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M-028

Formerly Utilized Sites Remedial Action Program (FUSRAP)

ADMINISTRATIVE RECORD

for Maywood, New Jersey

U.S. Department of Energy

036924

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MAY 1 8 1986

U.S. Department of Energy
Oak Ridge Operations
Post Office Box E
Oak Ridge, Tennessee 37831

Attention: J. F. Wing
Technical Services Division

Subject: Bechtel Job No. 14501, FUSRAP Project
DOE Contract No. DE-AC05-81OR20722
Maywood Interim Storage Site Annual Site
Environmental Monitoring Report
File No. 148, 138

Dear Mr. Wing:

Enclosed per your request are 15 copies of the subject report. It is our understanding that you will transmit 10 copies of the report to Mr. Carl Welty of DOE-HQ in advance of distribution to the remaining addressees on the EMR mailing list. We are in the process of reproducing the reports needed for the remaining distribution, and will await labels and transmittal letters from you before completing the distribution.

This report incorporates comments on the first draft and has been revised according to the guidance contained in the Delaney to Keller memorandum of March 24, 1986, that was subsequently hand-carried to us April 1, 1986. The report also incorporates the review comments you provided in a meeting with Alice Feldman on April 29. Per your direction, we have added new text discussing the concentrations of chemical contaminants in groundwater at the MISS in connection with New Jersey Pollution Discharge Elimination System permit requirements. This new portion reflects the comments provided by you and Bob Atkin after reviewing the material in our office on May 12.

CONCURRENCE

amf				

It is our understanding that the enclosed reports are considered to have undergone final review and approval by ORO. We will await receipt of further direction from Billie Queener regarding mailing of reports to the full distribution.

Very truly yours,

Joseph F. Nemec

Joseph F. Nemec
Program Manager - FUSRAP

AMF/bjs
Enclosures: As Stated

cc: J. R. Kannard
B. A. Hughlett
E. L. Keller
J. F. Nemec

DOE/OR/20722-96

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

MAYWOOD INTERIM STORAGE SITE ANNUAL SITE ENVIRONMENTAL REPORT

Maywood, New Jersey

Calendar Year 1985

May 1986

Bechtel National, Inc.
Advanced Technology Division

DOE/OR/20722-96

MAYWOOD INTERIM STORAGE SITE
ANNUAL SITE ENVIRONMENTAL REPORT
CALENDAR YEAR 1985

MAY 1986

Prepared for

UNITED STATES DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

Under Contract No. DE-AC05-81OR20722

By

Bechtel National, Inc.

Advanced Technology Division

P. O. Box 350

Oak Ridge, Tennessee

Bechtel Job No. 14501

ABSTRACT

During 1985, the environmental monitoring program was continued at the Maywood Interim Storage Site (MISS), a U.S. Department of Energy (DOE) facility located in the Borough of Maywood and the Township of Rochelle Park, New Jersey. The MISS is presently used for the storage of low-level radioactively contaminated soils. Monitoring results show that the MISS is in compliance with DOE concentration guides and radiation protection standards. Derived Concentration Guides (DCGs) represent the concentrations of radionuclides in air or water that would limit the radiation dose to 100 mrem/yr. The applicable guides have been revised since the 1984 environmental monitoring report was published. The guides applied in 1984 were based on a radiation protection standard of 500 mrem/yr; the guides applied for 1985 are based on a standard of 100 mrem/yr.

The MISS is part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), a DOE program to identify, decontaminate, or otherwise control sites where low-level radioactive contamination (exceeding current guidelines) remains from the early years of the nation's atomic energy program, or from commercial operations causing conditions that Congress has mandated DOE to remedy. The environmental monitoring program is carried out by Bechtel National, Inc. (BNI), Project Management Contractor for FUSRAP.

The monitoring program at the MISS measures thorium, uranium, and radium concentrations in surface water and groundwater, thoron and radon gas concentrations in air, and external gamma radiation dose rates. Potential radiation doses to the public are also calculated.

To determine whether the site is in compliance with DOE standards, environmental measurements are expressed as percentages of the applicable DCG, while the calculated doses to the public are expressed as percentages of the radiation protection standard.

During 1985, annual average thoron concentrations ranged from less than 1 percent to 32 percent of the DOE guide. Annual average radon concentrations ranged from 7 to 17 percent of the DOE guide. The highest annual average total external gamma dose rate measured at the MISS was 627 percent of the radiation protection standard but was in an area of known contamination. The highest average annual concentration of uranium in surface water monitored in the vicinity of the MISS was 0.5 percent of the DOE DCG; for radium-226 it was 0.4 percent of the applicable DCG, and for thorium-232 it was 0.4 percent. In groundwater, the highest annual average concentration of uranium was 11 percent of the DCG. For radium-226 it was less than 1 percent of the applicable DCG, and for thorium-232 it was less than 1 percent.

The highest annual average concentration of uranium in sediment at the MISS was 0.83 pCi/g; for radium-226 it was 0.45 pCi/g; and for thorium-232 it was 0.29 pCi/g. There are no specific guidelines for radionuclide concentrations in sediment.

The MISS was designated for remedial action under FUSRAP because radioactivity above applicable limits was found to exist at the site and its vicinity. Elevated levels of radiation still exist in areas where remedial action has not yet been completed. Further detail regarding radiation levels measured in 1985 can be found in Section 3.0 of this report.

Radon concentrations, external gamma exposure rates, and radionuclide concentrations in groundwater at the site were lower than those measured in 1984; radionuclide concentrations in surface water were roughly equivalent to 1984 levels.

The calculated radiation dose to the maximally exposed individual at the MISS was 1.25 mrem, which is 1.25 percent of the radiation protection standard.

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1.0 INTRODUCTION

This report presents the findings of the environmental monitoring program conducted at the Maywood Interim Storage Site (MISS) during calendar year 1985. Environmental monitoring began at the MISS in 1984. As part of the research and development decontamination program authorized by Congress under the 1984 Energy and Water Appropriations Act, Bechtel National, Inc. is conducting remedial action at the site and at vicinity properties. The work is being performed as part of the U.S. Department of Energy (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP), one of four remedial action programs under the direction of the DOE Division of Facility and Site Decommissioning Projects.

1.1 LOCATION AND DESCRIPTION

The MISS is located in the Borough of Maywood and the Township of Rochelle Park, New Jersey, in the County of Bergen, New Jersey, approximately 19.2 km (12 mi) north-northwest of downtown Manhattan (New York City) and 20.8 km (13 mi) northeast of Newark, New Jersey (Figures 1-1, 1-2). Figure 1-3 is an aerial photograph of the site. The MISS is bounded by New Jersey Route 17 on the west, a railroad line on the northeast, and commercial/industrial areas on the south and east. The site occupies 4.7 ha (11.7 acres) of a 12-ha (30-acre) property owned by the Stepan Company (formerly Maywood Chemical Works). The MISS is a fenced vacant lot; the Stepan Company property is also enclosed by a fence and is currently used for chemical processing activities.

Site activities are conducted in a manner designed to preclude the migration of contaminants from the MISS via groundwater or surface water. During construction, pollution control measures include the use of prudent engineering controls, such as installation of sedimentation barriers in excavation areas and discharges of treated, impounded surface water in batches in accordance with New Jersey Department of Environmental Protection (NJDEP) requirements.

