7. Letter, J.R. Kannard, Bechtel National, Inc., to J.D. Berger, Oak Ridge Associated Universities. "Middlesex Landfill Post-Remedial Action Data", CCN 043207, February 13, 1987.

8. Letter J.D. Berger, Oak Ridge Associated Universities, to J.J. Fiore, U.S. Department of Energy, Office of Nuclear Energy. "Verification of Remedial Actions at the Middlesex Municipal Landfill", March 16, 1987.

# APPENDIX A

## CRITERIA APPLICABLE TO THE MIDDLESEX MUNICIPAL LANDFILL SITE

## APPENDIX A

### Criteria Applicable to the Middlesex Municipal Landfill Site

The Department of Energy's radiological criteria for remedial action are presented in the "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. The portions of those guidelines applicable to the Middlesex Municipal Landfill Site are:

1. Radionuclide Concentrations in Soil

Radium 226 and Thorium 232

5 pCi/g (above background) averaged over the first 15 cm of soil below the surface; 15 pCi/g (above background) when averaged over any 15-cm-thick soil layer below the surface layer. Averaging may be performed over a contiguous 100 $m^2$ surface area.

Uranium 238

A site-specific uranium concentration guideline was not developed for the landfill, because the contaminant at this site would be expected to have a uranium content comparable to or lower than the corresponding radium-226 concentrations. Radium-226 will thus be the controlling radionuclide, even though some uranium levels may also be elevated. For other FUSRAP sites, where a uranium soil concentration guideline has been developed, the values are typically 40 to 75 pCi/g.

2. Direct Radiation

External direct gamma radiation levels should be such that, under reasonable conditions of site use and occupancy, an individual would not receive a dose equivalent in excess of 100 mrem/y above background.

# APPENDIX B

## MAJOR SAMPLING AND ANALYTICAL EQUIPMENT

## APPENDIX B

### Major Sampling And Analytical Equipment

The display or description of a specific product is not to be construed as an endorsement of that product or its manufacturer by the authors or their employer.

A. Direct Radiation Measurements

Eberline PRM-6
Portable Ratemeter
(Eberline, Sante Fe, NM)

Victoreen NaI Gamma Scintillation Probe
Model 489-55
(Victoreen, Inc., Cleveland, OH)

Reuter-Stokes Pressurized Ionization Chamber
Model RSS-111
(Reuter-Stokes, Cleveland, OH)

B. Laboratory Analysis

Ge(Li) Detector
Model LGCC2220SD, 23% Efficiency
(Princeton Gamma-Tech, Princeton, NJ)

Used in conjuction with:
Lead Shield, SPG-16
(Applied Physical Technology, Smyrna, GA)

High-Purity Germanium
Model GMX-23195-S, 23% Efficiency
(EG&G ORTEC, Oak Ridge, TN)

Used in conjunction with:
Lead Shield, G-16
(Gamma Products Inc., Palos Hills, IL)

High Purity Germanium Coaxial Well Detector
Model GWL-110210-PWS-S, 23% Efficiency
(EG&G ORTEC, Oak Ridge, TN)

Used in conjunction with:
Lead Shield Model G-16
(Applied Physical Technology, Atlanta, GA)

High Purity Germanium Detector
Model IGC25, 25% Efficiency
(Princeton Gamma-Tech, Princeton, NJ)

Used in conjunction with:
Lead Shield
(Nuclear Data, Schaumburg, IL)

Multichannel Analyzer
ND-66/ND-680 System
(Nuclear Data, Inc., Schaumburg, IL)

# APPENDIX C

# MEASUREMENT AND ANALYTICAL PROCEDURES

## APPENDIX C

### Measurement and Analytical Procedures

#### Gamma Surface Scans

Walkover surface scans were performed at approximately 1 meter intervals, using Eberline Model PRM-6 portable ratemeters with Victoreen Model 489-55 gamma scintillation probes, containing 3.2 cm x 3.8 cm NaI(Tl) scintillation crystals. Relative count rates were monitored using earphones and increased rates above the ambient background levels were noted.

#### Gamma Exposure Rate Measurements

Measurements of gamma radiation levels were performed using Eberline Model PRM-6 portable ratemeters with Victoreen Model 489-55 gamma scintillation probes. Count rates (cpm) were converted to exposure rates (μR/h) using calibration factors determined by comparison of gamma scintillation probe responses at various exposure levels as measured with a pressurized ionization chamber.

#### Soil Sample Analysis

##### Gamma Spectrometery

Soil samples were dried, mixed, and a portion placed in a 0.5 l Marinelli beaker. The quantity placed in each beaker was chosen to reproduce the calibrated counting geometry and ranged from 600 to 900 g of soil. Beakers were sealed and radon and radon daughters allowed to reach equilibrium with radium. Net soil weights were determined and the samples counted using germanium detectors coupled to a Nuclear Data Model ND-680 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. Energy peaks reviewed for determination of radionuclide concentrations were:

Ra-226 - 0.609 MeV from Bi-214*

Th-232 - 0.911 MeV from Ac-228*

U-238 - 0.094 MeV or 0.063 MeV from Th-234 or 1.001 MeV from Pa-234*

*Secular Equilibrium Assumed.

## Uncertainties and Detection Limits

The uncertainties associated with the analytical data, presented in the tables of this report, represent the 95% ($2\sigma$) confidence levels, based only on counting statistics. Other sources of error associated with the analyses introduce an additional uncertainty of ± 6 to 10% in the results.

When the net sample count was less than the $2\sigma$ statistical deviation of the background count, the sample concentration was reported as less than the minimum detectable concentration (<MDC). Because of variation in background levels and the effects of the Compton continuum caused by other constituents in the samples, the MDC's for specific radionuclides differ from sample to sample.

## Calibration and Quality Assurance

Laboratory and field survey procedures are documented in the following manuals developed specifically for the Oak Ridge Associated Universities' Radiological Site Assessment Program: "Survey Procedures Manual", Revision 2, March 1986; "Laboratory Procedures Manual", Revision 2, May 1986; and "Quality Assurance Manual", Revision 0, July 1986. Instruments were calibrated with NBS-traceable standards. Quality control procedures on all instruments included daily background and check-source measurements to confirm equipment operation within acceptable statistical fluctuations. The ORAU laboratory participates in the EPA and EML Quality Assurance Programs. All samples received by ORAU from BNI as part of this verification will be permanently archived.

Exhibit II (8) - State, County, and Local Comments on Remedial Action


| | Page |
|---|---|
| The State of New Jersey was kept fully informed of all DOE activities associated with the cleanup of Middlesex Municipal Landfill. Copies of many reports, including the post-remedial action report, were transmitted to the New Jersey Department of Environmental Protection. The letter transmitting the post-remedial action report to the Borough of Middlesex and to the New Jersey Department of Environmental Protection is included in this exhibit. | II-317 |
| Prior to the commencement of remedial action, a Memorandum of Understanding between the Borough of Middlesex, NJDEP, and DOE was agreed to and signed. It is included in this section of the docket. | II-318 |

MAR 30 1987

Ronald S. Dobies, Mayor
Borough of Middlesex
Borough Hall
1200 Mountain Avenue
Middlesex, New Jersey 08846

Dear Mayor Dobies:

POST-REMEDIAL ACTION REPORT, MIDDLESEX MUNICIPAL LANDFILL

I am pleased to inform you that the results of the post-remedial action radiological survey have been verified and that remedial action on the Middlesex Municipal Landfill Site has been satisfactorily completed. The property is now in compliance with the standards and guidelines applicable to the remedial action activities in Middlesex. The data supporting this determination are in the enclosed post-remedial action report. This report also describes the radiological surveys and remedial actions conducted on the Borough property.

A formal certification statement on the Borough property will be forwarded to you this Fall.

Thank you for your cooperation and if there are any questions, call me on 615-576-0948.

Sincerely,
ORIGINAL SIGNED BY:
S. W. AHRENDS

S. W. Ahrends, Director
Technical Services Division

CE-53:Atkin

Enclosure:
As stated

DSD FILE NO.: 11772

cc w/encl.:
Dr. Ronald Cohen, Middlesex
W. Henrich, Middlesex
J. T. McHugh, Middlesex
Ed Kaup, NJDEP
Jeanette Eng, NJDEP
J. Feldman, USEPA
P. Giardina, USEPA

CE-53:RGAtkin:db:3/27/87:6-1826
ATKIN IBM WP a:dobies.ltr

bcc w/encl.: J. Fiore, NE-23 (2 copies)
J. Peterson, ANL
P. Owen, ORNL (2 copies)
A. Wallo, NE-23
J. Wagoner, NE-23

bcc w/o enc.: G. Hovey, BNI
B. Berven, ORNL
J. Berger, ORAU
W. Range, M-4
C. Seehorn, CC-10
G. Benedict, CE-50

CONCURRENCE

| RTG SYMBOL | INITIALS/SIG | DATE |
|---|---|---|
| CE-53 | Atkin | 3/27 |
| CE-53 | LF Campbell | 3/27/ |
| CE-53 | Wing | |
| CE-53 | Ahrends | 3-27-8 |
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(7-79)

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DEC 18 1979

Honorable Martin S. Matuskiewicz
Mayor of Middlesex
1200 Mountain Avenue
Middlesex New Jersey 07043

Dear Mayor Matuskiewicz:

I am very pleased to transmit with this letter a signed copy of the Memorandum of Understanding between the United States Government, acting through the Department of Energy, the Borough of Middlesex, New Jersey, and the State of New Jersey, acting through the Department of Environmental Protection, relating to the undertaking of remedial action efforts in the Borough of Middlesex and the Township of Piscataway, New Jersey.

In transmitting this memorandum, we would like to clarify the meaning of certain terms as used in this agreement to prevent any possible future misunderstandings. The substance of all of these clarifications were orally discussed with you at the meeting held in Trenton, New Jersey, between the State, DOE, and the Borough of Middlesex, on November 16, 1979.

As used in paragraph 3a, the word "immediate" means "first priority". It is DOE's intention that the first remedial action to be undertaken will be that at the Rectory at 650 Harris Street in Middlesex and at the property located at 432 William Street in Piscataway. Also note that with respect to paragraph 9, the NEPA requirements have already been satisfied for these properties.

In paragraph 4, the referred to "level of not exceeding 5pCi/gm" constitutes the criteria upon which cleanup will be based. The phrase "approved remedial action criteria" in paragraph 13 refers to the criteria in effect at the time remedial action is started, i.e., 5pCi/gm, or a superseding criteria promulgated by USEPA, and determined by NJDEP and DOE to be applicable to conditions at Middlesex.

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Pursuant to paragraph 6, DOE intends at the time remedial action efforts are completed to return the properties involved to physical conditions comparable to those existing before remedial action efforts were undertaken by restoration of the functional and aesthetic values of the properties to the extent practicable by reasonable and achievable means.

To clarify DOE's certification process as described in paragraph 7, it should be noted that DOE will conduct overview surveys during the undertaking of the remedial action which will be followed by final certification surveys. In addition, the word "immediate" as used in paragraph 13 with respect to the final certification survey means "as soon as practicable after completion of remedial action at each specific site."

Finally, per paragraph 15, it is noted that this Memorandum is not intended by DOE to form the basis for any estoppel of the State or the Borough of Middlesex, nor is it intended that this agreement constitute any admission of any legal responsibility for any claim whatsoever by the State, Borough of Middlesex, or any third party.

In addition, we have reviewed and would concur in the clarification of paragraph 10 provided in the letter from George Tyler to Steven Miller, dated November 23, 1979. DOE, to the best of its ability and in accordance with federal statutes and regulations, will coordinate an investigation on a state-by-state or regional basis to find appropriate sites for the permanent disposal of low level and/or actively contaminated material referred to in the Memorandum of Understanding, and the NJDEP will use best efforts to locate a disposal site in New Jersey.

I, along with representatives of my staff, and others involved in implementing the remedial action program, will be at the meeting with you, the town council, and members of the public on December 17, 1979 at 8:00 p.m. at the Municipal Building in Middlesex. We will be prepared to discuss the Memorandum and the plans for implementing the remedial actions.

Your help and the fine cooperation from the State of New Jersey have been invaluable in reaching this understanding. I look forward to prompt, satisfactory completion of these remedial actions.

Sincerely,

[illegible]

Sheldon Meyers, Acting Deputy
Assistant Secretary for
Nuclear Waste Management

| CONCURRENCES | |
|---|---|
| SYM. | GC |
| INITIALS | [illegible]* |
| DATE | 12/14/79 |
| SYM. | GC |
| INITIALS | as Greenlee |
| DATE | at 12/ /7 |
| SYM. | NE-30 |
| INITIALS | DOE DeLane |
| DATE | 12/ /79 |
| SYM. | NE-30 |
| INITIALS | Kesler |
| DATE | will 12/ |
| SYM. | EM |
| INITIALS | Mott |
| DATE | 12/ /7 |
| SYM. | NE-30 |
| INITIALS | [illegible] |
| DATE | 12/17 |
| SYM. | NE-30 |
| INITIALS | Rosetows |
| DATE | 12/ /7 |
| SYM. | NE-30 |
| INITIALS | [illegible] |
| DATE | 12/17 |

Enclosure

* Previous concurrences valid.

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This Memorandum of Understanding by and between the United States of America (hereinafter called the "Government"), acting through the Department of Energy (hereinafter called the "DOE"), the Borough of Middlesex, New Jersey (hereinafter called the "Borough"), and the State of New Jersey acting through the Department of Environmental Protection (hereinafter called "NJDEP").

WITNESSETH THAT:

WHEREAS, the Manhattan Project was commissioned by the Government during the Second World War for the purpose of developing atomic weapons, and,

WHEREAS, there is located within the Borough a site formerly known as the Middlesex Sampling Plant and most recently utilized as a reserve training center for the U.S. Marine Sixth Motor Transport Battalion (hereinafter referred to as the "former sampling plant") which served as a storage depot and sampling plant for uranium and thorium ores from November 1943 to February 1955 as part of the Government's atomic weapons development program under the Manhattan Project and subsequently, the Atomic Energy Commission and,

WHEREAS, quantities of fill material were removed from the former sampling plant and disposed of at certain offsite properties, and,

WHEREAS, radiological surveys conducted since 1976 by Oak Ridge National Laboratory (ORNL) of the Marine Base, of properties immediately adjacent to the former sampling plant or contiguous to the adjacent properties, and of certain offsite properties have revealed measurable levels of low-level radioactively contaminated residues, constituting a potential minimal public health risk, and

WHEREAS, the parties agree that steps should be taken to eliminate this potential minimal public health risk (hereinafter referred to as the "remedial action");

NOW, THEREFORE, the parties herein have reached the following mutual understandings:

1. The DOE will conduct a remedial action program at the following locations subject to approved agreements with the affected property owners:

a. The site of the Rectory of the Church of Our Lady of Mount Virgin, 650 Harris Avenue at the corner of Harris Avenue and Drake Avenue Middlesex, New Jersey,

b. Property at 432 William Street, located on the southeast corner of Grant and William Streets, Piscataway, New Jersey,

c. [illegible] 41A, 43-45A, and 48-50 in Block 318, [illegible] 24-29, [illegible] and lot 47 in Block 319 in Middlesex Borough; lots 40-50 in Block 389; all lots in Block 395; all lots in Block 396; all lots in Block 412; and lot 1 in Block 413, all in the township of Piscataway, and all such properties immediately adjacent to the Marine Base or contiguous to such adjacent property as may be found to have radioactive contamination requiring remedial action.

d. Such other offsite properties as may be determined by DOE and NJDEP to require remedial action.

