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Formerly Utilized Sites Remedial Action Program (FUSRAP)

ADMINISTRATIVE RECORD

for Maywood, New Jersey

U.S. Department of Energy

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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 1986

June 1987

Bechtel National, Inc.

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ANNUAL SITE ENVIRONMENTAL REPORT
CALENDAR YEAR 1986

JUNE 1987

Prepared for

UNITED STATES DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

Under Contract No. DE-AC05-81OR20722

By

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045483

ABSTRACT

During 1986, 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.

The MISS is part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), a DOE program to identify, decontaminate, or otherwise control sites where residual radioactive materials (exceeding current guidelines) remain from the early years of the nation's atomic energy program, or from commercial operations causing conditions that Congress has mandated DOE to remedy. As part of the decontamination research and development project authorized by Congress under the 1984 Energy and Water Appropriations Act, remedial action is being conducted at this site and at vicinity properties by Bechtel National, Inc. (BNI), Project Management Contractor for FUSRAP. The environmental monitoring program is also carried out by BNI.

The monitoring program at the MISS measures thoron and radon gas concentrations in air; external gamma radiation levels; and thorium, uranium, and radium concentrations in surface water, groundwater, and sediment.

To verify that the site is in compliance with the DOE radiation protection standard (100 mrem/yr) and to assess the potential effect on public health, the radiation dose was calculated for the maximally exposed individual. Based on the conservative scenario described in the report, the maximally exposed individual would receive an annual external exposure approximately equivalent to 1 percent of the DOE radiation protection standard of 100 mrem/yr. This exposure is less than the exposure a person would receive during a round-trip flight from New York to Los Angeles (due to

greater amounts of cosmic radiation at higher altitudes). The cumulative dose to the population within an 80-km (50-mi) radius of the MISS that would result from radioactive materials present at the site would be indistinguishable from the dose the same population would receive from naturally occurring radioactive sources.

Results of the 1986 monitoring show that the MISS is in compliance with the DOE radiation protection standard.

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1.0 INTRODUCTION

This report presents the findings of the environmental monitoring program conducted at the U.S. Department of Energy's (DOE) Maywood Interim Storage Site (MISS) during calendar year 1986. 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 DOE Formerly Utilized Sites Remedial Action Program (FUSRAP).

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 and 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 fenced. 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 treatment of impounded surface water prior to discharge in accordance with New Jersey Department of Environmental Protection (NJDEP) requirements.

