146885
M-605

Formerly Utilized Sites Remedial Action Program (FUSRAP)

# ADMINISTRATIVE RECORD

## for Maywood, New Jersey

U.S. Department of Energy

0489-0613.1

146885

# Department of Energy

9 - 4 0

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831—8723

October 7, 1996

Ms. Angela Carpenter
U.S. Environmental Protection Agency
Region II
290 Broadway, 18th Floor
New York, New York 10007-1866

Dear Ms. Carpenter:

**MAYWOOD SITE - POST REMEDIAL ACTION REPORT FOR PROPERTIES IN LODI, NEW JERSEY**

As you know, the Formerly Utilized Sites Remedial Action Program (FUSRAP) performed cleanups at five residential properties in Lodi, New Jersey, in the summer and fall of 1995. The properties are part of FUSRAP's Maywood site.

Enclosed are copies of the Post Remedial Action Report for the properties. The report outlines the work that was done and provides verification that the cleanup successfully removed contamination above established cleanup guidelines, allowing the properties to be released for use without radiological restrictions.

If you have any questions regarding the report or about other aspects of our work at the Maywood site, please call me. My office phone number in Oak Ridge, Tennessee, is (423) 576-5724.

Sincerely,

A M. Cange

Susan M. Cange, Site Manager
Former Sites Restoration Division

Enclosures

146885

# Department of Energy

4 8 0

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831—8723

October 7, 1996

Ms. Donna Gaffigan
New Jersey Department of Environmental Protection
Bureau of Federal Case Management
CN-028
401 East State Street
Trenton, New Jersey 08625

Dear Ms. Gaffigan:

**MAYWOOD SITE - POST REMEDIAL ACTION REPORT FOR PROPERTIES IN LODI, NEW JERSEY**

The Department of Energy's Formerly Utilized Sites Remedial Action Program (FUSRAP) performed cleanups at five residential properties in Lodi, New Jersey, in the summer and fall of 1995. The properties are part of FUSRAP's Maywood site.

Enclosed are copies of the Post Remedial Action Report for the properties. The report outlines the work that was done and provides verification that the cleanup successfully removed contamination above established cleanup guidelines, allowing the properties to be released for use without radiological restrictions.

If you have any questions regarding the report or about other aspects of our work at the Maywood site, please call me. My office phone number in Oak Ridge, Tennessee, is (423) 576-5724.

Sincerely,

S. M. Cange

Susan M. Cange, Site Manager
Former Sites Restoration Division

Enclosures

146885

# Department of Energy

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831—8723

October 7, 1996

Mr. and Mrs. Sokol Shala
108 Avenue E
Lodi, New Jersey 07644

Dear Mr. and Mrs. Shala:

**MAYWOOD SITE - POST REMEDIAL ACTION REPORT FOR 108 AVENUE E**

Enclosed is the report that covers our work on five Lodi properties last fall, including your property at 108 Avenue E.

The report outlines the work that was done and provides verification that the cleanup successfully removed the contamination above established cleanup guidelines, allowing your property to be released from the Formerly Utilized Sites Remedial Action Program for use without radiological restrictions. A formal document called the Certification Docket will eventually be placed in the Federal Register concerning all of our cleanups in Lodi, and you will also receive a copy of this. Because the Certification Docket will be prepared at the conclusion of all of our Phase I work, which includes all residential and municipal properties, it will not be issued for quite some time, perhaps three to four years. But the report you have received with this letter is the official documentation for your property.

I know that the process of sample taking, surveying, planning and, finally, cleaning up the contamination has been a long one, and that you must be glad for it to come to an end regarding your property. I truly thank you for your patience and cooperation throughout.

Although the cleanup at your property is complete, please do not hesitate to call me or others on the project if you have questions or concerns about the work that was done or about our work in general in your community. My office phone number in Oak Ridge, Tennessee, is (423) 576-5724. We also have a toll-free line. Call 1-800-253-9759, leave a message, and someone will return your call promptly.

Again, on behalf of the entire New Jersey project team, thank you for being so understanding and cooperative throughout the planning and execution of our work.

Sincerely,

S. M. Cange

Susan M. Cange, Site Manager
Former Sites Restoration Division

Enclosures

146885

# Department of Energy

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831—8723

October 7, 1996

Ms. Constance Pucci
112 Avenue E
Lodi, New Jersey 07644

Dear Ms. Pucci:

**MAYWOOD SITE - POST REMEDIAL ACTION REPORT FOR 112 AVENUE E**

Enclosed is the report that covers our work on five Lodi properties last fall, including your property at 112 Avenue E.

The report outlines the work that was done and provides verification that the cleanup successfully removed the contamination above established cleanup guidelines, allowing your property to be released from the Formerly Utilized Sites Remedial Action Program for use without radiological restrictions. A formal document called the Certification Docket will eventually be placed in the Federal Register concerning all of our cleanups in Lodi, and you will also receive a copy of this. Because the Certification Docket will be prepared at the conclusion of all of our Phase I work, which includes all residential and municipal properties, it will not be issued for quite some time, perhaps three to four years. But the report you have received with this letter is the official documentation for your property.

I know that the process of sample taking, surveying, planning and, finally, cleaning up the contamination has been a long one, and that you must be glad for it to come to an end regarding your property. I truly thank you for your patience and cooperation throughout.

Although the cleanup at your property is complete, please do not hesitate to call me or others on the project if you have questions or concerns about the work that was done or about our work in general in your community. My office phone number in Oak Ridge, Tennessee, is (423) 576-5724. We also have a toll-free line. Call 1-800-253-9759, leave a message, and someone will return your call promptly.

Again, on behalf of the entire New Jersey project team, thank you for being so understanding and cooperative throughout the planning and execution of our work.

Sincerely,

S. M. Cange

Susan M. Cange, Site Manager
Former Sites Restoration Division

Enclosures

146885

**Department of Energy**

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831—8723

October 7, 1996

Mr. Oldrich Balvin
79 Avenue B
Lodi, New Jersey 07644

Dear Mr. Balvin:

**MAYWOOD SITE - POST REMEDIAL ACTION REPORT FOR 79 AVENUE B**

Enclosed is the report that covers our work on five Lodi properties last fall, including your property at 79 Avenue B.

The report outlines the work that was done and provides verification that the cleanup successfully removed the contamination above established cleanup guidelines, allowing your property to be released from the Formerly Utilized Sites Remedial Action Program for use without radiological restrictions. A formal document called the Certification Docket will eventually be placed in the Federal Register concerning all of our cleanups in Lodi, and you will also receive a copy of this. Because the Certification Docket will be prepared at the conclusion of all of our Phase I work, which includes all residential and municipal properties, it will not be issued for quite some time, perhaps three to four years. But the report you have received with this letter is the official documentation for your property.

I know that the process of sample taking, surveying, planning and, finally, cleaning up the contamination has been a long one, and that you must be glad for it to come to an end regarding your property. I truly thank you for your patience and cooperation throughout.

Although the cleanup at your property is complete, please do not hesitate to call me or others on the project if you have questions or concerns about the work that was done or about our work in general in your community. My office phone number in Oak Ridge, Tennessee, is (423) 576-5724. We also have a toll-free line. Call 1-800-253-9759, leave a message, and someone will return your call promptly.

Again, on behalf of the entire New Jersey project team, thank you for being so understanding and cooperative throughout the planning and execution of our work.

Sincerely,

S. M. Cange

Susan M. Cange, Site Manager
Former Sites Restoration Division

Enclosures

146885

# Department of Energy

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831—8723

October 7, 1996

Mr. Ronald Feder
113 Avenue E
Lodi, New Jersey 07644

Dear Mr. Feder:

**MAYWOOD SITE - POST REMEDIAL ACTION REPORT FOR 113 AVENUE E**

Enclosed is the report that covers our work on five Lodi properties last fall, including your property at 113 Avenue E.

The report outlines the work that was done and provides verification that the cleanup successfully removed the contamination above established cleanup guidelines, allowing your property to be released from the Formerly Utilized Sites Remedial Action Program for use without radiological restrictions. A formal document called the Certification Docket will eventually be placed in the Federal Register concerning all of our cleanups in Lodi, and you will also receive a copy of this. Because the Certification Docket will be prepared at the conclusion of all of our Phase I work, which includes all residential and municipal properties, it will not be issued for quite some time, perhaps three to four years. But the report you have received with this letter is the official documentation for your property.

I know that the process of sample taking, surveying, planning and, finally, cleaning up the contamination has been a long one, and that you must be glad for it to come to an end regarding your property. I truly thank you for your patience and cooperation throughout.

Although the cleanup at your property is complete, please do not hesitate to call me or others on the project if you have questions or concerns about the work that was done or about our work in general in your community. My office phone number in Oak Ridge, Tennessee, is (423) 576-5724. We also have a toll-free line. Call 1-800-253-9759, leave a message, and someone will return your call promptly.

Again, on behalf of the entire New Jersey project team, thank you for being so understanding and cooperative throughout the planning and execution of our work.

Sincerely,

S. M. Cange

Susan M. Cange, Site Manager
Former Sites Restoration Division

Enclosures

146885

# Department of Energy

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831—8723

October 7, 1996

Mr. and Mrs. Raymond Coss
90 Avenue C
Lodi, New Jersey 07644

Dear Mr. and Mrs. Coss:

**MAYWOOD SITE - POST REMEDIAL ACTION REPORT FOR 90 AVENUE C**

Enclosed is the report that covers our work on five Lodi properties last fall, including your property at 90 Avenue C.

The report outlines the work that was done and provides verification that the cleanup successfully removed the contamination above established cleanup guidelines, allowing your property to be released from the Formerly Utilized Sites Remedial Action Program for use without radiological restrictions. A formal document called the Certification Docket will eventually be placed in the Federal Register concerning all of our cleanups in Lodi, and you will also receive a copy of this. Because the Certification Docket will be prepared at the conclusion of all of our Phase I work, which includes all residential and municipal properties, it will not be issued for quite some time, perhaps three to four years. But the report you have received with this letter is the official documentation for your property.

I know that the process of sample taking, surveying, planning and, finally, cleaning up the contamination has been a long one, and that you must be glad for it to come to an end regarding your property. I truly thank you for your patience and cooperation throughout.

Although the cleanup at your property is complete, please do not hesitate to call me or others on the project if you have questions or concerns about the work that was done or about our work in general in your community. My office phone number in Oak Ridge, Tennessee, is (423) 576-5724. We also have a toll-free line. Call 1-800-253-9759, leave a message, and someone will return your call promptly.

Again, on behalf of the entire New Jersey project team, thank you for being so understanding and cooperative throughout the planning and execution of our work.

Sincerely,

S. M. Cange

Susan M. Cange, Site Manager
Former Sites Restoration Division

Enclosures

DOE/OR/21949-405

Formerly Utilized Sites Remedial Action Program (FUSRAP)
Contract No. DE-AC05-91OR21949

# POST-REMEDIAL ACTION REPORT FOR THE MAYWOOD SITE VICINITY PROPERTIES AT 79 AVENUE B, 90 AVENUE C, 108 AVENUE E, 112 AVENUE E, AND 113 AVENUE E

Maywood, New Jersey

September 1996

Bechtel National, Inc.

Printed on recycled/recyclable paper.

4.192 9669.1

DOE/OR/21949-405

# POST-REMEDIAL ACTION REPORT

# FOR THE

# MAYWOOD SITE VICINITY PROPERTIES

# AT 79 AVENUE B, 90 AVENUE C,

# 108 AVENUE E, 112 AVENUE E, AND 113 AVENUE E

# MAYWOOD, NEW JERSEY

SEPTEMBER 1996

Prepared for

United States Department of Energy

Oak Ridge Operations Office

Under Contract No. DE-AC05-91OR21949

By

Bechtel National, Inc.

Oak Ridge, Tennessee

Bechtel Job No. 14501

# CONTENTS

## FIGURES

# TABLES

# ACRONYMS

| | |
|---|---|
| BNI | Bechtel National, Inc. |
| DAC | derived air concentration |
| DCG | derived concentration guide |
| DOE | U.S. Department of Energy |
| EPA | U.S. Environmental Protection Agency |
| FUSRAP | Formerly Utilized Sites Remedial Action Program |
| IVC | independent verification contractor |
| MCW | Maywood Chemical Works |
| MISS | Maywood Interim Storage Site |
| ORNL | Oak Ridge National Laboratory |
| PIC | pressurized ionization chamber |
| PPE | personal protective equipment |
| RCRA | Resource Conservation and Recovery Act |
| TN | Thermo NUtech |

## UNITS OF MEASURE

| | |
|---|---|
| cm | centimeter |
| ft | foot |
| g | gram |
| h | hour |
| in. | inch |
| km | kilometer |
| L | liter |
| m | meter |
| $\mu$R | microroentgen |
| mi | mile |
| mrem | millirem |
| pCi | picocurie |
| yd | yard |
| yr | year |

# 1.0 INTRODUCTION

## 1.1 BACKGROUND

This report documents the remedial action conducted at five vicinity properties that are part of the Maywood site. The Maywood site is located in Bergen County, New Jersey, approximately 20 km (12 mi) north-northwest of New York City and 21 km (13 mi) northeast of Newark, New Jersey (Figure 1-1). The Maywood site consists of the Maywood Interim Storage Site (MISS) and 84 vicinity properties in the boroughs of Maywood and Lodi and the township of Rochelle Park.

Twenty-five of the vicinity properties were remediated during 1984-1985. The waste material from these efforts was placed in interim storage at MISS. Five other properties that were remediated in October 1995 are located at 79 Avenue B, 90 Avenue C, 108 Avenue E, 112 Avenue E, and 113 Avenue E in Lodi. The properties are approximately 3.4 km (2.1 mi) from MISS (Figure 1-2).

Remedial actions at these vicinity properties were performed as part of the U.S. Department of Energy's (DOE's) Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP was established to identify and clean up or otherwise control sites where residual radioactive contamination remains from the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has authorized DOE to remedy.