2. The DOE will conduct a remedial action program for the former sampling plant located at 239 Mountain Avenue, Middlesex, New Jersey, designated as lots 1A, 36-42 in Block 318 and lots 45-46 of Block 319, situated in the Borough of Middlesex, County of Middlesex, State of New Jersey.

3. The remedial action program contemplated by DOE consists of the following actions designed to expedite the project.

a. An immediate cleanup of those offsite properties identified in paragraph 1a and b above and the removed material stored temporarily at the former sampling plant.

b. Subject to receipt of any required approvals (including compliance with those requirements provided in paragraph 9 of this agreement), the DOE plans to conduct as a second phase a remedial action program at the following locations:

(1) A cleanup of all other offsite properties identified in paragraph 1 above and the removed material stored temporarily at the former sampling plant site, and

(2) A subsequent cleanup of the former sampling plant and removal of all material contaminated with radioactivity to a permanent disposal site.

4. All remedial actions performed pursuant to the above paragraph will consist of the removal of radioactively contaminated material to obtain a level of not exceeding 5 pCi/gm as measured by techniques agreed by the DOE and the NJDEP or criteria established by the USEPA which is agreed by DOE and NJDEP as applicable to the condition at Middlesex.

5. In addition, the DOE recognizes that remedial action is required for that portion of the municipal sanitary landfill area which includes parts of lots 1 and 2 in Blocks 219, parts of lots 4 and 5 in Block 221 and a portion of Genese Place in

the Borough of Middlesex. Any remedial action performed at these sites will be undertaken in accordance with paragraph 8 below. The DOE will seek the necessary authority to conduct such remedial action.

6. The DOE will restore property referenced above, together with any other properties which are subject to remedial action, to a condition comparable to their original condition by techniques of backfilling and landscaping and such other methods as may be agreed to between the DOE and individual property owners.

7. The DOE plans to store temporarily at the former sampling plant all such radioactively contaminated soils and materials removed from offsite properties referenced above. Such storage shall be designed in a manner to prevent the possibility of recontamination of the surrounding area and the site shall be managed by DOE in such a manner to restrict access to the former sampling plant. Radiation levels at the former sampling plant site shall be monitored by the DOE, NJDEP, and by the Borough of Middlesex. The DOE shall allow representatives from the Borough of Middlesex and from NJDEP access to the property at all reasonable times in order for radiation levels to be monitored. The DOE shall notify the NJDEP and the Borough of Middlesex in writing at periodic intervals, not less than twice per calendar year, of the radiation level at the former sampling plant. The Borough will be notified in writing at least 48 hours prior to any tests being made at the sampling plant site in order that the Borough may, if it desires, have one of its representatives present to observe the testing being done by the DOE. The DOE will not store at the former sampling plant, site materials, other than materials from those offsite and onsite areas specifically referenced in the Memorandum of Understanding, it being specifically understood and agreed between the parties that no contaminated materials will be brought into the Borough of Middlesex from areas other than the Borough of Middlesex and that property in the Township of Piscataway which is specifically referred to in this Memorandum of Understanding.

8. The DOE will commence remedial action and perform such action as soon as reasonably possible, consistent with the requirements of all laws and applicable regulations, and the findings of engineering and environmental analyses.

9. All DOE plans referenced in the Memorandum of Understanding with the exception of those plans described in paragraphs 1a. and b. above, are proposed actions until such time all the requirements of the National Environmental Policy Act (NEPA) are fully met. No final decisions can be made by DOE until the NEPA process is completed.

10. The DOE has requested the active cooperation of the NJDEP in locating a permanent disposal site for the radioactively contaminated material which the DOE will remove from temporary storage at the former sampling plant. The parties recognize that such cooperation is necessary to a satisfactory resolution of this matter. The NJDEP with the assistance of USDOE will use its best efforts to locate a permanent disposal site for the materials in order that the contaminated materials may be completely removed from the Borough of Middlesex as soon as possible.

11. The DOE will invite the participation of the NJDEP and the Borough of Middlesex in the referenced remedial action program specifically in the form of radiological monitoring services.

12. The Borough of Middlesex will assist the DOE in implementing the plans outlined above by relaying information to the public on the proposed project and by acting as an intermediary between the DOE and the public whenever requested by the DOE.

13. DOE will immediately upon completion of remedial action at each specific property site, conduct a final radiological site survey and after concurrence by NJDEP will issue a certification to each property owner and the Borough of Middlesex that the site meets the approved remedial action criteria as reflected in this Memorandum of Understanding.

14. All remedial action work performed by DOE and its contractors will be done at no cost to the Borough of Middlesex.

15. This Memorandum of Understanding does not in any way constitute or form the basis for any estoppel of the State, DOE, or the Borough of Middlesex, nor can it be admitted as evidence of any legal responsibility of the State, DOE, or the Borough of Middlesex for any claims whatsoever, nor can it give any third parties any rights or claims whatsoever.

16. The effective date of this Memorandum of Understanding is the date on which the last party signed below.

BOROUGH OF WEST LONDON

BY: [illegible]

Martin L. Matuszewicz, Mayor

Margaret [illegible], Clerk

Date: November 20, 1979

STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL
PROTECTION

BY: George J. Dyl[illegible]

Title: Director, Division of Environmental Quality

Date: November 23, 1979

U.S. DEPARTMENT OF ENERGY

BY: Sheldon Meyers

Title: Acting Deputy Assistant Secretary for Nuclear Waste Management

Date: _____

Honorable George J. Tyler
Director, State of Jersey
Department of Environmental Protection
Division of Environmental Quality
Trenton, New Jersey 08625

Dear Mr. Tyler:

I am very pleased to transmit with this letter a signed copy of the Memorandum of Understanding between the United States Government, acting through the Department of Energy, the Borough of Middlesex, New Jersey, and the State of New Jersey, acting through the Department of Environmental Protection, relating to the undertaking of remedial action efforts in the Borough of Middlesex and the Township of Piscataway, New Jersey.

In transmitting this memorandum, we would like to clarify the meaning of certain terms as used in this agreement to prevent any possible future misunderstandings. The substance of all of these clarifications were orally discussed with you at the meeting held in Trenton, New Jersey, between the State, DOE, and the Borough of Middlesex, on November 16, 1979.

As used in paragraph 3a, the word "immediate" means "first priority." It is DOE's intention that the first remedial action to be undertaken will be that at the Rectory at 650 Harris Street in Middlesex and at the property located at 432 William Street in Piscataway. Also note that with respect to paragraph 9, the NEPA requirements have already been satisfied for these properties.

In paragraph 4, the referred to "level of not exceeding 5pCi/gm" constitutes the criteria upon which cleanup will be based. The phrase "approved remedial action criteria" in paragraph 13 refers to the criteria in effect at the time remedial action is started, i.e., 5pCi/gm, or a superseding criteria promulgated by USEPA, and determined by NJDEP and DOE to be applicable to conditions at Middlesex.

OFFICIAL FILE COPY

Pursuant to paragraph 6, DOE intends at the time remedial action efforts are completed to return the properties involved to physical conditions comparable to those existing before remedial action efforts were undertaken by restoration of the functional and aesthetic values of the properties to the extent practicable by reasonable and achievable means.

To clarify DOE's certification process as described in paragraph it should be noted that DOE will conduct overview surveys during the undertaking of the remedial action which will be followed by final certification surveys. In addition, the word "immediate" used in paragraph 13 with respect to the final certification sur means "as soon as practicable after completion of remedial actio each specific site."

Finally, per paragraph 15, it is noted that this Memorandum is intended by DOE to form the basis for any estoppel of the State or the Borough of Middlesex, nor is it intended that this agreem constitute any admission of any legal responsibility for any cl whatsoever by the State, Borough of Middlesex, or any third par

In addition, we have reviewed and would concur in the clarificat of paragraph 10 provided in the letter from George Tyler to Steven Miller, dated November 23, 1979. DOE, to the best of its ability and in accordance with federal statutes and regulations coordinate an investigation on a state-by-state or regional basis to find appropriate sites for the permanent disposal of low level actively contaminated material referred to in the Memorandum of Understanding, and the NJDEP will use best efforts to locate a disposal site in New Jersey.

I, along with representatives of my staff, and others involved i implementing the remedial action program, will be at the meetin you, or your representative, the town council and members of th on December 18, 1979 at 8:00 p.m. at the Municipal Building in Middlesex. We will be prepared to discuss the Memorandum and t for implementing the remedial actions.

Your help and the fine cooperation from the Mayor have been inv in reaching this understanding. I look forward to prompt, acti completion of these remedial actions.

Sincerely,

Sheldon Meyers, Acting Deputy
Assistant Secretary for
Nuclear Waste Management

Enclosure

| | |
|---|---|
| CONCURRENCES: | |
| SYM. SYMBOL | GC |
| INITIALS | Miller* |
| DATE | 12/14/79 |
| SYM. SYMBOL | GC |
| INITIALS | Greenlei |
| DATE | 12/ /79 |
| SYM. SYMBOL | NE-30 |
| INITIALS | Delaney |
| DATE | 12/ /79 |
| SYM. SYMBOL | NE-30 |
| INITIALS | Eanes |
| DATE | 12/ |
| SYM. SYMBOL | NE-30 |
| INITIALS | Oe |
| DATE | 12/ |
| SYM. SYMBOL | EV |
| INITIALS | Mott |
| DATE | 12/ / /7 |
| SYM. SYMBOL | NE-30 |
| INITIALS | Romanowski |
| DATE | 12/ /7 |
| SYM. SYMBOL | NE-30 |
| INITIALS | |
| DATE | 12/17/7 |

*Previous Concurrences



DOE FORM AD-1 (12-77)

MORANDUM OF UNDERSTANDING )

This Memorandum of Understanding by and between the United States of America (hereinafter called the "Government"), acting through the Department of Energy (hereinafter called the "DOE"), the Borough of Middlesex, New Jersey (hereinafter called the "Borough"), and the State of New Jersey acting through the Department of Environmental Protection (hereinafter called "NJDEP").

WITNESSETH THAT:

WHEREAS, the Manhattan Project was commissioned by the Government during the Second World War for the purpose of developing atomic weapons, and,

WHEREAS, there is located within the Borough a site formerly known as the Middlesex Sampling Plant and most recently utilized as a reserve training center for the U.S. Marine Sixth Motor Transport Battalion (hereinafter referred to as the "former sampling plant"), which served as a storage depot and sampling plant for uranium and thorium ores from November 1943 to February 1955 as part of the Government's atomic weapons development program under the Manhattan Project and subsequently, the Atomic Energy Commission and,

WHEREAS, quantities of fill material were removed from the former sampling plant and disposed of at certain offsite properties, and,

WHEREAS, radiological surveys conducted since 1976 by Oak Ridge National Laboratory (ORNL) of the Marine Base, of properties immediately adjacent to the former sampling plant or contiguous to the adjacent properties, and of certain offsite properties have revealed measurable levels of low-level radioactively contaminated residues, constituting a potential minimal public health risk, and

WHEREAS, the parties agree that steps should be taken to eliminate this potential minimal public health risk (hereinafter referred to as the "remedial action");

NOW, THEREFORE, the parties herein have reached the following mutual understandings:

1. The DOE will conduct a remedial action program at the following locations subject to approved agreements with the affected property owners:

a. The site of the Rectory of the Church of Our Lady of Mount Virgin, 650 Harris Avenue at the corner of Harris Avenue and Drake Avenue Middlesex, New Jersey,

b. Property at 432 William Street, located on the southeast corner of Grant and William Streets, Piscataway, New Jersey,

c. Lots 1-29, 38A-41A, 43-45A, and 48-50 in Block 318, lots 24-29, 39-44, and lot 47 in Block 319 in Middlesex Borough; lots 40-50 in Block 389; all lots in Block 395; all lots in Block 396; all lots in Block 412; and lot 1 in Block 413, all in the township of Piscataway, and all such properties immediately adjacent to the Marine Base or contiguous to such adjacent property as may be found to have radioactive contamination requiring remedial action.

d. Such other offsite properties as may be determined by DOE and NJDEP to require remedial action.

2. The DOE will conduct a remedial action program for the former sampling plant located at 239 Mountain Avenue, Middlesex, New Jersey, designated as lots 1A, 36-42 in Block 318 and lots 45-46 of Block 319, situated in the Borough of Middlesex, County of Middlesex, State of New Jersey.

3. The remedial action program contemplated by DOE consists of the following actions designed to expedite the project.

a. An immediate cleanup of those offsite properties identified in paragraph 1a and b above and the removed material stored temporarily at the former sampling plant.

b. Subject to receipt of any required approvals (including compliance with those requirements provided in paragraph 9 of this agreement), the DOE plans to conduct as a second phase a remedial action program at the following locations:

(1) A cleanup of all other offsite properties identified in paragraph 1 above and the removed material stored temporarily at the former sampling plant site, and

(2) A subsequent cleanup of the former sampling plant and removal of all material contaminated with radioactivity to a permanent disposal site.

4. All remedial actions performed pursuant to the above paragraph will consist of the removal of radioactively contaminated material to obtain a level of not exceeding 5 pCi/gm as measured by techniques agreed by the DOE and the NJDEP or criteria established by the USEPA which is agreed by DOE and NJDEP as applicable to the condition at Middlesex.

5. In addition, the DOE recognizes that remedial action is required for that portion of the municipal sanitary landfill area which includes parts of lots 1 and 2 in Blocks 219, parts of lots 4 and 5 in Block 221 and a portion of Genese Place in

the Borough of Middlesex. Any remedial action performed at this site will be undertaken in accordance with paragraph 8 below. The DOE will seek the necessary authority to conduct such remedial action.