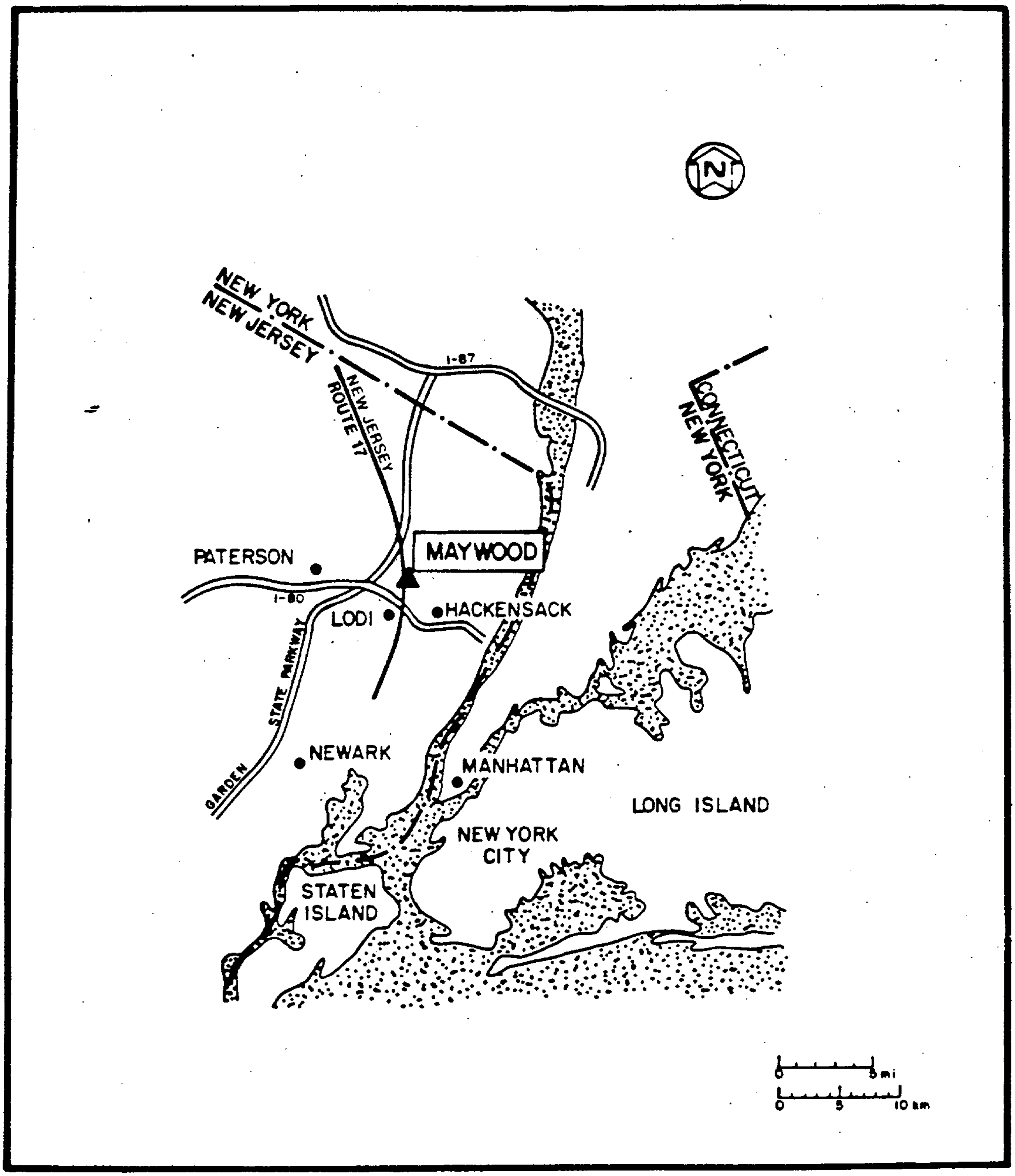


FIGURE 1-1 LOCATION OF MAYWOOD, NEW JERSEY

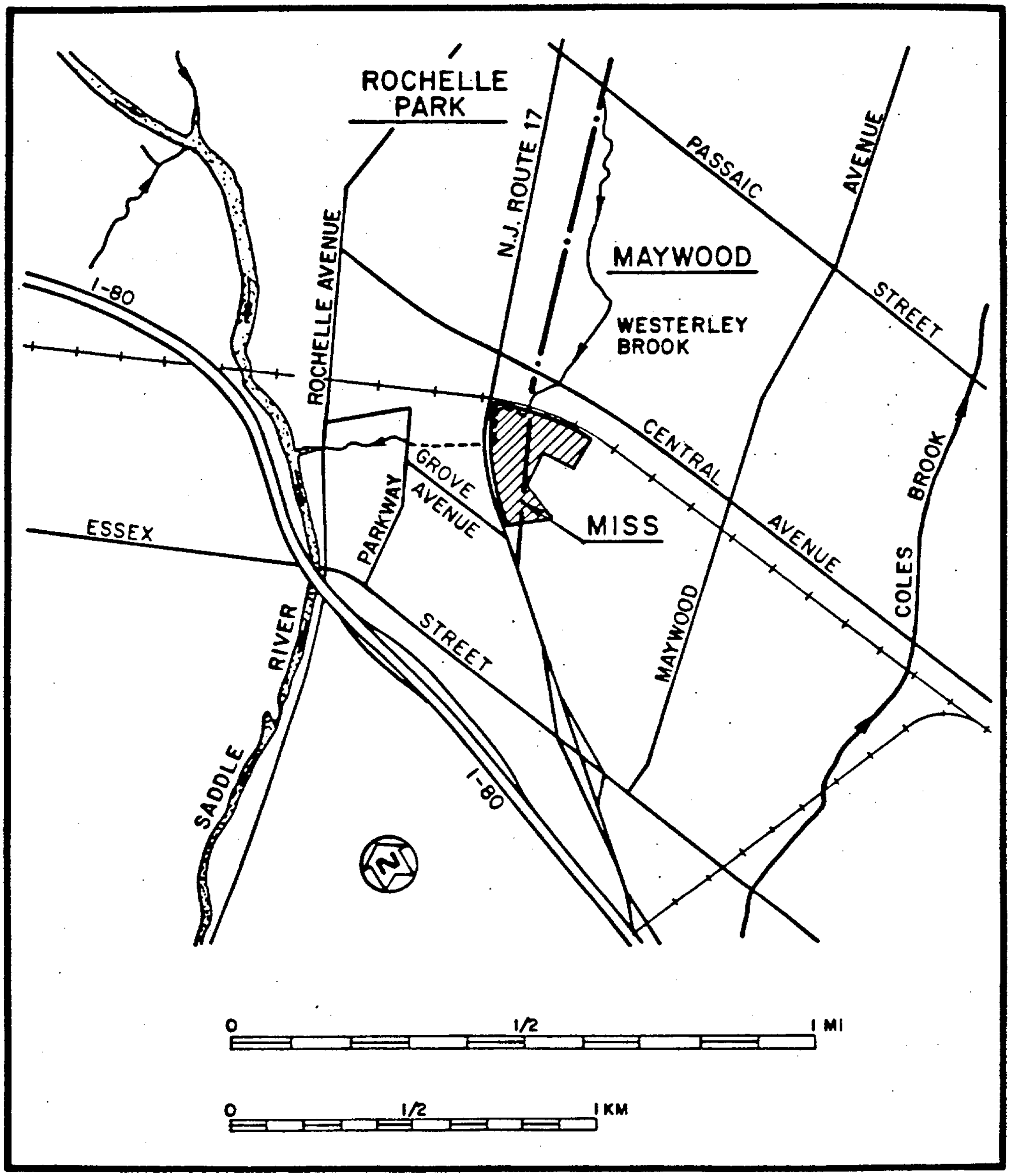


FIGURE 1-2 LOCATION OF THE MISS

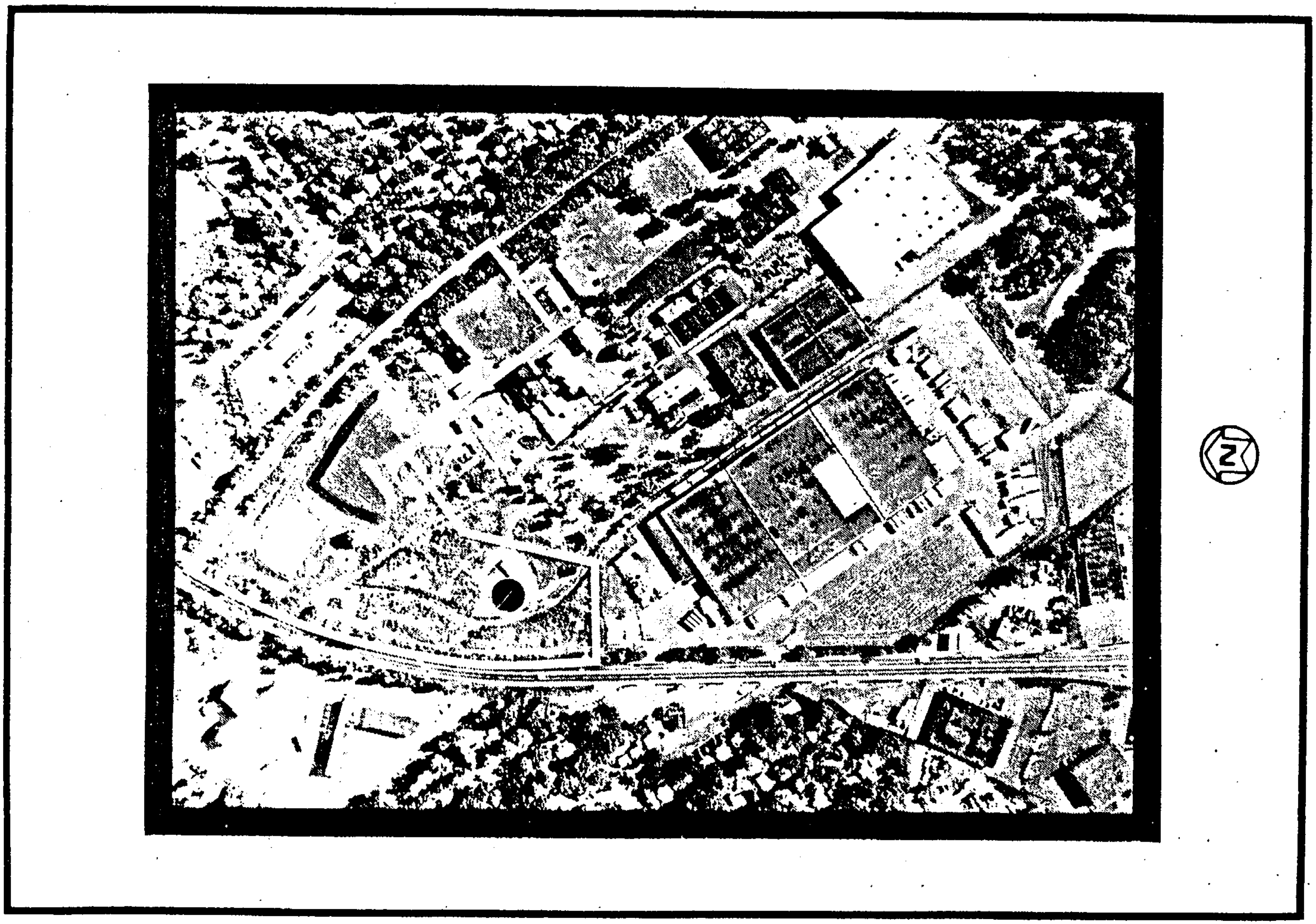


FIGURE 1-3 AERIAL VIEW OF THE MISS AND ITS VICINITY

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 and 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 Westerley 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/yr; the mean annual precipitation is approximately 120 cm (48 in.), with an average annual snowfall of 72.8 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 and 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 residual radioactive material 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. Some of the material

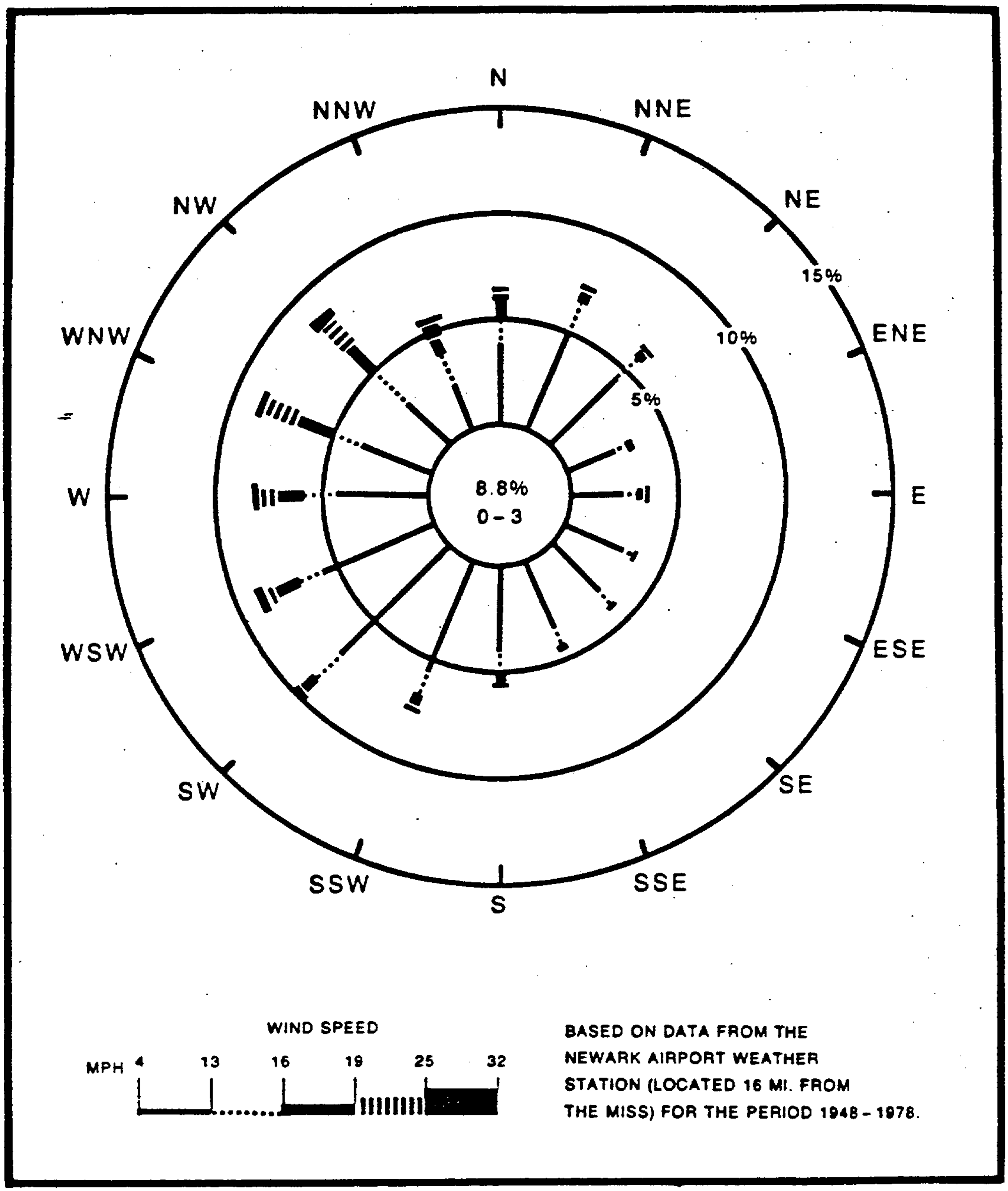
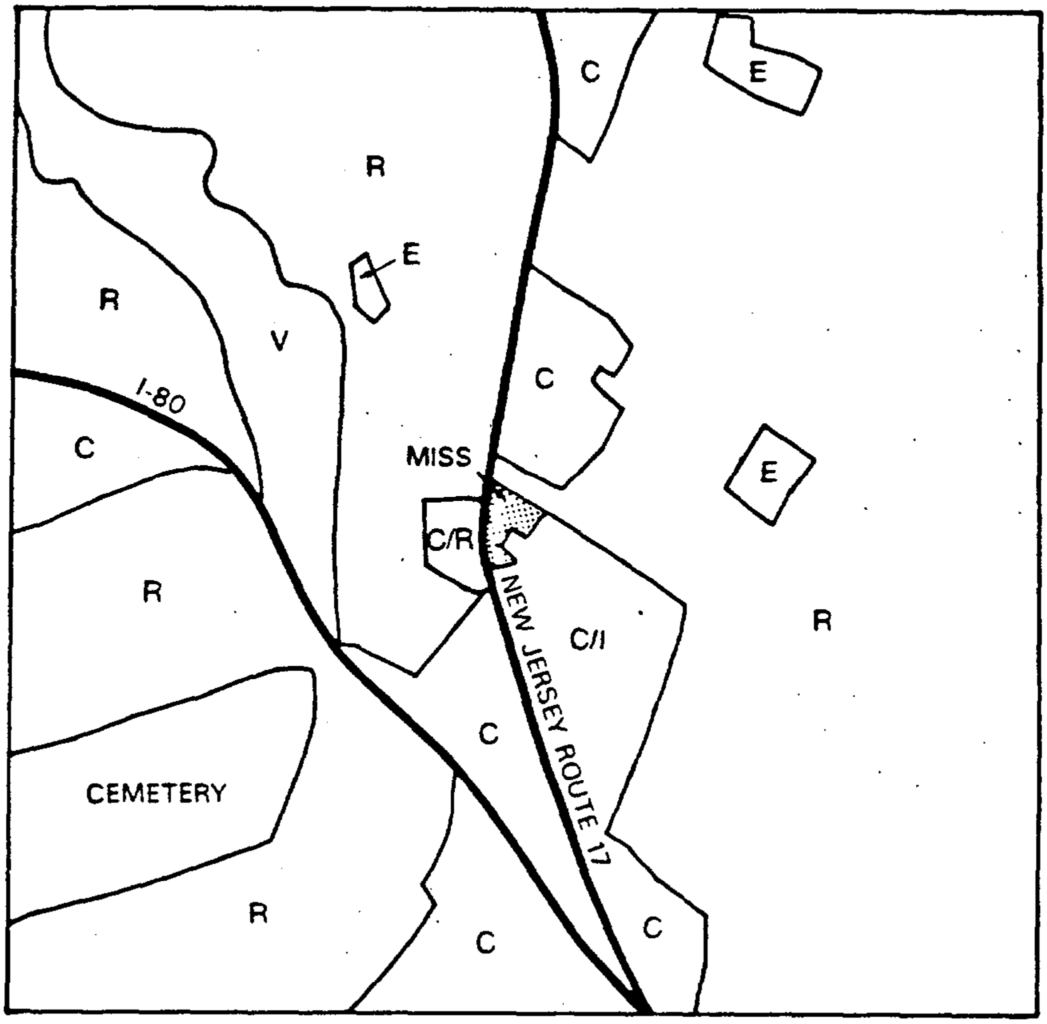


FIGURE 1-4 ANNUAL WIND ROSE FOR THE MISS



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
C/R MIXED COMMERCIAL/RESIDENTIAL

0 0.5 MI
0 0.8 KM

FIGURE 1-5 GENERALIZED LAND USE IN THE VICINITY OF THE MISS migrated off-site via natural drainage provided by the former Lodi Brook. In 1932, New Jersey Route 17 was built through this disposal area (Figure 1-2).

