NRC FORM 464 Part I (6-1998) U.S. NUCLEAR REGULATORY COMMISSION

RESPONSE TO FREEDOM OF INFORMATION ACT (FOIA) / PRIVACY ACT (PA) REQUEST

FOIA/PA	RESPONSE NUMBER
2000-0101	2

RESPONSE TYPE: FINAL √ PARTIAL

REQUESTER: Denise Wilt

DATE: JUL 11 2000

PART I. -- INFORMATION RELEASED

No additional agency records subject to the request have been located.

Requested records are available through another public distribution program. See Comments section.

APPENDICES — Agency records subject to the request that are identified in the listed appendices are already available for public inspection and copying at the NRC Public Document Room.

√ APPENDICES C — Agency records subject to the request that are identified in the listed appendices are being made available for public inspection and copying at the NRC Public Document Room.

Enclosed is information on how you may obtain access to and the charges for copying records located at the NRC Public Document Room, 2120 L Street, NW, Washington, DC.

APPENDICES — Agency records subject to the request are enclosed.

Records subject to the request that contain information originated by or of interest to another Federal agency have been referred to that agency (see comments section) for a disclosure determination and direct response to you.

√ We are continuing to process your request.

See Comments.

PART I.A -- FEES

AMOUNT *

$

* See comments for details

You will be billed by NRC for the amount listed.

You will receive a refund for the amount listed.

None. Minimum fee threshold not met.

Fees waived.

PART I.B -- INFORMATION NOT LOCATED OR WITHHELD FROM DISCLOSURE

No agency records subject to the request have been located.

Certain information in the requested records is being withheld from disclosure pursuant to the exemptions described in and for the reasons stated in Part II.

This determination may be appealed within 30 days by writing to the FOIA/PA Officer, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001. Clearly state on the envelope and in the letter that it is a "FOIA/PA Appeal."

PART I.C COMMENTS (Use attached Comments continuation page if required)

SIGNATURE - FREEDOM OF INFORMATION ACT AND PRIVACY ACT OFFICER

Carol Ann Reed Carol Ann Reed

APPENDIX C
RECORDS BEING RELEASED IN THEIR ENTIRETY

NO.	DATE	DESCRIPTION/(PAGE COUNT)
1.	4/8/82	Memorandum for R Haynes from J Joyner, Subject: Notification of Proposed Radiation Surveys Along Sheffield Brook and W. R. Grace and Company, Wayne, NJ (1 page)
2.	7/82	Radiological Survey of Sheffield Brook Wayne, New Jersey, Draft (70 pages)
3.	7/82	Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use of Termination of Licenses for Byproduct, Source, or Special Nuclear Material (6 pages)
4.	10/27/82	Letter to Willowbrook Nursing Home from J Kinneman (1 page)
5.	10/27/82	Letter to Township of Wayne from J Kinneman (1 page)
6.	10/28/82	Letter to Township of Wayne from J Kinneman (6 pages)
7.	10/29/82	Letter to D Casey from J Kinneman (1 page)
8.	10/29/82	Letter to M Resnikoff from J Kinneman (1 page)
9.	10/29/82	Letter to J O'Brien from J Kinneman (1 page)
10.	10/29/82	Letter to D Marco from J Kinneman (1 page)
11.	11/12/82	Letter to W Mott from R Page (1 page0
12.	11/12/82	Note to J Kinneman from J Eng with enclosures (45 pages)
13.	11/26/82	Letter to N Brady from W Dircks (2 pages)
14.	12/6/82	Letter to C Collica from J Glenn (1 page)
15.	12/10/82	Memorandum for S Showman from E Triner, Subject: Background Information for Commissioner Gilinsky's trip to Oyster Creek (8 pages)
16.	Undated	Office of the Secretary of Transportation, Special Permit No. 5330 with enclosures (131 pages)

17. 4/8/70 Application for Amendment to Special Nuclear Materials License SNM-840 for Nuclear Chemistry Facility (122 pages)

~~ENCLOSURES TRANSMITTED HEREWITH~~
~~CONTAIN 10 CFR 2.790 INFORMATION~~

Docket No. 40-00086 APR 8 1982 License No. STA-422

MEMORANDUM FOR: Ronald C. Haynes, Regional Administrator

FROM: James H. Joyner, Chief, Technical Programs Branch

SUBJECT: NOTIFICATION OF PROPOSED RADIATION SURVEYS ALONG SHEFFIELD BROOK AND W. R. GRACE AND COMPANY, WAYNE, NEW JERSEY

I recommend that we send the enclosed letter to the individuals who own property along the Sheffield Brook, to notify them of our proposed surveys and obtain their permission to perform surveys on their property.

James H. Joyner

James H. Joyner, Chief
Technical Programs Branch

Enclosure: As Stated

cc w/encl:
Public Document Room (PDR)
Nuclear Safety Information Center (NSIC)

bcc w/encl:
Region I Docket Room (with concurrences
W. Crow, NMSS
K. Abraham, RI

Folder 5
#3

ITEM # 563

ENCLOSURES TRANSMITTED HEREWITH
CONTAIN 10 CFR 2.790 INFORMATION

OFFICE ▶	R1:DETP	R1:DETP	R1:DETP	R1:DETP	R1:PAO	R1:DRA	R1:RA
SURNAME ▶	Campbell/wb	Kinneman	Joyner	T. Martin	Abraham	Allan	Haynes
DATE ▶	4/7/82	4/7/82	4/7/82	4/7/82	4/7/82	4/7/82	4/12/82

NRC FORM 318 (10-80) NRCM 0240

OFFICIAL RECORD COPY

Prepared by
Oak Ridge Associated
Universities

Prepared for
Division of Fuel
Cycle and
Material Safety

U.S. Nuclear
Regulatory
Commission

DRAFT

RADIOLOGICAL SURVEY OF SHEFFIELD BROOK WAYNE, NEW JERSEY

P. W. FRAME

Radiological Site Assessment Program
Manpower Education, Research, and Training Division

DRAFT

PRELIMINARY REPORT

July 1982

THIS IS A DRAFT OF A PRELIMINARY REPORT BY OAK RIDGE ASSOCIATED UNIVERSITIES ON THE FIRST PORTION OF ITS RADIOLOGICAL SURVEYS IN THE WAYNE, NEW JERSEY AREA. IT WAS SUBMITTED TO THE NUCLEAR REGULATORY COMMISSION STAFF FOR REVIEW AND COMMENT. IT IS EXPECTED THAT THERE WILL BE SOME CHANGES PRIOR TO PUBLICATION OF THE FINAL VERSION OF THIS REPORT.

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NOTICE

Analyses of samples and interpretation of data from this survey have not been completed. However, this preliminary report of survey findings has been prepared because of current interest in the radiological conditions of Sheffield Brook and the adjacent areas. Additional results will be incorporated into a final report as they become available. It is not anticipated that these additional results will substantially alter the evaluation of radiological conditions as presented here.

RADIOLOGICAL SURVEY
OF
SHEFFIELD BROOK
Wayne, New Jersey

Prepared for

Division of Fuel Cycle and Material Safety
U.S. Nuclear Regulatory Commission

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PRELIMINARY REPORT

July 1982

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RADIOLOGICAL SURVEY
OF
SHEFFIELD BROOK
Wayne, New Jersey

INTRODUCTION

In 1948, Rare Earths, Inc., of Wayne, New Jersey, began processing monazite sand to extract thorium and rare earths. The facility was aquired by the Davison Chemical Division of W.R. Grace in 1957; thorium ore processing activities continued until July 1967. The plant was permanently closed in April 1971. In 1974, Applied Health Physics Inc. decontaminated the site and the property was released by the Nuclear Regulatory Commission (NRC) for unrestricted use in January 1975. The buildings are currently occupied by Electro-Nucleonics Inc., under a long-term lease.

Solid wastes containing low (less than approximately 5%) concentrations of thorium were disposed of by on-site shallow land burial, in accordance with the regulations in effect at that time.[1] Although detailed records of quantities and compositions of waste are not available, W.R. Grace has estimated that approximately 9×10^4 kg of thorium-containing residues and slightly contaminated debris have been buried on the property. Potentially contaminated liquid wastes were monitored to assure that radionuclide concentrations were within the regulatory limits for release before they were discharged into a small drainage ditch that flows through the site.

In January 1981, as part of a review of formerly licensed facilities, the Nuclear Regulatory Commission measured direct radiation levels and radionuclide concentrations in soil on the W.R. Grace property. The results of these measurements indicated that exposure rates and soil contamination levels exceeded the present criteria for unrestricted use of the site. At the request of the State of New Jersey and the U.S. Environmental Protection Agency, an aerial radiological survey of the site and adjacent areas was conducted by EG&G in May 1981. This survey

identified elevated radiation levels, both on the W.R. Grace site and west of the site, along Sheffield Brook.[2] The NRC performed follow-up measurements along the brook in November 1981 and noted radiation levels up to 200 μrem/h and elevated concentrations of thorium in bank soil and stream sediment.[3]

At the request of the NRC Division of Fuel Cycle and Material Safety, a radiological survey of the Sheffield Brook area was conducted April 26-May 1, 1982 by the Radiological Site Assessement Program of Oak Ridge Associated Universities (ORAU), Oak Ridge, Tennessee. This report presents the preliminary findings of that survey.

SITE DESCRIPTION

The W.R. Grace property is located at 868 Black Oak Ridge Road about 2 km east of Pompton Plains and 3 km north of Wayne, in the northeast corner of New Jersey (Figure 1). Pompton Plains is situated in Passaic County on the west bank of the Pompton River while the W.R. Grace property and Wayne are located in Morris County, east of the river. The site occupies approximately 2.6 hectares most of which are surrounded by a chain link security fence. Two office buildings and a warehouse are the main structures on the site. The eastern and northern sections of the site are wooded with heavy brush and weeds along a small drainage stream. The land generally slopes toward the west and northwest.

The small drainage stream enters the site near the southeast corner of the site. This stream flows north; then turns west. Prior to leaving the property, the stream enters a conduit. This conduit carries the water into a mixing tank where it is combined with the overflow from an on-site artesian well. The water then flows under the facility's north parking lot to Black Oak Ridge Road where it is joined by two storm sewer lines. It resurfaces as Sheffield Brook after running west beneath Pompton Plains Cross Road for approximately 150 m.

From this point, it flows southwest for approximately 200 m in a straight channel or ditch. Dense stands of brush, 5 m deep on both sides of the bank, make access to the stream difficult. Beyond the stands of brush the land becomes open field containing scattered trees and tall grass. Approximately midway along this straight channel, the brook is joined by a small stream originating southwest of the W.R. Grace property from the combined discharges of two storm sewer systems. Small mounds of soil, apparently resulting from periodic dredging of the stream bed, are scattered along the banks this section of the brook.

At the end of the straight channel, Sheffield Brook turns west and continues in that direction until it passes under Farmingdale Road. The bank on the south side of the brook in this area rises sharply for about 5 m and is covered by brush and trees. The land north of the brook consists mostly of low soggy field subject to periodic overflow. West of Farmingdale Road the brook turns south and flows through a public park for approximately 150 m until it empties into the Pompton River. The eastern edge of the brook is overgrown with brush and trees, while the western bank is comparatively accessible from the park property. Figure 2 shows the location of Sheffield Brook and associated drainage streams.

SURVEY PROCEDURES

Objectives

The objectives of this survey were to determine:

1. direct radiation levels along Sheffield Brook, and

2. concentrations of radionuclides in soil, sediment, water, and vegetation from the vicinity of the brook.

Plan

The survey plan included the following activities:

1. Monitoring of gamma radiation levels at the ground surface along the banks of Sheffield Brook and associated streams.
2. Exposure rate measurements at 1 m above the surface for selected points along the brook.
3. Dose rate measurements at 1 cm above the surface for each of the locations at which gamma measurements at 1 m were taken.
4. Collection of surface soil and subsurface soil along Sheffield Brook and associated streams.
5. Collection of sediment samples along Sheffield Brook and its associated streams as well as five locations in the storm sewer system flowing into Sheffield Brook.
6. Collection of water samples from streams, storm sewers and local wells.
7. Collection of vegetation samples along the brook.
8. Collection of samples and measurements at off-site locations to provide baseline data for comparison.

ent of Direct Radiation

NaI(Tl) gamma scintillation ratemeters, walkover surface scans med to approximately 10 m on either side of Sheffield Brook from ins Cross Road to the Pompton River. General radiation levels s of significantly elevated levels were noted.

The brook was divided into 50 m intervals. At each of these intervals, exposure rates at 1 m above the surface were systematically measured at the edge of the brook and at 5 and 10 m from the edge. Measurements were also performed where the brook entered or exited conduits. These measurements were performed with NaI(Tl) scintillation ratemeters field-calibrated using a pressurized ionization chamber.

Beta-gamma dose rates at 1 cm above the surface were measured at each location where the 1 m gamma exposure rates were measured. These measurements were performed using G-M detectors and scalers. To evaluate contributions from both penetrating and non-pentrating radiations the measurements were made with the probes in both the open- and closed-shield configurations.

Three 50 m intervals were established along the small drainage stream which joins Sheffield Brook about 100 m southeast of Pompton Plains Cross Road. Surface gamma levels were monitored by a walkover scan. Exposure rate and dose rate measurements at 1 m and 1 cm, respectively, above the surface were performed at 50 m intervals along the stream bank.

A walkover surface gamma survey was performed along three small drainage streams that join Sheffield Brook west of Farmingdale Road.

Soil Sampling

Systematic surface (0-5 cm) soil samples were collected from both banks of Sheffield Brook at 50 m intervals and at least one additional surface sample was collected from each bank. These samples alternated between 5 and 10 m from the stream edge. Surface samples were also collected at 50 m intervals along the edge of the stream flowing into Sheffield Brook near Pompton Plain Cross Road, one of the drainage streams west of Farmingdale Road, and at several additional locations along the brook.

Systematic subsurface (30 cm, 60 cm, and 90 cm) samples were collected from 14 of the locations where systematic surface samples were obtained, at 100 m intervals and on alternating sides of the brook. The majority of these sampling locations were 5 or 10 m from the brook edge, however, several were considerably further (up to approximately 100 m) from the brook.

Biased surface and subsurface soil samples were collected from 30 locations indicated by the walkover survey to have elevated radiation levels.

Surface soil samples were collected using a garden trowel from which residual soil was cleaned between samples. Subsurface samples were collected from 15 cm diameter holes drilled with a portable motorized auger. Soil sampling locations are indicated in Figures 3, 4, 5.

Water Sampling

Surface water samples were collected at four locations along Sheffield Brook; the discharge from the W.R. Grace site, 100 m and 500 m upstream and downstream of Sheffield Brook on the Pompton River; and three locations on a small farm on the north side of Pompton Plains Cross Road. Water samples were also collected from five locations in the storm drain system feeding Sheffield Brook. Samples of well water were collected from the farm north of Pompton Plains Cross Road and from five local residents. Locations of these water samples are indicated on Figures 5 and 8.

Vegetation Sampling

Vegetation samples were collected at five locations in the vicinity of Sheffield Brook (see Figure 5). The samples consisted of grass, weeds, and other plants characteristic of the selected location.

Baseline and Background Measurements

Five soil samples, two water samples, and one vegetation sample were collected at locations approximately 0.25 to 10 m from the W.R. Grace and Sheffield Brook sites. Measurements of direct background radiation levels were performed at the locations of the soil samples. Figure 9 indicates the locations of these baseline samples and background measurements.

Equipment and Analytical Procedures

Appendix A contains a list of the major equipment and instrumentation used for this survey. Analytical procedures are described in detail in Appendix B.

RESULTS

Background Radiation and Baseline Concentrations

Background exposure rates in the Wayne-Pompton Plains, New Jersey, area ranged from 6 to 12 μR/h; surface beta-gamma dose rates ranged from 16 to 38 μrad/h.

Baseline radionuclide concentrations in soil, water, and vegetation are presented in Table 1. The concentrations in these samples are typical of those normally encountered in such media.

Direct Radiation Levels

Surface Survey

Surface exposure rates measured during the walkover scan ranged from 6 μR/h (background) to 423 μR/h. The highest levels were noted in two general areas. The first was a strip, approximately 5 m wide and 200 m

long on either side of Sheffield Brook, from Pompton Plains Cross Road to the end of the straight channel. Along this portion of the brook, elevated radiation levels were often associated with small piles of earth believed to be the result of dredging the stream. The two highest levels noted in this region, 423 μR/h and 365 μR/h, were associated with such piles. The other area was on the north side of Sheffield Brook, approximately 100 m east of Farmingdale Road. Exposure rates up to 423 μR/h were measured in the latter region.

The surface radiation levels along the brook were considerably lower west of Farmingdale Road. Only one sizable area along this section of the brook had elevated exposure levels. This was the area just south of the park access road and west of the footpath. Exposure rates in the area, up to 269 μR/h, resulted from a localized area of contamination. The slope of the land at this location is such that contamination here is not easily attributable to deposition from the brook.

Of the small streams feeding Sheffield Brook, only the one north of the brook, between Farmingdale Road and the footpath, showed notably elevated exposure levels. The highest level along this stream, 115 μR/h, was noted in a small area approximately 5 m north of the brook.

Figures 10 and 11 present the results of the surface scan in graphic form.

Exposure Rates at 1 Meter

Exposure rates measured systematically at 1 m above the ground at the edge of the brook ranged from 8 μR/h to 173 μR/h, averaging 51 μR/h. At 5 m from the brook the exposure rates ranged from 9 μR/h to 269 μR/h, averaging 58 μR/h; at 10 m from the brook the range was from 8 μR/h to 250 μR/h, with an average value of 38 μR/h. The pattern of these 1 m exposure rates was very similar to the pattern of the surface exposure levels noted by the walkover scan. These 1 m exposure rates are presented on Figures 12 and 13.

Beta-Gamma Surface Dose Rates

The surface beta-gamma dose rates along Sheffield Brook are presented in Figures 14 and 15, and ranged between 16 to 948 μrad/h. The levels showed a close correlation with the exposure rates at 1 m measured at the same locations. The absence of any significant difference between the open and closed-shield configurations indicated a negligible beta and low energy x-ray contribution.

Radionuclide Concentrations in Soil Samples

Radionuclide concentrations in surface and subsurface soils are presented in Tables 2 and 3. Elevated surface levels of Ra-228 and Th-228, representatives of natural thorium, are present over the entire length of Sheffield Brook and along one small associated drainage stream, adjacent to the township park. As with the direct radiation levels, elevated soil concentrations occurred more frequently along the portion of Sheffield Brook east of Farmingdale Road. The maximum Ra-228 and Th-228 concentrations in surface soil were 734 and 722 pCi/g, respectively, at sample location 105. The general pattern is a decrease in radionuclide concentration with distance from the W.R. Grace property and from the edge of the brook. However, there are exceptions to this pattern e.g. samples 131 and 135 collected comparatively close to the Pompton River both of which have Ra-228 and Th-228 concentrations above 100 pCi/g. Samples obtained along the storm drainage stream that joins Sheffield Brook south of Pompton Plains Cross Road and along the Pompton River were not significantly different from baseline levels.

Subsurface soil concentrations generally decreased with depth, although there were several locations where the concentrations were slightly higher at 30 or 60 cm deep. Samples 112 and 113 from a depth of 90 cm contained Ra-228 and Th-228 concentrations exceeding 100 pCi/g. Concentrations in other samples from this depth were considerably lower, most being in the range of baseline levels.

Elevated concentrations of Ra-226 were also measured in samples containing high concentrations of thorium. The maximum Ra-226 level,

46.8 pCi/g, was found in sample 105. Ra-226 concentrations were generally 5-10% of the thorium levels in the elevated soil samples.

There was good correlation between the results of the direct radiation surveys and the soil sample results. Locations of soil samples which exceed 5 pCi/g of Ra-228 (representative of the Th-232 level) are indicated on Figures 16 and 17.

Radionuclide Concentrations in Sediment Samples

Radionuclide concentrations in sediment samples are presented in Table 4. Concentrations in these samples follow the general pattern of the bank soil samples, being higher along that portion of the brook between Pompton Plains Cross Road and Farmingdale Road. The maximum concentrations of Ra-228 and Th-228 (61.0 and 53.9 pCi/g respectively) were measured at sample location 16. At locations 8 and 9, where the small stream flows into Sheffield Brook, the radionuclide concentrations show a dramatic decrease. Physical or chemical conditions may be inhibiting the deposition or enhancing the clearance of radionuclides in the sediment at that location.

Levels in sediment from the small stream entering Sheffield Brook south of Pompton Plains Cross Road were in the range of baseline soil samples. Levels in samples collected from the Pompton River upstream of Sheffield Brook were also in the range of baseline soil. Pompton River sediment samples downstream of the brook were slightly higher than the stream samples, but they also were within the baseline range. No consistent pattern in the distribution of elevated sediment levels was identified. However, west of Farmingdale Road the maximum thorium concentrations were noted at locations 24 and 31, which are both areas where the brook flow suddenly changes due to bends or constrictions.

Radium 226 concentrations in sediment did not exceed 5 pCi/g. Where elevated levels were noted they were generally less than 10% of the thorium concentrations.

Water Samples

Gross alpha levels measured in the water samples are presented in Table 5. These levels ranged from <0.7 pCi/l to 39 pCi/l. Gross alpha concentrations exceeding the 15 pCi/l guideline[4] for drinking water, established by the Environmental Protection Agency (EPA), were noted in three samples. Two of these (samples 8 and 9 -- 29 and 19 pCi/l respectively) were collected from the storm sewer system close to the W.R. Grace Property. Sample 6, containing 39 pCi/l, was collected from the Pompton River approximately 100 m downstream from its confluence with Sheffield Brook. A duplicate sample is being collected from the latter location for analysis since this level is highly inconsistent with the others in Sheffield Brook and Pompton River.

Additional analyses for specific radionuclides in these water samples are being performed.

Vegetation Samples

Radionuclide concentrations in the vegetation samples are presented in Table 6. Levels in sample 2 may be considered typical of those normally encountered in vegetation. Elevated concentrations of thorium were noted in all other samples, the highest levels being in samples 3 and 4 from areas having elevated exposure rates and high concentrations of radionuclides in the soil.

Additional radionuclide analyses are being performed on these samples.

SUMMARY

At the request of the Nuclear Regulatory Commission, the ORAU Radiological Site Assessment Program conducted a radiological survey of Sheffield Brook and adjacent properties in Wayne, New Jersey. The findings

of this survey indicate the presence of thorium contaminated soil and sediment along this brook. The thorium contamination apparently originated on the W.R. Grace property located near the intersection of Black Oak Ridge Road and Pompton Plains Cross Road. Thorium bearing ores were processed at this site from 1948 to 1971. Some wastes from these operations still remain on the property. It is believed that small quantities of thorium have entered the brook via the storm drainage and waste treatment discharges over an extended time period to be deposited along the streambed and banks. Periodic dredging along the eastern portion of the brook has deposited additional thorium contaminated sediments on the bank.

Direct radiation levels and radionuclide concentrations in the soil and sediment at many locations along Sheffield Brook exceed the guidelines proposed by the Nuclear Regulatory Commission for unrestricted land use. These guidelines, summarized in Appendix C, recommend maximum exposure rates of 10 μR/h above background and average natural thorium concentrations, i.e. Th-232 plus Th-228 in equilibrium with daughter products, of 10 pCi/g. It is estimated that 5000-10,000 cubic meters of soil must be removed from along Sheffield Brook to satisfy those guidelines.

The survey findings also show that the thorium contamination is generally limited to a narrow strip, approximately 10 m maximum on either side of the brook and that the contamination is primarily - although not completely - in the surface soil. Low concentrations noted in the surface streams and well water from this area indicate low leachability of the radionuclides.

While Ra-226 was also detected in elevated concentrations the levels are considerably less (5-10%) than the thorium concentrations. Since the recommended soil concentration guidelines for Th-232, Th-228, and Ra-226 are the same, thorium is the major radioactive material of concern on this site.

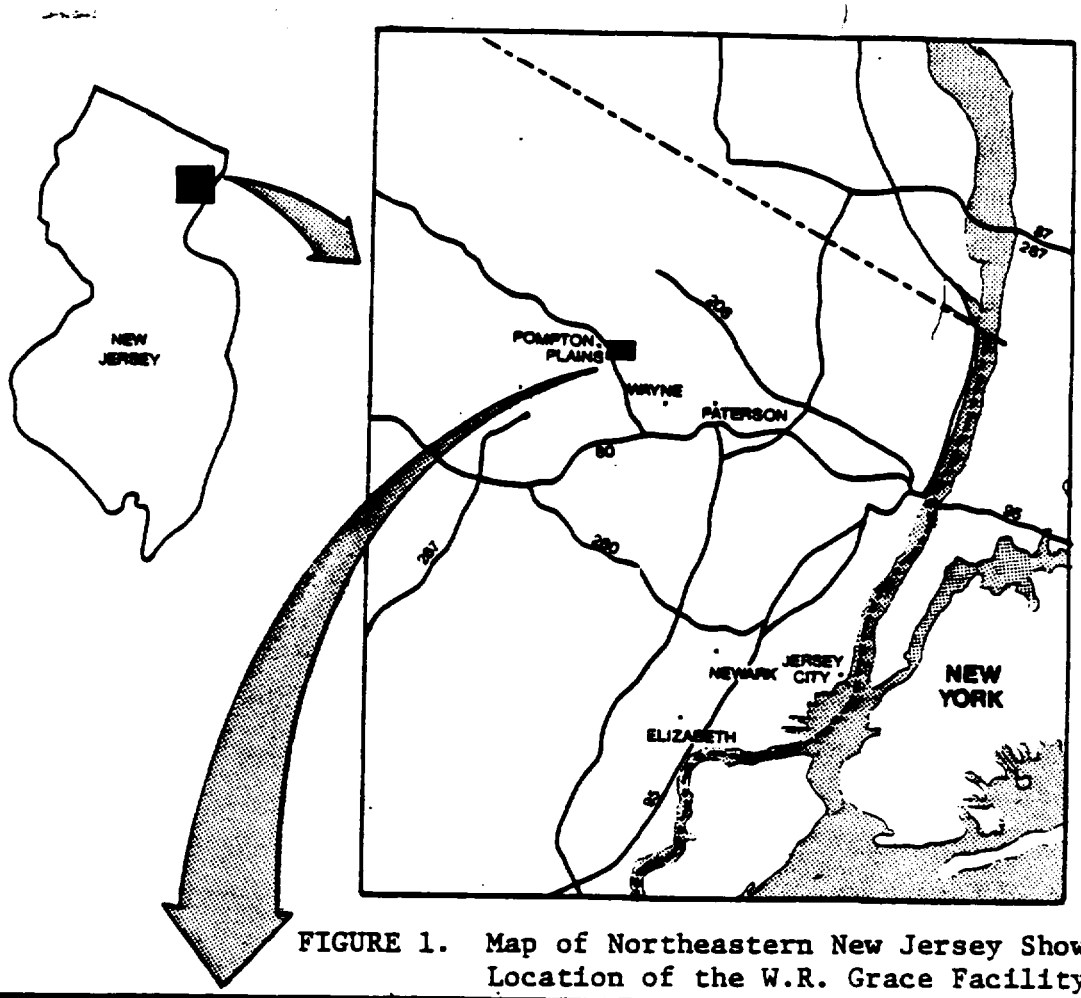

FIGURE 1. Map of Northeastern New Jersey Showing the Location of the W.R. Grace Facility.

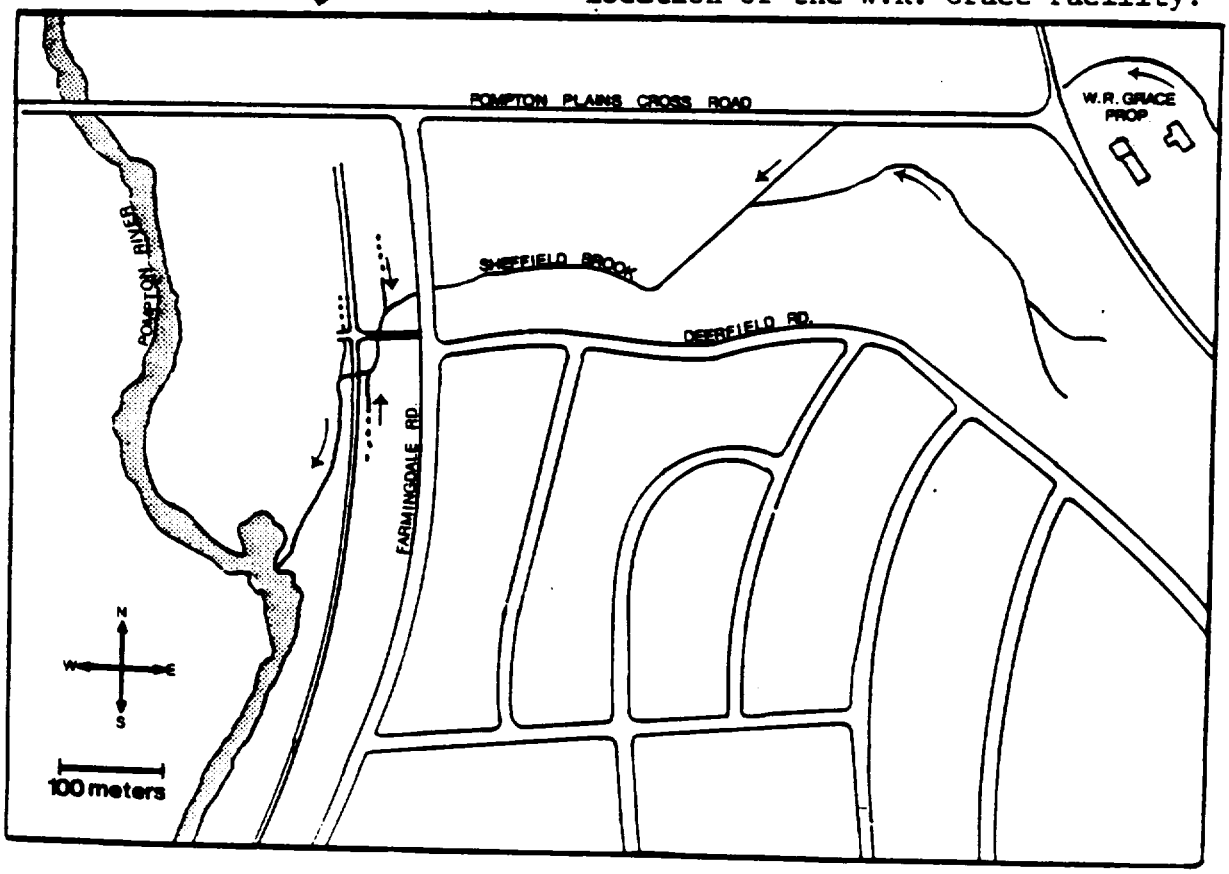

FIGURE 2. Portion of Wayne, New Jersey, Indicating the Locations of the W.R. Grace Property, Sheffield Brook and Associated Streams.

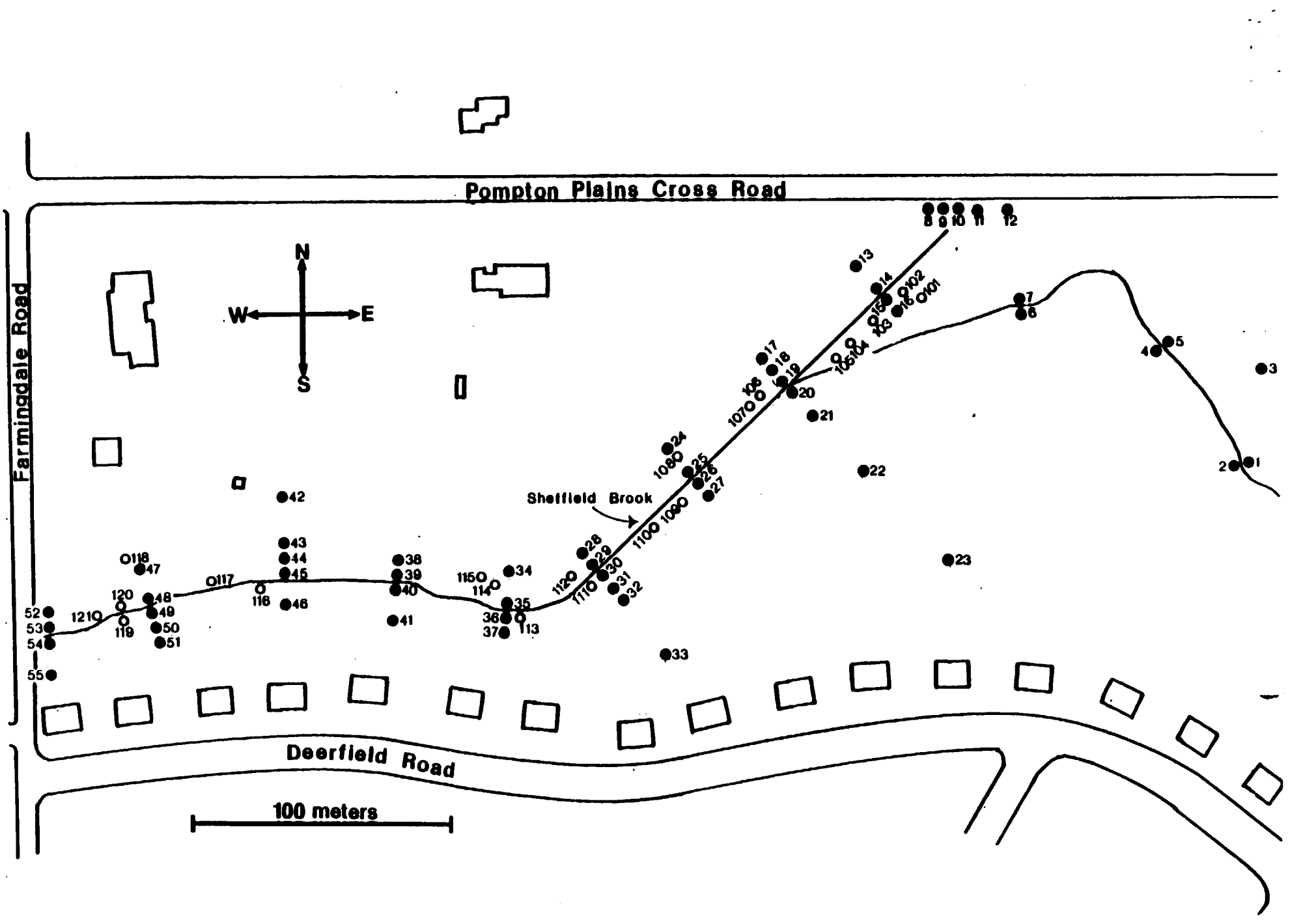

FIGURE 3. Map of Sheffield Brook, East of Farmingdale Road, Indicating Locations of Soil Samples.

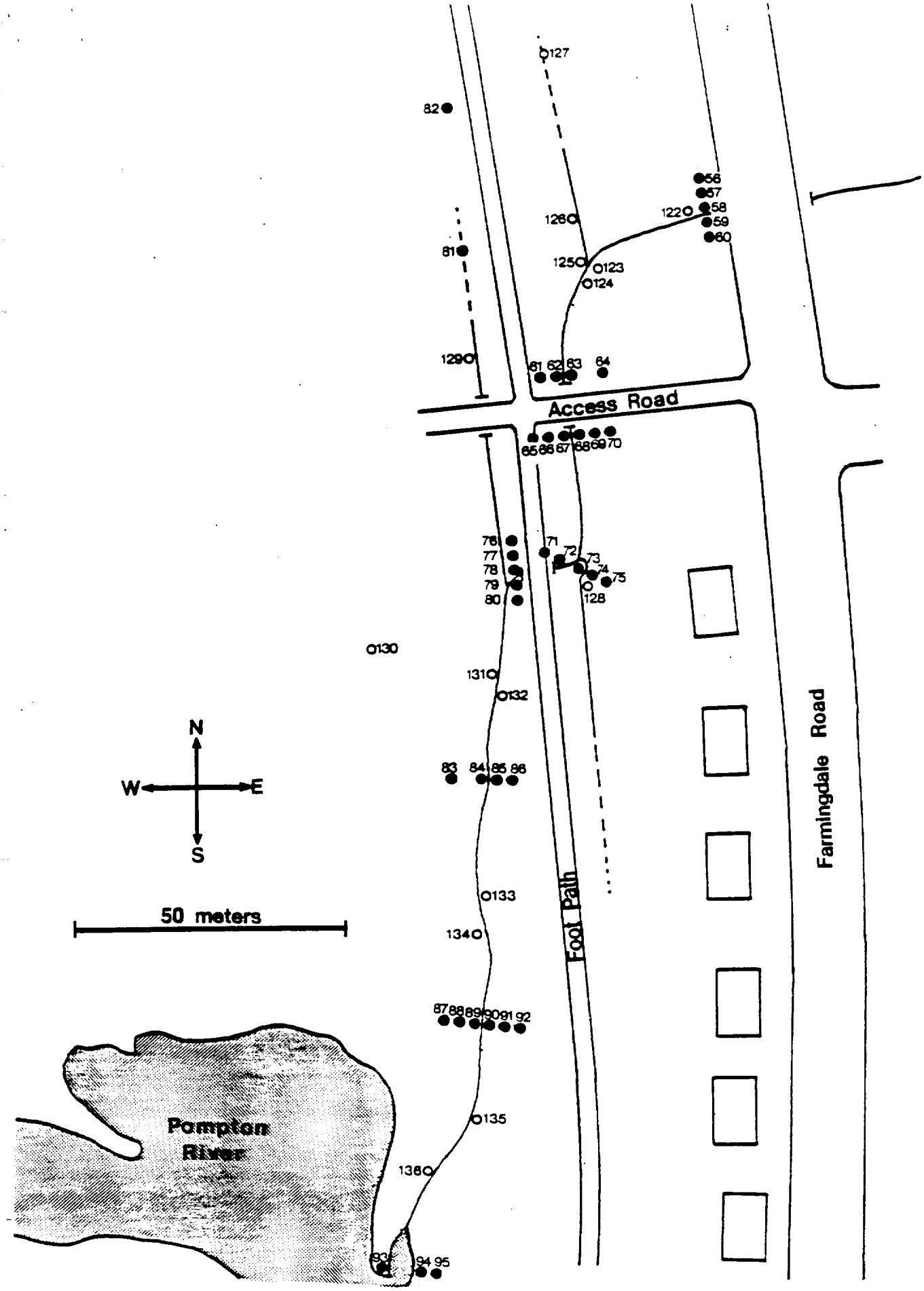

FIGURE 4. Map of Sheffield Brook, West of Farmingdale Road, Indicating Locations of Soil Samples.

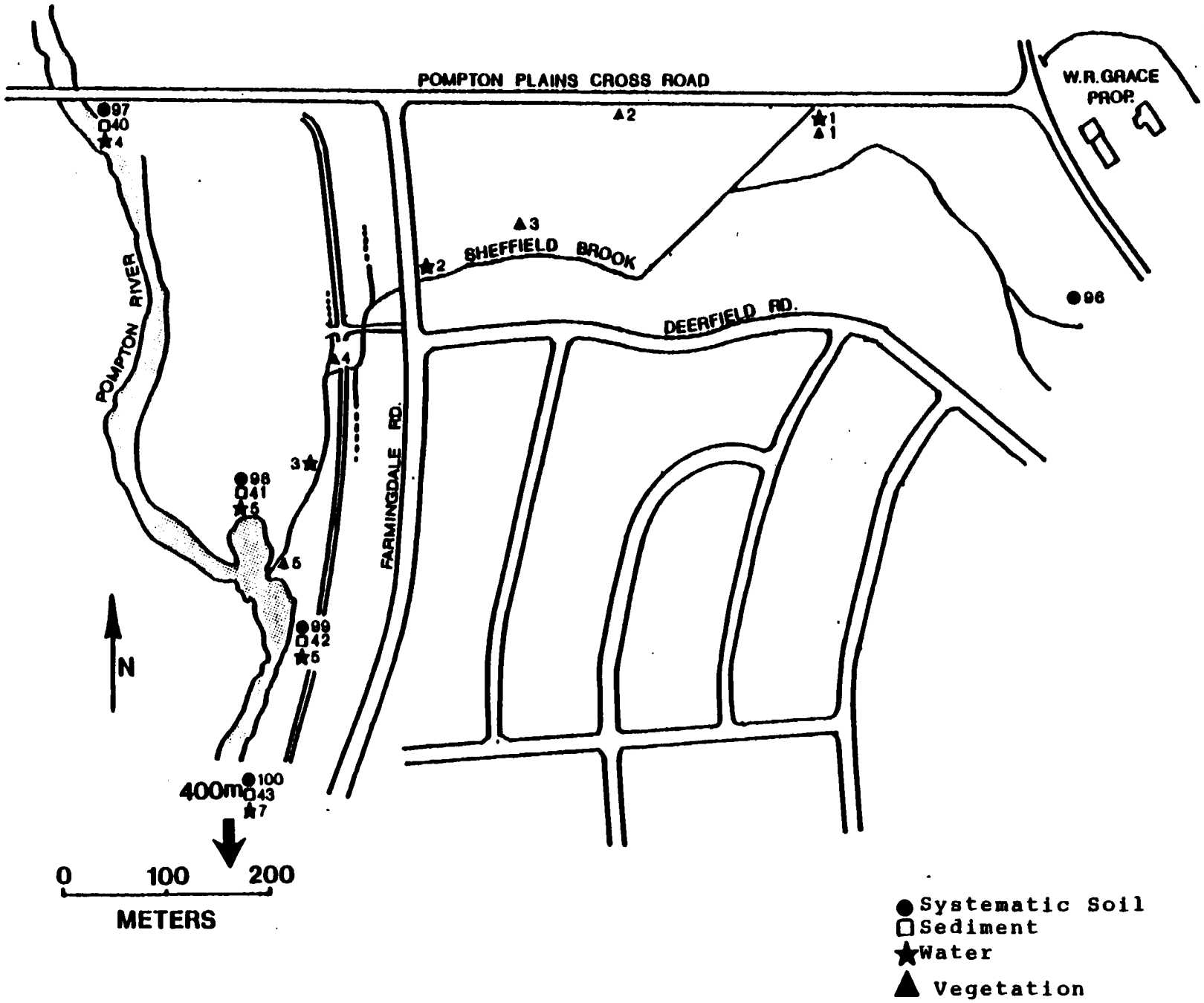

FIGURE 5. Map of Sheffield Brook and Vicinity Indicating Locations of

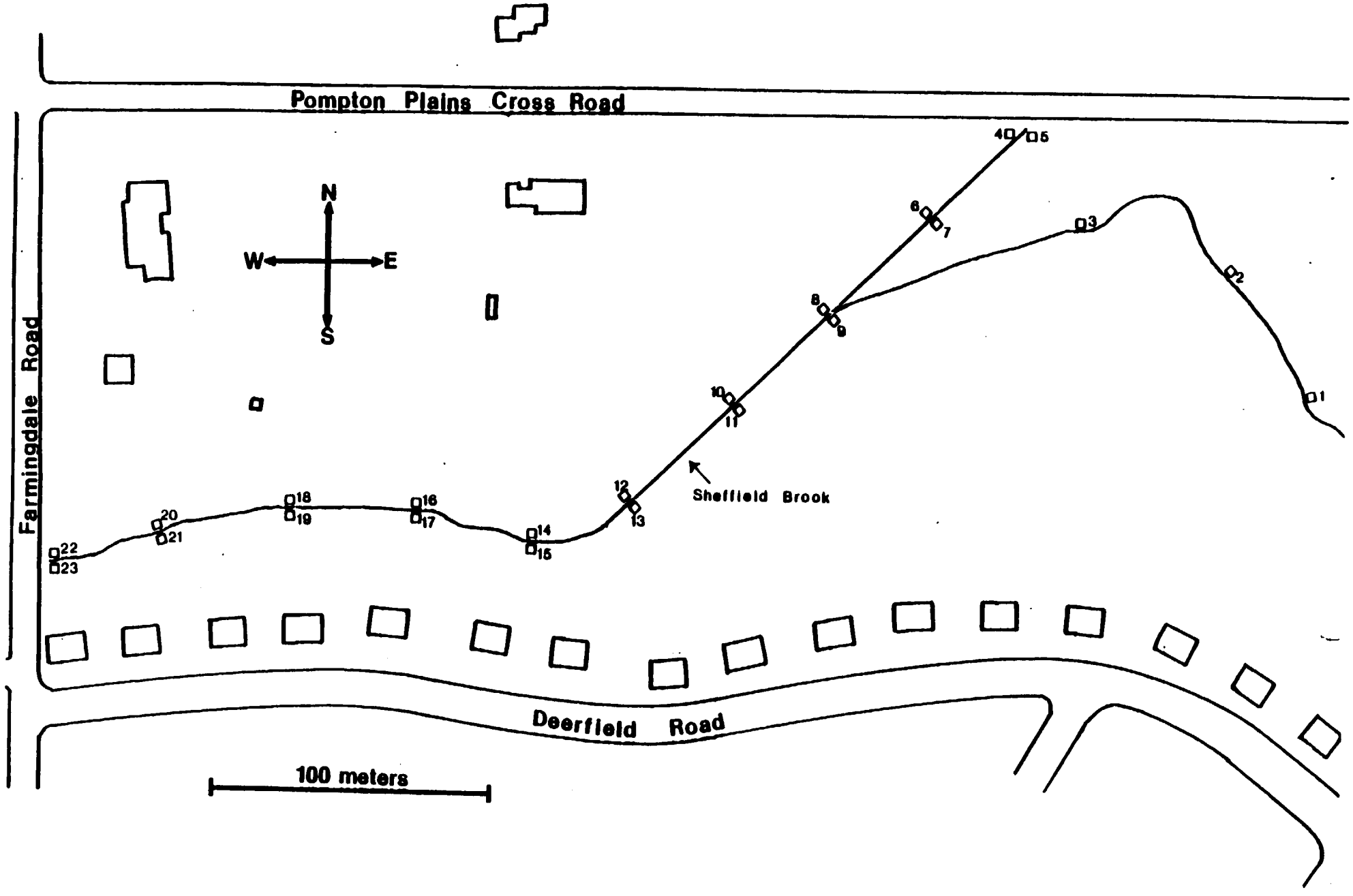

FIGURE 6. Map of Sheffield Brook, East of Farmingdale Road, Indicating Locations of Sediment Samples.