The objectives of FUSRAP, as they apply to the Maywood site, are

- to remove or otherwise control contamination on sites identified as contaminated above current DOE guidelines, and

- to achieve and maintain compliance with applicable criteria for the protection of human health and the environment.

FUSRAP was established in 1974 and currently includes 46 sites in 14 states. Congress assigned responsibility for the Maywood site to DOE in 1984 under the Energy and Water Development Appropriations Act; the site was then assigned to FUSRAP.

Bechtel National, Inc. (BNI), the project management contractor, assists DOE in the planning, management, and implementation of the cleanup of the Maywood site, including the vicinity properties. DOE-Headquarters uses Oak Ridge National Laboratory (ORNL) as an independent verification contractor (IVC) to provide autonomous assurance that site conditions following the remedial action meet the cleanup criteria.

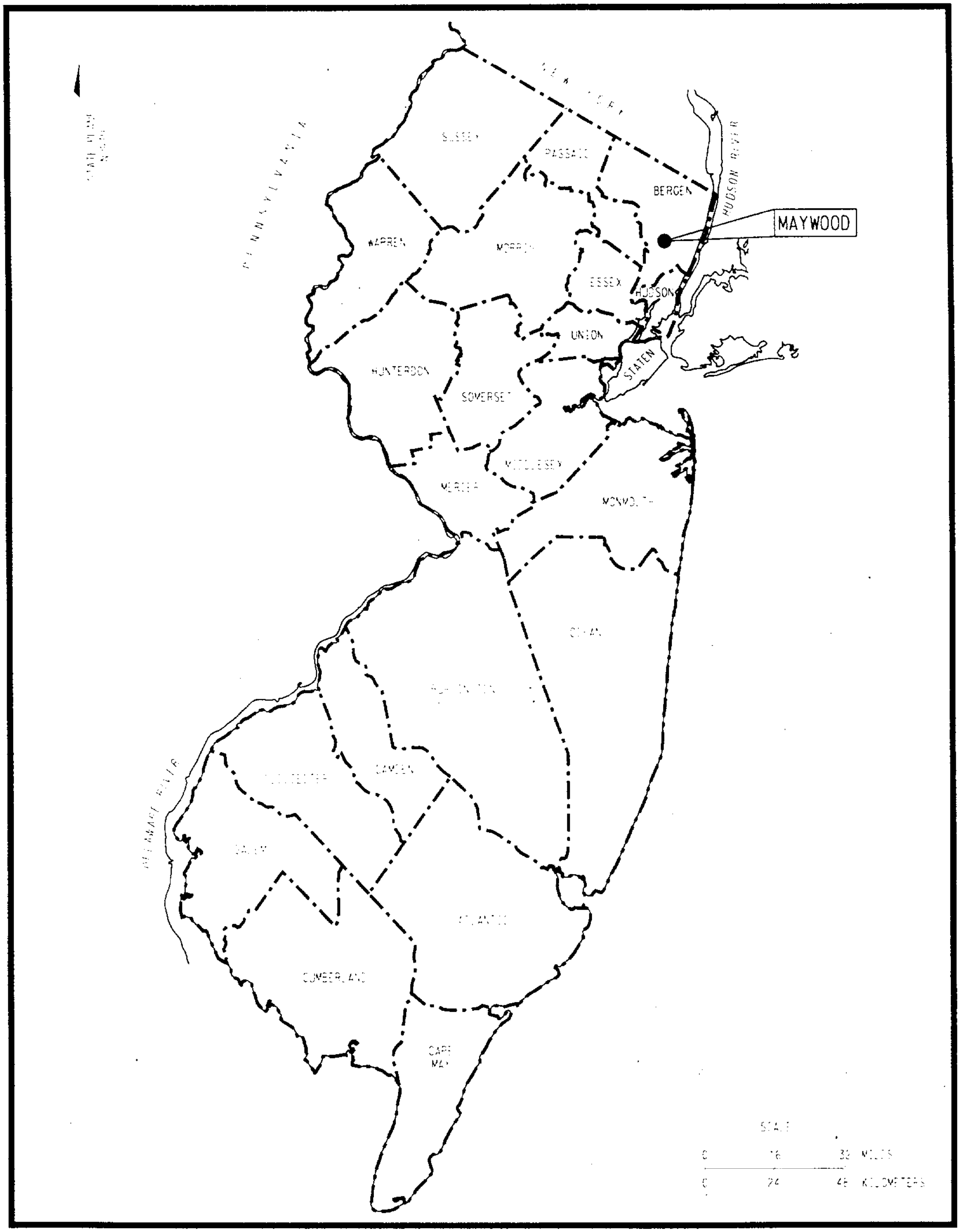
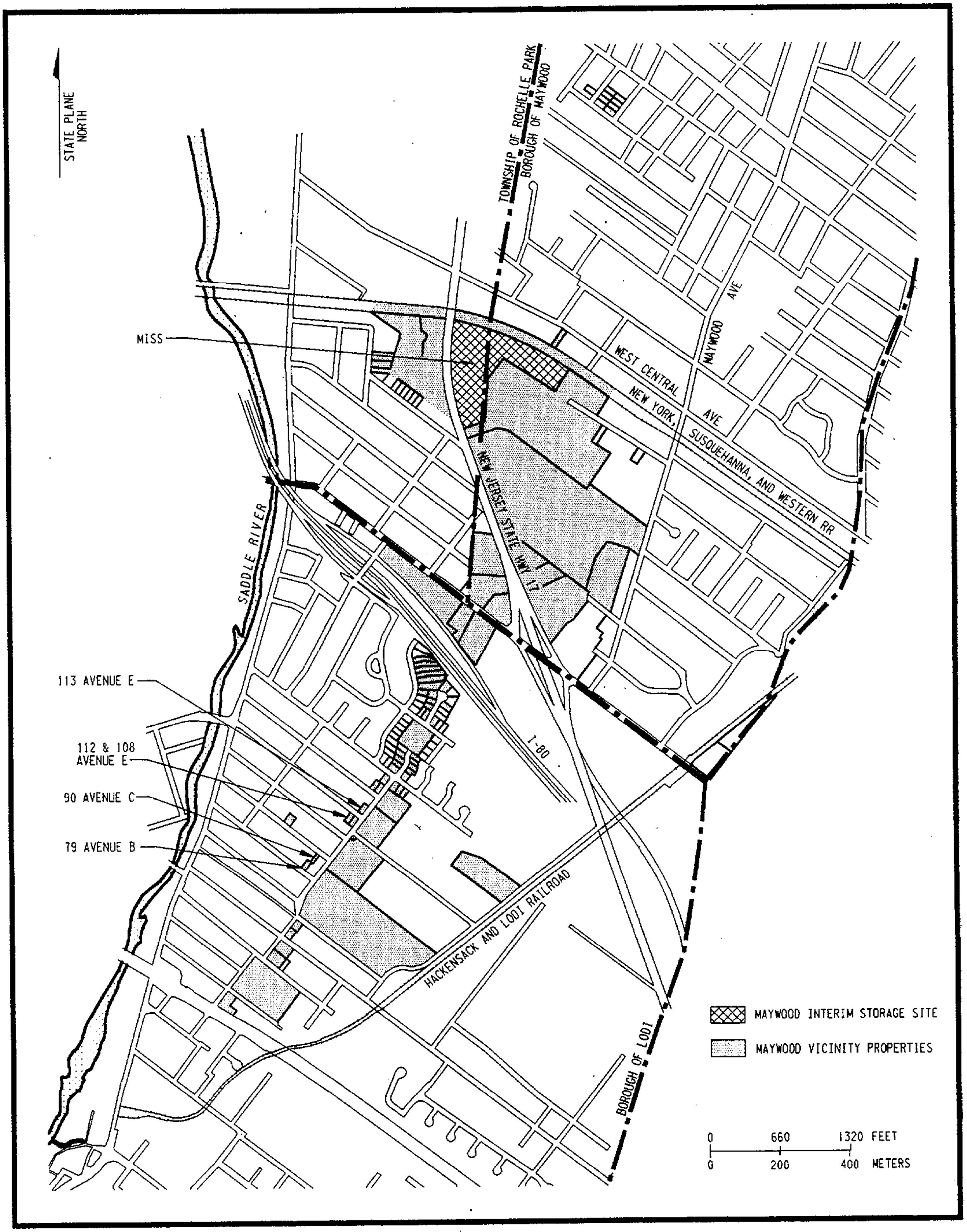



Figure 1-1
Location of Maywood, Bergen County, New Jersey




R77F006.DGN

**Figure 1-2**
**Locations of the Properties that Compose the Maywood Site**

## 1.2 HISTORY

### 1.2.1 Prior Remedial Actions

From 1916 to 1959, the former Maywood Chemical Works (MCW) extracted radioactive thorium and rare earths from monazite sand for use in manufacturing industrial products such as mantles for gas lanterns. Slurry that contained waste from the thorium processing operations was pumped to earthen diked areas. Some process wastes, along with tea and coca leaves from other MCW operations, were removed from the MCW property and used as mulch and fill on nearby properties, thereby contaminating those properties. Additional waste apparently migrated off the MCW property through natural drainage associated with the former Lodi Brook. In all, 84 commercial, governmental, and residential vicinity properties were radioactively contaminated by these transport mechanisms. Twenty-five residential properties were remediated during 1984-1985. A time-critical removal action was conducted at 90 Avenue C in 1991 to decontaminate a portion of the house at this address. Results were reported in the *Post-Remedial Action Report for the Time-Critical Removal Action at 90 Avenue C* (BNI 1993).

### 1.2.2 Characterization Before Current Remedial Action

Typically, FUSRAP sites are characterized before remediation. Results of radiological and chemical characterization of the five vicinity properties remediated in 1995 are reported in the *Remedial Investigation Report for the Maywood Site* (BNI 1992). In 1995, further characterization was performed to better delineate the areas of contamination. Results of the 1995 effort indicated that in some cases, the volume of soil above cleanup guidelines was lower than anticipated. For example, it was determined that there was no radioactive contamination beneath the basement of the residence at 112 Avenue E. Results of this effort are reported in *Results of Maywood Vicinity Property Data Gap Characterization* (BNI 1995a).

The 1992 radiological and chemical characterization of the five vicinity properties remediated in 1995 indicated that the radioactive contamination on these properties was primarily located in the top 30-60 cm (1-2 ft) of soil. Areas inferred to be radioactively contaminated on each property before remediation are discussed in Section 4 (and shown in figures in that section). Analytical results from the limited chemical sampling performed did not indicate the presence of chemical contamination in excess of regulatory guidelines or the presence of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA).

## 2.0 REMEDIAL ACTION GUIDELINES

Historical data indicate that radioactive contamination at the five vicinity properties consisted primarily of thorium-232 but also included uranium-238 and radium-226 and their respective decay products. Table 2-1 lists the DOE residual contamination guidelines for release of the Maywood Phase I vicinity properties without radiological restrictions. These guidelines were adopted by DOE based on an agreement with the U.S. Environmental Protection Agency (EPA) in 1994 (DOE 1994). Appendix A provides a brief introduction to the nature, sources, and basic units of radiation.

For the remediation of the five vicinity properties, the DOE radiological soil cleanup guideline was 5 pCi/g above background regardless of depth (see Table 2-1). This guideline applied to thorium-232 and radium-226 concentrations in soil and included only concentrations above naturally occurring background radioactivity in soils near the site. The DOE site-specific guideline for residual radioactive material is 100 pCi/g of total uranium above background regardless of depth. The resulting uranium-238 guideline is 50 pCi/g, assuming the uranium exists in the naturally occurring abundance of 1:1:0.046 for uranium-234, uranium-238, and uranium-235, respectively (Shleien 1992). The site-specific uranium guideline for Maywood was developed based on the reasonable exposure pathways that could be hypothesized for the site to ensure that the annual radiation dose (excluding radon) received by an individual member of the general public is less than 100 millirem (the unit used to measure radiation dose to man) per year.

The above remedial action guidelines are applied in determining the sum of the ratios. Five isotopes (uranium-238, radium-226, thorium-230, thorium-232, and radium-228) are of interest in performing this calculation. The calculation is performed by first subtracting the background concentration for each isotope from the reported value for that isotope. The subtraction of background concentrations can cause the values for some isotopes to be reduced to zero, and in some cases this causes the sum of ratios to be zero as well. Next, uranium-238 is divided by a specific guideline number (50 pCi/g in this case). Then the larger value of radium-226 or thorium-230 is chosen and divided by the appropriate guideline number (5 pCi/g for Maywood). The larger value of thorium-232 or radium-228 is also chosen and divided by the appropriate guideline number. Finally, the three calculated values are summed. If the sum of the three calculated values is 1.0 or less, the soil is below the applicable DOE guideline for radioactive contamination at Maywood and is thus considered clean.

Because the cleanup guidelines are based on activities in addition to background levels, it is important to establish the levels of naturally occurring background radioactivity in soils near the site. Background data serve as a frame of reference for evaluating the data from the vicinity properties because they present conditions typical of the areas unaffected by the activities at the former MCW site. During the remedial investigation, soil samples were obtained from three remote background locations in the general area of the vicinity properties. The locations were

**Table 2-1**
**Summary of DOE Guidelines for Residual Radioactive Contamination[a]**

**Basic Dose Limits**

The basic limit for the annual radiation dose received by an individual member of the general public is 100 mrem/yr. In implementing this limit, DOE applies as-low-as-reasonably-achievable (ALARA) principles to set site-specific guidelines.

**Soil Guidelines[b,c,d,e]**

| | |
|---|---|
| Radium-226<br>Radium-228<br>Thorium-230<br>Thorium-232 | 5 pCi/g when averaged over any 15-cm (6-in.)-thick layer of soil regardless of depth. |
| Uranium[f] | 100 pCi/g total uranium, 50 pCi/g uranium-238. |

| Radionuclide[g] | Allowable Surface Residual Contamination[g] (dpm/100 cm$^2$) Average[h,i] | Maximum[h,j] | Removable[h,k] |
|---|---|---|---|
| Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-124, I-129 | 100 | 300 | 20 |
| Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133 | 1,000 | 3,000 | 200 |
| U-Natural, U-235, U-238, and associated decay products | 5,000 α | 15,000 α | 1,000 α |
| Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission except Sr-90 and others noted above) | 5,000 β–γ | 15,000 β–γ | 1,000 β–γ |

[a]Department of Energy, 1990, Order 5400.5, "Radiation Protection of the Public and the Environment" (February 8). The soil guideline of 5 pCi/g regardless of depth is from DOE 1994.