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 under the auspices of the Atomic Energy Act of 1954 (Ref. 8). The Maywood Chemical Works stopped processing thorium in 1956 after approximately 40 years of production. 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. 8). Based on AEC inspections and information related to the Ballod property on the west side of Route 17, the Stepan Company agreed to take remedial action. The cleanup was begun in 1963. In 1966, 6,354 m^3 (8,360 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, 1,560 m^3 (2,053 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 6,536 m^3 (8,600 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 1-6; 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 Ballod property west of Route 17 was conducted by the AEC in 1968. Based on the findings of that survey, clearance was granted for release of the property for unrestricted use (Ref. 8). At the time of the survey, the AEC was not aware that unexcavated waste materials were present in the northeast corner of

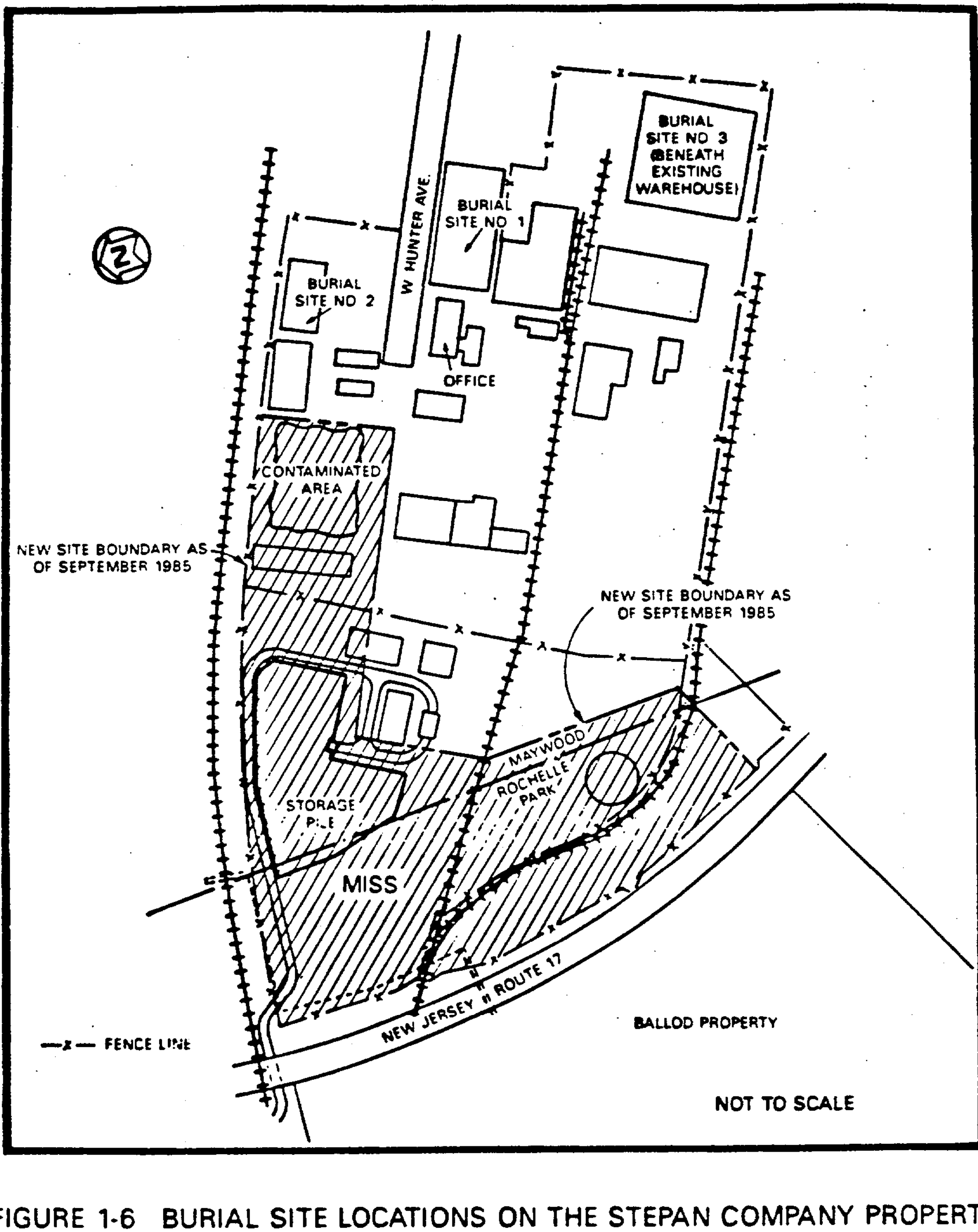


FIGURE 1-6 BURIAL SITE LOCATIONS ON THE STEPAN COMPANY PROPERTY

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. 8).

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. 9). 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. These surveys identified contaminated residential properties on Davison and Latham Streets.

In 1984, Oak Ridge National Laboratory (ORNL) surveyed the Lodi area with a mobile van (Ref. 10). 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.

In 1986 radiological characterization surveys were conducted on the Sears property and adjoining commercial properties southeast of the MISS; the New York, Susquehanna and Western Railroad property adjoining the northern boundary of the MISS; part of Route 17; the north Ballod property; one commercial property, one state-owned property, 26 residential properties, and one municipal property in Lodi. Remedial action is planned for subsequent years.

2.0 SUMMARY OF MONITORING RESULTS

During 1986, 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 radiation levels to verify compliance with the DOE radiation protection standard of 100 mrem/yr (Ref. 11). The potential radiation dose that might be received by the maximally exposed individual was calculated to determine the degree of compliance with the radiation protection standard.

Annual average concentrations of radon (including background) ranged from 6×10^{-10} to 9.9×10^{-9} uCi/ml (0.6 to 9.9 pCi/l) (Table 3-1). The average background radon concentration for the MISS was 1×10^{-9} uCi/ml (1.0 pCi/l). Thoron concentrations (including background) ranged from less than the minimum detectable limit to 9.2×10^{-9} uCi/ml (9.2 pCi/l) (Table 3-1). The average background thoron concentration for the MISS was 4×10^{-10} uCi/ml (0.4 pCi/l). A detailed discussion of 1986 radon and thoron concentrations is provided in Subsection 3.1.

Radon and thoron concentrations at the MISS generally decreased from 1984 to 1985 but increased again in 1986 (see Subsection 3.6.1) (Refs. 12 and 13). This increase can be attributed to abnormally dry weather in New Jersey in 1986 that resulted in an apparent state-wide increase in outgassing of radon and thoron from native rocks and soils. Two monitoring locations measured increases that are not totally explained by climatic effects. These are located in areas that are known to be contaminated and that are scheduled for remedial action.

Annual average external gamma radiation levels measured at the MISS ranged from 18 to 496 mR/yr above background (Table 3-2). The maximum was measured in an area of known contamination with no significant occupancy factor. These rates may be compared to the external gamma radiation levels from natural radiation in the vicinity of the MISS, which averaged 63 mR/yr. External radiation levels are discussed in Subsection 3.2. External gamma radiation levels decreased sharply from 1984 to 1986 (see Subsection 3.6.2) (Refs. 12 and 13).

In surface waters (Subsection 3.3.1), all measured concentrations of uranium, thorium-232, and radium-226 were equal to or less than concentrations measured upstream of the site. Concentrations of uranium and radium-226 in surface water have remained stable from 1984 through 1986. Concentration of thorium-232 have slightly decreased (see Subsection 3.6.3) (Refs. 12 and 13).

In groundwater at the MISS (Subsection 3.3.2), the highest annual average concentration of uranium in 1986 was 10×10^{-8} uCi/ml (100 pCi/l). The highest annual average concentration of thorium-232 was 3×10^{-10} uCi/ml (0.3 pCi/l); for radium-226 it was 1.5×10^{-9} uCi/ml (1.5 pCi/l). Concentrations of radionuclides in surface water and groundwater may be compared with the levels of radioactivity in the commonly consumed liquids listed in Appendix D, Radiation in the Environment.

Concentrations of uranium, radium-226, and thorium-232 in groundwater have remained essentially unchanged since groundwater monitoring began in 1985 (see Subsection 3.6.4) (Ref. 13).

The highest annual average concentrations of uranium, radium-226, and thorium-232 in sediments (Subsection 3.4) were 1.2 pCi/g, 0.4 pCi/g, and 0.7 pCi/g, respectively. Average concentrations of these radionuclides at the MISS may be compared with the levels of environmental radioactivity in phosphate fertilizers listed in Appendix D.

Calculations were made of the radiological dose received by the maximally exposed individual (Subsection 3.5.1). This individual is one who is assumed to be adjacent to the site and who would, when all potential routes of exposure are considered, receive the greatest dose. Exposure to external gamma radiation was the exposure pathway quantified. The maximum exposure this individual would receive is approximately 0.91 mR/yr above background. Since 1 mR is approximately equivalent to 1 mrem, this exposure is approximately equivalent to 0.91 percent of the DOE radiation protection standard.

The cumulative dose to the population within an 80-km (50-mi) radius of the MISS that would result from radioactive materials present at the site would be indistinguishable from the dose that the same population would receive from naturally occurring radioactive sources.

Results of the 1986 monitoring show that the MISS is in compliance with the DOE radiation protection standard.