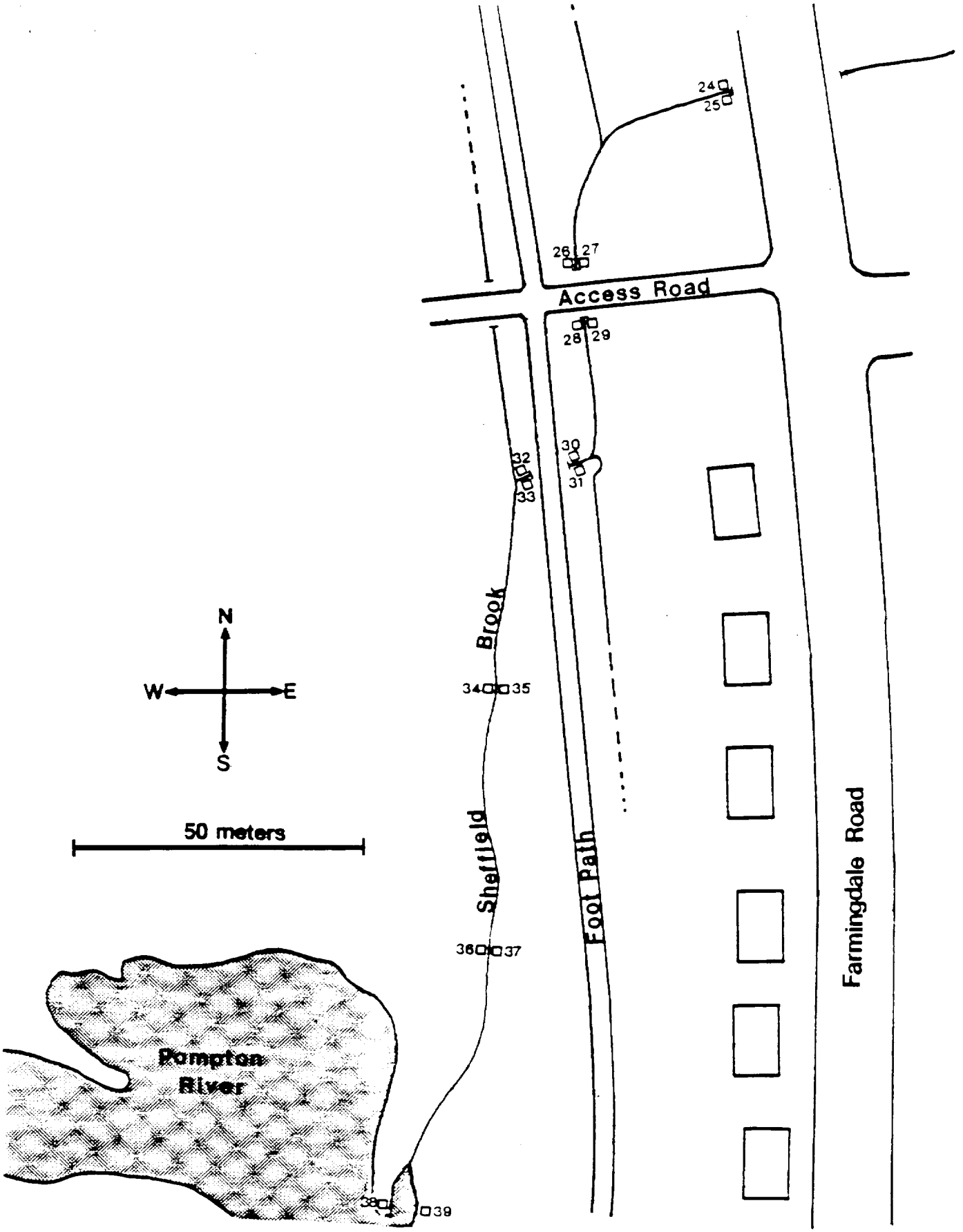

FIGURE 7. Map of Sheffield Brook, West of Farmingdale Road, Indicating Locations of Sediment Samples.

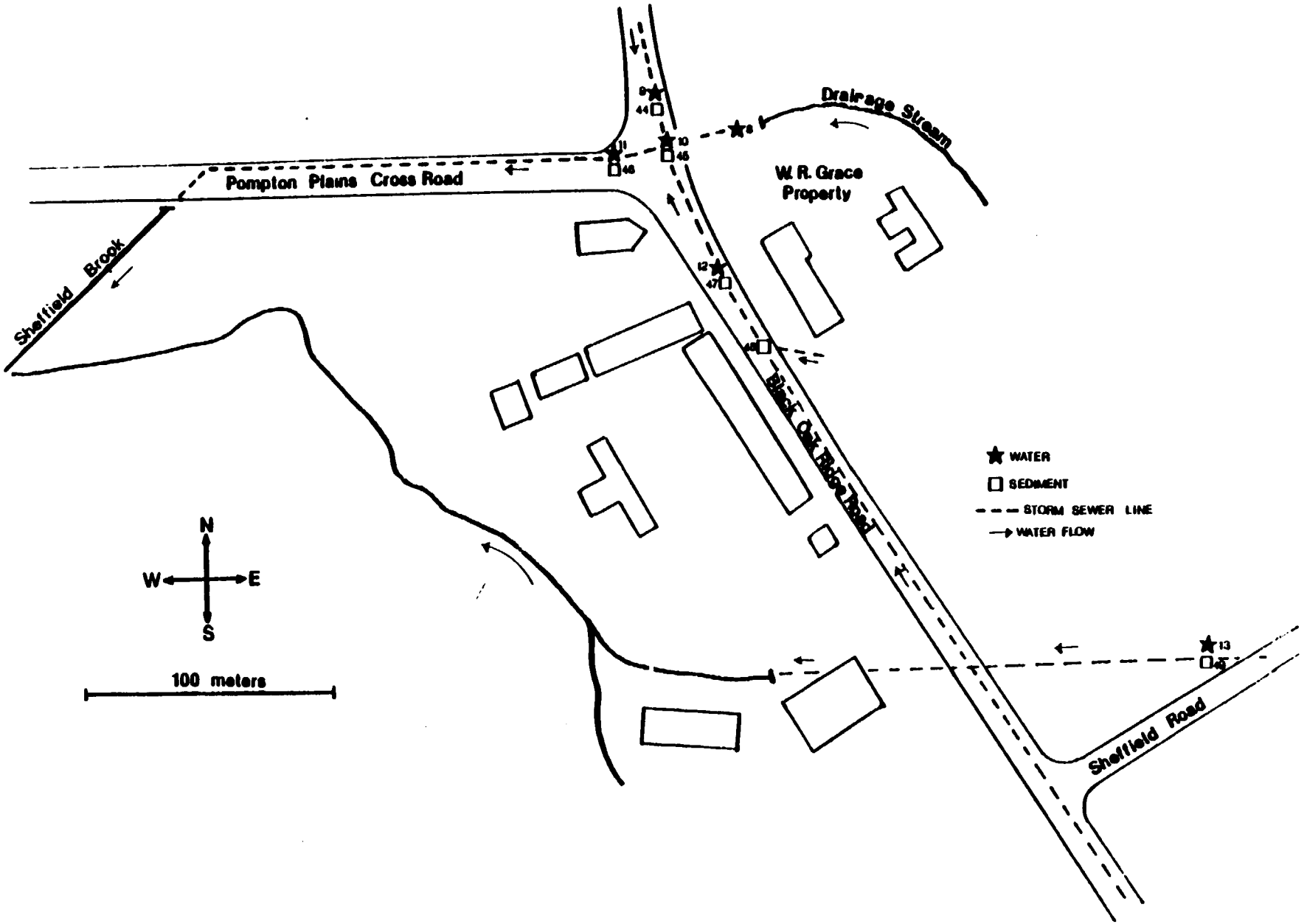

FIGURE 8. Plan View of Storm Sewer System Feeding Sheffield Brook, Indicating Locations of Sediment and Water Samples.

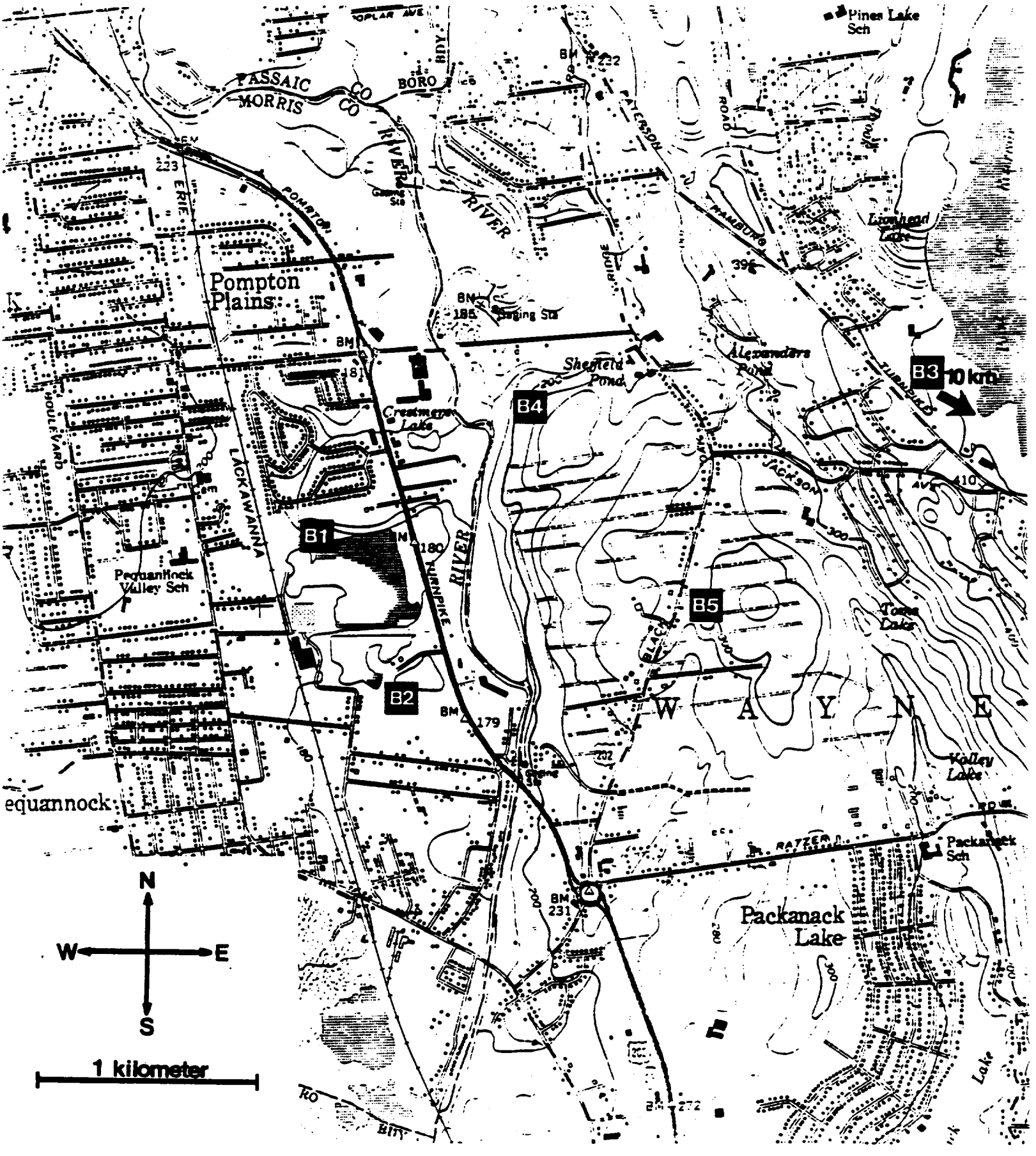

FIGURE 9. Locations of Background Measurements and Baseline Samples in the Wayne-Pompton Plains Area.

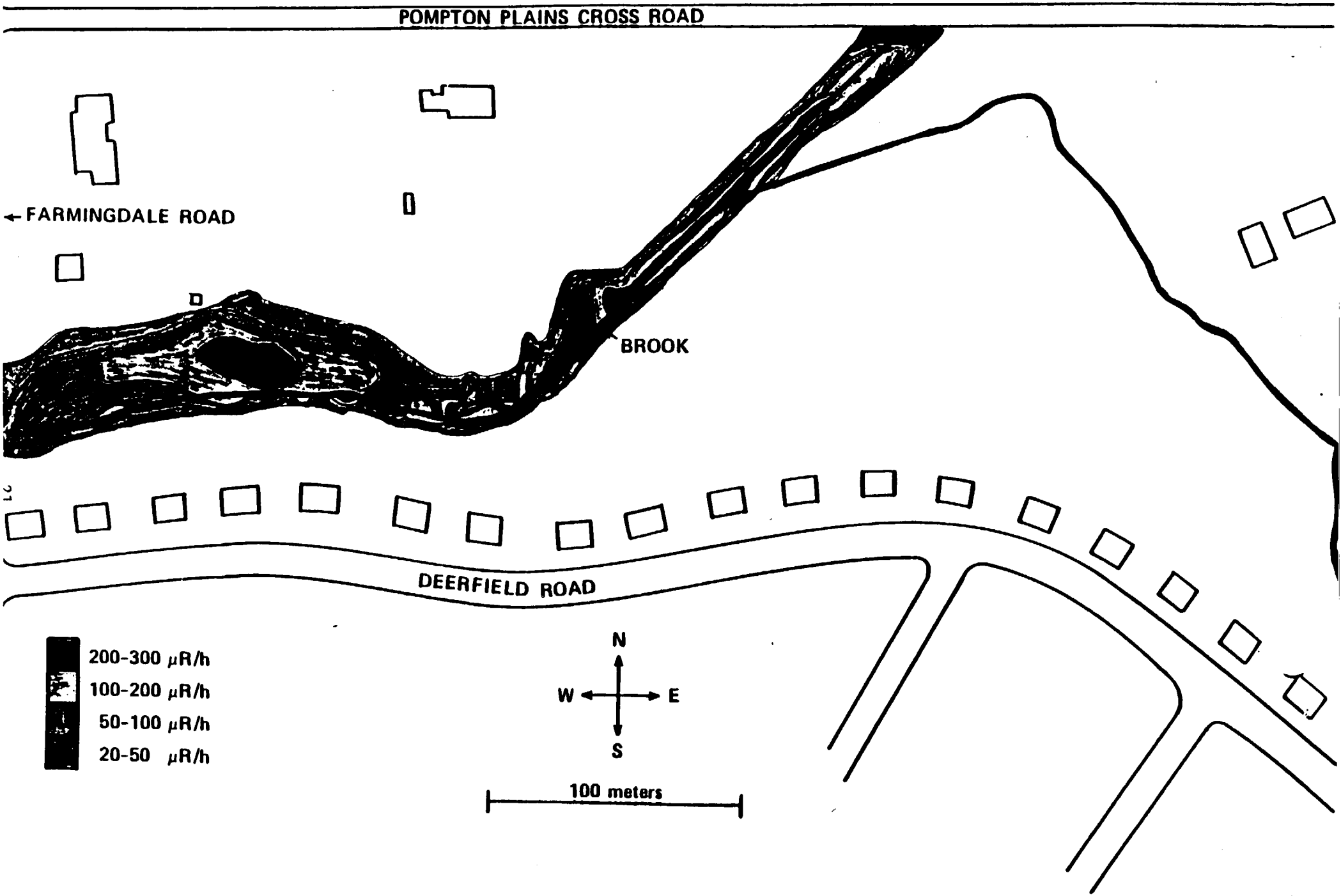

FIGURE 10. Surface Exposure Rates (μR/h) Along Sheffield Brook East of Farmingdale Road.

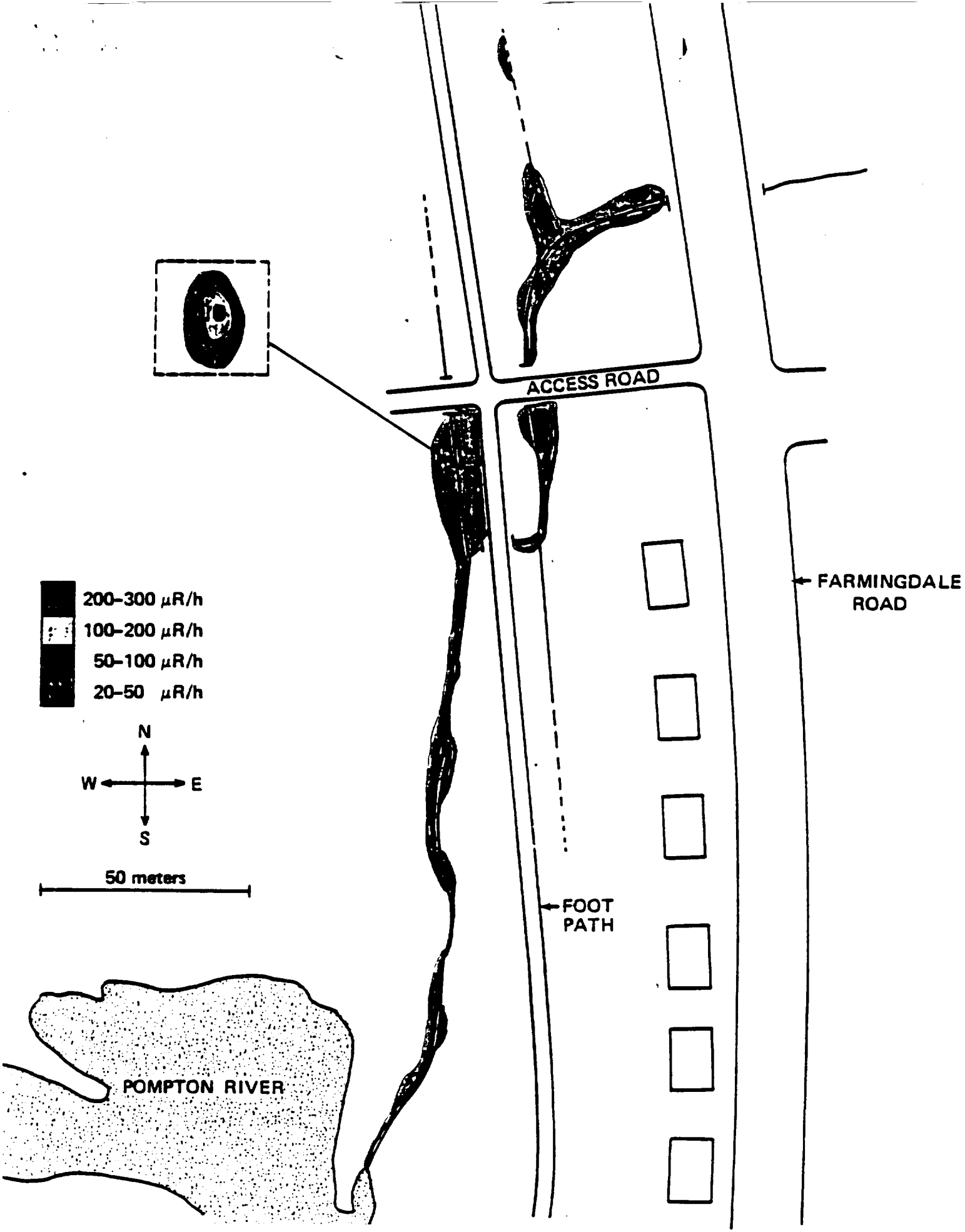

FIGURE 11. Surface Exposure Rates (μR/h) Along Sheffield Brook West of Farmingdale Road.

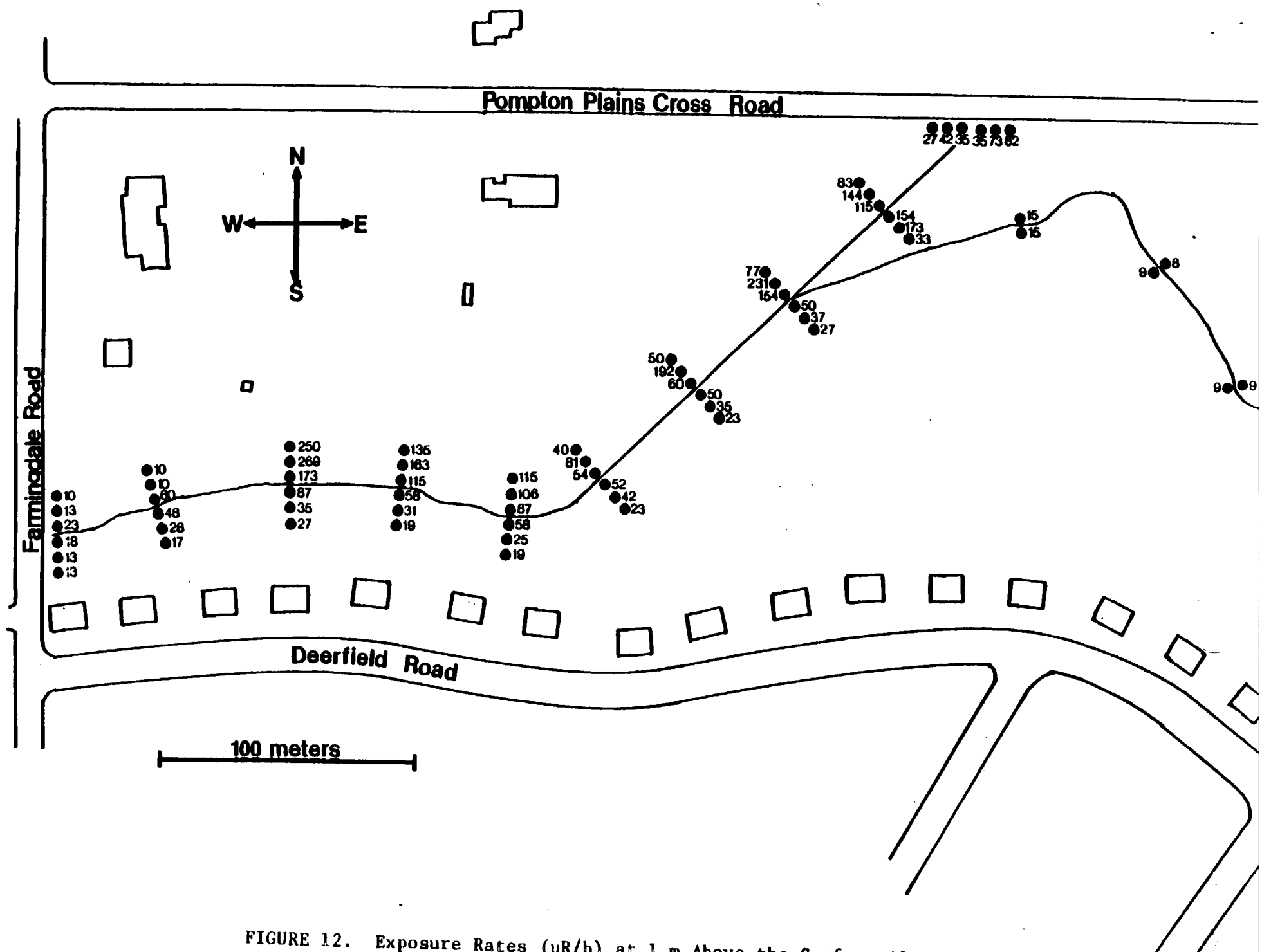

FIGURE 12. Exposure Rates (μR/h) at 1 m Above the Surface Along Sheffield

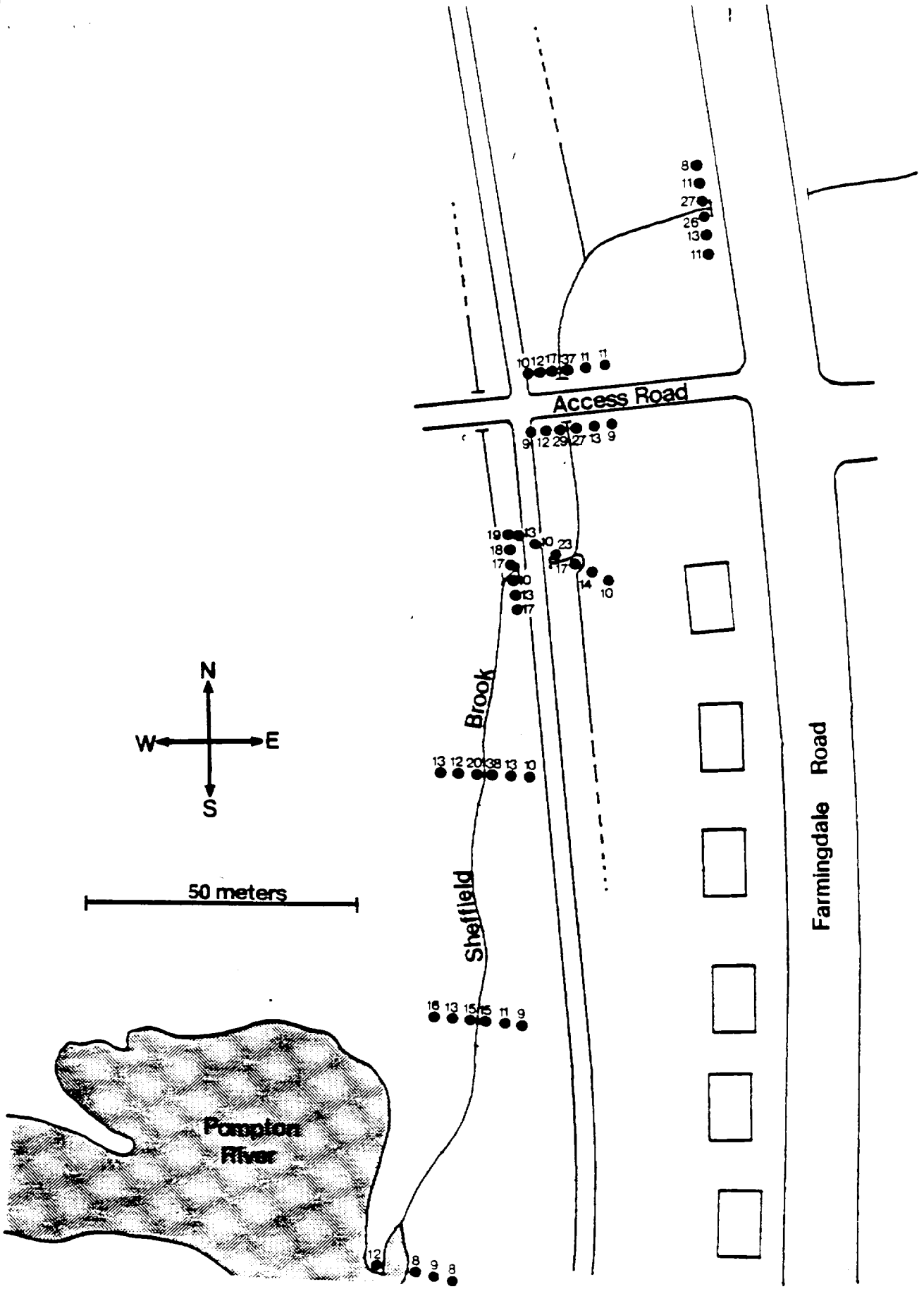

FIGURE 13. Exposure Rates (μR/h) at 1 m Above the Surface Along Sheffield Brook, West of Farmingdale Road.

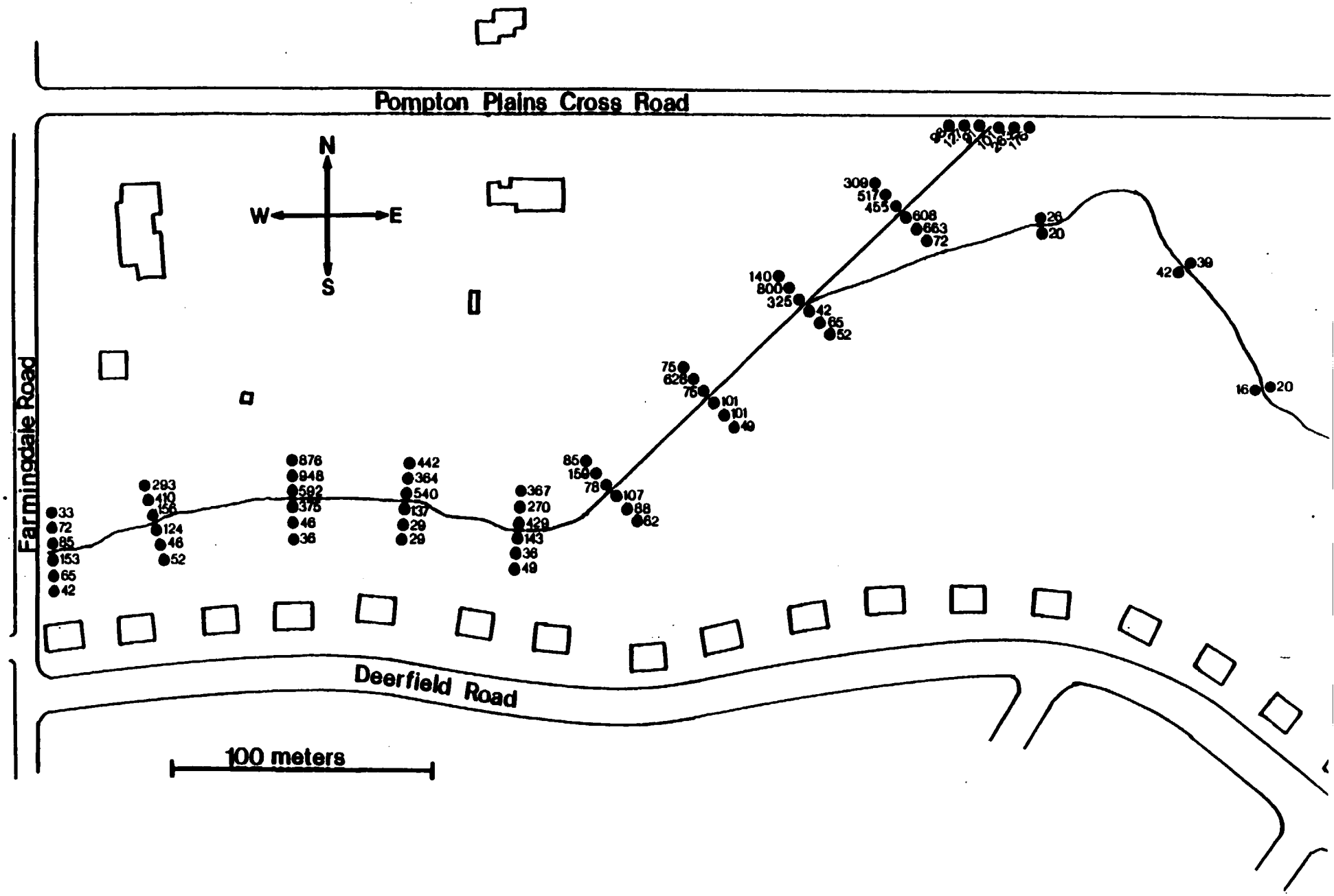

FIGURE 14. Surface Beta-Gamma Dose Rates (μrad/h) Along Sheffield Brook, East of Farmingdale Road.

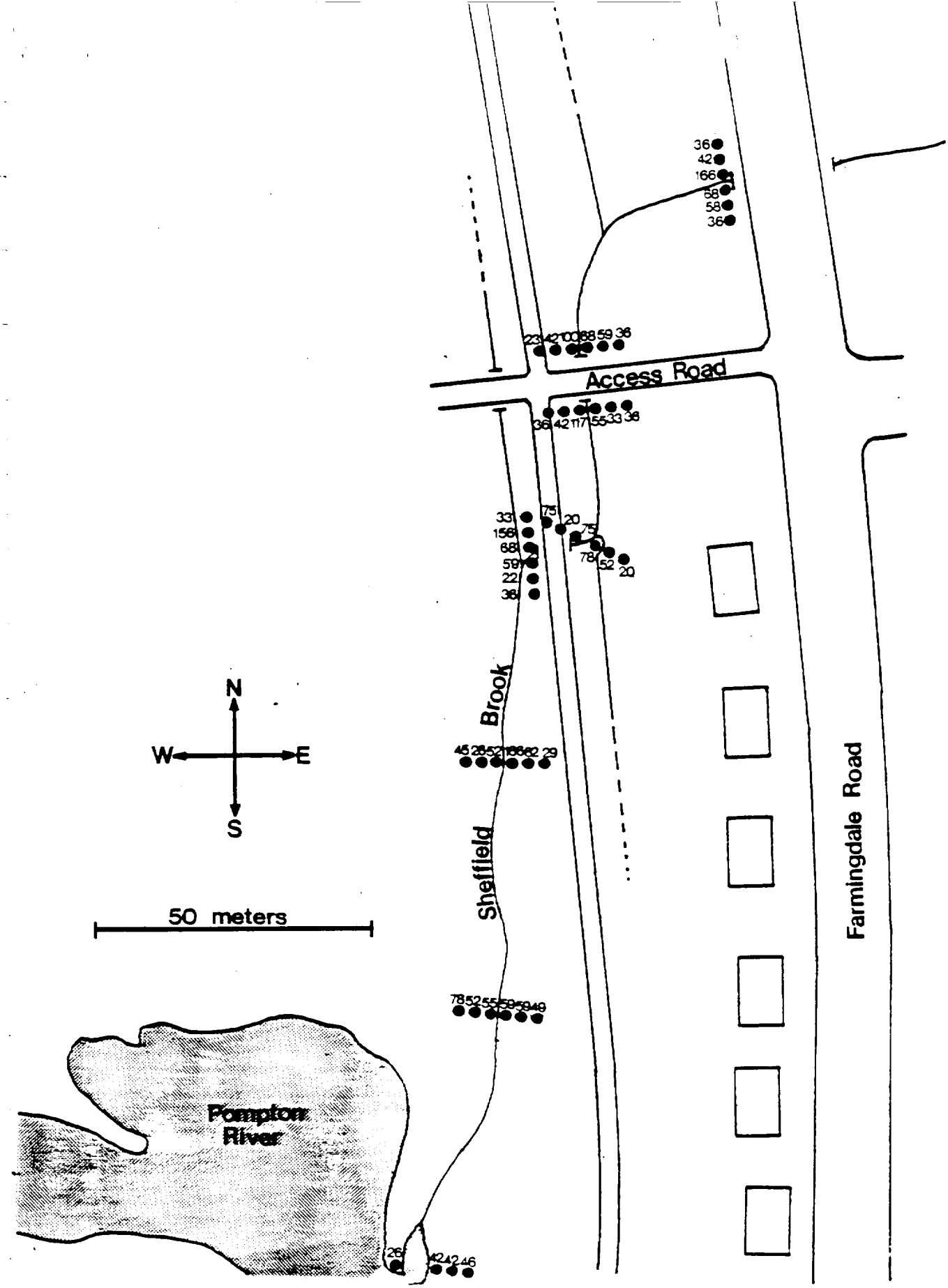

FIGURE 15. Surface Beta-Gamma Dose Rates (mrad/h) Along Sheffield Brook, West of Farmingdale Road.

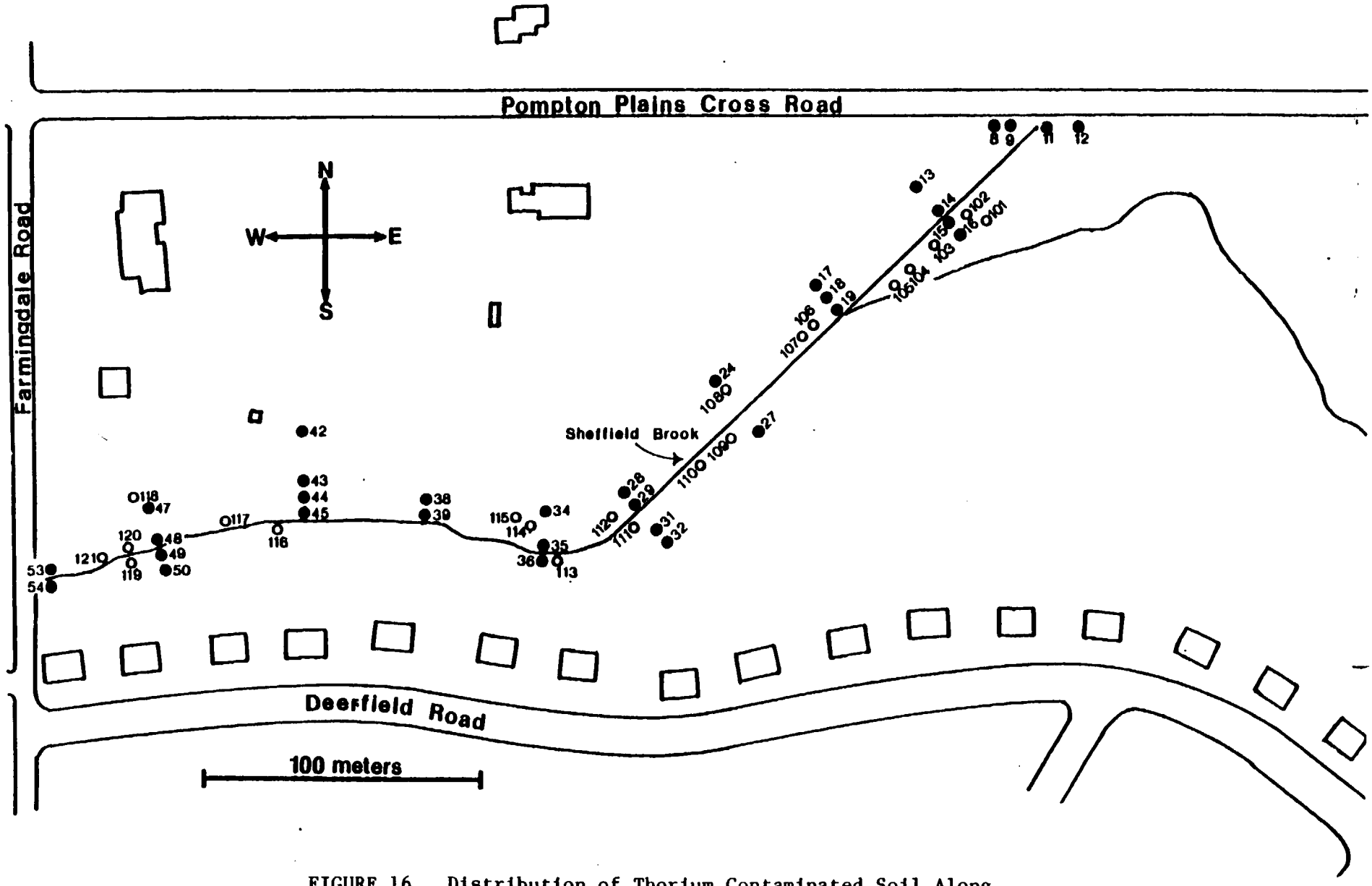

FIGURE 16. Distribution of Thorium Contaminated Soil Along Sheffield Brook, East of Farmingdale Road.

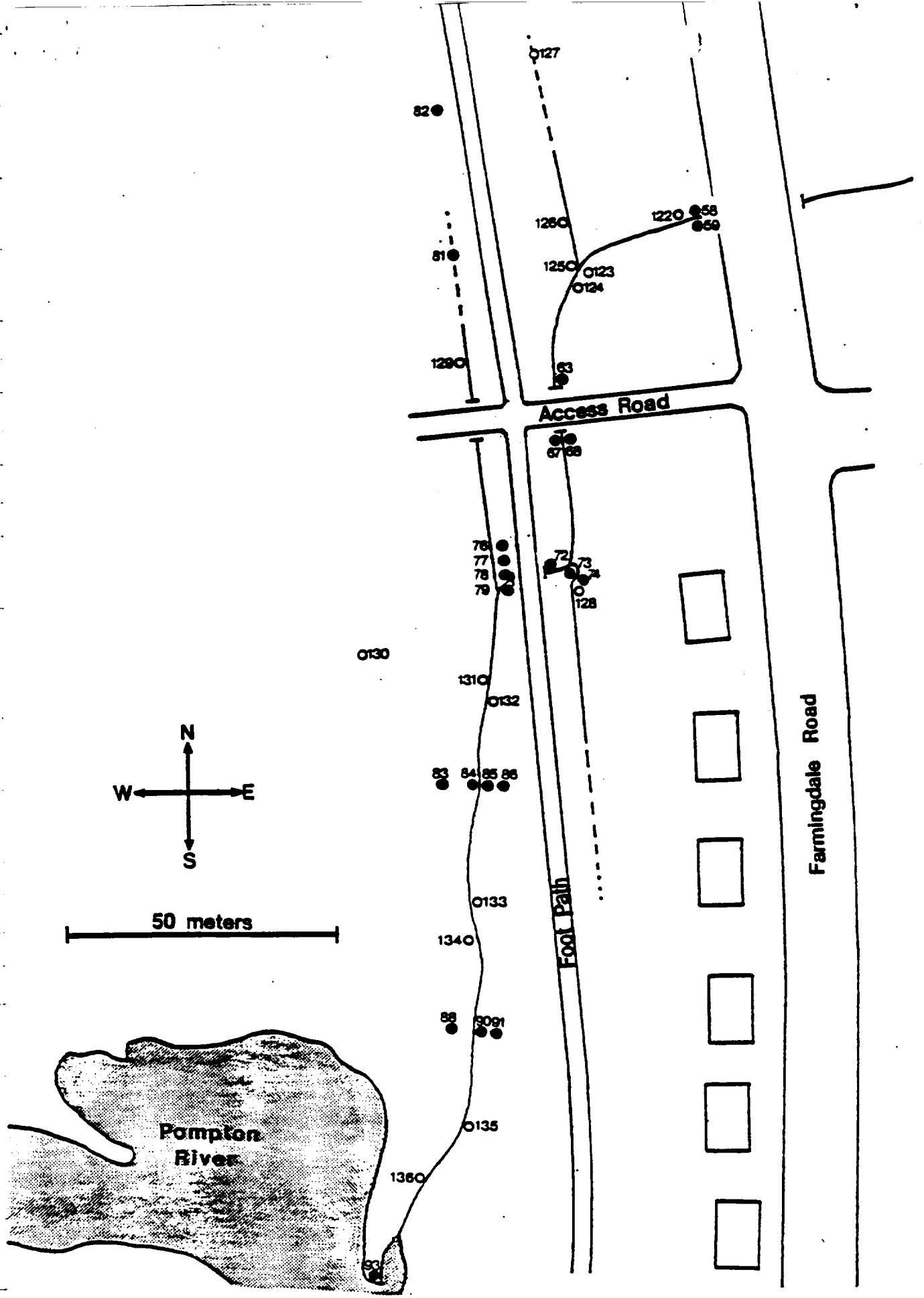

FIGURE 17. Distribution of Thorium Contaminated Soil Along Sheffield Brook, West of Farmingdale Road.

