1722 NJ.4 NJ.4-9

DOE/OR/20722-20

Formerly Utilized Sites Remedial Action Program (FUSRAP)
Contract No. DE-AC05-81OR20722

RADIOLOGICAL SURVEY REPORT FOR THE FORMER MIDDLESEX SAMPLING PLANT

Middlesex, New Jersey

Bechtel Job 14501
Bechtel National, Inc.
Advanced Technology Division

March 1985

Technical Information Center
Office of Scientific and Technical Information
U.S. Department of Energy

LEGAL NOTICE

DOE/OR/20722-20
UC-70A

RADIOLOGICAL SURVEY REPORT

FOR THE

FORMER MIDDLESEX SAMPLING PLANT

MARCH 1985

Prepared for

UNITED STATES DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

Under Contract No. DE-AC05-81OR20722

By

Bechtel National, Inc.

Advanced Technology Division

Oak Ridge, Tennessee

Bechtel Job No. 14501

ABSTRACT

The former Middlesex Sampling Plant (MSP), Middlesex, New Jersey is currently owned by the United States Department of Energy (DOE). It was used from 1943 to 1967 as a sampling and storage facility for uranium and thorium concentrates. During the course of operations, the buildings and grounds at the site became contaminated. In 1980, DOE initiated a multiphase remedial action project to clean up the site and several vicinity properties onto which contamination from the plant had migrated. Material from these properties was consolidated in a storage pile at the MSP during Phases I and II of the project. A decision by DOE regarding the final disposition of the site will be made once the results of an engineering evaluation of disposition alternatives and of other studies required by the National Environmental Policy Act are available.

This report describes the current radiological status of the MSP site as determined by a characterization survey performed to obtain information necessary for the development of the Phase III engineering design. The grounds and the four buildings on-site were surveyed; uranium-238 and radium-226 concentrations exceeded DOE remedial action guidelines. Approximately 69,000 m^3 (91,000 yd^3) of material must be removed for the site to comply with guidelines. This total comprises the following approximate volumes: 13,000 m^3 (17,000 yd^3) of asphalt/gravel and soil from the grounds, 3,650 m^3 (4,775 yd^3) from demolition of the Boiler House and Process Building, and 52,000 m^3 (69,000 yd^3) of contaminated material that is or will be stored on-site. In addition, parts of the Garage and Administration Building must be decontaminated.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

cm	centimeter
cm^2	square centimeter
dpm/cm^2	disintegrations per minute per square centimeter
ft	foot
gal	gallon
ha	hectare
l	liter
m	meter
µR/h	microroentgens per hour
mrad/h	millirads per hour
pCi/g	picocuries per gram
pCi/l	picocuries per liter
pCi/m^3	picocuries per cubic meter
$pCi/m^2/s$	picocuries per square meter per second
yd^3	cubic yards

1.0 INTRODUCTION AND SUMMARY

1.1 INTRODUCTION

A radiological characterization of the former Middlesex Sampling Plant (MSP) was performed by Bechtel National, Inc. (BNI) from April through June 1983. This report describes the procedures used in performing the survey, the results of the survey, and their significance.

The site is located in the Borough of Middlesex, Middlesex County, New Jersey as shown in Figure 1-1. It was designated for remedial action under the United States (U.S.) Department of Energy (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP) responsible for the cleanup of low-level radioactive contamination at former Manhattan Engineer District/Atomic Energy Commission (MED/AEC) sites.

The plant is a DOE-owned facility that was used for sampling and storage of uranium and thorium concentrates from 1943 until 1967. It is currently used for the interim storage of low-level radioactive soils and rubble resulting from remedial action on surrounding properties that had become contaminated as a result of MSP operations. DOE initiated this multiphase remedial action project at the MSP and vicinity properties in 1980. During Phases I and II, contaminated material from vicinity properties was consolidated at two storage piles on the MSP site in order to control migration of contaminants until a final disposition for the site is determined. BNI, the Project Management Contractor for FUSRAP, is performing a preliminary engineering evaluation to assess the alternatives of on-site stabilization of the waste or decontamination and decommissioning of the site. The results of this assessment and of others required by the National Environmental Policy Act will provide the basis for a DOE decision regarding the final disposition of the site.

BNI conducted the 1983 radiological characterization to provide the detailed information necessary for the Phase III engineering

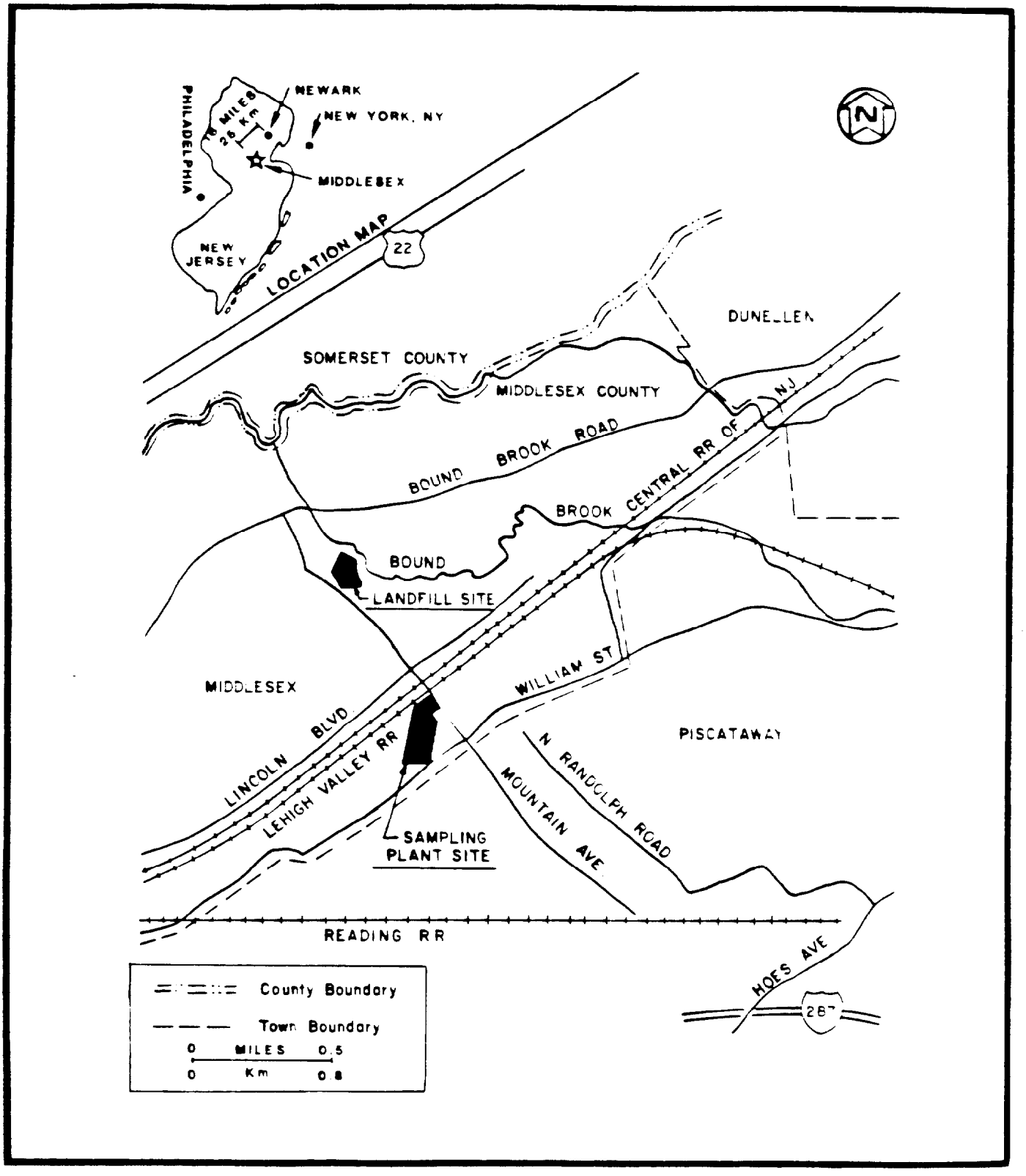


FIGURE 1-1 LOCATION OF THE FORMER MSP

evaluation. The major objectives of the characterization were to determine the boundaries of contamination on the grounds at the site and the extent of contamination in the four buildings remaining there. A further objective was to determine the feasibility of decontaminating these structures.

1.2 SUMMARY

The survey characterized the boundaries and extent of contamination at the former MSP property. It included both horizontal and vertical characterization of the grounds. As illustrated in subsequent figures, areas of surface and subsurface contamination are not identical, indicating that the asphalt with which much of the site has been paved has been contaminated.

The survey also determined the extent of contamination in the four buildings on-site. Surface measurements indicated extensive fixed alpha contamination in the Process Building and the Boiler House. As discussed in Section 5.0, preliminary assessment indicates that it will be necessary to demolish and remove these structures for the site to comply with remedial action guidelines.

Surface measurements obtained in the Garage and the Administration Building identified several areas in each building where contamination exceeds guidelines (Alpha surface limit of 200 dpm/100 cm^2 and beta-gamma dose rates of 1.0 mrad/h in any 100-cm^2 or 0.20 mrad/h averaged over any area not exceeding 1 m^2). It will be necessary to decontaminate these areas.

An estimated 69,000 m^3 (91,000 yd^3) of material must be removed for the site to meet remedial action guidelines. This total comprises the following approximate volumes: 13,000 m^3 (17,000 yd^3) of asphalt/gravel and soil from the grounds; 3,400 m^3 (4,500 yd^3) and 210 m^3 (275 yd^3) from demolition of the Process Building and Boiler House, respectively; 27,500 m^3 (36,000 yd^3) from the storage piles; and approximately 25,000 m^3 (33,000 yd^3) of contaminated material to be transferred to the site from the Middlesex Municipal Landfill.

2.0 SITE HISTORY AND DESCRIPTION

The MSP site is a 3.9-ha (9.6-acre) tract of land with improvements located in the Borough of Middlesex, Middlesex County, New Jersey. Figure 2-1 is an aerial view of the site. From 1943 to 1954, the MSP facility was used to receive and assay uranium ores — primarily "pitchblende", an ore containing high concentrations of uranium and radium. During this period, the buildings and grounds became extensively contaminated due to the manner in which the uranium ore was handled (Ref. 1). The material was reportedly received in burlap bags that were stacked on the bare ground. Some breakage of the bags occurred, ore concentrates spilled out, and subsequent rains led to runoff and leaching of contamination into the soil.

During uranium ore sampling and assay operations, a concrete floor was poured in the Process Building and an asphalt pad, ranging in thickness from 6 in. to 24 in., was placed over the grounds. Little effort was made to remove contaminated soil before concrete or asphalt was laid. However, a limited amount was removed and taken to the Middlesex Municipal Landfill (shown in Figure 1-1).

Uranium ores were assayed and stored at the MSP until 1954 when the new Feed Materials Processing Center at Fernald, Ohio, was completed and took over the operation. Shortly thereafter, the AEC began purchasing large amounts of thorium, most of which was received and sampled at the Middlesex facility. Due to changes in programs, the anticipated uses for the thorium did not develop and the AEC was left with a large stockpile (Ref. 2), which it decided to keep at the plant.

Approximately 11,000,000 kg (5,000,000 lb) of oxide, nitrate, concentrates, sludge, and sand were stored at the site. The thorium content ranged from about 3 percent in the sand to about 55 percent in the oxide (Ref. 3). The material was stored in the Process

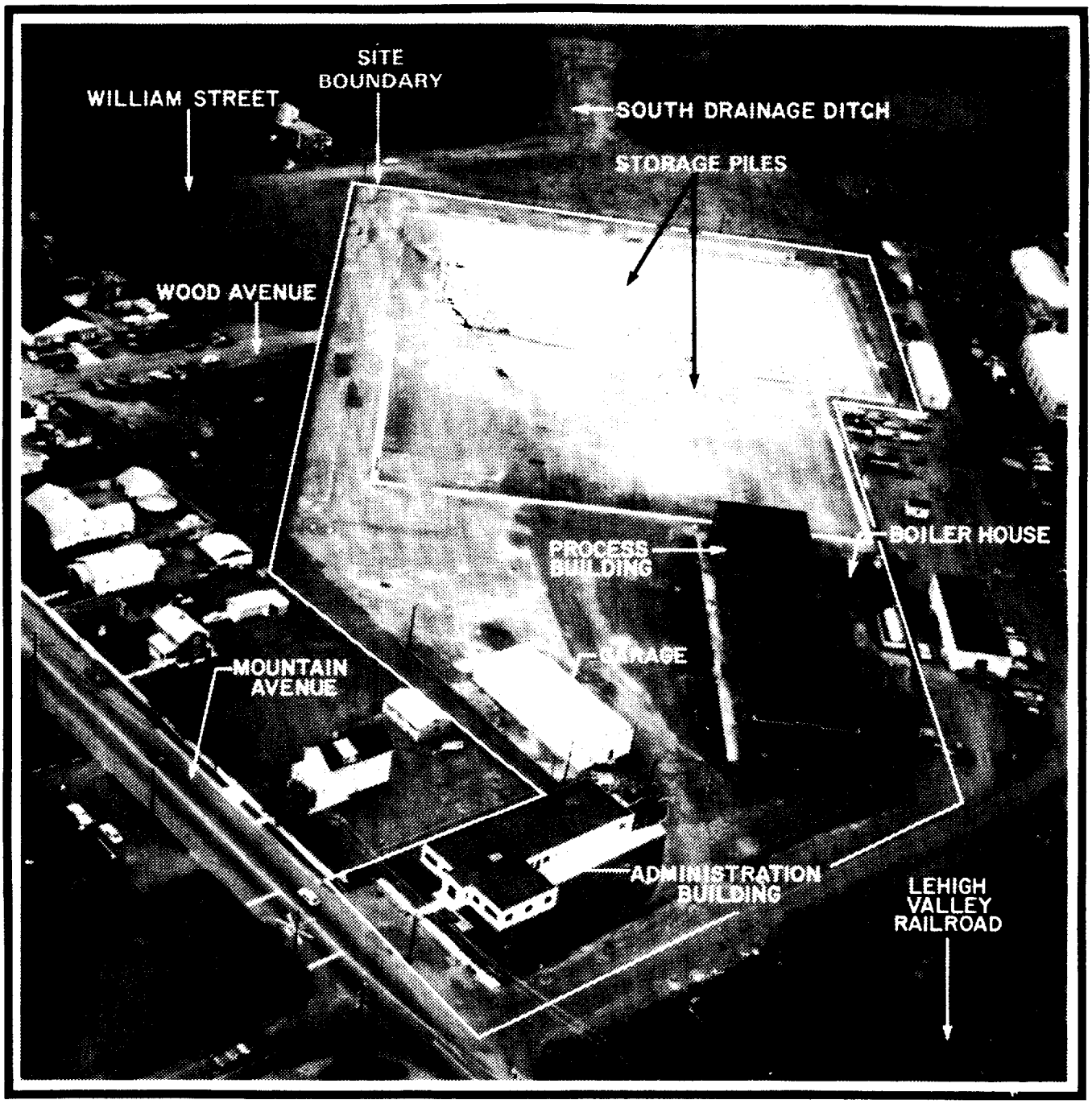


FIGURE 2-1 AERIAL VIEW OF THE FORMER MSP SITE, LOOKING SOUTH

Building and a quonset hut located near the eastern boundary of the site. It was stored in steel, fiber, and plywood drums of 76- to 208-liter (20- to 55-gal) capacity. Some of the drums were moved outside and later deteriorated on the asphalt pad, their contents weathering without containment.