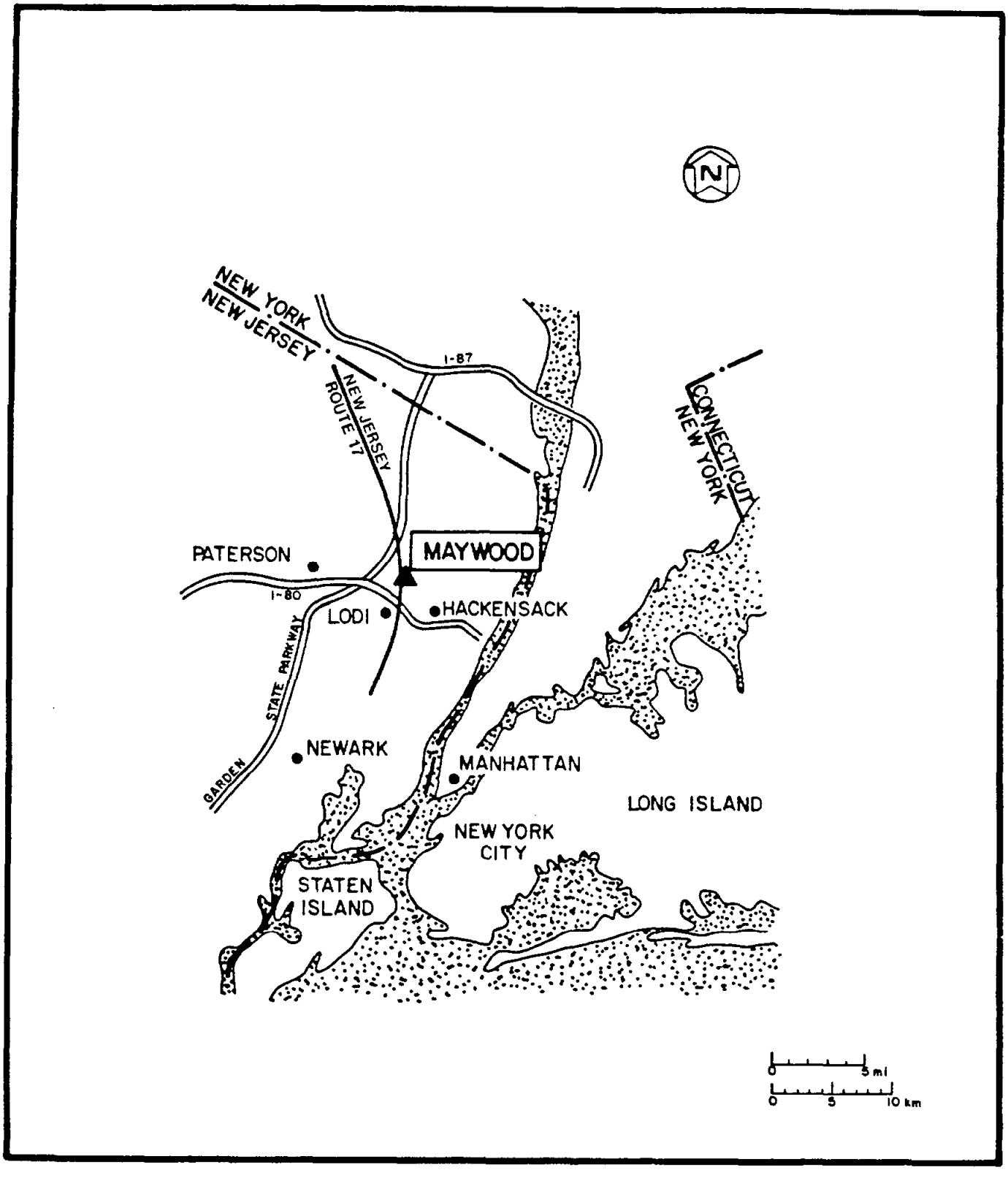


FIGURE 1-1 LOCATION OF MAYWOOD, NEW JERSEY

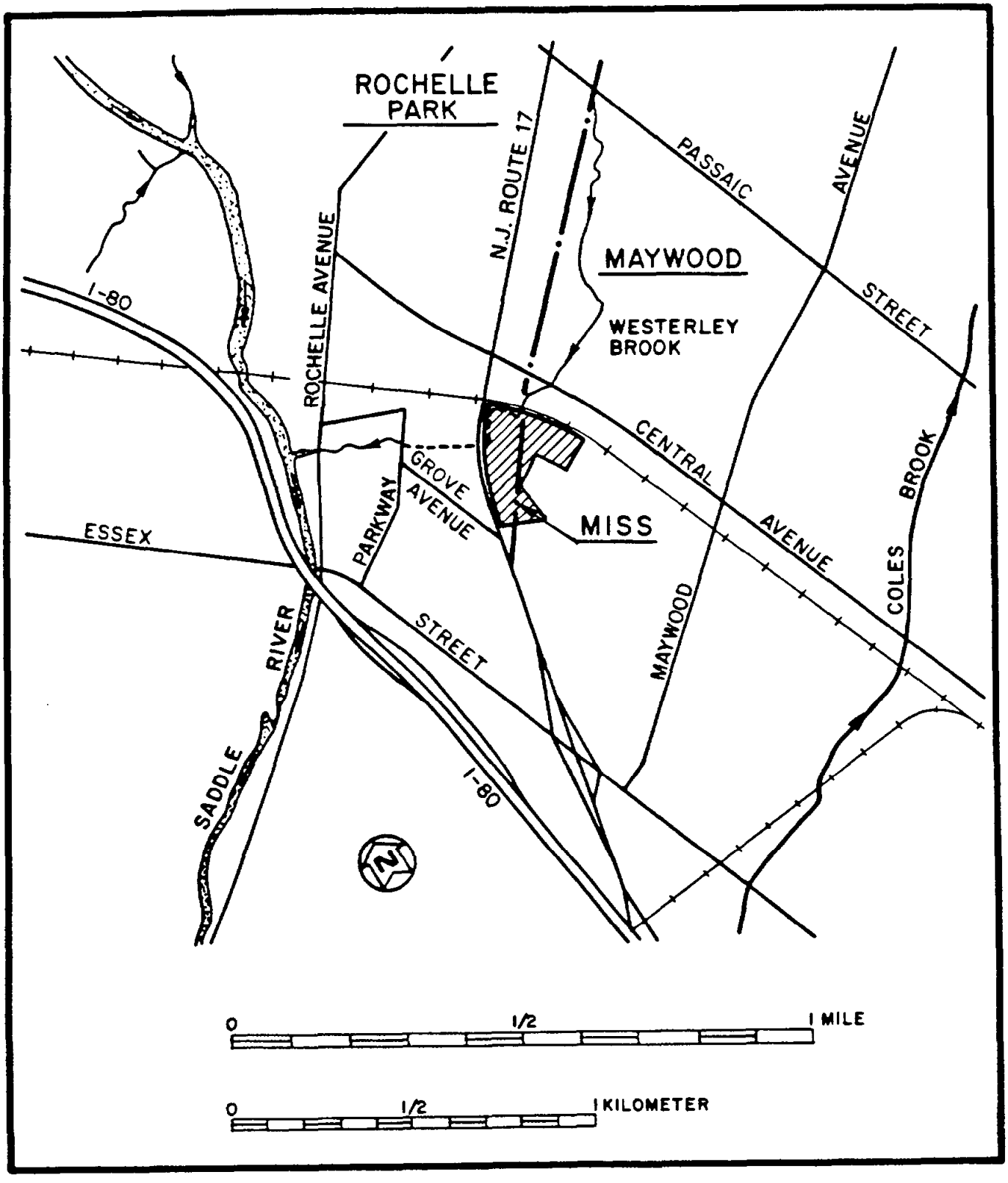


FIGURE 1-2 LOCATION OF THE MISS

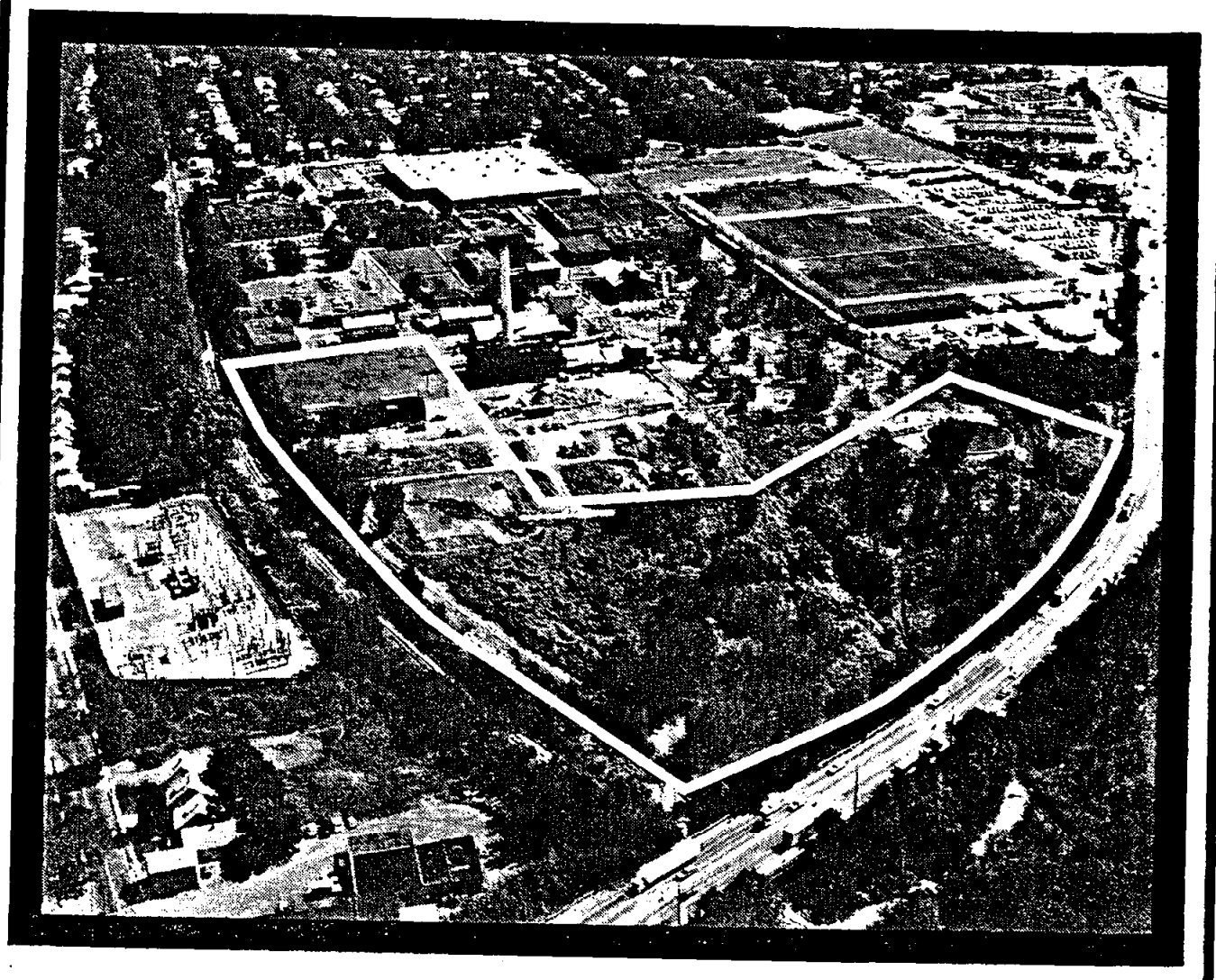


FIGURE 1-3 AERIAL VIEW OF THE MISS

The MISS is located within the glaciated section of the Piedmont Plateau of north-central New Jersey (Ref. 1). The terrain is generally level with intermittent shallow ditches and slight mounds (Ref. 2). The MISS slopes gently toward the Saddle River, which is located west of the site (Figure 1-2). It is underlain by sedimentary sandstone, mudstone, and siltstone of the Brunswick Formation (Refs. 3, 4). The bedrock lies close to the surface and is overlain by 1 to 4.5 m (3 to 15 ft) of weathered bedrock and unconsolidated glacial deposits of clay, silt, sand, and gravel. The depth of the glacial deposits varies considerably in the vicinity of the site. In addition, fill materials consisting primarily of soil and building rubble were placed on the site during its many years of industrial use (Ref. 3).

The MISS is located within the Saddle River drainage basin (Figure 1-2), approximately 0.8 km (0.5 mi) east of the Saddle River (a tributary of the Passaic River) and approximately 1.6 km (1 mi) west of the drainage divide of the Hackensack River basin (Ref. 3). The MISS is poorly drained. Rainwater runoff from the MISS empties into the Saddle River via Westerley Brook. The brook flows under the site through a concrete storm drain, passes under New Jersey Route 17, and eventually empties into the Saddle River. Neither the Saddle River nor Westerly Brook is used as a source of drinking water (Ref. 5).

The groundwater table is generally shallow, lying 2.1 to 3 m (7 to 10 ft) below the ground surface (Ref. 3). Groundwater in the Maywood area is available primarily from a bedrock aquifer and from unconsolidated surficial deposits; the former is generally considered to be the more significant groundwater resource. The wells that draw from the unconsolidated surficial deposits have generally low yields and are used for domestic purposes. However, some wells located in the thicker surficial deposits of stratified glacial drift have high yields and have been developed for industrial and public use.

The average frequency of precipitation in New Jersey is 120 days per year; the mean annual precipitation is approximately 120 cm (48 in.), with an average annual snowfall of 72.75 cm (29.1 in.) As shown in Figure 1-4, winds in the area blow predominantly from the southwest at a mean speed of 16.3 km/h (10.2 mph) (Refs. 6, 7).

The 1980 populations for Maywood and Rochelle Park were approximately 9,900 and 5,600 respectively: a decline from their respective populations of 11,000 and 6,400 in 1970. Within Bergen County, the 1970 and 1980 populations were approximately 898,000 and 845,000, respectively. The population in this county is expected to increase over the next 20 years (Ref. 1).

The MISS is zoned for commercial and industrial use. Generalized land use in the vicinity of the MISS is shown in Figure 1-5. The areas adjacent to the site are zoned primarily for limited commercial, light industrial, or single family residential use. With the exception of one house located on the east border of the Stepan Company property, the areas to the east and south of the site are used for industrial and restricted commercial purposes. The New York, Susquehanna and Western Railroad runs along the northern border of the MISS.

1.2 SITE HISTORY

The MISS was established to provide an interim storage site for low-level radioactive waste materials found in the vicinity of the former Maywood Chemical Works. From 1916 through 1956, the Maywood Chemical Works processed monazite sand (thorium ore) for use in the manufacture of industrial products such as mantles for gas lanterns. During this time, slurry containing process wastes from the thorium operations was pumped to diked areas west of the plant. Some of these process wastes were removed from the Maywood Chemical Works for use as mulch and fill on nearby properties, thereby contaminating them with radioactive thorium.