TABLE 1

RADIONUCLIDE CONCENTRATIONS IN BASELINE SOIL, VEGETATION, AND WATER SAMPLES

Sample Location	Depth (cm)	Radionuclide Concentrations (pCi/g)* Ra-228[b]	Th-228	Ra-226
Soil[a]				
B1 - P.V. Park	Surface	0.51 ± 0.23[c]	0.58 ± 0.27	0.47 ± 0.15
	30	0.72 ± 0.22	0.80 ± 0.21	0.47 ± 0.22
	60	0.69 ± 0.21	0.69 ± 0.21	0.49 ± 0.13
	90	0.45 ± 0.33	0.54 ± 0.17	0.50 ± 0.16
B2 - McDonald Park	Surface	0.69 ± 0.25	0.56 ± 0.23	0.45 ± 0.17
	30	1.00 ± 0.25	0.71 ± 0.30	0.58 ± 0.20
	60	0.56 ± 0.23	0.59 ± 0.18	0.37 ± 0.12
	90	0.72 ± 0.24	0.66 ± 0.21	0.40 ± 0.19
B3 - Orth Ave.	Surface	1.36 ± 0.33	1.60 ± 0.31	1.13 ± 0.26
	30	1.17 ± 0.23	1.39 ± 0.19	1.34 ± 0.17
	60	1.18 ± 0.24	1.31 ± 0.19	1.11 ± 0.17
B4 - Farmingdale Rd.	Surface	0.92 ± 0.32	1.00 ± 0.26	1.12 ± 0.25
	30	1.00 ± 0.29	1.21 ± 0.28	1.05 ± 0.21
B5 - Black Oak Ridge Rd.	Surface	0.85 ± 0.30	0.70 ± 0.21	0.85 ± 0.20
	30	0.91 ± 0.29	0.73 ± 0.22	0.65 ± 0.18
Range		0.45 to 1.36	0.54 to 1.60	0.37 to 1.34
Vegetation[d]				
2		0.17 ± 0.23	0.28 ± 0.18	0.36 ± 0.15

TABLE 1 (cont.)

RADIONUCLIDE CONCENTRATIONS IN BASELINE SOIL,
VEGETATION, AND WATER SAMPLES

Sample Location [a]	Radionuclide Concentrations in Water (pCi/l or $x10^{-9}$ µCi/ml)
	Gross Alpha
B1 - P.V. Park	0.95 ± 1.20
B2 - McDonald Park	<2.28
B6 - City Water	<1.56

[a] Refer to Figure 9.
[b] Assumed to be in equilibuium with Th-232.
[c] Error is 2σ based on counting statistics only.
[d] Refer to Figure 5.
* Other analyses not yet completed.

TABLE 2

RADIONUCLIDE CONCENTRATIONS IN SYSTEMATIC SOIL SAMPLES

Location[a]	Distance from Brook or Stream (m)	Depth (cm)	Radionuclide Concentrations (pCi/g)[a]		
			Ra-228[b]	Th-228	Ra-226
1	0 (edge)	surface	0.84 ± 0.29[c]	0.85 ± 0.22	0.56 ± 0.17
2	0	surface	0.65 ± 0.29	0.57 ± 0.18	0.45 ± 0.15
		30	0.77 ± 0.24	0.72 ± 0.18	0.63 ± 0.16
		60	0.74 ± 0.23	0.87 ± 0.20	0.66 ± 0.18
3	0	surface	1.01 ± 0.42	0.96 ± 0.36	0.84 ± 0.30
		30	1.09 ± 0.40	1.17 ± 0.41	1.07 ± 0.28
		60	0.87 ± 0.45	0.92 ± 0.33	0.75 ± 0.27
		90	0.71 ± 0.31	0.75 ± 0.29	0.93 ± 0.23
4	0	surface	0.79 ± 0.42	0.87 ± 0.33	0.64 ± 0.27
5	0	surface	0.69 ± 0.23	0.93 ± 0.24	0.62 ± 0.17
6	0	surface	0.86 ± 0.27	0.80 ± 0.26	0.57 ± 0.23
7	0	surface	1.05 ± 0.50	1.00 ± 0.35	0.81 ± 0.28
8	10	surface	30.8 ± 1.2	30.5 ± 1.1	2.41 ± 0.51
9	5	surface	18.4 ± 0.9	17.4 ± 0.8	1.47 ± 0.44
10	0	surface	1.74 ± 0.32	2.18 ± 0.29	0.87 ± 0.22
11	0	surface	10.7 ± 0.7	9.9 ± 0.6	1.05 ± 0.35
12	10	surface	9.80 ± 1.16	9.67 ± 1.03	1.83 ± 0.57
		30	19.5 ± 0.9	18.0 ± 0.8	2.11 ± 0.39
		60	5.16 ± 0.59	4.40 ± 0.43	0.75 ± 0.25
		90	2.14 ± 0.42	2.05 ± 0.31	0.94 ± 0.22
13	10	surface	52.6 ± 1.5	51.5 ± 1.3	4.92 ± 0.68
14	0	surface	71.4 ± 1.7	69.9 ± 1.6	5.34 ± 0.72
15	0	surface	132 ± 2	132 ± 2	11.4 ± 1.1
16	5	surface	116 ± 2	113 ± 2	7.49 ± 0.94
17	10	surface	29.6 ± 1.9	26.9 ± 1.5	1.42 ± 0.68
		30	12.4 ± 0.9	12.2 ± 0.7	1.43 ± 0.34
		60	3.68 ± 0.48	3.51 ± 0.39	1.08 ± 0.30
		90	3.06 ± 0.47	2.62 ± 0.37	0.81 ± 0.22

TABLE 2 (cont.)

RADIONUCLIDE CONCENTRATIONS IN SYSTEMATIC SOIL SAMPLES

Location	Distance from Brook or Stream (m)	Depth (cm)	Radionuclie Concentrations (pCi/g)		
			Ra-228	Th-228	Ra-226
18	5	surface	153 ± 3	144 ± 3	8.25 ± 1.12
19	0	surface	89.0 ± 2.0	83.1 ± 1.9	5.00 ± 0.90
20	0	surface	4.78 ± 0.53	4.77 ± 0.48	0.81 ± 0.32
21	10	surface	0.84 ± 0.36	0.65 ± 0.24	0.53 ± 0.20
22	50	surface	1.05 ± 0.39	1.47 ± 0.47	1.36 ± 0.28
23	100	surface	1.24 ± 0.44	1.36 ± 0.38	0.81 ± 0.32
24	10	surface	5.49 ± 0.57	5.82 ± 0.55	0.99 ± 0.30
25	0	surface	1.64 ± 0.34	2.18 ± 0.31	0.55 ± 0.18
26	0	surface	3.38 ± 0.55	3.69 ± 0.44	0.77 ± 0.25
27	5	surface	13.9 ± 1.1	13.6 ± 1.0	1.74 ± 0.49
28	5	surface	18.7 ± 1.2	18.9 ± 0.9	1.89 ± 0.41
29	0	surface	12.7 ± 0.8	13.2 ± 0.7	1.38 ± 0.36
30	0	surface	4.45 ± 0.53	5.00 ± 0.52	0.78 ± 0.27
31	5	surface	8.94 ± 0.99	8.91 ± 0.92	1.58 ± 0.46
		30	6.76 ± 0.67	5.93 ± 0.59	1.94 ± 0.33
		60	1.29 ± 0.40	1.21 ± 0.25	0.69 ± 0.19
		90	1.53 ± 1.21	1.33 ± 0.29	0.69 ± 0.18
32	10	surface	6.99 ± 1.06	6.95 ± 0.74	1.10 ± 0.40
33	50	surface	4.86 ± 1.18	3.98 ± 1.17	1.23 ± 0.58
		30	0.97 ± 6.39	1.18 ± 0.29	0.94 ± 0.23
		60	1.07 ± 0.29	1.06 ± 0.24	0.85 ± 0.17
		90	0.91 ± 0.25	0.93 ± 0.22	0.76 ± 0.18
34	10	surface	36.9 ± 1.2	32.4 ± 1.2	1.92 ± 0.55
35	0	surface	40.2 ± 1.5	34.4 ± 1.2	2.67 ± 0.60
36	0	surface	18.6 ± 1.1	16.5 ± 0.9	1.29 ± 0.44

TABLE 2 (cont.)

RADIONUCLIDE CONCENTRATIONS IN SYSTEMATIC SOIL SAMPLES

Location	Distance from Brook or Stream (m)	Depth (cm)	Radionuclide Concentrations (pCi/g)		
			Ra-228	Th-228	Ra-226
37	5	surface	1.50 ± 0.41	1.48 ± 0.36	1.00 ± 0.21
38	5	surface	34.4 ± 1.8	27.7 ± 1.3	1.68 ± 0.58
		30	102 ± 2	88.4 ± 2.0	6.38 ± 0.96
		60	17.8 ± 1.1	15.8 ± 0.9	1.83 ± 0.40
		90	5.79 ± 0.88	7.98 ± 0.75	0.64 ± 0.38
39	0	surface	20.8 ± 1.3	19.4 ± 1.0	1.49 ± 0.52
40	0	surface	2.31 ± 0.44	2.43 ± 0.38	0.74 ± 0.22
41	10	surface	1.31 ± 0.30	1.09 ± 0.30	0.94 ± 0.22
42	30	surface	29.5 ± 1.6	29.8 ± 1.4	2.18 ± 0.66
		30	1.22 ± 0.35	1.25 ± 0.27	0.72 ± 0.18
		60	1.03 ± 0.24	0.98 ± 0.22	0.61 ± 0.19
		90	0.79 ± 0.24	0.79 ± 0.18	0.69 ± 0.16
43	10	surface	84.3 ± 2.7	71.7 ± 2.2	2.79 ± 0.90
		30	17.8 ± 1.0	16.1 ± 0.9	1.27 ± 0.42
		60	7.06 ± 0.65	13.6 ± 0.6	0.92 ± 0.28
		90	6.29 ± 0.58	5.49 ± 0.50	0.82 ± 0.25
44	5	surface	573 ± 7	472 ± 5	7.87 ± 2.42
45	0	surface	18.8 ± 1.1	16.7 ± 0.9	1.38 ± 0.47
46	5	surface	1.41 ± 0.33	1.31 ± 0.30	0.86 ± 0.18
47	10	surface	143 ± 3	87.3 ± 2.6	3.40 ± 1.14
48	0	surface	24.8 ± 1.4	23.2 ± 2.4	1.71 ± 0.49
49	0	surface	21.8 ± 1.2	16.5 ± 0.9	1.37 ± 0.48
50	5	surface	5.23 ± 0.56	5.73 ± 0.51	0.95 ± 0.26
51	10	surface	1.04 ± 0.30	1.18 ± 0.26	0.61 ± 0.21
		30	1.05 ± 0.30	1.19 ± 0.26	0.67 ± 0.17
		60	0.90 ± 0.27	0.93 ± 0.24	0.58 ± 0.16
		90	1.47 ± 0.33	1.02 ± 0.25	0.61 ± 0.17
52	5	surface	1.00 ± 0.28	1.16 ± 0.28	0.62 ± 0.19

TABLE 2 (cont.)

RADIONUCLIDE CONCENTRATIONS IN SYSTEMATIC SOIL SAMPLES

Location	Distance from Brook or Stream (m)	Depth (cm)	Radionuclide Concentrations (pCi/g)		
			Ra-228	Th-228	Ra-226
53	0	surface	27.5 ± 1.5	27.4 ± 1.2	2.24 ± 0.52
54	0	surface	30.5 ± 1.5	28.9 ± 1.2	1.62 ± 0.52
55	10	surface	0.93 ± 0.34	0.87 ± 0.32	0.69 ± 0.23
56	10	surface	0.77 ± 0.39	0.96 ± 0.26	0.68 ± 0.24
57	5	surface	0.78 ± 0.21	0.93 ± 0.26	0.70 ± 0.19
		30	1.01 ± 0.28	1.09 ± 0.28	0.67 ± 0.16
		60	0.62 ± 0.25	0.70 ± 0.25	0.65 ± 0.16
		90	1.01 ± 0.30	0.90 ± 0.20	0.56 ± 0.15
58	0	surface	50.1 ± 2.2	48.2 ± 1.8	2.56 ± 0.73
59	0	surface	26.2 ± 1.5	24.3 ± 1.3	1.69 ± 0.60
60	5	surface	1.51 ± 0.37	1.70 ± 0.31	0.87 ± 0.22
61	5	surface	0.86 ± 0.42	1.03 ± 0.27	1.40 ± 0.60
62	0	surface	3.16 ± 0.43	3.01 ± 0.41	0.66 ± 0.29
63	0	surface	45.9 ± 2.1	44.5 ± 1.4	2.60 ± 0.65
64	10	surface	0.97 ± 0.39	0.93 ± 0.25	0.76 ± 0.20
65	10	surface	0.79 ± 0.49	1.04 ± 0.38	0.76 ± 0.24
		30	0.98 ± 0.29	0.92 ± 0.21	0.11 ± 0.14
		60	0.84 ± 0.33	0.99 ± 0.26	0.57 ± 0.25
		90	1.02 ± 0.30	0.94 ± 0.22	0.67 ± 0.17
66	5	surface	0.94 ± 0.29	1.03 ± 0.29	0.74 ± 0.16
67	0	surface	56.0 ± 2.3	43.1 ± 1.8	2.42 ± 0.80
68	0	surface	44.2 ± 2.1	33.1 ± 0.8	2.53 ± 0.74
69	5	surface	0.88 ± 0.40	1.06 ± 0.23	0.64 ± 0.18
70	10	surface	1.20 ± 0.35	0.98 ± 0.28	0.95 ± 0.21
71	5	surface	1.03 ± 0.43	2.56 ± 0.23	0.15 ± 0.19

TABLE 2 (cont.)

RADIONUCLIDE CONCENTRATIONS IN SYSTEMATIC SOIL SAMPLES

Location	Distance from Brook or Stream (m)	Depth (cm)	Radionuclide Concentrations (pCi/g)		
			Ra-228	Th-228	Ra-226
72	0	surface	20.2 ± 1.0	2.27 ± 0.90	1.39 ± 0.48
73	0	surface	18.4 ± 1.3	15.6 ± 1.1	1.20 ± 0.53
74	5	surface	7.23 ± 0.83	5.85 ± 1.21	0.47 ± 0.35
75	10	surface	1.44 ± 0.30	1.59 ± 0.67	0.87 ± 0.48
76	10	surface	150 ± 3	133 ± 3	7.91 ± 1.31
		30	66.2 ± 1.9	58.5 ± 1.6	3.72 ± 0.74
		60	13.5 ± 0.8	13.9 ± 0.66	1.45 ± 0.33
		90	8.17 ± 0.67	8.14 ± 0.60	1.19 ± 0.34
77	5	surface	38.6 ± 1.7	34.7 ± 1.3	2.85 ± 0.64
78	0	surface	12.5 ± 0.9	10.4 ± 0.7	1.22 ± 0.33
79	0	surface	7.01 ± 0.63	5.61 ± 0.57	0.89 ± 0.28
80	5	surface	1.36 ± 0.31	1.35 ± 0.24	0.65 ± 0.18
81	0	surface	5.10 ± 0.74	4.75 ± 0.64	1.01 ± 0.38
82	0	surface	9.96 ± 0.92	10.3 ± 0.8	1.13 ± 0.39
83	10	surface	5.55 ± 0.67	5.75 ± 0.64	0.83 ± 0.34
84	0	surface	6.43 ± 0.67	6.32 ± 0.61	1.23 ± 0.31
85	0	surface	30.6 ± 1.5	31.5 ± 1.4	2.82 ± 0.69
86	5	surface	7.01 ± 0.74	6.68 ± 0.33	1.09 ± 0.34
87	10	surface	1.12 ± 0.51	1.06 ± 0.27	0.88 ± 0.23
		30	1.59 ± 0.39	1.63 ± 0.29	0.89 ± 0.22
		60	0.85 ± 0.24	0.92 ± 0.23	0.57 ± 0.14
		90	0.34 ± 0.20	0.46 ± 0.16	0.51 ± 0.14
88	5	surface	8.57 ± 0.93	7.38 ± 0.71	1.09 ± 0.41
89	0	surface	1.85 ± 0.52	1.47 ± 0.38	1.01 ± 0.25

TABLE 2 (cont.)

RADIONUCLIDE CONCENTRATIONS IN SYSTEMATIC SOIL SAMPLES

Location	Distance from Brook or Stream (m)	Depth (cm)	Radionuclide Concentrations (pCi/g)		
			Ra-228	Th-228	Ra-226
90	0	surface	10.6 ± 1.0	10.3 ± 0.8	1.07 ± 0.45
91	5	surface	7.33 ± 0.83	7.57 ± 0.66	1.41 ± 0.38
92	10	surface	4.33 ± 0.67	3.74 ± 0.58	0.83 ± 0.31
93	0	surface	7.61 ± 0.43	6.52 ± 0.65	0.92 ± 0.31
94	0	surface	2.20 ± 0.54	1.74 ± 0.37	1.09 ± 0.26
95	5	surface	3.55 ± 0.66	3.85 ± 0.51	0.76 ± 0.27
96	20	surface	2.76 ± 0.40	2.68 ± 0.33	0.62 ± 0.22
97	0	surface	0.56 ± 0.37	4.36 ± 0.38	0.59 ± 0.21
98	0	surface	0.60 ± 0.34	0.66 + 0.20	0.54 ± 0.16
99	0	surface	1.04 ± 0.36	1.09 ± 0.26	0.72 ± 0.11
100	0	surface	0.71 ± 0.30	0.97 ± 0.24	0.83 ± 0.19

a Refer to Figures 3, 4, and 5.
b Assumed to be in equilibrium with Th-232.
c Error is 2 σ based on counting statistics.
* Other analyses not yet completed.

TABLE 3

RADIONUCLIDE CONCENTRATIONS IN BIASED SOIL SAMPLES

Location[a]	Depth (cm)	Radionuclide Concentrations (pCi/g)[a]		
		Ra-228[b]	Th-228	Ra-226
101	Surface	91.4 ± 3.2[c]	86.5 ± 2.6	3.38 ± 1.10
	30	182 ± 4	163 ± 4	9.61 ± 1.63
	60	44 ± 2	41.9 ± 1.9	3.43 ± 0.88
	90	31.2 ± 1.8	27.8 ± 1.5	1.81 ± 0.78
102	Surface	32.4 ± 1.6	32.3 ± 1.4	2.19 ± 0.63
	30	50.2 ± 2.2	44.1 ± 1.8	2.59 ± 0.88
	60	41.2 ± 1.9	41.8 ± 1.6	3.04 ± 0.72
	90	51.3 ± 2.1	50.8 ± 1.9	2.73 ± 0.82
103	Surface	275 ± 6	201 ± 4	13.6 ± 2.3
	30	102 ± 3	98.6 ± 2.9	7.16 ± 1.40
	60	87.8 ± 2.9	64.0 ± 2.2	4.08 ± 1.00
	90	30.9 ± 1.9	29.4 ± 1.6	2.29 ± 0.78
104	Surface	191 ± 5	187 ± 5	9.95 ± 2.18
105	Surface	734 ± 8	722 ± 8	46.8 ± 3.8
106	Surface	235 ± 6	227 ± 5	12.6 ± 2.3
107	Surface	307 ± 7	287 ± 6	11.9 ± 2.6
	30	37.9 ± 2.4	35.5 ± 1.8	3.26 ± 0.83
	60	28.9 ± 18.1	28.0 ± 1.5	2.06 ± 0.78
	90	9.93 ± 0.94	10.0 ± 0.7	1.47 ± 0.32
108	Surface	507 ± 8	479 ± 7	28.1 ± 3.4
109	Surface	9.11 ± 1.59	8.34 ± 1.02	1.21 ± 0.58
110	Surface	19.4 ± 1.5	16.9 ± 1.3	1.58 ± 0.64
	30	75.5 ± 4.0	60.4 ± 3.1	5.07 ± 1.52
	60	76.4 ± 3.3	62.6 ± 2.9	3.17 ± 0.99
	90	6.06 ± 0.86	4.44 ± 0.76	0.71 ± 0.42
111	Surface	19.1 ± 2.3	18.0 ± 1.9	1.31 ± 0.94
112	Surface	345 ± 4	310 ± 4	20.9 ± 1.7
	15	247 ± 5	230 ± 5	24.0 ± 2.4
	30	273 ± 5	260 ± 5	18.3 ± 2.3
	60	289 ± 5	261 ± 5	24.0 ± 2.5
	90	151 ± 4	139 ± 3	10.9 ± 1.6

TABLE 3 (cont.)

RADIONUCLIDE CONCENTRATIONS IN BIASED SOIL SAMPLES

Location	Depth (cm)	Radionuclide Concentrations (pCi/g)*		
		Ra-228	Th-228	Ra-226
113	Surface	23.7 ± 1.7	21.7 ± 1.5	1.03 ± 0.65
	30	152 ± 3	144 ± 3	6.88 ± 1.14
	60	57.7 ± 1.6	53.0 ± 1.5	2.71 ± 0.67
	90	136 ± 2	130 ± 2	7.49 ± 1.06
114	Surface	163 ± 2	139 ± 1	3.88 ± 0.93
115	Surface	170 ± 2	152 ± 4	9.46 ± 1.82
	30	20.9 ± 0.9	19.0 ± 0.9	2.11 ± 0.41
	60	7.28 ± 7.60	5.87 ± 0.61	1.24 ± 0.39
116	Surface	163 ± 6	111 ± 5	2.59 ± 1.69
	30	13.3 ± 1.3	13.6 ± 1.1	1.13 ± 0.29
	60	10.2 ± 0.9	6.88 ± 0.13	1.24 ± 0.38
	90	2.97 ± 0.44	2.18 ± 0.39	0.62 ± 0.11
117	Surface	90.8 ± 3.8	79.6 ± 3.2	3.94 ± 0.70
	30	27.2 ± 1.9	24.7 ± 1.4	1.82 ± 0.64
	60	8.11 ± 0.69	6.58 ± 0.57	1.09 ± 0.35
	90	4.84 ± 0.49	4.00 ± 0.43	0.80 ± 2.40
118	Surface	172 ± 5	124 ± 4	4.89 ± 1.80
	30	13.4 ± 0.8	10.5 ± 0.6	1.43 ± 0.35
	60	4.17 ± 0.54	3.32 ± 0.41	0.85 ± 0.26
	90	5.65 ± 0.73	5.05 ± 0.62	0.94 ± 0.35
119	Surface	56.1 ± 2.74	43.6 ± 2.0	2.33 ± 0.88
120	Surface	45.6 ± 2.9	35.7 ± 2.2	2.66 ± 1.06
121	Surface	10.3 ± 0.8	10.4 ± 0.6	1.19 ± 0.34
122	Surface	57.1 ± 1.7	43.1 ± 1.6	1.92 ± 0.66
123	Surface	13.4 ± 0.8	10.5 ± 6.4	1.43 ± 0.35
124	Surface	31.3 ± 1.8	23.2 ± 1.4	2.23 ± 0.69
125	Surface	68.9 ± 3.0	51.1 ± 2.3	3.19 ± 1.06
126	Surface	126 ± 3	112 ± 2	3.97 ± 0.98
	30	24.8 ± 1.0	22.3 ± 1.1	2.25 ± 0.48
	60	120 ± 4	114 ± 4	3.50 ± 1.48
	90	8.08 ± 0.93	8.14 ± 0.67	1.25 ± 0.42

TABLE 3 (cont.)

RADIONUCLIDE CONCENTRATIONS IN BIASED SOIL SAMPLES

Location	Depth (cm)	Radionuclide Concentrations (pCi/g)		
		Ra-228	Th-228	Ra-226
127	Surface	30.7 ± 2.1	29.2 ± 1.7	2.13 ± 0.83
128	Surface	44.7 ± 2.1	40.9 ± 1.8	2.29 ± 0.82
129	Surface	26.2 ± 1.8	25.6 ± 1.7	1.62 ± 0.78
130	Surface	9.08 ± 0.72	5.56 ± 0.63	0.93 ± 0.27
	30	24.1 ± 1.9	21.8 ± 1.4	1.69 ± 0.69
	60	6.09 ± 0.59	5.58 ± 0.47	0.76 ± 0.32
	90	0.90 ± 0.26	0.75 ± 0.17	0.42 ± 0.16
131	Surface	105 ± 3	90.4 ± 3.1	6.05 ± 1.46
132	Surface	57.3 ± 3.3	50.8 ± 2.4	2.77 ± 1.00
133	Surface	17.9 ± 1.0	15.3 ± 0.8	1.07 ± 0.41
134	Surface	18.6 ± 1.2	17.1 ± 0.9	1.05 ± 0.46
	30	5.25 ± 0.50	4.65 ± 0.43	0.64 ± 0.23
	60	1.79 ± 0.32	1.67 ± 0.25	0.45 ± 0.16
	90	0.54 ± 0.24	0.72 ± 0.17	0.33 ± 0.15
135	Surface	126 ± 2	119 ± 2	4.41 ± 1.02
136	Surface	12.8 ± 1.0	10.3 ± 0.8	1.29 ± 0.39

a Refer to Figures 3 and 4.
b Assumed to be in equilibrium with Th-232.
c Errors are 2σ based on counting statistics only.
Other analyses not yet completed.

TABLE 4

RADIONUCLIDE CONCENTRATIONS IN SEDIMENT SAMPLES

Location[a]	Radionuclide Concentrations (pCi/g)[c]		
	Ra-228[b]	Th-228	Ra-226
1	0.54 ± 0.36	0.57 ± 0.12	0.48 ± 0.10
2	0.58 ± 0.25	0.71 ± 0.23	0.36 ± 0.16
3	0.78 ± 0.19	0.67 ± 0.20	0.50 ± 0.14
4	5.38 ± 0.68	4.57 ± 0.52	0.98 ± 0.27
5	5.56 ± 0.57	5.39 ± 0.46	0.95 ± 0.24
6	44.3 ± 2.1	42.7 ± 1.8	3.72 ± 0.90
7	26.7 ± 1.9	24.5 ± 1.6	2.86 ± 0.80
8	0.88 ± 0.26	0.75 ± 0.24	0.55 ± 0.14
9	0.51 ± 0.20	0.46 ± 0.17	0.41 ± 0.13
10	1.21 ± 0.29	0.97 ± 0.23	0.47 ± 0.14
11	1.97 ± 0.30	1.76 ± 0.27	0.69 ± 0.17
12	3.02 ± 0.41	2.80 ± 0.33	0.63 ± 0.21
13	4.60 ± 0.51	4.88 ± 0.37	0.59 ± 0.21
14	26.7 ± 1.6	23.3 ± 1.2	0.93 ± 0.53
15	7.07 ± 0.57	7.04 ± 0.48	0.90 ± 0.31
16	61.0 ± 1.4	53.9 ± 1.3	4.16 ± 0.61
17	4.44 ± 0.41	3.69 ± 0.34	0.58 ± 0.19
18	16.8 ± 1.0	16.4 ± 0.7	1.16 ± 0.34
19	4.56 ± 0.44	3.41 ± 0.35	0.58 ± 0.19
20	32.0 ± 1.31	25.1 ± 1.0	1.99 ± 0.49
21	6.06 ± 0.51	5.75 ± 0.43	0.76 ± 0.21
22	16.4 ± 0.9	17.6 ± 0.8	0.67 ± 0.41
23	9.13 ± 0.63	7.31 ± 0.49	0.70 ± 0.25
24	21.2 ± 1.1	19.5 ± 1.0	1.15 ± 0.43
25	15.5 ± 0.9	14.4 ± 0.8	1.08 ± 0.37
26	7.64 ± 0.58	7.56 ± 0.51	0.92 ± 0.25
27	8.26 ± 0.65	8.48 ± 0.54	0.68 ± 0.20
28	7.56 ± 0.58	7.71 ± 0.54	0.86 ± 0.25
29	5.60 ± 0.49	6.06 ± 0.45	0.68 ± 0.23
30	5.59 ± 0.59	5.69 ± 0.44	0.62 ± 0.24
31	17.5 ± 1.1	17.2 ± 0.89	1.17 ± 0.42
32	8.91 ± 0.68	9.83 ± 0.61	0.98 ± 0.38
33	6.14 ± 0.53	6.26 ± 0.49	0.84 ± 0.24
34	4.07 ± 0.50	3.56 ± 0.39	0.69 ± 0.19
35	3.10 ± 0.41	2.62 ± 0.30	0.51 ± 0.17
36	3.93 ± 0.44	3.47 ± 0.36	0.68 ± 0.20
37	6.18 ± 0.54	6.04 ± 0.48	0.63 ± 0.23
38	9.73 ± 0.77	8.78 ± 0.22	1.00 ± 0.32
39	3.58 ± 0.50	2.76 ± 0.47	0.93 ± 0.25
40	<0.13	0.44 ± 0.24	0.31 ± 0.19
41	0.55 ± 0.25	0.72 ± 0.20	0.55 ± 0.18
42	1.01 ± 0.28	1.03 ± 0.29	0.60 ± 0.23
43	0.92 ± 0.27	0.87 ± 0.20	0.82 ± 0.19

TABLE 4 (cont.)

RADIONUCLIDE CONCENTRATIONS IN SEDIMENT SAMPLES

Location	Radionuclide Concentrations (pCi/g)		
	Ra-228	Th-228	Ra-226
44	1.23 ± 0.38	1.38 ± 0.28	0.48 ± 0.20
45	15.1 ± 0.80	14.9 ± 0.69	2.00 ± 0.38
46	7.92 ± 0.51	7.62 ± 0.45	1.50 ± 0.24
47	0.97 ± 0.25	1.02 ± 0.23	0.61 ± 0.18
48	0.57 ± 1.92	0.65 ± 0.16	0.48 ± 0.14
49	0.86 ± 0.24	0.83 ± 0.30	0.32 ± 0.17

[a] Refer to Figures 5, 6, 7, and 8.
[b] Assumed to be in equilibrium with Th-232.
[c] Error is 2σ based on counting statistics only.
* Other analyses not yet completed.

TABLE 5

RADIONUCLIDE CONCENTRATIONS IN WATER SAMPLES

	Sample Location[a]	Radionuclide Concentrations (pCi/l or x 10^{-9} µCi/ml) Gross Alpha*
1	Sheffield Brook	<2.7
2	Sheffield Brook	6.5 ± 1.7[b]
3	Sheffield Brook	<2.2
4	Pompton River - 500 m upstream	1.1 ± 1.4
5	Pompton River - 100 m upstream	<0.7
6	Pompton River - 100 m downstream	39 ± 9
7	Pompton River - 500 m downstream	0.8 ± 1.1
8	Storm Sewer	29 ± 4
9	Storm Sewer	19 ± 8
10	Storm Sewer	12 ± 6
11	Storm Sewer	<2.8
12	Storm Sewer	1.6 ± 1.3
13	Storm Sewer	<2.3
14	Surface water - Farm	3.5 ± 4.0
15	Surface water - Farm	<2.3
16	Well water - Farm	<1.0
17	Well water - Farm	1.6 ± 1.4
18	Well water - Wendt Lane	<2.2

TABLE 5 (cont.)

RADIONUCLIDE CONCENTRATIONS IN WATER SAMPLES

Sample Location [a]	Radionuclide Concentrations (pCi/l or x 10^{-9} µCi/ml) Gross Alpha*
19 Well water - Wendt Lane	<2.2
20 Well water - Deerfield Road	6.8 ± 5.8
21 Well water - Farmingdale Road	12 ± 6

[a] Refer to Figures 5 and 8.
[b] Error is 2σ based on counting statistics only.
* Other analyses not yet completed.

TABLE 6

RADIONUCLIDE CONCENTRATIONS IN VEGETATION SAMPLES

Location[a]	Radionuclide Concentrations (pCi/g)*		
	Ra-228[b]	Th-228	Ra-226
1	2.04 ± 0.47[c]	0.99 ± 0.21	0.34 ± 0.15
2	0.17 ± 0.23	0.28 ± 0.18	0.36 ± 0.15
3	12.8 ± 0.41	10.1 ± 0.32	0.71 ± 0.16
4	6.96 ± 0.36	4.11 ± 0.24	0.44 ± 0.13
5	1.97 ± 0.19	1.83 ± 0.16	0.39 ± 0.10

[a] Refer to Figure 5.
[b] Assumed to be in equilibrium with Th-232.
[c] Error is 2σ based on counting statistics only.
* Other analyses not yet complete.

REFERENCES

1. Title 10, Code of Federal Regulations, Part 20. Standards for Protection Against Radiation, U.S. Government Printing Office, regulations published prior to January, 1981.

2. T.S. Dahlstrom. An Aerial Radiological Survey of the W.R. Grace Property, Wayne Township, New Jersey. EG&G Survey Report, NRC-8113, November 1981.

3. U.S. Nuclear Regulatory Commission, Office of Inspection and Enforcement. Report #99990001/81-21, January 1981.

4. Title 40, Code of Federal Regulations, Part 141. Interim Primary Drinking Water Regulations. Federal Register, July 1976.

APPENDIX A

MAJOR ANALYTICAL EQUIPMENT

APPENDIX A

Major Analytical Equipment

The display or description of a specific product is not be be construed as an endorsement of that product or its manufacturer by the authors or their employers.

A. Direct Radiation Measurements

Eberline "RASCAL"
Portable Ratemeter-Scaler
Model PRS-1
Compensated G-M Probe, Model HP-270
(Eberline Instrument, Santa Fe, NM)

Eberline PRM-6
Portable Ratemeter
Scintillation Probe, Model 489-55
(Victoreen, Inc., Cleveland, OH)

Pressurized Ionization Chamber (PIC)
Model RSS-111
(Reuter-Stokes, Cleveland, OH)

B. Laboratory Analysis

Ge(Li) Detector
Model LGCC2220SD, 23% efficiency
(Princeton Gamma-Tech, Princeton, NJ)

Used in conjunction with:
Lead shield, SPG-16
(Applied Physical Technology, Smyrna, GA)

Pulse Height Analyzer, ND680
Model 88-0629 with associated computer package
(Nuclear Data, Inc., Schaumburg, IL)

Alpha Spectroscopy System
Tracor Northern 1705
Pulcir PA-1 Alpha Module
(Pulcir, Inc., Oak Ridge, TN)

Low Background Alpha-Beta Counter
Model LB5100-2080
(Tennelec, Inc., Oak Ridge, TN)

APPENDIX B

ANALYTICAL PROCEDURES

APPENDIX B

Analytical Procedures

Gamma Scintillation Measurements

Walkover surface scans and measurements of gamma exposure rates were performed using an Eberline PRM-6 portable ratemeter with a Victoreen Model 489-55 gamma scintillation probe containing a 3.2 cm x 3.8 cm NaI(Tl) scintillation crystal. Count rates (cpm) were converted to exposure levels (μR/h) using a factor of 520 cpm = 1 μR/h. This factor was determined by comparing the response of the scintillation detector with that of a Reuter Stokes Model RSS-111 pressurized ionization chamber at several locations along Sheffield Brook.

Beta-Gamma Dose Rate Measurements

Measurements were performed using Eberline "Rascal" Model PRS-1 portable ratemeters with Model HP-270 energy compensated G-M probes. Dose rates (μrad/h) were determined by comparison of the response of a Victoreen Model 440 ionization chamber survey meter to that of the G-M probes for a composite of soil samples from the site. The conversion factor determined was 0.63 cpm = 1 μrad/h.

Soil and Sediment Sample Analysis

Soil samples were dried at 120° C, finely ground, mixed, and a portion placed in a one-liter Marinelli beaker. The quantity placed in each beaker was chosen to reproduce the calibrated counting geometry and typically ranged from 500 to 800 g of soil. Net soil weights were determined and the samples counted using a 23% Ge(Li) detector (Princeton Gamma Tech) coupled to a Nuclear Data model ND-680 pulse height analyzer. The following energy peaks were used for determination of the radionuclides of concern:

Ra-228 - 0.911 MeV from Ac-228

Th-228 - 0.583 MeV from Tl-208

Ra-226 - 0.609 MeV from Bi-214

*U-235 - 0.143 MeV

*U-238 - 1.001 MeV from Pa-234m

Peak identification and concentration calculations were provided by computer analyses.

Several randomly selected samples were analyzed for isotopic thorium by alpha spectroscopy. These analyses indicated equal concentrations of Th-232 and Th-228, confirming that the entire thorium series is in equlibrium in the off-site residues.

Water Samples

Water samples were rough filtered through Whatman No. 2 filter paper. Remaining suspended solids were removed by a filtration through 0.45 µm pore size membrane filters. The filters, together with attached solids, were discarded; the filtrate was acidified by the addition of 20 ml of concentrated nitric acid.

Gross Alpha Analysis

Fifty milliliters of each sample was evaporated to dryness and counted on a Tennelec Model LB5100 low background proportional counter.

Gamma Spectrometry

Three and one half liters of each sample was placed in Marinelli beakers and analyzed by Ge(Li) gamma spectrometry using the same techniques as for soil samples.

Analysis not yet complete.

Radium-226/228 Analysis

Samples were analyzed for Ra-226 and 228 using the standard technique EPA 600/4-75-008 (Revised). (Procedures will be described in detail in the final report.)

*Polonium-210 and Lead-210

Radiochemical procedures were used for analysis of Po-210 and Pb-210. (Procedures will be described in detail in the final report.)

*Thorium and Uranium isotopic analysis

Alpha spectrometry analysis for Th-228, Th-232, U-234, U-235, and U-238 was performed by an outside analytical laboratory.

Vegetation Analysis

Gamma Spectrometry

Vegetation samples were air dried, chopped, and mixed. Aliquots were placed in 3.5 l Marinelli beakers and analyzed for identifiable photopeaks in the same manner described above for soil sample analysis.

Calibration and Quality Assurance

Laboratory analytical instruments are calibrated using NBS - traceable standards. Portable survey instruments for exposure rate and dose rate measurements are calibrated by comparison of their responses to those of other instruments having NBS - traceable calibration. Field comparisons or comparisons using samples typical of the area are used to develop these calibrations. Quality control procedures on all instruments included daily background and check-source measurements to confirm lack of malfunctions and nonstatistical deviations in equipment. The ORAU Laboratory participates in the EPA Quality Assurance Program.

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* *Analyses not yet complete.*

APPENDIX C

NRC GUIDELINES FOR CONCENTRATIONS OF THORIUM AND URANIUM IN SOIL

APPENDIX C

NRC Guidelines for Concentrations of Thorium and Uranium in Soil

On October 23, 1981, the Nuclear Regulatory Commission published in the Federal Register a notice of Branch Technical Position "Disposal or Onsite Storage of Thorium and Uranium Wastes from Past Operations." This document establishes guidelines for concentrations of uranium and thorium in soil, that will limit maximum radiation received by the public under various conditons of land usage. These concentrations are as follows:

Material	Maximum Concentrations (pCi/g) for various options*			
	1[a]	2[b]	3[c]	4[d]
Natural Thorium (Th-232 & Th-228) with daughters present and in equilibrium	10	50	—	500
Natural Uranium (U-238 & U-234) with daughters present and in equilibrium	10	—	40	200
Depleted Uranium:				
Soluble	35	100	—	1,000
Insoluble	35	300	—	3,000
Enriched Uranium:				
Soluble	30	100	—	1,000
Insoluble	30	250	—	2,500

[a] Based on EPA cleanup standards which limit radiation to 1 mrad/yr to lung and 3 mrad/yr to bone from ingestion and inhalation and 10 μR/h above background from direct external exposure.
[b] Based on limiting individual doses to 170 mrem/yr.
[c] Based on limiting equivalent exposure to 0.02 working level or less.
[d] Based on limiting individual doses to 500 mrem/yr and in case of natural uranium, limiting exposure to 0.02 working level or less.

Option 1 concentrations permit unrestricted use of the property and is the guideline applicable to surface soils in all areas. Options 2, 3, and 4 apply to buried wastes and assume possible intrusions into the burial

sites. The presence of wastes at these concentrations may require restrictions on property use. Regardless of the concentrations in the buried materials, surface soil must meet the Option 1 concentration guidelines.

For the Sheffield Brook area the soils must therefore meet the radionuclide guidelines of 10 pCi/g of natural thorium plus natural uranium.

APPENDIX 1

Measurements of Concentrations of Radioactive Materials in Soil

	^{226}Ra (^{238}U)	^{228}Ra (^{232}Th)
Average Soil, NCRP-45[1]	0.6 pCi/g	1 pCi/g
Soil from Farm	0.4 pCi/g ±.1	0.7 pCi/g ±.2
Soil at Residence	0.47 pCi/g ±.08	1.7 pCi/g ±.3
Soil from Contruction Firm	0.56 pCi/g ±.08	0.8 pCi/g ±.2
Average Soil, UNSCEAR[2]	0.3-1.4	0.2-1.3

[1]National Council on Radiation Protection Report No. 45, "Natural Background Radiation in the United States," 1975.

[2]United Nations Scientific Committee on the Effects of Atomic Radiation "Sources and Effects of Ionizing Radiation," 1977.

U. S. NUCLEAR REGULATORY COMMISSION

Region I

Report No. 99990001/82-03

Subject: Wayne, and Riverdale, New Jersey Surveys for Radioactive Material in Uncontrolled Locations

Inspection At: Wayne, New Jersey

Inspection Conducted: April 28 and May 13, 1982

Inspectors: M. Campbell, Radiation Specialist — 6/28/82 date signed

Approved By: M. Campbell for J. D. Kinneman, Chief, Materials Program Section No. 1 — 6/28/82 date signed

Inspection Summary: Inspection on April 28 and May 13, 1982

Areas Inspected: Measurements of environmental radiation levels in Wayne and Riverdale, New Jersey. This inspection involved 20 inspector hours by one region based inspector.

Results: There is one area of Wayne, New Jersey where radioactive material exist as contamination in uncontrolled areas which is not part of the Sheffield Brook area. This contamination is in a small spot on an industrial property. There is one other area where reported contamination could not be confirmed. This is in a landfill in Riverdale, New Jersey.

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DETAILS

1. Persons Contacted

Individual A
R. Mandel, Former Vice President, Rare Earths, Incorporated
P. Garino, Former Plant Chemist, Rare Earths, Incorporated
E. Fullard, Former Furnace Operator, Rare Earths, Incorporated

2. Background

In 1948, Rare Earths, Incorporated began processing ores to extract thorium. In 1957, the Davison Chemical Division of the W. R. Grace and Company bought the property belonging to Rare Earths, Incorporated in Wayne. Processing ceased in 1971. The thorium processing area was decontaminated between 1973 and 1974. In early 1975, the facility was released for unrestricted use by the NRC. In early 1981, onsite thorium contamination was surveyed and was found to be in excess of current decontamination limits. In November 1981, the report of an aerial survey showed offsite thorium contamination along the Sheffield Brook. NRC activities in this regard are documented in Report No. 99990001/81-21. In April, 1982, further surveys of the Sheffield Brook areas were conducted by Oak Ridge Associated Universities under contract with the NRC. This report covers surveys of areas which will not be included in the Oak Ridge Associated Universities report.