Use of thorium from the Middlesex inventory resumed in September 1964; in January 1966 a decision was made to remove all thorium from Middlesex. This was completed in June of that year (Ref. 4).

In April 1965 health physics personnel from DOE (then AEC) Oak Ridge Operations Office made some preliminary radiological measurements to determine the radiological condition of the site. Uranium and thorium contamination was found on the grounds, in the buildings, and on equipment. Cleanup operations began in 1966 with the removal of most of the equipment and initial decontamination and restoration of the buildings. These operations were completed in 1967 (Refs. 4, 5, and 6) and the site was certified by the AEC for unrestricted release based on existing guidelines.

In 1968 the AEC officially reported the MSP as excess property; the General Services Administration transferred it to the Department of the Navy U.S. Marine Corps, which used it for reserve training until March 1979.

In 1976 the former MSP property was designated a FUSRAP site and was resurveyed to determine whether or not additional remedial action was required (Ref. 7). All private and municipal property in the immediate vicinity was decontaminated and backfilled in 1980 and 1981 during Phases I and II of the Middlesex remedial action program. Residues and rubble were placed in an interim storage pile near the southwest corner of the site (Ref. 8). A smaller storage pile of organic ashes from Phase II incineration operations was created adjacent to the main pile.

3.0 SURVEY PROCEDURES

3.1 FIELD MEASUREMENTS

The current radiological field survey was conducted in accordance with the FUSRAP Radiological Protection Program (Ref. 9), Project Instruction 20.01, Revision 1 and used an extension of the same grid as that used during Phase II. The grid consisted of mutually perpendicular lines spaced 10 m (33 ft) apart as shown in Figure 3-1. In areas of elevated readings, a smaller grid of 2.5 m x 2.5 m (8.2 ft x 8.2 ft) was established by the field survey crew to obtain closely spaced measurements for better definition of the contamination boundaries.

3.1.1 Methods of Measurement

Beta-gamma measurements were made on the ground surface at 2.5-m (8.2-ft) intervals within the grid blocks. The measurements were made using a pancake [Geiger-Mueller (G-M)] geometry probe coupled to a digital ratemeter/scaler [Eberline Instrument Corporation (EIC) models HP-210 and PRS-1, respectively].

Near-surface gamma radiation measurements were made 30 cm (12 in.) above the ground surface at 2.5-m (8.2-ft) intervals within the grid using a 5 cm x 5 cm (2 in. x 2 in.) sodium-iodide (NaI) detector. This detector (EIC model SPA-3) was mounted in a probe assembly surrounded by a conical lead shield to reduce the gamma intensity through the sides, thus producing a downward directional response. The near-surface gamma readings provide a reliable estimate of the concentrations of radium-226 in surface soil.

Gamma exposure rates at 1 m (3 ft) above the ground were measured using a pressurized ionization chamber (PIC) with a response to gamma radiation that is proportional to exposure in roentgens. Readings were made at 5-m (16-ft) intervals above all open area surfaces where the residue piles did not invalidate the measurements.

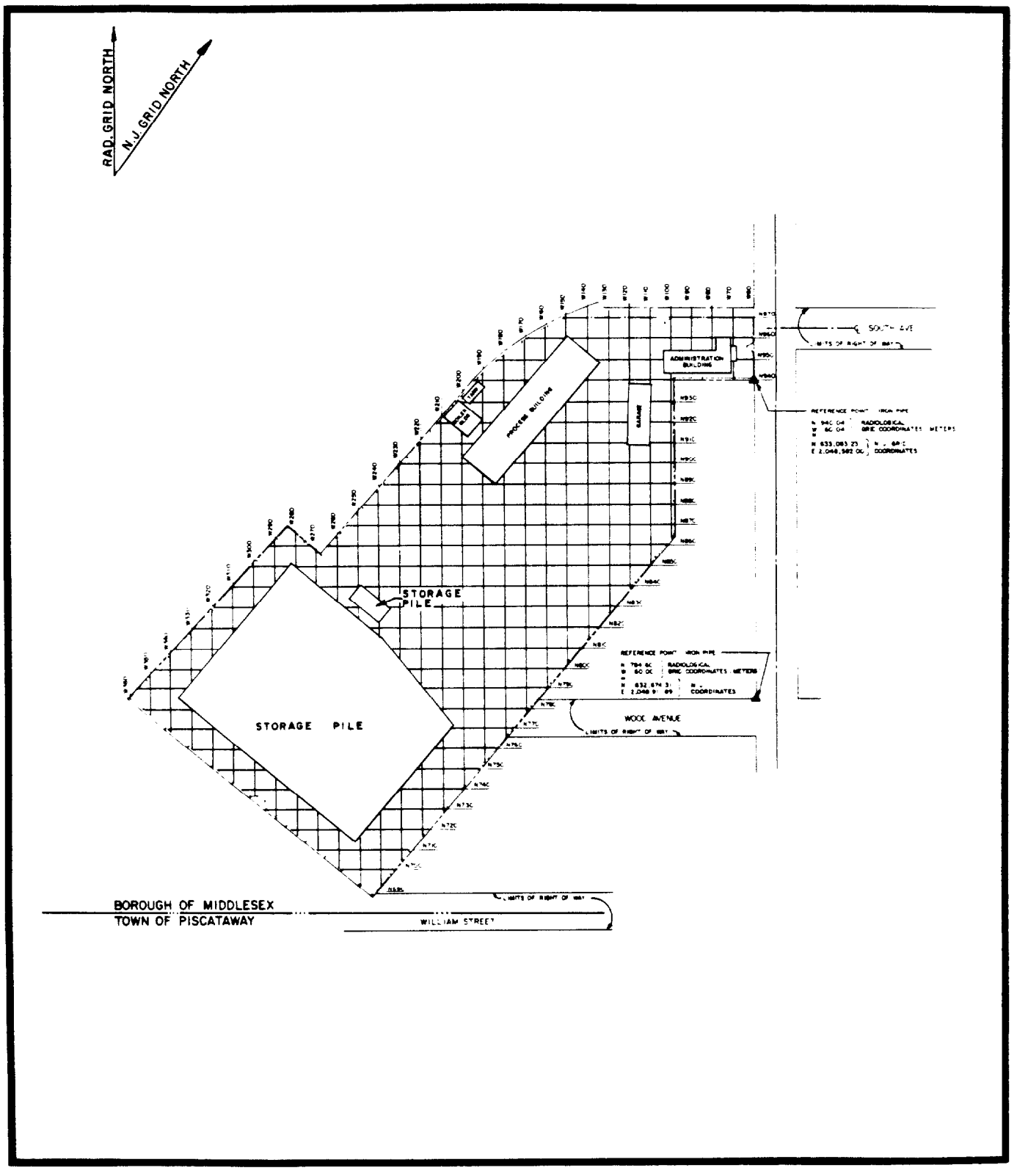


FIGURE 3-1 MASTER SURVEY GRID FOR THE FORMER MSP SITE

Boreholes were drilled over the entire site on a 15-m (50-ft) grid as shown in Figure 3-2. On-site areas excluded from drilling were those under the two residue storage piles located on the southern portion of the asphalt storage pad and a 0.6-m (2-ft) strip along the inside of the perimeter fence that had been excavated during Phase II. The boreholes were drilled to the soil-shale interface, and temporarily cased with a PVC tube for gamma logging. Gamma logs or profiles of boreholes were measured using a SPA-3 detector. By calibrating these measurements with the results from laboratory analysis of soil samples, borehole logs can provide a reliable estimate of radium-226 concentration in subsurface soil.

3.1.2 Sample Collection and Analysis

In this report, all soil samples (except for those around the Administration Building) will be considered subsurface samples in view of the thickness of asphalt covering the site. The corresponding guidelines will apply.

Soil samples were collected with Shelby tube samplers at the asphalt/soil interface of each borehole (Figure 3-2). Core samples were removed in approximately 10-cm (4-in.) increments. Each sample was placed in a 0.5-liter (0.1-gal) plastic container, capped, and labelled. The majority of soil samples were analyzed on-site for uranium-238, radium-226, and thorium-232 in the EIC mobile laboratory (in situ van). The samples were counted for 10 minutes by gamma spectroscopy using an intrinsic germanium detector housed in a lead counting cave lined with cadmium and copper.

Subsurface water samples were collected and analyzed for uranium-238 and radium-226. The samples were shipped to the EIC laboratory in Albuquerque, New Mexico for analysis by standard radiochemical techniques.

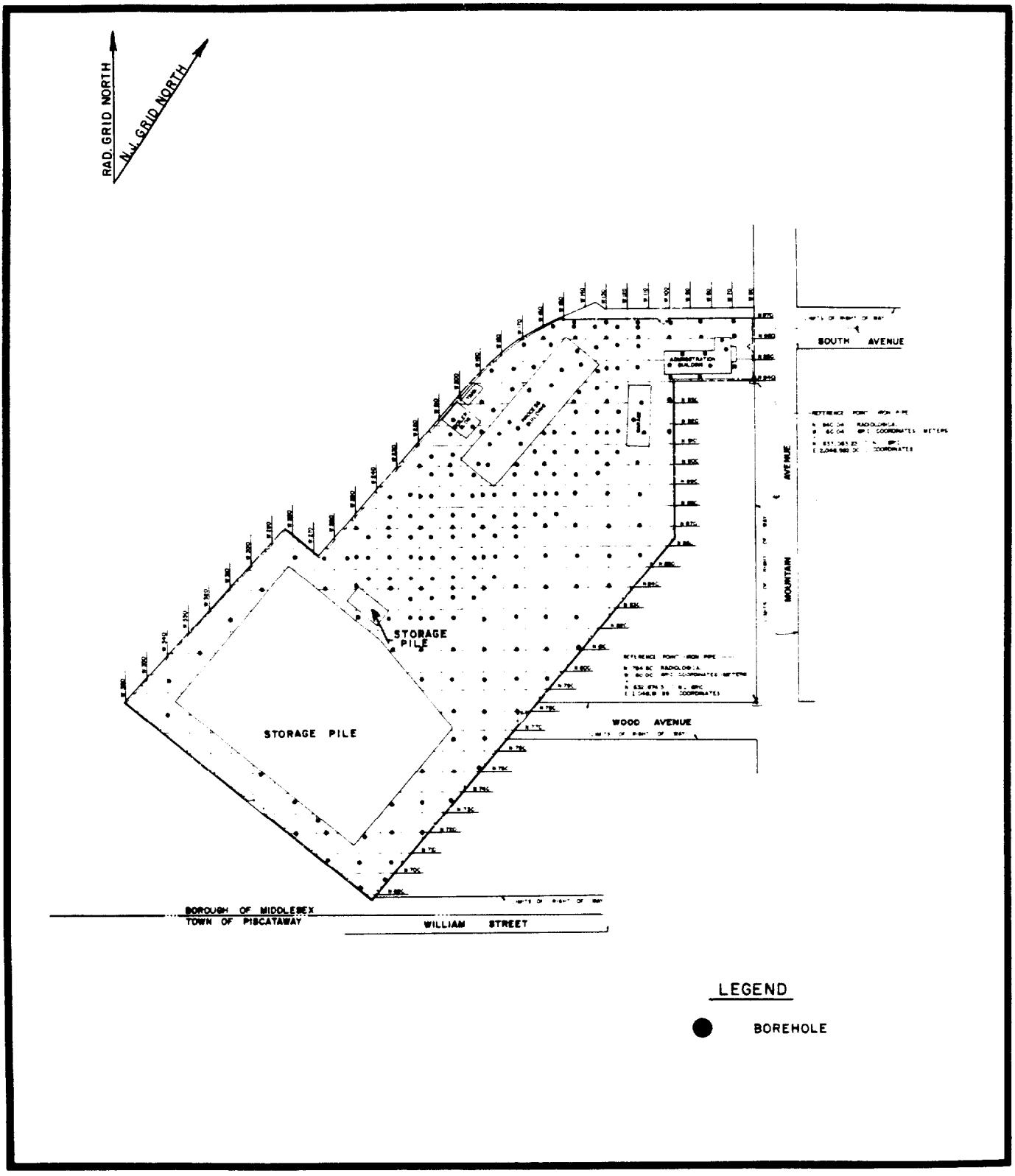


FIGURE 3-2 BOREHOLE LOCATIONS AT THE FORMER MSP SITE

3.2 BUILDING MEASUREMENTS

Indoor measurements were also made in accordance with the FUSRAP Radiological Protection Program (Ref. 9). The building survey followed a 2 m x 2 m (6.5 ft x 6.5 ft) grid established on the walls, floors, and roofs of the four structures remaining on the site: the Process Building, Boiler House, Administration Building, and Garage. Their locations are shown in Figure 2-1.

Each building was monitored through a series of measurements appropriate to its functions and documented historical contamination levels. The monitoring program comprised, in varying degrees, a radiological survey of each structure including the walls, floors, ceilings, ventilation systems, drain systems, roofs, and subsurface materials.

3.2.1 Interior Measurements

The floors of each building were monitored for alpha and beta-gamma radiation on the 2-m (6.5-ft) grid. A total of five alpha surface measurements were made in each grid segment using a 59-cm^2 (9-$in.^2$) zinc sulfide scintillation probe (EIC model AC-3) coupled with a PRS-1 detector. Beta-gamma and gamma measurements were made in the same grid section locations as the alpha measurements. Beta-gamma measurements were made using a thin-window G-M detector (EIC Model HP-210). The detectors were in contact with the floor surfaces during one-half-minute counts. Measurements for alpha and beta-gamma were also made at the floor/wall intersections in each building. The number of readings obtained varied in each building depending on its historical data and size.

Gamma measurements were made using an NaI detector (EIC Model SPA-3) supported 30 cm (12 in.) above the surface of the floor in a cone shield. The detector was used in an unshielded configuration to measure gamma radiation levels at 1 m (3 ft) above surfaces and in other locations such as drains and sumps.

Alpha and beta-gamma radiation measurements were taken on most interior lower wall surfaces of the four buildings. Only original interior wall surfaces were surveyed; interior partitions were not included. Wall measurements were obtained in the same manner as measurements taken on floors. In this report, the lower walls are considered to be from the floor to 2 m (6.5 ft) above the floor, the area with which human contact is considered most likely to occur. Interior wall readings were also taken from the second story walls in the Process Building.

Horizontal surfaces such as window sills were scanned for alpha and beta-gamma radiation.

Ceilings were monitored on a 4-m (13-ft) grid in the same manner as floors. Specific measurement points were selected on both vertical and horizontal surfaces such as beams, pipes, and ledges.

Following a review of the directly measured alpha and beta-gamma radiation levels from building surfaces, standard paper smears were used to determine whether or not surface contamination was removable. Smear samples were collected only from surfaces where surface radiation levels exceeded DOE criteria. Approximately 175 samples were collected on interior building and equipment surfaces.

During the survey, one particulate air sampler (EIC model RAS-1) was deployed in each of the four buildings. Samples were collected in accordance with the FUSRAP Radiological Protection Program (Ref. 9) when work was being performed inside the buildings. The filters were sent to the EIC laboratory in Albuquerque, New Mexico for gross alpha analysis.