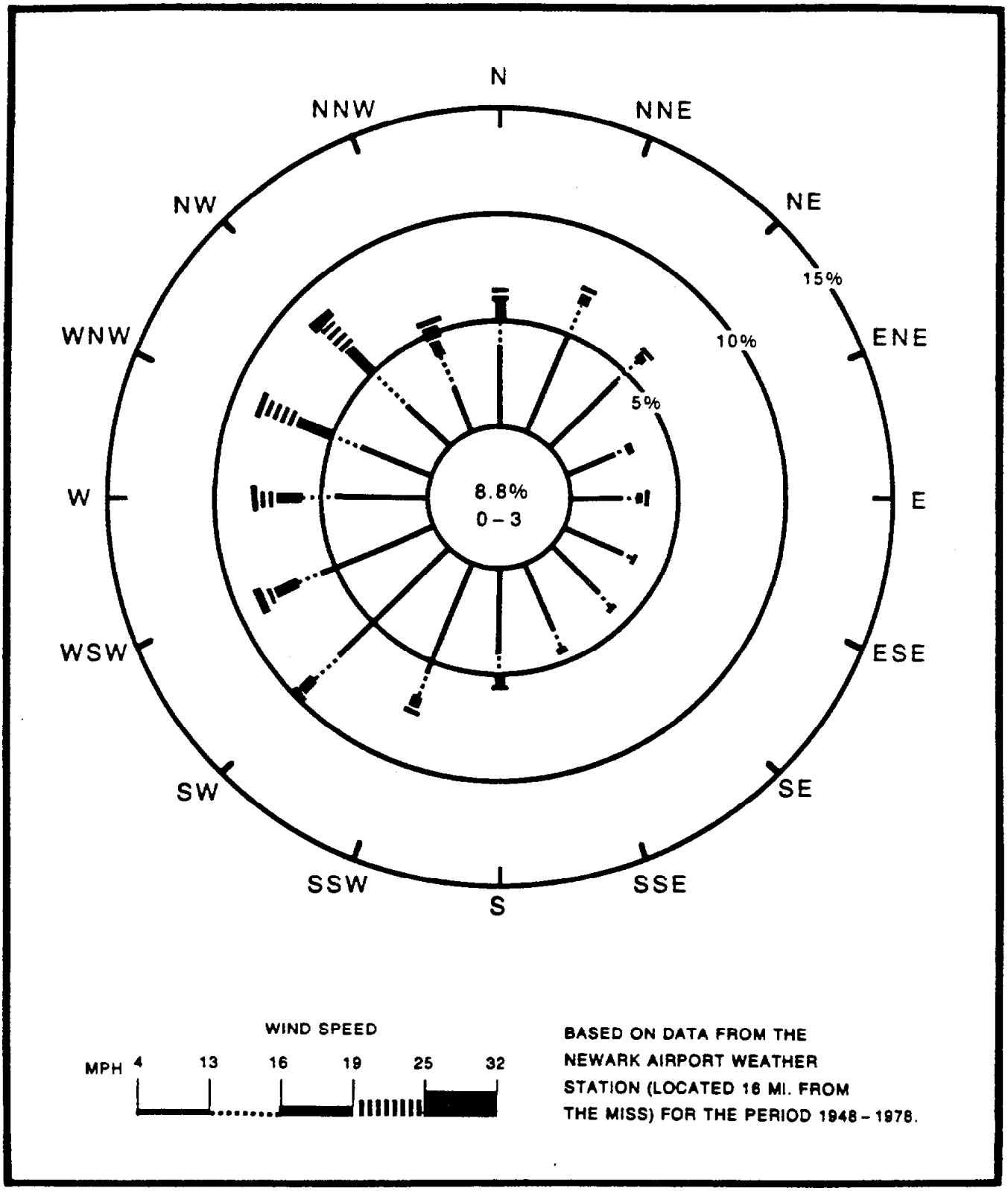
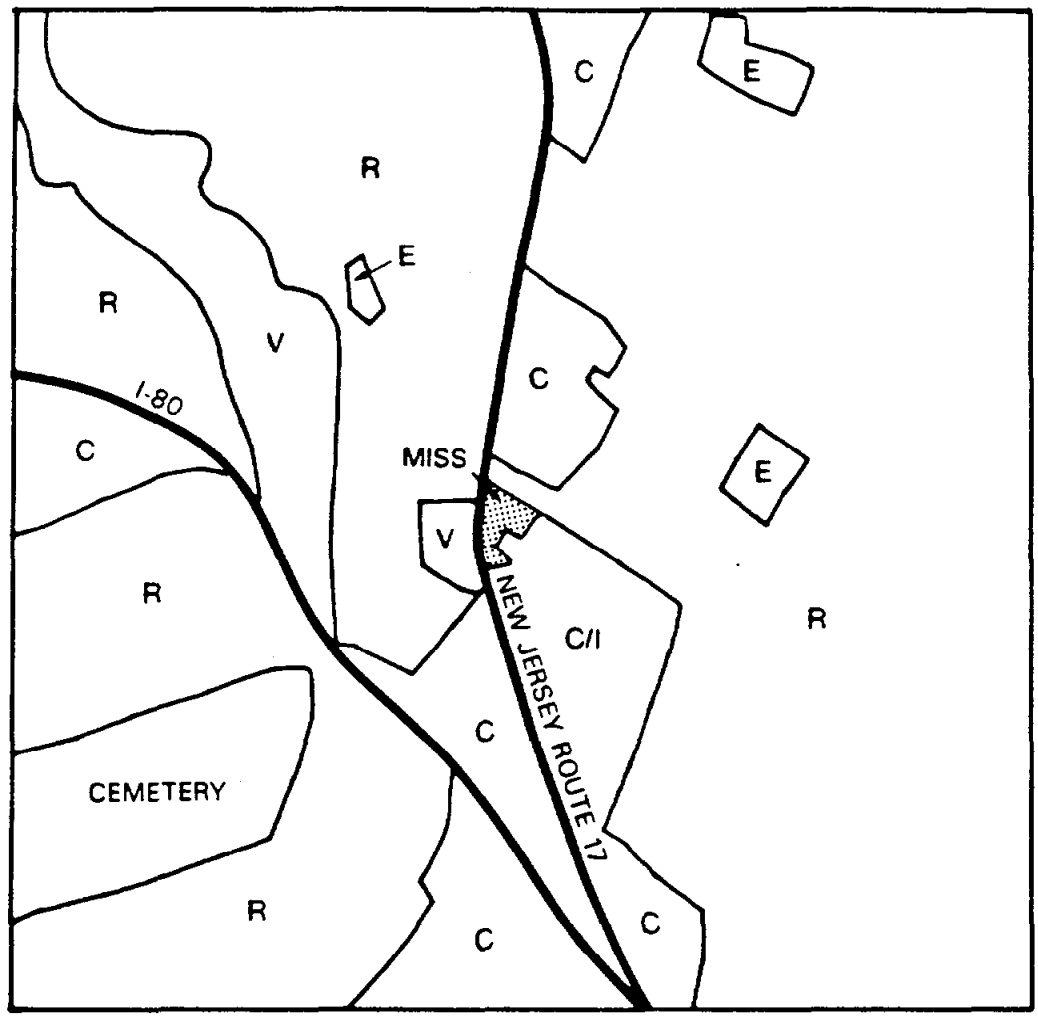


FIGURE 1-4 ANNUAL WIND ROSE FOR THE MISS, 1985



BASED ON AERIAL PHOTOGRAPHS, SITE VISITS AND USGS TOPOGRAPHIC MAP 1:24000 SCALE, HACKENSACK, NJ QUADRANGLE (PHOTO REVISED 1981)

R RESIDENTIAL
C COMMERCIAL
C/I MIXED COMMERCIAL/INDUSTRIAL
E EDUCATIONAL
V VACANT

0 0.5 MILES

N

FIGURE 1-5 GENERALIZED LAND USES IN THE VICINITY OF THE MISS

In 1954, the Atomic Energy Commission (AEC) issued License R-103 to the Maywood Chemical Works, thereby allowing it to continue to possess, process, manufacture, and distribute radioactive materials (Ref. 8) under the auspices of the Atomic Energy Act of 1954. The Maywood Chemical Works stopped processing thorium in 1956 after approximately 40 years of production. During this time, process wastes from the operations were pumped to diked areas west of the plant. In 1932, New Jersey Route 17 was built through this disposal area (Figure 1-2). The Maywood Chemical Works was sold to the Stepan Company in 1959.

In 1961, the Stepan Company was issued an AEC radioactive materials license (STC-130) (Ref. 9). Based on AEC inspections and information related to the Ballod property on the west side of New Jersey State Route 17, the Stepan Company agreed to take remedial action. The cleanup was begun in 1963. In 1966, 6354 m^3 (8360 yd^3) of waste was removed from the area east of Route 17 and buried on site at Burial Site No. 1, which is now overlain by grass. In 1967, 1560 m^3 (2053 yd^3) of waste were removed from the same general area and buried on site at Burial Site No. 2, which is now a parking lot. In 1968 the Stepan Company obtained permission from the AEC to transfer an additional 6536 m^3 (8600 yd^3) of waste from the south end of the Ballod property and bury it on site at Burial Site No. 3, an area where a warehouse was later built (Ref. 8). Figure 1-6 shows the approximate locations of these burial sites. The location of an area formerly occupied by thorium processing facilities is also shown in Figure 1-5; this area is known to be contaminated (Ref. 3).

At the request of the Stepan Company, a radiological survey of the south end of the property west of New Jersey Route 17 (the Ballod property) was conducted by the AEC in 1968. Based on the findings of that survey (Ref. 8), clearance was granted for release of the property for unrestricted use. At the time of the survey, the AEC was not aware that unexcavated waste materials were present in the northeast corner of the property. In 1968 this portion of the Stepan Company property was sold to a private citizen who later sold it to the current owners, Ballod and Associates (Ref. 10).

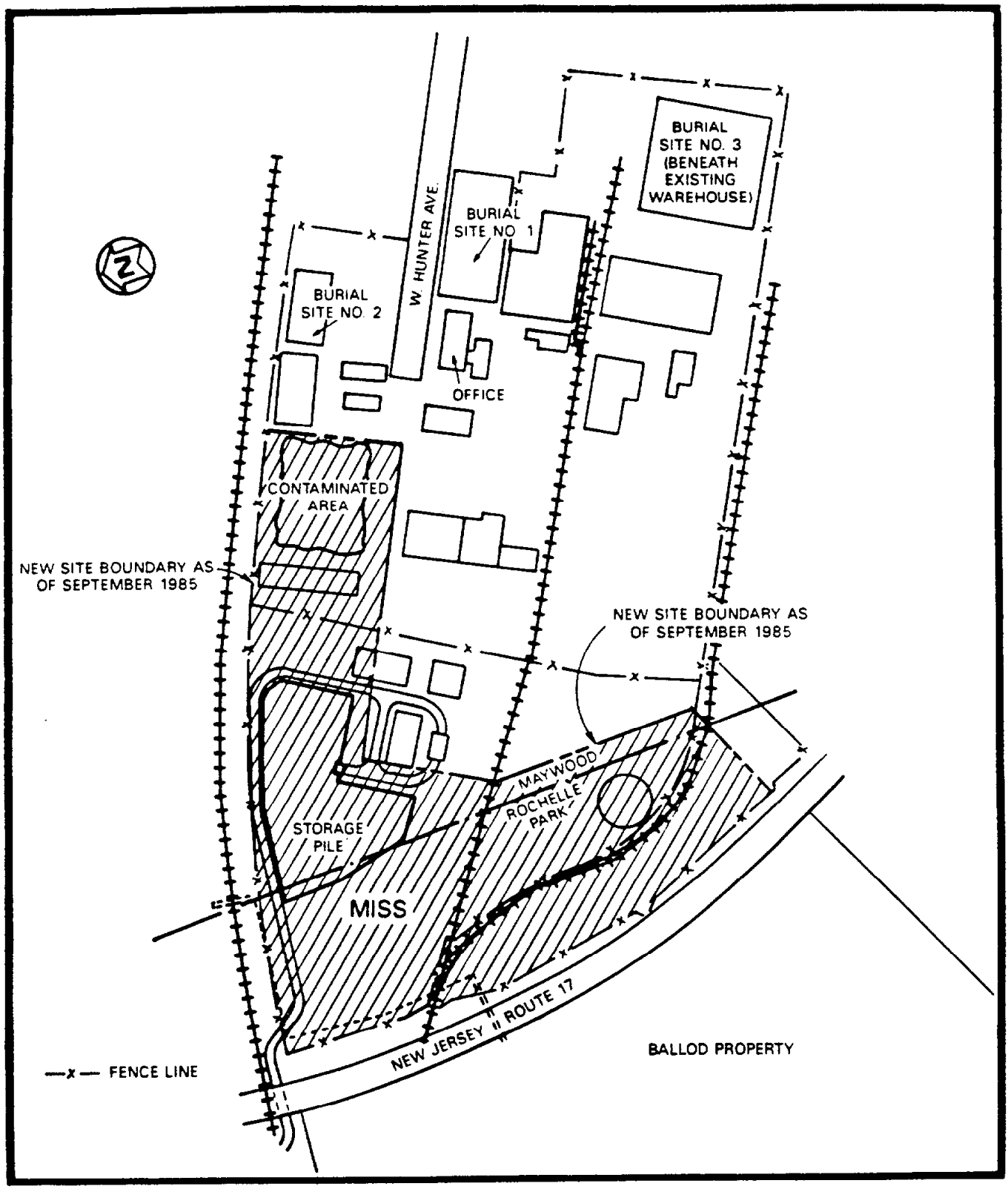


FIGURE 1-6 BURIAL SITE LOCATIONS ON THE STEPAN COMPANY PROPERTY

In 1980 the U.S. Nuclear Regulatory Commission (NRC) was notified that elevated readings were obtained on the Ballod and Associates property (Ref. 8). This information prompted the NRC to request a comprehensive survey to assess the radiological condition of the property. The survey was performed by Oak Ridge Associated Universities (ORAU) with the assistance of a representative from the Region I office of the NRC in February 1981 (Ref. 2).