6. The DOE will restore property referenced above, together with any other properties which are subject to remedial action, to a condition comparable to their original condition by techniques of backfilling and landscaping and such other methods as may be agreed to between the DOE and individual property owners.

7. The DOE plans to store temporarily at the former sampling plant all such radioactively contaminated soils and materials removed from offsite properties referenced above. Such storage shall be designed in a manner to prevent the possibility of recontamination of the surrounding area and the site shall be managed by DOE in such a manner to restrict access to the former sampling plant. Radiation levels at the former sampling plant site shall be monitored by the DOE, NJDEP, and by the Borough of Middlesex. The DOE shall allow representatives from the Borough of Middlesex and from NJDEP access to the property at all reasonable times in order for radiation levels to be monitored. The DOE shall notify the NJDEP and the Borough of Middlesex in writing at periodic intervals, not less than twice per calendar year, of the radiation level at the former sampling plant. The Borough will be notified in writing at least 48 hours prior to any tests being made at the sampling plant site in order that the Borough may, if it desires, have one of its representatives present to observe the testing being done by the DOE. The DOE will not store at the former sampling plant, site materials, other than materials from those offsite and onsite areas specifically referenced in the Memorandum of Understanding, it being specifically understood and agreed between the parties that no contaminated materials will be brought into the Borough of Middlesex from areas other than the Borough of Middlesex and that property in the Township of Piscataway which is specifically referred to in this Memorandum of Understanding.

8. The DOE will commence remedial action and perform such action as soon as reasonably possible, consistent with the requirements of all laws and applicable regulations, and the findings of engineering and environmental analyses.

9. All DOE plans referenced in the Memorandum of Understanding with the exception of those plans described in paragraphs 1a. and b. above, are proposed actions until such time all the requirements of the National Environmental Policy Act (NEPA) are fully met. No final decisions can be made by DOE until the NEPA process is completed.

10. The DOE has requested the active cooperation of the NJDEP in locating a permanent disposal site for the radioactively contaminated material which the DOE will remove from temporary storage at the former sampling plant. The parties recognize that such cooperation is necessary to a satisfactory resolution of this matter. The NJDEP with the assistance of USDOE will use its best efforts to locate a permanent disposal site for the materials in order that the contaminated materials may be completely removed from the Borough of Middlesex as soon as possible.

11. The DOE will invite the participation of the NJDEP and the Borough of Middlesex in the referenced remedial action program specifically in the form of radiological monitoring services.

12. The Borough of Middlesex will assist the DOE in implementing the plans outlined above by relaying information to the public on the proposed project and by acting as an intermediary between the DOE and the public whenever requested by the DOE.

13. DOE will immediately upon completion of remedial action at each specific property site, conduct a final radiological site survey and after concurrence by NJDEP will issue a certification to each property owner and the Borough of Middlesex that the site meets the approved remedial action criteria as reflected in this Memorandum of Understanding.

14. All remedial action work performed by DOE and its contractors will be done at no cost to the Borough of Middlesex.

15. This Memorandum of Understanding does not in any way constitute or form the basis for any estoppel of the State, DOE, or the Borough of Middlesex, nor can it be admitted as evidence of any legal responsibility of the State, DOE, or the Borough of Middlesex for any claims whatsoever, nor can it give any third parties any rights or claims whatsoever.

16. The effective date of this Memorandum of Understanding is the date on which the last party signed below.

BOROUGH OF MIDDLESEX

BY: [signature]
Martin S. Matuszkiewicz, Mayor
Margaret Hanania, Clerk

Date: November 20, 1979

STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL
PROTECTION

BY: [signature]

Title: Director, Division of Environmental Quality

Date: November 23, 1979

U.S. DEPARTMENT OF ENERGY

BY: [signature]

Title: Acting Deputy Assistant Secretary for Nuclear Waste Management

Date: _____

Exhibit II (9) - Restrictions

There are no DOE-imposed restrictions on use of the subject properties following the completion of remedial action under FUSRAP.

Exhibit II (10) - Federal Register Notice

This section contains the text of the notice that was approved by DOE for publication in the Federal Register. It documents the certification that the two properties comprising the Middlesex Municipal Landfill are in compliance with all applicable decontamination criteria and standards.

[6450-01]

DEPARTMENT OF ENERGY

# Certification of the Radiological Condition of Middlesex Municipal Landfill in Middlesex, New Jersey

AGENCY: Office of Remedial Action and Waste Technology, Office of Nuclear Energy, Department of Energy.

ACTION: Notice of certification.

SUMMARY: The Department of Energy has completed radiological surveys and taken remedial action to decontaminate the two properties in Middlesex, New Jersey that comprise the Middlesex Municipal Landfill. The properties were found to contain quantities of radioactive material from activities conducted at the former Middlesex Sampling Plant.

FOR FURTHER INFORMATION CONTACT:

J.J. Fiore, Director
Division of Facility and Site Decommissioning Projects
Office of Remedial Action and Waste Technology
U.S. Department of Energy
Washington, D.C. 20545

(301) 353-5272

SUPPLEMENTARY INFORMATION:

The Department of Energy (DOE), Office of Nuclear Energy, Office of Remedial Action and Waste Technology, Division of Facility and Site Decommissioning Projects, has implemented a remedial action project in the Middlesex, New Jersey area as part of the Atomic Energy Act of 1954, as amended. This project is being carried out under the Formerly Utilized Sites Remedial Action Program (FUSRAP), a DOE program to decontaminate or otherwise control sites where residual radioactive materials remain from the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has mandated DOE to remedy. The ultimate objective of the remedial action program at Middlesex is to ensure that any properties contaminated as a result of activities at the former Middlesex Sampling Plant (MSP) can be certified to be within current radiological guidelines and applicable standards established to protect the general public.

In 1948, during the construction of an asphalt pad at the MSP, dirt contaminated with pitchblende (a naturally occurring uranium ore) was removed from the MSP by a contractor and taken to the Middlesex Municipal Landfill (MML). Subsequent landfill operations resulted in varying depths of cover material being placed over the contaminated materials.

During a local civil defense exercise in May 1960, monitors detected elevated levels of radiation in the landfill. A radiological survey confirmed gamma radiation levels 20 to 50 times the natural background value over an area of less than 0.6 acre. In 1961 the AEC removed the portion of the contaminated materials lying nearest the surface (about 650 $yd^3$) and covered the area with approximately 2 ft of clean dirt. The contaminated soil was removed to the AEC New Brunswick Laboratory site in New Brunswick, New Jersey.

No further action was taken until 1974, when a radiological survey of the site was conducted by the Atomic Energy Commission (AEC). In 1978, another radiological survey of the site was conducted by Oak Ridge National Laboratory (ORNL) to provide additional data and to provide a basis for evaluating changes in site conditions over the 4-year period since the previous survey.

DOE developed a remedial action plan to remove the materials in the landfill. DOE coordinated its activities with the New Jersey Department of Environmental Protection and the Borough of Middlesex.

In 1984 and 1986, the landfill was decontaminated, resulting in the removal of 31,000 $yd^3$ of contaminated materials. The materials removed during remedial action are being stored temporarily at MSP. Post-remedial action surveys have demonstrated and DOE has certified that radiological conditions on the affected properties are

consistent with applicable criteria and that the use of the two properties comprising the landfill presents no radiological hazard to the general public or to site occupants. These findings are supported by the DOE Certification Docket for the Remedial Action Performed at the Middlesex Municipal Landfill in Middlesex, New Jersey in 1984 and 1986. Accordingly, the two properties comprising the landfill are released from the Formerly Utilized Sites Remedial Action Program.

The certification docket will be available for review between 8:00 a.m. and 4:00 p.m., Monday through Friday (except Federal holidays), in the U.S. Department of Energy Public Reading Room located in Room 1E-190 of the Forrestal Building, 1000 Independence Avenue S.W., Washington, D.C. The certification docket will also be available in the Public Document Room, U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, Tennessee, and at the Middlesex Borough Library, Mountain Avenue, Middlesex, New Jersey.

The U.S. Department of Energy, Oak Ridge Operations Office, Technical Services Division, has issued the following statement:

STATEMENT OF CERTIFICATION: THE TWO PROPERTIES COMPRISING THE MIDDLESEX MUNICIPAL LANDFILL

The U.S. Department of Energy, Oak Ridge Operations Office, Technical Services Division, has reviewed the radiological data obtained following remedial action at the two subject properties. Based on this review, DOE has certified that the properties listed below are in compliance with all applicable decontamination criteria and standards. This certification of compliance provides assurance that use of the properties will result in no radiological exposure above DOE criteria and standards to members of the general public or to site occupants. Accordingly, the following properties are released from the Formerly Utilized Sites Remedial Action Program:

Parcel 1 located on 1190 Mountain Avenue, Borough of Middlesex, identified as Block 219, Lot 1.

Parcel 2 located on Mountain Avenue, Borough of Middlesex, identified as Block 219, Lot 2.

J.E. Baublitz

J.E. Baublitz, Acting Director
Office of Remedial Action
and Waste Technology
Office of Nuclear Energy
U.S. Department of Energy

Dated: 4/21/89

Exhibit II (11) - Approved Certification Statements

The following statements document the certification of the two subject properties.

E F 1325 8
2-84)

United States Government **Department of Energy**

# memorandum

DATE: APR 20 1989

REPLY TO ATTN OF: NE-23: Fiore

SUBJECT: Recommendation for Certification of Remedial Action at Properties Comprising the Middlesex Municipal Landfill in Middlesex, New Jersey.

TO: J.E. Baublitz, Acting Director
Office of Remedial Action and Waste Technology, NE-20

I am attaching for your signature the Federal Register Notice for the two properties comprising the Middlesex Municipal Landfill in Middlesex, New Jersey. Also attached are the signed Statements of Certification for the respective properties.

In 1948, during the construction of an asphalt pad at the Middlesex Sampling Plant contaminated dirt was removed and transported to the Middlesex Municipal Landfill. Subsequent landfill operations resulted in varying depths of cover material being placed over the contaminated materials.

During a local civil defense exercise in May 1960, elevated levels of radiation were detected in the landfill. In 1961, the AEC removed that part of contaminated materials lying nearest the surface and covered the area with approximately 2 ft of clean dirt.

No further action was taken until 1974, when a radiological survey of the site was conducted by the Atomic Energy Commission. In 1978, another radiological survey of the site was conducted by Oak Ridge National Laboratory to provide additional data and to provide a basis for evaluating changes in site conditions over the 4-year span.

During 1984 and 1986, the Office of Nuclear Energy performed remedial actions at the two properties comprising the Middlesex Municipal Landfill in Middlesex, New Jersey. These properties are:

Parcel 1 located on 1190 Mountain Avenue, Borough of Middlesex, identified as Block 219, Lot 1.

Parcel 2 located on Mountain Avenue, Borough of Middlesex, identified as Block 219, Lot 2.

Based on a review of all documents related to these properties, we have concluded that they should be certified to be in compliance with criteria and standards established for the Middlesex Municipal Landfill remedial action project. These criteria were established in accordance with DOE guidelines and orders to protect public health and the environment and are consistent with other appropriate Nuclear Regulatory Commission and Environmental Protection Agency guidelines.

The Division of Facility and Site Decommissioning Projects has provided the attached docket to effect the certification of the subject properties.

Following your approval of the certification, this office and/or the Oak Ridge Operations Office, Technical Services Division, will notify interested state and local agencies, the public, local land offices, and the specific property owners of the certification actions by correspondence and local newspaper announcements, as appropriate. The documents transmitted with the Statements of Certification and the Federal Register notice will be compiled in final docket form by the Division of Facility and Site Decommissioning Projects for retention in accordance with DOE Order 1324.2 (Disposal Schedule 25).

/s/ A. Wallo

J.J. Fiore, Director
for Division of Facility and Site
Decommissioning Projects
Office of Nuclear Energy
U.S. Department of Energy

Attachments:
As Stated

**STATEMENT OF CERTIFICATION: PROPERTY FORMING PART OF THE MIDDLESEX MUNICIPAL LANDFILL**

The U.S. Department of Energy, Oak Ridge Operations Office, Technical Services Division, has reviewed and analyzed the radiological data obtained following remedial action at the Middlesex Municipal Landfill, which was contaminated by material from the former Middlesex Sampling Plant in Middlesex, New Jersey. Based on this analysis, the Department of Energy certifies that the following property is in compliance with Department of Energy decontamination criteria and standards developed to protect health, safety, and the environment:

Parcel 1 located on 1190 Mountain Avenue, Borough of Middlesex, identified as Block 219, Lot 1.

This certification of compliance provides assurance that use of the property will result in no radiological exposure above applicable criteria and standards to members of the general public or to site occupants.

By: Bryan D. Walker
Acting Director
Technical Services Division
Oak Ridge Operations Office
U.S. Department of Energy

Date: 4/7/89

**STATEMENT OF CERTIFICATION: PROPERTY FORMING PART OF THE MIDDLESEX MUNICIPAL LANDFILL**

The U.S. Department of Energy, Oak Ridge Operations Office, Technical Services Division, has reviewed and analyzed the radiological data obtained following remedial action at the Middlesex Municipal Landfill, which was contaminated by material from the former Middlesex Sampling Plant in Middlesex, New Jersey. Based on this analysis, the Department of Energy certifies that the following property is in compliance with Department of Energy decontamination criteria and standards developed to protect health, safety, and the environment:

Parcel 2 located on Mountain Avenue, Borough of Middlesex, identified as Block 219, Lot 2.

This certification of compliance provides assurance that use of the property will result in no radiological exposure above applicable criteria and standards to members of the general public or to site occupants.

By: Bryan D. Walker
Acting Director
Technical Services Division
Oak Ridge Operations Office
U.S. Department of Energy

Date: 4/7/89

# *Exhibit III* *Diagrams of the Remedial Action Performed at the Middlesex Municipal Landfill in Middlesex, New Jersey*

# EXHIBIT III

## DIAGRAMS OF THE REMEDIAL ACTION PERFORMED AT THE MIDDLESEX MUNICIPAL LANDFILL IN MIDDLESEX, NEW JERSEY IN 1984 AND 1986

Figures 1 through 18 on the following pages are taken from the post-remedial action report; they illustrate the progression and extent of remedial action performed at the subject properties. Figure 19 shows the overall areas where remedial action was conducted in 1984 and 1986; it also shows ownership of the properties.