During work activities radon samples were also collected daily using gas bag containers and pulse pumps. Integrated samples, collected over 3-hour periods, were taken twice daily. These samples were collected per the FUSRAP Radiological Protection Program (Ref. 9) and were counted on-site in the in situ van, using a SAC-R5 alpha counter.

Radon flux measurements were made on the interior walls and floors of the four buildings in accordance with procedures outlined in the Procedures Manual for the ORNL Remedial Action Survey and Certification Activities (RASCA) Program (Ref. 10). Activated charcoal canisters were deployed for a period of 48 hours. The Environmental Monitoring Laboratory in New York City was used to activate the charcoal and count the canisters after they were retrieved.

Fifteen-centimeter-diameter (6-in.-diameter) boreholes were drilled through the concrete floors of each building to the soil/shale interface. Borehole locations were based on reviews of surface monitoring data. These holes were temporarily cased with PVC tubing for the purpose of gamma logging. Gamma profiles were measured using a SPA-3 detector. Samples were taken from these holes using the same technique as described in Subsection 3.1.2.

Gamma profile measurements were normalized to the soil sample results from laboratory analysis to provide reliable estimates of radium-226 concentrations in the soils below the four buildings.

3.2.2 Exterior Measurements

Building exteriors were monitored in the same manner as the interiors. The concrete dock and roof along the east side of the Process Building were monitored in the same manner as the floors. The inside surface of the roof parapet and its ceramic top were monitored at 2.5-m (8.2-ft) intervals.

Approximately 160 smear samples were collected from exterior building surfaces where surface radiation levels exceeded DOE criteria.

4.0 SURVEY RESULTS

4.1 FIELD MEASUREMENT RESULTS

In this report, all direct field survey measurements and laboratory results represent gross readings; background measurements and concentrations were not subtracted. Background levels applicable to Middlesex have been previously measured. New Jersey statewide background soil concentrations in pCi/g have been measured as 0.86 for radium-226, 0.89 for thorium-232, and 0.87 for uranium-238. Average background for the external gamma exposure rate is 6.1 μR/h (Ref. 11).

4.1.1 Measurements Made to Define the Limits of Contamination

Both beta-gamma dose rate measurements made at the ground surface and near-surface gamma radiation measurements were used to define the areal extent of contamination. Beta-gamma dose rate measurements ranged from less than 0.01 to 7.25 mrad/h. DOE criteria for release of property for unrestricted use state that beta-gamma dose rates at 1 cm from the surface shall not exceed an average of 0.2 mrad/h over a 1-m^2 area or a maximum of 1.0 mrad/h in an area no greater than 100 cm^2 (Ref. 13).

Elevated near-surface gamma-radiation measurement readings are considered to be those that are equal to or greater than twice background. These readings would, under normal circumstances, be correlated with soil sample analysis to establish a calibration factor relating the detector's response in counts per minute (cpm) to the specific radionuclide concentration in pCi/g. Because the MSP site grounds are covered with varying thicknesses of asphalt, a correlation factor could not be determined. However, high gamma readings did generally relate to elevated concentrations of radionuclides in the soil. Results were determined for uranium-238, radium-226, and thorium-232. The maximum concentration for uranium-238 was 961 pCi/g; the DOE remedial action guideline for

uranium-238 is 150 pCi/g above background. The maximum radium-226 concentration was 736 pCi/g compared with the DOE limit of 15 pCi/g above background for subsurface soil. The maximum thorium-232 concentration was 19.3 pCi/g compared with the DOE limit of 15 pCi/g above background for subsurface soil. These guidelines are presented in Table 4-1. The lateral excavation limits are based on gamma readings, which supply reasonable guidance for the removal of soil containing radionuclide concentrations in excess of guidelines. Locations at which readings above guidelines were observed in samples from the asphalt/soil interface are shown in Figure 4-1; results are listed in Table 4-2.

The major contaminants in soil samples taken from borings were uranium-238 and radium-226. The maximum uranium-238 concentration was 398 pCi/g; the maximum radium-226 concentration was 208 pCi/g. Locations at which readings above guidelines were observed in samples from borings are shown in Figure 4-2. Correlations between concentrations of radionuclides in soil samples given in Table 4-3 and borehole gamma count rates were used to determine the depth of contamination.

4.1.2 Measurements Made to Assess Other Radiological Conditions at the Site

Samples were taken of water that was present in several of the borings. These samples were analyzed for uranium and radium at the EIC Laboratory in Albuquerque, New Mexico. The uranium-238 concentration ranged from 1.5 to 1,288 pCi/l; the radium-226 concentration ranged from less than 0.1 to 71.0 pCi/l. The DOE maximum permissible concentrations in water for release to uncontrolled areas are 600 pCi/l for uranium-238 and 30 pCi/l for radium-226 (Ref. 12). Water sample results are listed in Table 4-4.

Gamma exposure rates were measured using a PIC at 1 m above the ground. The exposure rates ranged from 16 to 371 μR/h. As noted earlier, the natural background gamma exposure rate was measured as

TABLE 4-1

RESIDUAL CONTAMINATION GUIDELINES AND CRITERIA FOR FUSRAP SITES

Soil and Sediment[a,b]	Guidelines (above background)
Uranium-238[c]	150 pCi/g
Uranium-235[c]	140 pCi/g
Uranium-234[c]	150 pCi/g
Radium-226 and Thorium-232	5 pCi/g when 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
Radionuclides in Water	**Criteria**
Total Uranium	600 pCi/l
Radium-226	30 pCi/l
Surface Contamination	
Beta-Gamma Dose Rate	Avg. 0.2 mrad/h[d]; max. 1.0 mrad/h[e]
Alpha Surface for Natural Uranium, Uranium-238, Uranium-235, and Associated Decay Products	200 dpm/100 cm^2 [f]
Removable Surface Contamination	
Gross Alpha Activity	40 dpm/100 cm^2 [f]
Gross Beta-Gamma Activity	1000 dpm/100 cm^2
External Gamma Radiation	60 μR/h above background
Air Particulates	0.1 pCi/m^3
Radon Flux	20 pCi/m^2/s
Time-Integrated Radon	30 pCi/l

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

[b]Localized concentrations in excess of these limits are allowable provided that the average over 100 m^2 is not exceeded.

[c]Assumes that no other uranium isotopes are present.

[d]Measurements of average contamination are averaged over areas of no greater than 1 m^2.

[e]The maximum contamination levels apply to areas of not more than 100 cm2.

[f]Although other isotopes in the uranium-238 decay chain are present in the buildings, the effect of adding them into the limit calculation would be to raise the limit. Hence the 200 dpm/100 cm^2 and 40 dpm/100 cm^2 limits are conservative.

Sources: DOE (Refs. 12 and 13)

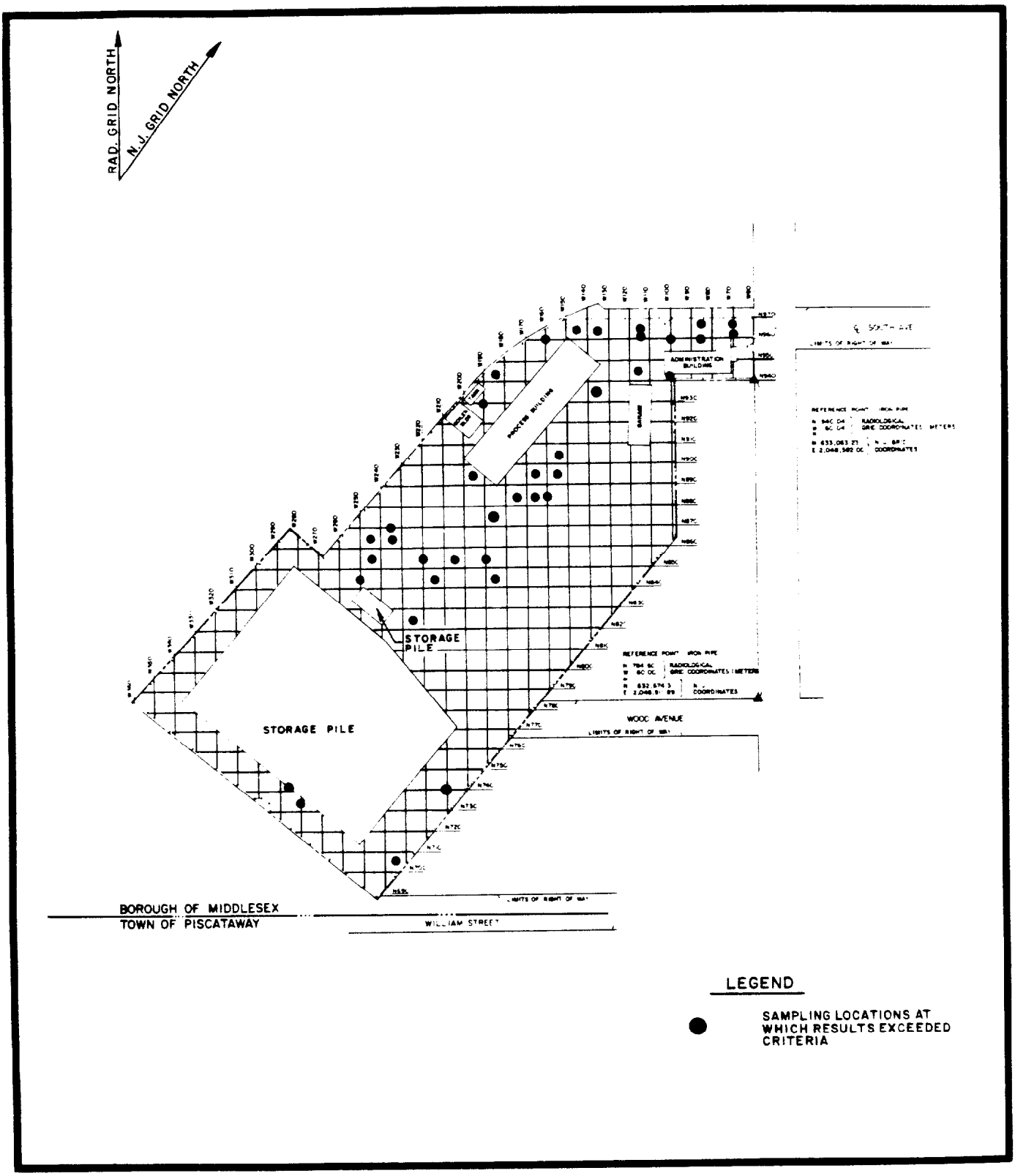


FIGURE 4-1 LOCATIONS OF SOIL SAMPLES FROM THE ASPHALT/SOIL INTERFACE THAT EXCEEDED URANIUM-238, RADIUM-226, AND THORIUM-232 GUIDELINES

TABLE 4-2

GAMMA SPECTROMETRY ANALYSIS OF SOIL SAMPLES FROM THE ASPHALT/SOIL INTERFACE

Coordinates		Concentration (pCi/g +/- 2 sigma)		
E,W	N,S	Uranium-238	Radium-226	Thorium-232
-85.00	945.00	---	0.8 ± 0.1	1.1 ± 0.3
-68.00	945.00	---	4.5 ± 0.3	0.7 ± 0.5
-190.00	930.00	56.6 ± 5.3	36.0 ± 0.9	---
-130.00	930.00	---	0.8 ± 0.2	0.9 ± 0.3
-108.00	930.00	---	0.5 ± 0.1	0.9 ± 0.2
-205.00	915.00	12.9 ± 2.6	9.8 ± 0.5	0.7 ± 0.5
-190.00	915.00	15.2 ± 3.2	11.2 ± 0.5	---
-160.00	915.00	---	1.4 ± 0.2	0.7 ± 0.2
-145.00	915.00	0.4 ± 0.9	0.5 ± 0.1	0.7 ± 0.2
-130.00	915.00	7.3 ± 2.4	8.1 ± 0.4	0.8 ± 0.5
-108.00	915.00	---	0.6 ± 0.2	0.7 ± 0.2
-220.00	900.00	6.7 ± 1.7	3.2 ± 0.3	0.3 ± 0.2
-205.00	890.00	10.7 ± 2.7	8.6 ± 0.5	1.0 ± 0.8
-160.00	900.00	1.3 ± 2.7	9.3 ± 0.5	6.6 ± 0.2
-150.00	900.00	5.8 ± 2.2	5.8 ± 0.4	0.6 ± 0.4
-115.00	900.00	3.8 ± 1.8	2.3 ± 0.2	---
-235.00	885.00	---	1.1 ± 0.2	1.9 ± 0.3
-220.00	885.00	1.5 ± 1.6	2.6 ± 0.2	1.0 ± 0.4
-205.00	885.00	4.2 ± 1.8	0.9 ± 1.7	0.6 ± 0.4
-190.00	890.00	8.8 ± 4.6	4.8 ± 0.3	0.5 ± 0.4
-175.00	885.00	98.7 ± 8.0	72.2 ± 1.3	0.5 ± 1.0
-160.00	885.00	91.5 ± 5.6	60.3 ± 1.2	---
-145.00	885.00	2.3 ± 1.4	1.6 ± 0.2	1.1 ± 0.3
-130.00	885.00	---	1.2 ± 0.1	1.2 ± 0.3
-115.00	885.00	3.5 ± 1.3	0.5 ± 0.1	1.3 ± 0.3
-247.50	870.00	1.7 ± 0.2	0.9 ± 0.2	1.2 ± 0.5
-235.00	870.00	419.6 ± 16.5	468.7 ± 3.7	---
-220.00	870.00	---	0.6 ± 0.2	1.4 ± 0.3
-205.00	870.00	1.2 ± 2.5	4.9 ± 0.4	0.5 ± 0.3
-190.00	870.00	0.9 ± 0.2	1.0 ± 0.2	0.5 ± 0.3
-175.00	870.00	6.3 ± 0.3	4.5 ± 0.3	0.9 ± 0.4
-162.50	870.00	2.6 ± 2.3	3.7 ± 0.3	0.5 ± 0.3
-145.00	870.00	9.9 ± 0.5	7.6 ± 0.5	0.9 ± 0.5
-130.00	870.00	12.1 ± 2.0	5.5 ± 0.3	0.5 ± 0.3
-115.00	870.00	---	0.3 ± 0.2	0.9 ± 0.5
-280.00	850.00	8.2 ± 2.0	2.1 ± 0.3	---
-262.50	855.00	1.3 ± 1.1	0.7 ± 0.1	---
-250.00	845.00	35.8 ± 5.5	35.2 ± 0.9	3.2 ± 0.8
-220.00	855.00	95.1 ± 6.4	50.4 ± 1.3	---
-205.00	855.00	31.2 ± 3.5	1.3 ± 0.4	19.3 ± 1.0
-190.00	855.00	961.4 ± 23.9	735.7 ± 5.4	---
-177.50	855.00	2.8 ± 2.0	2.6 ± 0.2	0.6 ± 0.3
-160.00	855.00	1.9 ± 1.8	2.4 ± 0.3	0.7 ± 0.5
-145.00	855.00	1.7 ± 1.1	0.4 ± 0.1	0.7 ± 0.3

TABLE 4-2 (continued)