[b]Soil guidelines are also used for sediment because there are no sediment guidelines.

[c]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 must be reduced so that (1) the dose for the mixtures will not exceed the basic dose limit, or (2) the sum of ratios of the soil concentration of each radionuclide to the allowable limit for the radionuclide will not exceed 1 ("unity").

[d]These guidelines represent allowable residual concentration exceeding background levels averaged across any 15-cm (6-in.)-thick layer to any depth and over any contiguous 100-m$^2$ (1,076-ft$^2$) surface area, except as noted.

[e]If the average concentration in any surface or below-surface area less than or equal to 25 m$^2$ (269 ft$^2$) exceeds the authorized limit or guideline by a factor of $(100/A)^{1/2}$, where A is the area of the elevated region in square meters, limits for "hot spots" will also be applicable. Procedures for calculating these hot spot limits, which depend on the extent of the elevated local concentrations, are given in the supplement. In addition, every reasonable effort shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit for soil, irrespective of the average concentration in the soil.

[f]Guidelines are calculated on a site-specific basis using a DOE manual developed for this use.

[g]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.

[h]Measurements of average contamination should not be averaged over more than 1 m$^2$ (10.8 ft). For objects of less surface area, the average must be derived for each such object.

[i]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 (0.4 in.).

[j]The maximum contamination level applies to an area of not more than 100 cm$^2$ (16 in.$^2$).

[k]The amount of removable radioactive material per 100 cm$^2$ (16 in.$^2$) 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$^2$ (16 in.$^2$) is determined, the activity per unit area should be based on the actual area or the entire surface should be wiped. The number in this column are maximum amounts.

selected on the basis of their proximity to the site, relative independence from potential influence of the site, and representativeness of area land uses. The background locations are shown in Figure 2-1. Samples from these background areas were analyzed for radium-226, thorium-232, and uranium-238. Background external gamma radiation exposure rates were also measured at these three background locations using a pressurized ionization chamber (PIC). The average concentration of thorium-232 in background samples was 1.0 pCi/g, with a range of 0.9 to 1.1 pCi/g. The average background concentration of radium-226 was 0.7 pCi/g with a range of 0.5 to 0.8 pCi/g. The average background concentration for uranium-238 was 2.9 pCi/g with a range of 2.4 to 3.5 pCi/g (BNI 1992). The average background external radiation exposure rate was determined to be 9.0 $\mu$R/h.

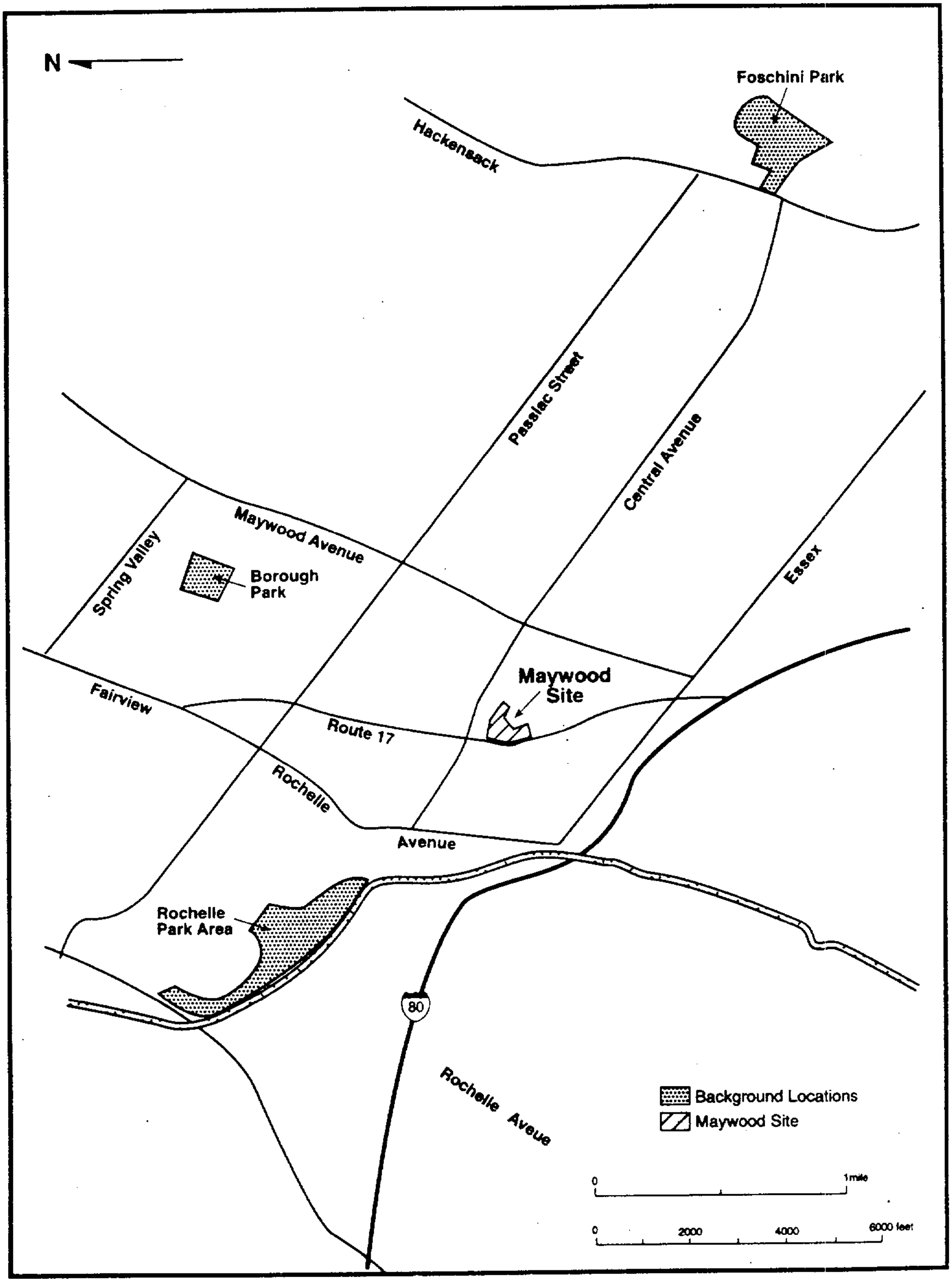



Figure 2-1
Background Sample Locations in Relation to the Maywood Interim Storage Site

# 3.0 REMEDIAL ACTION

## 3.1 CLEANUP ACTIVITIES

In addition to the characterization program conducted in 1992, the five vicinity properties were surveyed immediately before remediation in 1995 to more accurately define the boundaries of radioactive contamination. Waste classification sampling was performed before remediation began to characterize the waste stream (soil) for disposal. Walkover surface scans were also taken during remediation to direct the excavation. As remediation was completed, exposure rate measurements were taken with a PIC to confirm that residual radiation levels were in compliance with applicable DOE guidelines (Table 2-1), and soil samples were collected and analyzed to establish that residual radioactive material above the applicable DOE guidelines had been removed.

The primary technique used in the remedial action was excavation of the contaminated materials. A jackhammer was used to break up concrete, asphalt, and debris before removal. Because of the limited working space available, small volumes of soil from the residential properties were removed with picks and shovels, while a backhoe was used to remove larger volumes. Following remedial action, areas were restored to the condition agreed upon by the property owners.

After the material was excavated, direct gamma measurements were taken with an Eberline SPA-3 gamma scintillation detector. After survey results indicated that remediation was complete, post-remediation soil samples were then collected from the excavated areas in accordance with the "Post-Remedial Action Survey Plan for the Maywood Vicinity Properties" (BNI 1995b). The soil samples were sent to the Wayne Interim Storage Site in Wayne, New Jersey, for gamma spectral analysis to ensure that all soils contaminated above the DOE criteria had been removed. If the analysis showed that residual radioactive material remained above criteria, then additional excavation occurred and additional post-remedial action samples were collected and analyzed. The rationale for the sampling program and the analytical results are presented in Section 4.

The remedial action was conducted in October 1995. During remediation, approximately 124 $m^3$ (163 $yd^3$) of radioactively contaminated soil was removed from the five properties. Excavated material was transported to MISS, where it was immediately loaded into two railcars and shipped to Envirocare of Utah. Table 3-1 lists the volume of soil removed from each vicinity property.

The use of the Wayne sample preparation and gamma spectroscopy system provided either same-day or one-day analysis of samples. A substantial cost savings for the project resulted from reduced stand-down time, and the remedial action guidelines were met. To ensure that the

**Table 3-1**

**Volume of Contaminated Soil Removed at Each Vicinity Property**

| Vicinity Property | Soil Removed, $m^3$ ($yd^3$) |
|---|---|
| 79 Avenue B | 15 (20) |
| 90 Avenue C | 49 (64) |
| 108 Avenue E | 12 (16) |
| 112 Avenue E | 21 (28) |
| 113 Avenue E | 27 (35) |

gamma spectroscopy system at the Wayne site was providing reliable results, 10 percent of the samples analyzed during the remedial action were shipped to the BNI radiological support contractor laboratory, Thermo NUtech (TN), for confirmatory laboratory analysis. The average relative percent difference between the two sets of samples was 12 percent.

The final costs associated with the removal actions totaled $1,175.000.

## 3.2 CONTAMINATION CONTROL DURING REMEDIAL ACTION

During the removal action, engineering and administrative controls (such as dust control, hazardous work permits, and installation of a silt fence) and personal protective equipment (PPE) were used to protect remediation workers and members of the public from exposure to radiation in excess of applicable standards. These measures also controlled the migration of radioactive material to uncontaminated areas next to these vicinity properties.

All personnel working in contaminated areas were required to wear disposable coveralls, safety glasses, rubber boots, hardhat, and gloves.

Workers exiting controlled areas were subjected to a radioactive contamination survey (frisked) at the control point with a hand-held radiation detection instrument. The frisk was conducted by personnel who have received Radiological Worker II training. This procedure ensured that workers were not contaminated and prevented the potential spread of radioactive material from the work area. A frisk is simply a search for radioactive material that may have been transferred onto the skin or clothing of individuals inside the work area. The hand-held Geiger-Mueller radiation detection instrument is held approximately 1 cm away from the area to be frisked and moved slowly (about 2 in. per second) across the body or clothing by the worker. Portions of the PPE worn by the workers that were suspected or known to be contaminated were packaged and shipped to Envirocare for disposal.

The primary pathway by which persons onsite and offsite could be exposed to radioactive material during removal activities at the site was inhalation and ingestion of radioactively contaminated airborne dust generated during excavation. During remedial action, the spread of contamination and personnel exposure were minimized by the following measures:

- A fine water mist was sprayed as needed to control dust during soil removal and transport.

- Trucks hauling contaminated materials were fitted with liners, and the loads were covered with tarps to prevent loss of the contents.

- Silt fences were placed around excavated areas, to prevent runoff of potentially contaminated sediment, until sampling results confirmed that contamination had been removed.

During remediation, particulate air sampling devices were placed in the areas being cleaned. The concentrations of thorium-232 ranged from $4.6 \times 10^{-6}$ to $1.7 \times 10^{-4}$ pCi/L. These concentrations were conservatively derived by collecting air particulate samples daily from lapel air samplers worn by workers. After the gross alpha activity per volume of air that passed through the filter was determined, this activity was assumed to be the result of thorium-232 activity only. This is a conservative assumption (i.e., likely to overestimate actual exposures) because the DOE thorium-232 derived air concentration (DAC) is the lowest DAC of all radionuclides present at Maywood; thus, it is the most protective of human health. The activity of each air sample was compared with the applicable DOE guideline, which is a DAC of $1.0 \times 10^{-3}$ pCi/L for occupational exposures (10 CFR 835) to airborne thorium-232. The effective DAC was not exceeded at any time during the remediation.

Area air particulate sampling was also performed adjacent to areas being remediated to ensure that no member of the general public was exposed above DOE guidelines (DOE Order 5400.5). These guidelines were established by the International Commission on Radiation Protection and the National Commission on Radiation Protection and adopted by DOE to protect the environment and members of the general public. Eberline RAS-1 high-volume and SKC low-volume samplers were used, and the filters were collected daily and counted after four days to allow for radon decay. The limits expressed in DOE Order 5400.5 are derived concentration guides (DCGs); a DCG is the concentration of a particular radionuclide that would provide an effective dose equivalent of 100 mrem/yr, DOE's primary dose limit, to an individual continuously inhaling the radionuclide for an entire year. Concentrations of thorium-232 measured by area air particulate monitors ranged from $7.8 \times 10^{-7}$ to $1.8 \times 10^{-5}$ pCi/L. The DCG is $1.0 \times 10^{-5}$ pCi/L for thorium-232. Even though the DCG was exceeded for one eight-hour period, a person would have to be exposed to the thorium-232 DCG continuously for one year to receive a dose greater than the 100-mrem/yr guideline. Because this remediation lasted only one month and measurements were collected over an 8-h period, no excess risk was presented to the public.

# 4.0 POST-REMEDIAL ACTION MEASUREMENTS

After each portion of the property was decontaminated, a radiological survey of that area was conducted to confirm that all radioactive contamination above the cleanup criteria (Table 2-1) had been removed. Initial post-remediation surveys were conducted by TN on behalf of BNI. Survey techniques including walkover gamma scans, external gamma radiation exposure rate measurements, and soil sampling were conducted as specified in the "Post-Remedial Action Survey Plan for the Maywood Vicinity Properties" (BNI 1995b). ORNL, as the IVC, performed independent verification surveys of the remediated areas using similar or identical survey techniques. The IVC survey data and conclusions will be issued as a separate report by ORNL.