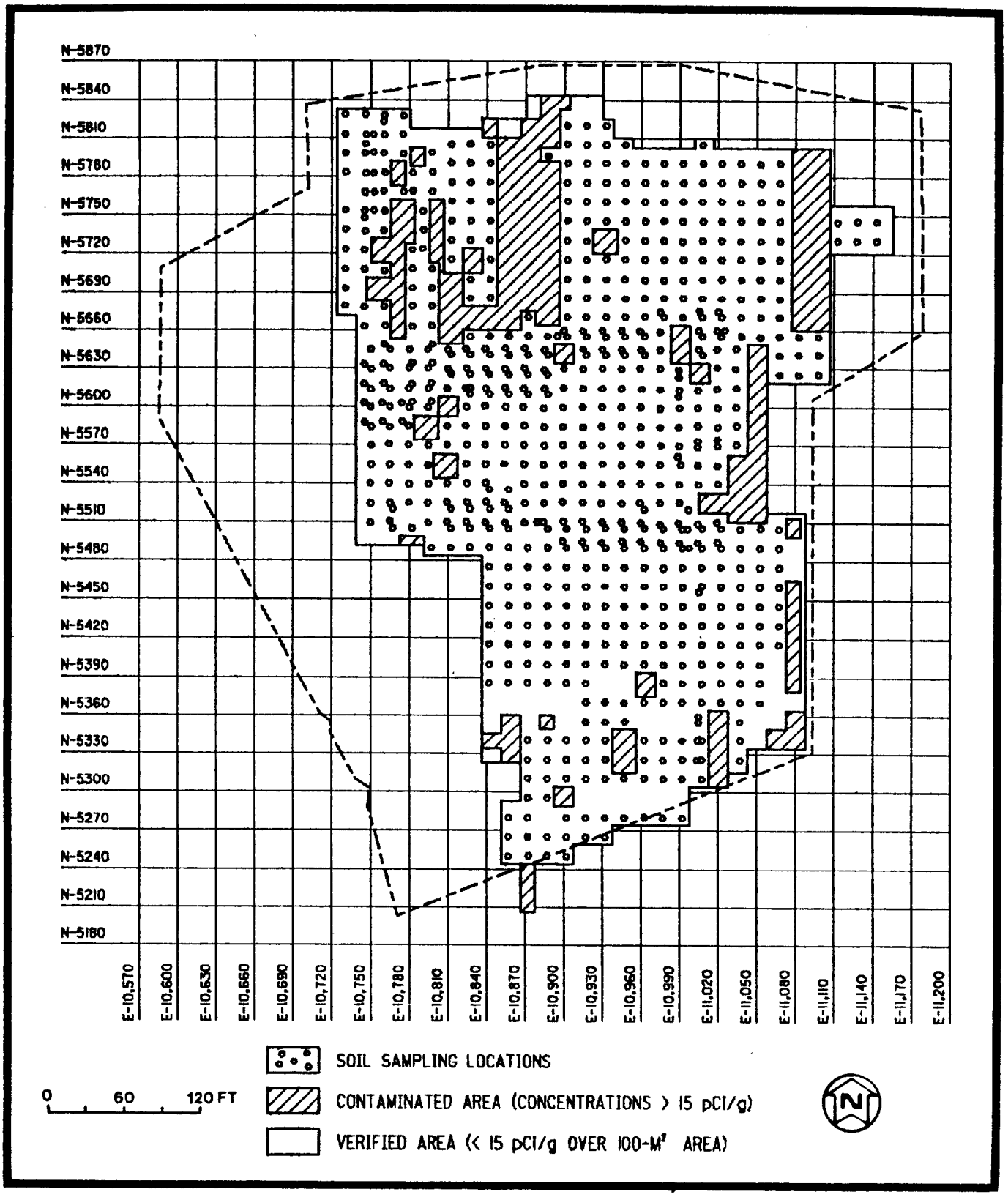


FIGURE 1 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 1

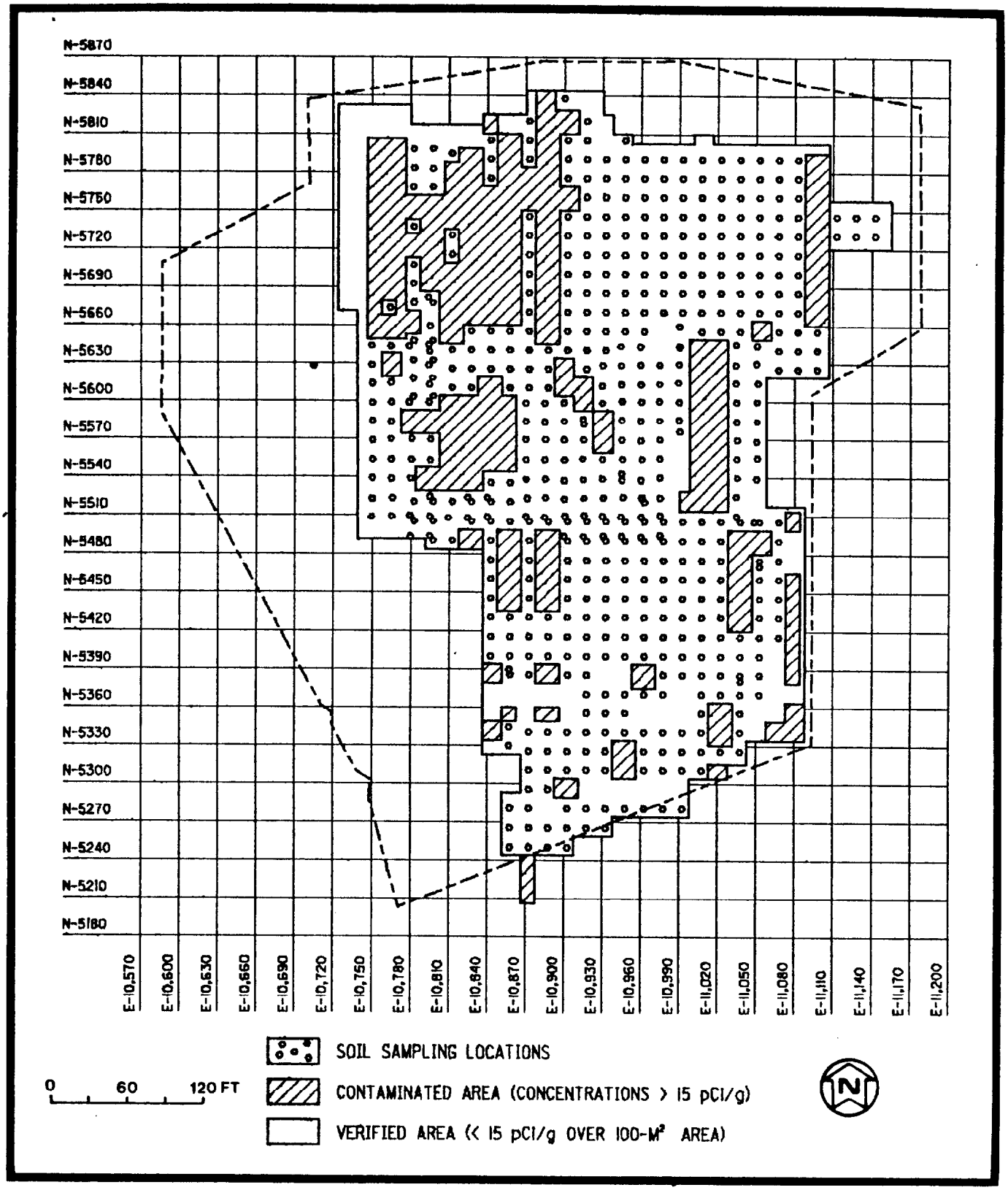


FIGURE 2 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 2

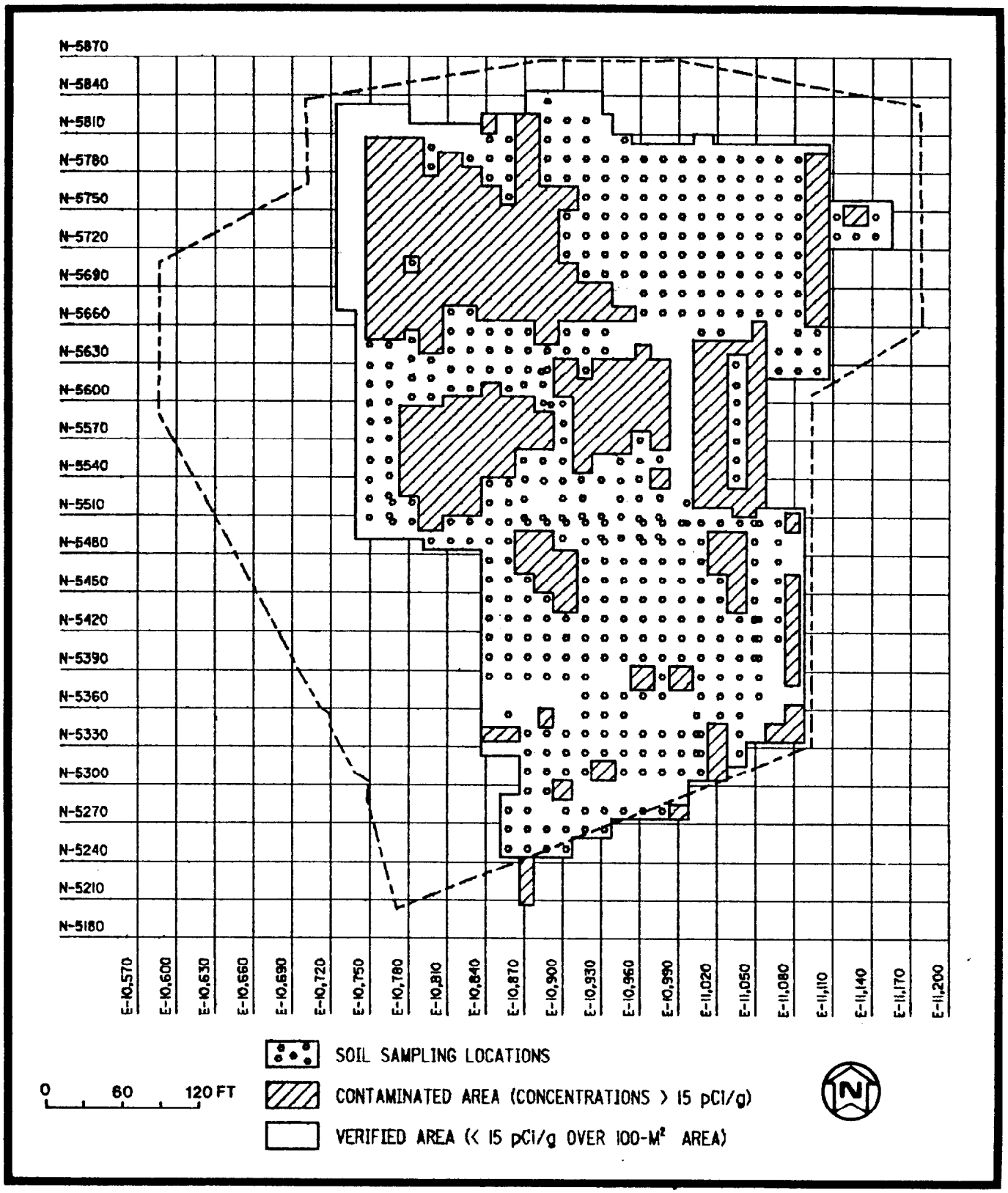


FIGURE 3 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 3

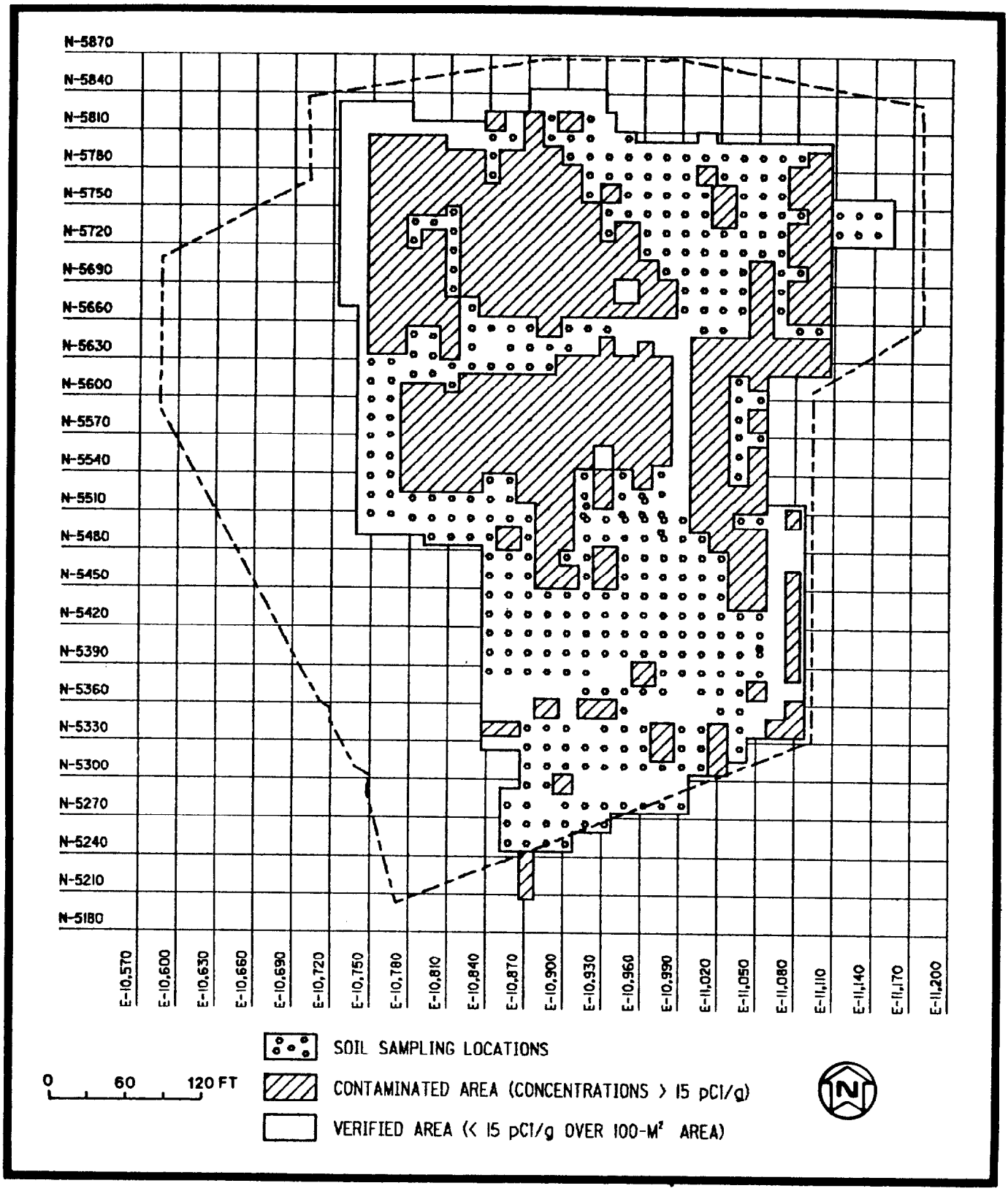


FIGURE 4 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 4