Coordinates		Concentration (pCi/g +/- 2 sigma)		
E,W	N,S	Uranium-238	Radium-226	Thorium-232
-130.00	855.00	1.8 ± 1.4	1.0 ± 0.2	1.3 ± 0.4
-115.00	855.00	5.2 ± 1.7	1.7 ± 0.3	0.8 ± 0.2
-295.00	840.00	---	0.4 ± 0.1	---
-265.00	840.00	1.2 ± 1.7	1.2 ± 0.2	0.7 ± 0.3
-250.00	840.00	1.6 ± 1.2	0.6 ± 0.1	0.7 ± 0.2
-235.00	840.00	33.4 ± 3.1	13.5 ± 0.6	1.1 ± 0.6
-220.00	840.00	10.3 ± 1.9	2.1 ± 0.3	0.7 ± 0.4
-205.00	840.00	28.2 ± 3.1	13.0 ± 0.6	1.4 ± 0.4
-190.00	840.00	2.6 ± 1.8	5.5 ± 0.3	1.0 ± 0.3
-160.00	840.00	---	1.0 ± 0.2	0.9 ± 0.3
-145.00	840.00	---	0.5 ± 0.2	1.3 ± 0.3
-130.00	840.00	---	0.7 ± 0.2	0.9 ± 0.2
-310.00	825.00	0.6 ± 1.0	0.8 ± 0.2	0.4 ± 0.2
-250.00	825.00	---	0.5 ± 0.1	0.4 ± 0.3
-235.00	825.00	---	0.2 ± 0.1	0.1 ± 0.2
-220.00	825.00	4.5 ± 0.3	3.8 ± 0.3	1.1 ± 0.3
-202.50	825.00	11.4 ± 2.0	3.2 ± 0.3	1.3 ± 0.4
-190.00	825.00	0.7 ± 1.7	1.0 ± 0.2	0.8 ± 0.2
-175.00	825.00	5.0 ± 1.9	2.6 ± 0.3	0.7 ± 0.3
-160.00	825.00	---	0.6 ± 0.2	1.1 ± 0.4
-325.00	810.00	2.9 ± 1.2	2.7 ± 0.2	---
-235.00	810.00	1.6 ± 1.6	2.1 ± 0.3	---
-215.00	810.00	33.8 ± 4.1	13.4 ± 0.7	0.5 ± 0.9
-205.00	810.00	9.9 ± 3.2	7.4 ± 0.4	0.9 ± 0.5
-190.00	810.00	3.6 ± 3.3	1.2 ± 0.2	---
-175.00	810.00	---	1.0 ± 0.2	0.3 ± 0.4
-160.00	810.00	---	1.6 ± 0.2	0.8 ± 0.3
-147.50	810.00	---	0.9 ± 0.2	0.8 ± 0.4
-340.00	795.00	1.2 ± 1.1	1.1 ± 0.2	0.4 ± 0.2
-215.00	795.00	1.9 ± 3.0	0.8 ± 0.2	1.1 ± 0.3
-207.50	795.00	---	0.3 ± 0.3	1.3 ± 0.2
-130.00	900.00	---	0.5 ± 0.2	1.3 ± 0.3
-175.00	795.00	4.2 ± 1.4	2.1 ± 0.2	1.1 ± 0.3
-160.00	795.00	---	0.7 ± 0.2	1.2 ± 0.3
-340.00	770.00	2.4 ± 1.9	5.9 ± 0.3	0.3 ± 0.3
-215.00	780.00	2.2 ± 1.0	0.7 ± 0.2	0.3 ± 0.3
-192.50	780.00	5.1 ± 1.8	0.9 ± 0.2	1.7 ± 0.4
-175.00	780.00	2.2 ± 0.9	0.4 ± 0.2	1.7 ± 0.3
-205.00	765.00	2.6 ± 1.7	1.0 ± 0.2	0.7 ± 0.3
-190.00	765.00	1.6 ± 2.0	1.4 ± 0.2	0.5 ± 0.2
-285.00	745.00	17.1 ± 5.5	21.8 ± 1.0	3.8 ± 1.0
-220.00	747.50	10.5 ± 1.5	2.9 ± 0.2	1.0 ± 0.3
-192.50	750.00	0.9 ± 1.7	0.5 ± 0.1	0.6 ± 0.2
-280.00	735.00	15.3 ± 10.9	687.0 ± 1.2	---
-235.00	735.00	7.8 ± 1.6	5.8 ± 0.4	0.8 ± 0.3
-220.00	735.00	2.3 ± 1.9	1.4 ± 0.2	---
-210.00	740.00	208.9 ± 8.2	48.5 ± 1.2	---

TABLE 4-2 (continued)

Coordinates		Concentration (pCi/g +/- 2 sigma)		
E,W	N,S	Uranium-238	Radium-226	Thorium-232
-280.00	717.50	---	1.0 ± 0.2	1.7 ± 0.7
-265.00	720.00	2.9 ± 2.1	1.2 ± 0.3	0.5 ± 0.4
-235.00	720.00	4.7 ± 2.6	0.9 ± 0.3	1.4 ± 0.4
-220.00	720.00	5.1 ± 0.9	0.8 ± 0.1	0.9 ± 0.2
-260.00	710.00	---	1.3 ± 0.3	0.9 ± 0.5
-250.00	705.00	33.2 ± 2.7	1.2 ± 0.2	1.0 ± 0.3
-250.00	705.00	5.2 ± 1.9	1.2 ± 0.3	0.5 ± 0.4
-235.00	695.00	0.5 ± 1.4	0.7 ± 0.1	---
-267.50	731.00	2.8 ± 1.7	0.8 ± 0.2	0.3 ± 0.3
-170.00	777.50	86.9 ± 4.6	6.0 ± 0.4	1.1 ± 0.6
-185.00	945.00	307.6 ± 9.9	45.4 ± 1.2	---
-125.00	915.00	5.5 ± 0.4	6.8 ± 0.5	1.2 ± 0.5
-135.00	915.00	---	6.0 ± 0.5	---
-142.50	925.00	---	1.1 ± 0.3	1.6 ± 0.6
-125.00	925.00	---	1.0 ± 0.3	1.8 ± 0.4
-235.00	705.00	73.5 ± 4.9	50.7 ± 1.2	3.8 ± 1.0
-235.00	855.00	15.4 ± 4.7	7.2 ± 0.6	2.1 ± 0.7
-250.00	720.00	21.9 ± 3.4	1.7 ± 0.3	2.1 ± 0.4
-145.00	865.00	---	1.2 ± 0.3	1.9 ± 0.4
-145.00	825.00	---	1.6 ± 0.3	2.8 ± 0.5
-155.00	965.00	10.2 ± 0.5	2.5 ± 0.4	0.7 ± 0.2
-145.00	965.00	---	1.4 ± 0.5	1.1 ± 0.4
-135.00	965.00	246.0 ± 7.8	20.8 ± 0.9	3.0 ± 0.8
-125.00	965.00	---	1.1 ± 0.2	1.2 ± 0.4
-115.00	965.00	121.4 ± 8.0	62.4 ± 1.7	4.6 ± 1.0
-156.00	955.00	---	3.4 ± 0.4	3.5 ± 0.6
-135.00	955.00	---	0.7 ± 0.2	2.2 ± 0.5
-125.00	955.00	---	1.3 ± 0.4	1.5 ± 0.7
-115.00	955.00	---	4.1 ± 0.4	1.2 ± 0.4
-166.00	945.00	---	4.8 ± 0.6	1.9 ± 0.5
-135.00	945.00	9.0 ± 3.3	3.8 ± 0.4	1.5 ± 0.4
-125.00	945.00	---	1.2 ± 0.2	2.4 ± 0.5
-175.00	935.00	---	2.9 ± 0.4	2.0 ± 0.5
-145.00	935.00	---	10.9 ± 0.7	---
-135.00	935.00	23.7 ± 5.4	15.0 ± 0.8	---
-125.00	934.00	---	0.9 ± 0.3	1.1 ± 0.4
-185.00	925.00	---	1.9 ± 0.3	1.7 ± 0.6
-135.00	925.00	4.5 ± 2.2	1.3 ± 0.3	2.9 ± 0.6
-192.50	915.00	---	1.4 ± 0.4	2.4 ± 0.6
-155.00	915.00	14.5 ± 2.8	8.9 ± 0.6	---
-214.00	905.00	---	1.0 ± 0.2	1.1 ± 0.5
-205.00	905.00	---	1.1 ± 0.2	1.7 ± 0.4
-165.00	905.00	22.3 ± 4.5	8.9 ± 0.7	1.7 ± 0.4
-155.00	905.00	132.7 ± 9.4	158.0 ± 2.6	---
-145.00	905.00	7.0 ± 4.6	5.6 ± 0.6	0.8 ± 0.5
-135.00	905.00	---	1.8 ± 0.2	1.8 ± 0.4
-125.00	905.00	2.4 ± 0.5	12.8 ± 0.9	2.2 ± 0.7

TABLE 4-2 (continued)

Coordinates		Concentration (pCi/g +/- 2 sigma)		
E,W	N,S	Uranium-238	Radium-226	Thorium-232
-215.00	895.00	---	1.2 ± 0.2	3.0 ± 0.6
-205.00	895.00	289.3 ± 9.0	2.7 ± 0.4	---
-195.00	895.00	20.2 ± 3.8	27.4 ± 1.1	4.8 ± 0.9
-175.00	895.00	13.3 ± 5.7	12.3 ± 0.8	---
-165.00	895.00	128.9 ± 12.1	98.6 ± 2.1	---
-165.00	896.00	---	1.2 ± 0.3	2.3 ± 0.4
-155.00	895.00	---	55.7 ± 1.5	---
-145.00	895.00	8.2 ± 4.3	7.0 ± 0.6	3.3 ± 0.6
-135.00	895.00	5.2 ± 2.5	3.0 ± 0.4	2.1 ± 0.4
-225.00	885.00	13.9 ± 5.1	13.2 ± 0.7	1.6 ± 0.8
-215.00	885.00	52.4 ± 8.2	7.5 ± 0.6	1.5 ± 0.4
-195.00	885.00	6.7 ± 3.7	7.5 ± 0.6	---
-185.00	885.00	58.2 ± 5.1	8.2 ± 0.7	2.2 ± 0.7
-165.00	885.00	469.8 ± 15.5	293.3 ± 4.0	---
-155.00	885.00	---	1.9 ± 0.3	2.1 ± 0.6
-235.00	875.00	10.3 ± 4.0	7.6 ± 0.6	1.0 ± 0.1
-225.00	875.00	---	2.2 ± 0.3	2.4 ± 0.5
-215.00	875.00	---	1.1 ± 0.3	1.9 ± 0.4
-205.00	875.00	---	1.6 ± 0.3	2.5 ± 0.5
-195.00	875.00	---	0.6 ± 0.3	2.3 ± 0.5
-185.00	875.00	93.9 ± 6.4	35.6 ± 1.4	---
-175.00	875.00	30.0 ± 4.9	8.1 ± 0.7	3.0 ± 0.6
-165.00	875.00	7.9 ± 3.8	5.6 ± 0.5	---
-155.00	875.00	---	0.9 ± 0.2	0.9 ± 0.2
-245.00	865.00	---	48.6 ± 1.9	---
-225.00	865.00	31.5 ± 5.0	13.6 ± 0.7	3.5 ± 0.7
-215.00	865.00	---	1.4 ± 0.2	1.4 ± 0.5
-205.00	865.00	---	1.1 ± 0.4	2.3 ± 0.6
-195.00	865.00	6.2 ± 2.5	2.1 ± 0.3	2.6 ± 0.6
-185.00	865.00	8.5 ± 3.1	2.9 ± 0.4	---
-255.00	855.00	8.3 ± 4.5	2.3 ± 0.6	3.0 ± 1.2
-245.00	855.00	27.7 ± 3.7	19.0 ± 0.8	1.3 ± 0.4
-225.00	855.00	32.0 ± 4.4	1.3 ± 0.2	1.9 ± 0.4
-215.00	855.00	---	1.9 ± 0.3	2.5 ± 0.4
-185.00	855.00	22.5 ± 4.0	7.1 ± 0.6	2.4 ± 0.5
-245.00	845.00	9.7 ± 5.4	2.2 ± 0.3	2.5 ± 0.4
-235.00	845.00	---	1.1 ± 0.3	1.6 ± 0.5
-225.00	845.00	6.7 ± 3.1	4.2 ± 0.5	2.6 ± 0.5
-215.00	845.00	78.0 ± 7.8	32.4 ± 1.2	1.4 ± 1.2
-205.00	845.00	5.4 ± 2.4	1.6 ± 0.3	2.1 ± 0.7
-195.00	845.00	31.3 ± 4.4	2.8 ± 0.4	1.3 ± 0.4
-185.00	845.00	40.2 ± 4.8	34.4 ± 1.3	3.7 ± 1.2
-225.00	835.00	---	6.9 ± 0.5	1.5 ± 0.5
-215.00	835.00	---	2.0 ± 0.3	---
-205.00	835.00	6.6 ± 3.1	3.3 ± 0.4	2.8 ± 0.6
-195.00	835.00	4.1 ± 1.8	1.3 ± 0.3	2.2 ± 0.5
-225.00	825.00	31.6 ± 7.5	19.3 ± 0.9	2.3 ± 0.7

TABLE 4-2 (continued)

Page 5 of 5

Coordinates		Concentration (pCi/g +/- 2 sigma)		
E,W	N,S	Uranium-238	Radium-226	Thorium-232
-215.00	825.00	21.5 ± 2.6	5.0 ± 0.5	2.2 ± 0.4
-235.00	865.00	116.4 ± 11.9	108.3 ± 2.3	---
-175.00	865.00	3.9 ± 2.6	1.1 ± 0.2	1.8 ± 0.4
-145.00	965.00	384.1 ± 12.7	151.7 ± 2.4	---
-135.00	968.00	7.5 ± 2.9	4.0 ± 0.5	1.5 ± 0.6
-115.00	968.00	---	1.2 ± 0.2	1.5 ± 0.5
-100.00	968.00	---	0.4 ± 0.2	1.5 ± 0.3
-85.00	968.00	28.8 ± 7.8	30.7 ± 1.1	5.0 ± 1.0
-70.00	968.00	63.2 ± 18.7	38.6 ± 1.6	13.5 ± 1.5
-160.00	960.00	143.4 ± 9.2	100.4 ± 1.9	---
-145.00	960.00	---	4.3 ± 0.4	1.4 ± 0.4
-130.00	960.00	---	1.2 ± 0.3	1.0 ± 0.4
-115.00	960.00	29.1 ± 9.6	20.1 ± 1.0	3.7 ± 0.8
-100.00	960.00	83.4 ± 8.4	69.8 ± 2.0	7.1 ± 1.6
-85.00	960.00	70.4 ± 12.9	35.8 ± 1.6	3.6 ± 0.9
-70.00	963.00	54.2 ± 7.0	18.1 ± 0.8	1.7 ± 0.6
-115.00	945.00	29.2 ± 7.6	31.0 ± 1.2	2.5 ± 0.8
-130.00	945.00	---	1.0 ± 0.2	2.7 ± 0.6
-115.00	945.00	---	1.3 ± 0.3	1.7 ± 0.3
-100.00	942.00	173.7 ± 10.2	126.3 ± 2.4	---
-180.00	940.00	4.0 ± 2.4	2.4 ± 0.4	1.7 ± 0.4