3.0 DATA COLLECTION, ANALYSIS, AND EVALUATION

This section provides the results of 1986 environmental monitoring at the MISS (Ref. 14), and includes descriptions of the sampling, monitoring, and analytical procedures. Calculations were made to determine the estimated maximum possible radiation dose based on environmental conditions, measurements recorded, and evaluation of potential exposure pathways.

Data are presented in summary tables by sample category. Summaries of data include minimum and maximum values recorded, number of data points collected, and average annual value. The average value for a given sampling location is the average of individual results for that 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 no more than one value is less than the limit of sensitivity of the analytical method, that value is considered as being equal to the limit of sensitivity, and the average value is reported without the "less than" notation.

During 1986, the routine environmental monitoring program for the MISS included radon and thoron gas monitoring, external gamma radiation measurements, surface water and sediment sampling, and groundwater sampling of monitoring wells within the site boundary (which is a fenced and posted area).

Trend tables are provided for radon and thoron, external gamma radiation levels, surface water, and groundwater. These tables list annual averages for each monitoring location for 1984, 1985, and 1986 to allow for comparisons of data and identification of trends in monitoring results (see Subsection 3.6).

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. One of the detectors is 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. Detectors are exchanged quarterly by site personnel and returned to the Terradex Corporation for analysis.

Table 3-1 lists thoron and radon concentrations (including background) recorded at the MISS in 1986. Annual average concentrations of thoron ranged from less than the minimum detectable limit to 9.2×10^{-9} uCi/ml (9.2 pCi/l). The average background concentration, as measured at Location 14 (the Department of Health in Paterson, New Jersey), was 4×10^{-10} uCi/ml (0.4 pCi/l).

Annual average concentrations of radon-222 ranged from 6×10^{-10} to 9.9×10^{-9} uCi/ml (0.6 pCi/l to 9.9 pCi/l). The 1986 average background radon concentration, as measured at Location 14 at the Department of Health in Paterson, was 1×10^{-9} uCi/ml (1 pCi/l).

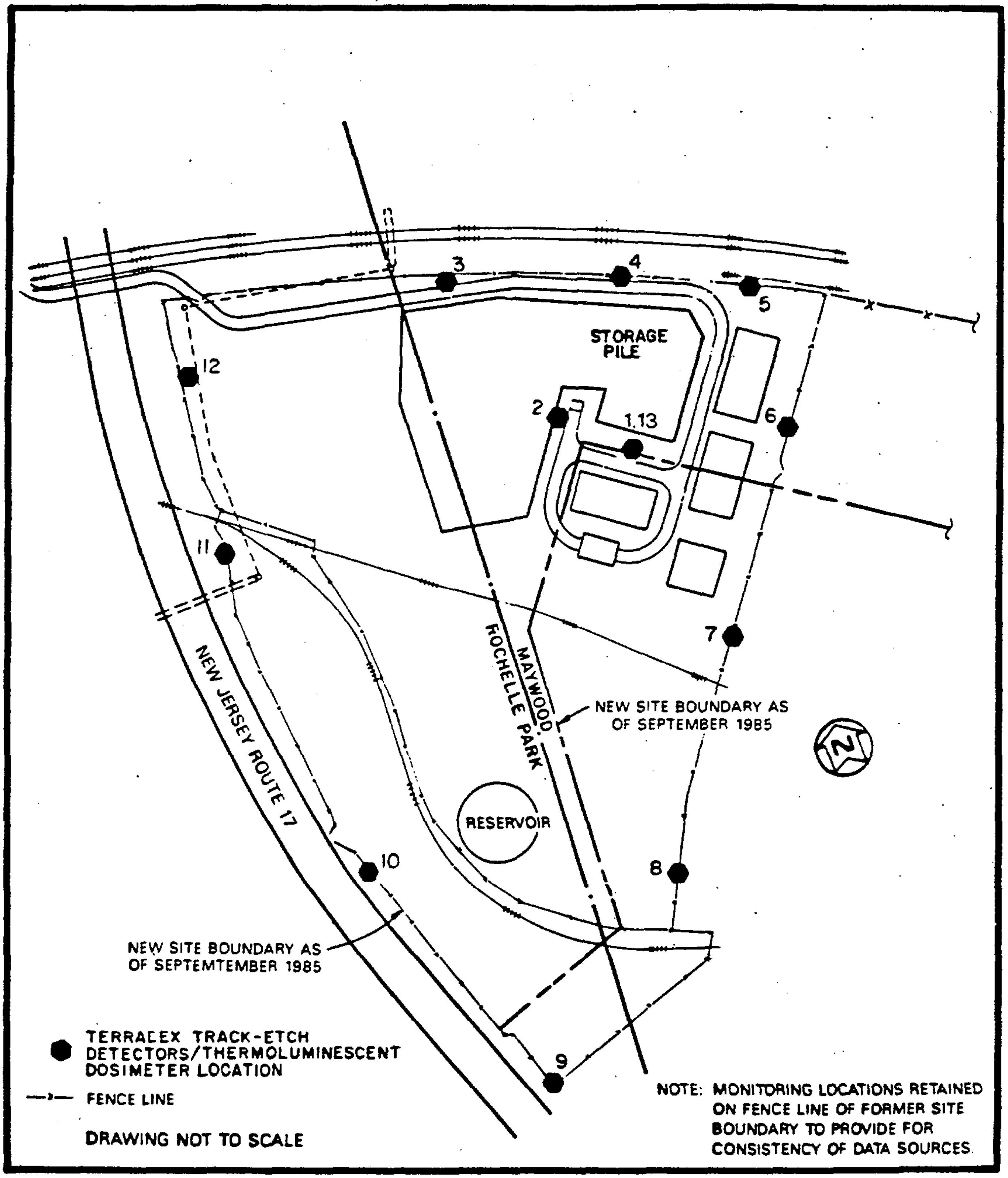


FIGURE 3-1 RADON AND EXTERNAL GAMMA RADIATION MONITORING LOCATIONS AT THE MISS

TABLE 3-1

CONCENTRATIONS OF THORON AND RADON AT THE MISS, 1986

Sampling Location[a]	Number of Measurements	Concentrations (10^{-9} uCi/ml)[b,c] Minimum	Maximum	Average
Thoron (Rn-220)				
1	4	<MDL[d]	0.4	<MDL
2	3[e]	<MDL	0.2	<MDL
3	4	<MDL	0.3	0.1
4	4	<MDL	0.9	<MDL
5	3[e]	4.7	11.8	9.2
6	4	<MDL	1.5	0.6
7	4	<MDL	0.4	<MDL
8	4	<MDL	0.9	0.07
9	4	<MDL	0.2	<MDL
10	4	3.9	9.8	6.0
11	4	<MDL	2.4	0.04
12	4	0.1	3.9	1.7
13[f]	4	0.2	0.8	0.6
14[g]	3[h]	<MDL	1.3	0.4
Radon (Rn-222)				
1	4	0.3	0.9	0.6
2	3[e]	0.4	2.3	1.2
3	4	0.3	2.9	1.2
4	4	1.0	2.9	1.6
5	3[e]	6.0	12.2	9.9
6	4	1.2	3.3	1.9
7	4	0.6	1.5	0.9
8	4	0.3	1.4	0.8
9	4	0.3	1.7	0.9
10	4	4.5	10.9	6.5
11	4	0.2	3.1	1.3
12	4	1.4	4.5	2.6
13[f]	4	0.5	2.3	1.2
14[g]	3[e]	0.1	2.1	1.0

[a] Sampling locations shown in Figure 3-1.

[b] 1×10^{-9} uCi/ml is equivalent to 1 pCi/l.

[c] All results include background.

[d] No detectable thoron (radon-220) or less than minimum detectable limit (MDL).

[e] Detectors were missing in the second quarter.

[f] Location 13 is a quality control for Location 1.

[g] Located at the Department of Health, Paterson, NJ.

[h] Detector was missing in the third quarter.

For a comparison of radon and thoron concentrations measured at the MISS from 1984-1986, see Subsection 3.6.1.

3.2 EXTERNAL GAMMA RADIATION LEVELS

External gamma radiation levels 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 radiation levels at the site boundary and in the area adjacent to the contaminated storage pile.

The external gamma radiation levels are measured using lithium fluoride (LiF) thermoluminescent dosimeters (TLDs), which are exchanged quarterly. Each dosimeter contains five TLD chips, the responses of which are averaged. Analysis is performed by Thermo Analytical/Eberline (TMA/E).

The results for external gamma monitoring are presented in Table 3-2. External radiation data for the first quarter of 1986 were invalidated because the dosimeters were exposed to radiation during shipment to the laboratory. The magnitude and nonuniformity of the exposure prevented a correction of the data. In the fourth quarter of 1986, procedures were implemented to reduce the probability of such in-transit exposures occurring in the future.

The average background radiation level for the MISS area (63 mR/yr) has been subtracted from the radiation levels in Table 3-2 to provide an estimate of the effect of the site on measured radiation levels at the site boundary. Of the seven locations (on the north and west boundaries of the site) where members of the public might have access, but no significant occupancy factor, the highest average external gamma radiation level was recorded at Location 10 (near State Route 17), an area known to be contaminated prior to DOE acquisition (Ref. 3).

TABLE 3-2

EXTERNAL GAMMA RADIATION LEVELS AT THE MISS, 1986

Sampling Location[a]	Number of Measurements[b]	Radiation Level (mR/yr)[c,d] Minimum	Maximum	Average
Boundary				
3	3	24	47	38
4	3	73	101	91
5	2[e]	165	179	172
6	3	59	110	83
7	3	0[f]	47	24
8	3	0[f]	42	18
9	3	0[f]	51	23
10[g]	3	469	547	496
11	3	27	87	50
12	3	78	99	88
On-Site				
1	3	26	37	41
2	3	40	60	51
13[h]	3	16	56	35
Background				
14[i]	3	50	83	63

[a]Sampling locations are shown in Figure 3.1

[b]First quarter data invalidated by in-transit exposure.

[c]Average background has been subtracted.

[d]Divide by 4 to compare with 1985 mrem/quarter values.

[e]Detector was missing during the second quarter.

[f]Measurement was less than or equal to the measured background value.

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

[h]Location 13 is a quality control for Location 1.

[i]Located at the Department of Health, Paterson, NJ.