3. Measurements of Environmental Radiation Levels

a. Measurements of Radiation Levels at Nearby Farm

Immediately adjacent to the Sheffield Brook area is a farm where produce is grown for commercial sale. The aerial survey showed radiation levels in excess of background along the nearby Sheffield Brook. Although the aerial survey showed that most of this farm did not have radiation levels in excess of background, the resolution on the aerial survey results was sufficiently poor that the southeast portion of the farm was included in the area which showed higher than background radiation levels. This survey was to determine whether those radiation levels were from the Sheffield Brook area. On April 28, 1982, an NRC inspector performed radiation level measurements with a Ludlum 12S micro R meter and took a sample of the soil from the farm. The measurements with the micro R meter showed no radiation levels in excess of background. Analysis of the soil sample performed in the Region I laboratory showed background concentrations of naturally occurring radioactive material (Appendix 1).

b. Surveys of Residence Adjacent to W. R. Grace and Company Property

On April 28, 1982, an NRC inspector performed surveys of the residential property immediately adjacent to the W. R. Grace and Company property at the request of the residents. No radiation levels in excess of

0.035 mR/hr were measured on the edge of this property. Radiation levels in the portion of the yard not obstructed by weeds were less than 0.020 mR/hr. A sample of the soil from the vegetable garden at this residence showed background concentrations of naturally occurring radioactive material (Appendix 1). Further surveys on this property will be conducted by Oak Ridge Associated Universities in July, 1982.

c. Measurements of Radiation Levels at Nearby Construction Company

On April 28, 1982, an inspector performed measurements of radiation levels at a contracting firm which stores top soil and other building materials near the Sheffield Brook area. No radiation levels above background were observed near the building materials used by this contracting firm. A sample of the construction materials showed background concentrations of naturally occurring radioactive materials (Appendix 1). One area measuring 1 mR/hr was discovered on the ground where the earth moving equipment is stored. A sample of the soil from this location was taken by Oak Ridge Associated Universities. The results of the analysis of the sample will be included in their report.

d. Measurements of Radiation Levels at Reported Dump in Riverdale, New Jersey

On May 11, 1982, the Region I office was contacted by Individual A, who claimed that he had been employed by Rare Earths, Incorporated. He stated that he had been assigned to dump quantities of "thorium waste" in an area in Riverdale, New Jersey which was being used as an unauthorized dump site during the mid-fifties. On May 13, 1982, an NRC inspector met with this individual and visited the area where the individual claimed to have dumped this material. The area is along Route 23 at the circle where Route 23 intersects Route 511. Measurements of surface radiation levels showed no radiation levels in excess of 0.015 mR/hr. The area had evidently been used to dump industrial and other wastes but there was no evidence of radioactive materials.

On June 3, 1982, the inspector interviewed the former vice president of Rare Earths, Incorporated by telephone. He stated that the area near the Riverdale Circle had been used for disposal of barium sulfate resulting from processing bastnasite ore for rare earths. He stated that the bastnasite ore may have contained some thorium but that it would have contained much less than monazite sand. He noted that the bastnasite ore contained approximately 15% rare earth oxides, whereas monazite sand contained 60% rare earth oxides, and that the Atomic Energy Commission only required licensure for the monazite sand. He stated that he recalled that during the mid-fifties, Rare Earths, Incorporated processed both bastnasite ore and monazite sand, and that all of the wastes from the monazite processing were disposed of on the property in Wayne, New Jersey.

The inspector interviewed the former plant chemist for Rare Earths, Incorporated by telephone. He stated that he had worked for Rare Earths, Incorporated in the mid-fifties. He recalled that both bastnasite ore and monazite sand were processed, but he did not recall disposal of any materials offsite.

The inspector also interviewed the former furnace operator for Rare Earths, Incorporated by telephone. He confirmed that he was employed by Rare Earths, Incorporated during the mid-fifties. He remembered that material had been transported offsite for disposal. He was not sure which material(s) were disposed of offsite, but he thought that it may have been the residual sludge from the processing of monazite sand. He recalled that at one point he and the vice president worked down 25 pounds of the sludge to determine if they could profitably extract thorium, but that the result was about "one pea" of material.

OCT 2 7 1982

Docket No. 40-00086 License No. STA-422

SGL Industries
76 Euclid Avenue
Haddonfield, New Jersey 08033

Gentlemen:

Earlier this year this office requested permission to conduct surveys on property owned by you in Wayne, New Jersey. Enclosed is a copy of the Final Report, Radiological Survey of Sheffield Brook, Wayne, New Jersey, dated October, 1982. This report does not include the results of surveys and measurements made on the W. R. Grace and Company property on Black Oak Ridge Road. These results will be the subject of an additional report.

If you have any questions concerning this report, you may call me at (215) 337-5252.

Sincerely,

Original Signed By:

John D. Kinneman, Chief
Nuclear Materials Section A

bcc w/encl:
Region I Docket Room (with concurrences)

RI:DETP
Kinneman/gwc
10/27/82

OFFICIAL RECORD COPY

W.R. Grace
Docket file

December 6, 1982

John D. Kinneman, Chief
Materials Program Section No. 1
U.S. Nuclear Regulatory Commission
Region 1
631 Park Avenue
King of Prussia, PA 19406

Dear Mr. Kinneman,

For your information, enclosed please find report submitted by Dr. M. Resnikoff, Consultant, regarding the surveys of Sheffield Brook by the NRC and the DEP.

Sincerely,

Arthur R. Bartolozzi
Health Officer

November 30, 1982

MEMO

TO: Mayor W. Jasinski, Town Council, A. Bartolozzi

FROM: M. Resnikoff, consultant on thorium contamination

RE: Radiological Surveys of Sheffield Brook by the Nuclear Regulatory Commission and the New Jersey Department of Environmental Protection

In this memo, the Nuclear Regulatory Commission (NRC) and New Jersey Department of Environmental Protection (DEP) reports on radiological surveys of Sheffield Brook are critically reviewed and recommendations offerred to the Town Council for its consideration.

On October, 1982, both the NRC and DEP released reports of radiological surveys of Sheffield Brook taken Spring, 1982. This followed aerial surveys taken May, 1981 by EG & G, and preliminary ground measurements taken by the NRC November, 1981. One report is due December, 1982, an NRC radiological survey of the Grace & Co. property.

The final NRC report, virtually identical to the preliminary report released July, 1982 and confirmed by the DEP report, shows that Sheffield Brook is contaminated with radioactive materials, thorium and its decay products. This contamination extends the length of Sheffield Brook, about 700 meters (from the Grace property at Black Oak Ridge Road, to the Pompton River), up to 70 meters in width and one meter in depth. The levels of contamination are above the EPA interim cleanup standards and also above NRC guidelines. According to the NRC, approximately 13,000 cubic meters of contaminated earth would have to be removed to reduce radiation levels to NRC guidelines. Despite the request of the Town of Wayne, neither the NRC nor DEP offer recommendations on what to do with this contamination which presently exceeds legal limits. Neither the federal agencies (NRC and DOE) nor Grace & Co. have assumed responsibility for the cleanup, nor proferred a plan with fixed goals and timelines. If the federal agencies perform the cleanup, Congress would have to appropriate the money, presumably according to an NRC or DOE recommended plan. The Mayor, Committee of the Town Council, or Town Attorney, should enter into informal negotiations with the federal agencies and the office of Representative Roe on a cleanup plan.

Water Contamination Levels

People are primarily affected by radioactivity from Sheffield Brook/ Grace property in two ways: by direct exposure near the site and through ingestion of contaminated water. While the reports show that radioactive concentrations in water are below drinking water standards (the most restrictive standard), the levels downstream of the Grace property are much higher than up stream levels indicating that radioactivity is leaching from the site and the soil by Sheffield Brook.

DEP sampling shows gross alpha radioactivity upstream of the Grace property (W1) as 0.68 pCi/l, and leaving the Grace property (entering the sewer lines, W13) as 5.67 pCi/l. See Figure 1 for the location of sampling locat-

ions. It therefore appears that the radioactivity concentrations increase due to surface drainage from the Grace site.

The surface drainage then enters an underground sewer line upon leaving the Grace property. Two sewer lines feed into the Grace property drainage and dilute the radioactivity levels. In moving further downstream, the radioactivity levels in Sheffield Brook again increase. This information is summarized in Table 1 below, the DEP measuring points being shown in Figure 1.

The NRC measurements are, in general, higher than those of DEP. For example, the radioactivity concentrations of the drainage ditch leaving the Grace & Co. property are 5.67 pCi/l (W13, DEP) versus 29 pCi/l (#8,NRC). The reason for this discrepancy is not clear since the methods are virtually identical. The NRC report did not list radioactivity measurements upstream of the Grace & Co property. Perhaps the December NRC report will have this information.

In sum, while the radiation levels in water are below EPA standards, measurements by DEP show unmistakable leaching of radioactivity, primarily radium-228 which is more soluble. This leaching is from both the Grace property and from property downstream. The NRC measurements show radioactivity concentrations at the drainage ditch leaving the Grace property above the EPA drinking water standards.

Direct Radiation Exposure Levels

The radioactivity released from the Grace property via Sheffield Brook over the years has washed over an extended area, and has been dredged onto the stream banks. This radioactivity emanates from thorium-232 and its decay products, some of which emit gamma radioactivity, causing whole body radiation exposures. The levels near Pompton Plains Cross Road range from 6 to 10 μR/h (background levels) up to 420 μR/h near Sheffield Brook, or about 40 times background. The band of land about Sheffield Brook with these higher than background levels is about 50 meters in width.

West of Farmingdale Road the radiation levels are lower and the band of land with greater than background radioactivity has a width 10 to 20 meters.

Do these levels exceed radiation standards? A range of standards, along with different methods of interpretation, exist. According to the NRC, no individual member of the general public is to receive more than 500 millirems per year (mr/y) (57 μR/h, assuming continual occupation). For an operating nuclear fuel cycle facility, the fencepost dose limit is 25 millirems per year. The guideline for a nuclear reactor is 5 mr/y. For inactive uranium mill tailings sites, a situation most closely resembling Wayne, the external exposure rate limit is equivalent to 10 μR/h. According to DEP, this latter value is exceeded in an area greater than 18,000 m^2 surface area along Sheffield Brook, from the Grace property to the Pompton River.

Soil Measurements

The levels of radioactivity in soil (in units of picocuries per gram, pCi/g) vary from background up to 722 pCi/g. Baseline soil measurements in

the Wayne area vary from 0.58 pCi/g to 1.6 pCi/g. Clearly, the levels near Sheffield Brook exceed this natural radioactivity by a wide margin. The general surface area of higher than natural background thorium-228 closely parallels the area where higher radiation exposures occur.

The EPA standards for remedial action are 5 pCi/g for radium-226. The NRC criteria, set in 1981, is 5 pCi/g for thorium-232 for unrestricted use, which corresponds to a direct exposure rate of 10 μR/h above background. The levels along Sheffield Brook greatly exceed these levels. DEP estimates that a surface area of 18,000 m^2 would not meet these criteria. The NRC estimates that about 13,000 cubic meters of soil would have to be removed to reach a concentration limit of 10 pCi/g.

NRC Hazard Evaluation Faulty

While the NRC has declined to state whether or not Sheffield Brook should be decontaminated, its views on the hazard level and its understanding, are clearly stated in Appendix E. To determine the hazard, the NRC estimates the length of time a person would be exposed to radiation at Sheffield Brook, the exposure per year received, and the increased cancer risk incurred. One could disagree over details such as the amount of radiation exposure and the risk of low level ionizing radiation, but before entering into such a discussion, it is important to recognize that the NRC has changed the rules of the game at Wayne. At reactors or fuel cycle facilities, one customarily calculates a fence post dose to a hypothetical individual who spends 24 hours per day in residence. This dose must be less than 5 mr/y for a reactor and 25 mr/y for a fuel cycle facility. At Wayne such calculations would yield a dose up to 3700 mr/y from direct exposure alone, much higher than the limit of 500 mr/y. The NRC therefore takes a 10% occupancy factor, reducing the highest level to 370 mr/y, below the 500 mr/y limit. Second, the definition of the term "unrestricted release" has also been altered to fit the circumstances at Wayne. Customarily, when the NRC releases a site for "unrestricted" use, this implies that neither the former licensee nor the NRC would need to monitor and inspect the site. The Grace property and Sheffield Brook are in this category - no licenses are being held. While the NRC assumes an "occupancy factor" of 10%, they have no way of ensuring compliance. Property can be sold and uses will change over the long time periods that this radioactive material will remain toxic. Any future landowner or child can use the site as he or she wishes.

The NRC also compares the Wayne site to Florida (phosphate rock, 80 pCi/g) and Tennesee (bituminous rock, 30-50 pCi/g). These are natural rock formations that are not the result of human activities. However, in Wayne, monazite sands were imported from overseas and other outside areas, and processed at Wayne. The residues left at Wayne are the result of human activities in transporting and processing these sands.

It is important to recognize that a radioactive dump was created at Wayne without proper findings being made by the AEC. No analysis was performed by AEC Staff to evaluate the suitability of the Grace property for final disposal of thorium residues. No effective control was exercised by the AEC in preventing the Sheffield Brook area from becoming contaminated. The NRC has a conflict of interest in judging, in retrospect, whether proper findings were originally made and whether the site is hazardous.

Table 1. Radioactivity Concentrations in Water Samples

Sample No.	Location Description	Gross Alpha (pCi/l)	Comments
W_1	Sheffield Brook upstream of Grace property	0.68	
W_{13}	Sheffield Brook leaving Grace Property	5.67	radioactivity concentrations increase in passing over Grace property
W_2	Sheffield Brook at Pompton Plains Cross Road	1.69	radioactivity concentrations diluted by two additional sewer lines
W_3	Sheffield Brook, 50 meters north of Farmingdale Road	2.10	
W_4	Confluence of Sheffield Brook and Pompton River	9.22	radioactivity concentrations continue to increase in passing over contaminated soil

Data from DEP radiological survey

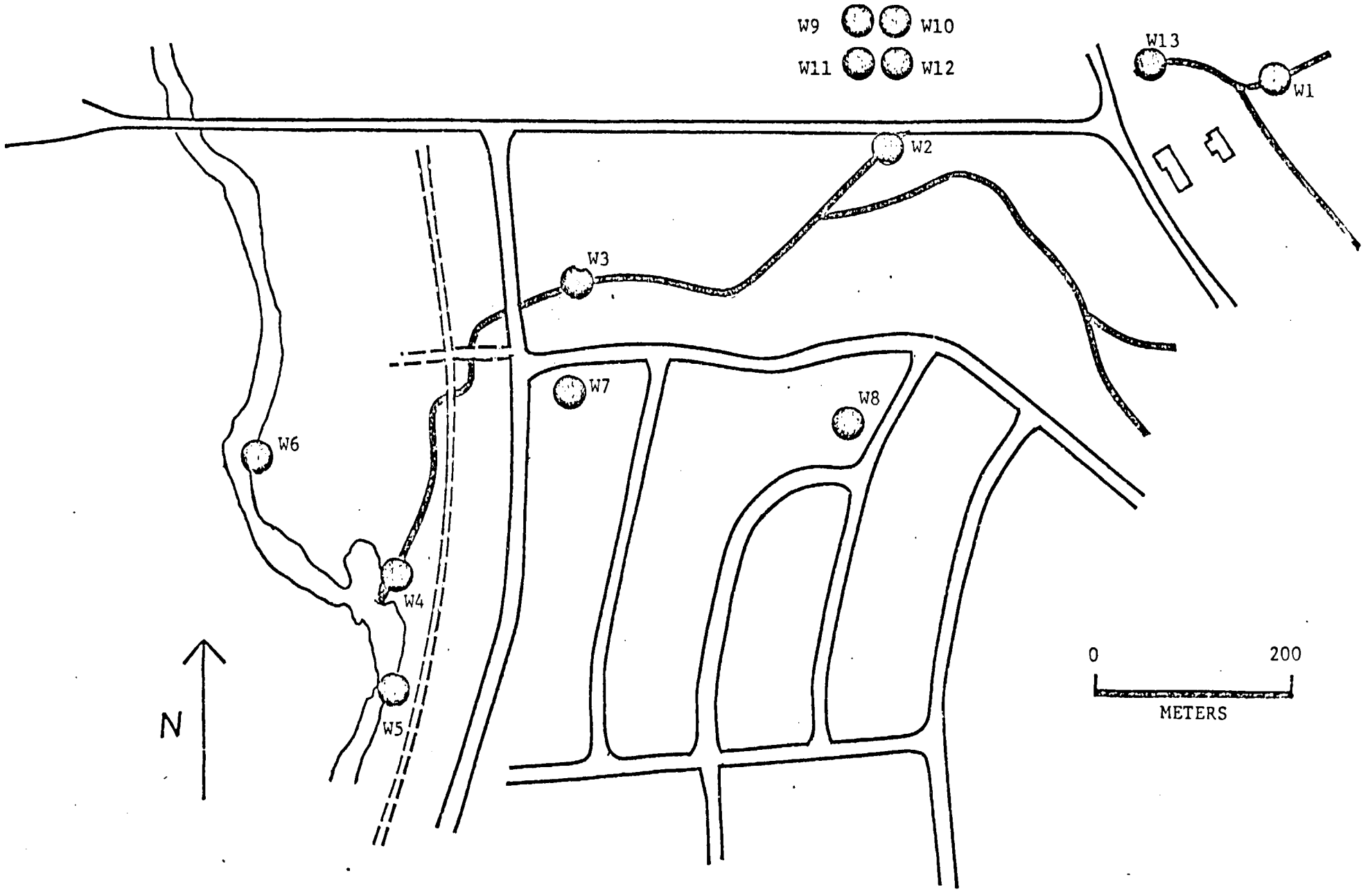

FIGURE 1: WATER SAMPLING LOCATIONS

From DEP radiological survey

GUIDELINES FOR DECONTAMINATION OF FACILITIES AND EQUIPMENT PRIOR TO RELEASE FOR UNRESTRICTED USE OR TERMINATION OF LICENSES FOR BYPRODUCT, SOURCE, OR SPECIAL NUCLEAR MATERIAL

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

July 1982

ITEM # 564

43

(6)

GUIDELINES FOR DECONTAMINATION OF FACILITIES AND EQUIPMENT PRIOR TO RELEASE FOR UNRESTRICTED USE OR TERMINATION OF LICENSES FOR BYPRODUCT, SOURCE, OR SPECIAL NUCLEAR MATERIAL

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

November 1976

ITEM # _____

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

1. The licensee shall make a reasonable effort to eliminate residual contamination.

2. Radioactivity on equipment or surfaces shall not be covered by paint, plating, or other covering material unless contamination levels, as determined by a survey and documented, are below the limits specified in Table I prior to applying the covering. A reasonable effort must be made to minimize the contamination prior to use of any covering.

3. The radioactivity on the interior surfaces of pipes, drain lines, or ductwork shall be determined by making measurements at all traps, and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or ductwork. Surfaces of premises, equipment, or scrap, which are likely to be contaminated but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement shall be presumed to be contaminated in excess of the limits.

4. Upon request, the Commission may authorize a licensee to relinquish possession or control of premises, equipment, or scrap having surfaces contaminated with materials in excess of the limits specified. This may include, but would not be limited to, special circumstances such as razing of buildings, transfer of premises to another organization continuing work with radioactive materials, or conversion of facilities to a long-term storage or standby status. Such request must:

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

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

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

   a. Identify the premies.

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

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

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

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

Table II-1. Acceptable surface contamination levels

Nuclides[a]	Average[b,c,f]	Maximum[b,d,f]	Removable[b,e,f]
U-nat, U-235, U-238, and associated decay products	5,000 dpm α/100 cm²	15,000 dpm α/100 cm²	1,000 dpm α/100 cm²
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/100 cm²	300 dpm/100 cm²	20 dpm/100 cm²
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000 dpm/100 cm²	3,000 dpm/100 cm²	200 dpm/100 cm²
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except SR-90 and other noted above	5,000 dpm βγ/100 cm²	15,000 dpm βγ/100 cm²	1,000 dpm βγ/100 cm²

[a] Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

[b] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

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

[d] The maximum contamination level applies to an area of not more than 100 cm².

[e] The amount of removable radioactive material per 100 cm² of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

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

Distribution:
EDO 12470
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PDR
CA
Docket No. 40-00086
R. DeYoung
J. Davis
G. Kerr
G. Cunningham
L. Underwood
J. Allan, RI
R. Haynes, RI
T. Martin, RI
J. Kinneman, RI
J. Joyner, RI
Region I Docket File

W.R. Grace
Docket file
(10)

OCT 2 7 1982

Willowbrook Nursing Home
897 Black Oak Ridge Road
Wayne, New Jersey 07470

Gentlemen:

Subject: Radiological Surveys of Sheffield Brook, Final Report

Enclosed for your information is a copy of the subject report. This report does not contain the results of measurements made on the W. R. Grace and Company property on Black Oak Ridge Road in Wayne. These measurements will be the subject of a separate report.

If you have any questions concerning this report you may call me at (215) 337-5252.

Sincerely,

Original Signed By:

John D. Kinneman, Chief
Nuclear Materials Section A

Enclosure: As stated

bcc:
Region I Docket Room (w/concurrences)

RI:DETP
Kinneman/gwc
10/27/82

OFFICIAL RECORD COPY

ITEM # 584

C14

OCT 2 7 1982

Docket No. 40-00086 License No. STA-422

Township of Wayne
ATTN: Honorable Walter Jasinski
Mayor
475 Valley Road
Wayne, New Jersey 07470

Gentlemen:

Subject: Radiological Surveys of Sheffield Brook, Final Report

Enclosed for your information is a copy of the subject report. This report does not contain the results of measurements made on the W. R. Grace and Company property on Black Oak Ridge Road in Wayne. These measurements will be the subject of a separate report.

If you have any questions concerning this report you may call me at (215) 337-5252.

Sincerely,

Original Signed By:

John D. Kinneman, Chief
Nuclear Materials Section A

Enclosure: As stated

cc w/encl:
Joseph DiDonato, President, Municiple Council
John Leidy, Business Administrator
Arthur Bartolozzi, Health Officer

bcc:
Region I Docket Room (w/concurrences)

RI:DETP
Kinneman/gwc
10/27/82

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ITEM # 585

c/s

OCT 2 8 1982

Docket No. 40-00086 License No. STA-422

Township of Wayne
ATTN: John Leidy
Business Adminstrator
475 Valley Road
Wayne, New Jersey 07470

Gentlemen:

On September 23, 1982 a NRC Region I inspector visited the site where dredging of the Pompton River has occurred near the west bank, north of the cove where Sheffield Brook enters the River. Samples of the material dredged from the River were taken by the inspector and were analyzed in our laboratory. These samples showed no detectable radioactivity above normal background. Radiation levels measured on the bank near the area of the dredging and on the sand-gravel removed from the river are indicative of normal background radiation levels.

We hope this information and the attached report will be helpful to you in discussing this matter with the citizens of the Township of Wayne.

Sincerely,

Original Signed By:

John D. Kinneman, Chief
Nuclear Materials Section A

Enclosure: Region I Report No. 99990001/82-12

cc w/encl:
W. R. Grace and Company
Davidson Chemical Division
ATTN: Mr. Burton Mobley
Manager, Environmental Control
P. O. Box 2117
Baltimore, Maryland 21203

Public Document Room (PDR)
Nuclear Safety Information Center (NSIC)
State of New Jersey

bcc w/encl:
Region I Docket Room (with concurrences)
J. Suermann, OCA
RI:DE&TP
Kinneman/cgl

10/27/82

RI:DE&TP
Johansen
10/27/82

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ITEM # 570

U. S. NUCLEAR REGULATORY COMMISSION
REGION I

Report No. 99990001/82-12

Docket No. 40-00086

License No. STA-422 Priority IV Category E

Licensee: W. R. Grace and Company

Wayne, N. J.

Facility Name: W. R. Grace

Inspection At: West Bank of Pompton River North of Sheffield Brook

Inspection Conducted: September 23, 1982

Inspectors: _____ _____
J. Johansen, Radiation Specialist date

_____ _____
date

_____ _____
date

Approved by: _____ 10/25/82
John D. Kinneman, Chief, Nuclear Materials, Section A date

Inspection Summary:
Inspection on September 23, 1982 Special inspection limited to determination of radiation levels and gathering of samples of material dredged from near the west bank of the Pompton River north of the cove where the Sheffield Brook enters on the east bank of the River and interviews with representatives of the construction company performing the dredging. The inspection involved 3 hours on site by one NRC inspector.
Results: No radioactivity other than normal background was detected in the samples analyzed. Radiation levels measured were indicative of area background.

Region I Form 12
(Rev. February 1982)

1. Persons Contacted

A. Mr. Patrick Krammer, Ferro Construction Co.

B. Mr. David M. Kulp, Ferro Construction Co.

C. Mr. Jack VanLenten, Ferro Construction Co.

2. Background

NRC Region I was notified by Mr. John Leity, Manager of Wayne Township, New Jersey that the Pompton River was being dredged in an area near Sheffield Brook. Citizens of Wayne had expressed concern that the dredging of the Pompton River near Sheffield Brook might result in spreading of radioactive thorium.

3. Investigation

On September 21, 1982 individual A stated to the inspector during a telephone conversation that dredging of the Pomptom River had occurred only on the west side of the river, north (upstream) of the cove where Sheffield Brook enters the Pompton River. He stated that the individuals who performed the work should be at the site around 9:00 a.m. on September 23, 1982.

On September 23, 1982, the inspector observed that there was evidence of dredging along the west bank of the Pompton River south of the Jackson Avenue Bridge (Pompton Plains Cross Road). No evidence of dredging could be seen either along the east bank of the river north of the cove where Sheffield Brook enters the river, or within and south of the cove along the east and west banks of the river (See Attachment 1).

The inspector talked with individuals B and C at the dredging site. They confirmed the information given the inspector and stated that they had performed the dredging and removal of the material (sand-gravel) from the west side of the Pompton River. They took the inspector to an area on the north side of Jackson Avenue and pointed out piles of sand-gravel which had come from the west side of the river, north of the cove.

4. Measurements and Samples

Measurements of radiation levels along the west bank of the River where dredging had taken place and at the sand-gravel pile north of Jackson Avenue did not exceed 10 micro R per hour as measured with a Ludlum Model 12S micro R meter, calibrated August 25, 1982.

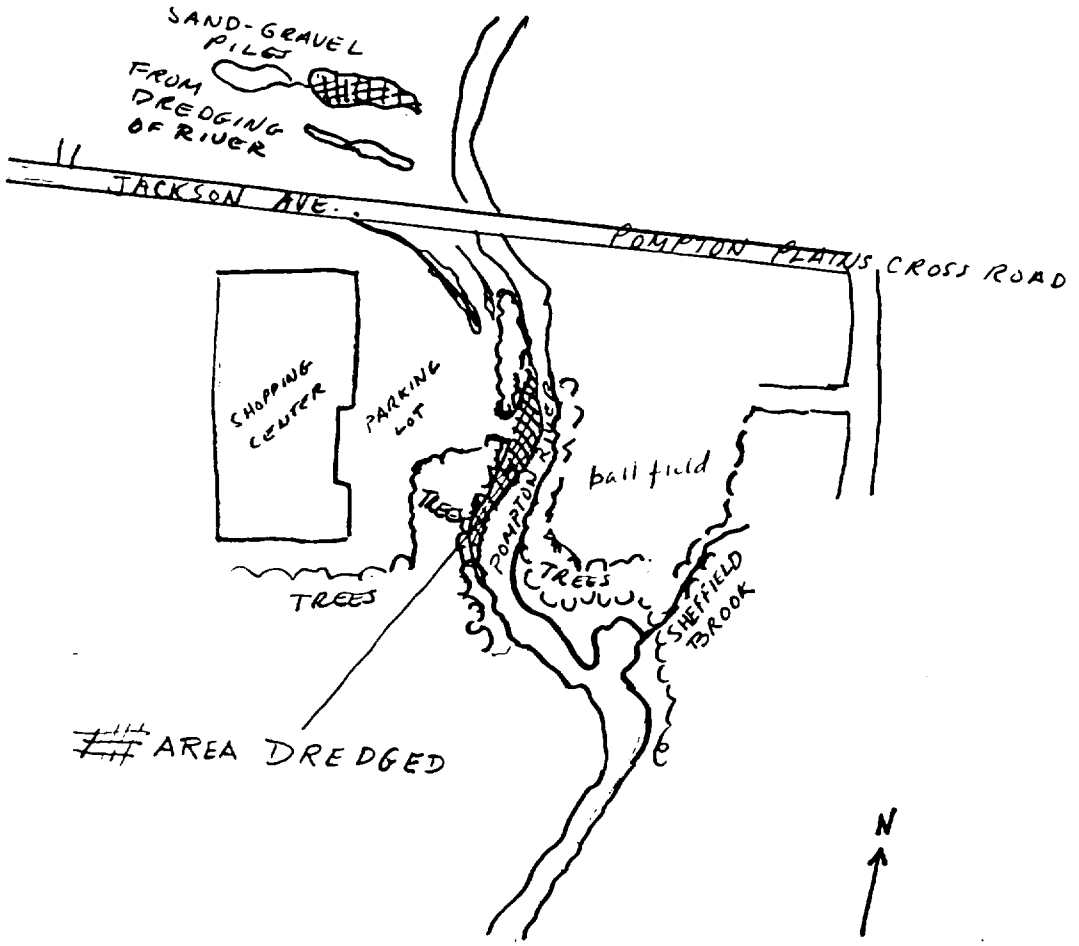
Five sand-gravel samples were taken from various places on the sand piles and one sample was taken from the west bank of the river as far south as evidence indicated dredging had occurred. The samples were returned to Region I for analysis.

5. Sample Analysis Results

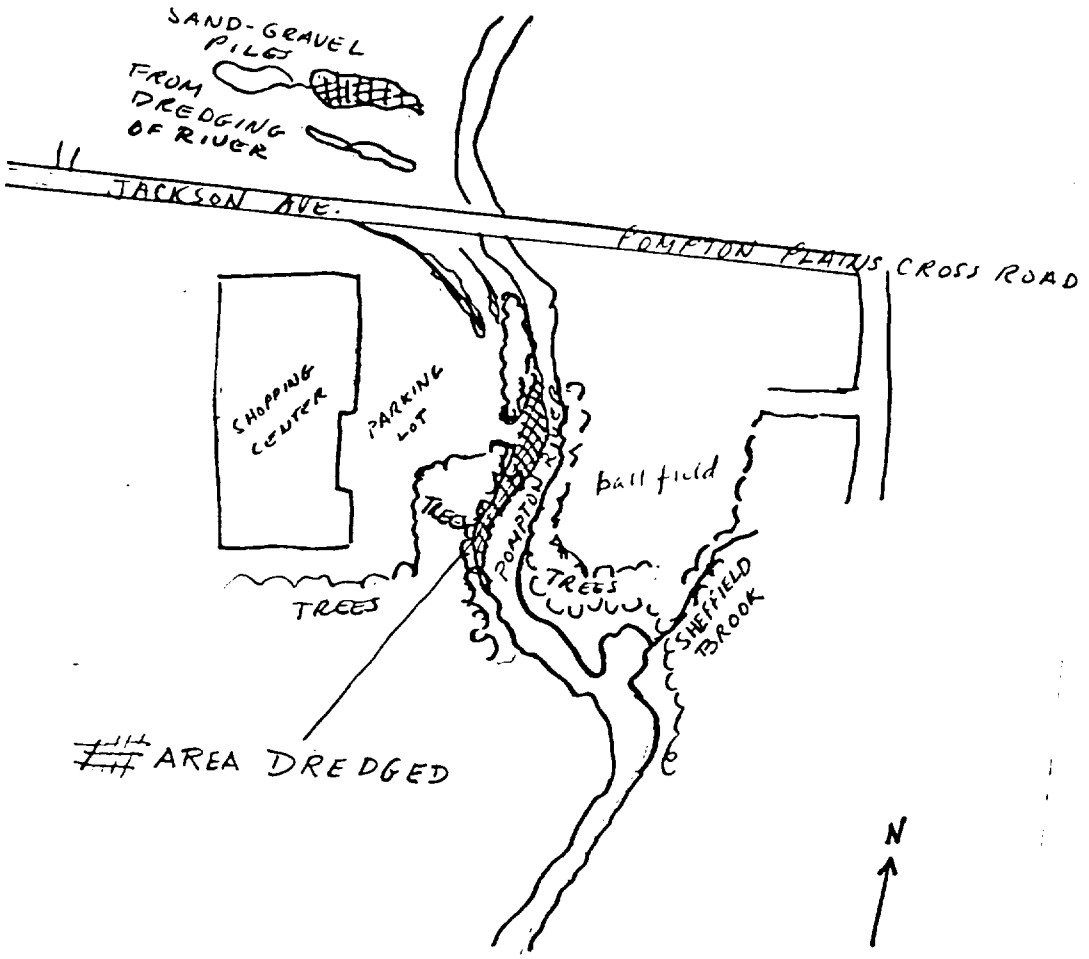
All six soil samples were analyzed for radioactivity using a GeLi detector coupled with a computer based multi channel analyzer in the Region I Laboratory. No radioactivity above normal background was detected in these samples.

6. Conclusion

No thorium was identified as a result of the dredging of the west bank of the Pompton River north of the cove where Sheffield Brook enters the river. Radiation levels measured were indicative of background radiation of the area.



ATTACHMENT #1
Report No. 99990001/82-12



ATTACHMENT #1
Report No. 99990001/82-12

OCT 2 9 1982

Docket No. 40-00086 License No. STA-422

Mr. Dan Casey
c/o Senator Nick Brady
Rm. 939A
970 Broad Street
Newark, New Jersey 07102

Gentlemen:

Subject: Radiological Surveys of Sheffield Brook, Final Report

Enclosed for your information is a copy of the subject report. This report does not contain the results of measurements made on the W.R. Grace and Company property on Black Oak Ridge Road in Wayne. These measurements will be the subject of a separate report.

If you have any questions concerning this report you may call me at (215) 337-5252.

Sincerely,

for John D. Kinneman, Chief
Nuclear Materials Section A

Enclosure:
As stated

bcc:
Region I Docket Room (w/concurrences)

ITEM # 572

OFFICE	RI:DETP						
SURNAME	Kinneman						
DATE	10/27/82						

NRC FORM 318 (10-80) NRCM 0240 OFFICIAL RECORD COPY

OCT 2 9 1982

Docket No. 40-00086 License No. STA-422

Dr. Marvin Resnikoff
c/o The Council on Economic Priorities
84 5th Avenue
New York, New York 10011

Gentlemen:

Subject: Radiological Surveys of Sheffield Brook, Final Report

Enclosed for your information is a copy of the subject report. This report does not contain the results of measurements made on the W.R.Grace and Company property on Black Oak Ridge Road in Wayne. These measurements will be the subject of a separate report.

If you have any questions concerning this report you may call me at (215) 337-5252.

Sincerely,

ORIGINAL SIGNED BY
JACK DAVIS

John D. Kinneman, Chief
Nuclear Materials Section A

Enclosure:
As stated

bcc:
Region I Docket Room (w/concurrences)

ITEM # 571

OFFICE	RI:DETP						
SURNAME	Kinneman						
DATE	10/ /82						

NRC FORM 318 (10-80) NRCM 0240 OFFICIAL RECORD COPY USGPO 1981—335-960

OCT 2 9 1982

Docket No. 40-00086 License No. STA-422

John O'Brien
Township Clerk
City Hall
475 Valley Road
Wayne, New Jersey 07470

Gentlemen:

Subject: Radiological Surveys of Sheffield Brook, Final Report

Enclosed for your information is a copy of the subject report. This report does not contain the results of measurements made on the W.R. Grace and Company property on Black Oak Ridge Road in Wayne. These measurements will be the subject of a separate report.

If you have any questions concerning this report you may call me at (215) 337-5252.

Sincerely,

Original Signed By:
JACK DAVIS
for John D. Kinneman, Chief
Nuclear Materials Section A

Enclosure:
As stated

bcc:
Region I Docket Room (w/concurrences)

ITEM # 577 19

OFFICE	RI:DEIP						
SURNAME	Kinneman						
DATE	10/29/82						

NRC FORM 318 (10-80) NRCM 0240 OFFICIAL RECORD COPY USGPO: 1981—335-9

OCT 2 9 1982

Docket No. 40-00086 License No. STA-422

Mr. Dennis Marco
c/o Senator Bill Bradley
P.O. Box 1720
Union, New Jersey 07083

Gentlemen:

Subject: Radiological Surveys of Sheffield Brook Final Report

Enclosed for your information is a copy of the subject report. This report does not contain the results of measurements made on the W.R. Grace and Company property on Black Oak Ridge Road in Wayne. These measurements will be the subject of a separate report.

If you have any questions concerning this report you may call me at (215) 337-5252.

Sincerely,

for John D. Kinneman, Chief
Nuclear Materials Section A

Enclosure:
As stated

bcc:
Region I Docket Room (w/concurrences)

ITEM # 566 4/10

OFFICE ▶	RA:DETP						
SURNAME ▶	Kinneman						
DATE ▶	10/29/82						

NRC FORM 318 (10-80) NRCM 0240 OFFICIAL RECORD COPY USGPO 1980—329

Distribution:
Docket 40-86
NMSS R/F
FCUP R/F
WTCrow
RGPage

JKinneman
Region I

NOV 12 1982

Dr. William Mott
Public Safety Division
Office of Operational Safety (EP323)
U. S. Department of Energy
Washington, D. C. 20545

Dear Dr. Mott:

Enclosed are three additional copies of the Radiological Survey Report of Sheffield Brook in Wayne, New Jersey. Five copies were previously hand-carried to your office. The survey report of the W. R. Grace plant site will be sent to you some time in January 1983, when it is completed.

Unless we hear differently, we will assume that any remedial action related to either Sheffield Brook or the W. R. Grace site will be included in DOE's Formerly Utilized Site Remedial Action Program, as you indicated in your April 21, 1982, letter to me.

Sincerely,

(Signed) RGP

R. G. Page, Chief
Uranium Fuel Licensing Branch
Division of Fuel Cycle and
Material Safety, NMSS

Enclosures: As stated

cc: B. Mobley, W. R. Grace Company

4/11

ITEM # 568

OFFICE	FCUP	FCUP					
SURNAME	WTCrow/lt	RGPage					
DATE	11/12/82	11/ /82					

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF ENVIRONMENTAL QUALITY
BUREAU OF RADIATION PROTECTION
380 SCOTCH ROAD. TRENTON. N. J. 08628

Nov 12, 1982

To John Kunneman -

The attached report contains an Addendum with our Ra-226 in water analyses.

Jeanette Eng

12/26/82

Sorry about that. Onsite report should be done in Jan.

C/12

ITEM # 576

45

TABLE OF CONTENTS

TABLE OF FIGURES AND TABLES

Members of the Bureau of Radiation Protection
who participated in this study:

Jeanette Eng
Joseph Morris
Frederick Rauch
Kent Tosch
Duncan White

ADDENDUM

In November 1982, the radium analyses of water samples W2, W4, and W13 were completed. The following radium-226 concentrations should be added to Column 5 of page 26.

Sample No.	Radium 226
W2	0.22 ± 0.10 pCi/l
W4	0.52 ± 0.10 pCi/l
W13	0.43 ± 0.10 pCi/l

RADIOLOGICAL SURVEY
OF
SHEFFIELD BROOK
WAYNE, NEW JERSEY

OCTOBER, 1982

Site Decontamination Assessment Section
Bureau of Radiation Protection
New Jersey Department of Environmental Protection

RADIOLOGICAL SURVEY

OF

SHEFFIELD BROOK

WAYNE, NEW JERSEY

MENT OF ENVIRONMENTAL PR

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State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF ENVIRONMENTAL QUALITY
JOHN FITCH PLAZA, CN 027, TRENTON, N. J. 08625

Enclosed is the New Jersey Department of Environmental Protection's report, Radiological Survey of Sheffield Brook, Wayne, New Jersey. The report contains the DEP's technical findings from the April/May 1982 survey of the Sheffield Brook area.

A comparison of the area's radiological condition and current property use to the radiological standards for the general public, show that it is unlikely that an individual would be exposed to radiation levels that exceed existing federal and state radiation standards. However, property use can change in the future which could result in individuals receiving radiation doses above these standards, therefore an evaluation of the surveyed area should be based on more stringent environmental standards.

A comparison of the area's radiological condition to the most conservative environmental standards indicates that future remedial actions should be considered for approximately 18,000 square meters in the Sheffield Brook area. A comparison of results of water samples taken during the survey show all water samples meet federal and state radiological standards established for drinking water. Air sampling shows radon-222 concentration to be within background levels for New Jersey.

Sincerely,

Steven G. Kuhrtz

Steven G. Kuhrtz, Director

A. INTRODUCTION

History

In 1948, Rare Earths, Incorporated, began its operation at the Wayne, New Jersey, site to extract thorium and rare earth compounds from ore. With the passage of the Federal Atomic Energy Act in 1954, Rare Earths, Inc., received an AEC (Atomic Energy Commission) license in 1954 to possess monazite ore. In 1956, Rare Earths, Inc., became affliated with the Davidson Chemical Company, a division of W. R. Grace and Company. Monazite processing activities continued under W. R. Grace through 1971.

Most of the monazite handled by Rare Earths/W. R. Grace were from Idaho, Australia, or Malaysia. Alluvial monazite sands containing typically 60% rare earth oxides and 3-4% thorium oxide were processed at this site. In the processing to extract rare earths and thorium, various waste streams were produced. Some of the wastes such as tailings, yttrium sludges, and sulphate residues were buried on-site. Sheffield Brook was the discharge point for treated liquid effluents.

In 1971, W. R. Grace ceased processing monazite ore and amended its AEC license for storage only. In 1975, after decommissioning of the site, the AEC terminated the storage license and released the site for unrestricted use, provided the land deed indicated that radioactive material is buried on the property.

In 1980, the New Jersey Department of Environmental Protection requested that an aerial survey be performed over the W. R. Grace facility in Wayne, New Jersey. The request was initiated by DEP to determine the radiological condition of former radiation facilities. The November 1981 report on the aerial survey performed in May 1981 by EG & G indicated elevated radiation levels at the plant site and an area west of the plant.[1] The U.S. Nuclear Regulatory Commission's preliminary field survey verified that elevated radiation levels existed along Sheffield Brook. It was determined that a more detailed radiological survey was needed to provide information on the extent and degree of the contamination. Radiological surveys of the off-site areas were performed in April and May 1982 by the Oak Ridge Associated Universities (ORAU) for the U.S. Nuclear Regulatory Commission and by the Bureau of Radiation Protection for the New Jersey Department of Environmental Protection.

N.J. DEP Radiological Survey

The radiological survey by DEP covered:

a. Measurement of gamma radiation with field instruments along Sheffield Brook and associated areas.

b. Measurement of radionuclide concentrations in soil samples and brook sediment samples.

c. Measurements of radioactivity in water samples from Sheffield Brook, Pompton River, and nearby wells.

d. Measurment of radon gas (Rn-222) concentration in air as a result of radium in soil.

The report is arranged such that sections on gamma radiation, soil samples, water samples, and air samples include sampling procedures, analytical technique, and data obtained. The final section of the report will compare the radiological data with radiological standards.