As excavation proceeded in exterior areas, walkover surface scans were conducted to determine whether all soil that was radioactively contaminated in excess of DOE remedial action guidelines had been removed from the remediated areas. An Eberline SPA-3 gamma scintillation detector was used for the surveys. The walkover survey provided immediate feedback so that additional excavation could be performed if residual contamination appeared to exceed remedial action guidelines. Soil samples were also collected throughout the excavation and analyzed at the Wayne laboratory. The sample analysis provided an additional check on the surface scans. The area was scanned after each lift of soil was removed to verify that the contamination had been removed.

External gamma radiation exposure rates were measured with a PIC at 1 m (3 ft) above the ground surface in each remediated area. Readings taken at this height provide an estimate of the potential exposure from external gamma radiation to the critical body organs. PIC readings are compared with the background exposure rate (9.0 $\mu$R/h) established for the area.

Composite post-remediation soil samples were also taken from the excavated areas and analyzed to determine the radionuclide concentrations in the remaining soil before the excavations were backfilled. Samples were composited to provide samples representative of each 100-$m^2$ (1,076-$ft^2$) area remediated as specified in the "Post-Remedial Action Survey Plan for the Maywood Vicinity Properties" (BNI 1995b). All soil results presented in the tables include the background levels of each radioisotope. Soil sampling was the primary method used to confirm that all radioactive contamination exceeding DOE cleanup guidelines had been removed. Soil samples were analyzed using gamma spectroscopy.

In the tables included in this section, use of the "less than" (<) notation in reporting survey results indicates that radioactivity was not present at levels that were quantifiable with the instruments and techniques used. Each "less than" value represents the lower limit of the quantitative capacity of the instrument and technique and depends on various factors, including the type of detector used, the counting time, and the background count rate. The actual level of radioactivity is less than the value preceded by the "less than" symbol.

## 4.1 79 AVENUE B

Figure 4-1 shows the area of proposed excavation at 79 Avenue B based on 1992 characterization data gathered before excavation. Figure 4-2 shows the locations of external gamma exposure rate measurements, soil sampling locations, and areas of excavation at 79 Avenue B. The actual area of excavation is smaller than the proposed area of excavation because additional data gathered just before excavation indicated that the area of contamination was smaller than indicated by the 1992 data. Additional data were collected to support remedial design and planning for remedial action.

The area shown in Figure 4-1, which extends beneath and south of the shed, was delineated on the basis of one surface soil sample with a thorium-232 result of 5.6 pCi/g, including background. Because this result almost exceeded the soil criteria, the area was designated for further investigation (BNI 1992).

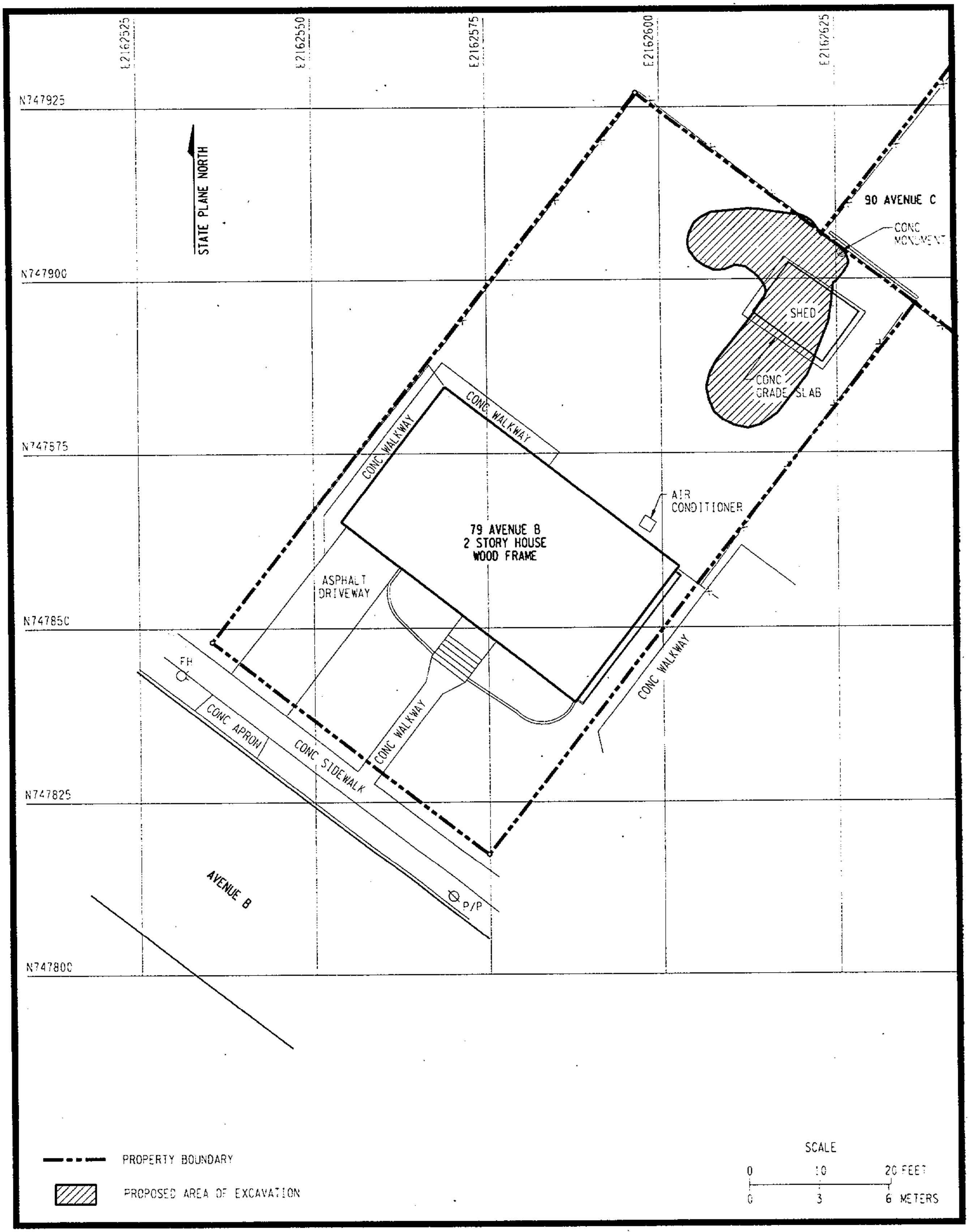
The preconstruction walkover survey showed no elevated radiation readings in this area. Surface soil samples were collected in the area beneath and south of the shed (the shed was removed). The results showed no residual radioactive material present above criteria.

Table 4-1 presents the results of the post-remedial action soil analyses, and Table 4-2 lists the external gamma radiation exposure rates. Only one post-remedial action sample was collected from 79 Avenue B because of the small area of contamination.

The result of thorium-232 analysis of the soil sample at 79 Avenue B was 3.85 pCi/g, the radium-226 result was 0.52 pCi/g, the uranium-238 result was less than 3.32 pCi/g, and the sum of the ratios was 0.542. These results are below the cleanup criteria presented in Table 2-1. The two exposure rates measured at 79 Avenue B were 10.2 $\mu$R/h and 10.1 $\mu$R/h. These values are comparable to the average background exposure rate of 9.0 $\mu$R/h; hence, any exposure to the public would be essentially indistinguishable from background.

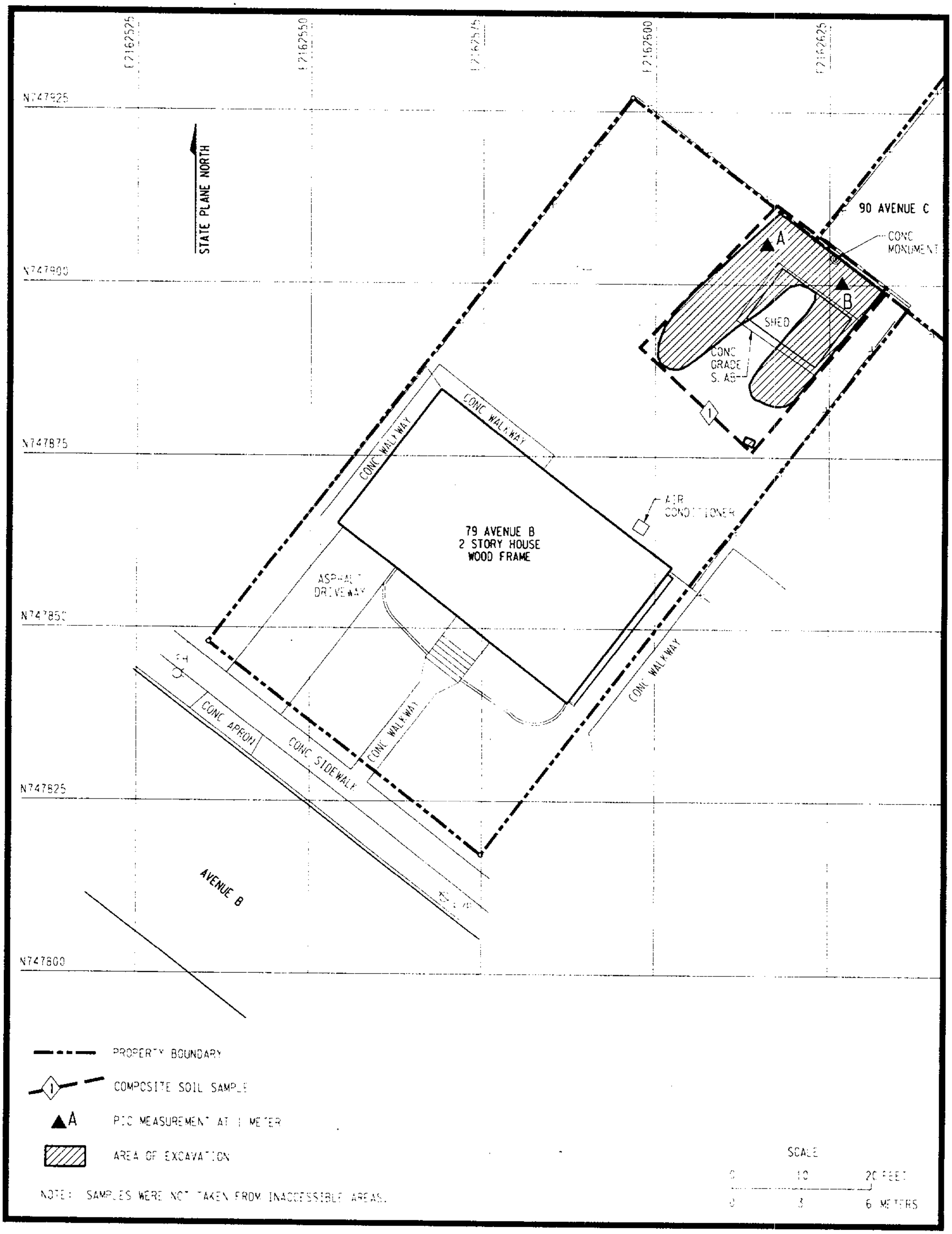
## 4.2 90 AVENUE C

Figure 4-3 shows the area of proposed excavation at 90 Avenue C based on 1992 characterization data gathered before excavation. External gamma exposure rate measurement locations and post-remedial action soil sampling locations at 90 Avenue C are shown in Figure 4-4. The area of excavation shown in Figure 4-4 is larger than was proposed. The additional excavation occurred because radioactive contamination extended beneath the driveway. No soil samples had been collected from this area previously (BNI 1992). During remediation, test pits were dug north of the area of excavation to ensure that the radioactive contamination did not extend any further under the driveway.




138F211.DGN

**Figure 4-1**
**79 Avenue B**
**Pre-Remedial Action Area of Suspected Contamination**




R77F008.DGN

Figure 4-2
79 Avenue B
Areas of Excavation and Post-Remedial Action Soil Sampling Locations