The NRC also requested that an aerial radiological survey of the Stepan Company site, the Ballod and Associates property, and the surrounding area be conducted. This survey, which was conducted by EG&G in January 1981, resulted in the discovery of other anomalies (readings distinctly higher than those of surrounding areas) (Ref. 11). Elevated gamma readings (greater than the local background level) were detected directly over the Stepan Company chemical plant, as well as immediately to the west and south of the plant. Two other points of elevated background gamma radiation were detected approximately 0.8 km (0.5 mi) from the center of the plant: one to the northeast of the plant and the other to the south of the plant. Followup ground surveys were performed to determine the nature of these anomalies.

In 1984, Oak Ridge National Laboratory (ORNL) surveyed the Lodi area with a mobile van (Ref. 12). Eight residential properties were found to be contaminated with thorium-232; additional properties were found to be contaminated with radium-226 and uranium. The presence of radium-226 and uranium appears to be associated with the presence of natural uranium ore.

In 1984, DOE negotiated an agreement with the Stepan Company for access to a 4.7 ha (11.7-acre) portion of the Stepan Company property on which to establish the MISS, pending execution of an agreement to transfer ownership of the site to DOE. Development of the storage site commenced, and contaminated materials removed from 17 vicinity properties in Maywood and Rochelle Park were brought to the site in 1984. In 1985, remedial action was conducted at eight

residential properties in the Borough of Lodi as well as at the Ballod property in Rochelle Park. In September 1985, ownership of the MISS property was transferred to DOE. Further remedial action will be performed in subsequent years.

2.0 SUMMARY OF MONITORING RESULTS

During 1985, the environmental monitoring program at the MISS was continued. The program includes the sampling of air, water, and sediments and the measurement of external gamma exposure rates to determine compliance with applicable guides. These guides specify the maximum concentrations of individual types of radioactive materials (radionuclides) that may be present in air or water. This is a health protection measure to limit exposure to an individual to the DOE radiation protection standard of 100 mrem/yr. The revised DOE Derived Concentration Guides (DCGs) for radioactive materials and the revised DOE radiation protection standard (Ref. 13) are included in Appendix B. A discussion of the new radiation protection standard and associated DCGs is also presented in Appendix B. Radiation doses at the MISS during 1985 were calculated to permit a comparison with dose levels permitted by the radiation protection standard.

Radon and thoron gas concentrations at all monitoring locations were less than the DOE guides for release to uncontrolled areas. Annual average radon concentrations ranged from 7 to 17 percent of the guide. The measured value of background radon concentration for the MISS was 13 percent of the guide. Thoron concentrations ranged from less than 1 percent to 32 percent of the DOE guide. The measured value of background thoron concentration for the MISS was less than 1 percent of the guide. Both radon and thoron concentrations were lower at the MISS in 1985 than in 1984. A detailed discussion of radon and thoron concentrations is provided in Section 3.1 of this report.

Total external dose rates measured at the MISS ranged from 15 to 627 mrem/yr. The maximum rate was measured in an area of known contamination. These rates may be compared to the external dose rate from radiation in the vicinity of the MISS, which was measured at 108 mrem/yr.

In surface waters, all measured concentrations of uranium, thorium-232 and radium-226 were less than 1 percent of the applicable Derived Concentration Guide. See Section 3.3.1 for further detail.

The highest annual average concentration of uranium in groundwater at the MISS in 1985 was 2.0 percent of the Derived Concentration Guide. However, a single sample from Well 5A showed a concentration of 11 percent of the Derived Concentration Guide for uranium. The highest annual average concentration of thorium-232 was 0.6 percent of the Derived Concentration Guide; for radium-226 it was also 0.6 percent of the Derived Concentration Guide (the average for radium-226 is based on three samples from Well 1B).

While there are no concentration guides for uranium, radium-226, and thorium-232 in stream sediments, all average concentrations of these radionuclides at the MISS were below the limits established by DOE for remedial action under FUSRAP. See Section 3.4 for further detail.

The site was designated for remedial action under FUSRAP because elevated levels of radiation were found to exist at the MISS and its vicinity. Elevated levels of radiation still exist where remedial action has not been completed.

During 1985, releases of small amounts of radioactive materials from MISS to the environment occurred. The rate of radon release was slightly enhanced as the result of disturbance of the soil during normal construction activities. Similarly, small concentrations of uranium, thorium-232, and radium-226 were present in rainwater runoff from the site during 1985. All such releases were below applicable guides as determined by site and vicinity monitoring data for radon and by measured concentrations of uranium, thorium-232, and radium-226 in waters leaving the site via natural drainage paths.

Calculations were made of radiological doses received by a maximally exposed individual. This individual is one who is assumed, when all

potential routes of exposure are considered, to receive the greatest dose. The maximum dose this individual would receive is approximately 1 mrem, or 1 percent of the radiation protection standard. This calculation is based on the assumption that the individual would walk along the western boundary of the site (where monitored radiation levels are the highest) twice a day, 365 days a year.

The internal exposure pathway that would result in the greatest dose to an individual is the ingestion of contaminated groundwater. An individual who obtained all drinking water from the well with the highest annual average radionuclide concentrations would receive a dose of 15 mrem; or 15 percent of the radiation protection standard.

The cumulative dose to the population within an 80-km (50-mi) radius contributed by on-site radioactive materials would be indistinguishable from the dose the same population would receive from naturally occurring radioactive sources.

With the exception of measured external dose rates recorded in areas of known surface contamination, results of the 1985 monitoring show that the MISS was in compliance with the DOE Derived Concentration Guides and radiation protection standard.

3.0 DATA COLLECTION, ANALYSIS, AND EVALUATION

This section provides the results of 1985 environmental monitoring at the MISS (Ref. 14), including the sampling, monitoring, and analytical procedures and the extent of compliance with applicable DOE Derived Concentration Guides (DCGs) and radiation protection standards. The DCGs, in most cases, specify the concentration of a particular radionuclide in air or water that would limit the dose to the most highly exposed individual to less than 100 mrem per year. Radiation doses were calculated to determine hypothetical exposure levels, which were compared with this value. The DOE DCGs for radionuclides of concern at MISS and the applicable DOE radiation protection standards are included in Appendix B of this report.

Data are presented in summary tables for each type of monitoring. Summaries of data include sampling locations, minimum and maximum values recorded, number of data points collected, average value, and, where appropriate, percent of applicable standard or DCG. The average value is the arithmetic average of the sum of individual results for the respective sampling location. Individual sources of error (e.g., analytical error, sampling error) were not estimated. The "less than" (<) notation is used to denote sample analysis results that are below the limit of sensitivity of the analytical method based on a statistical analysis of parameters. In computing the averages, where values are less than the limit of sensitivity of the analytical method, values are considered as being equal to the limit of sensitivity, and the average value is reported without the notation "less than."

During 1985, air, water, and sediment samples were collected by site personnel, and external radiation exposure rates were measured to determine the radioactivity concentrations in the environs of the site. Surface and groundwater, radon, and external gamma radiation sampling were conducted quarterly; sediment sampling was conducted annually.

3.1 RADON MONITORING

Two forms of radon gas are present at the MISS. The more common form, radon-222, is part of the natural uranium decay chain. The other form, radon-220, is part of the natural thorium decay chain. To distinguish between these two forms of radon, the term "thoron" (the common name for radon-220) will be used in this report.

Radon gas detectors are maintained on-site near the storage pile and at approximately equal intervals along the site perimeter. Two of the detectors are designated for quality control. The locations of the radon monitors are shown in Figure 3-1.

Terradex paired Type F and Type M Track-Etch detectors are used to monitor for radon and thoron. Although this technique is experimental, it is the only one commercially available for detecting thoron at environmental levels. In the presence of thoron, the Type M detector provides an accurate measurement of radon concentrations. The thoron concentration is obtained by subtracting the Type M reading from the Type F reading (Ref. 15). A negative or zero value indicates the absence of thoron. The Terradex Corporation performs the analysis.

Table 3-1 lists thoron and radon concentrations recorded at the MISS. Annual average concentrations of thoron ranged from 2×10^{-11} to 3.2×10^{-9} uCi/ml (0.02 pCi/l to 3.2 pCi/l). These values are less than 1 percent and 32 percent, respectively, of the DOE guide of 1×10^{-8} uCi/ml (10 pCi/l). The highest annual average concentration was recorded at Location 5 on the northeast corner of the MISS boundary. The 1985 background concentration, as measured at Location 14 (the Department of Health in Paterson, New Jersey) was 1×10^{-10} uCi/ml (0.1 pCi/l), which is less than 1 percent of the guide.