To compare the 1986 external radiation levels reported in Table 3-2 with those measured in 1985 (Ref. 12), the 1986 values for minimum, maximum, and average should be divided by 4 since they are expressed as annual values, whereas the 1985 values were expressed as quarterly values.

For comparisons of external gamma radiation levels measured from 1984 through 1986, see Subsection 3.6.2.

3.3 WATER SAMPLING

During 1986, quarterly 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

Surface water sampling locations were established on the Saddle River (Location 1) and on Westerley Brook (Locations 2, 3, and 4). Location 4 was accessible by way of a manhole, which has been welded shut and is no longer accessible. Locations 5 and 6 were established on the Ballod property west of the MISS. However, since no standing water was present at Locations 5 and 6 during 1986 quarterly sampling, no surface water samples could be obtained there. Surface water collection locations were selected based on migration potential and discharge routes from the site. Because surface water runoff from the site discharges via underground Westerley Brook, samples were collected both upstream (Location 3) and downstream (Locations 1 and 2) of the site.

Nominal 1-liter (0.26 gal) grab samples were collected to fill a 4-liter (1-gal) container. The samples were analyzed by TMA/E for total uranium, thorium-232, and dissolved radium-226. The concentration of total uranium was determined by a fluorometric

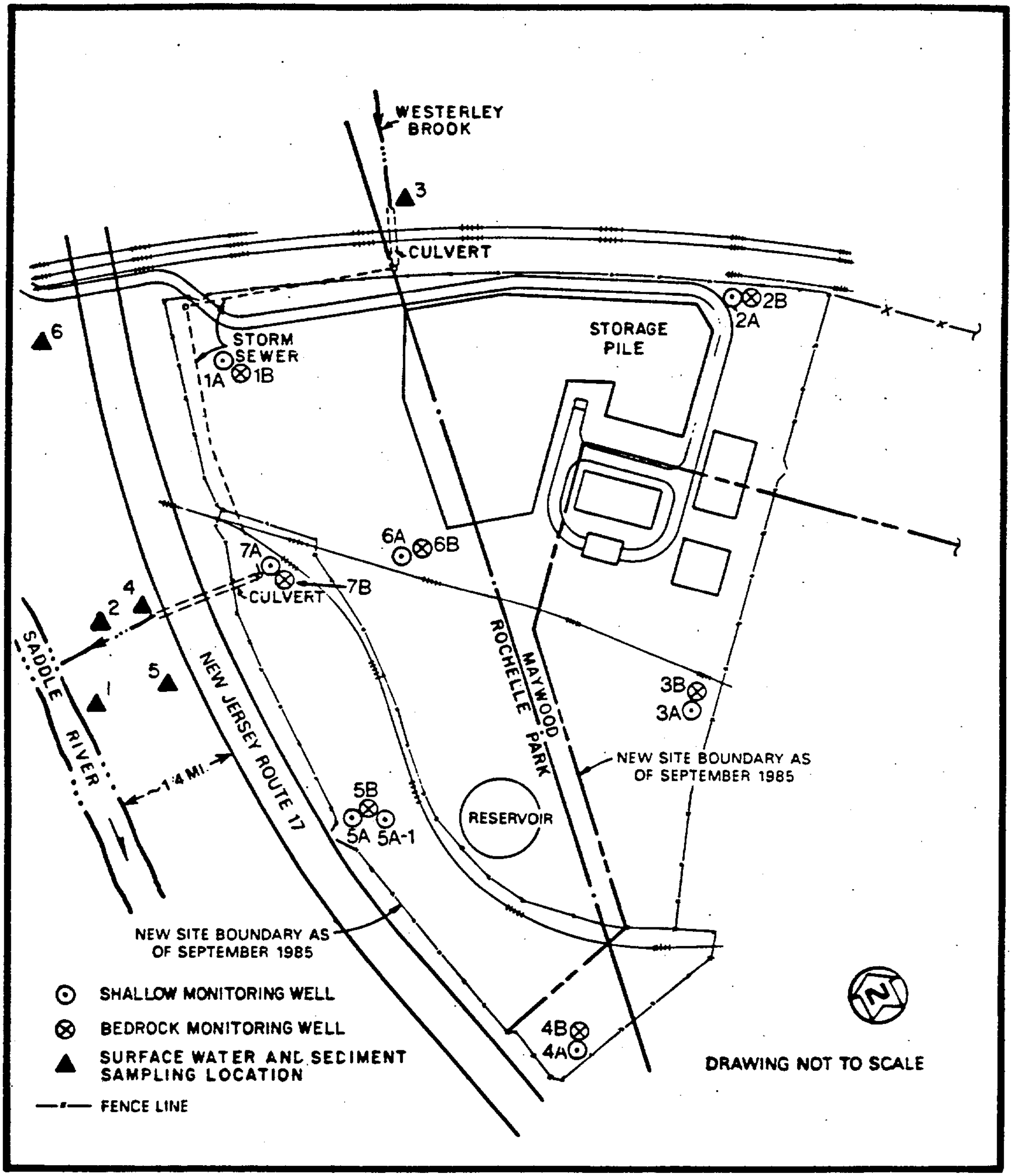


FIGURE 3-2 SURFACE WATER, GROUNDWATER, AND SEDIMENT SAMPLING LOCATIONS IN THE VICINITY OF THE MISS

method. Radium-226 concentrations in water were determined by radon emanation. This method consists of precipitating radium as the sulfate, transferring the treated sulfate to a radon bubbler, wherein radon-222 is allowed to come to equilibrium with its radium-226 parent. The radon-222 gas is then withdrawn into a scintillation cell and counted using the gross alpha technique. The quantity of radon-222 detected in this manner is directly proportional to the quantity of radium-226 originally present in the sample. Thorium-232 was eluted in solution, electrodeposited on stainless steel discs, and counted by alpha spectrometry.

Analysis results are presented in Table 3-3. Average concentrations of total uranium in surface water were all less than 3×10^{-9} uCi/ml (less than 3.0 pCi/l). The annual average concentration of radium-226 in surface water ranged from 4×10^{-10} to 6×10^{-10} uCi/ml (0.4 to 0.6 pCi/l). Annual average radium-226 concentrations were lower downstream than upstream. Annual average thorium-232 concentrations ranged from less than the limit of sensitivity of the analytical method to 1×10^{-10} uCi/ml (0.1 pCi/l). Thorium-232 concentrations were the same upstream and downstream. These values may be compared with the levels of radioactivity in the commonly consumed liquids listed in Appendix D.

For comparisons of radionuclide concentrations measured in surface water from 1984 through 1986, see Subsection 3.6.3.

3.3.2 Groundwater

During 1986, groundwater samples were collected quarterly from 15 on-site wells at 7 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 2A and 2B are upgradient monitoring locations for the MISS waste pile. All other wells are generally downgradient monitoring locations. Well locations were selected on the basis of available geohydrological data.

TABLE 3-3

CONCENTRATIONS OF TOTAL URANIUM, RADIUM-226, AND THORIUM-232 IN SURFACE WATER AT THE MISS, 1986

Sampling Location[a]	Number of Samples	Concentration (10^{-9} uCi/ml)[b,c] Minimum	Maximum	Average[d]
Total Uranium				
1	4	<3.0	<3.0	<3.0
2	4	<3.0	<3.0	<3.0
3	4	<3.0	<3.0	<3.0
Radium-226				
1	4	0.3	0.5	0.4
2	4	<0.1	0.9	0.4
3	4	<0.1	1.1	0.6
Thorium-232				
1	3[e]	<0.1	<0.1	<0.1
2	3[e]	<0.1	0.2	0.1
3	3[e]	<0.1	0.2	0.1

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

[b]All results include background.

[c]1×10^{-9} uCi/ml is equivalent to 1 pCi/l.

[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]Thorium-232 analysis was omitted in the first quarter of 1986.

After the wells had been pumped dry or two casing volumes had been removed, nominal 1-liter (0.26-gal) grab samples were collected to fill a 4-liter (1-gal) container. Samples were analyzed by TMA/E for total uranium, thorium-232, and radium-226 using the analytical methods applied to surface water analyses.

Analysis results are presented in Tables 3-4, 3-5, and 3-6, respectively. Annual average uranium concentrations ranged from 3×10^{-10} to 10×10^{-8} uCi/ml (0.3 to 100 pCi/l). Average thorium-232 concentrations ranged from 1×10^{-10} to 3×10^{-10} uCi/ml (0.1 to 0.3 pCi/l). Average radium-226 concentrations ranged from 2×10^{-10} to 1.5×10^{-9} uCi/ml (0.2 to 1.5 pCi/l). These concentrations may be compared to the levels of radioactivity in the commonly consumed liquids listed in Appendix D. For a comparison of radionuclide concentrations in groundwater measured in 1985 and 1986, see Subsection 3.6.4.

3.4 SEDIMENT SAMPLING

Sediment samples that consisted of composites weighing approximately 500 g (1.1 lb) were obtained at surface water sampling locations where sediment was present. The rationale for selection of the individual sampling locations is given in Subsection 3.3.1. Samples were analyzed by TMA/E for isotopic uranium, radium-226, and thorium-232. The concentrations of isotopic uranium and thorium-232 were determined using alpha spectrometry after the uranium and thorium-232 had been leached, extracted, and electroplated on metal substrates. Radium-226 concentration was determined by radon emanation (described earlier).

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 0.8 pCi/g to a maximum of 1.2 pCi/g. The isotopic uranium concentrations were summed to estimate the total uranium concentrations shown in Table 3-7.

TABLE 3-4

CONCENTRATIONS OF TOTAL URANIUM IN GROUNDWATER AT THE MISS, 1986

Sampling Location[a]	Number of Samples	Concentration (10^{-9} uCi/ml)[b] Minimum	Maximum	Average[c]
1B	4	1.0	2.0	1.6
2A	4	0.4	1.1	0.6
2B	4	<0.2	0.6	0.5
3A	4	0.3	0.8	0.6
3B	4	<0.2	0.4	0.3
4B	4	<0.2	1.2	0.5
5A	2[d]	98.9	101.0	100.0
5B	4	<0.2	0.5	0.3
6A	3[d]	5.1	10.4	8.4
6B	4	0.6	1.1	0.8
7B	4	4.0	6.4	4.7

[a]Sampling locations are shown in Figure 3-2. Wells 1A, 4A, 5A-1, and 7A were dry during all sampling periods and are therefore not listed.

[b]1×10^{-9} uCi/ml is equivalent to 1 pCi/l.

[c]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."