B. SITE DESCRIPTION

The study area is located in the western half of Wayne Township in Passaic County along Sheffield Brook, a tributary to the Pompton River. Sheffield Brook originates east of the W. R. Grace property at 868 Black Oak Ridge Road flowing in a westerly direction onto the Grace Property. A drainage ditch empties into the brook in the back (east section) of the property. The brook flows west from the Grace property via a conduit under the parking lot, reemerging 200 meters to the west on the south side of Pompton Plains Cross Road.

The Sheffield Brook, at this point, flows 200 meters southwesterly in a straight channel. Spoils from past dredging operations are found along the banks of the stream, especially the west bank. These berms are covered with heavy brush, but grass and trees become dominant at distances ten or more meters from the brook. Indication of past farming activities are evident in this area.

A tributary empties into the Sheffield, 75 meters south of the road, originating behind commercial buildings across the street from W. R. Grace.

At the end of the channel, the brook turns west and proceeds towards Farmingdale Road. On the south side of the brook, the terrain rises rapidly (approximately 20 feet elevation) under a cover of trees and shrubs. To the north, the land is wet and marshy, covered by tall grass.

West of Farmingdale Road, the brook turns south, navigates another 175 meters before emptying into the Pompton River. Along this stretch, soccer and ball fields are found to the west and a wooded area with elevated dirt path to the east.

An area subject to periodic flooding is located to the north of the brook (where it turns south past Farmingdale Road). This low area (two meters below the elevation of the dirt path) continues north for 125 meters under heavy brush. A conduit behind the pumping station on Farmingdale Road permits movement of water further north, continuing towards Pompton Plains Cross Road. It continues under the road, and north towards the spillway on the Pompton River.

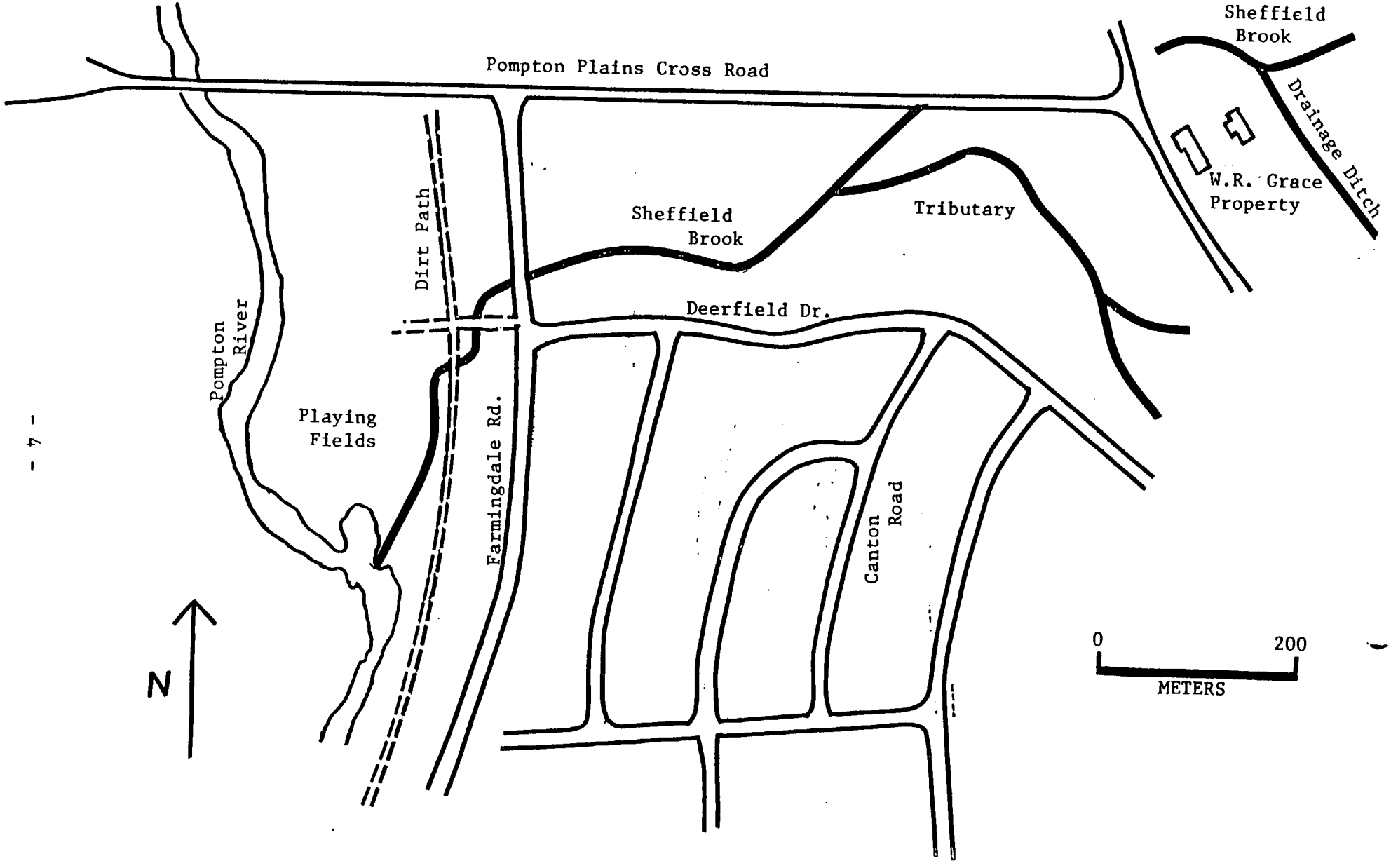

FIGURE 1: MAP OF SHEFFIELD BROOK AND VICINITY

C. FIELD MEASUREMENT OF GAMMA RADIATION LEVELS

Field Survey

A surface gamma radiation survey was performed along Sheffield Brook, its tributaries and related areas in order to determine the extent of the radiation contamination identified in the aerial survey. Over 38,000 m^2 of area west of W. R. Grace site was surveyed with a sodium iodide (NaI(Tl)) scintillometer (see Figure 1).

In conducting the survey, a center line was established along the main channel of Sheffield Brook. In areas not obstructed by heavy shrubbery and vegetation, ground level gamma radiation readings were taken every 10 meters (otherwise, 50 meter intervals) down the brook and at five meter intervals away from the brook. Readings were taken extending out 20 to 40 meters on each side at the brook, but in a few cases, extended beyond 100 meters until background readings were obtained.

Ground level measurements taken with a scintillometer were recorded in counts per minute (cpm). The scintillometer response to a uniform background gamma radiation field in the Wayne area was determined to be 1000 cpm. About 4000 field measurements were used to develop a map of the gamma radiation levels in Sheffield Brook area. Because of the large area surveyed, the map is divided into four parts (see Figures 2A, 2B, 2C and 2D).

The scintillometer was field calibrated over a range of gamma radiation fields against a pressurized ionization chamber. Consequently, the scintillometer count rates can be converted to exposure rates in microroentgens per hour (μR/hr). The conversion factor is 113 cpm = 1 μR/hr.

Field Survey Results

Ground level exposure rates ranged from 7 to 354 μR/hr. Higher readings (a maximum of 354 μR/hr) were found east of Farmingdale Road. Lower exposure rates (a maximum at 151 μR/hr) were found in areas west of Farmingdale Road.

In Figure 2A, the region with a maximum ground level rate of 354 μR/hr was found along a narrow berm on the west bank. This berm appears to have resulted from dredging operation at the brook. Exposure rates over 40 μR/hr are generally confined to the first ten meters on either side of the stream.

In Figure 2B, the highest exposure rates are confined to the northern bank in a low lying area to the west. As noted above, the highest exposure rate is 354 μR/hr. North of the brook, elevated exposure rates extended 30 to 40 meters. South of the brook, exposure rates drop off rapidly because of the steep enbankments. Residential homes at the top of the enbankment are consequently exposed only to natural background rates. Commercial structures located north of the brook are also in an area of background levels.

To the west at Farmingdale Road, three small regions exceeded 90 μR/hr. Following the brook to the south of the access road (Figure 2C), contamination was limited to the first 10 meters along east and west banks at the brook. The maximum exposure rate of 151 μR/hr was found on a small mound just south of the access road on the west bank.

The long narrow strip of contamination seen in Figure 2D is a drainage ditch originating at Sheffield Brook heading north through a conduit behind the pumping house toward Pompton Plains Cross Road. This is bordered to the west by a dirt path and is generally two meters lower than the path. Exposure rates ranged from 115 μR/hr at Sheffield Brook to 17 μR/hr at Pompton Plains Cross Road. The drainage ditch continues north under Pompton Plains Cross Road where a small area with a maximum rate of 26 μR/hr was found. Also in Figure 2D, a small area north at the access road and west of the dirt path is fed by a conduit where a maximum rate of 35 μR/hr was found. The only contamination found on the playing fields was an area around the soccer goal closest to the access road. A maximum exposure rate of 22 μR/hr was measure.

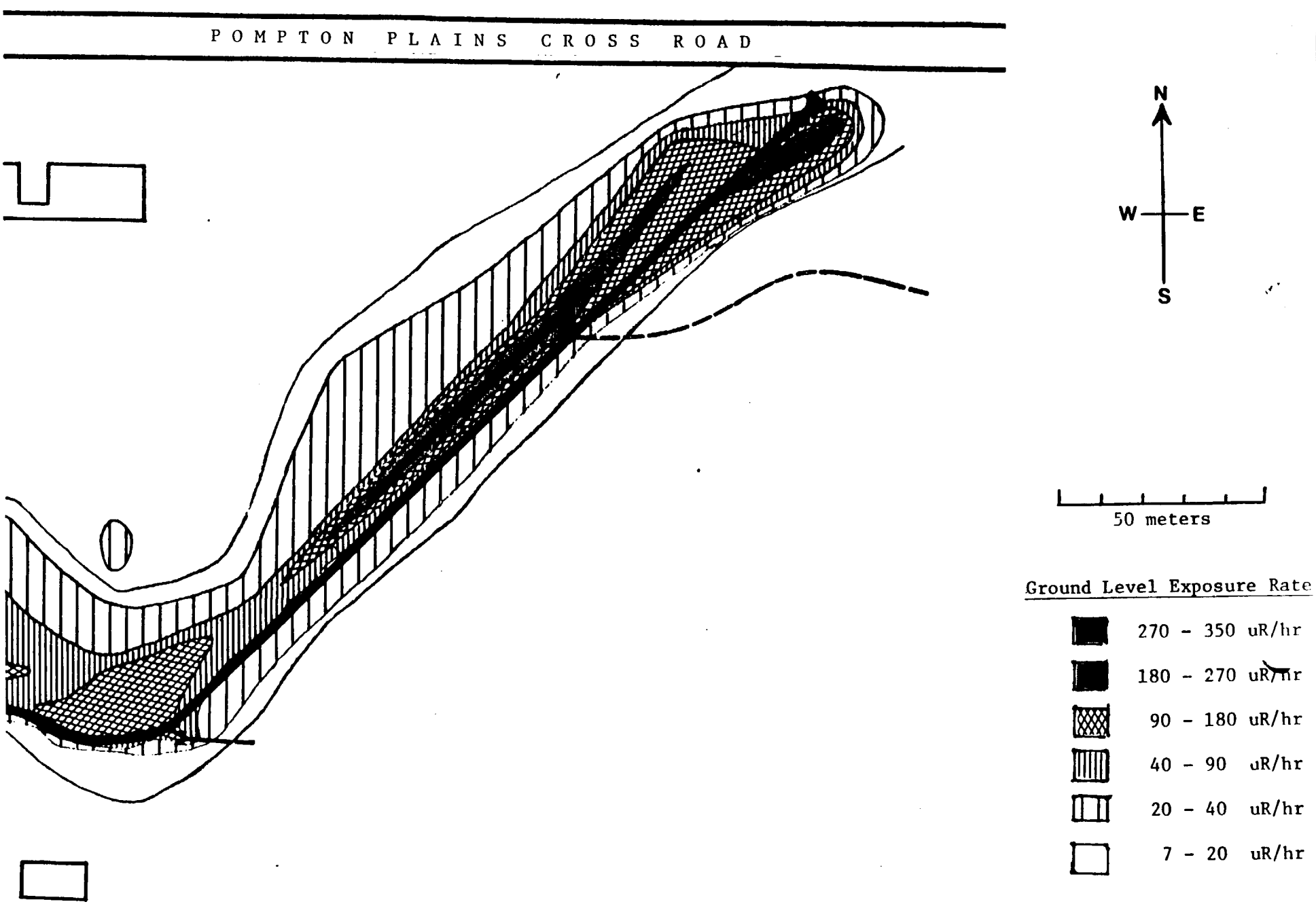

FIGURE 2A: FIELD SURVEY OF GAMMA RADIATION. GROUND LEVEL EXPOSURE RATE IN uR/HR., INCLUDING BACKGROUND.

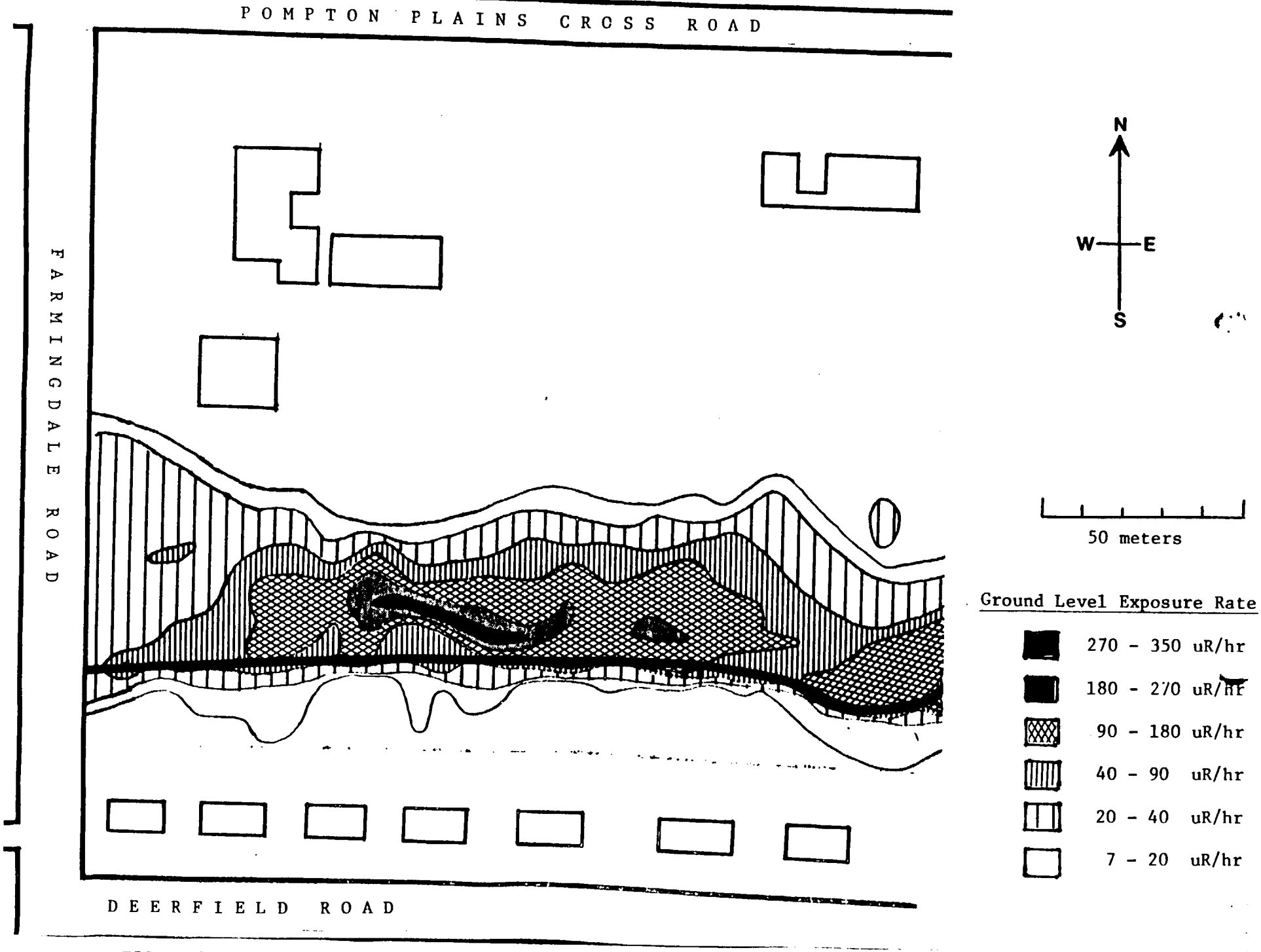

FIGURE 2B: FIELD SURVEY OF GAMMA RADIATION. GROUND LEVEL EXPOSURE RATE IN uR/HR., INCLUDING BACKGROUND.

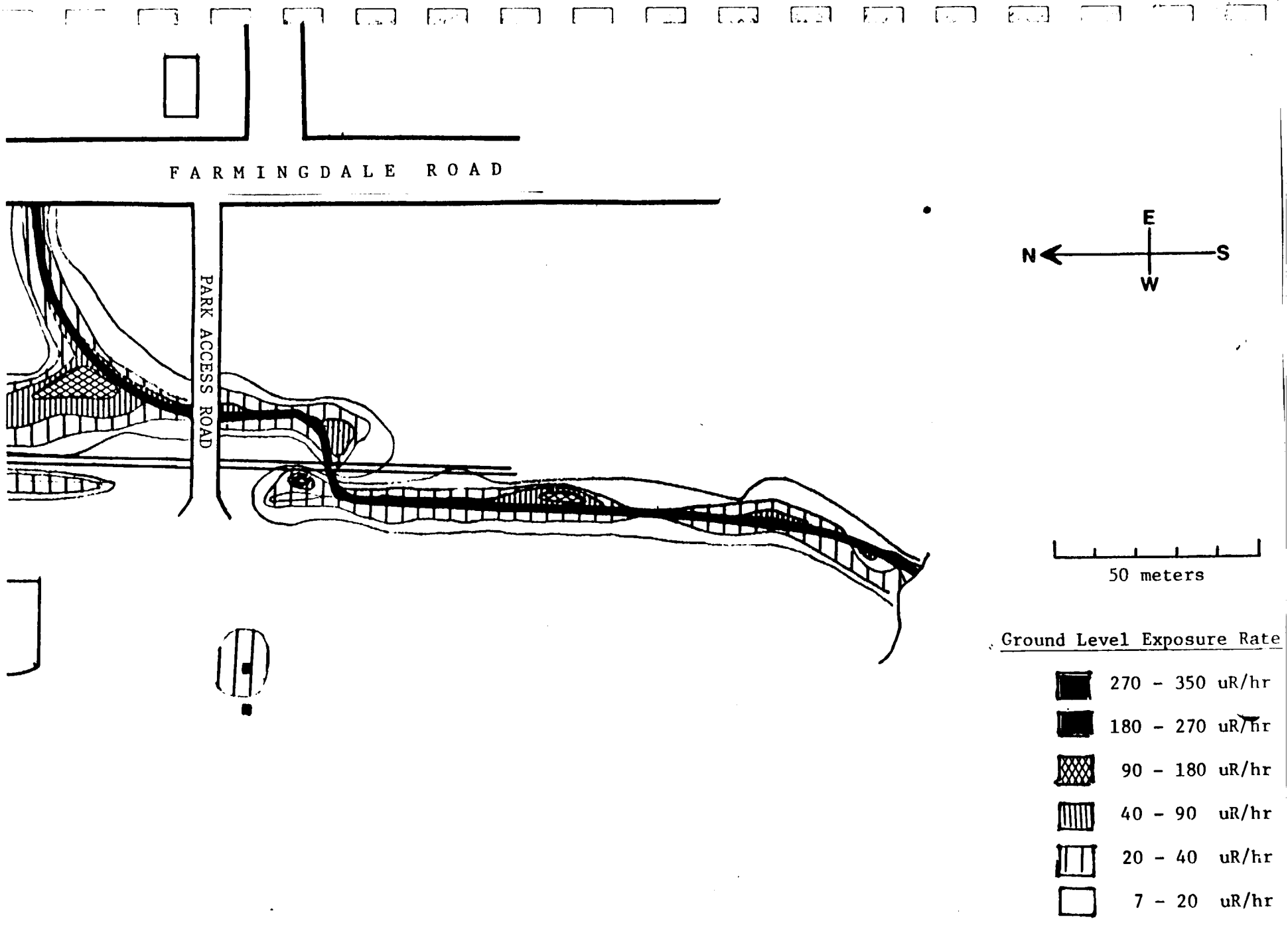

FIGURE 2C: FIELD SURVEY OF GAMMA RADIATION. GROUND LEVEL EXPOSURE RATE IN uR/HR., INCLUDING BACKGROUND.

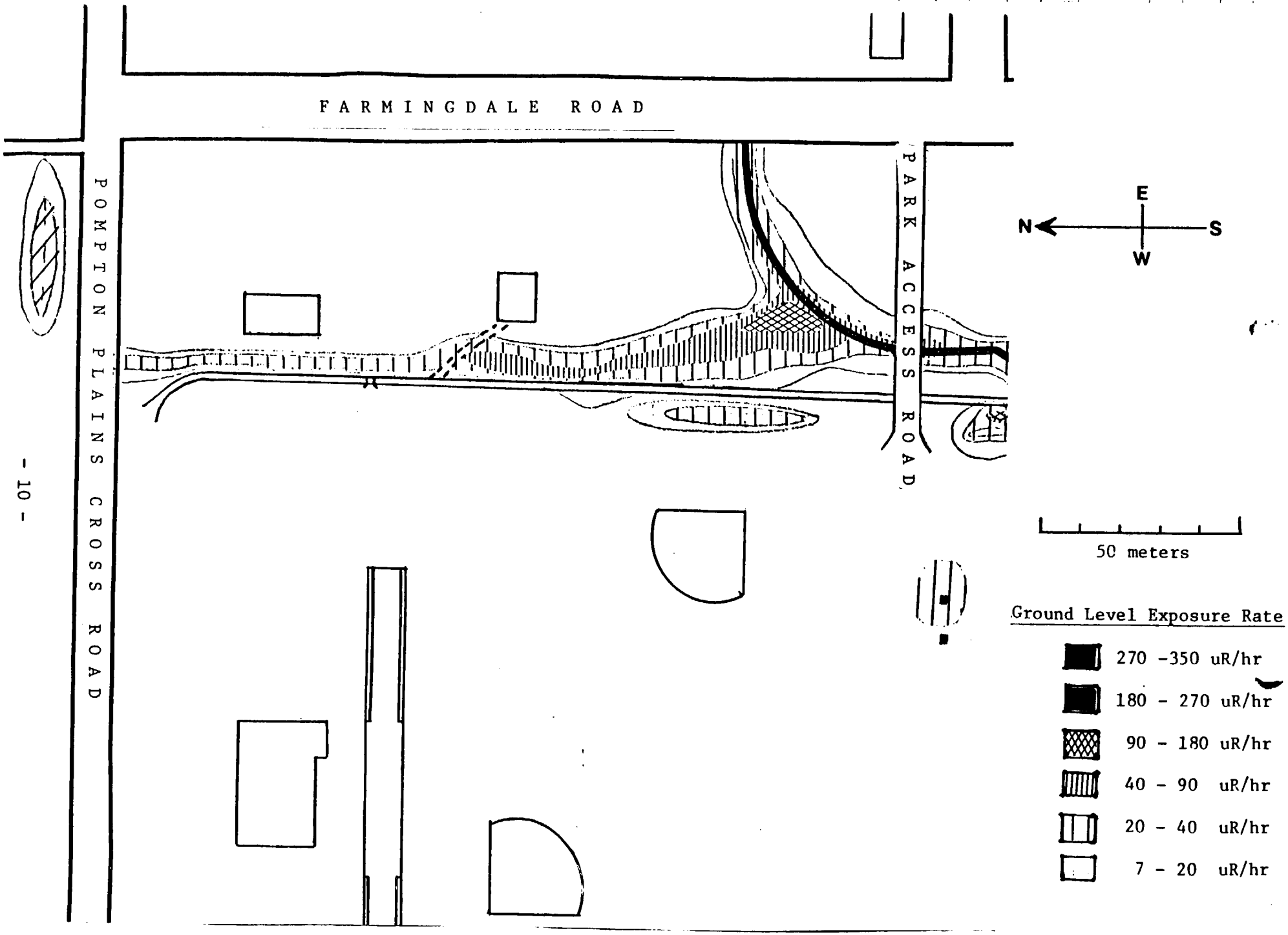

FIGURE 2D: FIELD SURVEY OF GAMMA RADIATION. GROUND LEVEL EXPOSURE RATE IN uR/HR., INCLUDING BACKGROUND.

D. SOIL AND SEDIMENT SAMPLING

Sample Collection and Analysis

Surface soil samples were collected at various locations along the surface gamma survey grid. Along Sheffield Brook, profile soil samples were collected at the banks and at 5 and 10 meters from the brook. Sediment samples were taken in the brook at 50 meter intervals whenever possible. Bias samples were taken in areas not systematically sampled when field investigations indicated the need. Such areas are the soccer field and northern run-off area located west of Farmingdale Road. Figures 3A and 3B identify the soil sampling locations. Figures 4A and 4B identify the sediment sampling locations.

Surface samples were collected with a garden trowel to a depth of 15 centimeters. About 1,000 grams of soil was taken per sample. Samples were bagged, sealed with tape and marked with location, date and instrument reading. At the laboratory, samples were dried for 24 hours at 105^{o} C and mechanically crushed in order to pass through a 10 mesh sieve. A 372-cc sample was put into a cottage cheese container and sealed. A minimum of three weeks elapsed before counting to allow radionuclides to reach secular equilibrium.

Samples were counted for a minimum of 5,000 seconds on a coaxial instrinsic germanium detector coupled to a multi-channel analyzer. Low activity samples were counted longer, usually 10,000 or 30,000 seconds.

Peaks were identified and quantified by computer analysis. The following energy peaks were identified and concentrations calculated for:

Ra-226	352 keV (Pb-214 peak)
	609 keV (Bi-214 peak)
	1764 keV (Bi-214 peak)
Th-232	239 keV (Pb-212 peak)
	583 keV (Tl-208 peak)
	911 keV (Ac-228 peak)
K-40	1460 keV

Soil and Sediment Results

Results of radiological concentrations in soil and sediment samples are tabulated in Tables 1 and 2, respectively. Due to the meandering nature of Sheffield Brook, results in Tables 1 and 2 are tabulated according to side of the bank the samples were taken from instead of by cardinal directions. The left (LB) or right bank (RB) is determined by facing downstream. In Table 1, the number added to LB or RB refers to the distance away from the brook. For example, LB + 0 means left bank, zero meters from brook, and RB + 20 means right bank, 20 meters from the brook. For Table 2, RB and LB refer to which side of the stream bed the sediment sample was taken. For comparison, radionuclide concentrations for background soil samples are found in Table 3.

Analytic results of gamma spectroscopy of thorium-232 decay products (Tl-208, Pb-212 and Ac-228) showed no quantitative difference between individual daughters, indicating the thorium chain is in equilibrium. Hence, unless otherwise noted in the tables, the Th-232 concentration is based on the Ac-228 (911 keV) peak. The same conclusion was reached for radium-226 and its daughters (Bi-214 and Pb-214). Unless otherwise noted, Ra-226 concentration is based on the Bi-214 (609 keV) peak.

The thorium and radium concentrations in soil samples are tabulated in Table 2. The greatest concentrations of thorium in soil samples were found in two locations east of Farmingdale Road. One region was located on the berms found along the east and west banks of the channelized portion of the brook. The highest thorium concentration in this area was 562 $\pm$ 5 pCi/g (S-14), one of eight samples with concentrations greater than 100 pCi/g. These berms were probably dredging spoils from past brook maintenance programs.

The second area of high thorium concentration in the soil was the low lying wet areas north of the brook as it flows west toward Farmingdale Road. The greatest concentrations were 522 $\pm$ 7 and 549 $\pm$ 7 pCi/g (S-33 and S-34) along line h, 5 and 10 meters from the right bank. Deposition of the material was probably the result of its movement during flooding in the area.

Generally, radionuclide concentration from soil samples collected west of Farmingdale Road were lower than concentrations found in samples collected on the east side of the road. The highest concentration of 81.7 $\pm$ 2.4 pCi/g (S-77) was obtained for a small region to the south of the access road on a small mound.

Radium-226 concentration correleated with the thorium concentration, but were lower by a factor of 20 to 50. The highest radium-226 concentration of 39.5 $\pm$ 8.2 pCi/g (S-32) was located east of Farmingdale Road. No samples west of Farmingdale Road exceeded 5 pCi/g for radium-226.

Sediment samples taken along the brook were lower than soil samples taken on land. Sediment sample data are tabulated in Table 2. The greatest concentration of thorium (22.2 $\pm$ 0.8 pCi/g, SS-18) was obtained 100 meters from the brook's confluence with the Pompton River. Thorium concentration in sediment samples was generally higher west of Farmingdale Road than to the east of the road. The channeled portion of the brook had the lowest thorium concentration. No sediment sample had Ra-226 concentrations exceeding 2 pCi/g.

The potassium-40 in soil and sediment samples was determined. The K-40 concentration was in the range of 24 to 72 pCi/g with a mean of 30 pCi/g.

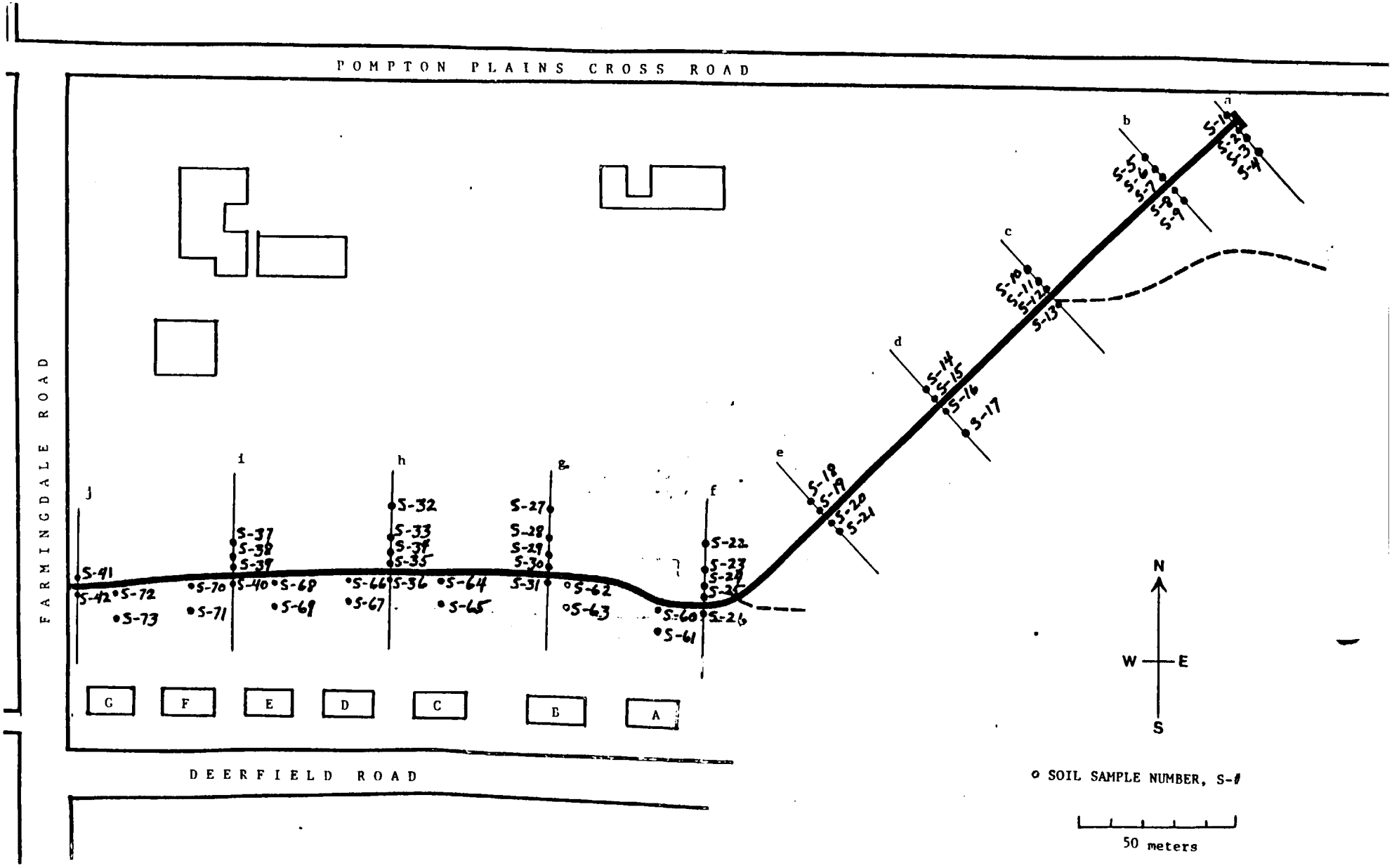

FIGURE 3A: SOIL SAMPLING LOCATIONS
EAST OF FARMINGDALE ROAD

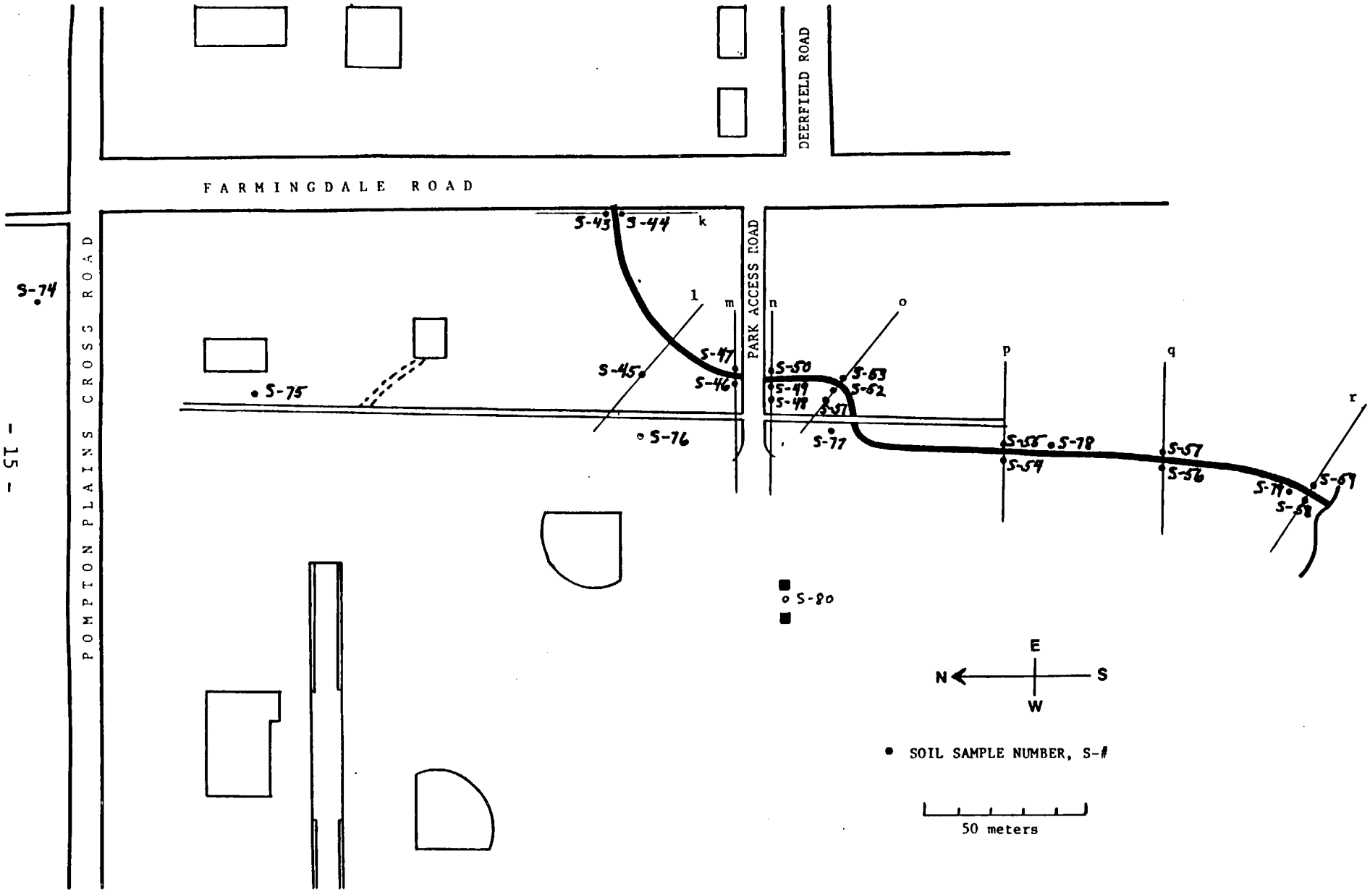

FIGURE 3B: SOIL SAMPLING LOCATIONS
WEST OF FARMINGDALE ROAD

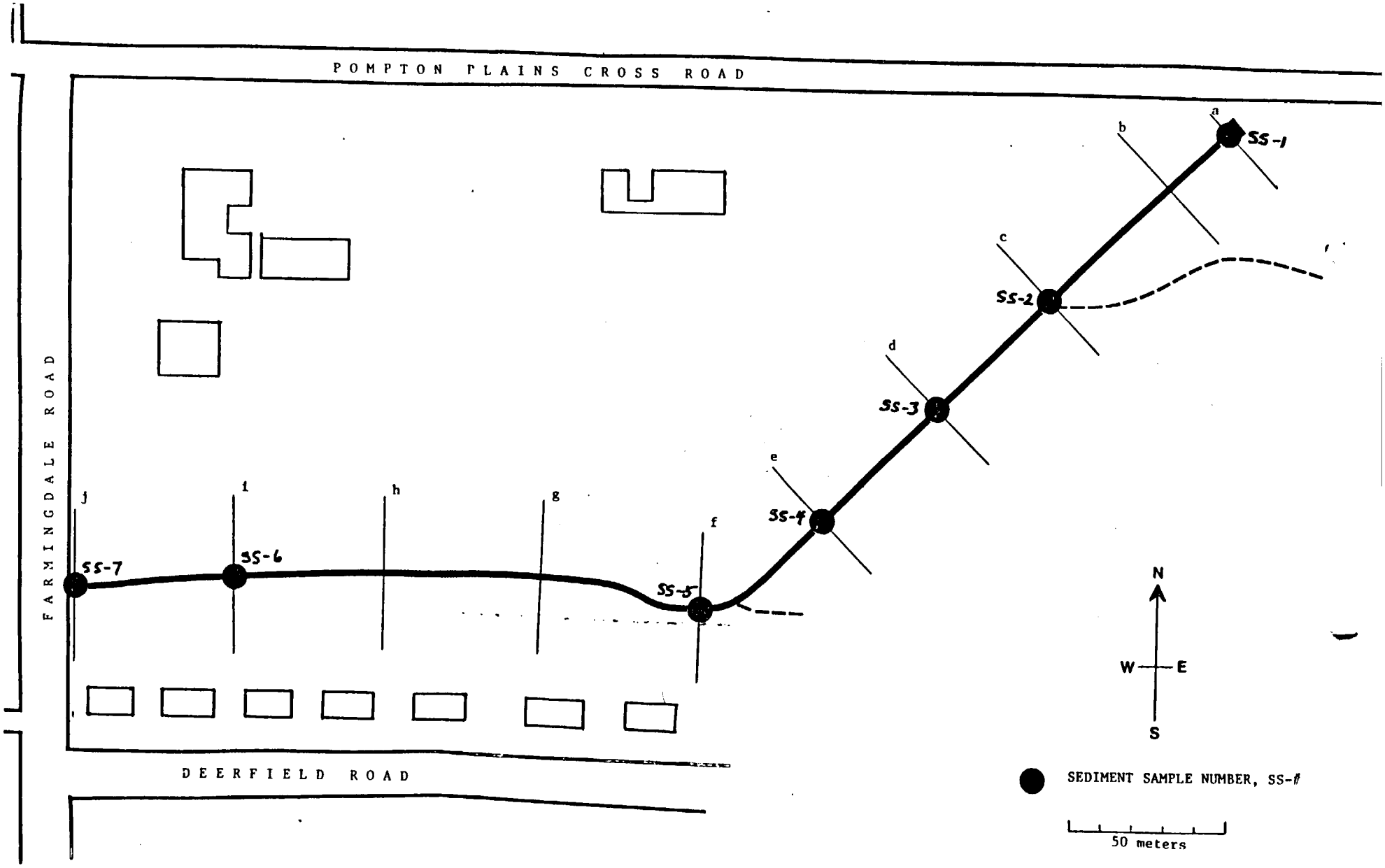

FIGURE 4A: SEDIMENT SAMPLING LOCATIONS
EAST OF FARMINGDALE ROAD

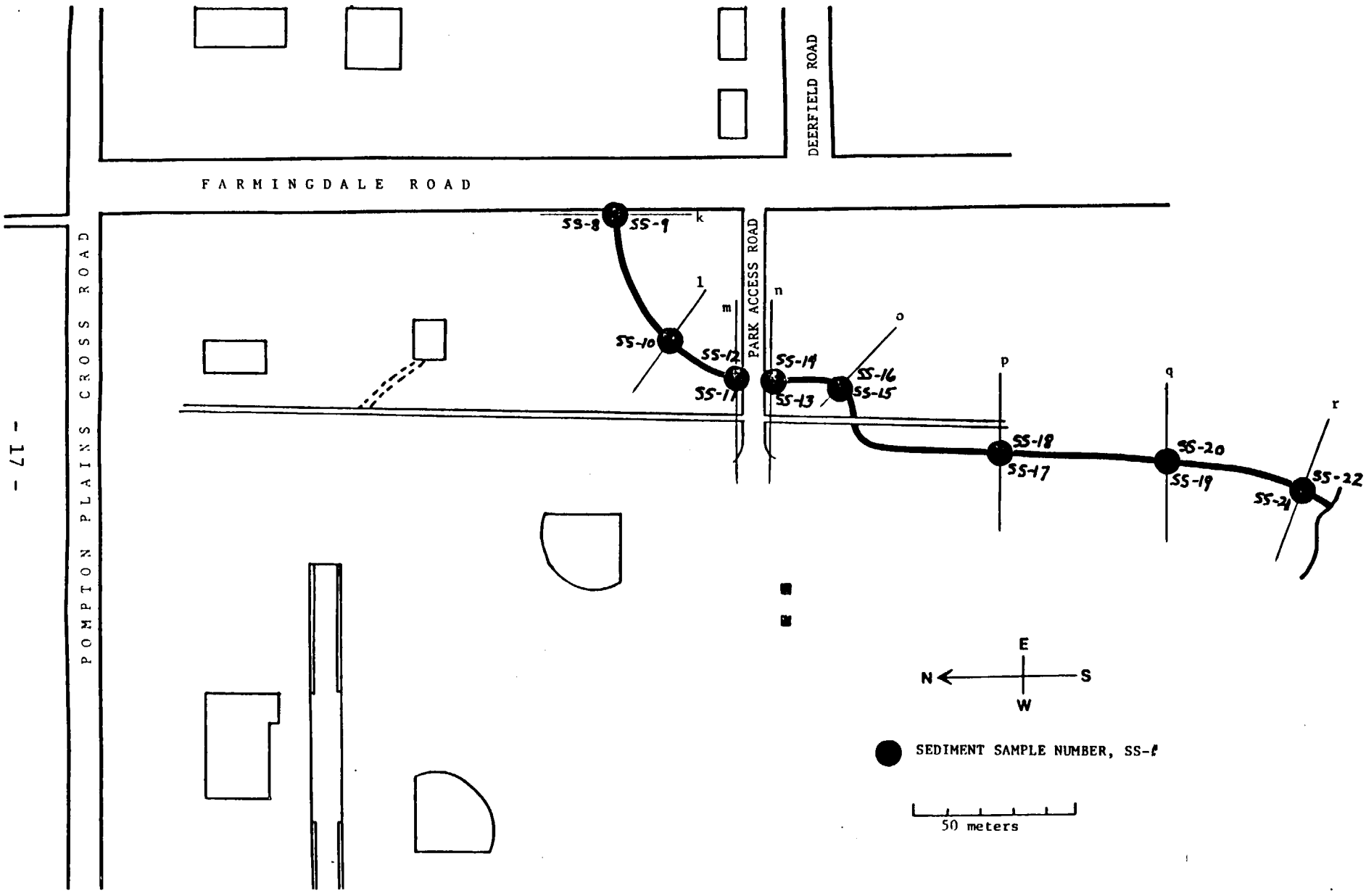

FIGURE 4B: SEDIMENT SAMPLING LOCATIONS
WEST OF FARMINGDALE ROAD

TABLE 1

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

(Concentration in pCi/g)