## Table 4-1

### Post-Remedial Action Radionuclide Concentrations at Maywood Vicinity Properties

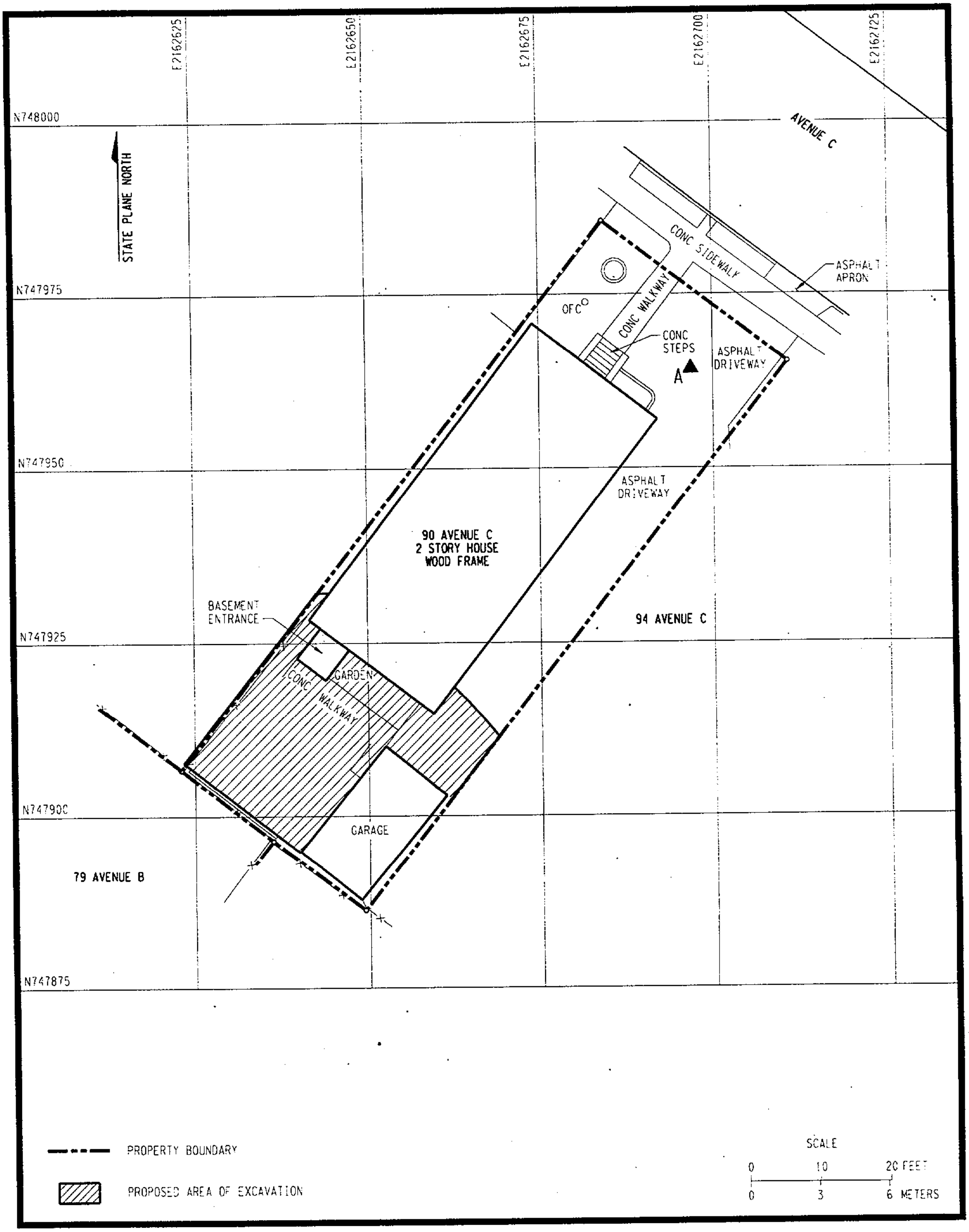
| Property | Sample Number | Concentration (pCi/g±2 sigma)[a] Thorium-232 | Radium-226 | Uranium-238 | Sum of Ratios[b] |
|---|---|---|---|---|---|
| 79 Ave B | 138RS120 | 3.85±0.206 | 0.52±0.095 | <3.32[c] | 0.542 |
| 90 Ave C | 138RS143 | 1.01±0.099 | 0.50±0.059 | <2.2[c] | -0.052 |
| | 138RS145 | 1.22±0.108 | 0.46±0.062 | <2.24[c] | -0.017 |
| 108 Ave E | 138RS160 | 3.48±0.180 | 0.51±0.082 | 4.89±1.19 | 0.498 |
| | 138RS162 | 2.88±0.167 | 0.59±0.078 | 2.82±1.07 | 0.352 |
| 112 Ave E | 138RS161 | 2.07±0.199 | 0.63±0.115 | <4.11[c] | 0.224 |
| | 138RS166 | 1.35±0.113 | 0.48±0.064 | <2.33[c] | 0.015 |
| | 138RS180 | 3.06±0.161 | 0.58±0.075 | <3.05[c] | 0.391 |
| | 9[d] | 9.56 | 0.93 | 9.11 | |
| 113 Ave E | 138RS146 | 3.45±0.173 | 0.61±0.076 | <3.31[c] | 0.480 |
| | 138RS147 | 1.85±0.120 | 0.64±0.068 | <2.52[c] | 0.150 |
| | 138RS148 | 1.97±0.143 | 0.48±0.076 | <3.03[c] | 0.153 |
| | 138RS149 | 2.33±0.107 | 0.56±0.052 | 1.59±0.672 | 0.212 |
| | 138RS154 | 3.17±0.172 | 0.67±0.080 | <3.24[c] | 0.435 |
| | 138RS157 | 2.18±0.150 | 0.53±0.073 | <2.94[c] | 0.203 |
| | 138RS175 | 0.87±0.091 | 0.53±0.060 | <2.11[c] | -0.076 |
| | 138RS175A | 0.83±0.082 | 0.44±0.052 | <1.95[c] | -0.105 |

[a]Results include background (1.0 pCi/g thorium-232, 0.7 pCi/g radium-226, and 2.9 pCi/g uranium-238).
[b]The sum of the ratios was less than 1 for each of these properties.
[c]The actual level of radioactivity is less than the value preceded by the "less than" (<) symbol.
[d]Results listed are calculated average concentrations of four samples collected from a hot spot with an approximate area of 4.9 m$^2$ on 112 Avenue E.

Table 4-2
Post-Remedial Action Gamma Radiation Exposure Rates for the Maywood Properties

| Coordinates | | Location | Exposure Rate |
|---|---|---|---|
| East | North | | (μR/h)[a] |
| 79 Avenue B [Figure 4-2] | | | |
| 2162616 | 747906 | A | 10.2 |
| 2162627 | 747900 | B | 10.1 |
| 90 Avenue C [Figure 4-4] | | | |
| 2162697 | 747964 | A | 9.2 |
| 2162678 | 747931 | B | 9.0 |
| 2162643 | 747910 | C | 8.8 |
| 108 Avenue E [Figure 4-6] | | | |
| 2163009 | 748344 | A | 8.4 |
| 2163017 | 748353 | B | 8.8 |
| 2163020 | 748337 | C | 9.2 |
| 2163035 | 748346 | D | 9.2 |
| 2162994 | 748294 | E | 8.2 |
| 2162973 | 748282 | F | 7.8 |
| 2162967 | 748296 | G | 8.2 |
| 2162978 | 748321 | H | 8.2 |
| 112 Avenue E [Figure 4-8] | | | |
| 2162994 | 748266 | A | 7.8 |
| 2163014 | 748284 | B | 8.2 |
| 2163017 | 748243 | C | 8.1 |
| 2163043 | 748273 | D | 8.3 |
| 2163020 | 748269 | E | 8.5 |
| 2163015 | 748262 | F | 8.4 |
| 2163052 | 748272 | G | 9.4 |
| 2163073 | 748306 | H | 9.9 |
| 2163083 | 748320 | I | 10.6 |
| 2163046 | 748308 | J | 9.0 |
| 2163057 | 748327 | K | 9.2 |
| 113 Avenue E [Figure 4-10] | | | |
| 2163073 | 748370 | A | 10.5 |
| 2163088 | 748392 | B | 8.6 |
| 2163107 | 748378 | C | 9.1 |
| 2163088 | 748359 | D | 10.3 |
| 2163125 | 748364 | E | 8.8 |
| 2163142 | 748386 | F | 8.8 |
| 2163139 | 748405 | G | 8.7 |
| 2163161 | 748420 | H | 8.5 |
| 2163145 | 748433 | I | 8.3 |
| 2163129 | 748442 | J | 8.1 |
| 2163125 | 748427 | K | 8.0 |
| 2163109 | 748415 | L | 9.3 |

[a]Results include background.




138F212.DGN

**Figure 4-3**
**90 Avenue C**
**Pre-Remedial Action Area of Suspected Contamination**

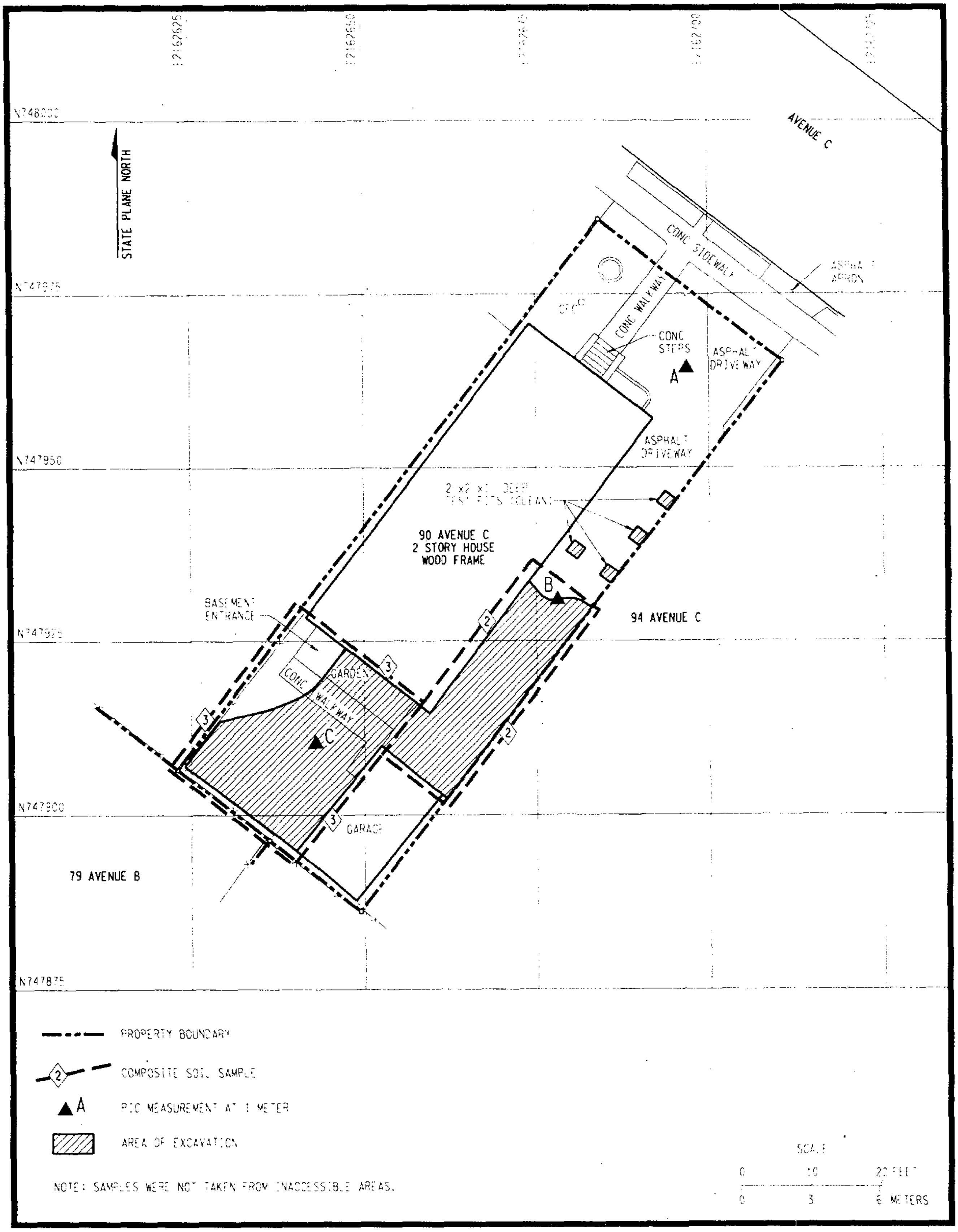



Figure 4-4
90 Avenue C
Areas of Excavation and Post-Remedial Action Soil Sampling Locations

No residual radioactive material above criteria is present underneath the house at 90 Ave C. The contaminated area was removed during the time-critical removal action performed in 1991 (BNI 1993).

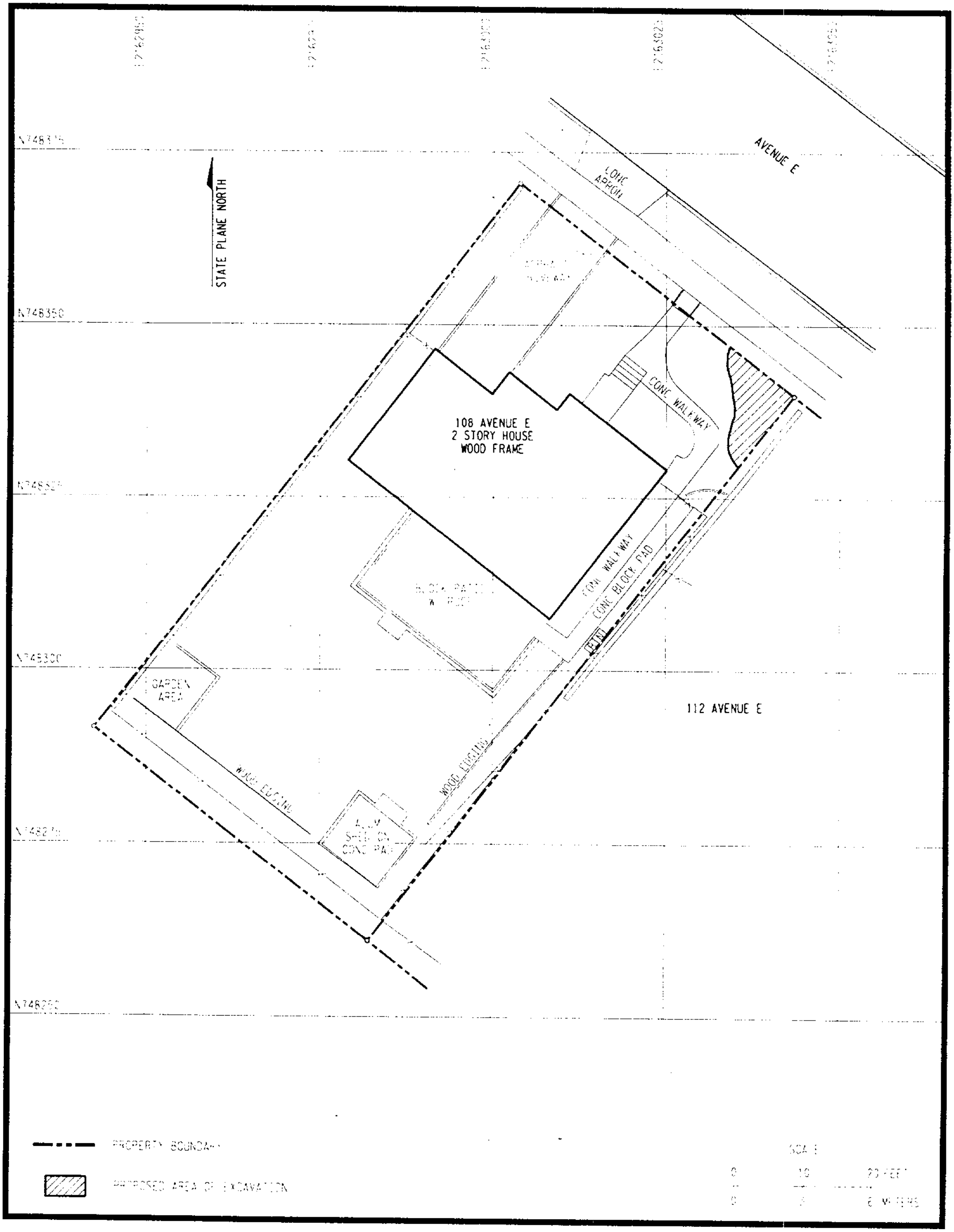
Table 4-1 presents soil analysis results, and Table 4-2 lists gamma radiation exposure rates for this property. Two post-remedial action soil samples were collected from this vicinity property and analyzed for thorium-232, radium-226, and uranium-238. The results for thorium-232 showed concentrations of 1.01 and 1.22 pCi/g; both results are below the cleanup criteria. The results for radium-226 were 0.50 pCi/g and 0.46 pCi/g and were both below cleanup criteria. The uranium-238 results, less than 2.20 pCi/g and less than 2.24 pCi/g, were also below cleanup criteria. Because both radium-226 and uranium-238 were present at background concentrations, both of the sum of the ratio calculations were zero and thus below the cleanup criterion of 1.00. At this property, three gamma exposure rate measurements ranged from 8.8 to 9.2 $\mu$R/h, with an average of 9.0 $\mu$R/h, including background. This is comparable to the background exposure rate of 9.0 $\mu$R/h. Hence, any exposure to the public would be essentially equivalent to background.