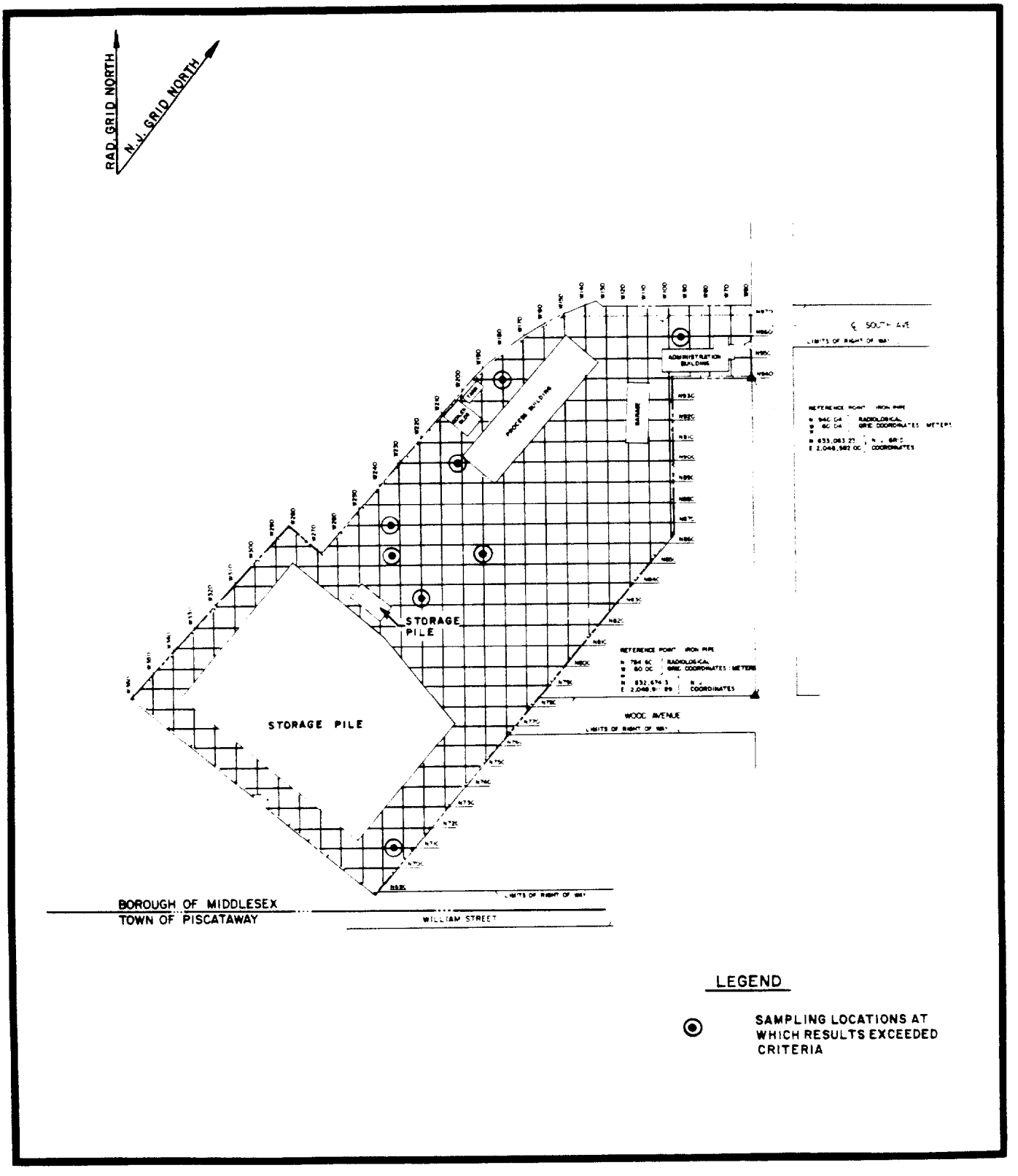


FIGURE 4-2 LOCATIONS OF SOIL SAMPLES FROM BORINGS THAT EXCEEDED URANIUM-238, RADIUM-226, AND THORIUM-232 GUIDELINES

TABLE 4-3

GAMMA SPECTROMETRY ANALYSIS OF SOIL SAMPLES FROM BORINGS

Page 1 of 2

Coordinates E,W	Coordinates N,S	Depth (cm)	Concentration (pCi/g +/- 2 sigma) Uranium-238	Radium-226	Thorium-232
-180.00	940.00	33.0	---	4.4 ± 0.5	1.5 ± 0.6
-180.00	940.00	43.2	---	0.9 ± 0.2	2.2 ± 0.8
-180.00	940.00	53.3	31.6 ± 4.7	47.7 ± 1.4	4.2 ± 1.1
-180.00	940.00	76.2	---	0.8 ± 0.3	1.5 ± 0.4
-180.00	940.00	86.4	1.2 ± 0.2	2.6 ± 0.4	2.1 ± 0.5
-180.00	940.00	96.5	---	3.6 ± 0.4	3.1 ± 0.5
-180.00	940.00	106.7	---	1.6 ± 0.3	2.5 ± 0.4
-180.00	940.00	116.8	---	1.1 ± 0.2	2.3 ± 0.8
-180.00	940.00	147.3	9.0 ± 2.6	1.7 ± 0.3	2.0 ± 0.4
-170.00	950.00	38.1	6.5 ± 2.3	1.2 ± 0.2	1.7 ± 0.4
-170.00	950.00	48.3	---	0.8 ± 0.2	---
-170.00	950.00	58.4	---	0.9 ± 0.4	---
-170.00	950.00	68.6	---	0.9 ± 0.2	1.4 ± 0.3
-170.00	950.00	78.7	---	0.8 ± 0.3	1.5 ± 0.4
-170.00	950.00	88.9	---	0.8 ± 0.2	1.3 ± 0.4
-170.00	950.00	119.4	---	1.4 ± 0.3	2.2 ± 0.8
-170.00	950.00	149.9	---	0.9 ± 0.7	2.7 ± 0.7
-137.50	960.00	35.6	---	1.2 ± 0.3	---
-137.50	960.00	48.3	---	1.3 ± 0.2	1.5 ± 0.4
-137.50	960.00	58.4	---	1.0 ± 0.2	1.2 ± 0.3
-137.50	960.00	68.6	---	1.2 ± 0.3	1.1 ± 0.5
-137.50	960.00	78.7	---	1.0 ± 0.2	1.0 ± 0.7
-137.50	960.00	86.4	2.8 ± 1.7	1.0 ± 0.2	1.6 ± 0.4
-137.50	960.00	111.8	3.8 ± 2.3	1.3 ± 0.4	1.8 ± 0.6
-92.50	960.00	10.2	59.7 ± 10.7	32.0 ± 1.5	3.1 ± 0.9
-92.50	960.00	20.3	40.5 ± 4.9	36.9 ± 1.3	2.2 ± 1.0
-92.50	960.00	30.5	15.0 ± 4.0	6.8 ± 0.6	1.5 ± 0.8
-92.50	960.00	43.2	---	4.7 ± 0.7	3.4 ± 1.0
-92.50	960.00	73.7	11.3 ± 4.5	3.7 ± 0.8	3.0 ± 1.7
-92.50	960.00	104.1	---	1.4 ± 0.4	2.8 ± 0.8
-92.50	960.00	147.3	6.5 ± 3.4	1.1 ± 0.4	3.0 ± 0.7
-220.00	832.50	30.5	---	79.2 ± 1.6	1.5 ± 1.0
-220.00	832.50	91.4	20.9 ± 6.5	19.5 ± 1.1	4.1 ± 0.9
-220.00	832.50	121.9	---	2.6 ± 0.4	1.6 ± 0.5
-220.00	832.50	152.4	---	1.3 ± 0.4	2.0 ± 0.5
-235.00	710.00	40.6	21.4 ± 5.9	21.5 ± 1.0	3.0 ± 0.9
-235.00	710.00	50.8	---	1.7 ± 0.3	2.0 ± 0.6
-235.00	710.00	61.0	---	1.1 ± 0.2	1.8 ± 0.4
-235.00	710.00	71.1	---	1.2 ± 0.3	2.0 ± 0.4
-235.00	710.00	81.3	---	1.1 ± 0.2	3.3 ± 0.6
-235.00	710.00	104.1	---	1.0 ± 0.8	2.1 ± 0.7
-235.00	710.00	127.0	---	1.4 ± 0.4	2.3 ± 1.0
-212.50	732.50	76.2	16.5 ± 5.4	6.9 ± 0.6	0.8 ± 0.7
-212.50	732.50	86.4	11.8 ± 3.4	1.9 ± 0.3	2.5 ± 0.5
-212.50	732.50	111.8	8.1 ± 5.5	2.1 ± 0.5	---
-204.00	900.00	33.0	---	1.6 ± 0.3	1.8 ± 0.4

TABLE 4-3 (continued)

Coordinates E,W	Coordinates N,S	Depth (cm)	Concentration (pCi/g +/- 2 sigma) Uranium-238	Radium-226	Thorium-232
-204.00	900.00	43.2	---	1.6 ± 0.4	3.2 ± 0.7
-204.00	900.00	68.6	---	4.5 ± 0.6	---
-204.00	900.00	99.1	37.9 ± 9.2	28.9 ± 1.7	---
-204.00	900.00	129.5	---	2.5 ± 0.4	3.4 ± 0.8
-204.00	900.00	160.0	6.4 ± 3.0	1.1 ± 0.8	---
-234.00	870.00	73.7	29.2 ± 4.8	24.3 ± 1.1	1.4 ± 0.6
-234.00	870.00	83.8	15.8 ± 2.6	1.2 ± 0.3	1.7 ± 0.5
-234.00	870.00	94.0	3.1 ± 1.6	1.0 ± 0.3	1.3 ± 0.3
-234.00	870.00	104.1	---	0.8 ± 0.2	1.2 ± 0.4
-234.00	870.00	114.3	---	1.2 ± 0.2	1.2 ± 0.5
-234.00	870.00	134.6	---	1.7 ± 0.4	3.6 ± 0.9
-234.00	855.00	33.0	26.8 ± 5.2	8.8 ± 0.7	1.8 ± 0.5
-234.00	855.00	43.2	9.8 ± 4.1	7.7 ± 0.6	2.4 ± 1.2
-234.00	855.00	53.3	58.8 ± 4.5	27.9 ± 1.0	1.6 ± 0.8
-234.00	855.00	83.8	29.2 ± 9.8	54.6 ± 1.7	2.7 ± 1.1
-234.00	855.00	144.8	25.7 ± 4.8	8.5 ± 0.7	---
-234.00	855.00	152.4	11.8 ± 4.7	2.0 ± 0.6	3.8 ± 1.2
-190.00	856.00	99.1	397.7 ± 25.3	208.4 ± 5.5	---
-190.00	856.00	114.3	89.1 ± 19.9	67.4 ± 3.5	---
-190.00	856.00	127.0	---	2.9 ± 0.6	2.5 ± 0.8

TABLE 4-4

RADIOCHEMICAL ANALYSIS OF SUBSURFACE WATER SAMPLES

Coordinates		Concentration (pCi/l +/- 2 sigma)	
E,W	N,S	Uranium-238	Radium-226
-175	795	33.0	0.2 ± 0.1
-190	930	1288.0	71.0 ± 21.0
-108	915	1.8	0.1
-130	900	4.5	0.3 ± 0.1
-145	855	1.5	0.3 ± 0.1
-175	870	68.0	0.4 ± 0.1
-185	945	33.0	1.4 ± 0.4
-192.5	780	12.7	0.2 ± 0.1
200	720	86.3	0.6 ± 0.2
-207	795	3.0	0.2 ± 0.1
-235	695	6.7	0.1 ± 0.1
-235	810	1.5	0.3 ± 0.1
-235	825	5.8	0.8 ± 0.2
-235	855	209.0	26.0 ± 8.0
-235	870	7.9	1.5 ± 0.5
-236	705	33.0	0.9 ± 0.3
-247.5	870	34.8	2.7 ± 0.8
-250	697.5	11.0	0.2 ± 0.1
-250	825	1.5	0.1
-250	840	2.4	0.1
-265.5	855	2.1	0.2 ± 0.1
-340	795	17.9	0.9 ± 0.3

TABLE 4-5

PRESSURIZED IONIZATION CHAMBER (PIC) READINGS AT SELECTED LOCATIONS

Page 1 of 4

Coordinates E,W	Coordinates N,S	PIC* micro-R/h
-350.00	790.00	16.20
-340.00	780.00	26.80
-340.00	800.00	17.00
-330.00	770.00	17.60
-330.00	800.00	19.60
-330.00	810.00	21.80
-320.00	760.00	17.80
-320.00	810.00	25.60
-320.00	820.00	23.80
-310.00	750.00	16.80
-310.00	830.00	55.40
-300.00	840.00	59.80
-290.00	740.00	24.40
-290.00	850.00	37.80
-290.00	860.00	17.20
-285.00	735.00	41.00
-280.00	860.00	48.60
-275.00	725.00	57.40
-275.00	735.00	37.60
-270.00	850.00	24.80
-265.00	715.00	53.00
-265.00	725.00	30.60
-260.00	840.00	21.20
-260.00	850.00	24.80
-255.00	705.00	35.20
-255.00	715.00	36.40
-250.00	730.00	33.20
-250.00	830.00	31.00
-250.00	840.00	27.00
-250.00	860.00	33.00
-245.00	695.00	19.20
-245.00	705.00	21.00
-245.00	715.00	21.60
-245.00	825.00	32.40
-240.00	700.00	17.20
-240.00	710.00	17.80
-240.00	720.00	22.00
-240.00	730.00	31.00
-240.00	820.00	33.80
-240.00	860.00	23.20
-240.00	870.00	33.60
-230.00	710.00	19.60
-230.00	720.00	57.60
-230.00	730.00	26.00

TABLE 4-5 (continued)

Coordinates E,W	Coordinates N,S	PIC* micro-R/h
-230.00	740.00	29.80
-230.00	810.00	34.20
-230.00	820.00	38.80
-230.00	840.00	22.60
-230.00	870.00	21.20
-230.00	880.00	60.40
-220.00	720.00	23.40
-220.00	730.00	63.60
-220.00	750.00	42.80
-220.00	800.00	28.20
-220.00	810.00	24.80
-220.00	840.00	19.60
-220.00	850.00	23.20
-220.00	880.00	27.60
-220.00	890.00	75.40
-210.00	730.00	29.40
-210.00	740.00	107.00
-210.00	750.00	92.80
-210.00	760.00	43.00
-210.00	790.00	41.40
-210.00	800.00	28.40
-210.00	820.00	17.60
-210.00	850.00	21.00
-210.00	860.00	18.80
-210.00	890.00	25.60
-210.00	910.00	55.80
-200.00	750.00	40.60
-200.00	760.00	121.80
-200.00	770.00	46.00
-200.00	780.00	25.40
-200.00	790.00	22.60
-200.00	820.00	78.00
-200.00	830.00	18.40
-200.00	860.00	53.00
-200.00	870.00	28.40
-200.00	890.00	22.20
-200.00	900.00	56.60
-200.00	910.00	49.20
-190.00	760.00	29.60
-190.00	770.00	72.80
-190.00	780.00	22.00
-190.00	800.00	40.80
-190.00	830.00	117.60
-190.00	840.00	23.80
-190.00	870.00	20.60
-190.00	890.00	49.20
-190.00	920.00	49.00