Sample No.	Location	Th-232	Ra-226
S-1	line a, RB + 0	3.9 ± 0.4	0.8 ± 0.1
S-2	" LB + 0	8.1 ± 0.7	1.0 ± 0.2
S-3	" LB + 5	244 ± 4	10.3 ± 0.9
S-4	" LB + 10	103 ± 2	3.6 ± 0.5
S-5	line b, RB + 10	107 ± 2	6.0 ± 0.6
S-6	" RB + 5	49.8 ± 1.3	2.5 ± 0.4
S-7	" RB + 0	81.5 ± 1.7	3.5 ± 0.5
S-8	" LB + 0	125 ± 3	6.0 ± 0.6
S-9	" LB + 5	136 ± 3	6.2 ± 0.6
S-10	line c, RB + 10	28.2 ± 1.1	2.8 ± 0.8 (2)
S-11	" RB + 5	182 ± 3	7.9 ± 0.8
S-12	" RB + 0	104 ± 2	5.3 ± 0.5
S-13	" LB + 0	3.3 ± 0.5	MDA
S-14	line d, RB + 5	562 ± 5	29.3 ± 1.5
S-15	" RB + 0	3.5 ± 0.5	MDA
S-16	" LB + 0	4.1 ± 0.2	1.0 ± 0.1
S-17	" LB + 10	17.6 ± 1.2	1.7 ± 0.25
S-18	line e, RB + 5	11.1 ± 0.7	0.8 ± 0.25 (1)
S-19	" RB + 0	8.2 ± 0.6	1.0 ± 0.2
S-20	" LB + 0	5.3 ± 0.2	1.0 ± 0.1
S-21	" LB + 5	19.6 ± 1.1	2.2 ± 0.5
S-22	line f, RB + 20	6.9 ± 0.5	1.0 ± 0.2
S-23	" RB + 10	29.9 ± 1.1	1.5 ± 0.3
S-24	" RB + 5	8.2 ± 0.6	MDA
S-25	" RB + 0	15.4 ± 0.3	1.2 ± 0.1

TABLE 1 - contd.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

(Concentration in pCi/g)

Sample No.	Location	Th-232	Ra-226
S-26	line f, LB + 0	20.7 ± 0.9	1.3 ± 0.3
S-27	line g, RB + 20	77.1 ± 1.9	3.0 ± 0.4
S-28	" RB + 10	56.5 ± 1.7	MDA
S-29	" RB + 5	115 ± 2	3.9 ± 0.6
S-30	" RB + 0	18.1 ± 0.9	1.2 ± 0.3
S-31	" LB + 0	3.6 ± 0.2	0.8 ± 0.08
S-32	line h, RB + 20	172 ± 4	39.5 ± 8.2
S-33	" RB + 10	522 ± 7	10.5 ± 1.6
S-34	" RB + 5	549 ± 7	14.6 ± 1.6
S-35	" RB + 0	31.6 ± 1.1	3.8 ± 1.0(2)
S-36	" LB + 0	56.4 ± 1.6	2.9 ± 0.5
S-37	line i, RB + 10	160 ± 3	5.5 ± 0.8
S-38	" RB + 5	144 ± 3	4.9 ± 0.8
S-39	" RB + 0	19.3 ± 1.0	1.4 ± 0.3
S-40	" LB + 0	20.8 ± 0.9	1.5 ± 0.3(1)
S-41	line j, RB + 0	1.6 ± 0.3	0.7 ± 0.2
S-42	" LB + 0	22.5 ± 1.0	1.5 ± 0.3
S-43	line k, RB + 0	48.4 ± 1.0	3.4 ± 0.3
S-44	" LB + 0	21.3 ± 1.2	1.9 ± 0.3
S-45	line l, RB + 15	49.7 ± 1.4	2.8 ± 0.4
S-46	line m, RB + 0	4.6 ± 0.5	0.7 ± 0.2(1)
S-47	" LB + 0	9.2 ± 0.6	1.0 ± 0.2
S-48	line n RB + 5	4.2 ± 0.6	1.2 ± 0.2
S-49	" RB + 0	34.0 ± 0.8	2.4 ± 0.3
S-50	" LB + 0	40.6 ± 1.3	2.4 ± 0.4

TABLE 1 - contd.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

(Concentration in pCi/g)

Sample No.	Location	Th-232	Ra-226
S-51	line 0, RB + 5	1.6 ± 0.4	0.8 ± 0.2
S-52	" RB + 0	21.2 ± 0.9	1.6 ± 0.2
S-53	" LB + 0	22.3 ± 0.4	1.8 ± 0.1
S-54	line p, RB + 0	2.75 + 0.2	1.2 + 0.1
S-55	" LB + 0	33.7 ± 1.2	2.8 ± 0.4
S-56	line q, RB + 0	1.9 ± 0.2	1.1 ± 0.07
S-57	" LB + 0	9.5 ± 0.8	1.9 ± 0.3
S-58	line r, RB + 0	2.4 ± 0.6	1.9 ± 0.5
S-59	" LB + 0	9.45 ± 0.8	MDA
S-60	Residence A, stream	10.6 ± 0.6	0.8 ± 0.2
S-61	" A, 10 meter	1.3 ± 0.15	0.7 ± 0.07
S-62	" B, stream	19.2 ± 1.0	1.9 ± 0.3
S-63	" B, 10 meter	1.5 ± 0.2	1.0 ± 0.1
S-64	" C, stream	20.0 ± 0.9	1.7 ± 0.1
S-65	" C, 10 meter	1.6 ± 0.2	0.8 ± 0.08
S-66	" D, stream	13.9 ± 0.3	1.2 ± 0.1
S-67	" D, 10 meter	1.5 ± 0.2	0.8 ± 0.08
S-68	" E, stream	21.7 ± 0.9	1.5 ± 0.3
S-69	" E, 10 meter	2.9 ± 0.2	1.0 ± 0.08
S-70	" F, stream	22.8 ± 1.0	1.6 ± 0.3
S-71	" F, 10 meter	2.8 ± 0.2	0.9 ± 0.09
S-72	" G, stream	19.1 ± 0.9	1.4 ± 0.3
S-73	" G, 10 meter	2.9 ± 0.2	1.0 ± 0.1
S-74	North of Pompton Plains Cross Road	11.9 ± 0.8	1.2 ± 0.2
S-75	50 meters South of Pompton Plains Cross Road	31.2 ± 1.1	1.4 ± 0.3

TABLE 1 - contd.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

(Concentration in pCi/g)

Sample No.	Location	Th-232	Ra-226
S-76	20 meters North of Access Road, West of Dirt Path	23.4 ± 1.3	MDA
S-77	25 meters South of Access Road, West of Dirt Path	81.7 ± 2.4	4.7 ± 0.6
S-78	90 meters South of Access Road	29.7 ± 1.2	1.6 ± 0.4
S-79	160 meters South of Access Road	8.0 ± 0.7	1.5 ± 0.2
S-80	Goal Post on Soccer Field	5.6 ± 0.5	0.9 ± 0.2(1)

Explantions:

(1) Ra-226 determined by Pb-214 (352 keV) peak.

(2) Ra-226 determined by Bi-214 (1764 keV) peak.

MDA (Minimum Detectable Activity) = 0.13 pCi/g

TABLE 2

RADIONUCLIDE CONCENTRATION IN SEDIMENT SAMPLES

Sample No.	Location	Th-232 (pCi/g)	Ra-226 (pCi/g
SS-1	line a	4.2 ± 0.5	0.6 ± 0.15
SS-2	" c	1.6 ± 0.5	0.6 ± 0.2
SS-3	" d	1.5 ± 0.1	0.6 ± 0.06
SS-4	" e	3.1 ± 0.4	MDA
SS-5	" f	3.6 ± 0.1	0.06 ± 0.05
SS-6	" i	8.2 ± 0.6	1.3 ± 0.5
SS-7	" j	11.45 ± 0.6	1.0 ± 0.2
SS-8	line k, RB	9.4 ± 0.6	1.0 ± 0.2
SS-9	" k, LB	12.4 ± 0.7	1.5 ± 0.2
SS-10	line l	5.55 ± 0.45	0.9 ± 0.2
SS-11	line m, RB	5.0 ± 0.5	1.0 ± 0.2
SS-12	" m, LB	7.1 ± 0.5	1.8 ± 0.5(2)
SS-13	line n, RB	8.5 ± 0.5	1.0 ± 0.2
SS-14	" n, LB	6.5 ± 0.2	0.9 ± 0.07
SS-15	line o, RB	2.8 ± 0.1(1)	0.7 ± 0.07
SS-16	" o, LB	7.7 ± 0.6	1.0 ± 0.2
SS-17	line p, RB	3.6 ± 0.3	0.7 ± 0.1(2)
SS-18	" p, LB	22.2 ± 0.8	1.7 ± 0.3
SS-19	line q, RB	5.0 ± 0.5	0.8 ± 0.2
SS-20	" q, LB	5.55 ± 0.5	1.1 ± 0.2
SS-21	line r, RB	12.1 ± 0.8	1.6 ± 0.3
SS-22	" r, LB	11.5 ± 0.7	1.4 ± 0.3

Explanations:

(1) Th-232 determined by Tl-208 (583 keV) peak.

(2) Ra-226 determined by Pb-214 (352 keV) peak.

RB: sediment location near right bank.

LB: sediment location near left bank.

MDA (Minimum Detectable Activity) = 0.13 pCi/g

TABLE 3

BACKGROUND SOIL SAMPLES
(Concentrations in pCi/g)

	Location	Th-232	Ra-226	K-40
1.	Pequannock, along Erie Lackawanna R.R. Tracks	2.2 ± 0.2	0.85 ± 0.06	28.0± 0.6
2.	Wayne - Soccer Field	1.2 ± 0.1	0.6 ± 0.05	29.1± 0.6
3.	Wayne - Pompton River Spillway	1.8 ± 0.1	0.7 ± 0.04	27.5± 0.4
4.	Literature (ORNL/TM 7374)[2]	0.31 to 1.5	0.24 to 1.4	
5.	Literature (UNSCEAR, 1977)[3]			
	Soil	0.2 to 1.3	0.3 to 1.4	3 to 20
	Rock	2.2	1.6	27

E. WATER SAMPLING

Sample Collection and Analyses

Surface water grab samples were taken along Sheffield Brook and Pompton River. These samples were analyzed for gross alpha, gross beta and gamma radiation. Samples were collected in one-gallon plastic containers, acidified, filtered, and analyzed according to EPA procedures for drinking water samples. Sample locations included: the Sheffield at Pompton Plains Cross Road, the Sheffield 50 meters east of Farmingdale Road, the confluence of the Sheffield and Pompton River; Pompton River 200 meters upstream and 100 meters downstream. These locations are shown in Figure 5.

Well water grab samples were taken at two private residences and from the farm north of Pompton Plains Cross Road. Samples were analyzed for gross alpha, gross beta and gamma radiation. Some water samples were further analyzed for radium-226.

For gamma spectroscopy, 500 ml of acidified sample was placed in Marinelli beakers and analyzed on coaxial intrinsic germanium detector coupled to a multi-channel analyzer.

After sample was filtered, evaporated and dried, analysis for gross alpha and gross beta was performed on a low background proportional counter.

Water Results

Analytical results for seven surface samples and six residential/ commercial samples are contained in Table 5. The highest gross alpha and beta concentrations of 9.22 ± 2.49 pCi/l and 8.41 ± 0.99 pCi/l were found for a water sample from the confluence of Sheffield Brook and the Pompton River (W-4).

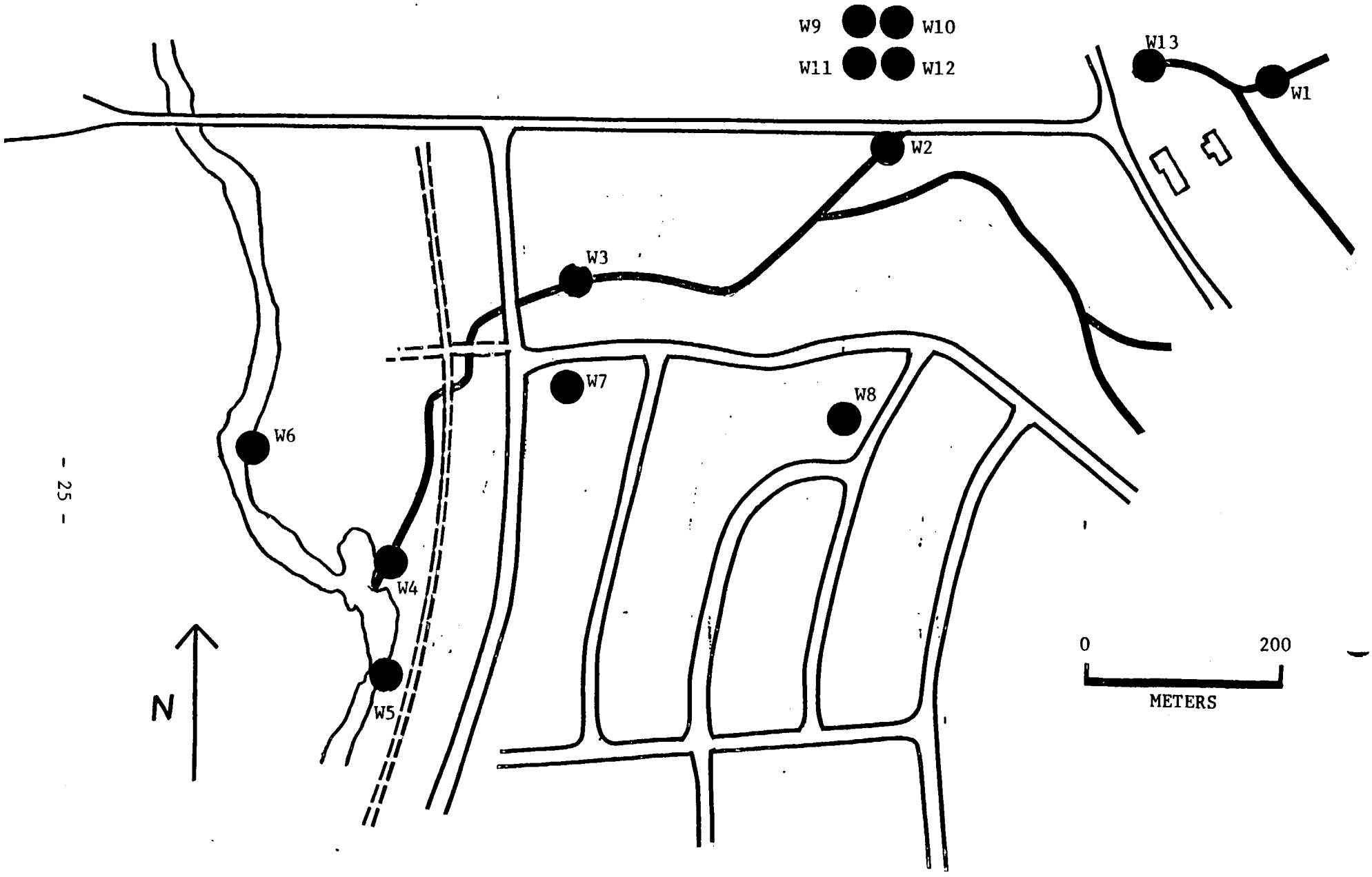

FIGURE 5: WATER SAMPLING LOCATIONS

TABLE 4

RADIONUCLIDE CONCENTRATION IN WATER SAMPLES
(Concentrations in pCi/l)

Sample No.	Location Description	Gross Alpha	Gross Beta	Ra-226
W1	Sheffield Brook Upstream of Grace Property	0.68 ± 1.62	1.39 ± 0.67	
W2	Sheffield Brook at PPCR	1.69 ± 1.86	6.84 ± 0.89	(1)
W3	Sheffield Brook 50 meters North of Farmingdale Rd.	2.10 ± 1.57	2.89 ± 0.71	
W4	Confluence of Sheffield and Pompton River	9.22 ± 2.49	8.41 ± 0.99	(1)
W5	Pompton River 100 meters downstream of Sheffield	1.58 ± 0.99	2.57 ± 0.62	
W6	Pompton River 200 meters upstream of Sheffield	0.84 ± 0.93	2.14 ± 0.59	
W7	Well at Deerfield Drive Residence	2.66 ± 2.35	1.42 ± 0.80	
W8	Well at Canton Road Residence	1.91 ± 1.87	1.60 ± 0.71	
W9	Farm North of PPCR Spring	5.99 ± 2.71	2.03 ± 0.78	0.09 ± 0.06
W10	Farm North of PPCR Packing House Well	5.19 ± 2.71	1.70 ± 0.77	0.17 ± 0.07
W11	Farm North of PPCR Well #2	4.13 ± 3.11	2.11 ± 0.86	0.13 ± 0.06
W12	Farm North of PPCR Morris Canal	0.82 ± 1.16	1.68 ± 0.58	0.16 ± 0.07
W13	Sheffield Brook leaving W.R. Grace property	5.67 ± 2.61	4.01 ± 0.91	(1)

In all analyses, gamma spectroscopy showed no activity above the system's minimum detectable activity (MDA = 50 pCi/l)

(1) Radium analysis not completed.

TABLE 5

RADIONUCLIDE CONCENTRATIONS IN DRINKING WATER
(Concentrations in pCi/l)

Potable Water Sources[4]	Gross Alpha	Gross Beta
Passaic Valley Water Commission	0.09 ± 0.30	2.48 ± 0.26
Pequannock Twp. Water Department	0.24 ± 0.52	(1)
Pompton Lakes MUA	0.85 ± 0.35	(1)
Riverdale Water Department	0.64 ± 0.40	(1)
Wayne Twp. Water Department	0.58 ± 0.43	(1)
Lincoln Park Water Utility	0.47 ± 0.36	(1)

USEPA/NJDEP Safe Drinking Water Standards (NJAC; 7:10-5.1 et seq.)

Gross Alpha	15 pCi/l
Gross Beta	50 pCi/l
Ra-226 and Ra-228	5 pCi/l

Explanation

(1) According to procedures for Safe Drinking Water, gross beta analysis is not required for water supplies serving less than 100,000 users.

F. AIR SAMPLING FOR RADON-222

Radon-222 Sampling

Two grab samples were taken in the study area as shown on Figure 6. A bias sample was taken in the area known to have the highest radium-226 levels of up to 40 pCi/g. The second one was a background sample taken in an area not believed to be influenced by activities at W. R. Grace.

The samples were taken at ground level on a sunny, breezy day. Background for individual cells were counted the previous day. Samples were allowed to reach secular equilibrium before counting.

Radon-222 Results

Concentration of radon gas (Rn-222) in the two grab samples did not statistically differ, although the mean for bias sample was slightly higher. Radon concentration in air depends on diurnal and seasonal variations. Higher radon levels can be measured during the daylight hours and summer season. Lower levels are found in evening hours and winter season.

As shown in Table 6, these concentrations are within the range at values recorded by EML at its background environmental station in Chester, New Jersey, and meet both State and NRC guidelines for radon concentration in air.

TABLE 6

GRAB SAMPLING FOR RADON-222

Concentration of Radon-222

Location	pCi/l ± 2 sigma
line n, RB + 20 meters	0.6 ± 0.2
Center of Soccer Field	0.4 ± 0.1

Values Cited in Literature

1. UNSCEAR [3]	0.1 pCi/l
2. Environmental Measurement Laboratory Regional Baseline Station, Chester, New Jersey. [5]	
Hourly Measurement Range	0.01 pCi/l to 2.6 pCi/l
Range of Yearly Averages (Arithmetic Mean)	0.19 pCi/l to 0.24 pCi/l

Standards

NRC 10 CFR 20.106	3.0 pCi/l
NJ NJAC;7:28-6.5	1.0 pCi/l

G. SUMMARY

The purpose of the radiological ground survey along Sheffield Brook and its tributaries was to define the extent of offsite radiological contamination identified in the aerial survey of Wayne, New Jersey. The ground survey involved taking field measurements of direct radiation and samples of scil, sediment, water, and air for radiological analyses.

Generally, the topography of the surveyed area is marshy lowlands with extensive vegetation which is not easily accessible. An exception to this region is the area west of Farmingdale Road.

Measurements of gamma radiation along the Sheffield Brook show that above background exposure rates were confined to within forty meters of the banks along the brook to the east of Farmingdale Road and to within ten meters of the banks along the brook to the west of Farmingdale Road. Gamma radiation levels ranged from background level of 7 μR/hr to 354 μR/hr.

Gamma spectroscopic analyses show that the only significant radionuclides present in soil and sediment samples are related to the thorium and uranium decay chains. The results of analyses show thorium-232 and radium-226 in the soil samples to range from 1.5 to 562 pCi/g and 0.7 to 39.5 pCi/g, respectively. Background soil concentrations for thorium and uranium are less than 2 pCi/g. Results of water analyses indicate the presence of gross alpha and gross beta activity but no gamma activity. The results of air analyses show radon concentration to be within background levels.

Federal and State Radiation Standards

Both federal and state radiation regulations limit radiation dose for an individual member of the general public to 500 mrem/yr. Federal guidance provides an additional restriction of 170 mrem/yr for a defined segment of the population. There has been additional work done to establish standards for unrestricted use where there is no or little directly attributable benefit as in the case of terminated facilities, residual contamination, or remedial actions. The objective of these standards is to limit whole body equivalent dose to 10 mrem/yr or less.

Under the Uranium Mill Tailing Radiation Control Act (UMTRCA), the U.S. Environmental Protection Agency established standards for remedial action at inactive uranium mill sites. The UMTRCA standards are 5 pCi/g above background for radium-226, 20 μR/hr above background for indoor gamma radiation exposure and 0.015 WL including background for radon progeny in structures (45FR27366, April 22, 1980). The limit of 5 pCi/g radium in soil concentration would limit external exposure rate to 10 μR/hr.

Prior to the issuance of the UMTRCA standards by EPA, the U.S. Department of Energy with the New Jersey Department of Environmental Protection developed criteria for use at DOE remedial action projects in New Jersey. These criteria are 5 pCi/g above background for radium-226 and 40 pCi/g above background for uranium-238 not in equilibrium with its progeny.

In 1981, the U.S. Nuclear Regulatory Commission developed a technical position paper for residual thorium or uranium wastes from past processing facilities (46FR52061, October 23, 1981). The criteria presented varied according to associated land use restriction. The criteria ranged from 5 pCi/g for thorium-232 in equilibrium with all its progeny for unrestricted use to 250 pCi/g for restricted use. Concentrations exceeding 250 pCi/g should be disposed in a facility licensed for disposal.

Under the Safe Drinking Water Act, the U.S. Environmental Protection Agency established radiological standards for potable water. These standards, subsequently adopted by the State of New Jersey, provided a limit of 4 mrem/yr for water at the consumer tap. These drinking water standards were not established for untreated potable or nonpotable water sources, but they are the most stringent water standards promulgated to date. For comparison, the U.S. EPA/N.J. DEP drinking water limits are 15 pCi/l for gross alpha, 50 pCi/l for gross beta, and 5 pCi/l for radium-226 and radium-228

Comparison of Surveyed Area to Radiological Standards

A comparison of the area's radiological condition and current property use to the radiological standard for the general public, show that it is unlikely that an individual would receive a whole body dose that exceeds the radiological standard of 500 mrem/yr. However, property use can change in the future which may cause individuals to receive doses greater than 500 mrem/yr,

hence evaluation of the surveyed area should be based on more stringent environmental standards.

A comparison of the area's radiological condition to the most conservative environmental standards of 10 μR/hr above background for external exposure rate and 5 pCi/g above background for thorium-232, show that about 18,000 m^2 in the Sheffield Brook area would not meet these standards.

A comparison of the results of water samples taken during the survey show all water samples meet standards for gross alpha and gross beta established for drinking water.

Air sampling show radon-222 concentrations in the area to be within the background levels for New Jersey.

H. BIBLIOGRAPHY

1. "An Aerial Radiological Survey of the W. R. Grace Property, Wayne Township, New Jersey, May 1981", EG&G Energy Measurements Group, EG&G Survey Report NRC-8113, November 1981.

2. Myrick, T.D., B.A. Berven and F.F. Maywood, "State Background Radiation Levels - Results of Measurements Taken During 1975 - 1979", Oak Ridge National Laboratory Report ORNL/TM 7374, November, 1981.

3. "Sources and Effects of Ionizing Radiation", United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 1977 Report to the General Assembly, 1977.

4. Radiation files on radiological analyses for the Safe Drinking Water Program, Bureau of Environmental Laboratories, N.J. Department of Environmental Protection.

5. "Environmental Measurements Laboratory, Regional Baseline Station, Chester, New Jersey", EML-399, Environmental Measurements Laboratory, U.S. Department of Energy, November, 1981.

I. APPENDIX

EQUIPMENT USED

1. Eberline NaI(Tl) scintillation probe (SPA-3 Model) with Victoreen Thyac III (Model 490) Portable Survey Meter.

2. Reuter Stokes Pressurized Ionization Chamber (Model RSS-111).

3. EDA Portable Radon Detector (RD-200)
   ZnS (Ag) Scintillator coupled to high gain photomulti lier and scaler (33% efficiency).

4. Canberra Coaxial Germanium Detector with Series 85 Multi-Channel Analyzer (relative efficiency 14%)

5. Low background proportion counter (Gross Alpha, Gross Beta, Ra-226)
   a. Tennelec LB-5110
   b. Beckman Low Beta I & II

CALIBRATION OF SURVEY EQUIPMENT

1. Gamma Scintillation -

   The NaI(Tl) scintillimeter was calibrated by the manufactures in December 1981. In field calibration of two inch by two inch NaI(Tl) scintillation probe at ground level and one meter with a pressurized ionization chamber (PIC) by comparing the instantaneous count rate (counts per minute) to the exposure rate (microroengtens per hour) at several locations in the study area. PIC was calibrated at the DOE's Environmental Measurements Laboratory.

2. Soil and Sediment Samples -

   The Canberra Series 85 MCA (Multi-Channel Analyzer) with a coaxial instrinsic germanium detector was calibrated using an eleven point standard purchased from Amersham. Standards were counted in the same geometry as the soil and sediment samples. Amersham standards are traceable to the U.S. National Bureau of Standards (NBS).

3. Water Samples -

   a. gamma spectroscopy - An eleven point NBS traceable standard was used in a 500 ml Marinelli beaker and calibrated on the Canberra Series 85 MCA.

   b. gross alpha/beta and Radium-226 - Countere were calibrated with NBS traceable standards. The New Jersey Radiation Laboratory uses procedures approved by EPA and participates in EPA's quality assurance program.

4. Radon-222 -

   The EDA Instrument's portable radon detector (RD-200) was calibrated at DOE's Environmental Monitoring Laboratory, Periodic checks with the manufacturer's check source are performed.

RADIOACTIVE DECAY PROPERTIES OF THE ^{40}K AND THE ^{232}Th SERIES [3]

Nuclide	Historical name	Half-life	Major radiation energies (MeV) and intensities		
			α	β	γ
^{40}K		1.26 10^9 y	–	1.32 (89%)	1.46 (11%)
10.7% | 89.3%					
^{40}Ar — ^{40}Ca		Stable	–		
$^{232}_{90}Th$	Thorium	1.41 10^{10} y	3.95 (24%) 4.01 (76%)	–	–
$^{228}_{88}Ra$	Mesothorium I	5.8 y	–	0.055 (100%)	–
$^{228}_{89}Ac$	Mesothorium II	6.13 h	–	1.18 (35%) 1.75 (12%) 2.09 (12%)	0.34 (15%) 0.908 (25%) 0.96 (20%)
$^{228}_{90}Th$	Radiothorium	1.910 y	5.34 (28%) 5.43 (71%)	–	0.084 (1.6%) 0.214 (0.3%)
$^{224}_{88}Ra$	Thorium X	3.64 d	5.45 (6%) 5.68 (94%)	–	0.241 (3.7%)
$^{220}_{86}Rn$	Emanation Thoron (Tn)	55 s	6.29 (100%)	–	0.55 (0.07%)
$^{216}_{84}Po$	Thorium A	0.15 s	6.78 (100%)	–	–
$^{212}_{82}Pb$	Thorium B	10.64 h	–	0.346 (81%) 0.586 (14%)	0.239 (47%) 0.300 (3.2%)
$^{212}_{83}Bi$	Thorium C	60.6 min	6.05 (25%) 6.09 (10%)	1.55 (5%) 2.26 (55%)	0.040 (2%) 0.727 (7%) 1.620 (1.8%)
64.0% | 36.0%					
$^{212}_{84}Po$	Thorium C'	304 ns	8.78 (100%)	–	–
$^{208}_{81}Tl$	Thorium C''	3.10 min	–	1.28 (25%) 1.52 (21%) 1.80 (50%)	0.511 (23%) 0.583 (86%) 0.860 (12%) 2.614 (100%)
$^{208}_{82}Pb$	Thorium D	Stable	–	–	–

RADIOACTIVE DECAY PROPERTIES OF THE ^{238}U SERIES [3]

Nuclide	Historical name	Half-life	Major radiation energies (MeV) and intensities		
			α	β	γ
$^{238}_{92}U$	Uranium I	4.51 10^9 y	4.15 (25%) 4.20 (75%)	–	–
$^{234}_{90}Th$	Uranium X_1	24.1 d	–	0.103 (21%) 0.193 (79%)	0.063 (3.5%) 0.093 (4%)
$^{234m}_{91}Pa$	Uranium X_2	1.17 min	–	2.29 (98%)	0.765 (0.30%) 1.001 (0.60%)
99.87% | 0.13%					
$^{234}_{91}Pa$	Uranium Z	6.75 h	–	0.53 (66%) 1.13 (13%)	0.100 (50%) 0.70 (24%) 0.90 (70%)
$^{234}_{92}U$	Uranium II	2.47 10^5 y	4.72 (28%) 4.77 (72%)	–	0.053 (0.2%)
$^{230}_{90}Th$	Ionium	8.0 10^4 y	4.62 (24%) 4.68 (76%)	–	0.068 (0.6%) 0.142 (0.07%)
$^{226}_{88}Ra$	Radium	1602 y	4.60 (6%) 4.78 (95%)	–	0.186 (4%)
$^{222}_{86}Rn$	Emanation Radon (Rn)	3.823 d	5.49 (100%)	–	0.510 (0.07%)
$^{218}_{84}Po$	Radium A	3.05 min	6.00 (~100%)	0.33 (~0.019%)	–
99.98% | 0.02%					
$^{214}_{82}Pb$	Radium B	26.8 min	–	0.65 (50%) 0.71 (40%) 0.98 (6%)	0.295 (19%) 0.352 (36%)
$^{218}_{85}At$	Astatine	~2 s	6.65 (6%) 6.70 (94%)	? (~0.1%)	–
$^{214}_{83}Bi$	Radium C	19.7 min	5.45 (0.012%) 5.51 (0.008%)	1.0 (23%) 1.51 (40%) 3.26 (19%)	0.609 (47%) 1.120 (17%) 1.764 (17%)
99.98% | 0.02%					
$^{214}_{84}Po$	Radium C'	164 μs	7.69 (100%)	–	0.799 (0.014%)
$^{210}_{81}Tl$	Radium C''	1.3 min	–	1.3 (25%) 1.9 (56%) 2.3 (19%)	0.296 (80%) 0.795 (100%) 1.31 (21%)
$^{210}_{82}Pb$	Radium D	21 y	3.72 (.000002%)	0.016 (85%) 0.061 (15%)	0.047 (4%)
$^{210}_{83}Bi$	Radium E	5.01 d	4.65 (.00007%) 4.69 (.00005%)	1.161 (~100%)	–
~100% | .00013%					
$^{210}_{84}Po$	Radium F	138.4 d	5.305 (100%)	–	0.803 (0.0011%)
$^{206}_{81}Tl$	Radium E''	4.19 min	–	1.571 (100%)	–
$^{206}_{82}Pb$	Radium G	Stable	–	–	–

NOV 2 6 1982

DISTRIBUTION:
See Next Page

The Honorable Nicholas F. Brady
United States Senate
Washington, D. C. 20510

Dear Senator Brady:

I am pleased to address the issue identified in the letter dated October 14, 1982, from Mrs. Marilyn Casson, which was enclosed with your letter of November 8, 1982 to Mr. Carlton C. Kammerer of our Office of Congressional Affairs. Mrs. Casson's letter concerned thorium contamination in Wayne, New Jersey. Background information concerning this problem was previously provided to you with my letter dated July 1, 1982.

The surveys referred to in my July 1 letter have been completed. Enclosed is a copy of a report, "Radiological Survey of Sheffield Brook," which contains the results of a portion of those surveys. The results of the remaining surveys, conducted primarily on the W. R. Grace and Company property on Black Oak Ridge Road, will be contained in a report which is scheduled to be available early in 1983. We will provide you with a copy of that report when it is issued. Based on the results of all surveys and measurements to date, the Nuclear Regulatory Commission (NRC) continues to conclude that the thorium contamination in Wayne does not pose an immediate threat to the health and safety of local residents.

The U. S. Department of Energy is responsible for administering a program (the Formerly Utilized Site Remedial Action Program - FUSRAP) that was created to provide for cleanup of sites contaminated with radioactive material when the contamination resulted from certain U.S. Government sponsored work. Since U.S. Government sponsored work was formerly conducted at the W. R. Grace and Company property in Wayne, the results of our surveys will be transmitted to the DOE so that the site can be considered for inclusion in the FUSRAP.

We realize that this issue is of significant concern to you and your constituents, and are working to resolve it. We will keep you informed of our progress.

Sincerely,

(Signed) T. A. Rehm

for William J. Dircks
Executive Director
for Operations

413

ITEM # 565

Enclosure:
As Stated

EDO WJDircks 11/24/82 OCA 11/ /82

(2)

COM29 (Transmitted to OEDO from RI via word processor on 11/23/82)

OFFICE	RI:DE&TP	RI:DE&TP	RI:DE&TP	RI:SLO	RI:PAO	RI:DRA	RI:RA
SURNAME	Kinneman/cgl	Joyner	Martin	Brenneman	Abraham	Allan	Haynes
DATE	11/22/82	11/23/82	11/23/82	11/23/82	11/23/82	11/23/82	11/23/82

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Region I Docket File

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Docket No. 40-00086 License No. STA-422

Carl J. Collica, M.S., DABR
C/O Norwalk Hospital
Norwalk, Connecticut 06856

Dear Carl:

This refers to your letter dated November 10, 1982.

I think you are aware that this office has been conducting an extensive review and surveys of the area surrounding the W.R. Grace and Company property in Wayne, New Jersey. Our contractor, Oak Ridge Associated Universities has conducted surveys in the area of the railroad siding you discuss in your letter. Preliminary results indicate the presence of thorium, but low (less than one millirem per hour) radiation levels. Their final report will be available in early 1983. I have placed you on the list to receive a copy.

If I can be of any additional assistance, do not hesitate to call.

Sincerely,

Original Signed By
John E. Glenn, Ph.D.

John E. Glenn, Chief
Nuclear Materials Section B

OFFICE	RI:DETP	RI:DETR					
SURNAME	Kinneman,	Glenn					
DATE	12/3/82	12/6/82					

NRC FORM 318 (10-80) NRCM 0240 OFFICIAL RECORD COPY USGPO: 1981—335-960

DEC 10 1982

MEMORANDUM FOR: Sandy Showman, Administrative Assistant
to Commissioner Gilinsky

FROM: Edwin G. Triner, Director
Division of Budget and Analysis
Office of Resource Management

SUBJECT: BACKGROUND INFORMATION FOR COMMISSIONER GILINSKY'S TRIP TO OYSTER CREEK

Attached is the information you requested on Oyster Creek for Commissioner Gilinsky's trip. Additional information is also provided on Hope Creek, Salem and the W. R. Grace and Company facilities located in New Jersey.

The information was primarily obtained from the NRR Licensing Project Managers, where available, the Resident Inspectors, Region I personnel and recent Congressional correspondence.

If you have any questions, please contact me.

Original Signed by
Edwin G. Triner

Edwin G. Triner, Director
Division of Budget and Analysis
Office of Resource Management

Attachments:
As stated

cc: D. Garner
B. Liaw
G. Zech
S. Droggitis
T. Rehm

bcc: L. Barry, RM
R. Scroggins, RM
E. Triner, RM/B
J. Clark, RM/BMA
L. Underwood, RM/BMA
RM/B R/F (6)
RM/BMA (2)
J. Lombardo, NRR (Oyster Creek)
C. Grimes, NRR (Oyster Creek)
J. Thomas, Resident Inspector (Oyster Creek)
Bob Summers, Resident Inspector (Salem)
Dave Wagner, NRR (Hope Creek)
W. H. Bateman, Resident Inspector (Hope Creek)
J. D. Kinneman, Region I (W. R. Grace & Co.)

d15

OFFICE ➤	RM/BMA	RM/BMA	RM/B
NAME ➤	Underwood:js	Clark	Triner
DATE ➤	12/9/82	12/9/82	12/10/82

ITEM # 575

(8)

HOPE CREEK UNIT NO. 1

Utility:	Public Service Electric & Gas
Location:	18 mi SE of Wilmington, Delaware Salem County, New Jersey
Docket No:	50-354
CPPR & Date:	CPPR-120 11/4/74
Application for Operating License:	Expected 3/83
Power Level:	1067 MWe; 3440 MWt
Reactor Type:	BWR
Architect/Engineer:	Bechtel
Nuclear Steam Supply System (NSSS) Vendor:	Bechtel
Constructor:	General Electric
NRC Licensing Project Manager:	Dave Wagner (Tel: 492-9536)
IE (Senior) Resident Inspector:	William H. Bateman (Tel: 609-935-5151)

Applicant's Percent Construction Complete: 60 percent
Applicant's Estimated Fuel Load Date: January 1986

Status of Construction

- Most of the concrete work is finished.
- Pulling of electrical cable has not yet begun.
- Installation of piping, steel structures and equipment installation are in process.
- The containment dome was recently set in place.

Hope Creek 2

Cancellation of Unit 2 by the Applicant was based on economic consideration and lower than anticipated load growth.

Dismantling of Unit 2 is almost complete. A portion of the tower still remains.

SALEM

Utility:	Public Service Electric & Gas	
Location:	20 mi S of Wilmington, Delaware Salem County, New Jersey	
	Unit 1	Unit 2
Docket No:	50-272	50-311
Operating License/Date:	DPR-70 12/1/76	DPR-75 5/25/81
Initial Criticality:	12/11/76	8/8/80
Elec. Ener. 1st Gener:	12/25/76	6/3/81
Commercial Operation:	6/30/77	10/13/81
Power Level:	1079 MWe; 3338 MWt	Same
Reactor Type:	PWR	"
Architect/Engineer:	Public Service & Gas Co.	"
Nuclear Steam Supply System (NSSS) Vendor:	Westinghouse	"
Constructor:	United Engineers & Constructors	"
Turbine Supplier:	Westinghouse	"
Condenser Cooling Method:	Once thru	"
Condenser Cooling Water:	Delaware River	"
NRC Licensing Project Manager:	William Ross (Tel: 492-7829)	"
New Project Manager will be:	Don Fischer	"
IE Resident Inspector:	Bob Summers (Tel: 609-935-3850)	"

< what about Lief?

Salem Unit No. 1

Unit 1 has just completed refueling. The reactor has been shut down since the second week of October 1982.

Bad welds have been found in the component cooling water heat exchanger which was just put in this past spring. Due to these problems, a great deal of safety-related piping needs to be repaired or replaced.

Salem Unit No. 2

Unit 2 has been operating at a reduced power level since August 1982 due to problems experienced with safety valves.

The reactor is presently operating at 81 percent power and is approaching a refueling outage. Power level is being reduced due to fuel depletion. Refueling is scheduled for mid-January 1983.

Salem Units 1 and 2

Enforcement Action

A Notice of Violation and a Notice of Proposed Imposition of Civil Penalty in the amount of $40,000 was issued to the licensee on October 27, 1982. This action was based on a violation relating to an inadequate vital area physical barrier.

The licensee has agreed with the NRC findings and has submitted payment in response to the fine.

Emergency Preparedness Exercise

An annual full-scale emergency preparedness exercise was held October 13, 1982. The licensee and FEMA representatives from the States of New Jersey and Delaware participated in the exercise. An NRC team was present to observe the on-site portion of the exercise.

Systematic Assessment of Licensee's Performance (SALP)

The NRC has completed its annual (9/1/81 - 9/1/82) Systematic Assessment of Licensee's Performance. The report was issued to the licensee the end of November 1982.

Physical Security

A recent task force which was set up to look at safeguards and their effects on plant safety will be visiting the site throughout this week. The task force is chaired by Ron Haynes, Regional Administrator, Region I. Salem will conclude the list of plants to be reviewed.

OYSTER CREEK (UNIT 1)

Utility:	General Public Utilities Nuclear Corporation (GPU)
Location:	5 mi S of Toms River, New Jersey Ocean County, New Jersey
Docket No:	50-219
Operating License/Date:	DPR-16 8/1/69
Initial Criticality:	5/3/69
Elec. Ener. 1st Gener:	9/23/69
Commercial Operation:	12/1/69
Power Level:	620 MWe; 1930 MWt
Reactor Type:	BWR
Architect/Engineer:	Burns & Roe
Nuclear Steam Supply System (NSSS) Vendor:	General Electric
Constructor:	Burns & Roe
Turbine Supplier:	General Electric
Condenser Cooling Method:	Once thru
Condenser Cooling Water:	Barnegat Bay
NRC Licensing Project Manager:	James Lombardo (Tel: 492-7167)
IE (Senior) Resident Inspector:	John Thomas (Tel: 609-693-0702)

The reactor is operating at 49 percent power.

Extended Outages

A refueling outage is scheduled beginning January 15, 1983 through November 1983. During this time extensive modifications and maintenance activities are scheduled. Major items scheduled are:

- Mark I Torus Structural Modifications
- New Cable Spreading Room
- Turbine Inspections

In addition to these modifications, 168 NRC-required modifications (NUREG-0612, 0661, 0696, 0737, 0803 and various orders and letters) will be completed along with 15 plant modifications/major maintenance activities. On completion of this outage, operations will then resume for approximately nine months through August 1984. A second outage is scheduled for mid-1984 which will continue for approximately six to eight months. GPU Nuclear estimates the total cost of both outages to be in excess of $150 million.

IE Bulletin No. 82-03, dated October 14, 1982, and Revision 1, dated October 28, 1982, "Stress Corrosion, Cracking and Thick-Wall, Large-Diameter, Stainless Steel, Recirculation System Piping at BWR Plants," requires inspection of recirculation piping. Region I states this may also require additional maintenance work.

Oyster Creek (Unit 1)

Systematic Evaluation Program (SEP)

A draft Integrated Plant Safety Assessment Report (IPSAR) for the Oyster Creek plant was issued September 1982, NUREG-0822. This issuance represents the first evaluation of a boiling water reactor to be completed under Phase II of the Systematic Evaluation Program.

The final IPSAR is under management review and is expected to be forwarded to the Commission the end of December 1982. Licensee and NRC staff now agree on all proposed corrective actions.