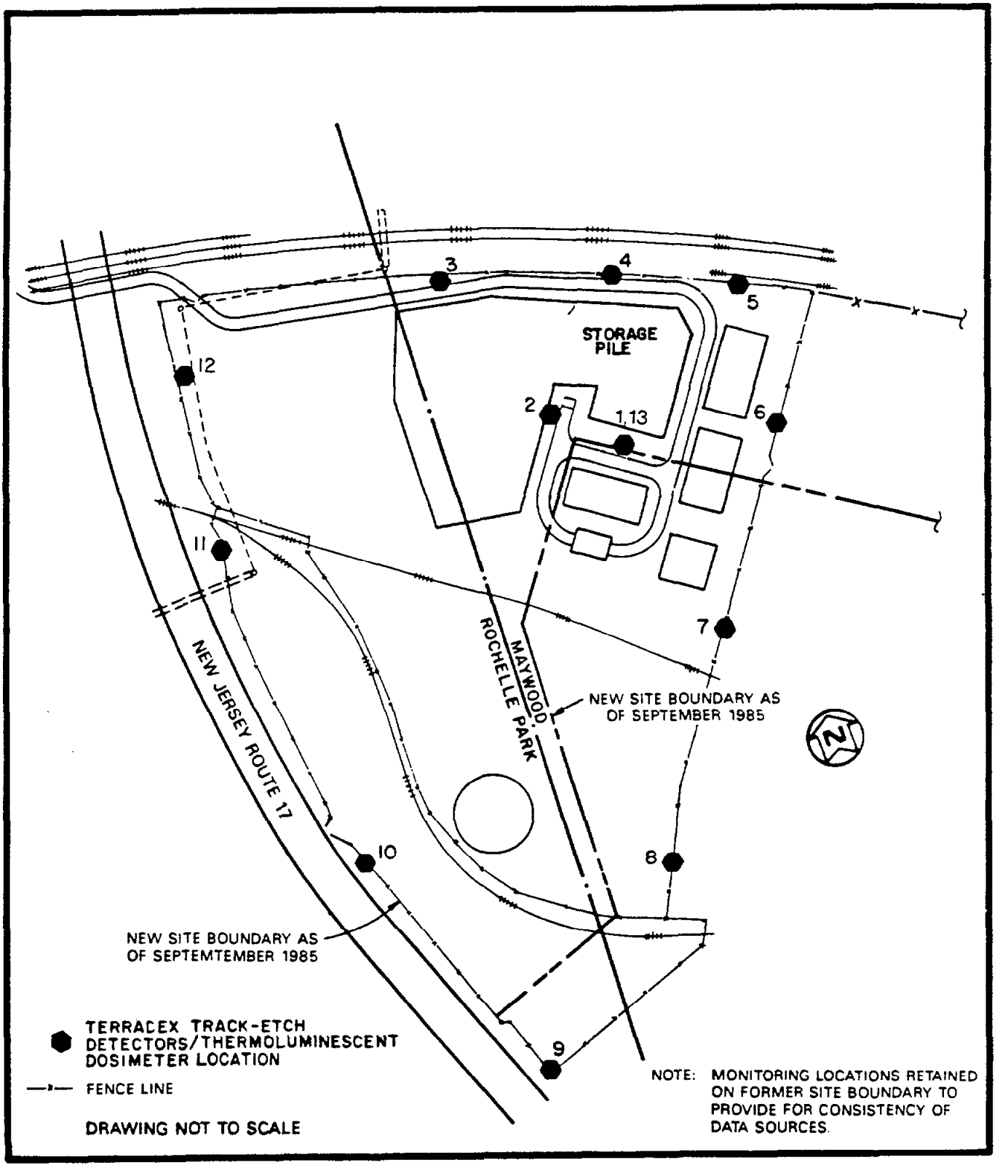


FIGURE 3-1 RADON AND EXTERNAL GAMMA RADIATION MONITORING LOCATIONS AT THE MISS

TABLE 3-1

CONCENTRATIONS OF THORON AND RADON AT THE MISS, 1985

Sampling Location[a]	Number of Measurements	Concentrations[b] ($n \times 10^9$ uCi/ml)[c] Minimum	Maximum	Average	Percent of Standard[d] (Annual Average)
Thoron (Rn-220)					
1	4	<MDA[e]	1.5	0.5	5
2	3[f]	0.4	0.9	0.6	6
3	4	<MDA	0.7	0.3	3
4	4	<MDA	0.9	0.5	5
5	4	1.4	5.3	3.2	32
6	4	0.2	2.0	1.0	10
7	4	0.1	0.5	0.3	3
8	4	<MDA	0.1	0.02	0.2
9	4	<MDA	0.7	0.2	2
10	3[f]	1.4	3.7	2.7	27
11	3[f]	0.1	0.3	0.2	2
12	4	0.5	2.2	1.2	12
13[g]	3[f]	<MDA	8.0	2.9	29
14[h]	4	<MDA	0.2	0.1	1
Radon (Rn-222)					
1	4	0.1	0.5	0.3	10
2	3[f]	0.04	0.3	0.2	7
3	4	0.2	0.4	0.3	10
4	4	0.1	0.8	0.4	13
5	4	0.2	1.0	0.5	17
6	4	0.1	0.4	0.2	7
7	4	0.1	0.4	0.2	7
8	4	0.1	0.6	0.3	10
9	4	0.1	0.4	0.2	7
10	3[f]	0.1	0.9	0.4	13
11	3[f]	0.2	0.3	0.2	7
12	4	0.04	0.5	0.2	7
13[g]	3[f]	0.1	0.5	0.3	10
14[h]	4	0.1	0.5	0.4	13

[a]Sampling locations shown in Figure 3-1. Location 13 is quality control station for Location 1.

[b]All results include background.

[c]Multiply n (the listed concentration) by 10^9 to obtain uCi/ml.

[d]DOE limit for thoron (radon-220) is 10 pCi/l (annual average above background) for uncontrolled areas. DOE limit for radon-222 is 3 pCi/l (annual average above background) for uncontrolled areas.

[e]No detectable thoron (radon-220) or less than minimum detectable activity (MDA).

[f]Detectors missing; no data for affected sampling period.

[g]QC station for Location 1.

[h]Background monitoring station at the Department of Health, Paterson, New Jersey.

Annual average concentrations of radon-222 ranged from 2×10^{-10} to 5×10^{-10} uCi/ml (0.2 pCi/l to 0.5 pCi/l). These values are 7.0 and 17.0 percent, respectively, of the DOE guide of 3×10^{-9} uCi/ml (3 pCi/l). The highest annual average concentration of radon-222, 5×10^{-10} uCi/ml, (0.5 pCi/l) was recorded at Location 5 on the northeast boundary. The 1985 average background radon concentration, as measured at Location 14 at the Department of Health in Paterson, was 4×10^{-10} uCi/ml (0.4 pCi/l), which is 13.0 percent of the DOE guide.

The radon monitoring program was in effect during the last 4 months of 1984. A comparison of the 4-month average for 1984 to the 1985 annual average for all of the boundary monitoring locations shows thoron (radon-220) levels to have dropped from 2×10^{-9} to 1×10^{-9} uCi/ml (2 to 1 pCi/l) and radon-222 levels to have dropped from 1.2×10^{-9} to 3×10^{-10} uCi/ml (1.2 to 0.3 pCi/l). Although the seasonal variations in the 1984 and 1985 monitoring periods may have contributed to this reduction, the magnitude of the decrease in radon and thorium levels at the site boundary cannot be attributed solely to seasonal variations.

3.2 EXTERNAL GAMMA DOSE RATES

External gamma dose rates were measured at 12 monitoring locations. Ten of the locations are spaced at approximately equal intervals on the site boundary, and the other two are on the perimeter of the on-site storage pile. All locations correspond to radon detector locations, as shown in Figure 3-1. Sample locations were selected to monitor dose rates at the site boundary and in the area adjacent to the contaminated storage pile.

The external gamma dose rates are measured using lithium fluoride (LiF) thermoluminescent dosimeters (TLDs). Each monitor contains five TLD chips, the responses of which are averaged. TLDs are exchanged quarterly. The results for gamma dose monitoring are

presented in Table 3-2. In order to provide an estimate of the impact of dose rates at the site boundary, a correction has been made to account for background levels.

At five of the boundary locations, measured total dose rates in 1985 exceeded the radiation protection standard of 100 mrem/yr; total dose rates were below the limit at the other five boundary locations (Ref. 15). Of the seven locations where members of the public could be exposed, the highest total dose rate was recorded at Location 10 (near State Route 17), an area known to be contaminated (Ref. 3). This reading, 627 mrem/yr, is 627 percent of the annual limit of 100 mrem.

There has been a downward trend in external dose rates at the site boundary as construction has progressed at the site. The 1985 average dose rate for all site boundary monitoring locations was 140 mrem/yr: 41 percent lower than the 1984 average dose rate of 237 mrem/yr.

3.3 WATER SAMPLING

During 1985, sampling was performed to determine the concentrations of uranium, thorium-232 and radium-226 in surface water and groundwater at both on-site and off-site locations. Both surface water and groundwater sampling locations are shown in Figure 3-2.

3.3.1 Surface Water

Quarterly surface water sampling locations were established for the Saddle River (Location 1) and from Westerly Brook (Locations 2, 3, and 4). Location 4 is accessible only by way of a manhole. Since the manhole cover is currently welded shut, no samples could be collected from Location 4. Two surface locations (Locations 5 and 6) were established on the Ballod property for sample collection. However, since no standing water was present at Locations 5 and 6 during 1985 quarterly sampling, no surface water samples could be obtained. Surface water collection locations were selected based on

TABLE 3-2

EXTERNAL GAMMA DOSE RATES AT THE MISS, 1985

Sampling Location[a]	No. of Measurements	Dose Rate (mrem/qtr)[b] Minimum	Maximum	Average	Total mrem/yr	Percent of Standard[c]
Boundary						
3	4	4	9	7	27	27
4	4	24	40	33	130	130
5	4	44	87	68	272	272
6	4	18	31	27	106	106
7	4	0	10	4	15	15
8	4	2	7	4	15	15
9	4	4	17	10	38	38
10[d]	3[e,f]	143	185	157	627	627
11	4	12	17	14	57	57
12	4	37	51	45	180	180
On-Site						
1	4	10	13	12	48	48
2	3[e,f]	10	14	13	50	50
13	3[e,f]	6	18	11	46	46
Background						
14[g]	4	25	29	27	108	108

[a]Sampling locations are shown in Figure 5. Location 13 is a QC TLD for Location 1.

[b]Measured background has been subtracted. Dose rate is based on continuous occupancy throughout the year.

[c]The DOE radiation protection standard is 100 mrem/yr.

[d]Location 10 is in an area of known contamination (Ref. 3).

[e]Location 10 TLD missing 2nd quarter; Location 2 TLD missing 3rd quarter; Location 13 TLD missing 1st quarter.

[f]Where quarterly data were not obtained for a particular sampling location, the quarterly average for that location was used in calculating total mrem/yr.

[g]Background monitoring location at the Department of Health, Paterson, New Jersey.

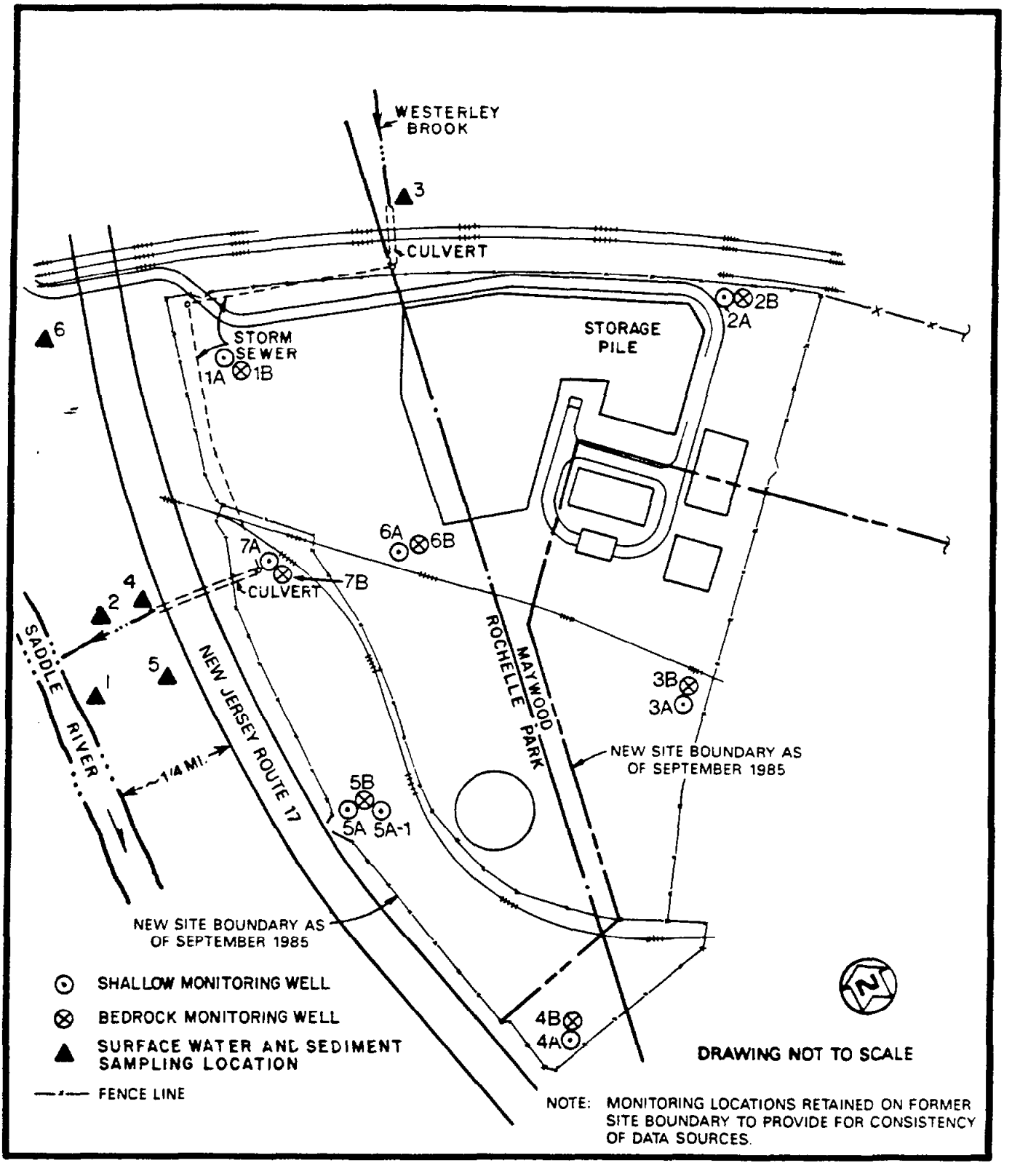


FIGURE 3-2 SURFACE WATER, GROUNDWATER, AND SEDIMENT SAMPLING LOCATIONS AT THE MISS

migration potential and discharge routes from the site. Because surface water runoff from the site discharges via underground Westerly Brook, samples were collected both upstream and downstream of the site.