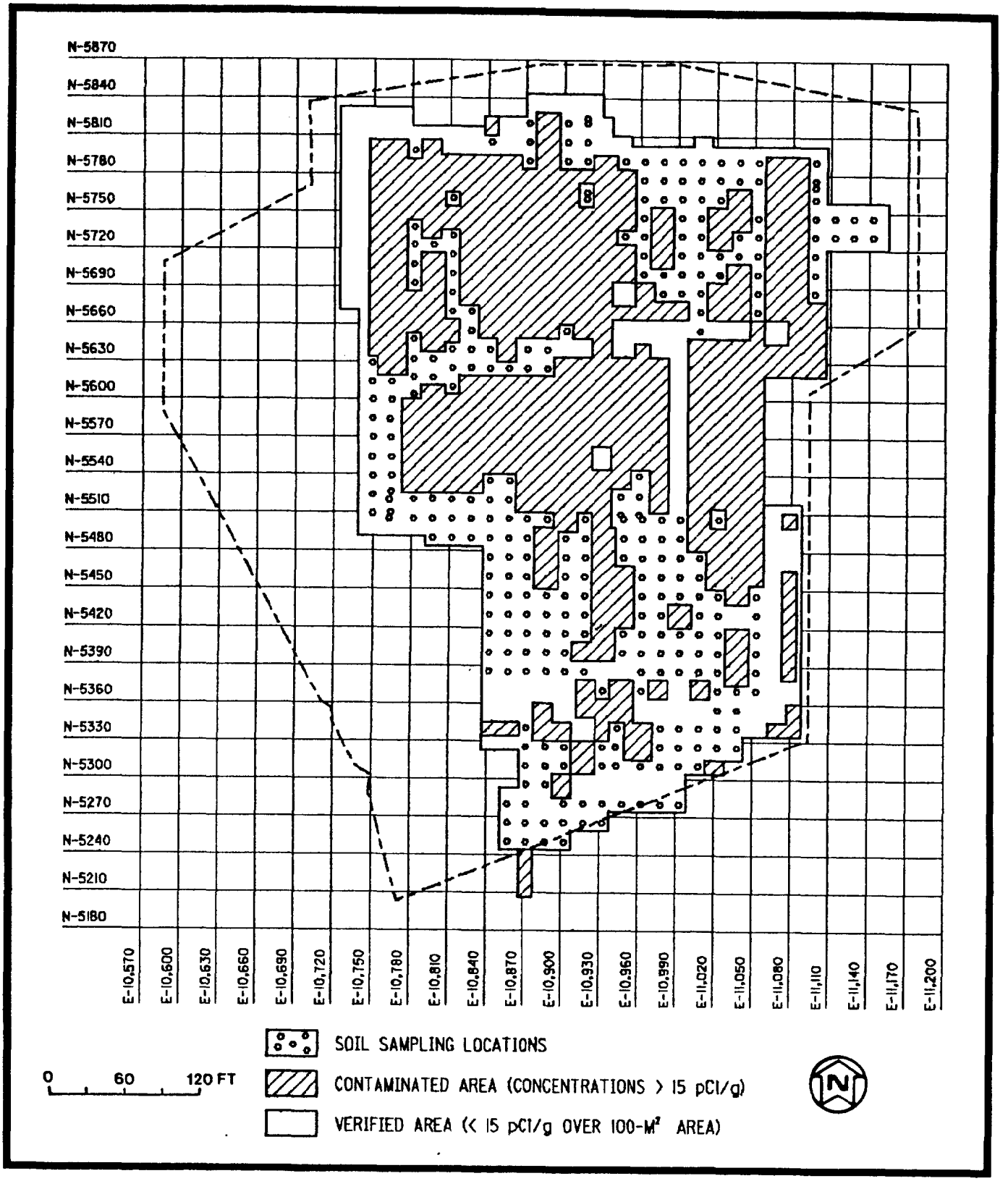


FIGURE 5 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 5

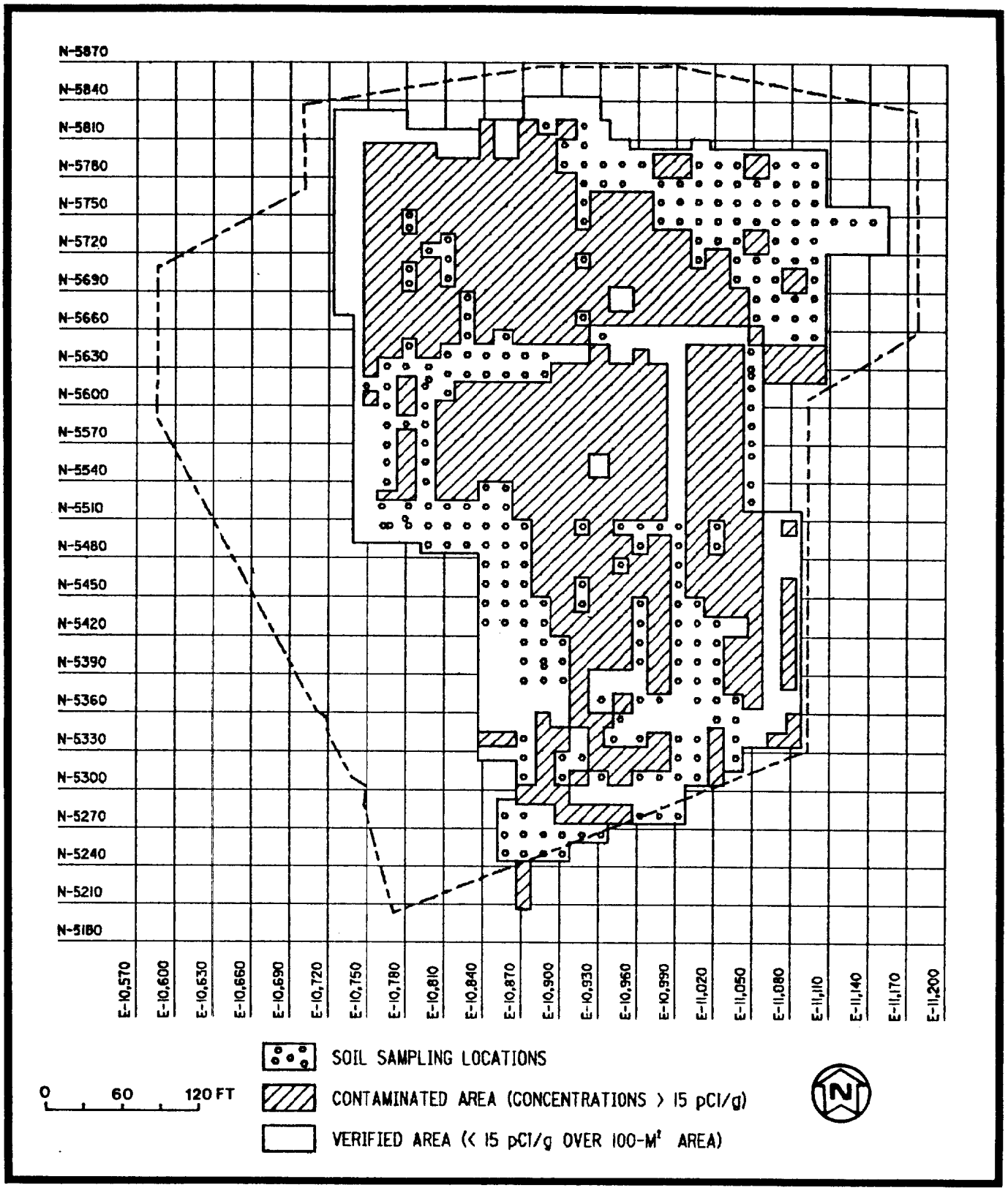


FIGURE 6 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 6

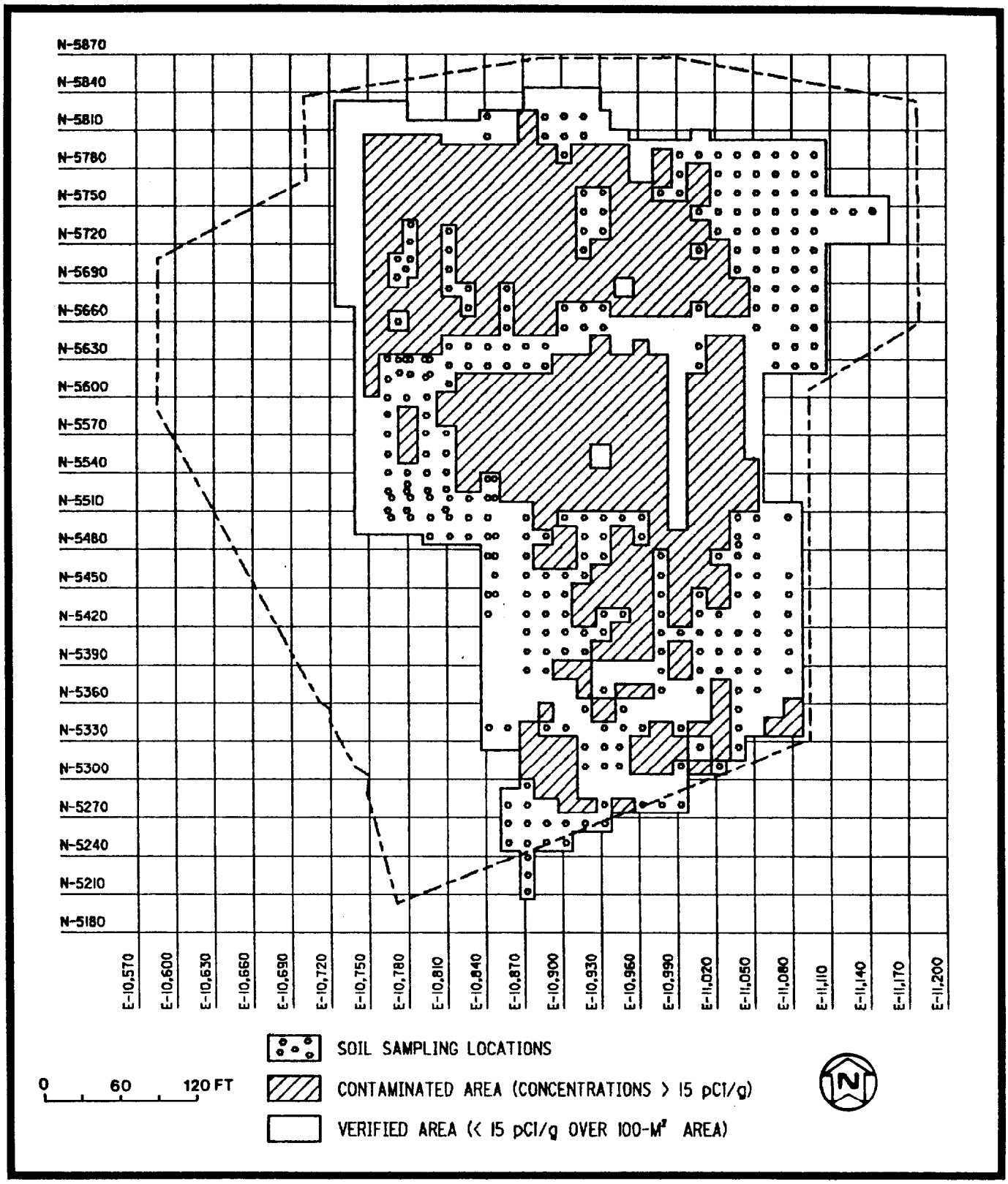


FIGURE 7 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 7

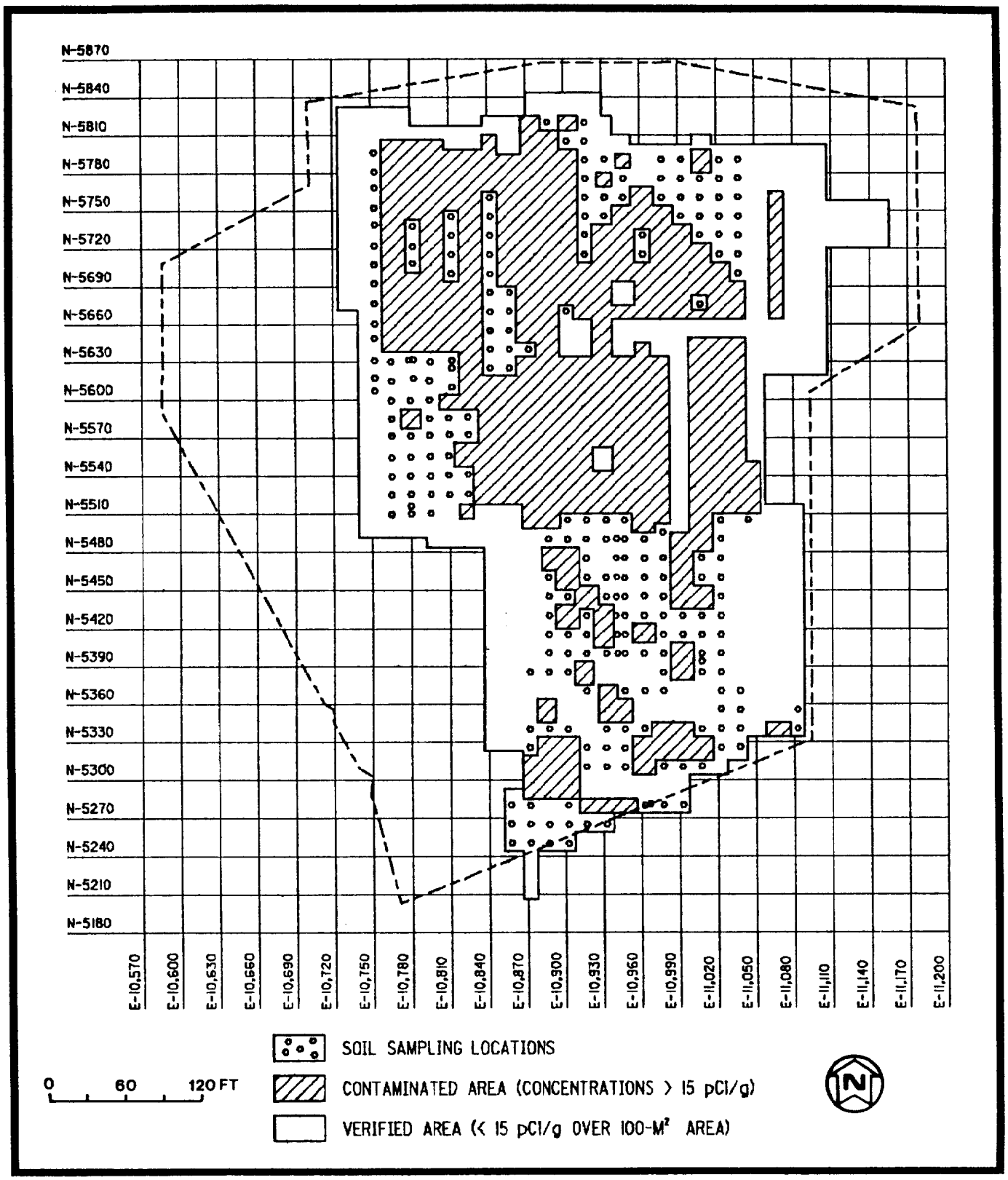