Enforcement Action

A Notice of Violation and Proposed Imposition of Civil Penalties (NV/PICP) in the amount of $40,000 was issued on November 30, 1982 to GPU for violations resulting from inadequate testing to establish valve operability.

W. R. GRACE AND COMPANY
Wayne, New Jersey
(Pompton Plains Site)

A great deal of public attention has been raised concerning radioactive contamination on the W. R. Grace site and surrounding area along the Sheffield Brook in Wayne, New Jersey.

In May 1981, at the request of the State of New Jersey, EG&G conducted an aerial radiological survey of the surrounding area of the W. R. Grace site. Survey results indicated slightly elevated radiation levels on the W. R. Grace property and along the Sheffield Brook which drains the property. These surveys taken indicated that radioactive levels and surface soil contamination exceeded NRC's current criteria for unrestricted use.

In May 1982, Oak Ridge Associated Universities (ORAU) was contracted by the NRC to perform additional surveys. An off-site survey included radiation-level measurements and analysis of numerous soils and water samples. Analysis of several samples of water from the brook revealed no radioactive contamination in the water. No radiation levels above normal background exists in any residence. Areas where radioactive levels are above normal background are near the rear boundaries of the properties that abut the brook. A final report of this survey was released in October 1982.

An on-site survey of the W. R. Grace and Company property which began in July 1982 has also been completed. A preliminary report is expected to be available in late December 1982 or early January 1983. The NRC is waiting for publication of the report from ORAU. Although no official position has been made, it is believed that the site does not appear to meet present criteria for release for unrestricted use. However, the NRC does not believe that the thorium contamination poses an immediate threat to the health and safety of local residents.

Both on-site and off-site survey reports have been submitted to the Department of Energy (DOE) to be considered for inclusion in DOE's Formerly Utilized Site Remedial Action Program (FUSRAP). FUSRAP is a national program administered by the DOE to provide, in two stages: 1) an assessment and cleanup of sites contaminated with radioactive materials associated with the Manhattan Project and the former Atomic Energy Commission sponsored work; and 2) to take remedial action, if any. The DOE has agreed to include the W. R. Grace site in the FUSRAP program.

Not so They've only agreed to consider including it under FUSRAP

A question remaining unanswered is who will decide whether the contaminated soil must be removed and who will bear the expense for the removal, if removal is determined to be necessary. The property is still owned by the W. R. Grace and Company. The DOE may have authority to take remedial action to remove radioactive material as a result of work conducted under certain contracts to the then AEC.

A summary of the historical background of the W. R. Grace and Company is attached.

W. R. Grace and Company

Listed below are NRC responses to recent Congressional letters forwarding constituent concerns regarding the contamination of the water, air and soil, and its effects on the health and safety of local residences:

1. NRC response dated August 27, 1982 to Congresswoman Bouquard

2. NRC responses (2) dated July 1, 1982 and November 26, 1982 to Senator Brady

3. NRC response dated August 10, 1982 to Senator Bradley

4. NRC response dated September 29, 1982 to Congressman Courter

5. NRC responses (6)--dated May 21, 1982, August 27, 1982, September 2, 1982, September 29, 1982 (2), and November 1, 1982--to Congressman Roe.

Attachment:
Historical Background of W. R. Grace and Company

OFFICE OF THE SECRETARY OF TRANSPORTATION

WASHINGTON, D. C. 20590

SPECIAL PERMIT NO. 5330

This special permit is issued pursuant to the authority of §173.22(a)(1), Department of Transportation (DOT) Regulations for the Transportation of Explosives and Other Dangerous Articles, 49 CFR Parts 171-190, as amended.

1. The GENERAL ELECTRIC COMPANY is hereby authorized to ship fissile radioactive material, n.o.s., further described as plutonium or enriched uranium, under the provisions of §§173.393(g)(2) and 173.393(m) of the DOT regulations, in accordance with the provisions of the U. S. Atomic Energy Commission (USAEC) license numbers SNM-960, Amendment 71-7, dated July 10, 1967, and SNM-54, Amendment 71-2, dated August 4, 1967, and as further provided for herein.

2. The authorized packaging shall consist of a metal drum birdcage-type structure. Solid materials will be packaged within 2 inner metal cans. Solutions will be packaged within a vented polyethylene bottle (not to exceed 20% nitric acid). The package model number is BP-1. The package meets all of the requirements of a DOT Specification 6L (§178.103) container, except that the steel drum may be Spec. 17H, the pipe may be Schedule 80, and the supporting structure is tubular. The marking requirement of §178.103-6(a)(1) is waived.

3. The closure device must have affixed to it a tamper-proof lock wire and seal adequate to prevent inadvertent opening of the container, and of a type that must be broken if the package is opened.

4. The authorized contents of each package shall consist of not more than the following:

c/16

ITEM # 562

WAB/GR/cw

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Type of Contents	Quantity	Fissile Class II Units	Fissile Class III Quantity Per Vehicle
Uranium-235 as noted in S178.103-2, any enrichment	5 kilograms	0.3	200
Plutonium nitrate, concentration not exceeding 250 grams Pu per liter	3.3 liters	0.2	300
Plutonium oxide, density not exceeding 3.77 g/cc Pu;Pu-240 content not less than 5.0%; or mixture of plutonium oxide and uranium-235 oxide	5 kilograms	0.3	200

A hydrostatic test shall be performed on the inner pipe, at 300 psig. Such test shall be conducted prior to first use, and annually thereafter. Failure to pass the test shall result in disqualification of the container.

5. The authorized package meets the criteria of the International Atomic Energy Agency for Type B packaging for fissile radioactive materials.

6. Fissile Class III shipments must be made with exclusive use of the transport vehicle assigned to the shipper designated herein, or, as an alternative, the transport vehicle must be accompanied by an escort in a separate vehicle, such escort having the capability, equipment and authority to provide administrative controls adequate to assure public safety in the event of an accident.

7. Prior to each shipment authorized by this permit, the consignee shall be notified of the dates of shipment and expected arrival.

NAB/GR/cw

8. The outside of each package shall be plainly and durably marked "DOT SP 5330" and "FISSILE RADIOACTIVE MATERIAL", in connection with and in addition to the other markings and labels prescribed by the DOT regulations. Each bill of lading, shipping order or other shipping paper issued in connection with shipments made under this permit must bear the notation "DOT SPECIAL PERMIT NO. 5330" in connection with the commodity description and label notation thereon. In accordance with S173.9(c) of the DOT regulations, the special permit identification may be either tag or label securely affixed to each package. Shipments destined for export shall also bear the marking "TYPE B".

9. This permit does not relieve the shipper or carrier from compliance with any requirement of the DOT regulations, except as specifically provided for herein.

10. This permit authorizes shipments only by rail freight, rail express, cargo aircraft and motor vehicle.

11. This permit shall expire August 31, 1969.

Issued at Washington, D. C., this 23rd day of August, 1967.

W. K. Byrd
Acting Director
Office of Hazardous Materials

Approved:

E. G. Cox
For the Administrator
Federal Highway Administration

W. K. Byrd
For the Administrator
Federal Railroad Administration

JAB/GR/cw

Page 12 placed by WGL 2/22/71

6.7 The primary function of this Committee is to review each proposed equipment or any proposed operating procedures with regard to process safety, ventilation and nuclear criticality safety. The Committee must be satisfied that the procedures and the equipment are safe, and it must formally approve them prior to use.

6.8 A second function of this Committee is to inspect the operations and the health and safety records for compliance with approved procedures and pertinent AEC regulations at least once in each month that operations involving special nuclear material are being performed. The Committee will report the results of each inspection and its recommendations to the General Manager, Research Division.

6.9 In the event of an accident or emergency involving special nuclear material, the Nuclear Safety Committee will stand ready to aid in the solution or correction of the problem.

6.10 Responsibilities and their Delegation-- The General Manager--Research Division has established the policy that all operations on the site involving special nuclear material will be performed only in accordance with written procedures that have been reviewed and approved for their adequacy relative to the protection of personnel and the public from the nuclear hazard. This policy is implemented through delegations to appropriate managers and groups responsible for individual aspects of the nuclear activities. Implementation is simplified somewhat by the straight forward operations which are to be performed upon the special nuclear materials and by the limited scope of these operations.

6.11 Mr. G. E. Ashby has overall responsibility for the preparation of operating procedures. These procedures are detailed, specific and complete with regard to practices involving safety, be it chemical, nuclear, criticality or radiation safety.

6.12 The members of the Nuclear Safety Committee have the responsibility for approving each procedure involving the handling or processing of special nuclear material as being adequate to protect personnel and the public from the nuclear hazard, and as being in compliance with pertinent AEC regulations and with the provisions of this amendment.

6.13 Mr. D. R. Telesca has the direct responsibility for carrying out every operation involving special nuclear material in accordance with the provisions of this license amendment as implemented by approved operating procedures.

6.14 Mr. W. K. O'Loughlin has overall responsibility for the Health and Safety program; the security of the facilities as required to safeguard the special nuclear material; and the medical program.

6.15 Mr. J. N. Lomonte is directly responsible for carrying out the Health and Safety program. This program includes routine air and smear sampling for contamination and frequent inspection of the operations for strict compliance with the procedures and the limitations and arrangement of special nuclear materials set forth therein. Mr. Lomonte reports any deficiency to the Plant Manager for correction. Any hazardous condition or non-compliance noted shall be corrected promptly by the operating personnel. Any failure to do so is immediately reported by Health and Safety to the General Manager who will, if necessary to protect the health and safety of personnel or the public, discontinue operations until the deficiency is corrected.

Mr. Reese is 45. He did his undergraduate work in Chemical Engineering at the University of Cincinnati and at the University of Alabama the latter as a part of his service in the U.S. Army during World War II. During that service he earned three battle stars in Germany and was decorated with the Silver and Bronze Stars. He left the service with the rank of Captain. He is a member of ANS, AIF, INMM, ASM, and AIMME. He has been and is active on numerous working committees of each.

6.29 Training--Prior to working with fissile materials, each employee who is to work in the nuclear area will attend a four hour basic course covering nuclear criticality safety, radiation safety, and the use and maintenance of safety equipment. These will be followed monthly with safety meetings, each of about one hour duration, on pertinent safety matters including the above.

The part of the basic instruction in safety dealing with nuclear criticality will define the chain reaction, how it is sustained, and describe the mechanisms used to prevent a criticality accident. This instruction will be prepared and presented by the criticality member of the Nuclear Safety Committee, or his alternate.

The radiation safety instruction will include a definition of the types of radiation of concern; exposure mechanisms; operating practices to minimize exposure, and the methods used to determine exposure such as film badges, air sampling, area monitoring and biological analyses. Records will be discussed. This portion of the instruction will be prepared and presented by the radiation safety member of the Nuclear Safety Committee, or his alternate.

Following this basic instruction period, each employee will be instructed in the part of the operation he is to perform. He will be given sufficient

7.9 Particle Formation-- The sol is pumped from the storage tanks into the column feed tank 10-11. This mixture is then continuously circulated through constant overflow tank 10-12. A stream from this tank is continuously fed to the additive mixer 05-3 followed by the column feed tank 10-13A or 13B and thence into one of the particle formation columns 13-6A or 6B through a series of hollow needles at the top. The droplets of feed fall into a counter-flowing stream of hexanol, introduced at the bottom of the unit. In falling through the hexanol, the sol is dewatered and solid UO_2 particles are formed. These are collected in the conical bottom section cylinder. Hexanol flows out the top of the unit to solids filter 06-7A or 7B and then to washer 10-18 where it is continuously washed with water. It then passes through the backup particle trap 10-19 and then to the still 09-1 to remove excess water. It is then recycled to the unit.

7.10 The particle formation units 13-6A and 6B are simply long, bare columns six inches in diameter spaced 36 inches on centers which taper down to two inches at the bottom. The particles are periodically drained into a four inch diameter collection container 13-4A or 4B which is transferred by hand to the washing station.

7.11 Drying and Sintering-- The collector, containing about 500 grams of green particles is removed from the particle formation unit and moved to the wash station. Here the particles are transferred to a four inch glass pipe which has a metal filter at both ends to retain the particles. The particles are drained of the residual hexanol, washed then drained.

7.12 The hexanol that is removed is permitted to separate in a six inch diameter pipe tank 10-24. It is then decanted and sent to the hexanol storage tank 10-22. The aqueous washes are also collected in tank 10-24 from which they are sent to the waste hold tank 10-42A or 42B which contains borosilicate glass raschig rings as a neutron poison although, these waste solutions normally contain only trace quantities of fissionable material. Ports are provided in the top of these two tanks for periodic inspection of raschig ring level.

7.13 The washed particles are then poured into a one inch deep tray and moved to the vacuum drying station 13-10A. This batch unit is evacuated and heated to 250 C to assure complete removal of moisture from the particles. The dryer is cooled and the tray of dried particles is transported to the weighing station 14-2.

7.14 The weigh station is connected to a series of glove boxes and in this complex which is under inert gas, the particles are weighed and particles with undesirable physical characteristics are separated out and returned to dissolution. Good particles are stored in one of the standard canisters--04-8 which measure 3.5 inches outside diameter by nine inches in length. Approximately three kg of green particles will fill one of these containers.

7.15 The standard canister with a three kg sintering charge in it is moved to the sintering furnace 01-1 which is a three inch vertical pipe. The contents of the container are emptied into the furnace and the particle are subjected to high temperature in the presence of hydrogen. The furnace is allowed to cool and the densified particles are removed from the furnace into a storage canister using reactor unloading device 04-11. They are then returned to the weigh station.

7.16 Screening, Sampling, and Blending-- At this point approximately 250-gram quantities of the particles are weighed into polyethlene bottles. These bottles are in turn placed in storage racks in the dry box.

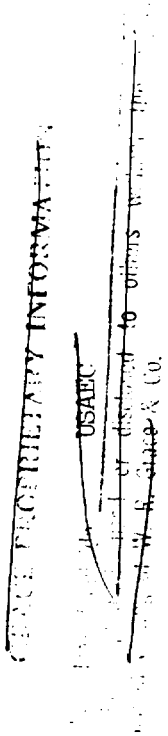
7.17 One at a time, charges of particles are placed in a set of eight inch diameter Rotap screens and the product is sized. Off-size material is bottled and transferred to scrap or recycle storage. Material which meets product size requirements is next tested for shape on an inclined plane. Again product which does not meet specifications is bottled and sent to scrap or recycle storage. Samples are taken of material which has met all of the size and shape requirements to determine the density of the product.

7.18 A number of individual batches of satisfactory product are next blended and split, and additional samples taken. Larger lots are again blended, split, and sampled, and finally bottled in the standard canister in approximately three kg lots, for storage until finishing is to be carried out. All particle blending is performed in a blender which is bare wall and housed in a glove box under inert gas. All of the glove boxes have cartridge type replaceable filters on the exhaust outlet.

7.19 Finishing the Particles-- Next approximately three kg batches of UO_2 particles which meet product specifications are placed in the finishing reactor 01-3. This unit is a three inch diameter tube about forty inches long installed inside a furnace. The particles are fluidiz with a mixture of argon and hydrogen. Part of the hydrogen passes over

heated metal chloride, vaporizing it and carrying the metal chloride into the fluid bed reactor where the chloride is reduced, depositing a thin metal coating on the UO_2 particles. The exit gases, which contain HCl, are cooled, filtered to remove any solids in filter 06-22A or 22B, and bubbled through sodium hydroxide solution to remove them from the off gas stream.

7.20 Screening and Washing-- The coated particles are then cooled and transferred in one of the standard canisters to a screening station 14-8 where again off-size particles are separated out, bottled, and removed to scrap recovery storage. Particles which fall within the acceptable range are transferred to a washing station in glove box 14-9. Herein the particles are washed first with acid, then with water, and finally with ethyl alcohol. The washing solutions pass through filter 03-31 on their way to 10-36, the waste holdup tank. The washed particle are placed in a one inch deep tray and placed in an oven where they are dried under vacuum.



7.21 Blending, Sampling, and Shipment-- The dried coated particles are put through a splitter in glove box 14-11 and then sampled for final product acceptability tests. Various lots are blended, split again, sampled for final retention samples, and then weighed out into final shipping bottles. The amount of U-235 per three inch bottle will not exceed 11 kg. The finished product will be stored in safe storage rack 11-14 and it will finally be placed in packages approved for the shipment of this material.

7.24 Emergency Equipment-- A cache of emergency equipment is maintained away from the working area in a waterproof structure located south of the 16A facility and near the entrance to the site as noted on Figure 3.2. The emergency station equipment consists of:

1) Scott Air-Pak (2)

2) First Aid Kit equipped for treating hemorrage, lacerations, burns, and shock.

3) Disposable plastic suits, boots, head covers, and full-face respirators.

4) Decontamination equipment, detergents, and waste containers.

5) Portable Survey Meter, Victoreen Instrument Co. Model Thyac III.

7.25 Industrial Safety Equipment-- In conjunction with the radiation safety program at the site, industrial health and safety of plant personnel is a continuing concern which is given considerable attention in all projects on the site. Some of the major equipment and facilities which are available to protect property and personnel include portable fire extinguishers, fire hoses and automatic sprinkler systems, a well equipped dispensary attended daily by a registered nurse, and a wide range of typical industrial safety equipment for individual and general use.

8.0 RADIATION SAFETY PROGRAMS AND PROCEDURES

A system of instructions is established whereby personnel at the facility are informed of policies, procedures and announcements relating to safety.

8.1 Programs and procedures are established as needed to minimize exposure to radiation. Steps are taken to familiarize all personnel who might be subjected to radiation exposure in the Nuclear Chemistry Facility with the programs and procedures. It is the philosophy of the Company to keep radiation exposures to the lowest practicable level in every instance.

8.2 Personnel Work Rules-- Work rules are established to minimize the hazards to personnel handling and processing radioactive materials. These rules include:

a) Protective clothing, as specified in paragraph 7.8, is furnished by the company and the type of clothing to be worn in a specific activity is based upon the potential for contamination from that activity.

b) Outer footwear worn in restricted areas is not to be worn into unrestricted areas.

c) Preparation, storage or eating of food is not permitted in process areas.

d) Hands are to be washed before eating.

e) Smoking is not permitted in radioactive material areas.

f) Safety goggles, safety glasses or other personal protection gear specified by signs or instructions for use in a

8.4 Personnel Monitoring-- No one is permitted to enter any area containing radioactive materials without a beta-gamma film badge. Personnel are instructed in the use and care of their film badge, so that it will in fact depict the radiation received. They are instructed in the use of the hand monitors and as to the levels of cleanliness required when leaving radiation areas. Individuals who normally work in radiation areas will receive a bioassay to determine the extent of inhaled or ingested uranium at least once each six months. In the event of release of radioactive material or other indication that anyone may have ingested or inhaled an abnormally large quantity of uranium, bioassays will be conducted to establish the extent of internal exposure to the individuals involved. A bioassay is performed upon each individual employed in the Nuclear Chemistry Facility at the time of his termination, in order to assess the extent of internal deposition of uranium, if any.

8.5 Medical Program-- The medical program at the Center is under the direction of a physician who is at the Center one afternoon each week and at any other time his services are needed.

Each employee working in any area containing radioactive material has a clinical urinalysis at least once every six months, a complete blood count once a year, a complete physical examination yearly, and a chest x-ray every two years. All personnel leaving

employment are given physical examinations. Laboratory findings indicating any unusual problem are followed up immediately.

A dispensary is maintained at the Center for the immediate care of all minor injuries, such as minor burns, abrasions, bruises, etc. All visits to the dispensary by employees are recorded in a log book, and this information is transferred to the employee's permanent medical record.

All employees are instructed and advised about the chemical toxicity of various material used in the plant, chemical burns, minor injuries, and personal hygiene measures that should be followed to minimize the intake of all chemical substances that might be injurious to their health.

Close cooperation with the Health and Safety Department is maintained and all results of sampling for radioactivity and film badge readings are reviewed by the Medical Director.

8.6 Surveys-- The work area is continuously sampled for airborne activity in order to provide a record of activity levels. In addition, breathing zone areas, particularly in locations where airborne activity is most likely to occur, are surveyed periodically with portable instruments to assure that the airborne activity is indeed at acceptable levels. The maximum acceptable level of alpha activity in air, as represented by the survey sample, is 1×10^{-10} μCi/ml. In the event that the continuous sampler filter paper reads abnormally high or exceeds the above limit, a special survey with portable equipment will be undertaken to determine the source of the activity. Steps will be taken to physically correct the abnormality.

8.7 Any equipment or packages to be removed from the radioactive materials area into an unrestricted area will be surveyed and will be permitted to leave the area only upon presentation of a release slip signed by the Health and Safety representative. Radioactive contamination of all packages and equipment leaving the restricted area shall be within the following limits:

1. The maximum amount of fixed alpha activity in disintegrations per minute per 100 square centimeters should not exceed 25,000.
2. The average amount of fixed alpha activity in disintegrations per minute per 100 square centimeters should not exceed 5,000.
3. The maximum amount of removable (capable of being removed by wiping the surface with a filter paper or soft absorbent paper) alpha activity in disintegrations per minute per 100 square centimeters should not exceed 1,000.

   a) The maximum level at one centimeter from the most highly contaminated surface of a building or piece of equipment measured with an open-window beta-gamma survey meter through a tissue equivalent absorber of not more than seven milligrams per square centimeter should not exceed one millirad per hour.

b) The average radiation level at one centimeter from the contaminated surface of the building or equipment measured in the same manner should not exceed 0.2 millirad per hour.

8.8 Survey instruments are calibrated routinely as follows:

a) Instruments reading alpha are calibrated with sources furnished with the instrument or with standards prepared by the National Bureau of Standards.

b) Instruments reading Beta-Gamma are calibrated with a cobalt 60 source.

c) The gamma alarm system has a built-in remote calibration source. The instruments are checked weekly and each source is smear checked each six months for leakage.

The portable instruments are calibrated monthly.

8.9 Air sampling vacuum pumps are removed from service periodically and reconditioned. They are then recalibrated with a flow meter and tagged with flow data and date of calibration.

8.10 Fire fighting equipment including hoses and extinguishers are checked periodically as required by the State and the insurance carrier.

8.11 Posting and Labeling-- Areas that may contain radioactive materials are posted in accordance with the provisions of 10 CFR Part 20 and the Plant Manager is charged with the responsibility of implementing the established posting procedures.

In lieu of labeling each package as required by 10 CFR 20.203(f), containers of radioactive material that are not to leave the area are labeled with the type of material, contents and U-235 enrichment. Each container is identified by color coded label or tape, as recommended by the Institute for Nuclear Materials Management, as follows:

Uranium enriched above 5% in U-235--------Yellow

Uranium enriched below 5% in U-235--------Green

Natural Uranium----------Purple

Depleted Uranium----------Gray

In order to avoid confusion, tapes and labels in these colors are not used for any other purpose in the nuclear facilities at the Center.

In addition, individuals are further warned by a sign posted at the entrance to each area where radioactive material may be found which reads:

EVERY CONTAINER OR VESSEL
IN THIS AREA
MAY CONTAIN RADIOACTIVE MATERIAL

Areas or equipment that require the use of goggles or other safety equipment are so posted.

8.13 Reports and Records-- Individual exposure records obtained from the monthly reading of the film badges are maintained in the permanent records of each employee as are the results of individual clinical tests relating to radioactivity. An AEC Form 5 File is maintained for each employee. Entries are made at the end of each calendar quarter. The activity in the work area as represented by air samples and smear tests are logged in graphic form to alert supervision to any undesirable trends, so that timely corrective action can be taken.

8.14 Industrial Safety Program-- The W. R. Grace & Company has long been involved in chemical operations involving toxic, flammable and corrosive materials. Over the years it has developed an excellent Industrial Safety Program. In addition, most of the employees at the Center who will be working in these facilities have had prior safety training in school and in industry. Each employee is instructed in safe practices, and the responsibility for working in a safe manner is placed upon him.

The benefits of training in operating safety and in good housekeeping practices carry over into the nuclear area.

Procedural controls are placed upon the storage and use of flammable, corrosive and toxic chemicals. Modern fire fighting and emergency equipment is available and fire prevention practices are followed in accordance with applicable codes.

8.18 It shall be the responsibility of the General Manager to establish when personnel may return to the various work areas on the site; to notify the AEC of the accident; and to coordinate decontamination during the recovery phase.

8.19 Radiation Safety Review-- Any new facilities or any changes in facilities or operating procedures having to do with radioactive materials must be reviewed and approved by the Nuclear Safety Committee. The principal area of interest in this review other than nuclear criticality safety is to assure that adequate health protection facilities have been provided for safe operation.

8.20 In the event of an emergency in the Building 16A facility, and in the absence of the Plant Manager or the Production General Foreman, the Shift Foreman will have responsibility for handling the emergency within the uranium containing facility. The Emergency Controller has the responsibility for the rest of the site and he will continue to do so.

(b) Radiation Safety.

This system is a completely closed liquid system which poses no new problems.

(c) Safeguards.

Material leaves the system as product from the column which is handled as discussed in the next paragraph and a very small quantity may find its way to the cartridge filter which material is eventually accounted for as scrap.

10.5 Particle Washing and Drying--The small beaker of particles taken from the column is transferred to one of the four inch wash containers which is drained of drying agent. The drying agent is piped by way of a cartridge filter to the redrying system. The particles are rinsed with an aqueous solution and placed in a drying tray. These one inch deep trays are placed in the vacuum furnace and the particles are dried. Alternatively a one inch thick slab container may be used for this operation. The aqueous wash passes through the particulate filter and to the waste water collection tanks.

(a) Nuclear Safety.

The particles are maintained in safe geometry containers of four inch diameter, or in safe volume slabs. The maximum volume in one location is 4.4 liters of total tray capacity in the furnace. No other trays are permitted in the area and the furnace opening is fitted to accomodate only these trays. The material is not densified appreciably in the dryer but the moderator is removed thus decreasing reactivity.

The maximum particle density at this point is 35% of theory giving a maximum random density in the tray of 2.1 g/cc U-235. The maximum charge

6.11 Mr. G. E. Ashby has overall responsibility for the preparation of the formal operating procedures. These procedures are detailed, specific and complete with regard to practices involving safety, be it chemical, nuclear, criticality or radiation safety.

6.12 The members of the Nuclear Safety Committee have the responsibility for approving, by signature, each procedure involving the handling or processing of special nuclear material as being adequate to protect personnel and the public from the nuclear hazard, and as being in compliance with pertinent AEC regulations and with the provisions of this amendment. A negative finding by the Committee as to the adequacy of criticality or radiation safety will not be overruled by anyone.

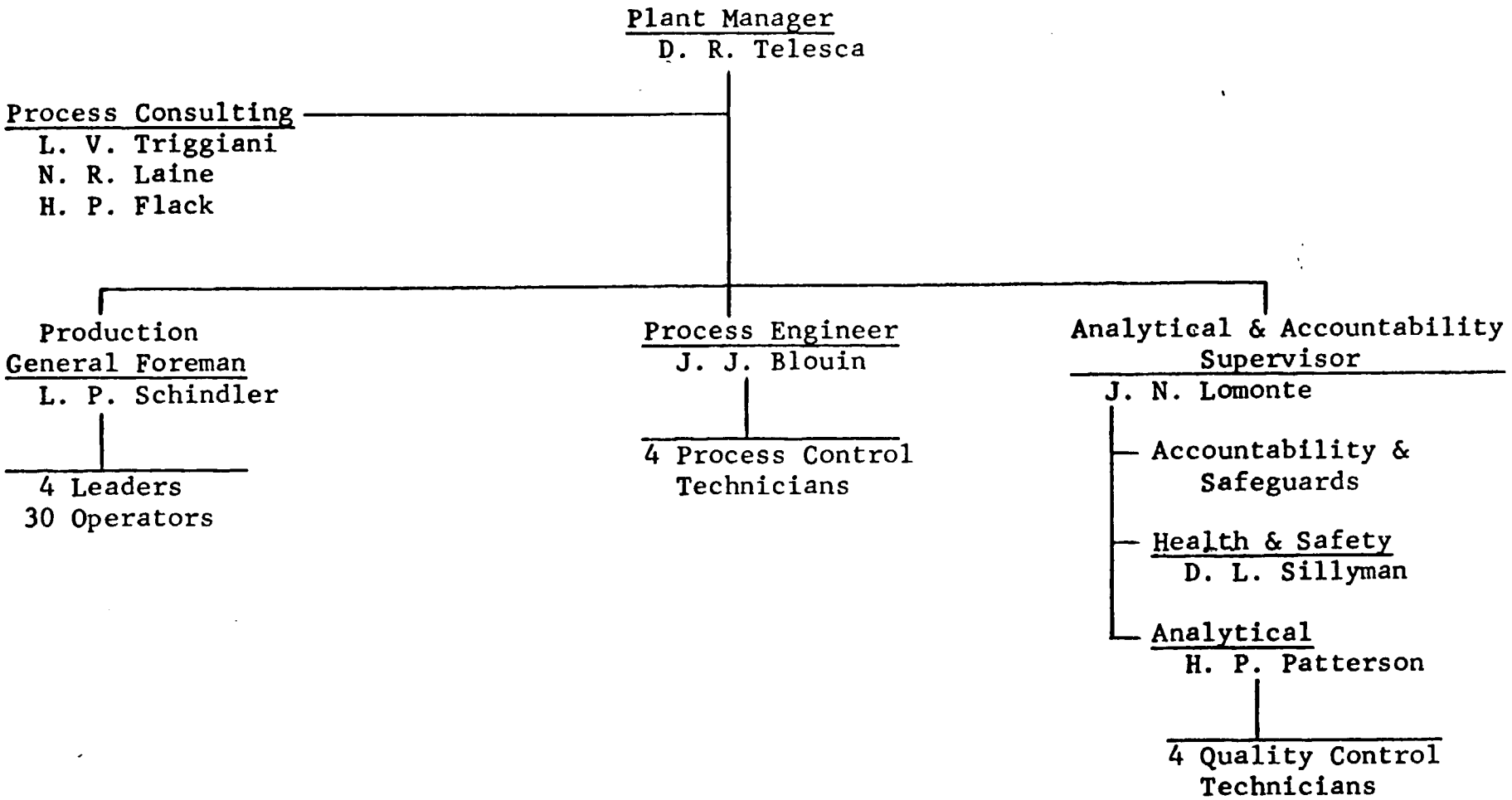
6.13 Mr. D. R. Telesca has the direct responsibility for carrying out every operation involving special nuclear material in accordance with the provisions of this license amendment as implemented by approved operating procedures.

6.14 Mr. W. K. O'Loughlin has overall responsibility for the Health and Safety program; the security of the facilities as required to safeguard the special nuclear material; and the medical program.

6.15 Mr. J. N. Lomonte is directly responsible for carrying out the Health and Safety program. This program includes routine air and smear sampling for contamination and frequent inspection of the operations for strict compliance with the procedures and the limitations and arrangement of special nuclear materials set forth therein. Mr. Lomonte reports any deficiency to the Plant Manager for correction. Any hazardous condition or non-compliance noted shall be corrected promptly by the operating personnel. Any failure to do so is immediately reported by Health and Safety to the General Manager who will, if necessary to protect the health and safety of personnel or the public, discontinue operations until the deficiency is corrected.

Figure 6.5

NUCLEAR CHEMISTRY FACILITY ORGANIZATION



6.2 The Laboratory Director is Mr. T. G. Gibian, a Vice-President of W. R. Grace & Co. who has overall responsibility for all activities at the Center.

6.3 The General Manager of the Research Division is Dr. M. G. Sanchez, Vice-President of the Technical Group. Dr. Sanchez is very much involved in the nuclear activities at the Center and as General Manager he carries the responsibility for all aspects of the facilities involving special nuclear material.

6.4 The Manager of Nuclear Operations is Mr. G. E. Ashby, Divisional Vice-President who has overall responsibility for nuclear operations and the nuclear processes, just as Mr. W. K. O'Loughlin, Divisional Vice-President has overall responsibility for the administrative aspects of carrying on operations involving special nuclear material.

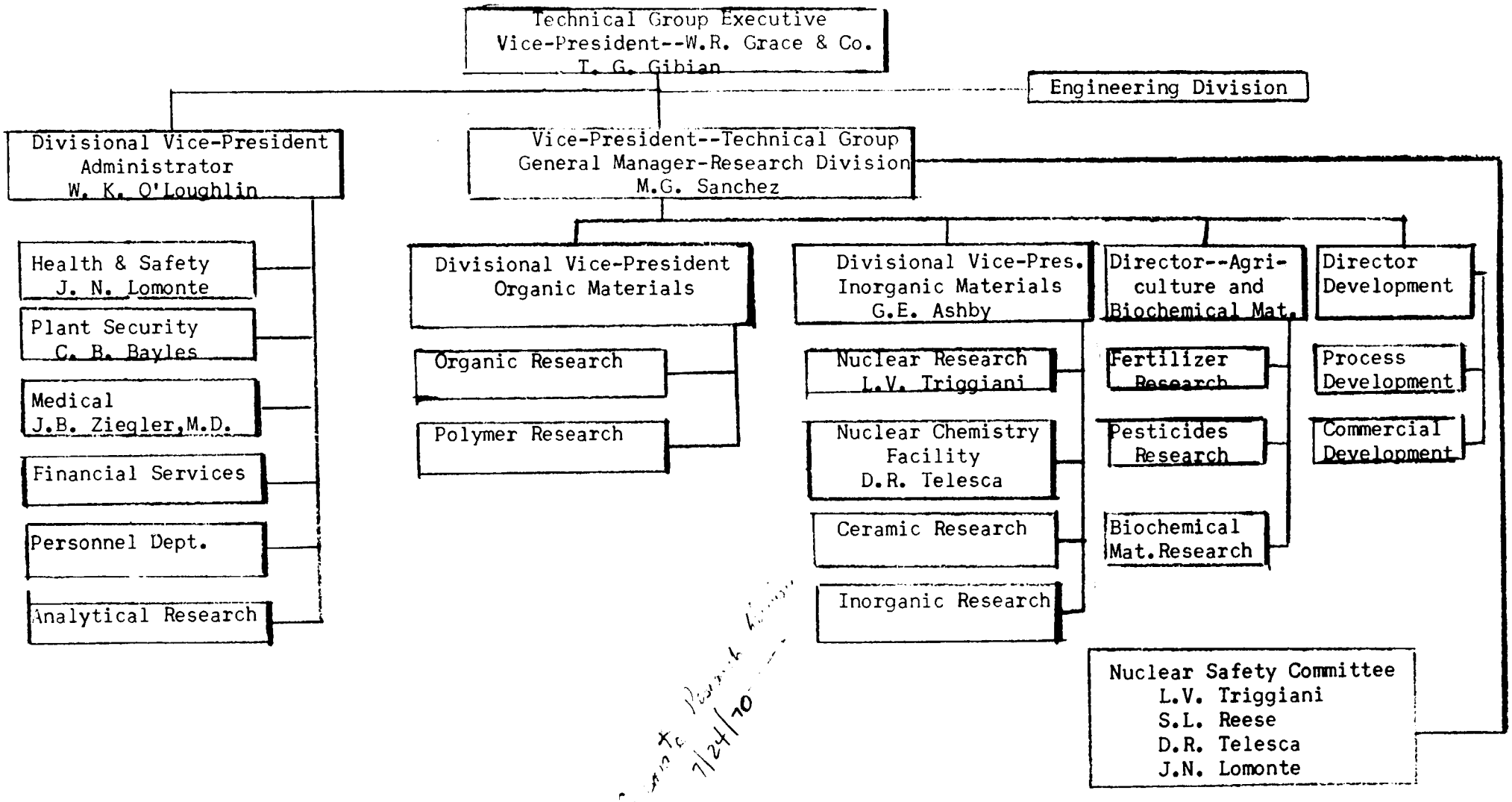
6.5 The Plant Manager is Mr. D. R. Telesca under whom the operations involving special nuclear material are carried out. The organization established to carry out the work is shown in Figure 6.5.

6.6 Nuclear Safety Committee--In addition to the usual line and staff functions essential to the safe operation in the facility, the General Manager has established a Nuclear Safety Committee and he appoints the members to the Committee. This Committee, composed of four individual members, is experienced in all aspects of nuclear safety and in operations involving special nuclear material as follows:

FIGURE 6.1

ORGANIZATION OF THE RESEARCH DIVISION

WASHINGTON RESEARCH CENTER--W.R. Grace & Company



3.0 LOCATION AND GENERAL DESCRIPTION OF WASHINGTON RESEARCH CENTER

3.1 Location-- The Washington Research Center is located in a rural area in Howard County, Maryland. Clarksville is three miles to the west, Simpsonville is two miles to the east. Howard County is substantially rural, the principal urban area in the county is Columbia (with a population of 4,000) located four miles northeast of the Washington Research Center. The Washington Research Center employs approximately 500 people.

3.2 Site Description-- The Center is located on a 147 acre tract of rolling farm and wooded land with northern most part of the acreage extending across a section of the Middle Patuxent River. The topographic map, Figure 3.2, shows the site and the building arrangement.

3.3 Description of Facilities-- The facilities in which the increased quantities of special nuclear materials under this amendment, are to be stored and processed are located in Building 16A shown on Figure 3.2.

3.4 The medical department and first aid room are located in Building 2 shown in Figure 3.2 as is the Health and Safety Department. The location of the structure in which the emergency equipment is stored can also be seen on Figure 3.2.

3.5 The analytical laboratory in which certain analyses are performed on small samples containing special nuclear material is also found in Building 16A.

average 4×10^5 liters, dropping off to 2.4×10^5 per day on weekends. The 10^3 liters of process liquids to be discarded daily are thus subjected to dilution on the order of 100 or more prior to release.

11.4 In the course of the operation some disposable solid materials will undoubtedly become contaminated. For the most part these will consist of clothing, gloves and the like which will contain only trace quantities of fissile materials and which may be disposed of by burial at a licensed burial facility.

Material that could contain appreciable quantities of fissile materials such as filters will be monitored for activity. If the presence of a significant quantity of fissile material is indicated, the item will be packaged in DOT specification containers for shipment to scrap recovery. None of these materials pose a fire hazard.

11.5 The bottoms from the boildown are drained into a container four inches in diameter or less and the solution is poured directly into the shipping container bottle. This bottle is loaded while in the shipping package to assure safe spacing from other containers. The combined area of the collection container and either leg of the boildown does not exceed the cross sectional area of a 5 inch schedule 40 pipe. When the collection container is below the boildown it is the bottom extension of a two inch cross and is therefore safe per Table III of TID 7016 Revision 1. The package is moved to the pad outside of the building and then to Building 20 for storage, again the number of packages permitted in any array shall be as approved for transport or as permitted by amendment to this license.

shell heat exchanger 02-1 spaced 27 inches on center from the dissolver. The dissolver operates at atmospheric pressure, whereas the cooling system is maintained under 15 psig so that a leak would result in a flow into the reactor. The heating-cooling system pressure and the liquid level in its expansion tank are both read and recorded before uranium is introduced into the dissolver for each dissolution. If either are found to be low, they are corrected. The dissolver is then inspected and a determination is made that it does not leak before proceeding with dissolution. The solution filter 06-2A or 2B measures four inches in diameter and is therefore safe. The uranium solution is stored in three five inch PVC pipe columns which are located in one plane on 27 inch centers. To protect against distortion of these tanks, should the dissolver solution inadvertently be introduced into a tank while still hot, a steel sleeve surrounds each of the three tanks.

(b) Radiation Safety.

The system is a closed solution system except for the introduction of urania powder into the top of the dissolver. To minimize dusting in transferring the powder from the bottle to the dissolver, the bottle is conical in shape at one end and this cone is inserted into the small port in the top of the dissolver thus open pouring is avoided. The top of the dissolver is inside a small box with a sliding window front. This window is normally closed. The face velocity with the window open exceeds 100 fpm. This enclosure is vented through a small absolute filter into the process ventilation system.

TABLE 9.9

COMPARISON OF SOLUTION TANK CAPACITY WITH CATCH TRAY CAPACITY

Fissile Solution Tank No.	Description	Tank Volume cubic inches	Catch Tray Size inches	Tray Volume cubic inches
13-1	Dissolver	377	48 x 48 x 1½	3450
10-3A 10-3B 10-3C	Dissolver Product Hold Tanks	3140 each	84 x 108 x 1½	13608
10-4 10-5 10-7	Dialysis Tank Aerator Anolyte Tank	3375 Largest	84 x 108 x 1½	13608
10-10A 10-10B 10-11	Sol Storage Tank Sol Storage Tank Column Feed Tank	3140 each	84 x 108 x 1½	13608
10-37A 10-37B 10-39	Boildown Feed Boildown Feed Boildown	3391 Largest	84 x 108 x 1½	13608

7.22 Liquid Waste Concentration--Any liquid wastes from the process that may contain uranium are sampled, and if the activity is above the limits for discharge to the sewer without dilution, they are sent to boildown feed tanks 10-37A or 37B. From here the solution is concentrated in a small thermosiphon evaporator 02-10. The overheads are condensed and collected in condensate receivers 10-41A or 41B. The condensate from this final decontamination treatment is checked for activity to be sure it is suitable for release before it is discharged to the plant sewer.

7.23 Radiation Protection Facilities and Equipment--The nuclear facilities at the Washington Research Center are equipped and operated in a manner that affords a high degree of safety against the possibility of serious exposure to radioactivity either on site or in the surrounding area. The safety equipment and supplies available on the site are discussed in the following paragraphs, and the monitoring equipment is listed in Table 7.22.

Personnel regularly working in the facility are provided with the following protective clothing:

1) coveralls or lab coats
2) shoes or disposable shoe covers

The regular staff is required to wear the above clothing. Visitors and casual entrants into these working areas are provided with lab coats and shoe covers.

dissolver batch. Upon receipt, the bird cages will be taken to the storage room on the upper level wherein they will be locked. As soon as practical after receipt, the containers of UO_2 will be taken, one at a time, from the birdcages and the gross weight of each container will be verified. Samples will be taken and these samples will be composited and the composite analyzed to verify enrichment and product purity specifications. When processing is to begin, the quantity required for a dissolver batch will be weighed out in a dry box 14-1 and emptied into the dissolver. As each receiving container is emptied, its tare weight will be verified. Thus, a check will be obtained upon the vendor's shipping weights.

7.5 Dissolution-- Dissolution of the UO_2 is carried out in a vertical, cylindrical dissolver 13-1 of four inch pipe 30 inches long jacketed by a bare, six inch, water jacket.

7.6 The pre-weighed UO_2 charge is added to the dissolver through a removable head. Dissolvent and oxidizing agent are metered into the tank. The mixture is stirred by means of an impeller during the course of dissolution. Temperature is controlled by regulating the amount of steam admitted to the heating coils in the secondary heat exchanger 02-1 in this closed heating and cooling system. A positive pressure of 15 psig is maintained on the heating-cooling system thus a leak would push liquid into the dissolver. This pressure is recorded on the run sheet before each use, and the level of liquid in the expansion tank will also be recorded. If either is below the established level the unit is examined for a possible leak before use. A small quantity of gas and vapors are emitted and they are filtered before being sent to the exhaust system. The final uranium solution is cooled and drawn off through a filter (06-2A or 2B) into a dilution tank (103A, 3B, or 3C) which is made of five inch PVC pipe jacketed with a steel sleeve to prevent expansion in the event that hot solution is inadvertently drained from the dissolver.

Carlson
Moseley
Howard
Crocker

7.0 PROCESS EQUIPMENT

This document contains paragraphs 7.1 through 7.21 (pages 22 through 28, and Figures 7.3a and 7.3b of the application). Also included herewith is Drawing E-69020-51, which is a part of Appendix B.

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dissolver batch. Upon receipt, the bird cages will be taken to the storage room on the upper level wherein they will be locked. As soon as practical after receipt, the containers of UO_2 will be taken, one at a time, from the birdcages and the gross weight of each container will be verified. Samples will be taken and these samples will be composited and the composite analyzed to verify enrichment and product purity specifications. When processing is to begin, the quantity required for a dissolver batch will be weighed out in dry box 14-1 and emptied into the dissolver. As each receiving container is emptied, its tare weight will be verified. Thus, a check will be obtained upon the vendor's shipping weights.