Nominal 1-liter (0.26 gal) grab samples were collected to fill a 4-liter container. The samples were analyzed by Eberline Analytical Corporation for total uranium, thorium-232, and dissolved radium-226. Total uranium was determined by a fluorometric method. Radium-226 concentrations were determined by precipitating radium-226 as the sulfate, transferring the sulfate to a radon bubbler where the radon-222 daughter is allowed to come to equilibrium, and then counting the radon-222 by alpha spectrometry to determine the amount of parent radium-226 activity originally present. The concentration of thorium-232 was determined by eluting the thorium in solution, electrodepositing it on stainless steel discs, and counting it by alpha spectrometry. Analysis results are presented in Table 3-3.

The highest annual average concentration of uranium in surface water was found to be 3×10^{-9} uCi/ml (3.0 pCi/l), or 0.5 percent of the DCG for uranium in water, which is 6×10^{-7} uCi/ml (600 pCi/l). The average concentration of radium-226 in surface water ranged from 2×10^{-10} to 4×10^{-10} uCi/ml (0.2 to 0.4 pCi/l). These values are 0.2 and 0.4 percent, respectively, of the DCG of 1×10^{-7} uCi/ml (100 pCi/l) for radium in water. All thorium-232 concentrations were less than the limit of sensitivity of the analytical method.

All measured concentrations of uranium, radium-226, and thorium-232 in surface water samples at the site in 1985 were less than 1 percent of the applicable DCGs. Concentrations measured in 1984 were less than 2 percent of the applicable guides.

TABLE 3-3

CONCENTRATIONS OF DISSOLVED TOTAL URANIUM, RADIUM-226,

AND THORIUM-232 IN SURFACE WATER AT THE MISS, 1985

Sampling Location[a]	Number of Samples	Concentration[b] (n x 10^9 uCi/ml)[c] Minimum	Maximum	Average[d]	Percent of Standard[e] (Annual Average)
Total Uranium					
1	4	<3.0	<3.0	3.0	0.5
2	4	<3.0	<3.0	3.0	0.5
3	4	<3.0	<3.0	3.0	0.5
5[f]	0	-	-	-	-
6[f]	0	-	-	-	-
Radium-226					
1	4	0.1	0.4	0.2	0.2
2	4	0.1	0.6	0.4	0.4
3	4	<0.1	1.0	0.4	0.4
5[f]	0	-	-	-	-
6[f]	0	-	-	-	-
Thorium-232					
1	4	<0.1	<0.3	0.2	0.4
2	4	<0.1	<0.2	0.1	0.2
3	4	<0.1	<0.2	0.1	0.2
5[f]	0	-	-	-	-
6[f]	0	-	-	-	-

[a]Sampling locations shown in Figure 3-2. Location 4 is accessible only by way of a manhole; no samples could be collected because the cover was welded shut.

[b]All results include background.

[c]Multiply n (the listed concentration) by 10^9 to obtain uCi/ml.

[d]In computing the average, quarterly values that are less than the limit of sensitivity are considered equal to the limit of sensitivity. Average values are reported without the notation "less than (<)."

[e]Percent of standard determined using average of quarterly samples only. DOE DCG is 6×10^7 uCi/ml (600 pCi/l) for uranium in water, 1×10^{-7} uCi/ml (100 pCi/l) for radium-226 in water, and 5×10^{-8} uCi/ml (50 pCi/l) for thorium-232 in water. See Appendix B for discussion of revised concentration guides.

[f]Samples collected only if standing water is present at the time of sampling.

3.3.2 Groundwater

During 1985, groundwater samples were collected quarterly from 15 on-site wells at seven locations (See Figure 3-2). All wells identified with the letter A monitor the shallow aquifer. Wells identified with the letter B monitor the bedrock aquifer. Wells 2 and 3 are upgradient monitoring locations for the MISS waste pile (but downgradient to Stepan burial areas as shown in Figure 1-6). Wells 1, 4, 5, 6, and 7 are generally downgradient monitoring locations. Well locations were selected based on the inventory of radioactive materials in various areas of the site and available geohydrologic data.

Groundwater samples were collected with a hand bailer after the wells had been pumped dry, or after two casing volumes had been removed. Samples were analyzed by Eberline Analytical Corporation for total uranium, thorium-232, and dissolved radium-226 using the analytical methods described for surface water.

Analysis results for uranium, thorium-232, and radium-226 in groundwater are presented in Tables 3-4, 3-5, and 3-6 respectively. Average uranium concentrations ranged from 3×10^{-9} to 6.3×10^{-8} uCi/ml (3 to 63 pCi/l). These values are less than 1 percent and 11 percent, respectively, of the DCG of 6×10^{-7} uCi/ml (600 pCi/l). The highest reading, 6.3×10^{-8} uCi/ml (63 pCi/l), was based on one sample obtained at on-site Well 5A. Average thorium-232 concentrations ranged from 1×10^{-10} to 3×10^{-10} uCi/ml (0.1 pCi/l to 0.3 pCi/l). All thorium-232 concentrations are less than 1 percent of the DCG. Average radium-226 concentrations ranged from 1×10^{-10} to 6×10^{-10} uCi/l (0.1 to 0.6 pCi/l). All radium-226 values were less than 1 percent of the DCG.

Since groundwater monitoring wells were installed late in 1984, no comparable data are available for 1984.

TABLE 3-4

CONCENTRATIONS OF DISSOLVED TOTAL URANIUM IN GROUNDWATER AT THE MISS, 1985

Sampling Location[a]	Number of Samples	Concentration[b] (n x 10^9 uCi/ml)[c] Minimum	Maximum	Average[d]	Percent of Standard[e] (Annual Average)
1A	1[f]	27	27	27	5.0
1B	3	<3	<3	3	0.5
2A	4	<3	4	3	0.5
2B	4	<3	17	12	2.0
3A	4	<3	<3	3	0.5
3B	4	<3	<3	3	0.5
4A	2[f]	<3	<3	3	0.5
4B	4	<3	<3	3	0.5
5A	1[f]	63	63	63	11.0
5A-1	0[f]	-	-	-	-
5B	4	<3	<3	3	0.5
6A	4	<3	17	9	2.0
6B	4	<3	8	5	0.8
7A	0[f]	-	-	-	-
7B	4	<3	19	12	2.0

[a]Sampling locations are shown in Figure 3-2.

[b]All results include background.

[c]Multiply n (the listed concentration) by 10^9 to obtain uCi/ml.

[d]In computing the average, quarterly values that are less than the limit of sensitivity are considered equal to the limit of sensitivity. Average values are reported without the notation "less than (<)."

[e]Percent of standard determined using the average value. The DOE DCG for uranium in water is 6 x 10^{-7} uCi/ml (600 pCi/l).

[f]Shallow well to monitor overburden. These wells typically do not contain water.

TABLE 3-5

CONCENTRATIONS OF DISSOLVED THORIUM-232 IN GROUNDWATER AT THE MISS, 1985

Sampling Location[a]	Number of Samples	Concentration[b] (n x 10^9 uCi/ml)[c] Minimum	Maximum	Average[d]	Percent of Standard[e] (Annual Average)
1A	1[f]	<0.1	<0.1	0.1	0.2
1B	3[g]	<0.1	<0.1	0.1	0.2
2A	4	0.2	0.3	0.3	0.6
2B	4	<0.1	<0.5	0.2	0.4
3A	4	<0.1	<0.1	0.1	0.2
3B	4	<0.1	0.5	0.2	0.4
4A	2[f]	<0.1	<0.1	0.1	0.2
4B	4	<0.1	<0.2	0.1	0.2
5A	1[f]	<0.1	<0.1	0.1	0.2
5A-1	0[f]	-	-	-	-
5B	4	<0.1	<0.4	0.2	0.4
6A	4	<0.1	<0.4	0.2	0.4
6B	4	<0.2	0.4	0.3	0.6
7A	0[f]	-	-	-	-
7B	4	<0.1	<0.3	0.2	0.4

[a]Sampling locations are shown in Figure 3-2.

[b]Multiply n (the listed concentration) by 10^9 to obtain uCi/ml.

[c]All results include background.

[d]In computing the average, quarterly values that are less than the limit of sensitivity are considered equal to the limit of sensitivity. Average values are reported without the notation "less than (<)."

[e]Percent of standard determined using the computed average value. The DOE DCG for thorium-232 in water is 5 x 10^{-8} uCi/ml (50 pCi/l).

[f]Shallow well to monitor overburden. These wells typically do not contain water.

[g]Analysis results not available for first quarter samples.

TABLE 3-6

CONCENTRATIONS OF DISSOLVED RADIUM-226 IN GROUNDWATER AT THE MISS, 1985

Sampling Location[a]	Number of Samples	Concentration[b] (n x 10^9 uCi/ml)[c] Minimum	Maximum	Average[d]	Percent of Standard[e] (Annual Average)
1A	1[f]	0.1	0.1	0.1	0.1
1B	3[g]	0.1	0.9	0.6	0.6
2A	4	<0.1	0.9	0.4	0.4
2B	4	<0.1	0.6	0.3	0.3
3A	4	<0.1	1.2	0.4	0.4
3B	4	<0.1	0.5	0.3	0.3
4A	2[f]	0.1	0.6	0.4	0.4
4B	4	0.1	0.6	0.3	0.3
5A	1[f]	0.2	0.2	0.2	0.2
5A-1	0[f]	-	-	-	-
5B	4	0.1	0.7	0.3	0.3
6A	4	<0.1	0.3	0.2	0.2
6B	4	0.2	0.5	0.4	0.4
7A	0[f]	-	-	-	-
7B	4	0.1	0.5	0.3	0.3

[a]Sampling locations are shown in Figure 3-2.

[b]All results include background.

[c]Multiply n (the listed concentration) by 10^9 to obtain uCi/ml.

[d]In computing the average, quarterly values that are less than the limit of sensitivity are considered equal to the limit of sensitivity. Average values are reported without the notation "less than (<)."

[e]Percent of standard determined using the computed average value. The DOE DCG is 1 x 10^{-7} uCi/ml (100 pCi/l) for radium-226 in water.

[f]Shallow well to monitor overburden. These wells typically do not contain water.

[g]Analysis results not available for first quarter samples.

3.4 SEDIMENT SAMPLING

Sediment samples are composites of approximately 500 g obtained at surface water sampling locations where sediment is present. They were analyzed by Eberline Analytical Corporation for isotopic uranium, radium-226, and thorium-232. The concentration of isotopic uranium was determined using alpha spectrometry after the uranium had been leached, organically extracted, and electroplated on a metal substrate. The concentration of thorium was determined using alpha spectrometry after the thorium had been leached, extracted, and electroplated on metal substrates. Radium-226 concentration was determined by radon emanation.

There are no specific guidelines for radionuclide concentrations in sediment. Decontamination of MISS is being conducted in accordance with DOE FUSRAP guidelines for radionuclides in soil. For purposes of comparison, these guidelines are: 5 pCi/g for radium-226 and thorium-232 in the upper 15 cm (6 in.) of soil and 15 pCi/g for radium-226 and thorium-232 at depths greater than 15 cm (6 in.) (Ref. 16). There are no specific DOE guidelines for uranium in soil.