FIGURE 8 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 8

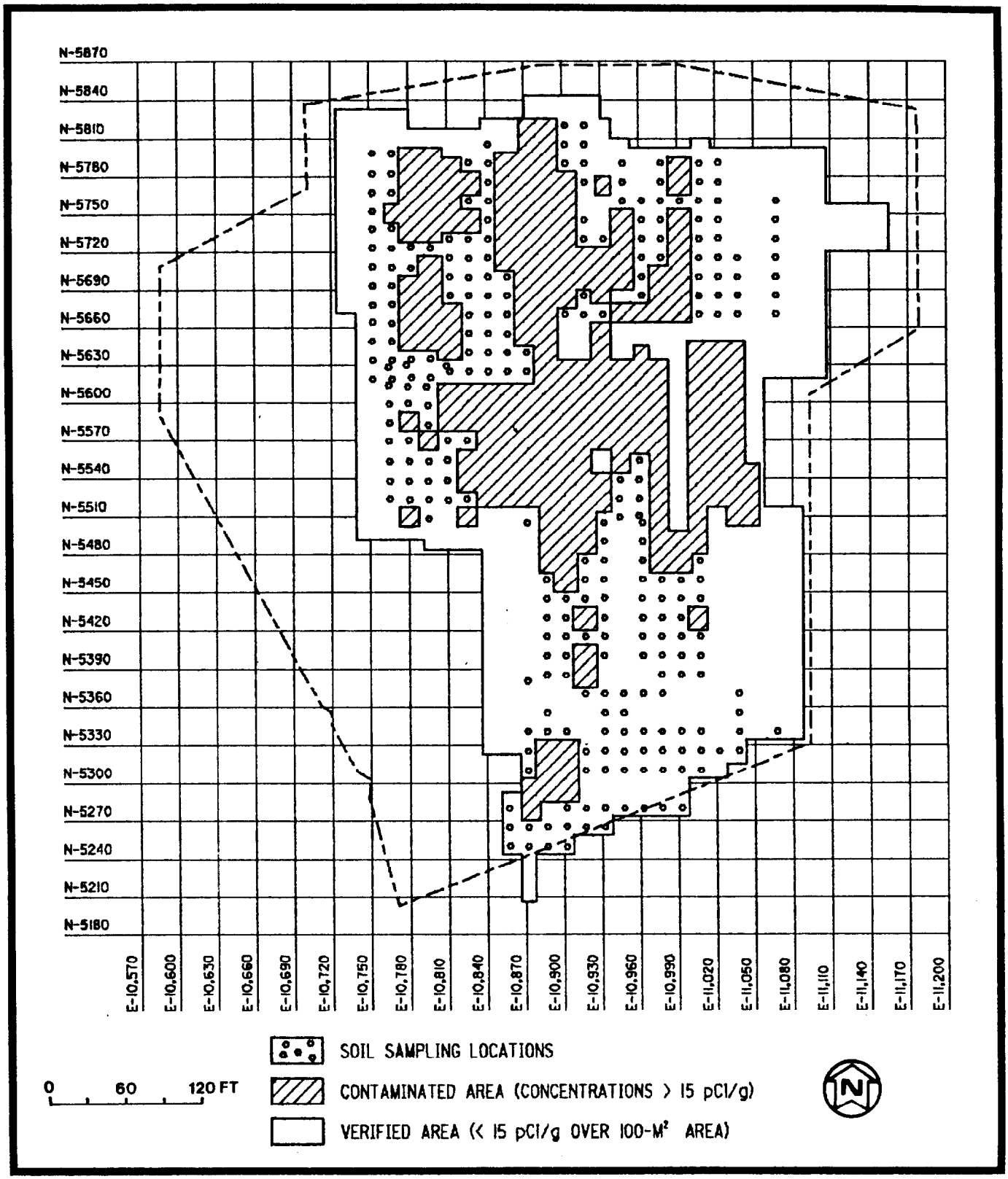


FIGURE 9 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 9

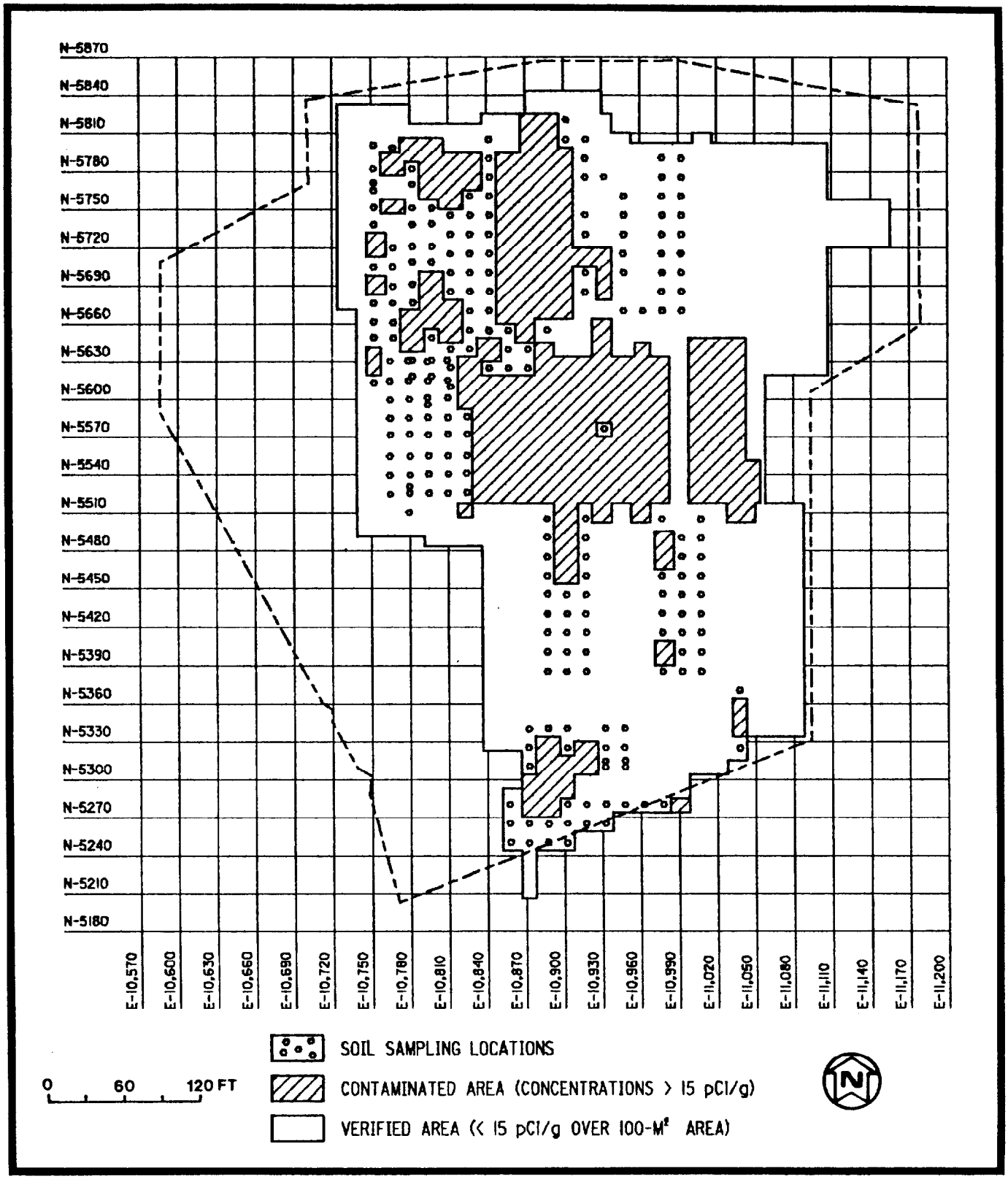


FIGURE 10 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 10

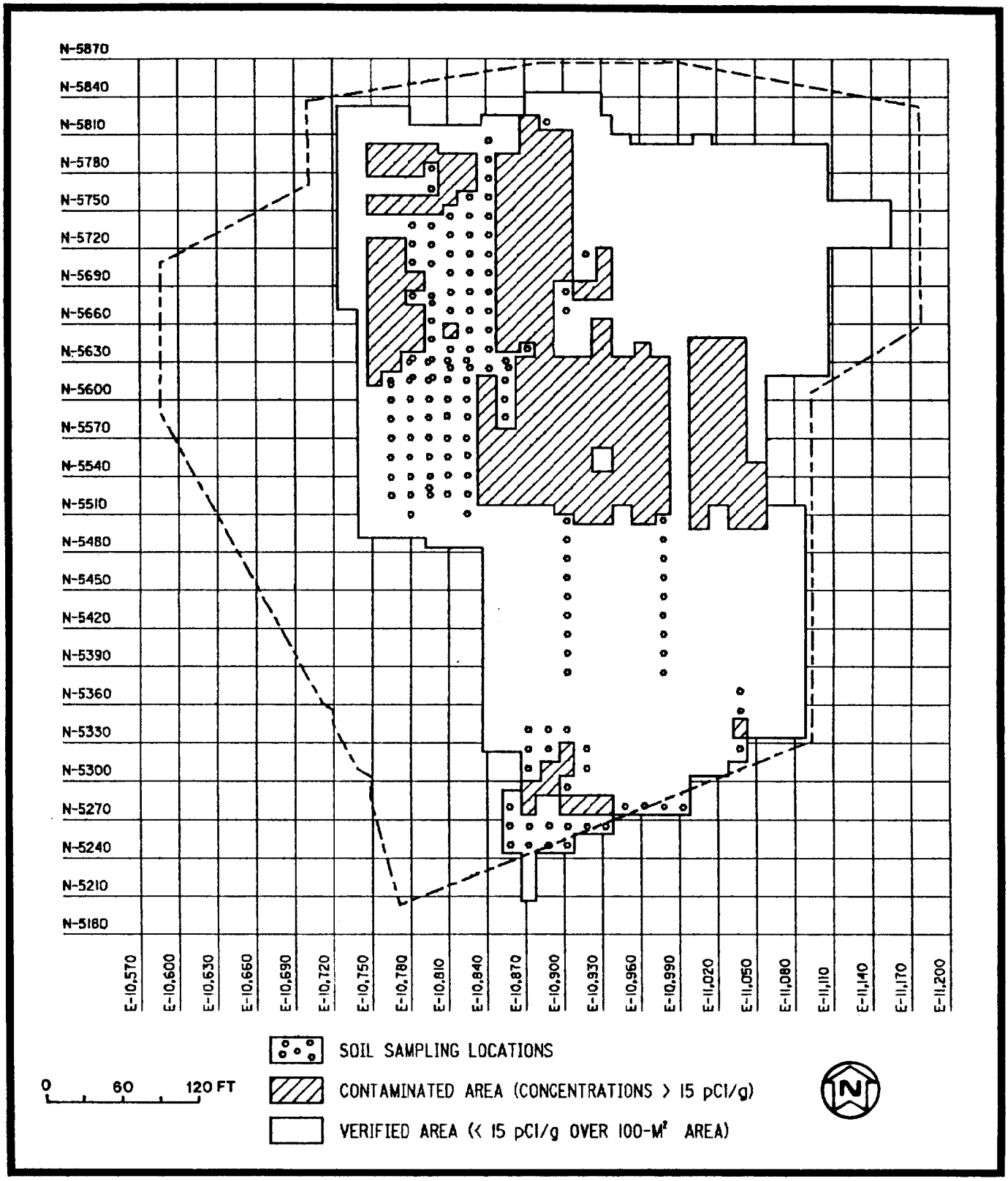


FIGURE 11 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 11

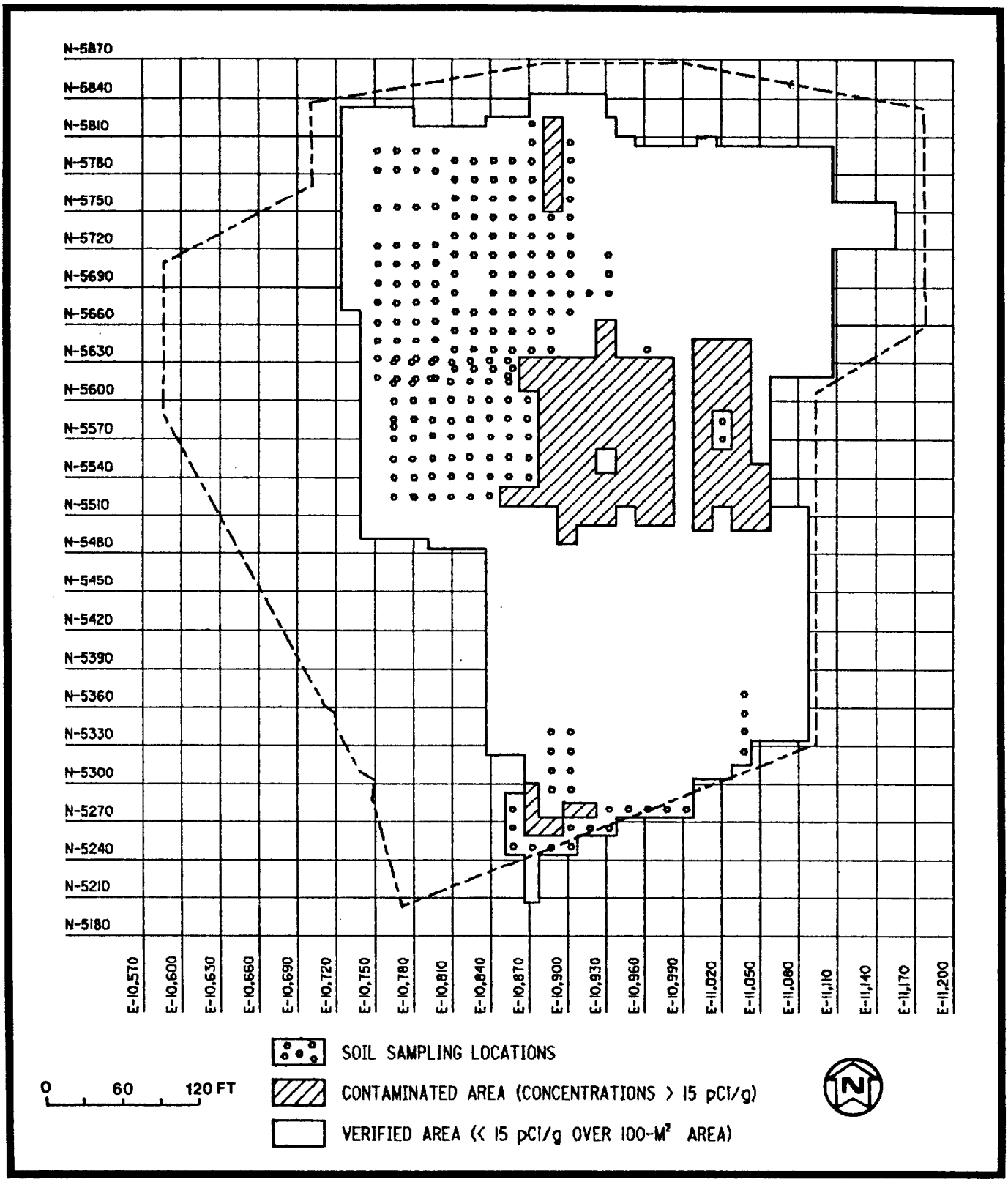