[d]Shallow well to monitor overburden. These wells typically do not contain water year round.

TABLE 3-5

CONCENTRATIONS OF THORIUM-232 IN GROUNDWATER AT THE MISS, 1986

Sampling Location[a]	Number of Samples	Concentration (10^{-9} uCi/ml)[b] Minimum	Maximum	Average[c]
1B	4	<0.02	<0.3	<0.2
2A	4	<0.03	<0.3	<0.2
2B	4	<0.02	<0.3	<0.2
3A	4	<0.1	<0.3	<0.2
3B	4	<0.1	<0.2	<0.1
4B	4	<0.1	<0.1	<0.1
5A	2[d]	<0.03	0.6	0.3
5B	4	<0.03	<0.1	<0.1
6A	3[d]	<0.1	0.4	0.1
6B	4	<0.1	<0.2	<0.2
7B	4	<0.1	<0.2	<0.2

[a]Sampling locations are shown in Figure 3-2. Wells 1A, 4A, 5A-1, and 7A were dry during all sampling periods and are therefore not listed.

[b]1 x 10^{-9} uCi/ml is equivalent to 1 pCi/l.

[c]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."

[d]Shallow well to monitor overburden. These wells typically do not contain water year round.

TABLE 3-6

CONCENTRATIONS OF RADIUM-226 IN GROUNDWATER AT THE MISS, 1986

Sampling Location[a]	Number of Samples	Concentration (10^{-9} uCi/ml)[b]		
		Minimum	Maximum	Average[c]
1B	4	0.4	0.7	0.6
2A	4	0.4	0.8	0.5
2B	4	<0.1	5.0	1.5
3A	4	<0.1	1.0	0.6
3B	4	0.2	0.6	0.5
4B	4	0.3	0.5	0.4
5A	2[d]	0.4	0.8	0.6
5B	4	0.1	0.5	0.2
6A	3[d]	0.3	0.6	0.4
6B	4	0.3	0.9	0.5
7B	4	0.1	0.6	0.4

[a]Sampling locations are shown in Figure 3-2. Wells 1A, 4A, 5A-1, and 7A were dry during all sampling periods and are therefore not listed.

[b]1×10^{-9} uCi/ml is equivalent to 1 pCi/l.

[c]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."

[d]Shallow well to monitor overburden. These wells typically do not contain water year round.

Analysis results for radium-226 (based on dry weight) are presented in Table 3-8. The maximum reading, 0.5 pCi/g, and the highest annual average, 0.4 pCi/g, were both obtained at Location 3, which is upstream from MISS. Results for thorium-232 (based on dry weight) are also presented in Table 3-8. The maximum reading of 1.9 pCi/g was obtained at Location 2; the highest annual average, 0.7 pCi/g, was also obtained at Location 2. These concentrations may be compared with the levels of radioactivity in phosphate fertilizers listed in Appendix D.

3.5 RADIATION DOSE

To assess the potential health effects of the radioactive materials stored at the MISS, radiological exposure pathways were evaluated to calculate the dose to the maximally exposed individual. This individual is one who is assumed to be adjacent to the site and who would, when all potential routes of exposure are considered, receive the greatest dose. An appraisal of potential pathways (exposure to external gamma radiation, ingestion of water, and inhalation of radon) suggested that external gamma radiation was the principal exposure mode.

The dose from ingesting groundwater or surface water from sources on the MISS was not calculated because it was considered unrealistic that ingestion of this water would occur. The MISS is fenced and locked, and security is well maintained. Since the MISS is fenced and locked, a member of the public could only consume water on the site by trespassing on the property every day to gain access to the water. To consume groundwater from a well at the MISS, the trespasser would have to be equipped with a means of removing the well cap, a power source, a pump, and a hose.

Radon concentrations measured at the boundary of the MISS were within the normal variations associated with background measurements, except for three locations. Given the amount of time that the maximally exposed individual would spend near these

TABLE 3-7

CONCENTRATIONS OF URANIUM IN SEDIMENT AT THE MISS, 1986

Sampling Location[a]	Number of Samples	Concentration [pCi/g (dry)] Minimum	Maximum	Average
Uranium-234				
1	4	0.2	0.7	0.5
2	4	0.3	0.5	0.4
3	4	0.2	0.5	0.4
Uranium-235				
1	4	0.02	0.06	0.02
2	4	0.02	0.04	0.02
3	4	0.01	0.05	0.02
Uranium-238				
1	4	0.2	0.6	0.4
2	4	0.3	2.3	0.8
3	4	0.2	0.6	0.4
Total Uranium[b]				
1	4	0.4	1.4	1.0
2	4	0.6	2.8	1.2
3	4	0.4	1.0	0.8

[a]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.

[b]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, 1986

Sampling Location[a]	Number of Samples	Concentration [pCi/g (dry)] Minimum	Maximum	Average
Radium-226				
1	4	0.1	0.4	0.2
2	4	0.1	0.5	0.3
3	4	0.3	0.5	0.4
Thorium-232				
1	4	0.3	1.4	0.7
2	4	0.3	1.9	0.7
3	4	0.3	0.5	0.4

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

locations, the dose from radon inhalation would be indistinguishable from the dose received from background concentrations. Consequently, this pathway would not contribute additional dose to the maximally exposed individual and was not considered in dose calculations presented in Subsection 3.5.1. Measured radon and thoron concentrations are discussed fully in Subsection 3.1.

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 dose from exposure to external gamma radiation was calculated at various monitoring locations that could be accessible by the public. These doses were then reviewed with regard to land use and occupancy factors for areas adjacent to the monitoring points.

Due to their distance from the site, residents in homes on Central Avenue north of the site boundary would receive exposures equivalent to background for the area. The highest annual average external radiation levels at the MISS in 1986 were measured along the western boundary of the site, with an average value of 164 mR/yr at TLD monitoring Locations 9 through 12. Therefore, the highest overall exposure from external gamma radiation 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 h/yr in the area. This maximally exposed individual would receive an exposure of 0.91 mR/yr above background. Since 1 mR is approximately equivalent to 1 mrem, this exposure is approximately equivalent to 0.91 percent of the DOE radiation protection standard of 100 mrem/yr, and is less than the exposure that a person would receive during a roundtrip flight between New York and Los Angeles from the increased cosmic radiation at higher altitudes.

3.5.2 Dose to the Population in the Vicinity of the MISS

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 external gamma radiation level at a distance of 1 m (3 ft) from a small-area radioactive source were 100 mR/yr, the external radiation level 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. 16). Therefore, radon exposure from site sources 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.

The cumulative dose to the population within an 80-km (50-mi) radius of the MISS that would result from radioactive materials present at the site would be indistinguishable from the dose the same population would receive from naturally occurring radioactive sources.

3.6 TRENDS

The environmental monitoring program at the MISS has been established to allow an annual assessment of the environmental conditions at the site, provide a historical record for comparisons from year to year, and permit detection of trends over time. In the following subsections, 1986 annual averages for each monitoring location for radon and thoron, external gamma radiation, surface water, and groundwater are compared with results for 1984 and 1985. As the environmental monitoring program continues at the MISS and more data are colleted, comparisons and analyses of trends will become more valid.

3.6.1 Radon

As shown in Table 3-9, thoron and radon concentrations at the MISS generally decreased from 1984 to 1985, only to increase again in 1986. This increase can be attributed to seasonal and climatic effects. An abnormally dry year in New Jersey in 1986 contributed to an apparent state-wide increase in outgassing of radon and thoron. This is supported by the increases in background levels of radon and thoron, and similar increases noted at other FUSRAP sites in New Jersey.

However, two monitoring locations (Locations 5 and 10) measured increased radon and thoron concentrations that cannot be explained entirely by seasonal or climatic effects. These two locations are in areas that are known to be contaminated and that are scheduled for remedial action. The impact on the public of radon and thoron concentrations measured in these areas would be indistinguishable from background (see Subsections 3.5.1 and 3.5.2).

3.6.2 External Gamma Radiation Levels

As shown in Table 3-10, external gamma radiation levels at the MISS have decreased sharply form 1984 to 1986.

TABLE 3-9

ANNUAL AVERAGE CONCENTRATIONS OF THORON AND RADON AT THE MISS, 1984-1986*

Sampling Location[a]	Concentration (10^{-9} uCi/ml)[b,c] 1984	1985	1986
Thoron (Rn-220)			
1	8.1	0.5	<MDL[d]
2	2.1	0.6	<MDL
3	2.1	0.3	0.1
4	1.4	0.5	<MDL
5	9.9	3.2	9.2
6	1.1	1.0	0.6
7	0.2	0.3	<MDL
8	0.6	0.02	0.07
9	<MDL	0.2	<MDL
10	2.1	2.7	6.0
11	<MDL	0.2	0.04
12	1.4	1.2	1.7
13	1.2	2.9	0.6
14[e]	<MDL	0.1	0.4
Radon (Rn-222)			
1	0.9	0.3	0.6
2	0.8	0.2	1.2
3	0.9	0.3	1.2
4	0.8	0.4	1.6
5	1.3	0.5	9.9
6	1.2	0.2	1.9
7	0.9	0.2	0.9
8	0.6	0.3	0.8
9	1.0	0.2	0.9
10	0.8	0.4	6.5
11	2.7	0.2	1.3
12	1.4	0.2	2.6
13	0.7	0.3	1.2
14[e]	1.3	0.4	1.0

[a]Sampling locations shown in Figure 3-1.
[b]1 x 10^{-9} uCi/ml is equivalent to 1 pCi/l.
[c]All results include background.
[d]No detectable thoron (radon-220) or less than minimum detectable limit.
[e]Background detector, located at Department of Health, Paterson, NJ.
*Sources for 1984 and 1985 data are the Annual Site Environmental Reports for the two years (Refs. 12 and 13). In some cases, previous years' data have been reported in different units of measurement. For ease of comparison, all data in trend tables are reported in the units used in the 1986 report. Applicable conversion factors are listed in Appendix B of this report.

3.6.3 Surface Water

Concentrations of uranium and radium-226 in surface water at the MISS have remained basically stable since 1984, as shown in Table 3-11. Thorium-232 concentrations have decreased slightly over the 3-year period.

3.6.4 Groundwater

Groundwater monitoring wells were installed at the MISS in 1985, and with only 2 years' data, it is not possible to define trends in radionuclide concentrations in groundwater. However, the comparison between 1985 and 1986 concentrations of uranium, radium-226, and thorium-232 (Table 3-12) show general stability in the concentrations of radionuclides in groundwater.