The results for isotopic uranium (based on dry weight) are presented in Table 3-7. Results of analysis for uranium showed concentrations ranging from less than 0.02 pCi/g to a maximum of 0.70 pCi/g. The isotopic uranium concentrations were summed to estimate the total uranium concentrations shown in Table 3-7. This resulted in an estimated maximum of 1.32 pCi/g for total uranium at Location 3, and an estimated maximum annual average of 0.83 pCi/g, also at Location 3.

Analysis results for radium-226 are presented in Table 3-8. The maximum reading, 0.90 pCi/g, and the highest annual average, 0.45 pCi/g, were both obtained at Location 3, which is upstream from MISS. Results for thorium-232 are also presented in Table 3-8. The maximum reading of 0.5 pCi/g was obtained at Locations 2 and 3; the highest annual average, 0.29 pCi/g, was obtained at Location 1.

TABLE 3-7

CONCENTRATIONS OF URANIUM IN SEDIMENTS AT THE MISS, 1985[a]

Sampling Location[b]	Number of Samples	Concentrations [pCi/g (dry)] Minimum	Maximum	Average
Uranium-234				
1	4	0.20	0.30	0.27
2	4	0.28	0.30	0.30
3	4	0.20	0.70	0.42
Uranium-235				
1	4	<0.02	<0.03	0.02
2	4	0.01	<0.07	0.04
3	4	<0.02	0.02	0.03
Uranium-238				
1	4	0.20	0.30	0.26
2	4	0.22	0.40	0.36
3	4	0.20	0.60	0.38
Total Uranium[c]				
1	4	0.42	0.63	0.55
2	4	0.51	0.77	0.70
3	4	0.42	1.32	0.83

[a]There are no specific limits for uranium in sediment.

[b]Sampling locations shown in Figure 3-2. Location 3 is upstream of the MISS and represents background. No sediment was available at sampling Locations 4, 5, and 6.

[c]Total uranium was determined by summing concentrations of all three isotopes.

TABLE 3-8

CONCENTRATIONS OF RADIUM-226 AND THORIUM-232 IN SEDIMENTS AT THE MISS, 1985[a]

Sampling Location[b]	Number of Samples	Concentrations [pCi/g (dry)] Minimum	Maximum	Average
Radium-226				
1	4	0.30	0.50	0.43
2	4	0.30	0.50	0.40
3	4	0.20	0.90	0.45
Thorium-232				
1	4	0.11	<0.40	0.29
2	4	<0.10	0.50	0.21
3	4	0.06	0.50	0.25

[a]There are no specific limits for radium, thorium, or uranium in sediment. However, decontamination of MISS is being conducted in accordance with DOE FUSRAP guidelines for radionuclides in soil. For radium and thorium, these guidelines are 5 pCi/g in the upper 15 cm (6 in.) and 15 pCi/g at depths greater than 15 cm (6 in.) (Ref. 16).

[b]Sampling locations shown in Figure 3-2. Location 3 is upstream of the MISS and represents background. No sediment was available at sampling Locations 4, 5, and 6.

Since sediment sampling was initiated at the end of 1984, 1984 data are insufficient to permit identification of trends.

3.5 RADIOLOGICAL EXPOSURE

To assess the potential health effects of the radioactive materials stored at the MISS, the radiological doses to a maximally exposed individual and to the population were evaluated. The maximally exposed individual is one who is assumed, when all potential routes of exposure are considered, to receive the greatest dose. An appraisal of potential pathways suggested that external gamma radiation and the ingestion of water containing thorium-232, natural uranium, and radium-226 were the principal exposure modes in both cases.

For each of the pathways considered at a given site, most organs in the body receive some radiological exposure. However, depending on the method of internal deposition and the chemical characteristics of the radionuclides, some organs receive a higher exposure than others. These are called "critical organs" because the effect of the exposure is maximized in them. When ingested, radium, thorium, and uranium tend to migrate and incorporate themselves into bone: the critical organ for this pathway.

Expression of measured concentrations in water in terms of internal dose to the bone requires several assumptions. First, an intake rate must be postulated. For these calculations, the maximum water intake rate [730 ml (0.2 gal) of tap water per day] of Reference Man was used (Ref. 17). Radionuclide intakes were converted to internal doses to the bone using the methodology described in ICRP 26 and 30 (Refs. 18 and 19). All reported doses are 50-yr dose commitments. The 50-yr dose commitment concept provides for the fact that an intake of a radionuclide with a long half-life (e.g., thorium, uranium, or radium) could result in an internal exposure for many years.

Gamma radiation from external sources is assumed to irradiate the body uniformly. The total body is therefore the critical organ for external gamma exposure. Internal organs are assumed to be exposed to the same level as the entire body. Exposure to organs resulting from internal and external sources is additive.

Inhalation of radon and thoron and their radioactive daughters is also a pathway; however, an accurate, quantitative determination of dose is not possible because of uncertainties concerning the distribution of exposure. In Subsection 3.1, measured radon and thoron concentrations are compared to applicable DOE guides, with the highest annual average at the MISS equal to approximately 17 percent of the applicable guide for radon and 32 percent for thoron.

3.5.1 Dose to Maximally Exposed Individual

To identify the maximally exposed individual in the vicinity of the MISS who would receive the highest dose from on-site radioactive materials, the combined dose from ingestion of water and exposure to external gamma radiation was calculated at various monitoring locations that could be accessible to the public. The cumulative doses from these pathways were then reviewed with regard to land use and occupancy factors for areas adjacent to the monitoring points. For the properties surrounding the MISS, the highest overall dose would be received by an individual walking along the western boundary of the site twice a day, 365 days a year at a speed of 4.8 km/h (3 mph), spending 8 minutes per day or 48.7 hours per year in the area. The highest annual average dose rate at the MISS in 1985 was measured along the western boundary of the site, with an average value of 226 mrem/yr at TLD monitoring locations 9 through 12. This maximally exposed individual would receive a dose of 1.25 mrem in a year or 1.25 percent of the DOE radiation protection standard of 100 mrem/yr. This does can also be compared to the measured background level of 108 mrem/yr for the MISS vicinity.

Wells 2B and 7B were the groundwater monitoring locations found to have the highest radionuclide concentrations based on four quarterly samples. Ingestion of water from either of these wells would result in a 50-yr dose commitment of less than 15 mrem to the critical organ (the bone surface), contributed primarily by uranium. The 15 mrem can be compared to the 620-mrem dose to the bone surfaces that would be received if a person ingested water that contained uranium concentrations equal to the DOE DCG for uncontrolled areas, which is 6×10^{-7} uCi/ml (600 pCi/l).

When this organ dose is converted to a total body dose, the value is 0.45 mrem. This results from multiplying the 15 mrem dose by the internal organ to whole body weighting factor of 0.03 (Ref. 18). Because of the insignificance of this dose, no attempt was made to separately quantify the contribution of materials at the MISS and natural background radionuclides.

3.5.2 Dose to Population

The dose to the population represents the conceptual cumulative radiation dose to all residents within an 80-km (50-mi) radius of a given site. This calculated dose includes contributions from all potential pathways. For the MISS, these pathways are direct exposure to gamma radiation, inhalation of radon gas, and ingestion of radioactively contaminated water.

The contribution to the population dose made by gamma radiation from on-site radioactive materials is too small to be measured; gamma radiation levels decrease rapidly as distance from the source of contamination increases. For example, if the gamma dose rate at a distance of 1 m (3 ft) from the radioactive source were 10 times the allowable, the dose rate at a distance of 6.3 m (21 ft) from the source would be indistinguishable from naturally occurring background radiation.

Similarly, radon gas is known to dissipate rapidly as distance from the radon source increases (Ref. 20). Therefore, radon exposure does not contribute significantly to population dose.

On the basis of radionuclide concentrations measured in water leaving the site, it also appears that there is no predictable pathway by which ingestion of water could result in a significant dose to the population. As water migrates farther from the source, radionuclide concentrations are further reduced, thereby lowering potential doses to even less significant levels.

Since the contributions to population dose via all three potential exposure pathways are inconsequential, calculation of dose to the population is not warranted.

The cumulative dose to the population within an 80-km (50-mi) radius contributed by on-site radioactive materials would be indistinguishable from the dose the same population would receive from naturally occurring radioactive sources.

4.0 RELATED ACTIVITIES AND SPECIAL STUDIES

4.1 RELATED ACTIVITIES

During calendar year 1985, site operations were conducted under Emergency Groundwater Permit No. NJ0054500, issued by the New Jersey Department of Environmental Protection (NJDEP), Water Resources Division, pending processing of the routine permit application. The New Jersey Pollutant Discharge Elimination System (NJPDES) regulates interim storage of waste at the MISS with the objective of preventing contamination of the groundwater. As such, the emergency permit prohibits discharges of water to groundwater. One of the NJPDES permit requirements was the installation of groundwater monitoring wells at the MISS. Installation of these wells was completed during 1985.

In accordance with permit requirements, chemical analyses were performed on samples collected from the groundwater monitoring wells shown in Figure 3-2. Monitoring wells 1A, 4A, and 7A were dry during all sampling periods. Wells designated "A" are shallow (approximately 10 ft below ground); "B" wells extend into the Brunswick formation bedrock aquifer (approximately 80 ft below ground). Groundwater flows from the northeast to the southwest in both the overburden and the bedrock aquifer; therefore, Wells 2A and 2B are the upgradient wells for the site.

Table 4-1 shows the concentrations of organic compounds, dissolved metals, and other inorganic ions found in samples collected from the groundwater monitoring wells. Table 4-2 lists the parameters for which analyses are required by NJPDES, but for which concentrations were below the limit of sensitivity of the analytical method (if present) and were therefore not detectable.

Most wells were found to contain moderate amounts of methylene chloride, bis (2-ethylhexyl) phthalate, and tetrachloroethylene. High concentrations of methylene chloride, bis (2-ethylhexyl)

TABLE 4-1

CONCENTRATIONS OF CHEMICAL CONTAMINANTS IN GROUNDWATER AT THE MISS, 1985[1]

Parameter/Unit	Range of Concentrations by Sampling Location (Monitoring Well No.)[2]										
	1B	2A[3]	2B[3]	3A	3B	4B	5A	5B	6A	6B	7B
Methylene chloride (ug/l)	108	1087	169	233	267	302	ND	100	175	145	512
Trichloroethylene (ug/l)	66	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND/9
Bis (2-ethylhexyl) phthalate (ug/l)	44/190	24/350	ND/53	ND/110	54/75	12/29	29	120/1200	57/61	ND/290	ND/36
Chloroform (ug/l)	ND	39	ND	ND	ND	ND	ND	ND	31	ND	27
Toluene (ug/l)	ND	38	ND	33	31	20/55	ND	ND	25	26	16
Di-n-octyl phthalate (ug/l)	ND	41	27	ND	ND	ND	ND	ND	ND	ND	ND
Benzene (ug/l)	ND	ND	143/150	ND	ND	420/1240	ND	ND/660	ND	ND	ND/7
Tetrachloroethylene (ug/l)	ND/130	ND/110	ND/30	42/90	ND/25	ND/170	ND	ND/33	ND/26	ND/100	ND/110
Trans-1,2-Dichloro-ethylene (ug/l)	ND/7	ND	ND	ND	ND	1100/2964	ND	ND	ND	ND	ND/17
1,1,2,2-Tetrachloro-ethane (ug/l)	ND	ND	ND	ND	ND	13	ND	ND	ND	ND	ND
Vinyl Chloride (ug/l)	ND	ND	ND	ND	ND	ND/220	ND	ND	ND	ND	ND
Total organic carbon (mg/l)	2/100	21/305	15/130	2/165	6/70	18/79	33	17/30	10/78	10/23	12/62
Total organic halide (ug/l)	99/572	78/841	182/1332	58/381	51/553	498/1465	113	74/216	58/140	100/220	80/164
Specific conductance (umhos/cm)	724/937	7007/7683	7460/10130	763/1210	2555/3530	1222/1780	2428	3258/3375	1879/3000	2887/4185	5542/7450
pH (pH units)	6.9/7.4	6.8/7.3	6.8/7.3	3.9/5.6	5.9/6.3	6.3/7.1	5.46	6.7/6.9	6.9/7.3	9.0/9.5	7.1/7.5
Arsenic[4] (mg/l)	ND	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium[4] (mg/l)	0.05	0.07	ND	3.5	0.007	0.03	ND	0.03	0.06	0.08	0.007
Boron[4] (mg/l)	ND	2.2	2.2	0.1	0.3	0.13	ND	1.0	12	0.7	15
Calcium[4] (mg/l)	85	220	300	66	200	150	ND	190	190	20	220
Chromium[4] (mg/l)	ND	2.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron[4] (mg/l)	0.03	3.8	0.05	2.7	ND	ND	ND	ND	0.07	2.7	0.05
Lead[4] (mg/l)	ND	0.04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Magnesium[4] (mg/l)	550	12	100	15	53	15	ND	7.9	45	10	73
Manganese[4] (mg/l)	26	0.58	0.42	1.9	15	3.4	ND	0.1	0.29	0.23	0.8
Potassium[4] (mg/l)	42	57	190	28	89	53	ND	310	110	52	190
Silicon[4] (mg/l)	3	19	8	14	5.8	7.5	ND	86	78	48	35
Sodium[4] (mg/l)	74	2800	2800	35	320	190	ND	290	65	870	1800
Strontium[4] (mg/l)	0.12	0.57	0.38	ND	0.3	0.21	ND	0.45	1.5	0.12	0.25
Tin[4] (mg/l)	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium[4] (mg/l)	ND	3.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc[4] (mg/l)	ND	ND	ND	0.04	0.02	ND	ND	ND	1.0	0.03	ND