### 4.3 108 AVENUE E

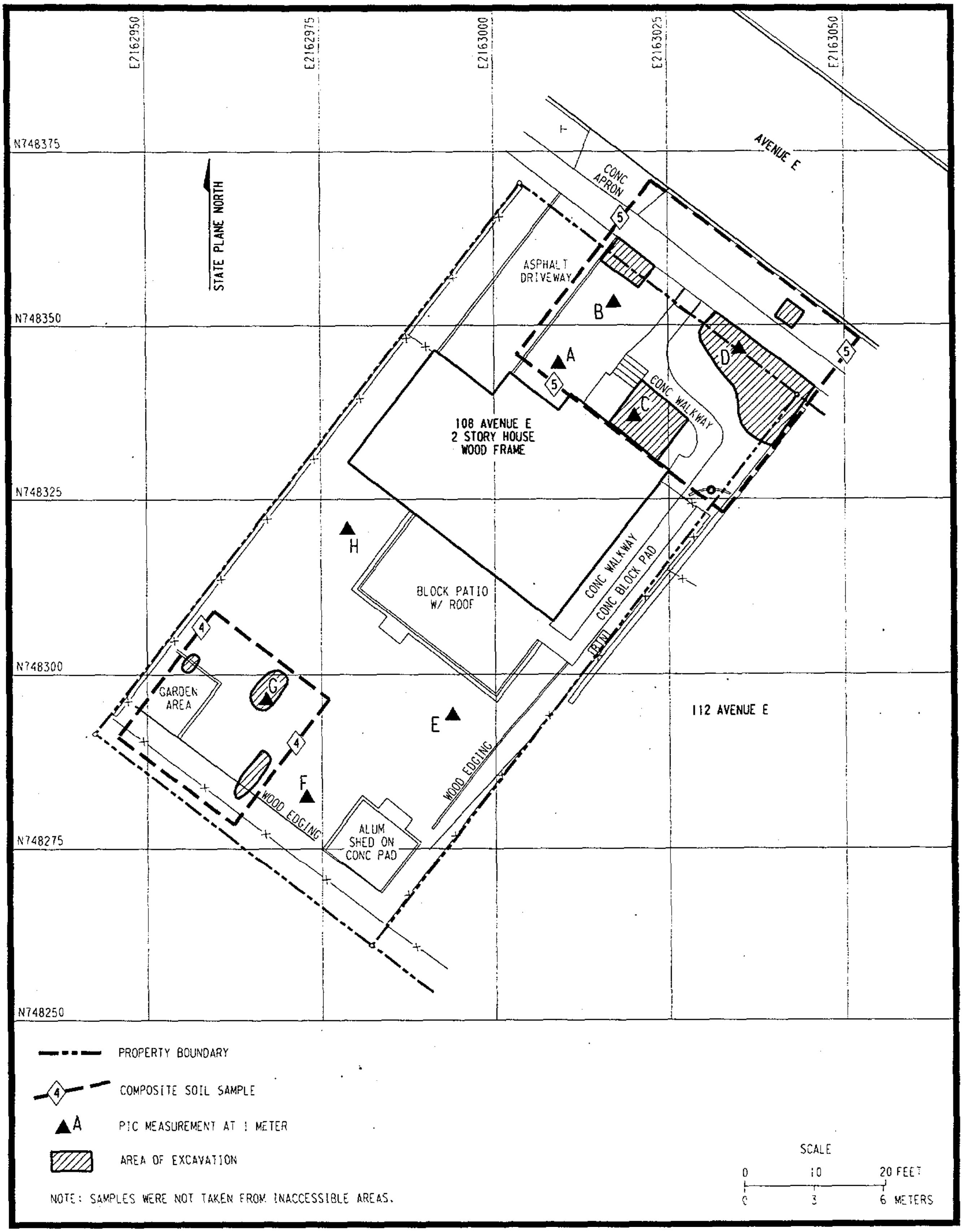
Figure 4-5 shows the area of proposed excavation at 108 Avenue E based on characterization data gathered before excavation. Figure 4-6 shows where external gamma exposure rate measurements and post-remedial action soil sampling were conducted at 108 Avenue E. Several additional areas of excavation shown in Figure 4-6 are not indicated in Figure 4-5. It is possible that human disturbance is responsible for the differences in contaminant distributions. The pre-construction soil samples and walkover surveys indicated levels of radioactivity that were very close to the cleanup criterion, but did not exceed it. These areas were remediated to ensure that all residual radioactive material above criteria was removed.

Most of the area proposed for excavation in the northeastern corner of the property did not have elevated radiation readings during the pre-construction walkover survey and, therefore, was not excavated.

Table 4-1 presents the results of post-remedial action soil analyses, and Table 4-2 presents the post-remedial external gamma exposure rate measurements. Two post-remedial action soil samples were collected from this vicinity property and analyzed for thorium-232, radium-226, and uranium-238. The results showed thorium-232 concentrations of 3.48 and 2.88 pCi/g, radium-226 results of 0.51 and 0.59 pCi/g, uranium-238 results of 4.89 and 2.82 pCi/g, and sum of ratio results of 0.498 and 0.352. All results are below the cleanup criteria. At this property, eight external gamma exposure rate measurements ranged from 7.8 to 9.2 $\mu$R/h, with an average of 8.5 $\mu$R/h, including background. This is comparable to the average background external




# Figure 4-5
108 Avenue E
Pre-Remedial Action Area of Suspected Contamination




R77F011.DGN

**Figure 4-6**
**108 Avenue E**
**Areas of Excavation and Post-Remedial Action Soil Sampling Locations**

gamma exposure rate of 9.0 $\mu$R/h. Hence, any exposure to the public would be indistinguishable from background.

## 4.4 112 AVENUE E

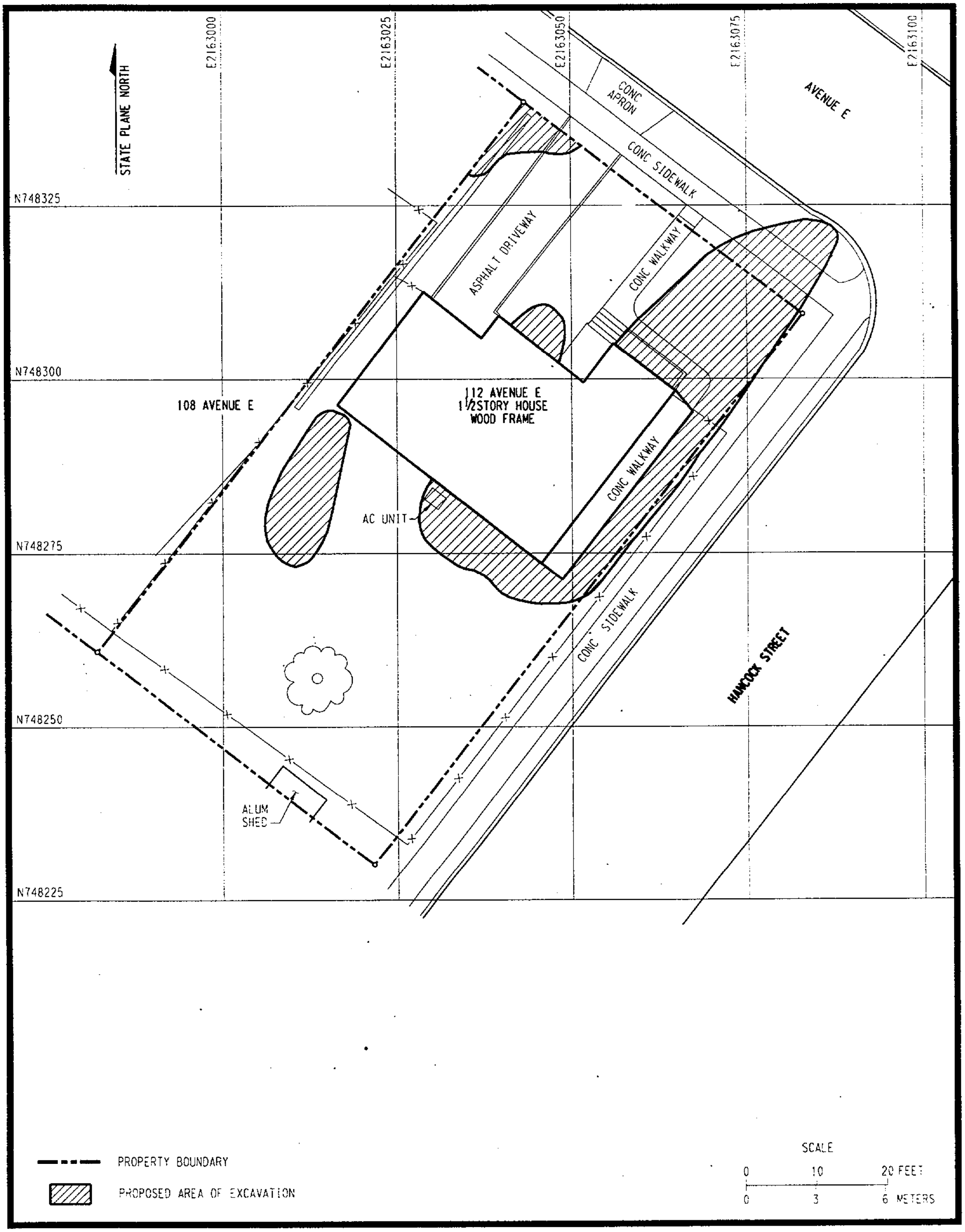
Figure 4-7 shows the area of proposed excavation at 112 Avenue E based on 1992 characterization data gathered before excavation. Locations of external gamma exposure rate measurements and post-remedial action soil sampling at 112 Avenue E are shown in Figure 4-8. A comparison of Figures 4-7 and 4-8 reveals differences in three areas of excavation. They are the long strip of excavation near the northwestern border of the property, the reduced excavation in the front yard, and the area under the tree in the backyard.

The strip near the northwestern border of the property was an area of marginally high radiation readings found during the pre-remedial action walkover survey. The area was excavated to ensure that there was no residual radioactive material above guidelines.

The area in the front yard that was not excavated was originally delineated as contaminated based on three contaminated surface soil samples (BNI 1992). Typically, when a pattern of contaminated samples such as this is encountered during characterization, the conservative assumption is made that the entire area between the samples is contaminated. This assumption was applied to this area on 112 Ave E. However, a more detailed investigation revealed that the samples actually represented small, isolated areas of contamination; therefore, only these areas were excavated.