TABLE 4-5 (continued)

Page 3 of 4

Coordinates E,W	Coordinates N,S	PIC* micro-R/h
-190.00	930.00	306.60
-180.00	770.00	20.20
-180.00	780.00	41.00
-180.00	800.00	21.00
-180.00	810.00	36.20
-180.00	840.00	50.20
-180.00	850.00	23.00
-180.00	870.00	24.80
-180.00	880.00	23.40
-180.00	890.00	30.00
-180.00	930.00	263.00
-180.00	940.00	371.40
-170.00	810.00	24.40
-170.00	820.00	43.00
-170.00	850.00	55.20
-170.00	880.00	25.80
-170.00	890.00	25.60
-170.00	900.00	28.60
-170.00	940.00	111.60
-170.00	950.00	245.40
-160.00	800.00	53.40
-160.00	830.00	31.80
-160.00	850.00	37.20
-160.00	900.00	27.60
-160.00	910.00	21.80
-160.00	950.00	61.40
-160.00	960.00	281.40
-157.50	917.50	32.00
-150.00	830.00	25.60
-150.00	860.00	71.60
-150.00	880.00	53.80
-150.00	910.00	21.60
-150.00	920.00	24.00
-150.00	960.00	307.00
-150.00	970.00	41.60
-140.00	820.00	33.60
-140.00	870.00	80.80
-140.00	900.00	24.40
-140.00	910.00	22.00
-140.00	920.00	17.80
-140.00	930.00	240.00
-140.00	940.00	27.20
-140.00	960.00	83.40
-130.00	840.00	79.40
-130.00	880.00	45.00
-130.00	930.00	20.80
-130.00	940.00	27.00

TABLE 4-5 (continued)

Page 4 of 4

Coordinates E,W	Coordinates N,S	PIC* micro-R/h
-130.00	950.00	35.60
-130.00	960.00	30.40
-125.00	915.00	23.00
-125.00	925.00	28.00
-120.00	840.00	49.80
-120.00	860.00	55.80
-120.00	900.00	53.60
-120.00	940.00	27.20
-110.00	880.00	73.80
-110.00	900.00	137.00
-110.00	940.00	53.80
-110.00	950.00	64.80
-110.00	960.00	27.60
-100.00	900.00	28.00
-100.00	910.00	25.60
-100.00	920.00	25.60
-100.00	930.00	24.00
-100.00	940.00	39.60
-100.00	960.00	175.60
-90.00	945.00	70.80
-90.00	960.00	81.20
-80.00	945.00	41.00
-80.00	965.00	44.60
-70.00	945.00	27.60
-70.00	960.00	43.00
-70.00	965.00	39.00

*Accuracy of the PIC is ±5 percent of reading at 10 μR/h.

TABLE 4-6

SUMMARY OF PRE-REMEDIAL ACTION BUILDING MEASUREMENT RESULTS

FORMER MIDDLESEX SAMPLING PLANT

PROCESS BUILDING

INTERIOR MEASUREMENT LOCATIONS	MEASUREMENT TYPE	NO. OF READINGS TAKEN	GRID BLOCK AVERAGE RANGE	MAXIMUM READING OBSERVED	UNITS	CRITERION
Floor	Beta-Gamma Dose Rates	1755	< 0.01 - 0.19	0.65	mrad/h	(1)
	Direct Alpha Activity on Surfaces	1755	58 - 2375	7089	dpm/100 cm^2	200(3)
Walls	Beta-Gamma Dose Rates	1610	< 0.01 - 0.15	0.28	mrad/h	(1)
	Direct Alpha Activity on Surfaces	1610	34 - 2422	3842	dpm/100 cm^2	200(3)
Window Ledges(2)	Beta-Gamma Dose Rate	116	< 0.01 - 0.48	0.48	mrad/h	(1)
	Direct Alpha Activity on Surfaces	116	68 - 2108	2108	dpm/100 cm^2	200(3)
Floor/Wall Intersections(2)	Beta-Gamma Dose Rate	179	< 0.01 - 1.43	1.43	mrad/h	(1)
	Direct Alpha Activity on Surfaces	179	34 - 4335	4335	dpm/100 cm^2	200(3)
Ceiling(2)	Beta-Gamma Dose Rate	81	< 0.01 - 0.26	0.26	mrad/h	(1)
	Direct Alpha Activity on Surfaces	81	0 - 2635	2635	dpm/100 cm^2	200(3)
Steel Beams(2)	Beta-Gamma Dose Rate	69	< 0.01 - 0.43	0.43	mrad/h	(1)
	Direct Alpha Activity on Surfaces	69	51 - 40256	40256	dpm/100 cm^2	200(3)
Wood Beams(2)	Beta-Gamma Dose Rate	71	< 0.01 - 0.64	0.64	mrad/h	(1)
	Direct Alpha Activity on Surfaces	71	17 - 13532	13532	dpm/100 cm^2	200(3)
Miscellaneous Items(2)	Beta-Gamma Dose Rate	20	< 0.01 - 0.08	0.08	mrad/h	(1)
	Direct Alpha Activity on Surfaces	20	51 - 5049	5049	dpm/100 cm^2	200(3)
Floor and Walls(2)	Radon Flux	25	0.42 - 168.0	168.0	$pCi/m^2/s$	20
Room Air	Air Particulate Activity	20	Below MDA - 0.05	0.05	pCi/m^3	3
	Time-Integrated Radon	9	0.40 - 3.54	3.54	pCi/l	30
EXTERIOR MEASUREMENT LOCATIONS						
Walls	Beta-Gamma Dose Rates	2445	< 0.01 - 0.40	0.49	mrad/h	(1)
	Direct Alpha Activity on Surfaces	2445	51 - 18887	18887	dpm/100 cm^2	200(3)
Roof	Beta-Gamma Dose Rates	1755	< 0.01 - 0.84	4.17	mrad/h	(1)
	Direct Alpha Activity on Surfaces	1755	41 - 527	1122	dpm/100 cm^2	200(3)
Window Ledges(2)	Beta-Gamma Dose Rates	88	< 0.01 - 0.26	0.26	mrad/h	(1)
	Direct Alpha Activity on Surfaces	88	17 - 5916	5916	dpm/100 cm^2	200(3)
Dock	Beta-Gamma Dose Rates	50	0.02 - 0.04	0.09	mrad/h	(1)
	Direct Alpha Activity on Surfaces	50	122 - 629	1416	dpm/100 cm^2	200(3)

TABLE 4-6
(continued)

BOILER HOUSE

INTERIOR MEASUREMENT LOCATION	MEASUREMENT TYPE	NO. OF READINGS TAKEN	GRID BLOCK AVERAGE RANGE	MAXIMUM READING OBSERVED	UNITS	CRITERION
Floors	Beta-Gamma Dose Rates	120	< 0.01 - 0.02	0.03	mrad/h	(1)
	Direct Alpha Activity on Surfaces	120	78 - 279	476	dpm/100 cm^2	200(3)
Walls	Beta-Gamma Dose Rates	170	< 0.01 - 0.05	0.08	mrad/h	(1)
	Direct Alpha Activity on Surfaces	170	54 - 364	612	dpm/100 cm^2	200(3)
Floor/Wall Intersection(2)	Beta-Gamma Dose Rates	34	< 0.01 - 0.05	0.05	mrad/h	(1)
	Direct Alpha Activity on Surfaces	34	34 - 442	442	dpm/100 cm^2	200(3)
Window Ledges(2)	Beta-Gamma Dose Rates	8	0.02 - 0.17	0.17	mrad/h	(1)
	Direct Alpha Activity on Surfaces	8	17 - 799	799	dpm/100 cm^2	200(3)
Miscellaneous Items(2)	Beta-Gamma Dose Rates	10	< 0.01 - 0.17	0.17	mrad/h	(1)
	Direct Alpha Activity on Surfaces	10	34 - 5049	5049	dpm/100 cm^2	200(3)
Floors and Walls(2)	Radon Flux Measurements	2	0.60 - 8.93	8.93	$pCi/m^2/s$	20
Room Air(2)	Air Particulate Activity	10	Below MDA - 0.05	0.05	pCi/m^3	3
	Time-Integrated Radon	1	0.53	0.53	pCi/l	30
EXTERIOR MEASUREMENT LOCATIONS						
Walls	Beta-Gamma Dose Rates	245	< 0.01 - 0.07	0.15	mrad/h	(1)
	Direct Alpha Activity on Surfaces	245	146 - 4482	6494	dpm/100 cm^2	200(3)
Roof	Beta-Gamma Dose Rates	240	< 0.01 - 0.02	0.03	mrad/h	(1)
	Direct Alpha Activity on Surfaces	240	51 - 153	272	dpm/100 cm^2	200(3)

TABLE 4-6
(continued)

ADMINISTRATION BUILDING

INTERIOR MEASUREMENT LOCATIONS	MEASUREMENT TYPE	NO. OF READINGS TAKEN	GRID BLOCK AVERAGE RANGE	MAXIMUM READING OBSERVED	UNITS	CRITERION
Floors	Beta-Gamma Dose Rate	600	< 0.01 - 0.07	0.09	mrad/h	(1)
	Direct Alpha Activity on Surfaces	600	0 - 1317	3536	dpm/100 cm^2	200(3)
Walls	Beta-Gamma Dose Rate	18	< 0.01 - 0.02	0.02	mrad/h	(1)
	Direct Alpha Activity on Surfaces	18	17 - 119	119	dpm/100 cm^2	200(3)
Floor/Wall Intersection(2)	Beta-Gamma Dose Rate	106	< 0.01 - 0.06	0.06	mrad/h	(1)
	Direct Alpha Activity on Surfaces	106	34 - 1360	1360	dpm/100 cm^2	200(3)
Window Ledges(2)	Beta-Gamma Dose Rate	26	< 0.01 - 0.02	0.02	mrad/h	(1)
	Direct Alpha Activity on Surfaces	26	34 - 204	204	dpm/100 cm^2	200(3)
Drains(2)	Beta-Gamma Dose Rate	8	< 0.01 - 0.13	0.13	mrad/h	(1)
	Direct Alpha Activity on Surfaces	8	34 - 1071	1071	dpm/100 cm^2	200(3)
Floors and Walls(2)	Radon Flux	2	0.11 - 0.15	0.15	$pCi/m^2/s$	20
Room Air	Air Particulate Activity	17	Below MDA - 0.09	0.09	pCi/m^3	3
	Time-Integrated Radon	2	Nondetectable		pCi/l	30
EXTERIOR MEASUREMENT LOCATIONS						
Window Ledges(2)	Beta-Gamma Dose Rate	25	< 0.01 - 0.02	0.02	mrad/h	(1)
	Direct Alpha Activity on Surfaces	25	17 - 68	68	dpm/100 cm^2	200(3)
Roof	Beta-Gamma Dose Rate	600	0.04 - 0.07	0.08	mrad/h	(1)

TABLE 4-6
(continued)

GARAGE

INTERIOR MEASUREMENT LOCATIONS	MEASUREMENT TYPE	NO. OF READINGS TAKEN	GRID BLOCK AVERAGE RANGE	MAXIMUM READING OBSERVED	UNITS	CRITERION
INTERIOR MEASUREMENT LOCATIONS						
Floor	Beta-Gamma Dose Rate	375	< 0.01 - 0.04	0.05	mrad/h	(1)
	Direct Alpha Activity on Surfaces	375	19 - 253	680	dpm/100 cm^2	200(3)
Floor/Wall Intersection(2)	Beta-Gamma Dose Rate	40	< 0.01 - 0.11	0.11	mrad/h	(1)
	Direct Alpha Activity on Surface	40	51 - 527	527	dpm/100 cm^2	200(3)
Miscellaneous Items(2)	Beta-Gamma Dose Rate	20	< 0.01 - 0.13	0.13	mrad/h	(1)
	Direct Alpha Activity on Surfaces	20	34 - 5015	5015	dpm/100 cm^2	200(3)
Room Air(2)	Air Particulate Activity	17	Below MDA - 0.10	0.10	pCi/m^3	3
	Time-Integrated Radon	2	Nondetectable		pCi/l	30
EXTERIOR MEASUREMENT LOCATIONS						
Roof	Beta-Gamma Dose Rate	195	< 0.01 - 0.02	0.02	mrad/h	(1)
	Direct Alpha Activity on Surfaces	195	68 - 144	204	dpm/100 cm^2	200(3)

(1) 1.0 mrad/h maximum dose rate in any 100-cm^2 area; 0.20 mrad/h average dose rate in any area not to exceed 1 m^2.

(2) Only one measurement was read per grid block.

(3) The 200 dpm/100 cm^2 is based on a one to one composition ratio of uranium-238 to radium-226 (Ref. 14).

MDA Minimum Detectable Activity

Alpha surface measurement averages ranged from 0 to 40,256 dpm/100 cm^2 (Table 4-6). The remedial action criterion for this equilibrium mixture of uranium-238 and radium-226 is 200 dpm/100 cm^2 (Table 4-6). Approximately 90 percent of the interior alpha surface measurements exceeded this limit.

Radon flux measurements were also taken on the floor and walls. Measurement results ranged from 0.42 to 168 pCi/m^2/s. The DOE criterion is 20 pCi/m^2/s (Ref. 13).

Exterior beta-gamma dose rates and alpha surface measurements were taken on the walls, roof, and dock. Approximately 90 percent of the exterior alpha surface contamination measurements exceeded the DOE criterion (200 dpm/100 cm^2). The exterior grid block averages for alpha surface measurements ranged from 17 to 18,887 dpm/100 cm^2. Beta-gamma dose rate averages per grid block ranged from less than 0.01 to 0.84 mrad/h, with a maximum reading of 4.17 mrad/h.

Smear samples were collected from 280 locations on surfaces that exhibited radiation levels in excess of DOE criteria. Results from these samples indicated that removable activity was less than 20 dpm alpha and less than 70 dpm beta, both of which are below criteria (40 dmp/100 cm^2 and 1,000 dpm/100 cm^2, respectively).

4.2.2 Boiler House

The Boiler House is a one-story building. It was surveyed in the same manner as the Process Building.

The floors showed beta-gamma dose rate averages per grid block below the DOE criterion of 1.0 mrad/h. Alpha measurement averages per grid block ranged from 78 to 279 dpm/100 cm^2 with a maximum reading of 476 dpm/100 cm^2. Areas of alpha surface contamination in excess of the DOE limit are shown in Figure 4-3.