TABLE 3-10

ANNUAL AVERAGE EXTERNAL GAMMA RADIATION LEVELS AT THE MISS, 1984-1986*

Sampling Location[a]	Radiation Level (mR/yr)[b] 1984	1985	1986
Boundary			
3	196	27	38
4	182	130	91
5	368	272	172
6	287	106	83
7	147	15	24
8	148	15	18
9	176	38	23
10[c]	759	627	496
11	90	57	50
12	208	180	88
On-Site			
1	91	48	41
2	89	50	51
13	80	46	35
Background			
14	-[d]	108	63

[a]Sampling locations are shown in Figure 3.1.

[b]Average background has been subtracted.

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

[d]Background detector added in 1985.

*Sources for 1984 and 1985 data are the Annual Site Environmental Reports for the two years (Refs. 12 and 13). In some cases, previous years' data have been reported in different units of measurement. For ease of comparison, all data in trend tables are reported in the units used in the 1986 report. Applicable conversion factors are listed in Appendix B of this report.

TABLE 3-11

ANNUAL AVERAGE CONCENTRATIONS OF TOTAL URANIUM, RADIUM-226, AND THORIUM-232 IN SURFACE WATER AT THE MISS, 1984-1986*

Sampling Location[a]	Concentration (10^{-9} uCi/ml)[b,c] 1984	1985	1986
Total Uranium			
1	3	<3.0	<3.0
2	3	<3.0	<3.0
3	3	<3.0	<3.0
Radium-226			
1	0.4	0.2	0.4
2	0.2	0.4	0.4
3	0.7	0.4	0.6
Thorium-232			
1	0.4	0.2	<0.1
2	0.5	0.1	0.1
3	0.4	0.1	0.1

[a] Sampling locations shown in Figure 3-2. Locations 4, 5, and 6 are not reported because there was no data for these locations for 1986, and only very limited data for previous years.

[b] 1 x 10^{-9} uCi/ml is equivalent to 1 pCi/l.

[c] All results include background.

*Sources for 1984 and 1985 data are the Annual Site Environmental Reports for the two years (Refs. 12 and 13). In some cases, previous years' data have been reported in different units of measurement. For ease of comparison, all data in trend tables are reported in the units used in the 1986 report. Applicable conversion factors are listed in Appendix B of this report.

TABLE 3-12

ANNUAL AVERAGE CONCENTRATIONS OF TOTAL URANIUM, RADIUM-226, AND THORIUM-232 IN GROUNDWATER AT THE MISS, 1985-1986*

Sampling Location[a]	Concentration (10^{-9} uCi/ml)[b,c] 1985	1986
Total Uranium		
1A	27.0	–[c]
1B	<3.0	1.6
2A	3.0	0.6
2B	12.0	0.5
3A	<3.0	0.6
3B	<3.0	0.3
4A	<3.0	–[c]
4B	<3.0	0.5
5A	63.0	100.0
5A-1	–[c]	–[c]
5B	<3.0	0.3
6A	9.0	8.4
6B	5.0	0.8
7A	–[c]	–[c]
7B	12.0	4.7
Radium-226		
1A	0.1	–[c]
1B	0.6	0.6
2A	0.4	0.5
2B	0.3	1.5
3A	0.4	0.6
3B	0.3	0.5
4A	0.4	–[c]
4B	0.3	0.4
5A	0.2	0.6
5A-1	–[c]	–[c]
5B	0.3	0.2
6A	0.2	0.4
6B	0.4	0.5
7A	–[c]	–[c]
7B	0.3	0.4
Thorium-232		
1A	0.1	–[c]
1B	<0.1	<0.2
2A	0.3	<0.2
2B	<0.2	<0.2

TABLE 3-12
(continued)

Sampling Location[a]	Concentration (10^{-9} uCi/ml)[b,c] 1985	1986
3A	<0.1	<0.2
3B	<0.2	<0.1
4A	<0.1	_c
4B	<0.1	<0.1
5A	<0.1	0.3
5A-1	_c	_c
5B	<0.2	<0.1
6A	<0.2	0.1
6B	<0.3	<0.2
7A	_c	_c
7B	<0.2	<0.2

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

[b]1×10^{-9} uCi/ml is equivalent to 1 pCi/l.

[c]Shallow well to monitor overburden. These wells typically do not contain water year round.

*Source for 1985 data is the Annual Site Environmental Report for the year (Ref. 13). In some cases, previous years' data have been reported in different units of measurement. For ease of comparison, all data in trend tables are reported in the units used in the 1986 report. Applicable conversion factors are listed in Appendix B of this report.

4.0 RELATED ACTIVITIES AND SPECIAL STUDIES

4.1 RELATED ACTIVITIES

During calendar year 1986, 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, 5A-1, 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.

As required by NJPDES permit No. NJ0054500, groundwater samples from the MISS were analyzed for various chemical constituents. Samples are analyzed quarterly for pH, total organic carbon (TOC), total organic halides (TOX), and specific conductance. Once a year analyses are performed for New Jersey priority pollutants. Table 4-1 lists the results of chemical analyses performed on groundwater samples. This table lists the analytical results for only those characteristics and chemical contaminants that were detected. Numerous other chemical contaminants, for which analyses were completed under the permit requirements, were not detected in any of the groundwater samples (see Table 4-2).

TABLE 4-1

CONCENTRATIONS OF CHEMICAL CONTAMINANTS IN GROUNDWATER AT THE MISS, 1986[a]

Parameter/(Units)	Range of Concentrations by Sampling Location (Monitoring Well Number)[b]											
	1B	2A[c]	2B[c]	3A	3B	4A	4B	5A	5B	6A	6B	7B
pH (pH units)	7.0-7.2	7.0-7.2	6.9-7.3	5.8-6.1	6.1-6.4	6.55	7.0-7.5	6.30	7.1-7.5	6.8-6.9	9.0-9.3	7.1-7.4
Total Organic Carbon (mg/l)	2.1-7.3	54-154	58-154	4-9	8-18	14	16-32	9	12-22	8-74	9-38	4-41
Total Organic Halide (ug/l)	28-70	28-410	17-900	53-171	57-152	19	111-400	24	81-110	ND-35	24-40	26-79
Specific Conductance (umhos/cm)	785-990	5625-7400	8825-10500	980-1072	2050-3200	1650	1720-1910	2500	2388-3300	2450-2700	3100-4100	6275-8500
Benzene (ug/l)	ND	ND	180	ND	47	ND	28	ND	ND	ND	ND	ND
Chloroform (ug/l)	ND	ND	ND	ND	ND	ND	17	ND	ND	ND	ND	ND
Methylene Chloride (ug/l)	ND	ND	ND	95	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethane (ug/l)	40	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	51
Toluene (ug/l)	ND	ND	11	ND	ND	ND	ND	ND	25	9	ND	ND
1,1,1-Trichloroethylene (ug/l)	6.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Trans-Dichloroethylene (ug/l)	6.3	ND	ND	ND	ND	ND	21	ND	ND	ND	ND	19
Trichloroethylene (ug/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16

[a] Does not include parameters for which concentrations were below the limit of sensitivity of the analytical method used.

[b] ND - No detectable concentration. Where only one value is listed, only one sample was analyzed.

[c] Upgradient well.

TABLE 4-2

CHEMICAL CONTAMINANTS FOR WHICH CONCENTRATIONS IN GROUNDWATER AT THE MISS WERE BELOW THE ANALYTICAL LIMIT OF SENSITIVITY, 1986[a]

Acrolein
Acrylonitrile
Bromoform
Carbon Tetrachloride
Chlorobenzene
Chlorodibromomethane
Chloroethane
2-chloroethyl vinyl ether
Dichlorobromomethane
1,3-Dichloropylene
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethylene
1,2-Dichloropropane
1,3-Dichloropropene
Ethylbenzene
Methylene chloride
Methyl bromide
Methyl chloride
1,1,2,2-Tetrachloroethane
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Vinyl chloride
Anthracene
Acenaphthene
Acenaphthylene
Benzo (a) anthracene
Benzo (k) fluoranthene
Benzo (a) pyrene
Benzo (g,h,i) perylene
Benzidine
BIS (2-chlorethyl) ether
BIS (2-chloroethoxy) methane
BIS (2-Chloroisopropyl) ether
BIS (2-Ethylhexyl) phthalate
3,4-Benzofluoranthene
4-Bromophenylphenylether
Butylbenzylphthalate
2-Chloronaphthalene
4-Chlorophenylphenylether
Chrysene
Dibenzo (a,h) antracene
Di-N-Butyl phthalate
Di-N-Octyl phthalate
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
3,3-dichlorobenzidine
Diethylphthalate
Dimethylphthalate
2,4-Dinitrotoluene
2,6-Dinitrotoluene
1,2-Diphenylhydrazine
Fluoranthene
Fluorene
Hexachlorobenzene
Hexachlorobutadiene
Hexachloroethane
Hexachlorocyclopentadiene
Indeno (1,2,3-cd) pyrene
Isophorone
Naphthalene
Nitrobenzene
n-Nitrosodimethylamine
n-Nitrosodi-N-propylamine
Phenanthrene
Pyrene
1,2,4-Trichlorobenzene
2-Chlorophenol
2,4-Dichlorophenol
2,4-Dimethylphenol
4,6-Dinitro-O-cresol
p-Chloro-M-cresol
2,4-Dinitrophenol
2-Nitrophenol
4-Nitrophenol
Pentachlorophenol
Phenol
2,4,6-Trichlorophenol
Aldrin
BHC, alpha
BHC, beta
BHC, gamma
BHC, delta
Chlordane
Dieldrin
Endosulfan, alpha
Endosulfan, beta
Endosulfan sulfate
Endrin
Endrin aldehyde
Heptachlor
Heptachlor Epoxide
4,4'-DDT
4,4'-DDE
4,4'-DDD
PCB 1016
PCB 1221
PCB 1232
PCB 1242
PCB 1248
PCB 1254
PCB 1260

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

Generally, the highest concentration of chemicals were in deep, upgradient wells. In the deep wells, the highest concentrations of TOX and TOC were observed at Well 2B. Benzene was observed in three deep wells, with the highest concentration in Well 2B. The other two wells were on the perimeter of the site and roughly downgradient from Well 2B.