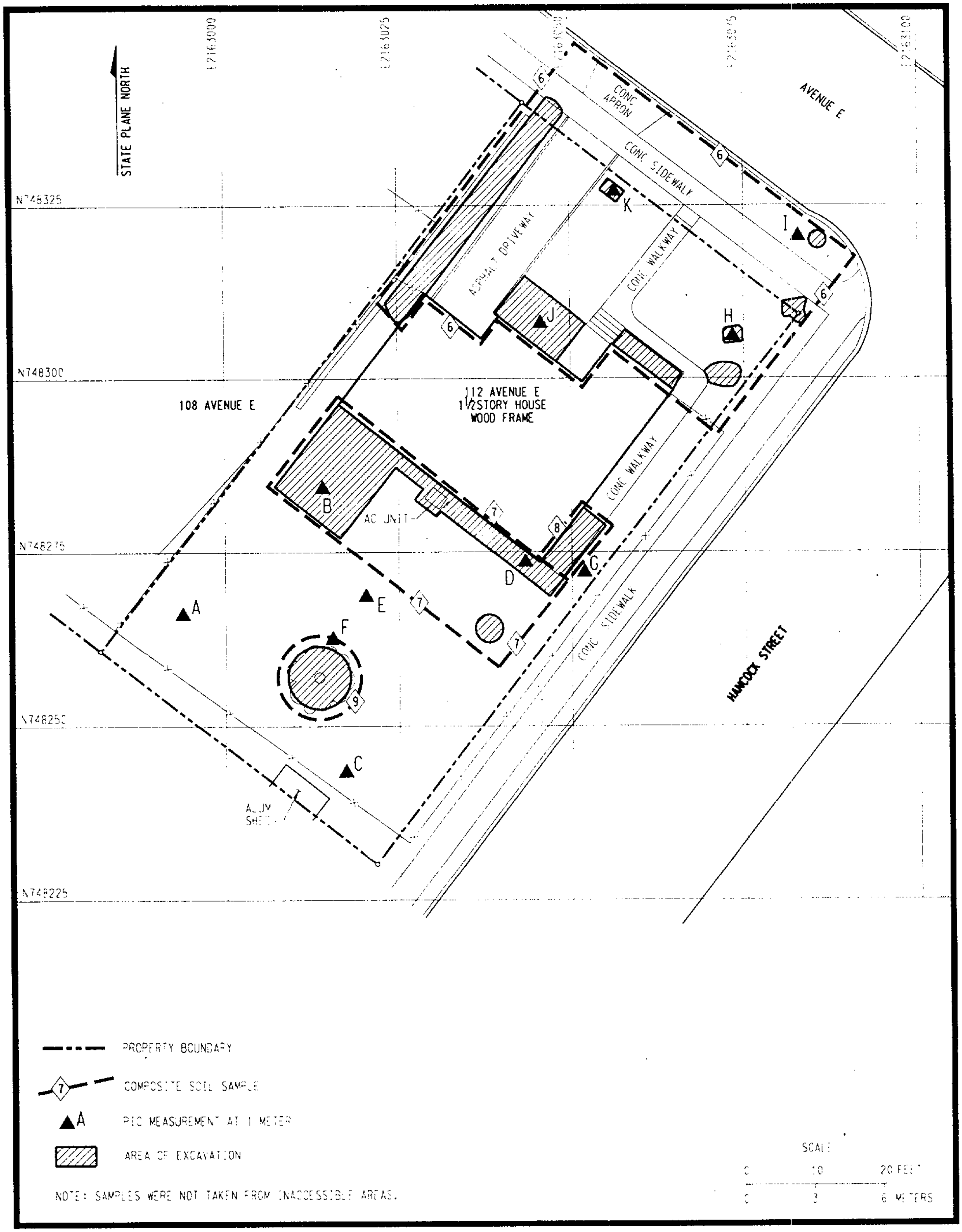
Table 4-1 presents the results of soil analyses, and Table 4-2 lists external gamma radiation exposure rates. Analyses of three post-remedial action soil samples from this vicinity property revealed thorium-232 levels ranging from 1.35 to 3.06 pCi/g, with an average of 2.16 pCi/g; radium-226 levels ranging from 0.48 to 0.63 pCi/g, with an average of 0.56 pCi/g; uranium-238 levels ranging from less than 2.33 to less than 4.11 pCi/g, with an average of 3.16 pCi/g; and sums of the ratios ranging from 0.015 to 0.391, with an average of 0.210; these results are below the cleanup criteria presented in Table 2-1. Eleven external gamma exposure rates measured at this property ranged from 7.8 to 10.6 $\mu$R/h; the average was 8.9 $\mu$R/h, including background. This is comparable to the average background exposure rate of 9.0 $\mu$R/h. Hence, any exposure to the public would be essentially equivalent to background.

As shown in Figure 4-8, sample 9 represents the area underneath a large tree in the backyard of 112 Avenue E (see footnote d in Table 4-1). A surface soil sample collected during the 1992 characterization near the tree in the backyard had a thorium-232 concentration of 0.6 pCi/g; thus, the area was not delineated for remediation. Radiation in the area around the tree was determined during the pre-construction walkover survey to be slightly elevated, and excavation was initiated. The levels of contamination discovered increased as the excavation




138F214.DGN

Figure 4-7
112 Avenue E
Pre-Remedial Action Area of Suspected Contamination




R77F012.CON

Figure 4-8
112 Avenue E
Areas of Excavation and Post-Remedial Action Soil Sampling Locations

progressed. All material above criteria was removed from the exposed roots except for a small inaccessible area beneath the tree. This material could not be excavated without uprooting the tree altogether. In these situations, DOE Order 5400.5 allows areas less than 25 $m^2$ (hot spots) to exceed the DOE residual contamination guideline by a factor of $(100/A)^{0.5}$, where A is the area in square meters. Four samples were collected from the inaccessible area under the tree. The thorium-232 concentrations ranged from 4.62 to 16.3 pCi/g, with an average concentration of 9.56 pCi/g, and the area was estimated to be 2.5 m in diameter. Therefore, the allowable concentration based on hot spot criteria is 22.6 pCi/g. None of the sample concentrations exceeded this level. Four of the 11 external gamma exposure rates measured at this property were in the backyard near the tree. These measurements ranged from 7.8 to 8.5 $\mu$R/h and are below the average background level for the area. Hence, any exposure to the public would be essentially equivalent to background.

### 4.5 113 AVENUE E

Figure 4-9 shows the area of proposed excavation at 113 Avenue E based on characterization data gathered before excavation. Figure 4-10 shows external gamma exposure rate measurement locations and post-remedial action soil sampling locations at 113 Avenue E. Several additional areas were excavated in addition to the proposed areas of excavation at 113 Avenue E. Specifically, there were areas in the backyard that had not been identified in the walkover survey or soil sampling during the 1992 characterization but were found by the pre-excavation walkover survey and soil sampling to be contaminated. It is possible that human disturbance is responsible for the differences in contaminant distributions.

At 113 Avenue E, most of the larger areas of excavation in the front and side yards corresponded to the areas that were proposed for excavation in 1992. The only area that differed significantly was in the southwestern corner of the front yard around the sidewalk. Two surface soil samples in this area collected during the original characterization were contaminated. The area shown in Figure 4-9 was delineated by conservatively assuming that the surface soil between the two samples was contaminated. However, the pre-construction walkover and sampling indicated two small spots of residual radioactive material above criteria.

It is possible that the radioactive contamination present in this area during the original characterization had since been inadvertently spread over the property. This would account for the absence of the large area of radioactive contamination in the front yard and the presence of numerous smaller areas of residual radioactive material in the back yard.

The results of soil analyses are provided in Table 4-1, and Table 4-2 lists gamma radiation exposure rates. Eight soil samples from this vicinity property contained thorium-232 at levels ranging from 0.83 to 3.45 pCi/g, with an average of 2.08 pCi/g; radium-226 at levels ranging from 0.44 to 0.67 pCi/g, with an average of 0.56 pCi/g; uranium-238 at levels ranging from

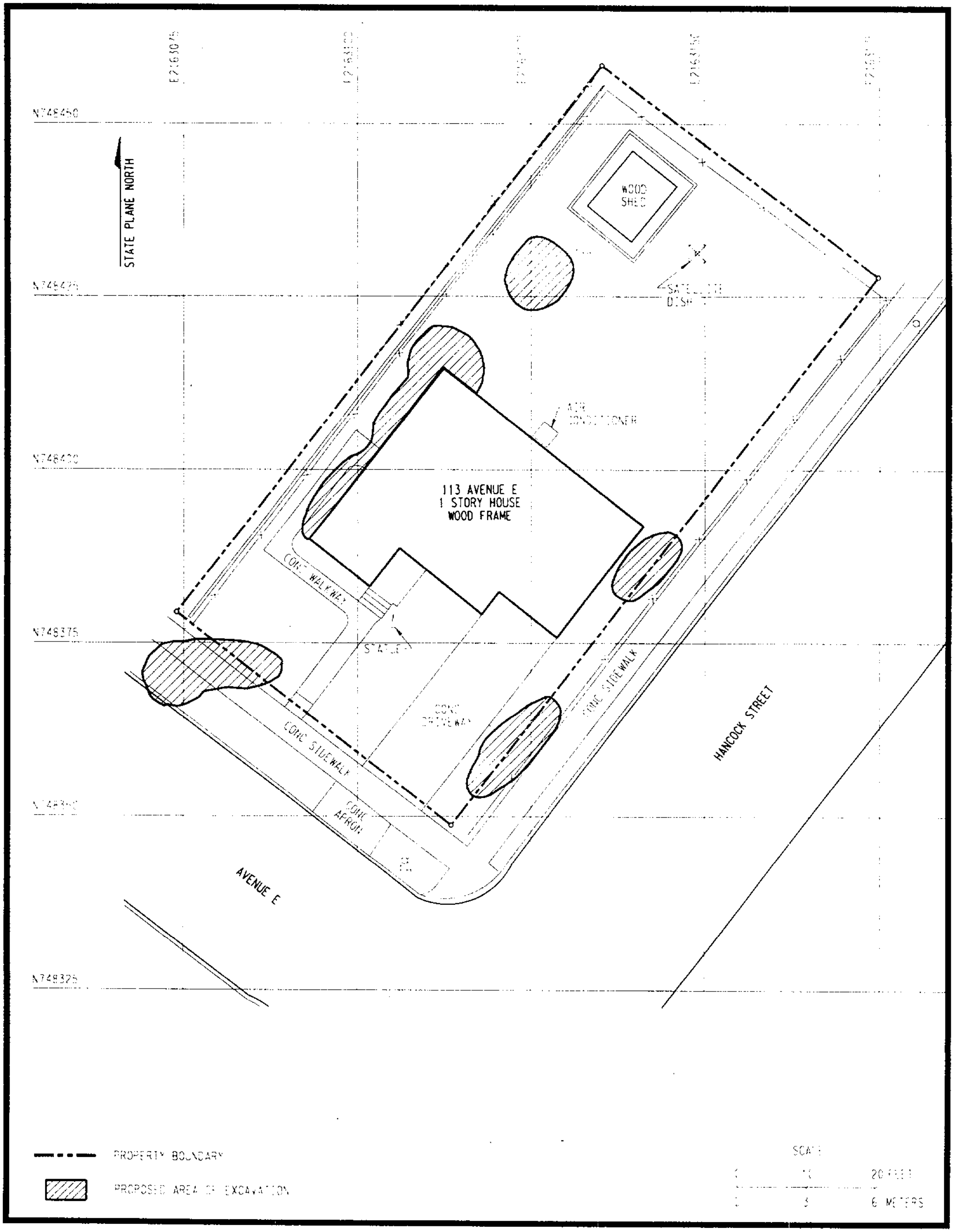



Figure 4-9
113 Avenue E
Pre-Remedial Action Area of Suspected Contamination

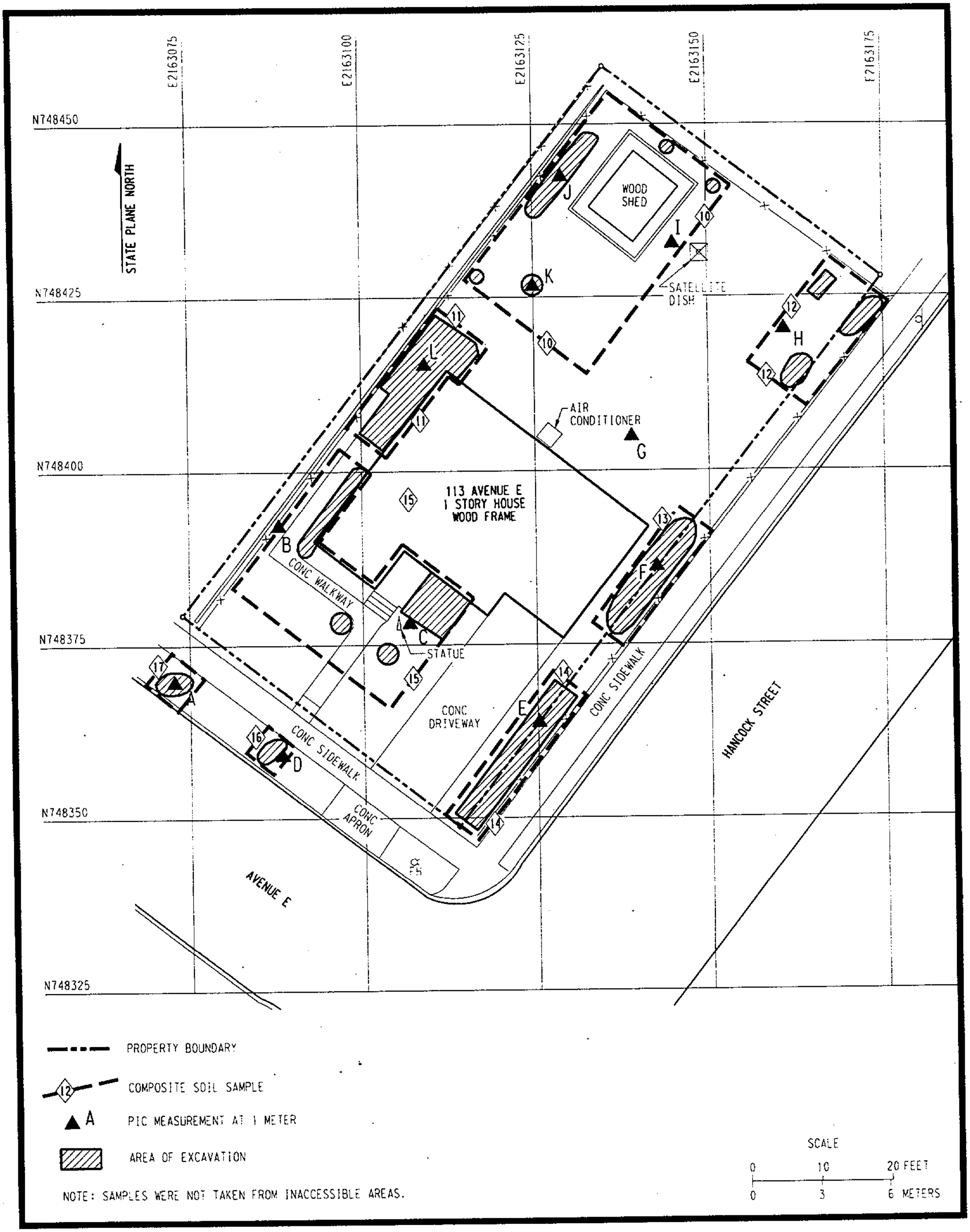



**Figure 4-10**
**113 Avenue E**
**Areas of Excavation and Post-Remedial Action Soil Sampling Locations**

1.59 to 3.31 pCi/g, with an average of 2.58 pCi/g;  and sums of the ratios ranging from less than 0 to 0.480, with an average of 0.182; these results are below the cleanup criteria in Table 2-1. Twelve gamma exposure rates measured at 113 Avenue E ranged from 8.0 to 10.5 $\mu$R/h; the average was 8.9 $\mu$R/h, including background. This is comparable to the background exposure rate of 9.0 $\mu$R/h. Hence, any exposure to the public would be essentially equivalent to background.