FIGURE 12 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 12

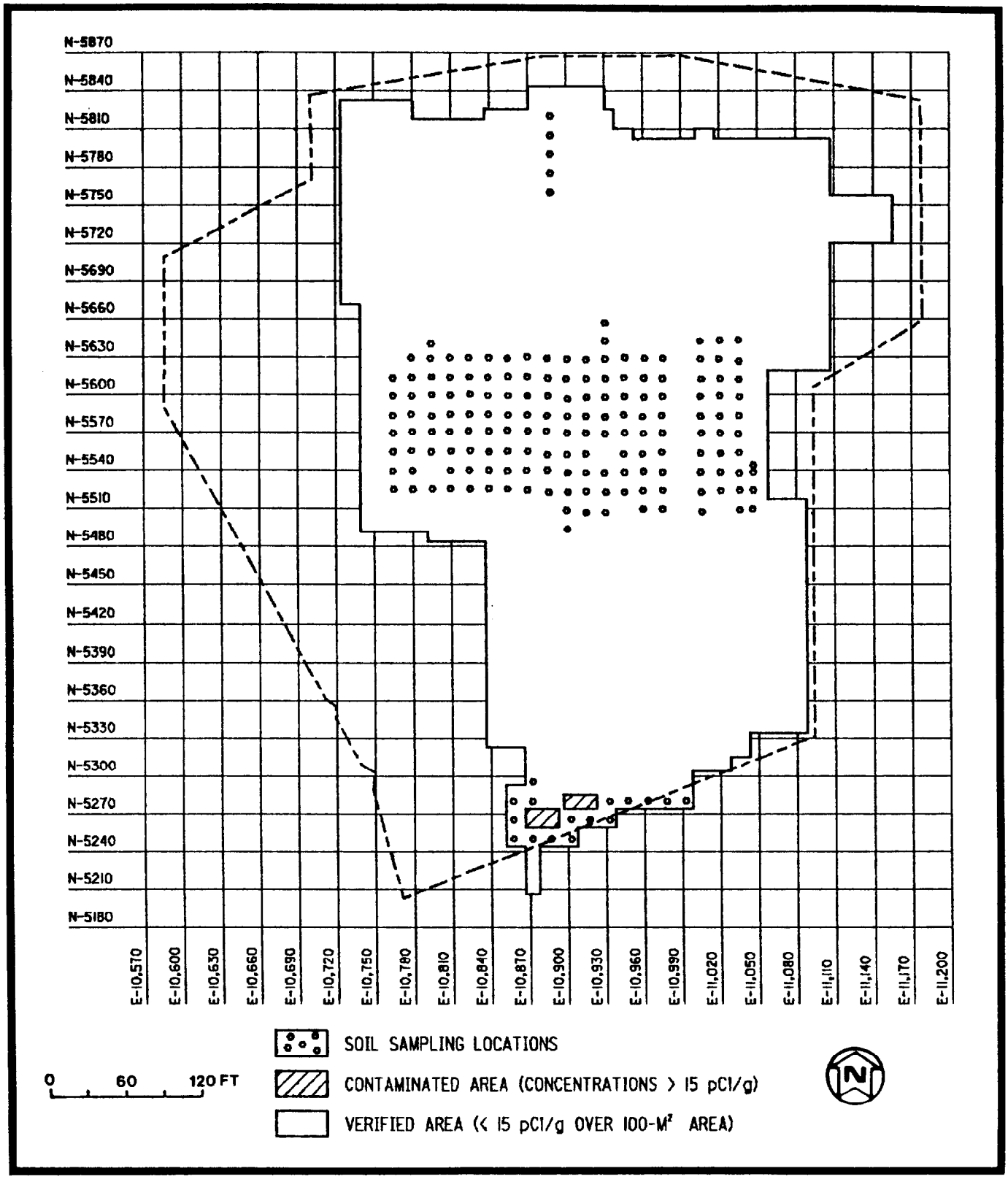


FIGURE 13 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 13

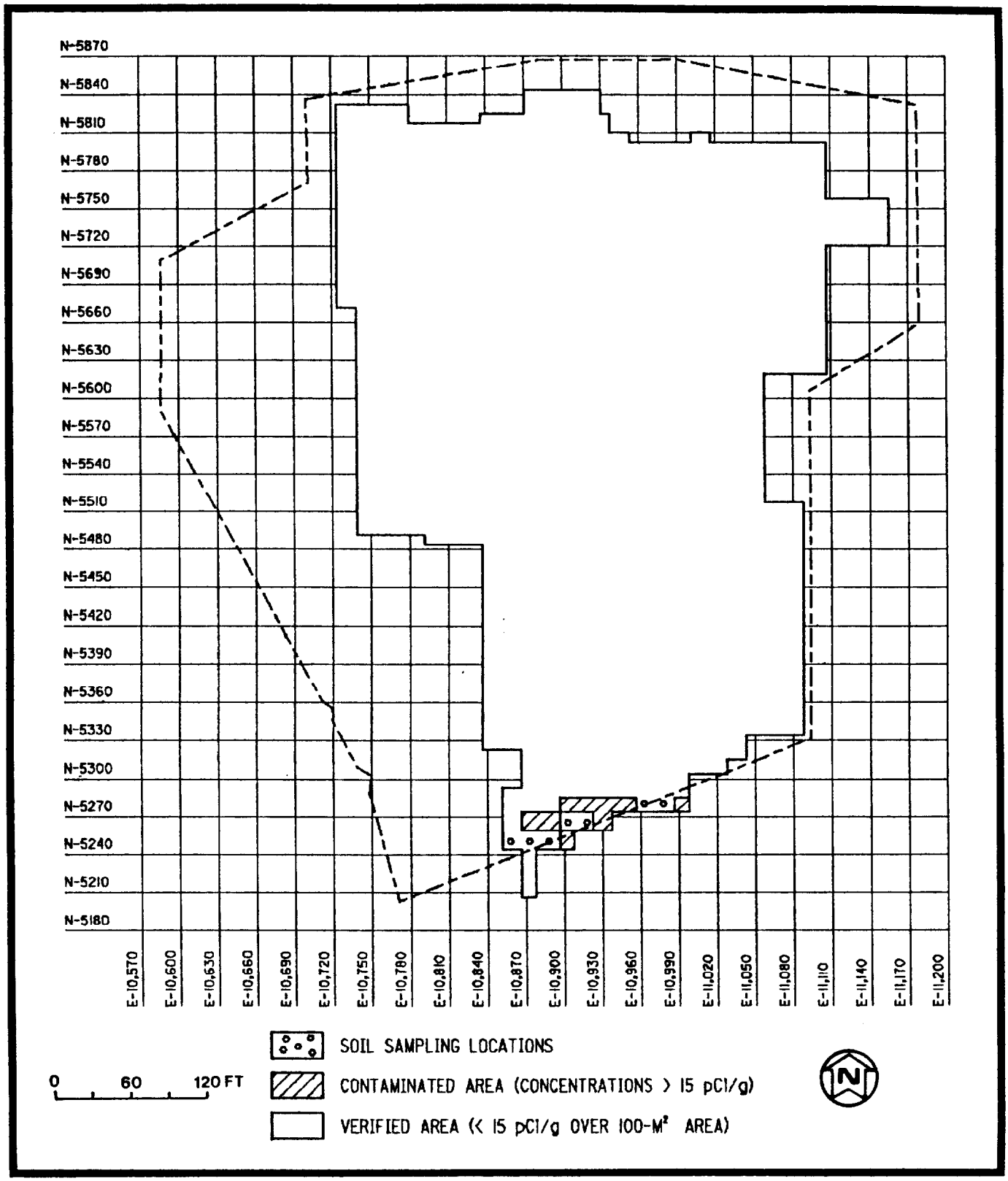


FIGURE 14 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 14

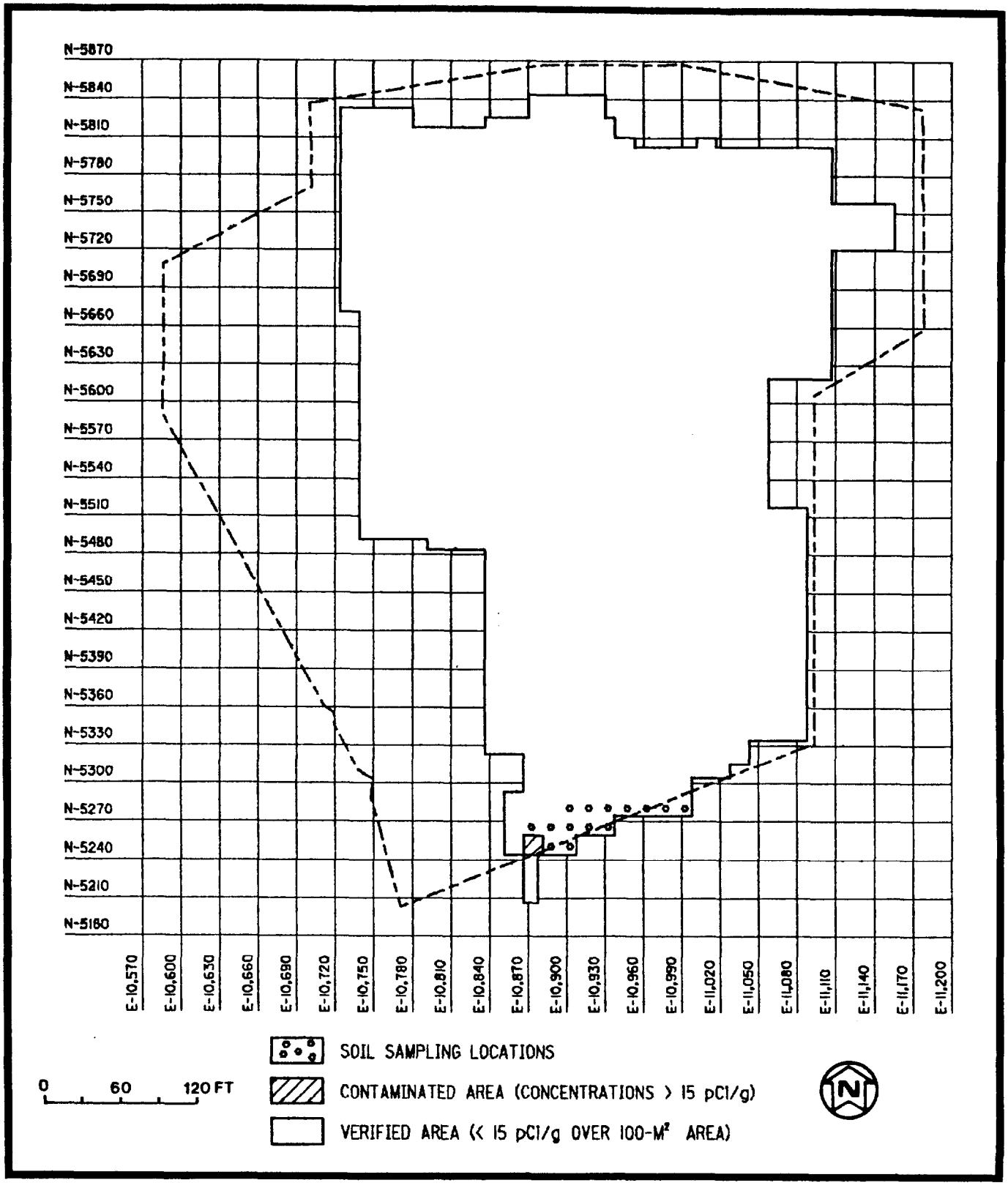


FIGURE 15 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 15

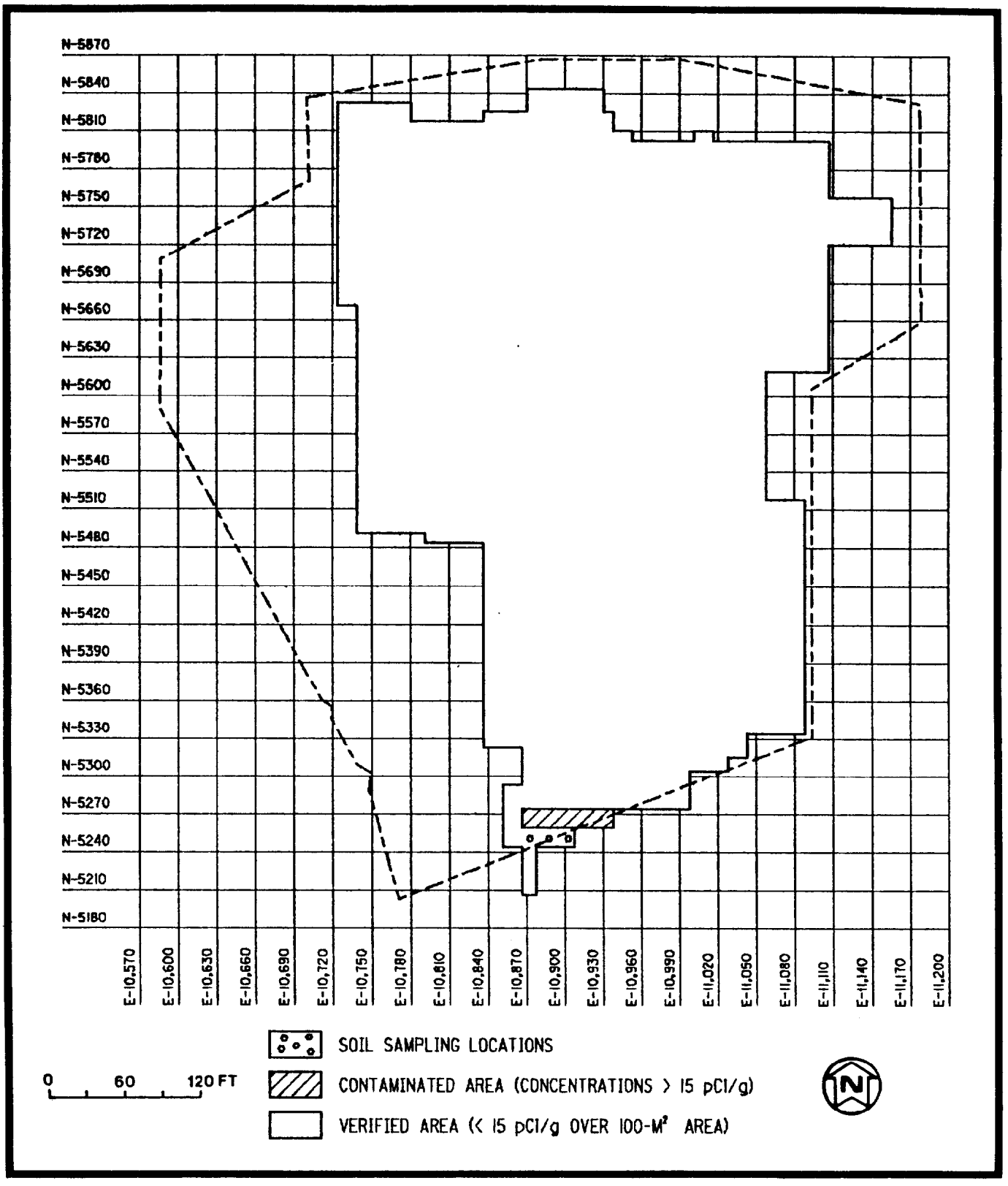