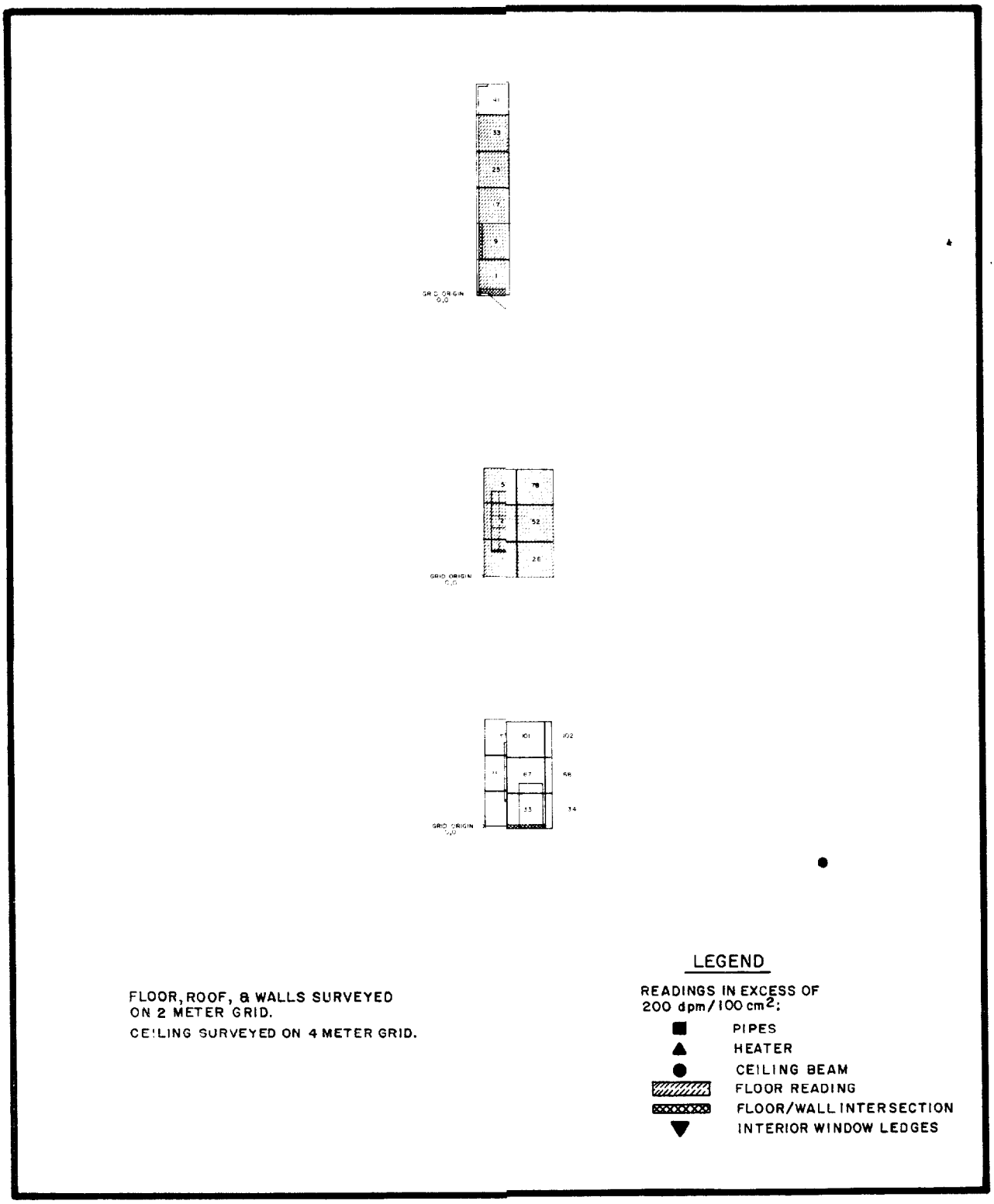


FIGURE 4-3 AREAS OF TRFACE CONTAMINATION

Radon flux measurements were taken on the floor and walls. Measurement results ranged from 0.60 to 8.93 $pCi/m^2/s$. All samples were below the DOE criterion.

Beta-gamma and alpha measurements were made at the floor/wall intersection. Measurements for beta-gamma radiation were all below the DOE criterion. Alpha surface contamination measurement averages per grid block ranged from 34 to 442 $dpm/100\ cm^2$. Areas where these exceeded the DOE limit are shown in Figure 4-3.

Beta-gamma dose rate measurements were taken on the interior walls. All readings were below the dose rate criterion.

The interior wall alpha measurement averages per grid block ranged from 54 to 364 $dpm/100\ cm^2$ with a maximum reading of $612\ dpm/100\ cm^2$. Areas of alpha contamination in excess of the DOE limit are shown in Figure 4-3.

Alpha measurement averages on interior window ledges ranged from 17 to 799 $dpm/100\ cm^2$. Beta-gamma dose rates were below the criterion.

Beta-gamma and alpha measurements were taken on three exterior walls, but the west wall was not accessible for survey measurements. Beta-gamma dose rates were all below the DOE criterion. Alpha measurement averages per grid block ranged from 146 to 4,482 $dpm/100\ cm^2$ with a maximum reading of $6,494\ dpm/100\ cm^2$. Alpha contamination exceeded the criterion on all exterior walls.

The roof grid is also shown in Figure 4-3. Beta-gamma dose rates measured there were all below the criterion. Alpha surface measurement averages per grid block ranged from 51 to 153 $dpm/100\ cm^2$ with a maximum reading of $272\ dpm/100\ cm^2$. Areas where readings in excess of the criterion were observed are shown on Figure 4-3.

Beta-gamma and alpha measurements were taken on ceiling beams, heaters, and interior pipes and light fixtures. Beta-gamma dose rates were all below the DOE criterion. Alpha surface measurements ranged from 34 to 5,049 dpm/100 cm^2. Areas of alpha contamination in excess of the criterion are shown in Figure 4-3.

Smear samples were collected from 23 locations on surfaces that exhibited radiation levels in excess of criteria. Results indicated that removable activity was less than 3 dpm alpha and less than 7 dpm beta, both of which are below their respective criteria.

4.2.3 Administration Building

A survey grid was established on the floor and roof of the single-story Administration Building; the walls were scanned and randomly spot surveyed. These measurements were referenced to the floor grid.

The floor was surveyed for beta-gamma dose rates and alpha contamination. Beta-gamma dose rate measurements were all below the criterion. Alpha averages per grid block ranged from 0 to 1,317 dpm/100 cm^2, with a maximum reading of 3,536 dpm/100 cm^2. Areas where readings exceeded the criterion are shown in Figure 4-4.

Two radon flux measurements were taken on the floor and in the pit area beneath the foyer. The results were 0.11 and 0.15 $pCi/m^2/s$, respectively.

Beta-gamma dose rates and alpha surface measurements were taken at the floor/wall intersection. All beta-gamma dose rates were below the criterion. Alpha surface measurements ranged from 34 to 1,360 dpm/100 cm^2. Areas where readings exceeded the criterion are shown in Figure 4-4.

The interior walls were scanned and randomly spot surveyed. Results were below the criteria for both beta-gamma and alpha measurements.

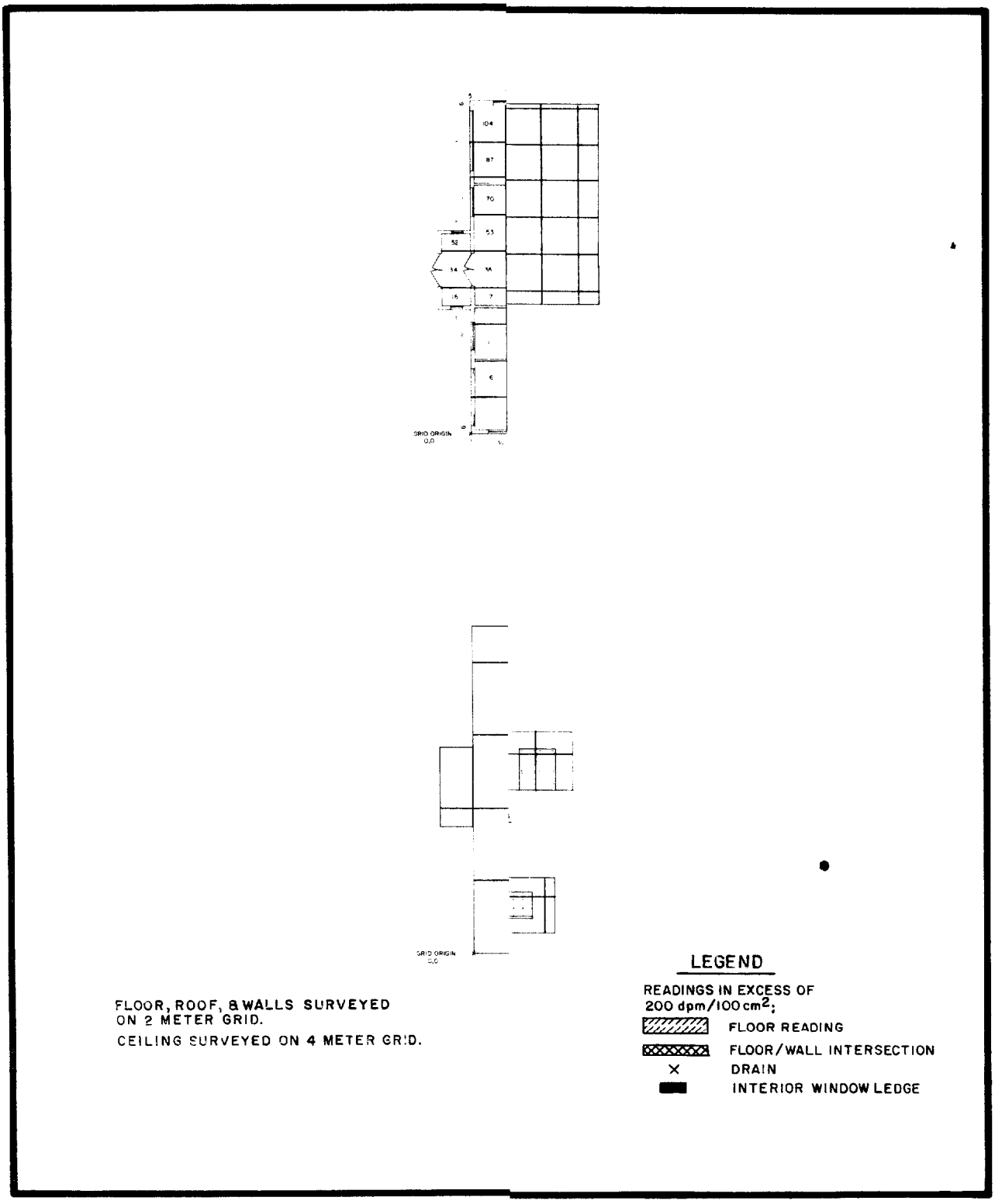


FIGURE 4-4 AREAS OF THE FOHA SURFACE CONTAMINATION

The roof grid is also shown in Figure 4-4. Beta-gamma measurements were all below the criterion. Alpha measurements were not made on the roof.

Beta-gamma and alpha measurements were made on the drains located inside. All beta-gamma dose rates were below the criterion. The maximum alpha surface measurement was 1,071 dpm/100 cm^2. Figure 4-4 shows the location of this drain.

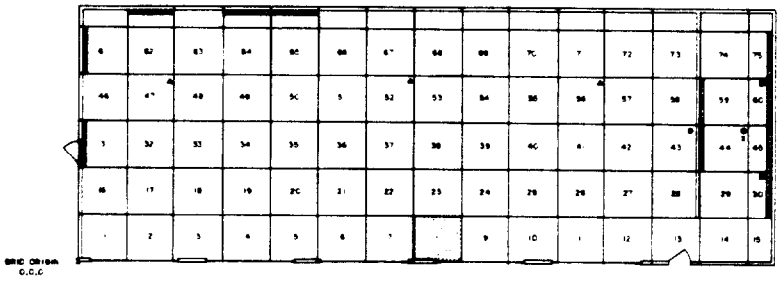
Smear samples were collected from 22 locations on building surfaces that exhibited radiation levels in excess of criteria. Results indicated that removable activity on these surfaces was less than 2 dpm alpha and less than 14 dpm beta, both of which are below their respective criteria.

4.2.4 Garage

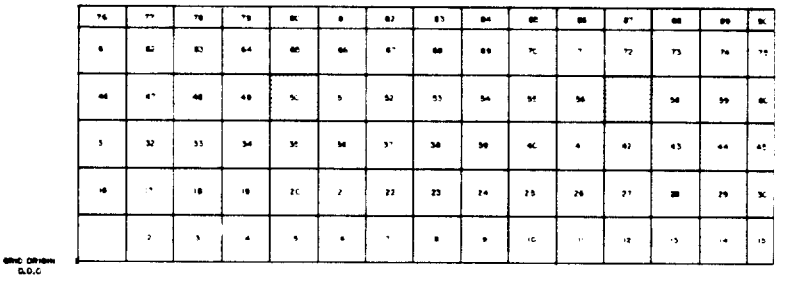
A survey grid was established on the floor and roof of the Garage. The walls were not gridded and surveyed since preliminary scan survey measurements indicated no elevated readings for beta-gamma or alpha contamination.

The floor was surveyed for both beta-gamma and alpha contamination. Beta-gamma dose rate averages per grid block ranged from less than 0.01 to 0.04 mrad/h, with a maximum reading of 0.05 mrad/h. All readings were below the DOE criterion. Alpha surface measurement averages per grid block ranged from 19 to 253 dpm/100 cm^2 with a maximum reading of 680 dpm/100 cm^2. Areas where readings exceeded the limit are shown in Figure 4-5.

Beta-gamma and alpha measurements were taken at the floor/wall intersection. All beta-gamma dose rates were below the criterion. Alpha measurements maximum reading was 527 dpm/100 cm^2. Areas where readings exceeded the criterion are shown in Figure 4-5.



FLOOR PLAN



ROOF PLAN

FLOOR & ROOF SURVEYED ON
2 METER GRID.

LEGEND

READINGS IN EXCESS OF
200 dpm/100 cm^2:

- HEATERS
- CEILING BEAM
- SIDE OF CEILING BEAM
- FLOOR/WALL INTERSECTION
- FLOOR READING

FIGURE 4-5 AREAS OF THE FORMER MSP GARAGE WHERE READINGS EXCEEDED THE LIMIT FOR ALPHA SURFACE CONTAMINATION

The roof grid is also shown in Figure 4-5. All beta-gamma dose rate measurements there were below the criterion. Alpha surface measurement averages per grid block ranged from 68 to 144 dpm/100 cm^2 with a maximum reading of 204 dpm/100 cm^2. Areas where readings exceeded the criterion are shown in Figure 4-5.

Beta-gamma dose rates and alpha measurements were taken inside on window ledges, ceiling beams, and heaters. All beta-gamma dose rate measurements were below the criterion. The maximum alpha surface measurement was 5,015 dpm/100 cm^2. These measurements are referenced to the floor grid, and areas where measurements exceeded the criterion are shown in Figure 4-5.

Smear samples were collected from 10 locations on building and equipment surfaces that exhibited radiation levels in excess of criteria. Results indicated that removable activity on building surfaces was less than 4 dpm alpha and less than 14 dpm beta, both of which are below their respective criteria. Low-level removable cativity was found on two heaters in the Garage. The maximum alpha and beta activities on these heaters were 27 dpm and 95 dpm, respectively.

5.0 SIGNIFICANCE OF FINDINGS

5.1 FIELD SURVEY

Results from near-surface gamma measurements were used to determine the extent of surface contamination; logs of borehole gamma readings and results of soil samples obtained from borings were used to determine the depth of contamination. These data were plotted on a site grid drawing to determine the areal extent of contamination. For uranium-238, the remedial action guideline is 150 pCi/g. For radium-226, the extent of contamination was determined based on the limit of 15 pCi/g when averaged over 15-cm (6-in.) thick soil layers more than 15 cm (6 in.) below the surface and less than 1.5 m (5 ft) below the surface (Table 4-1). The results of these determinations are shown in Figures 5-1 and 5-2. In situ gamma measurements indicate contamination in the first 15 cm (6 in.) of ground cover. Based on the thickness of the asphalt and the comparatively limited extent of subsurface contamination, the asphalt/gravel covering is contaminated to levels in excess of guidelines.