[1]Does not include parameters for which concentrations were below limit of sensitivity of analytical method and therefore undetectable. See Table 4-2.
[2]ND = No detectable concentration. Where only one value is listed, only one sample was analyzed.
[3]Upgradient well.
[4]Analyzed for dissolved metal.

TABLE 4-2

CHEMICAL CONTAMINANTS FOR WHICH CONCENTRATIONS IN GROUNDWATER AT THE MISS WERE BELOW THE ANALYTICAL LIMIT OF SENSITIVITY[a]

Acrolein	Diethylphthalate	Endrin
Acrylonitrile	Dimethylphthalate	Endrin aldehyde
Bromodichloromethane	2,4-Dinitrotoluene	Heptachlor
Bromoform	2,6-Dinitrotoluene	Heptachlor Epoxide
Bromomethane	1,2-Diphenylhydrazine	4,4'-DDT
Carbon Tetrachloride	Fluoranthene	4,4'-DDE
Chlorobenzene	Fluorene	4,4'-DDD
Chlorodibromomethane	Hexachlorobenzene	PCB 1016
Chloroethane	Hexachlorobutadiene	PCB 1221
2-Chloroethyl vinyl ether	Hexachloroethane	PCB 1232
Chloromethane	Hexachlorocyclopentadiene	PCB 1242
Dichlorodifluoromethane	Indeno (1,2,3-cd) pyrene	PCB 1248
1,1-Dichloroethane	Isophorone	PCB 1254
1,2-Dichloroethane	Naphthalene	PCB 1260
1,1-Dichloroethylene	Nitrobenzene	Toxaphene
1,2-Dichloropropane	n-Nitrosodimethylamine	Antimony
1,3-Dichloropropene	n-Nitrosodi-N-propylamine	Beryllium
Ethylbenzene	n-Nitrosodiphenylamine	Cadmium
1,1,1-Trichloroethane	Phenanthrene	Cobalt
1,1,2-Trichloroethane	Pyrene	Copper
Trichlorofluoromethane	1,2,4-Trichlorobenzene	Molybedenum
Acenaphthene	2,3,7,8-Tetrachlorodibenzo-p-dioxin	Nickel
Acenaphthylene	4-Chloro-3-methylphenol	Scandium
Benzo (a) anthracene	2-Chlorophenol	Selenium
Benzo (b) fluoranthene	2,4-Dichlorophenol	Silver
Benzo (k) fluoranthene	2,4-Dimethylphenol	Thallium
Benzo (a) pyrene	2,4-Dinitrophenol	
Benzo (g,h,i) perylene	2-Methyl-4-6-dinitrophenol	
Benzidine	2-Nitrophenol	
Bis (2-chloroethyl) ether	4-Nitrophenol	
Bis (2-chloroethoxy) methane	Pentachlorophenol	
Bis (2-chloroisopropyl) ether	Phenol	
4-Bromophenylphenylether	2,4,6-Trichlorophenol	
Butylbenzylphthalate	Aldrin	
2-Chloronaphthalene	BHC, alpha	
4-Chlorophenylphenylether	BHC, beta	
Chrysene	BHC, gamma	
Dibenzo (a,h) anthracene	BHC, delta	
DiButyl phthalate	Chlordane	
1,2-Dichlorobenzene	Dieldrin	
1,3-Dichlorobenzene	Endosulfan, alpha	
1,4-Dichlorobenzene	Endosulfan, beta	
3,3'-Dichlorobenzidine	Endosulfan sulfate	

[a]Analysis for these parameters required to meet NJDEP permit requirements.

phthalate, benzene, trans-1,2-dichloroethylene, and total organic halide were found in a few wells. Concentrations of the following parameters above NJPDES Permit #NJ0054500 standards were found in at least one or more wells: pH, arsenic, barium, chromium, iron, and manganese. Additionally, concentrations of total volatile organic compounds greater than 50 ug/l were in excess of NJPDES limits in some wells.

No distinct pattern of chemical concentrations was apparent for the deep wells. In the shallow (overburden) wells the highest concentration of chemicals was found in Well 2A (the upgradient well for the site). Concentrations were found to decrease across the site to the southwest, in the primary direction of groundwater flow. This may indicate that the principal source of contamination is off-site. Measurement of water level and water quality continues in order to provide clearer definition of groundwater gradient and flow directions and information as to the locations of likely contaminant source areas. A limited chemical characterization is presently under way to permit a determination of the presence and locations of chemicals on the site.

4.2 SPECIAL STUDIES

There were no special studies performed for the MISS in 1985.

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APPENDIX A

QUALITY ASSURANCE

APPENDIX A
QUALITY ASSURANCE

A comprehensive quality assurance program was maintained to ensure that the data collected were representative of actual concentrations in the environment. First, environmental data were obtained from a number of locations to prevent reliance on only a few results, which might not be representative of the existing range of concentrations. Second, newly collected data were compared with both recent results and historical data for each location and each environmental medium to ensure that deviations from previous conditions were identified and evaluated. Third, samples at all locations were collected using published procedures to ensure consistency in sample collection. Fourth, each analytical laboratory verified the quality of the data by conducting a continuing program of analytical quality control, participating in interlaboratory crosschecks, and performing replicate analyses. Fifth, chain of custody procedures were implemented to maintain traceability of samples and corresponding analytical results. This program ensures that the monitoring data can be used to evaluate accurately the environmental impacts from site operations.

The majority of the routine radioanalyses for the FUSRAP Environmental Monitoring Program were performed under subcontract by the Eberline Analytical Corporation (EAC), Albuquerque, New Mexico. This laboratory maintained an internal quality assurance program that involved routine calibration of counting instruments, source and background counts, routine yield determinations of radiochemical procedures, and replicate analyses to check precision. The accuracy of radionuclide determination was ensured through the use of standards traceable to the National Bureau of Standards, when available. The laboratory also participated in the Environmental Protection Agency's (EPA) Laboratory Intercomparison Studies Program. In this program, samples of different environmental media (water, milk, air filters, soil, foodstuffs, and tissue ash) containing one or more radionuclides in known amounts were prepared

and distributed to the participating laboratories. After the samples were analyzed, the results were forwarded to EPA for comparison with known values and with the results from other laboratories. This program enabled the laboratory to regularly evaluate the accuracy of its analyses and take corrective action if needed.

Interlaboratory comparison of the TLD results was provided by participation in the International Environmental Dosimeter Project sponsored jointly by the Department of Energy, the Nuclear Regulatory Commission, and the EPA.

To ensure the accuracy of dose calculations, all computed doses were double-checked by the originator and by an independent third party who also checked all input data and assumptions used in the calculations.

APPENDIX B
ENVIRONMENTAL STANDARDS

APPENDIX B
ENVIRONMENTAL STANDARDS

The radiation protection standards and associated Derived Concentration Guides (DCG) applicable to Department of Energy (DOE) installations have been modified (Ref. 13).

The radiation protection standard has been reduced from 500 mrem/yr to 100 mrem/yr. In conjunction with this reduction, evaluation of exposure pathways and resulting dose calculations are based on realistic assumptions. Realistic assumptions may include the use of occupancy factors in determining dose due to external gamma radiation; subtraction of background concentrations of radionuclides in air, water, and soil before calculating dose; closer review of water use, using the data that most closely represents actual exposure conditions rather than maximum values as applicable; and using average consumption rates of food and water per individual rather than maximums. Utilization of realistic assumptions will result in lower calculated doses than previous years. However, these doses will more accurately reflect the exposure potential from site activities.

The associated DCGs, which provide guides for the maximum permissible radioactivity in various environmental media, have also been revised. The new DCGs reflect changes to the radiation protection standard and new uptake models. On a case-by-case basis, the DCG for a given radionuclide may have increased, decreased, or remained unchanged. The DCGs for the common radionuclides at the MISS are presented in Table B-1. For comparative purposes, the old and revised DCGs are presented. Conversion factors for the new reporting units are provided in Table B-2.

TABLE B-1

RADIATION PROTECTION STANDARD[a] AND
RADIOACTIVITY CONCENTRATION GUIDES FOR THE MISS

Radionuclide	Transport Medium	Previous Guide (Uncontrolled Areas)	New Guide
Uranium-Natural	Water	600 pCi/l	Unchanged[b]
Radium-226	Water	30 pCi/l	1×10^{-7} uCi/ml (100 pCi/l)
Radon-220 (Thoron)	Air	10 pCi/l	Unchanged[b]
Radon-222	Air	3 pCi/l	Unchanged[b]
Thorium-232	Water	2,000 pCi/l	5×10^{-8} uCi/ml (50 pCi/l)

[a]The radiation protection standard was changed from 500 mrem/yr to 100 mrem/yr.

[b]The values are the same as in previous years, but are reported in different units.

TABLE B-2

CONVERSION FACTORS

1 year	=	8760 hours
1 liter	=	1000 ml
1 mrem	=	1000 uR
1 mrem/yr	=	11 uR/hr (assuming 8760 hours of exposure per year)
1 uCi	=	1,000,000 pCi
1 pCi	=	0.000001 uCi
1 pCi/l	=	10^{-9} uCi/ml
1 pCi/l	=	0.000000001 uCi/ml
1 uCi/ml	=	1,000,000,000 pCi/l
10^{-6}	=	0.000001
10^{-7}	=	0.0000001
10^{-8}	=	0.00000001
10^{-9}	=	0.000000001
10^{-10}	=	0.0000000001
7×10^{-10}	=	0.0000000007

APPENDIX C

ABBREVIATIONS

APPENDIX C
ABBREVIATIONS

cm	centimeter
cm/sec	centimeters per second
ft	foot
g	gram
gal	gallon
ha	hectare
in.	inch
km	kilometer
km/h	kilometers per hour
m	meter
m^3	cubic meters
mg	milligram
mg/l	milligrams per liter
mi	mile
ml	milliliter
mph	miles per hour
mrem	millirem
mrem/yr	millirem per year
m.s.l.	mean sea level
uCi/ml	microcuries per milliliter
ug/l	micrograms per liter
uR/h	microroentgens per hour
pCi	picocurie
pCi/g	picocuries per gram
pCi/l	picocuries per liter
wk	week
yd^3	cubic yards
yr	year

APPENDIX D

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