In the shallow (overburden) wells, the highest concentrations of chemicals were found in Wells 2A (the upgradient well for the site) and 3A. Methylene chloride and toluene were the only specific organic compounds detected in shallow wells. Concentrations tended 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 additional information on groundwater gradient and flow directions.

4.2 SPECIAL STUDIES

There were no special studies performed at the MISS in 1986.

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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, current monitoring data were compared with historical data for 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 cross-checks, 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 effects of site operations.

The majority of the routine radioanalyses for the FUSRAP Environmental Monitoring Program were performed under subcontract by Thermo Analytical/Eberline, 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 DOE long-term radiation protection standard is 100 mrem/yr (Ref. 13). Evaluation of exposure pathways and resulting dose calculations are based on assumptions such as occupancy factors in determining the dose from 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. Use of such assumptions will result in calculated doses that more accurately reflect the exposure potential from site activities.

TABLE B-1

CONVERSION FACTORS

1 year	=	8760 hours
1 liter	=	1000 ml
1 mR	$\cong$	1 mrem
1 mrem	$\cong$	1000 uR
1 mrem/yr	$\cong$	8.7 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

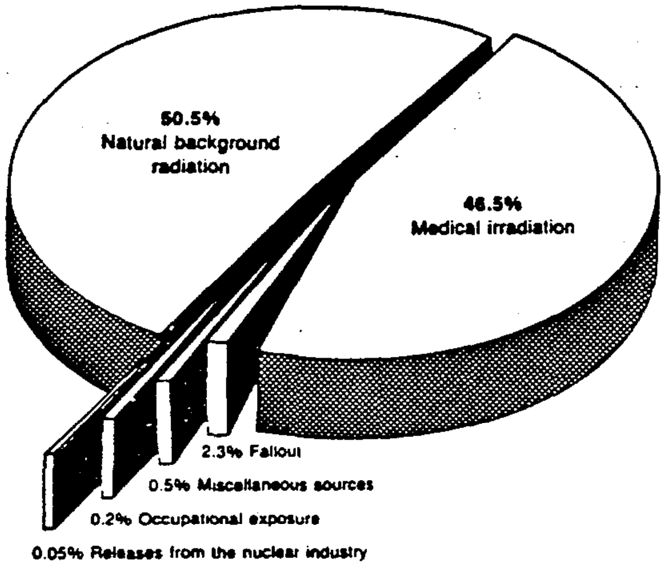
APPENDIX C
ABBREVIATIONS

cm	centimeter
cm/sec	centimeters per second
ft	foot
g	gram
gal	gallon
h	hour
ha	hectare
in.	inch
km	kilometer
km/h	kilometers per hour
lb	pound
m	meter
m^3	cubic meters
mg	milligram
mg/l	milligrams per liter
mi	mile
ml	milliliter
mph	miles per hour
mR	milliroentgen
mrem	millirem
mR/yr	milliroentgens per year
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
yd^3	cubic yards
yr	year

APPENDIX D
RADIATION IN THE ENVIRONMENT

Radiation in the Environment

Radiation is a natural part of our environment. When our planet was formed, radiation was present—and radiation surrounds it still. Natural radiation showers down from the distant reaches of the cosmos and continuously radiates from the rocks, soil, and water on the Earth itself.



Source: National Academy of Sciences, 1980; National Council of Radiation Protection and Measurement

During the last century, mankind has discovered radiation, how to use it, and how to control it. As a result, some manmade radiation has been added to the natural amounts present in our environment.

Many materials—both natural and manmade—that we come in contact with in our everyday lives are radioactive. These materials are composed of atoms that are unstable. The unstable atoms release particles or waves as they change into more stable forms. These particles and waves are collectively referred to as *radiation,* and a quantity of the unstable atoms is referred to as *radioactivity*.

Types of Ionizing Radiation

Radiation that has enough energy to disturb the electrical balance in the atoms of substances it passes through is called *ionizing radiation.* There are three basic forms of ionizing radiation.

Alpha

Alpha particles are the largest and slowest moving type of radiation. They are easily stopped by a sheet of paper or the skin. Alpha particles can only move through the air a few inches before being stopped by air molecules. However, alpha radiation is dangerous to sensitive tissue inside the body.

Beta

Beta particles are much smaller and faster moving than alpha particles. Beta particles pass through paper and can travel in the air for about 10 feet. However, they may be stopped by thin shielding such as a sheet of aluminum foil.

Gamma

Gamma radiation is a type of electromagnetic wave that travels at the speed of light. It takes a thick wall of steel, lead, or concrete to stop gamma rays. X rays and cosmic rays are similar to gamma radiation. X rays are produced by manmade devices; cosmic rays reach Earth from outer space.

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Units of Measure

Radiation can be measured in a variety of ways. Typically, units of measure show either the total amount of radioactivity present in a substance, or the level of radiation being given off.

The radioactivity of a substance is measured in terms of the number of transformations (changes into more stable forms) per unit of time. The *curie* is the standard unit for this measurement and is based on the amount of radioactivity contained in 1 gram of radium. Numerically, 1 curie is 37 billion transformations per second. The amounts of radioactivity that people normally work with are in the millicurie (one-thousandth of a curie) or microcurie (one-millionth of a curie) range. Quantities of radioactivity in the environment are in the picocurie, or pCi (one-trillionth of a curie) range.

Levels of radiation are measured in various units. The level of gamma radiation in the air is measured by the *roentgen*. This is a relatively large unit, so measurements are often calculated in milliroentgens. Radiation absorbed by humans is measured in either *rad* or *rem*. The rem is the most descriptive because it measures the ability of the specific type of radiation to do damage to biological tissue. Again, typical measurements will often be in the millirem, or mrem (one-thousandth of a rem) range. On the average, people receive about 180 mrem of radiation a year. Most of this radiation is from natural radiation and medical exposure.

RADIATION IN THE ENVIRONMENT

Cosmic Radiation

Cosmic radiation is high-energy gamma radiation that originates in outer space and filters through our atmosphere.

Sea Level.................. 26 mrem/year
(add one for each additional 100 feet in elevation)
Atlanta, GA (1,050 feet)...... 37 mrem/year
Denver, CO (5,300 feet)...... 79 mrem/year
Minneapolis, MN (815 feet)... 34 mrem/year
Salt Lake City, UT (4,400 feet).. 70 mrem/year
Spokane, WA (1,890 feet)..... 45 mrem/year

Terrestrial Radiation

Terrestrial sources are naturally radioactive elements in the soil and water such as thorium, radium, uranium, and carbon.

United States (average)...... 26 mrem/year
Denver, Colorado........... 90 mrem/year
Nile Delta, Egypt........... 350 mrem/year
Paris, France.............. 350 mrem/year
Coast of Kerala, India....... 400 mrem/year
McAipe, Brazil .... 2,558 mrem/year
Pocos de Caldas, Brazil... 7,000 mrem/year

Buildings

Based on occupancy 75 percent of the time.

Wood House............... 35 mrem/year
Brick House............... 45 mrem/year
Concrete House............ 45 mrem/year
Stone House............... 50 mrem/year

Specific Buildings

U.S. Capitol Building........ 85 mrem/year
Base of Statue of Liberty.... 325 mrem/year
Grand Central Station....... 525 mrem/year
The Vatican............... 800 mrem/year

Radon

Radon levels in buildings vary, depending on geographic location, from 0.1 to 200 pCi/liter.

Typical Radon Level........... 1.5 pCi/liter
Occupational Working Limit... 100.0 pCi/liter

The numbers given here are approximate or represent an average since samples vary.

mrem = millirem

pCi = picocurie

Foods

Food contributes an average of 20 mrem/year, mostly from carbon-14, hydrogen-3, potassium-40, radium-226, and thorium-232.

Beer....................... 390 pCi/liter
Domestic Tap Water........... 20 pCi/liter
Milk...................... 1,400 pCi/liter
Salad Oil.................. 4,900 pCi/liter
Whiskey.................. 1,200 pCi/liter

Brazil Nuts..................... 14 pCi/g
Flour......................... 0.14 pCi/g
Peanuts and Peanut Butter...... 0.12 pCi/g
Tea.......................... 0.40 pCi/g

Medical Treatment

The exposures from medical diagnosis vary widely according to the required procedure, the equipment and film used for x rays, and the skill of the operator.

Chest X Ray.................. 20 mrem
Dental X Ray, Whole Mouth...... 900 mrem

International Nuclear Weapons Test Fallout

Average for a U.S. citizen..... 1 mrem/year

Consumer Goods

Cigarettes (2 packs/day)... 8,000 mrem/year (Polonium-210)
Color Television............. 1 mrem/year
Gas Lantern Mantle......... 3 mrem/hour (thorium-232)
Highways.................. 4 mrem/year
Jet Airplane Travel/1,500 miles..... 1 mrem (cosmic)
Natural Gas Stove.......... 6-9 mrem/year (radon-222)
Phosphate Fertilizers*........ 4 mrem/year
Porcelain Dentures........ 1,500 mrem/year (uranium salts)
Radioluminescent Clock....... 9 mrem/year (radium-226)
Smoke Detector............ 0.2 mrem/year (americium-241)

*** Natural Radioactivity in Florida Phosphate Fertilizers (in pCi/gram)**

Material	Ra-226	U-238	Th-230	Th-232
Normal Superphosphate	21.3	20.1	18.9	0.6
Concentrated Superphosphate	21.0	58.0	48.0	1.3
Gypsum	33.0	6.0	13.0	0.3

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APPENDIX E

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ecommissioning
-23, Room D-428, HQ, GTN

045483

Bechtel National, Inc.

Interoffice Memorandum

To	IOM to File	File No.	7430/138
Subject	Publication of the Maywood Interim Storage Site Annual Site Environmental Report, Calendar Year 1986 Reference: CCN 044840	Date	June 11, 1987
		From	T. M. Dravecky
		Of	FUSRAP Project 14501
Copies to	W.C. Borden (w/a) C.M. Davis (w/a) R.W. Evers (w/a) G.K. Hovey (w/o) R.M. Howard (w/a) M.G. Jones (w/a) J.R. Kannard (w/a) C.P. Leichtweis (w/a) J.F. Schlatter (w/a)	At	Oak Ridge Ext. 6-4274

The published copy of the subject report is attached for your use. Acting for DOE-HQ, Jerry Wing notified BNI verbally on May 27 to proceed with publication of the report. The published report incorporates comments received from DOE-HQ and addressed in the referenced letter.

Attachment: As stated

Tom Dravecky

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