FIGURE 16 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 16

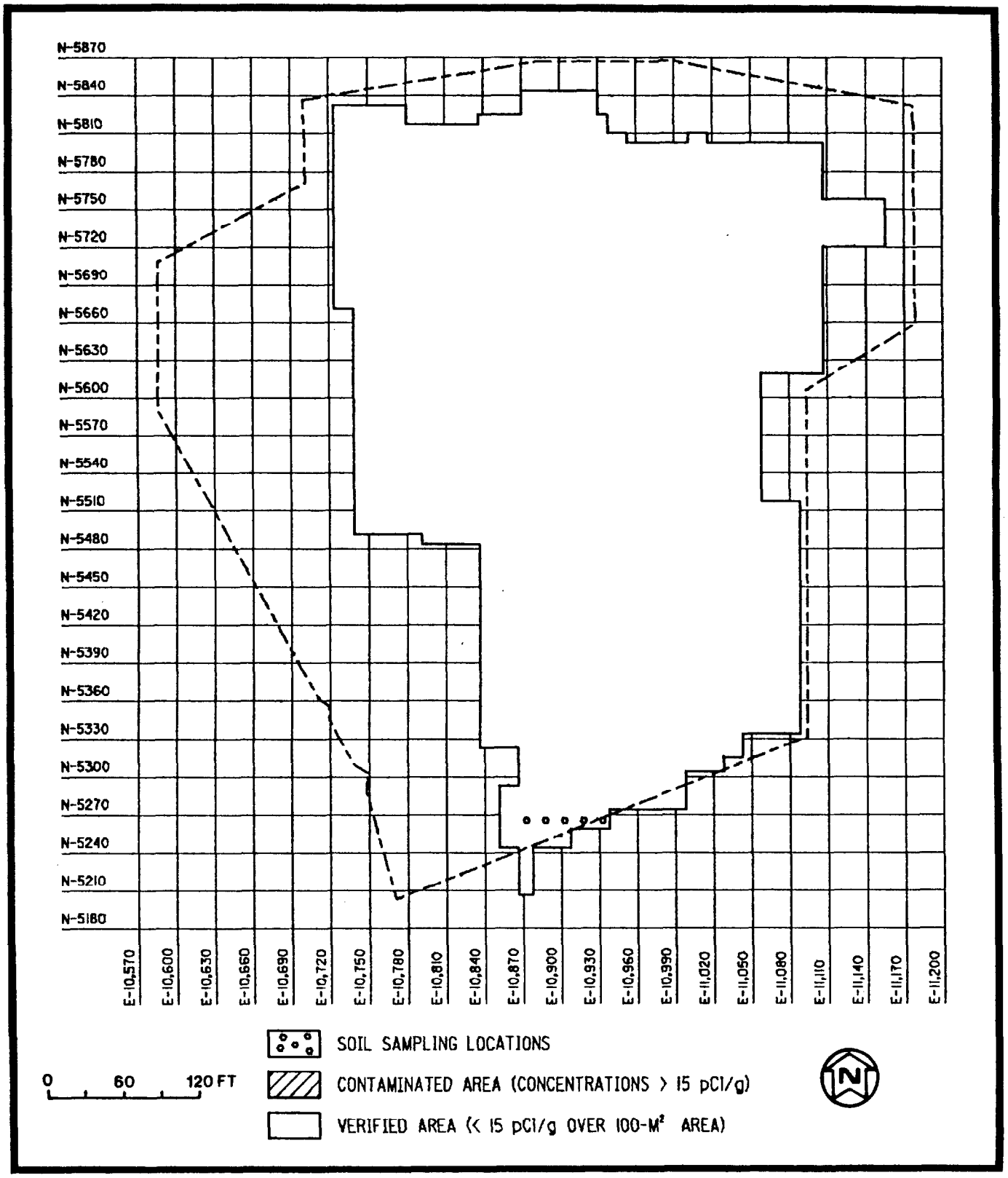


FIGURE 17 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 17

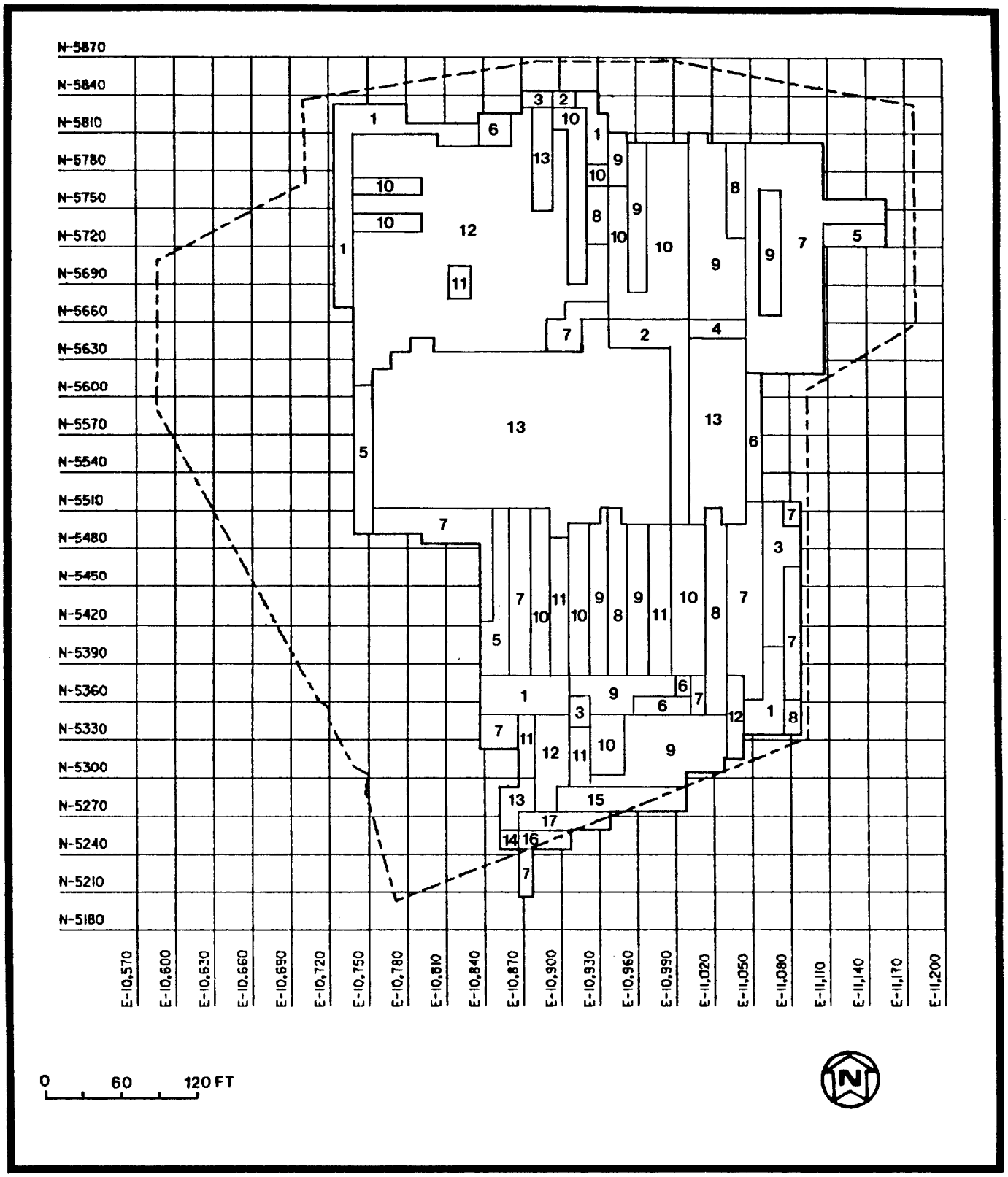


FIGURE 18 APPROXIMATE EXCAVATION DEPTHS (FT)

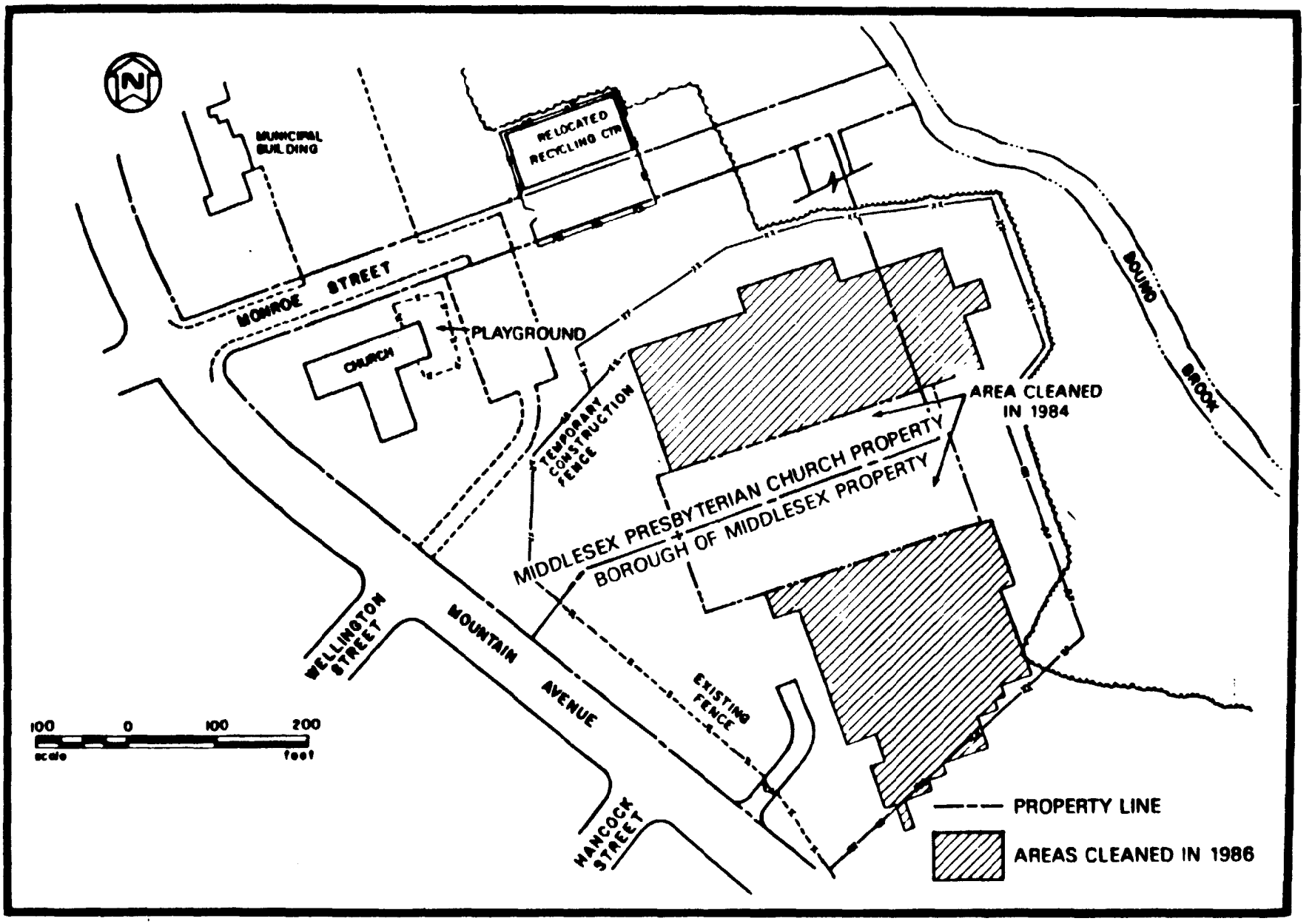


FIGURE 19 MAP OF THE MIDDLESEX MUNICIPAL LANDFILL AND VICINITY SHOWING LAND OWNERSHIP