# 5.0 POST-REMEDIAL ACTION STATUS

Analytical results of post-remedial action surveys indicate that the levels of radioactivity in the remediated areas are in compliance with applicable DOE cleanup guidelines for radioactive contamination. The IVC reviewed the post-remedial action surveys and results to determine whether the measurements obtained verify that these areas comply with the established DOE guidelines for the site.

The IVC is responsible for preparing a plan outlining the procedures used in conducting verification activities. These procedures specify a verification process requiring two methods of review (Types A and B). The IVC conducted both types, in full conformance to the approved verification plan.

Type A verification consisted of reviewing the post-remedial action survey results and collecting and analyzing additional samples as required. In performing the Type B verification review, the IVC conducted a survey of the site that included direct measurements, review of the post-remedial action survey methods and results, sampling, and laboratory analysis of separate soil samples.

After completing the verification study, the IVC will report its findings and recommendations to DOE Headquarters and the DOE Oak Ridge Operations Office. DOE will review the report to verify that the remedial action was successful. The IVC's published verification report will become part of the administrative record file for the Maywood site.

# 6.0 REFERENCES

Bechtel National, Inc. (BNI), 1992. *Remedial Investigation Report for the Maywood Site, Maywood, New Jersey*, DOE/OR/21949-337, Oak Ridge, Tenn. (December).

BNI, 1993. *Post-Remedial Action Report for the Time-Critical Removal Action at 90 Avenue C, Lodi, New Jersey*, DOE/OR/21949-353, Oak Ridge, Tenn. (March).

BNI, 1995a. *Results of Maywood Vicinity Property Data Gap Characterization, Rev. 1*, Technical Memorandum from A. George to M. Redmon, Oak Ridge, Tenn. (August).

BNI, 1995b. "Post-Remedial Action Survey Plan for the Maywood Vicinity Properties," CCN 136204, Oak Ridge, Tenn. (October).

U.S. Department of Energy (DOE), 1990. "Radiation Protection of the Public and the Environment," DOE Order 5400.5, Washington, D.C. (June).

DOE, 1994. "DOE Acceptance of EPA's Proposed Cleanup Levels," Letter from J. La Grone to W. Muszynski (April 13).

Environmental Protection Agency (EPA), 1980. "Standards for Protection Against Uranium Mill Tailings" (April).

Shleien, B., 1992. *The Health Physics and Radiological Health Handbook*, Revised Edition, Scinta Inc., Silver Spring, Maryland.

10 CFR 835, *Occupational Radiation Protection*.

# APPENDIX A RADIATION AT A GLANCE

# RADIATION AT A GLANCE

Of all activities at FUSRAP sites, those associated with radiation receive the most attention. What exactly is radiation and where does it come from? To answer these questions, it is best to start with a few basics.

All matter is made up of extremely small particles called atoms. Atoms contain even smaller particles called protons, neutrons, and electrons. When an atom has a stable mix of protons and neutrons, it is nonradioactive. However, when atoms have too many of either protons or neutrons, these unstable atoms can break apart, or decay, in an attempt to become stable. As atoms decay, energy is released; this released energy is called radiation.

**Sources of Radiation**

Radiation originates from natural events that happen all the time, but it can also be made by man. Most of the radiation people are exposed to occurs naturally. It has always been present, and every person who has ever lived has been exposed to radiation. Although modern technology may seem to have greatly increased the exposure rate, this is not necessarily the case. Exposure to man-made radiation varies greatly based on a given individual's lifestyle choices and medical treatments.

Sources of natural, or background, radiation include internal radiation from food (we all have approximately 500,000 atoms disintegrating in our bodies every minute), cosmic radiation from the sun and from outside the solar system, and terrestrial radiation from rocks, soils, and minerals (Figure A-1). People have no control over the amount of natural radiation around them, and the amount of natural radiation stays about the same over time. The natural radiation present in the environment today is not much different than it was hundreds of years ago. In general, over 80 percent of the radiation the average person is exposed to is from natural sources. Man-made radiation accounts for less than 20 percent of the total; most of it is from medical procedures.

Man-made sources of radiation include consumer products, medical procedures, and the nuclear industry. Some consumer products such as smoke detectors and even porcelain dentures contain radioactive elements. Probably the best-known source of man-made radiation is nuclear medicine. For example, to conduct a brain, liver, lung, or bone scan, doctors inject patients with radioactive compounds and then use radiation detectors to make a diagnosis by examining the resulting image of the organ.

Man-made radioactive materials also include cesium-137 and strontium-90, present in the environment as a result of previous nuclear weapons testing. As with background radiation, exposure to other sources of radiation varies greatly depending on individual choices, such as

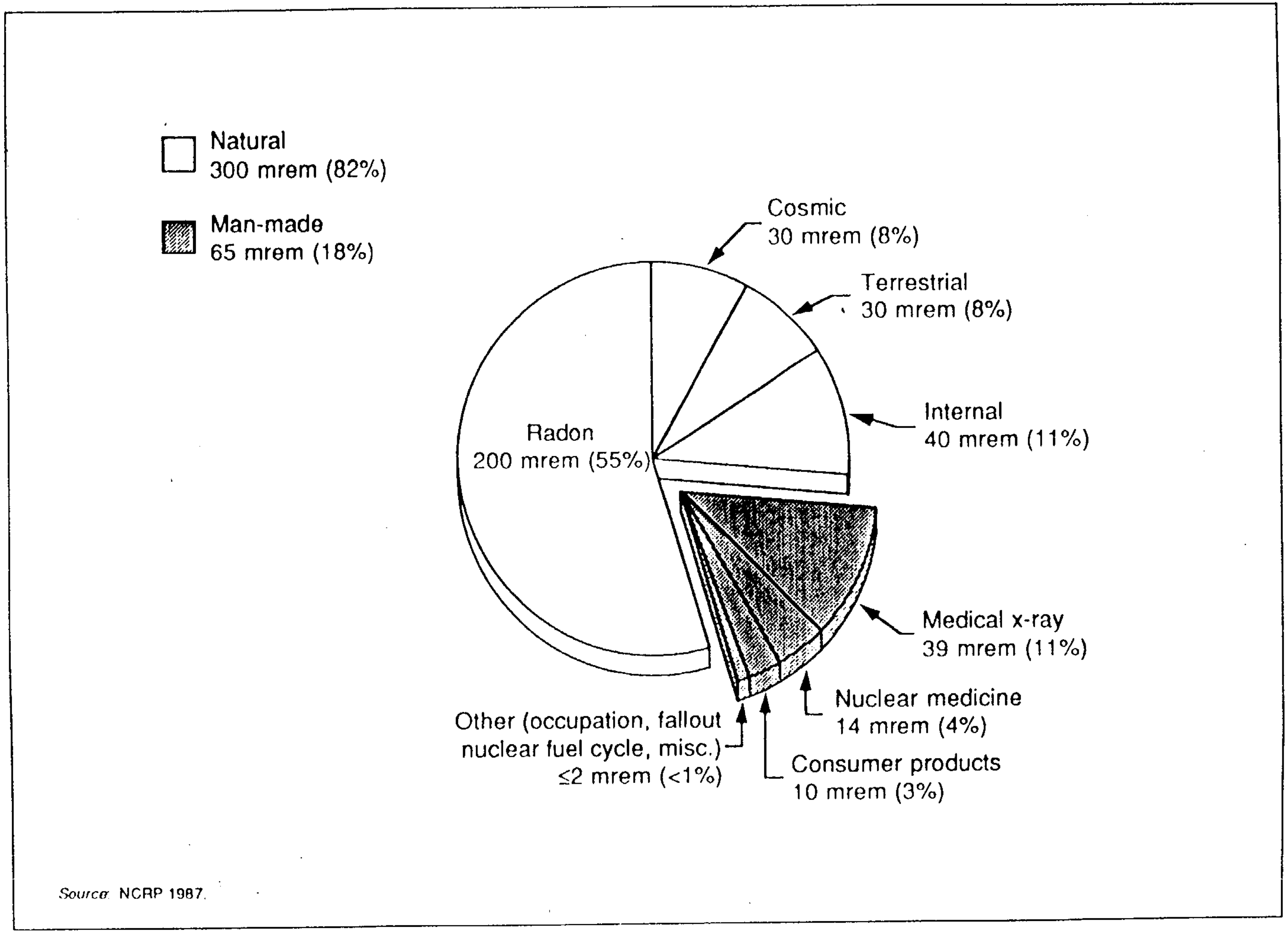



Figure A-1
Typical Annual Radiation Doses from Natural and Man-Made Sources

smoking tobacco products (polonium-210) and eating certain foods (bananas contain potassium-40).

### Levels of Radiation

The average dose caused by background radiation varies widely. In the United States, the average is about 300 mrem/yr; some people in other parts of the world receive a dose more than four times this amount. For example, in some areas of Brazil, doses to inhabitants can be more than 2,000 mrem/yr from background radiation. These wide variations are the result of several factors, most notably the types and amounts of radionuclides in the soil.

This diversity in background radiation is responsible for the large differences in doses. Because people live in areas with high levels of background radiation without proven harm, it is assumed by most in the scientific community that small variations in environmental radiation levels have an inconsequential effect, if any, on humans.

### Measuring Radiation

To determine the possible effects of radiation on the health of the environment and people, these effects must be measured. More precisely, the potential for radiation to cause damage must be ascertained. Measurements of these potential effects are derived from the activity of each isotope and are expressed in terms of the absorbed dose to an individual and the effective dose or potential to cause biological damage.

### Activity

When we measure the amount of radiation in the environment, what is actually being measured is the rate of radioactive decay, or radioactivity, of a given element. This radioactivity is expressed in a unit of measure known as a curie (Ci). A curie is a measure of radioactivity, not a set quantity of material. More specifically, one curie equals 37,000,000,000 ($3.7 \times 10^{10}$) radioactive disintegrations per second. One gram of a radioactive substance may contain the same amount of radioactivity as several tons of another radioactive substance. For example, one gram of tritium (a radioactive form of hydrogen) emits about 10,000 Ci, while one gram of uranium emits about 0.000000333 ($333 \times 10^{-9}$) Ci. Because the levels of radioactive contamination at most FUSRAP sites are very low, the picocurie is commonly used in reporting contaminant levels. One picocurie is equal to $1 \times 10^{-12}$ curies. Contaminants in water are reported in picocuries per liter (pCi/L), and contaminants in soil are reported in picocuries per gram (pCi/g).

## Absorbed Dose

The total amount of absorbed energy per unit mass as a result of exposure to radiation is expressed in a unit of measure known as a rad. However, in terms of human health, it is the relative effectiveness of the absorbed energy in causing biological damage that is important, not the actual amount of energy absorbed.

## Dose Equivalent

The absorbed dose needed to achieve a given level of biological damage is different for different kinds of radiation. To allow for the different biological effectiveness of different kinds of radiation, the concept of dose equivalent is used. The dose equivalent is the product of the absorbed dose and a dimensionless quality factor. The unit of dose equivalent is called the rem (roentgen-equivalent-man). A rem is a fairly large dose; therefore, the most common unit of dose equivalent is the millirem (mrem), or 1/1,000 of a rem. Table A-1 describes some potential health effects over a wide range of radiation doses.

**Table A-1**
**Comparison and Description of Various Dose Levels**

| Dose | Description |
|---|---|
| 1 mrem | Approximate daily dose from natural background radiation, including that due to radon. |
| 2.5 mrem | Cosmic dose to a person on a one-way airplane flight from New York to Los Angeles. |
| 4 mrem | Annual exposure limit set by EPA from manmade radiation in drinking water. |
| 10 mrem | Typical dose from one chest X-ray using modern equipment. |
| 10 mrem | Annual exposure limit, set by EPA, for exposures from airborne emissions (excluding radon) from operations of nuclear fuel cycle facilities, including power plants, uranium mines, and mills. |
| 25 mrem | Annual exposure limit set by EPA from low-level waste-related exposures. |
| 65 mrem | Average yearly dose to people in the United States from man-made sources. |
| 60-80 mrem | Average yearly dose from cosmic radiation to people in the Rocky Mountain states. |
| 83 mrem | Estimate of the largest dose any offsite person could have received from the March 28, 1979, Three Mile Island nuclear accident. |
| 100 mrem | Annual limit of dose from all DOE facilities to a member of the public who is not a radiation worker. |
| 110 mrem | Average occupational dose received by United States commercial radiation workers in 1980. |
| 170 mrem | Average yearly dose to an airline flight crew member from cosmic radiation. |
| 300 mrem | Average yearly dose to people in the United States from all sources of natural background radiation. |
| 900 mrem | Average dose from a lower-intestine diagnostic X-ray series. |
| 1,000-5,000 mrem | EPA's Protective Action Guidelines state that public officials should take emergency action when the dose to a member of the public from a nuclear accident will likely reach this range. |

| | |
|---|---|
| 5,000 mrem | Annual limit for occupational exposure of radiation workers set by the U.S. Nuclear Regulatory Commission and DOE. |
| 8,000 mrem | Average yearly dose to the lungs from smoking 1½ packs of cigarettes per day. |
| 10,000 mrem | The BEIR V report estimated that an acute dose at this level would result in a lifetime excess risk of death from cancer, caused by the radiation, of 0.8 percent. |
| 25,000 mrem | EPA's guideline for voluntary maximum dose to emergency workers for non-lifesaving work during an emergency. |
| 75,000 mrem | EPA's guideline for maximum dose to emergency workers volunteering for lifesaving work. |
| 50,000-600,000 mrem | Doses in this range received over a short period of time will produce radiation sickness in varying degrees. At the lower end of this range, people are expected to recover completely, given proper medical attention. At the top of this range, most people will die within 60 days. |