One water sample collected from an on-site borehole indicated an uranium-238 concentration of 1,288 pCi/l and a radium-226 concentration of 71 pCi/l. These concentrations exceed DOE criteria for unrestricted areas: 600 pCi/l for total uranium and 30 pCi/l for radium-226.

The maximum external gamma radiation measured at 1 m (3 ft) above the ground was 371 μR/h and the maximum beta-gamma dose rate at the surface was 7.25 mrad/h. Elevated concentrations of radium-226 and uranium-238 were found in surface and subsurface soils. Maximum concentrations were 735 pCi/g of radium-226 and 961 pCi/g of uranium-238.

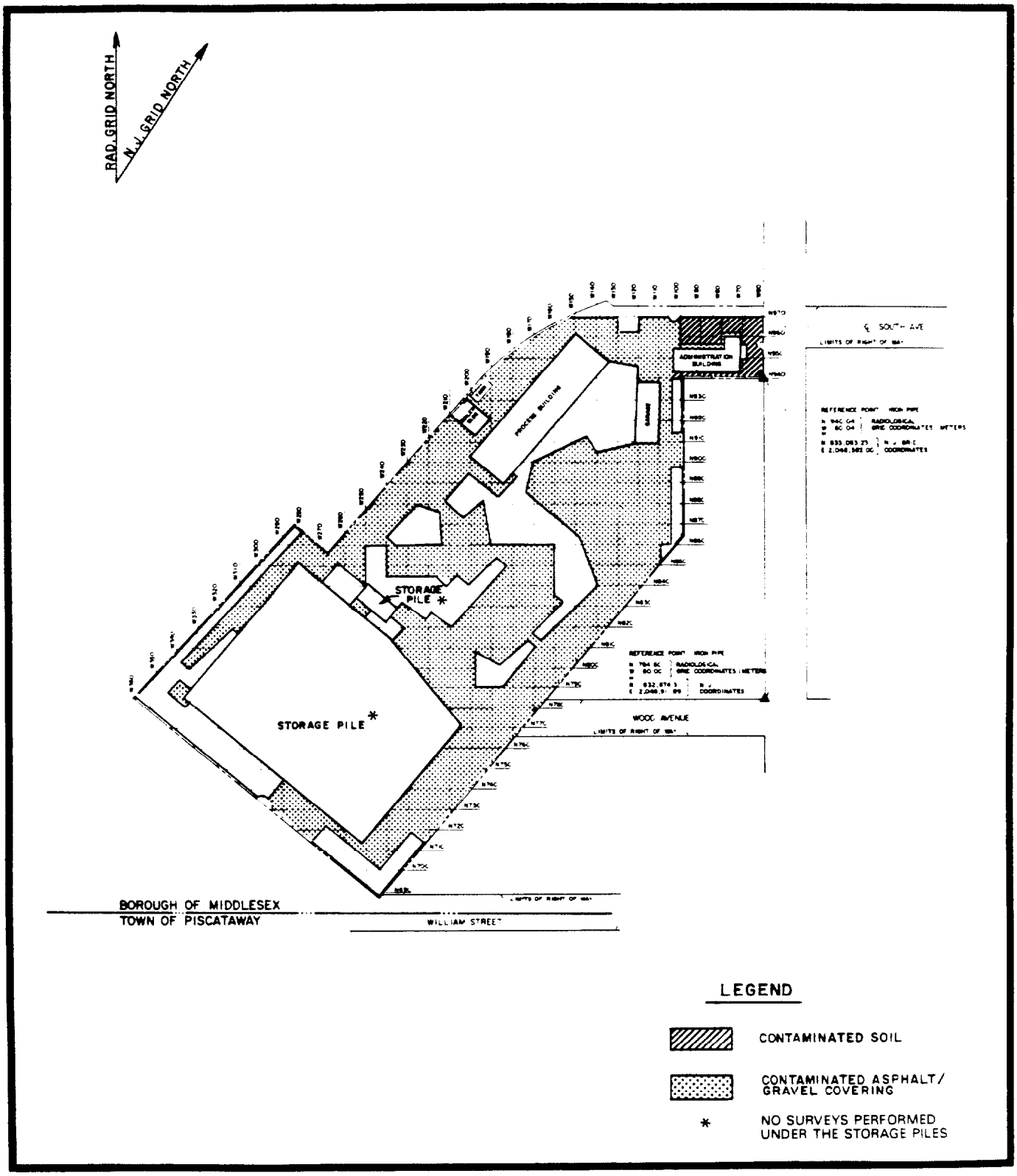


FIGURE 5-1 AREAS OF SURFACE CONTAMINATION BASED ON NEAR-SURFACE GAMMA MEASUREMENTS

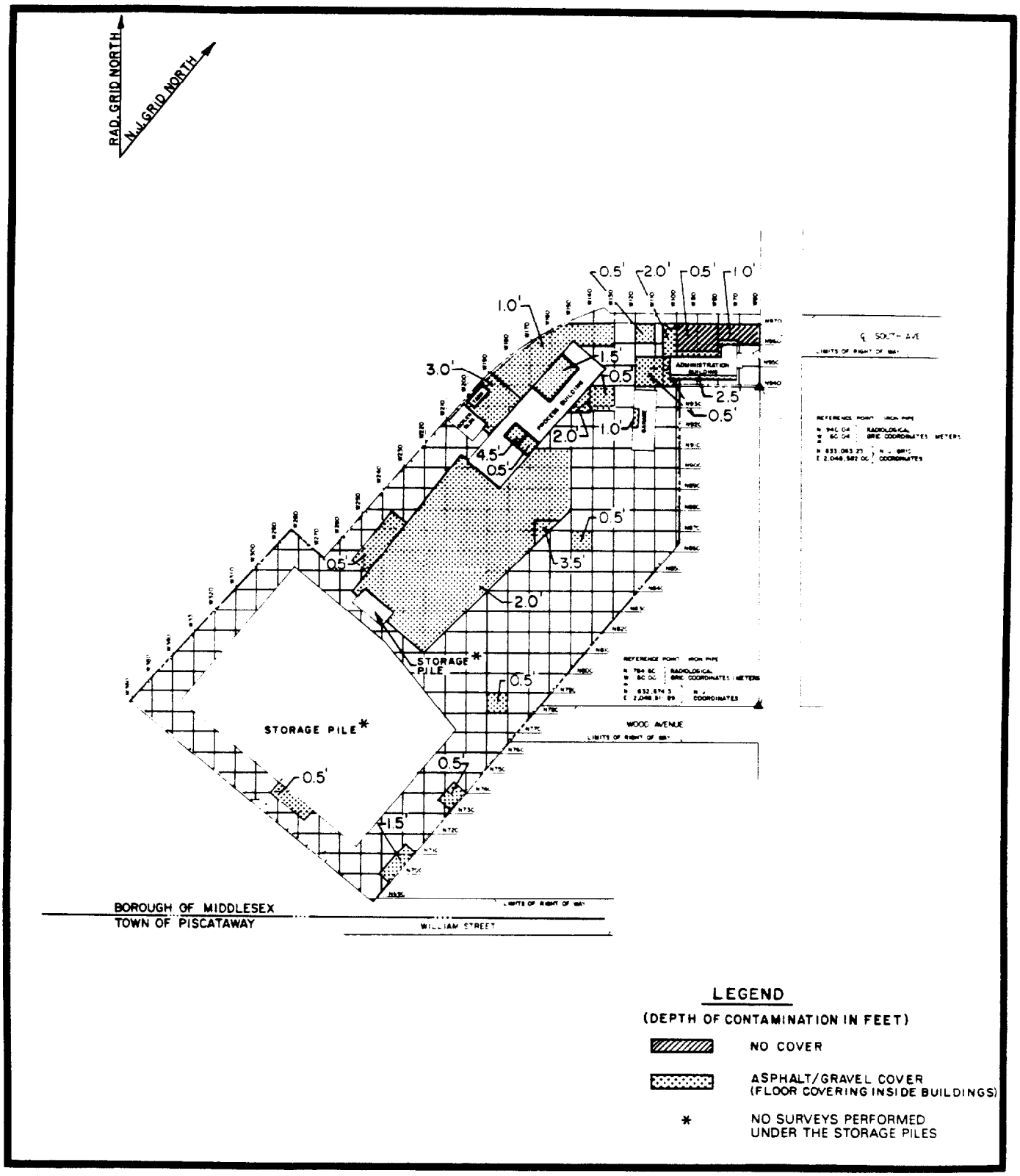


FIGURE 5-2 AREAS OF SUBSURFACE CONTAMINATION BASED ON SOIL SAMPLE RESULTS AND BORING LOGS

To comply with guidelines, approximately 13,000 m^3 (17,000 yd^3) of contaminated asphalt/gravel and soil will have to be removed from the grounds in addition to the 27,500 m^3 (36,000 yd^3) already in the storage piles and the approximately 25,000 m^3 (33,000 yd^3) of contaminated material to be transferred from the Middlesex Municipal Landfill.

5.2 BUILDING SURVEYS

During the comprehensive decontamination effort carried out at the former Sampling Plant in 1966-67 all removable surface contamination was cleaned using a variety of techniques such as vacuuming, sand blasting, and washing. Thereafter DOE (then AEC) certified that the residual radiation levels were within existing cleanup guidelines. The remaining radioactivity on above-grade building surfaces was believed to be firmly imbedded. The results of the present radiological characterization tend to support this conclusion since no removable radioactivity in excess of the current DOE criteria was found. Consequently, major demolition techniques will be required to remove existing residual radioactivity from building surfaces. The major portion of the rubble will result from the demolition of the Boiler House and the Process Building. Removal of surface contamination in several isolated areas of the Garage and Administration Building will be required. It is estimated that 3650 m^3 (4775 yd^3) of rubble will be generated from decontamination of the four buildings. Results of the radiological surveys conducted in the four buildings are presented in Table 4-6.

5.2.1 Process Building

Approximately ninety percent of all alpha measurements taken on the interior and exterior surfaces of the Process Building exceeded the criterion for surface contamination. The maximum reading observed was 40,256 dpm/100 cm^2. The maximum beta-gamma dose rate observed was 1.43 mrad/h.

The maximum radon flux measurement was 168 pCi/m^2/s; that for time-integrated radon was 3.54 pCi/l.

Subsurface soil samples from boreholes drilled through the first floor indicated contaminated soils at a depth of 1.4 m (4.5 ft). This depth corresponds to the original grade prior to installation of a concrete floor in the building. An estimated 19 m^3 (25 yd^3) of soil must be removed to comply with guidelines.

5.2.2 Boiler House

Readings from interior floors, walls, and the floor/wall intersections indicated alpha contamination in excess of the criterion in patchy areas, as shown in Figure 4-3. The maximum interior alpha surface measurement observed was 799 dpm/100 cm^2. All beta-gamma dose rate measurements were below the criterion.

Miscellaneous measurements taken on inside heaters, pipes, and beams showed some alpha contamination with a maximum reading of 5,049 dpm/100 cm^2.

The maximum radon flux measurement was 8.93 pCi/m^2/s; that for time-integrated radon was 0.53 pCi/l.

Three exterior walls were surveyed – the west exterior wall was not accessible – and about ninety percent of all alpha measurements exceeded the criterion. The maximum alpha surface measurement was 6,494 dpm/100 cm^2. All beta-gamma dose rates taken on the exterior walls were below the criterion.

The roof showed spotty contamination; the maximum measurement for alpha surface contamination was 272 dpm/100 cm^2.

Based on subsurface soil samples and gamma logs, the contamination in the soil under the Boiler House is below guidelines.

5.2.3 Administration Building

Interior measurements were taken on the floor, at the floor/wall intersections, on the drains, and at random locations on the walls. The maximum alpha surface measurement observed was 3,536 dpm/100 cm^2. All beta-gamma dose rate measurements were below the criterion.

The maximum radon flux measurement was 0.15 $pCi/m^2/s$; time-integrated radon was nondetectable.

Exterior beta-gamma dose rate measurements were taken on the roof; all readings were below the criterion.

A few areas of elevated alpha readings were found and will require hot spot decontamination. These areas are indicated on Figure 4-4.

5.2.4 Garage

Interior measurements were taken on the floors, at the floor/wall intersections, and on miscellaneous items inside the Garage. The maximum alpha level was 5,015 dpm/100 cm^2, observed on a heater. All interior beta-gamma dose rates were below the criterion.

Radon flux data was lost during processing. Time-integrated radon was nondetectable.

Exterior measurements were taken on the roof. Elevated alpha readings were observed in two areas as shown on Figure 4-5. The maximum measurement observed was 204 dpm/100 cm^2.

Several areas of elevated readings were found and will require hot spot decontamination. Areas where readings exceeded criteria are shown in Figure 4-5.

REFERENCES

1. U.S. Department of Energy. A Background Report for the Formerly Utilized MED/AEC Sites Program, DOE/EV-0097, September 1980.

2. Memorandum, F. P. Baronowski to R. E. Hollingsworth. "AEC Storage Facility at Middlesex, N.J.", April 6, 1965.

3. Memorandum, S. R. Sapirie, Mgr ORO-USAEC, to F. P. Baronowski. "Disposal of AEC Storage Site at Middlesex, N.J. and St. Louis Airport Storage Site," August 13, 1964.

4. Memorandum, S. R. Sapirie, Mgr ORO USAEC, to F. P. Baronowski, Air Production Division USAEC Headquarters. "Status Report on Middlesex Decontamination Program," August 12, 1966.

5. Memorandum, S. R. Sapirie, Mgr ORO USAEC, to F. P. Baronowski, Air Production Division USAEC Headquarters. "Transmittal of Study on Disposal of AEC Facility at Middlesex, New Jersey," September 17, 1965.

6. Isotopes, Inc. Decontamination of Middlesex Sampling Plant under USAEC Contract Number AT (40-1)-3637 from March 6, 1967 through June 30, 1967, Undated.

7. U.S. Department of Energy. Radiological Survey of the Middlesex Sampling Plant, Middlesex, New Jersey, DOE/EV-0005/1, Oak Ridge, TN, November, 1977.

8. Bechtel National, Inc. Final Report on Phase II Remedial Action at the Former Middlesex Sampling Plant and Associated Properties, Draft, Oak Ridge, TN, September 1984.

9. Bechtel National, Inc. Radiological Protection Program, Oak Ridge, TN, revised October 9, 1984.

10. Oak Ridge National Laboratory. Procedures Manual for the ORNL Remedial Action Survey and Certification Activities (RASCA) Program, Oak Ridge, TN, September 1982.

11. Oak Ridge National Laboratory. State Background Radiation Levels: Results of Measurements Taken During 1975-1979, ORNL/TM-7343, Oak Ridge, TN, November 1981.

12. U.S. Department of Energy. Order 5480.1A, "Environmental Protection, Safety, and Health Protection Program for DOE Operations," Washington, DC, 1982.

13. Letter, E. L. Keller to R. L. Rudolph. "Comments on the Radiological Survey Report for the Former Middlesex Sampling Plant, Middlesex, New Jersey and the Draft Radiological Survey Report for the DuPont Chambers Works Plant, Deepwater, New Jersey," September 11, 1984.

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