7.5 Dissolution--Dissolution of the UO_2 is carried out in a vertical, cylindrical dissolver 13-1 of four inch Schedule 40 steel pipe 30 inches long. This pipe has a 5/64 inch thick teflon liner on all internal surfaces and it is surrounded by a six inch Schedule 40 water jacket. The outer surface of the water jacket is bare and not subject to close reflectors.

7.6 The pre-weighed UO_2 charge is added to the dissolver through a removable head. Dissolvent and oxidizing agent are metered into the tank. The mixture is stirred by means of an impeller during the course of dissolution. Temperature is controlled by regulating the amount of steam admitted to the heating coils in the secondary heat exchanger 02-1 in this closed heating and cooling system. A positive pressure of 15 psig is maintained on the heating-cooling system thus a leak would push liquid into the dissolver. This pressure is recorded on the run sheet before each use, and the level of liquid in the expansion tank will also be recorded. If either is below the established level the unit is examined for a possible leak before use. A small quantity of gases and vapors are emitted and they are filtered before being sent to the exhaust system. The final uranium solution is cooled and drawn off through a filter (06-2A or 2B) into a dilution tank 10-3A, 3B, or 3C which is made of five inch PVC pipe jacketed with a steel sleeve to prevent expansion in the event that hot solution is inadvertently drained from the dissolver.

7.7 The solution in which the uranium is in the form of UO_2Cl_2 is adjusted in uranium and acid concentrations in the dilution tank to that desired for the next step (dialysis).

7.8 Dialysis--The adjusted UO_2Cl_2 solution is next transferred on a batch basis to the dialysis feed tank 10-4 which is a five inch diameter PVC tank, to which is attached a sight glass to permit observation of the color of the solution. The solution is then circulated to one side of the dialysis cell 13-2. The dialysis cell is separated into two compartments by a semi-permeable membrane. Water is circulated through the second (anolyte) side of the cell. In this cell, the chloride ion is essentially removed from the UO_2Cl_2 leaving the UO_2 in the form of a sol. All of the chloride goes off as chlorine gas which is scrubbed out in NaOH in tank 10-8. The spent caustic solution normally contains no fissile material and it is sent to holdup tank 10-42A or 42B. Some uranium does find its way into the anolyte as noted in Figure 7.12. The resulting solution is pumped from anolyte tank 10-7 to boildown feed tanks 10-37A or 37B. Hydrogen gas is also given off from the dialysis cell. This gas is diluted with sufficient air in aerators 10-5 or 10-7 to lower the hydrogen concentration well below the lower explosive limit. This mixture is vented to the plant ventilation system--where additional dilution of the hydrogen will occur placing it even farther below the explosive limit. The dialyzed sol is collected in storage tanks 10-10A or 10B made of five inch PVC pipe.

7.9 Particle Formation--The sol is pumped from the storage tanks into the column feed tank 10-11. This mixture is then continuously circulated through constant overflow tank 10-12. A stream from this tank is continuously fed to the additive mixer 05-3 followed by the column feed tank 10-13A or 13B and thence into one of the particle formation columns 13-6A or 6B through a series of hollow needles at the top. The droplets of feed are injected into a counter-flowing stream of hexanol, introduced at the bottom of the unit. In falling through the hexanol, the sol is dewatered and solid UO_2 particles are formed. These are collected in the conical bottom section cylinder. Hexanol flows out the top of the unit to solids filter 06-7A or 7B and then to washer 10-18 where it is continuously washed with water. It then passes through the backup hexanol-water separator 10-19 and then to the still 09-1 to remove excess water. It is then recycled to the unit.

7.10 The particle formation units 13-6A and 6B are simply long columns of six inch schedule 40 pipe spaced 36 inches on centers. They have a tapered section at the bottom so that the bottom outlet is two inches. The particles are periodically drained into a four inch diameter beaker and transferred by hand to the washing station, or continuously collected in slab container 13-4A or 4B, and transferred to the washing and drying station.

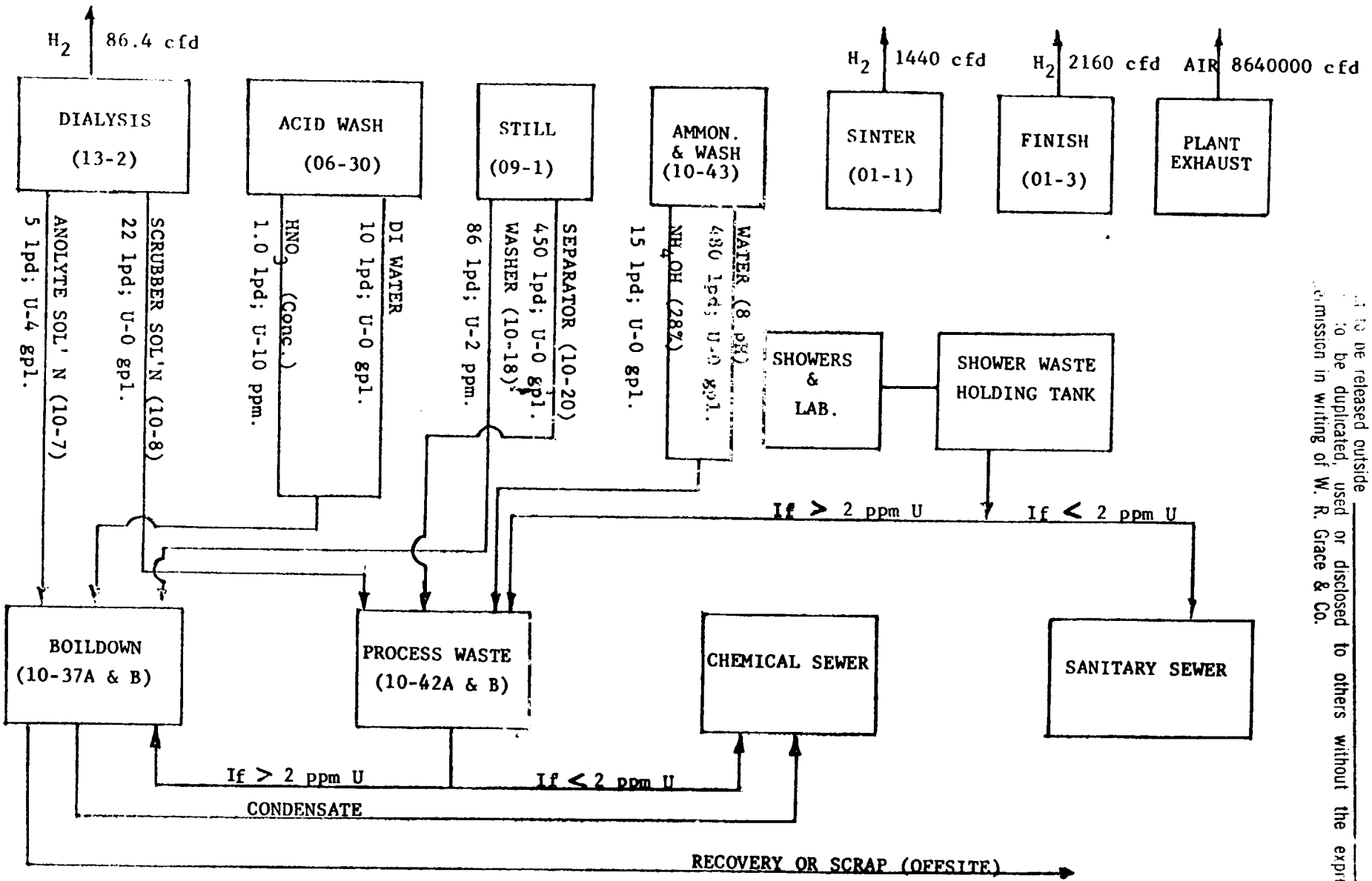
7.11 Drying and Sintering--The particles may be removed from the bottom of the formation column in one of two ways. Currently the particles are periodically removed in batches of a few hundred grams by drawing off into a beaker. The beaker is moved to the wash stand. This stand consists of a series of 4 inch diameter glass pipe, wash bottles 12-44A-44H twelve inches long which fit into fixed holders all located in the same plane and thus during the washing operation these units are fixed at 24 inches apart on centers. A batch of green particles is transferred to one of these washer units which has sintered metal filters at both ends to retain the particles.

A second method of particle removal involves an 8 inch by 12 inch by 1 inch thick metal slab container which is necked down to connect to the bottom of the column. The collector has a screen in it to separate the particles from the drying agent as it passes through the system and retain them. When full, the slab collector is valved off and removed to its own wash station; an empty collector is then attached to the column. The hexanol is drained from the glass wash units or the slab collector if it is used and aqueous wash solutions are then passed through the unit.

7.12 The hexanol that is removed is permitted to separate from the aqueous solution in 6 inch diameter pipe tanks 10-24 through 10-26. The aqueous solutions are routed to disposal by way of the waste hold tanks 10-42A or 42B and the hexanol that has separated out is pumped

WASTE STREAM FLOWSHEET
Basis: 24 Hr. Operating Day

Figure 7.12



lpd = liters per day; gpl = grams per liter; cfd = cubic feet per day

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to spent solvent tank 10-22. The wastes from the entire process and their treatment is shown pictorially in Figure 7.12.

7.13 When the glass wash bottle system is used the drained bottle containing the particles is removed from the stand and carried to the table on the opposite side of the vacuum dryer 08-7 where the particles are poured into a metal tray measuring 8-7/8 inches long by 5 inches wide by 2 inches deep. The cavity in the drying oven is such that two trays may be placed side by side in the oven at one time. The oven is evacuated and heated to about 250 C to assure complete removal of moisture from the particles. The dryer is cooled and a cover is placed upon each tray of dried particles which is then carried to the glove box transfer station 14-13. When the slab collector is used it is already in a furnace where it was placed for washing. The screened end is valved to vacuum. It is evacuated and heated to about 250 C. After cooling it is removed to transfer station 14-13, as are the trays described above.

7.14 The weigh station is connected to a series of glove boxes and in this complex, which is under inert gas, the particles are weighed and particles with undesirable physical characteristics are separated out and returned to dissolution. Good particles are stored in one of the standard canisters--04-8 which measure 3.5 inches outside diameter by nine inches in length. Approximately three kg of green particles will fill one of these containers.

7.15 The standard canister with a three kg sintering charge in it is moved to the sintering furnace 01-1 which is a three inch vertical pipe. The contents of the container are emptied into the furnace and the particles are subjected to high temperature in the presence of hydrogen. The furnace is allowed to cool and the densified particles are removed from the furnace into a storage canister using reactor unloading device 04-11. They are then returned to the weigh station.

heated metal chloride, vaporizing it and carrying the metal chloride into the fluid bed reactor where the chloride is reduced, depositing a thin metal coating on the UO_2 particles. The exit gases next pass through a glass disengaging section to remove any particles which may be entrained. The gases then pass through a filter to remove fine solids that may be entrained. The duplex filters 06-22A or 22B contain paper cartridges 2-3/4 inches in diameter which collect particles 0.08 microns in diameter or larger. They are enclosed in a 3-7/8 inch by 1/16 wall stainless steel container 10-1/2 inches long. The filters are used alternately. The quantity of fissile material collected per unit is normally extremely small. The gases then pass through a back siphon trap for the neutralizing solution and then they are bubbled through the sodium hydroxide neutralizing solution to remove HCl from this off gas stream.

7.20 Screening and Washing--The coated particles are then cooled and transferred in one of the standard canisters to a screening station 14-8 where again off-size particles are separated out, bottled, and removed to scrap recovery storage. Particles which fall within the acceptable range are transferred to a washing station in glove box 14-9. Herein the particles are washed first with acid, then with water, and finally with ethyl alcohol. The washing solutions pass through filter 03-31 on their way to 10-36, the waste holdup tank. The washed particles are placed in a one inch deep tray and placed in an oven where they are dried under vacuum.

7.21 Blending, Sampling, and Shipment---The dried coated particles are put through a splitter in glove box 14-11 and then sampled for final product acceptability tests. The finished product will be stored in safe storage rack 11-14 and it will finally be placed in packages approved for the shipment of this material. Various lots are blended, split again, sampled for final retention samples, and then weighed out into final shipping bottles. The amount of U-235 per shipping bottle will not exceed 11 kg. The loaded shipping bottles are stored in their birdcage shipping packages.

6.2 The Laboratory Director is Mr. T. G. Gibian, a Vice-President of W. R. Grace & Co. who has overall responsibility for all activities at the Center.

6.3 The General Manager of the Research Division is Dr. M. G. Sanchez, Vice-President of the Technical Group. Dr. Sanchez is very much involved in the nuclear activities at the Center and as General Manager he carries the responsibility for all aspects of the facilities involving special nuclear material.

6.4 The Manager of Nuclear Operations is Mr. G. E. Ashby, Divisional Vice-President who has overall responsibility for nuclear operations and the nuclear processes, just as Mr. W. K. O'Loughlin, Divisional Vice-President has overall responsibility for the administrative aspects of carrying on operations involving special nuclear material.

6.5 The Plant Manager is Mr. D. R. Telesca under whom the operations involving special nuclear material are carried out. The organization established to carry out the work is shown in Figure 6.5.

6.6 Nuclear Safety Committee--In addition to the usual line and staff functions essential to the safe operation in the facility, the General Manager has established a Nuclear Safety Committee and he appoints the members to the Committee. This Committee is composed of individuals experienced in all aspects of nuclear safety and in operations involving special nuclear material as follows:

Nuclear Criticality Safety--At least one member of the Nuclear Safety Committee shall have completed at least four years of college which included courses in the field of natural sciences, and he shall have at least two years of practical experience which shall include responsibility for the nuclear criticality safety aspects of plant operations involving large quantities of fissile materials.

Radiation Safety--At least one member of the Committee shall have completed at least four years of college or its equivalent where equivalent is defined as two years of practical experience in plant operations including radiation safety in lieu of a year of college. College training shall have included courses in the field of natural sciences and he shall have at least two years of practical experience which shall include responsibility for radiation safety aspects of plant operations involving operations with radioactive materials.

Process Safety--At least one member of the Committee shall have completed not less than four years of college or its equivalent where equivalent is defined as two years of practical experience in chemical processing for each year of college. College training shall have included courses in the field of natural sciences and shall include at least two years in a position of responsibility for the safe operation of processes of a chemical nature.

6.7 The primary function of this Committee is to review each proposed equipment change or any proposed operating procedures with regard to process safety, radiation and nuclear criticality safety. The Committee must be satisfied that the procedures and the equipment are safe, and each member must formally approve them by signature prior to use.

6.8 A second function of this Committee is to inspect the operations and the health and safety records for compliance with approved procedures and pertinent AEC regulations at least once in each month that operations involving special nuclear material are being performed. The Committee will report, in writing, the results of each inspection and its recommendations to the General Manager, Research Division.

6.9 In the event of an accident or emergency involving special nuclear material, the Nuclear Safety Committee will stand ready to aid in the solution or correction of the problem.

6.10 Responsibilities and their Delegation--The General Manager--Research Division has established the policy that all operations on the site involving special nuclear material will be performed only in accordance with written procedures that have been reviewed and approved for their adequacy relative to the protection of personnel and the public from the nuclear hazard. This policy is implemented through delegations to appropriate managers and groups responsible for individual aspects of the nuclear activities. Implementation is simplified somewhat by the straight forward operations which are to be performed upon the special nuclear materials and by the limited scope of these operations.

6.11 Mr. G. E. Ashby has overall responsibility for the preparation of operating procedures. These procedures are detailed, specific and complete with regard to practices involving safety, be it chemical, nuclear, criticality or radiation safety.

6.12 The members of the Nuclear Safety Committee have the responsibility for approving, by signature, each procedure involving the handling or processing of special nuclear material as being adequate to protect personnel and the public from the nuclear hazard, and as being in compliance with pertinent AEC regulations and with the provisions of this amendment. A negative finding by the Committee as to the adequacy of criticality or radiation safety will not be overruled by anyone.

6.13 Mr. D. R. Telesca has the direct responsibility for carrying out every operation involving special nuclear material in accordance with the provisions of this license amendment as implemented by approved operating procedures.

6.14 Mr. W. K. O'Loughlin has overall responsibility for the Health and Safety program; the security of the facilities as required to safeguard the special nuclear material; and the medical program.

6.15 Mr. J. N. Lomonte is directly responsible for carrying out the Health and Safety program. This program includes routine air and smear sampling for contamination and frequent inspection of the operations for strict compliance with the procedures and the limitations and arrangement of special nuclear materials set forth therein. Mr. Lomonte reports any deficiency to the Plant Manager for correction. Any hazardous condition or non-compliance noted shall be corrected promptly by the operating personnel. Any failure to do so is immediately reported by Health and Safety to the General Manager who will, if necessary to protect the health and safety of personnel or the public, discontinue operations until the deficiency is corrected.

Mr. Reese is 45. He did his undergraduate work in Chemical Engineering at the University of Cincinnati and at the University of Alabama the latter as a part of his service in the U.S. Army during World War II. During that service he earned three battle stars in Germany and was decorated with the Silver and Bronze Stars. He left the service with the rank of Captain. He is a member of ANS, AIF, INMM, ASM, and AIMME. He has been and is active on numerous working committees of each.

6.29 Training--Prior to working with fissile materials, each employee who is to work in the nuclear area will attend a four hour basic course covering nuclear criticality safety, radiation safety, and the use and maintenance of safety equipment.

The part of the basic instruction in safety dealing with nuclear criticality will define the chain reaction , how it is sustained, and describe the mechanisms used to prevent a criticality accident. This instruction will be prepared by the criticality member of the Nuclear Safety Committee.

The radiation safety instruction will include a definition of the types of radiation of concern; exposure mechanisms; operating practices to minimize exposure, and the methods used to determine exposure such as film badges, air sampling, area monitoring and biological analyses. Records will be discussed. This portion of the instruction will be prepared by the radiation safety member of the Nuclear Safety Committee.

Following this basic instruction period, each employee will be instructed in the part of the operation he is to perform. He will be given sufficient time to completely familiarize himself with the written procedure for that

operation. He will then carry out the operation with the help of his foreman who will explain how nuclear criticality and radiation safety are provided for in the operation. His understanding of both the operation he is to perform and the safety features involved will be determined by oral examination by the General Foreman. When the General Foreman is satisfied that the employee has demonstrated the capability of performing the operation satisfactorily and safely he will so indicate in the job qualification record. The employee may then perform the operation.

7.22 Liquid Waste Concentration--Any liquid wastes from the process that may contain uranium are sampled, and if the activity is above the limits for discharge to the sewer without dilution, they are sent to boildown feed tanks 10-37A or 37B. From here the solution is concentrated in a small thermosiphon evaporator 02-10. The overheads are condensed and collected in condensate receivers 10-41A or 41B. The condensate from this final decontamination treatment is checked for activity to be sure it is suitable for release before it is discharged to the plant sewer.

7.23 Radiation Protection Facilities and Equipment--The nuclear facilities at the Washington Research Center are equipped and operated in a manner that affords a high degree of safety against the possibility of serious exposure to radioactivity either on site or in the surrounding area. The safety equipment and supplies available on the site are discussed in the following paragraphs, and the monitoring equipment is listed in Table 7.22.

Personnel regularly working in the facility are provided with the following protective clothing:

1) coveralls or lab coats

2) shoes or disposable shoe covers

The regular staff is required to wear the above clothing. Visitors and casual entrants into these working areas are provided with lab coats and shoe covers.

TABLE 7.23 (con't.)

RADIATION PROTECTION EQUIPMENT

FUNCTION	EQUIPMENT PROVIDED	NUMBER	LOCATION	REMARKS
To Monitor Liquid Effluents:	Holdup Tank	2	Mezzanine level and ground floor	Samples counted on liquid scintillation counter estimated level of detection 3 CPM
To Detect Criticality Event: Alarm	Victoreen Instrument Co. Model 715 detectors or other approved sensors	3	1-in wall between lab rooms 1-in North wall with view of entire process 1-in Bldg. 20 storage	Alarm loud enough to alert entire Research Center
	Model 712 Control Panel with Evacuation Alarm or similar approved system	1	Control Panel at entrance in room 10; Claxon outside building	
Record Event	Eberline Instrument Co. Thermoluminescent (TLD) Area Badges, room temp. self-annealing	24	At various points in Bldg 16A	Would be read in case of an event to develop iso-dose lines and estimate exposure to personnel
Personnel Monitoring: Hands, Clothes etc.	Eberline Instrument Co. Monitor Model RM-3C with AC-3 Alpha Probe 0-500 cpm	3	At clothes change area	
Film Badges with high level dectector strips	From commercial supplier such as R.S. Landauer & Co., Tracerlab or other Company approved		Worn on person	Read once each month. High level strips read in case of criticality event

7.24 Emergency Equipment--A cache of emergency equipment is maintained away from the working area in a structure located south of the 16A facility and near the south entrance in Building 2. The emergency station equipment consists of:

1) Scott Air-Pak (2)

2) First Aid Kit equipped for treating hemorrage, lacerations, burns, and shock.

3) Disposable suits, boots, head covers, and full-face respirators.

4) Decontamination equipment, detergents, and waste containers.

5) Portable Survey Meter, Victoreen Instrument Co. Model Thyac III.

6) Portable ion chamber 0-1000R, Eberline Instrument Model PIC-6A

7.25 Industrial Safety Equipment--In conjunction with the radiation safety program at the site, industrial health and safety of plant personnel is a continuing concern which is given considerable attention in all projects on the site. Some of the major equipment and facilities which are available to protect property and personnel include portable fire extinguishers, fire hoses and automatic sprinkler systems, a well equipped dispensary attended daily by a registered nurse, and a wide range of typical industrial safety equipment for individual and general use.

particular area must be worn at all times in that area.

g) Coveralls or laboratory coats shall be worn at all times in areas containing radioactive materials.

h) Tampering with film badges or other safety equipment will not be tolerated.

8.3 Radiation Limits in Controlled Work Areas--All areas at the Center where radioactive materials are stored or used are classified as radiation areas as defined in 10 CFR, Part 20.202. Design levels of penetrating radiation are well below the maximum level of exposure established in 10 CFR, paragraph 20.101. Penetrating radiation levels in occupied areas do not routinely exceed 1 mr/hr. It is not anticipated that any individual will receive a radiation exposure in excess of that specified in 10 CFR, Part 20.101 (a); but in the event an unusual condition should occur, under which an individual might receive greater exposure than is permitted by said sub-paragraph (a) then the limits specified in sub-paragraph (b) shall be met. Any area found to be a high radiation area as defined in paragraph 20.202 (b)(3) shall be roped off and labeled as a high radiation area. Entrance to a high radiation area shall be in accordance with the provisions of paragraph 20.203 (c)(2).

8.4 Personnel Monitoring--No one is permitted to enter any area containing radioactive materials without a beta-gamma film badge. Personnel are instructed in the use and care of their film badge, so that it will in fact depict the radiation received. They are instructed in the use of the hand monitors and as to the levels of cleanliness required when leaving radiation areas. Individuals who normally work in radiation areas will receive a urinalysis to detect inhaled or ingested uranium at least once each month. In the event of release of radioactive material or indication that anyone may have ingested or inhaled uranium, such that analysis indicates a reading of 25 d/m per liter, lung counts will be conducted to establish the extent of internal exposure to the individuals involved. Additionally, unless the cause is known, this quantity of uranium in the system of any individual shall require further investigation by the radiation safety representative who will question the individual in an effort to determine the cause. If there is evidence that the operation being performed by the individual is the cause, corrective measures will be instituted. A bioassay is performed upon each individual employed in the Nuclear Chemistry Facility at the time of his termination, in order to assess the extent of internal deposition of uranium, if any.

8.5 Medical Program--The medical program at the Center is under the direction of a physician who is at the Center one afternoon each week and at any other time his services are needed.

Each employee working in any area containing radioactive material has a clinical urinalysis at least once every six months, a complete blood count once a year, a complete physical examination yearly, and a chest x-ray every two years. All personnel leaving employment are given physical

examinations. Laboratory findings indicating any unusual problem are followed up immediately.

A dispensary is maintained at the Center for the immediate care of all minor injuries, such as minor burns, abrasions, bruises, etc. All visits to the dispensary by employees are recorded in a log book, and this information is transferred to the employee's permanent medical record.

All employees are instructed and advised about the chemical toxicity of various material used in the plant, chemical burns, minor injuries, and personal hygiene measures that should be followed to minimize the intake of all chemical substances that might be injurious to their health.

Close cooperation with the Health and Safety Department is maintained and all results of sampling for radioactivity and film badge readings are reviewed by the Medical Director.

8.6 Surveys--The work area is continuously sampled for airborne activity in order to provide a record of activity levels at breathing levels in the areas most frequented. In addition, breathing zone areas, particularly in locations where airborne activity is most likely to occur, are surveyed periodically with portable instruments to assure that the airborne activity is indeed at acceptable levels. The sampler intake is located as near as possible to the worker's breathing zone. The maximum acceptable level of alpha activity in air, as represented by the survey sample, is 1×10^{-10} μCi/ml. In the event that the continuous sampler filter paper reads abnormally high or exceeds the above limit, a special survey with portable equipment will be undertaken to determine the source of the activity. Steps will be taken to physically correct the abnormality. The continuous

air samplers are calibrated monthly with a flowmeter. The portable samplers are checked in the same way. A tag is attached to each unit upon which the check date and flow rate is recorded.

Contamination surveys will be performed in both restricted and unrestricted areas with sufficient frequency to assure that acceptable contamination levels are maintained. Particular emphasis will be placed upon surveying areas where the material is not in a closed system. The following contamination levels are to serve as action level guides above which the area will be decontaminated to levels below these guides and the cause will be investigated and, where reasonably possible, it will be corrected.

Area	Total Activity 1/	Smearable Activity 2/
Unrestricted	γ 500 cpm β (2) 200 cpm 3/	500 d/m 0.2 mrad/hr
Restricted	γ 10,000 cpm β (2) 100 mrad/hr	5,000 d/m 10 mrad/hr

NOTES:

1/ Values of alpha in counts per minute (cpm) are as read with a PAC-3G survey instrument, not more than one centimeter from the surface.

2/ Smearable alpha values are in disintegrations per minute (d/m) per 100 square centimeters.

3/ Beta-gamma values in counts per minute are as read with a Thyac III survey meter at one centimeter from the surface.

8.7 Any equipment or packages to be removed from the radioactive materials area into an unrestricted area will be surveyed and will be permitted to leave the area only upon presentation of a release slip signed by the Health and Safety representative. Radioactive contamination of all packages and equipment leaving the restricted area shall be within the following limits:

1. The maximum amount of fixed alpha activity in disintegrations perminute per 100 square centimeters shall not exceed 25,000.
2. The average amount of fixed alpha activity in disintegrations per minute per 100 square centimeters shall not exceed 5,000.
3. The maximum amount of removable (capable of being removed by wiping the surface with a filter paper or soft absorbent paper) alpha activity in disintegrations per minute per 100 square centimeters shall not exceed 1,000.

    a) The maximum level at one centimeter from the most highly contaminated surface of a building or piece of equipment measured with an open-window beta-gamma survey meter through a tissue equivalent absorber of not more than seven milligrams per square centimeter shall not exceed one millirad per hour.

b) The average radiation level at one centimeter from the contaminated surface of the building or equipment measured in the same manner shall not exceed 0.2 millirad per hour.

8.8 Survey instruments are calibrated routinely as follows:

a) Instruments reading alpha are calibrated with sources furnished with the instrument or with standards prepared by the National Bureau of Standards.

b) Instruments reading Beta-Gamma are calibrated with a cobalt 60 source.

c) The gamma alarm system has a built-in remote calibration source. The instruments are checked weekly and each source is smear checked each six months for leakage.

The portable instruments are calibrated monthly.

8.9 Air sampling vacuum pumps are removed from service periodically and reconditioned. They are then recalibrated with a flowmeter and tagged with flow data and date of calibration.

8.10 Fire fighting equipment including hoses and extinguishers are checked periodically as required by the State and the insurance carrier.

8.12 Waste Disposal

The wastes generated in the facility are either liquid or solid. Procedures are established whereby:

a) Solid radioactive wastes are packaged in DOT approved packages for shipment to disposal.

b) Airborne solid radioactive wastes are removed by way of the ventilation system. Radioactive dust is evolved primarily in ventilated glove boxes. Each box or closed train has a prefilter which may either be disposed of as above when the pressure differential indicates that it is plugged, or it may be packaged and sent out for recovery of uranium values. All ventilation gases finally exhaust through filters designed to remove 99.9% of particulate 0.3 microns in size. All primary filters are of the fire-resistant type. When contaminated, these filters are shipped to disposal in DOT specification or special permit containers.

c) Liquid wastes include overheads from evaporation and various wash solutions. All solutions that could contain uranium are monitored, as described in Section II, and any solution that contains 5×10^{-6} microcuries of uranium per milliliter or less is released to the sewer. Solutions more concentrated in uranium are treated by distillation.

8.15 Emergency Plans--The Washington Research Center has a comprehensive emergency procedure for the protection and evacuation of personnel in the event of a non-nuclear emergency such as an explosion or fire. To this procedure has been added the procedure to be followed which will minimize exposure to personnel and damage to property in the unlikely event of a radiation emergency.

8.16 The fire protection plan has three basic elements. The elements are:

a) An adequate alarm system that will alert everyone on the site that an emergency has occurred and that they are to evacuate.

b) An indoctrination program by which all personnel on the site will know what to do if the emergency alarm sounds.

c) A predesignated organization that has the training and equipment to cope with the emergency.

Arrangements to detect an emergency and initiate these procedures through the guard force on off-shifts is provided for in the procedures. Howard County has an emergency center which will furnish police, fire department, and ambulance service to area hospitals in the event of an emergency. The phone number of the Emergency Center is posted at each phone. Company vehicles are also available to transport injured personnel to the hospital. The guard also has a copy of the list of people to call in the event of a radiation emergency, and he is instructed to assist in keeping people away from either Building 16-A or Building 20, whichever is the source of the radiation emergency.

8.17 The radiation emergency plan and the procedures for coping with radiation emergency have been superimposed upon the emergency procedures already operative at the site. A copy of this procedure is furnished with this application. A radiation emergency is made known by means of the alarm system described in paragraph 12.12. In the event of a radiation alarm originating in Building 16-A, only the people in Building 16-A and the adjoining Building 16 evacuate and they go around Building 2 to the rendezvous room in the south side of the building. All others are cautioned to stay in their buildings and when those outside hear the radiation sirens, they are instructed to go inside the nearest building in a direction away from Building 16-A and Building 20. In this way, they can avoid being exposed to fallout. The closest building to 16-A is Building 2 and the nearest end of this building is 175 feet from the nearest wall of 16-A. Without considering the radiation attenuation afforded by the two sets of brick veneer walls, we find that a dose of 1000R one-foot from the source, when divided by the square of the distance, results in a dose of 32 mr at the nearest point in Building 2; therefore, in our judgement, the least overall exposure to personnel in other buildings will result if they stay inside until the extent of the emergency can be determined.

In the event of a radiation alarm in the storage area in Building 20, both Building 20 and Building 11, which is adjacent to it, evacuate to the Building 2 rendezvous area. All other inhabited structures are more than 175 feet away (See figure 3.2) and need not be evacuated until the extent of the emergency is determined.

The extent of radiation exposure to personnel is ascertained immediately by questioning personnel and with portable meters. Those who have received large exposures are evacuated to the hospital. The Health and Safety Supervisor will assist the physician in obtaining these data. The Medical Director, Dr. Ziegler, is trained in the treatment of victims of radiation exposure. Dr. Joseph Workman, of the University of Maryland, is so trained also.

An emergency equipment box containing portable detection and dose rate instruments, suits and airpacks, and a copy of the emergency procedure is maintained near the south entrance of Building 2.

8.18 It shall be the responsibility of the General Manager to notify the AEC of the accident. The Plant Manager will establish when personnel may return to the various work areas on the site, and to coordinate decontamination during the recovery phase.

8.19 Radiation Safety Review--Any new facilities or any changes in facilities or operating procedures having to do with radioactive materials must be reviewed and approved by the Nuclear Safety Committee. The principal area of interest in this review other than nuclear criticality safety is to assure that adequate health protection facilities have been provided for safe operation. A decision by the Committee that operational safety is inadequate will not be overruled.

8.20 In the event of an emergency in the Building 16-A facility, and in the absence of the Plant Manager and the Production General Foreman, the senior man in Building 16-A will have responsibility for clearing the building, notifying the designated individuals and keeping people away from the facility until the emergency control organization can take charge. The Emergency Controller, or his alternate, has the responsibility for taking the actions necessary to cope with the emergency following the procedures in the WRC emergency plan.

8.20 The senior man who will be responsible in the event of an emergency will have the following minimum qualifications. He shall have a high school education or equivalent and at least one year of experience in nuclear processing. He shall have qualified to perform all of the operations being carried out and he shall have received training and understand the procedure he is to implement in the event of an emergency.

The emergency controller shall be a responsible member of management who is selected to perform the emergency controller function based upon demonstrated leadership and planning ability and his ability to make decisions under stress. He shall be familiar with all facets of the physical plant, the utilities and the emergency equipment at the site and its use. His work shall be at the site with a minimum of travel involved.

9.0 NUCLEAR CRITICALITY SAFETY

9.1 Summary of Program and Philosophy--The criticality safety program at the Center requires that each activity involving special nuclear material be analyzed for hazard potential, and that appropriate engineering and administrative safeguards be established to reduce to acceptable limits the potential for accidental criticality.

9.2 It is recognized that the only mishap in the operation that could instantly cause severe physical damage to personnel on site is from accidental criticality. It has been seen at other locations that such an event could be lethal to individuals in the immediate area. These events have also demonstrated that there is only moderate danger to personnel a short distance away, and very little danger to the public off-site in instances where the operation is relatively isolated as it is at the Center.

9.3 It is the philosophy of operation at the Center to rely upon engineered safety features in so far as is possible, and fortunately the type of operation performed permits extensive use of rigid equipment of safe geometry as the means of maintaining a subcritical condition. The process control group constantly checks the operation for strict adherence to the approved operating procedures including criticality controls. This is supplemented by frequent inspections by the Health and Safety specialist and at least once a month, when operating, by the Nuclear Safety Committee.

9.4 The limits selected to assure nuclear criticality safety in the storage, handling and processing of special nuclear material at the Center are listed in Table 9.4. The conditions applicable to these limitations are discussed in subsequent paragraphs. Safe limitations may be derived

TABLE 9.4

SPECIAL NUCLEAR MATERIAL LIMITATIONS

APPLICABLE TO THE OPERATIONS SUBJECT TO THIS LICENSE

Description of Material	Limiting Parameter	Operating Limit	Minimum Critical	Reference
1. Solution fully reflected	Mass of U-235	350 grams	820 grams(if reflected)	TID 7016 Rev. 1
2. High fired UO_2 full reflection, anhydrous	Mass of U-235	11 kg	>22.8 kg-130 kg (if reflected)	TID 7016 Rev. 1 Tables IV, I
3. Solution-Any U concentration full reflection	Cylinder Diameter	5 inch pipe	5.4 inches reflected	TID 7016 Rev. 1 Table 1 and App. A
4. Solution, maximum diameter-schedule 40 pipe with no reflectors immediately surrounding	Cylinder Diameter	6 inch pipe	>7 inches for 0.280 inch thick pipewall	TID 7016 Rev. 1 Fig 3, TID 7028, Fig 10
5. Cooling Jackets, maximum diameter schedule 40 pipe with no reflectors immediately surrounding	Diameter	6 inch pipe	>7 inches	(Same as #4)
6. Dense UO_2 up to 5 g/cc packed density(4.4 g/cc U-235), full reflection	Cylinder Diameter	4 inch pipe	>4.4 inches	TID 7028-Fig 10 and App. A
7. Dense UO_2, 7.7 g/cc packed density(6.7 g/cc U-235) full reflection	Cylinder Diameter	3.5 inch	>4.1 inches	TID 7028-Fig 10 and App. A
8. Spills or leaks onto floor (all solutions)	Slab thickness of catch tray	1½ inches	>2 inches reflected one side	TID 7028-Fig 11 and App. A
9. Waste Solutions	Neutron Poison in form of borosilicate glass raschig rings; filled containers in compliance with proposed ANS standard for such use	None for solutions	None for solutions	
10. Scrap solutions of known U-235 content	Concentration of U-235 in solution	5 g/l	12 g/l	TID 7016 Rev 1 Table 1

from values presented in technical publications such as TID 7016 Rev. 1, Nuclear Safety Guide, TID 7028, Critical Dimensions of Systems Containing U-235, Pu-239 and U-233, and others. Consideration has been given to higher enrichments, up to 97% U-235, which are contemplated. Their effect upon criticality parameters is examined in Appendix A.

9.5 Mass Limits--In the process itself there is no step where mass of U-235 in solution is the only criterion controlling nuclear criticality; however, this is the limit set for accumulations of materials in uncontrolled array such as samples and is the limit for the entire analytical area.

9.6 The high fired UO_2 in the process is devoid of hydrogenous material, hydrogen being the only effective moderator found in quantity in the entire process and therefore it is essentially unmoderated. The density of the UO_2 may approach theoretical for individual particles, but experience indicates a void fraction greater than 0.3 will be found resulting in an overall density in any accumulation of particles of less than 7.7 g/cc (10.9 g/cc x 0.7) and a U-235 density of less than 6.7 (7.7 g/cc x 0.88 U fraction). This places the critical mass for a fully reflected sphere of particles between 22.8 kg, the minimum critical mass for uranium metal at full density, and about 130 kg the critical mass for unmoderated salts. Absorption of water into this material, which is not hydroscopic, is precluded by keeping the material in sealed containers except when operations are being performed upon the material and this is done only in a glove box enclosure maintained under inert atmosphere. There are no sprinklers in the glove box area.

9.7 Geometry Limits--A series of cylinder diameter limitations are used in the process and in storage to assure safety under any foreseeable conditions. As shown in Figure 9.4--Item 3, the process solutions, many of which are near optimum concentration, are restricted to 5 inch cylindrical containers. None of the containers have close fitting reflectors and all have been spaced from walls to minimize neutron reflection from this source. In the case of solutions that normally contain from a trace of fissionable material to perhaps 20 g/l and in the case of cooling jackets, the diameter is increased and then only to that of 6 inch schedule pipe. No reflectors immediately surround these containers, the closest reflector being one wall at least 15 inches distance, thus assuring safety at any fissionable material solution concentration for the reflection available. The close fitting reflection is equivalent to about 0.280 inches of water, or less, which is the steel or PVC wall thickness, the chloride content of the PVC acting as a neutron absorber. The combination of normally low fissile solution concentration and less than nominal reflection provides an additional safety factor in the use of 6 inch schedule 40 pipe.

9.8 Once the oxide has been taken out of solution as solid particles, the density increases. Unfired particles could be as dense as 5 g/cc; although they more nearly average 3 g/cc. The container diameter used for these particles has been established at 4 inches. Conservatism is found in that the containers are of finite length of less than 3 feet and in none of the locations are they fully reflected. The densified particles are confined to containers measuring no more than 3.5 inches in diameter. Although the particles are only partially reflected in any location, safety is assured in the event of full reflection.

9.9 Under each grouping of equipment containing fissile material in solution is a chemically resistant tray which is sized at $1\frac{1}{2}$ inches depth to hold the contents of the largest single container or group of containers that could drain or siphon out together. These are compared individually in Table 9.9. Assuming full reflection from the floor and practically no reflection from the open top, this depth which would be subcritical for a fully reflected slab has ample safety.

9.10 Neutron Poisons--Poisons are not used in the process. Fixed poison in the form of borosilicate raschig rings which contain 12.5% natural B_2O_3 and are sized to uniformly occupy 23% of the tank volume are used in the waste solution collection tanks 10-42A and 42B all in compliance with proposed ANS standard entitled "Use of Borosilicate Glass Raschig Rings as a Fixed Neutron Absorber in Solutions of Fissile Material"--November 1965. The waste entering these tanks normally contain only traces of special nuclear material. The fixed poison in these tanks provide back-up protection against a failure elsewhere in the system. When the tanks are full, the solution is analyzed for special nuclear material. It is discarded to the sewer if found to be 4.4×10^{-6} μCi/ml or below, otherwise it is retained for recovery of the uranium via the boildown system. These tanks are maintained at a pH of four or less by acid additions to prevent uranium precipitation.

9.11 Concentration Limits--Throughout the process the solutions are, for the most part, confined such that they are safe by reason of features other than the concentration of fissionable material. Solutions such as waste solutions for scrap recovery which contain, by analysis, 5 g/l or less U^{235} may be safely stored in containers of any size. Precipitants are carefully excluded to avoid concentration by settling. The containers

of these solutions are stored above the freezing temperature of the solution to preclude the possibility of selective crystallization of the uranium compound.

9.12 Neutron Reflection--Process vessels containing solutions of fissile materials have been located a foot or more from building walls which lessens neutron reflection from the wall, and for operating convenience. Fox, Gilley and Calihan of ORNL determined that a close fitting concrete wall adjacent to one side of a container was equivalent to 0.2 inches of water reflection (ORNL-2367). At six inches separation its influence is reduced by several factors and its contribution as a reflector for practical purposes is negligible. This process system, as designed, has lower reactivity and enjoys increased safety by reason of reduced reflection in that the five inch vessels are safe fully reflected and the six inch vessels that could contain fissile material are conveniently located $3\frac{1}{2}$ feet or more distance from the nearest wall.

TABLE 9.13

INTERACTION BETWEEN UNITS IN REACTING ARRAYS

Description	Calculated 1/ Individual Unit K_{eff}	Permissable Total Solid Angle In Steradians	Actual Total 1/ Solid Angle of Array Steradians
Particle Storage Array	0.54	3.7	1.4
Solution Storage in Tanks 10-3A, 3B, 3C, 10-4, 10-5, 10-7, 10-10A, 10-B and 10-11	0.74	1.5	0.82
Particle Columns	Very Small	Large	0.36
Boildown Feed Tanks Boildown Evaporator	Small	Large	0.5

Note 1/ Calculations are included in Appendix B.

9.14 Design Integrity of Structures

(a) Whenever criticality control is directly dependent on the integrity of a structure used to retain the geometric form of a special nuclear material accumulation or the spacing within a storage array, the structure will be designed with an adequate strength factor to assure against failure under foreseeable loads or accident conditions. Materials of construction will be selected to resist fire and the degree to which any corrosive environment might affect nuclear safety will be considered and corrosion-resistant materials or coatings applied as necessary.

(b) Whenever criticality control is directly dependent on the integrity of a neutron isolating structure, the structure will be designed to assure against loss of integrity through foreseeable accident conditions such as fire, impact, melting, corrosion or leakage of materials.

9.15 Miscellaneous Containers

Dense particles are collected only in the $3\frac{1}{2}$ inch diameter containers and none larger are permitted in the particle area. Spills of solutions are cleaned up with a sponge and the solution is collected in a five inch diameter rigid bottle. Only this size container or smaller will be permitted in the operating area. Each five inch diameter bottle will be labeled "UNSAFE FOR USE WITH DENSE PARTICLES".

10.0 SAFETY ANALYSIS

10.1 General--In this section each process step is discussed relative to (a) Nuclear Safety, (b) Radiation Safety and (c) Safeguarding of Special Nuclear Material.

10.2 Dissolution--A quantity of uranium oxide powder amounting to a kilogram or two of U-235 is first weighed out in a glove box, then it is poured into the top of the dissolver. An inorganic acid is introduced to the dissolver, the system is agitated and heated to effect solution. After solution is completed, the system is cooled and the uranium containing solution is drawn off through a small filter to storage.

(a) Nuclear Safety.

One container of dry UO_2 from the shipping package and the 3.5 inch diameter dissolver charging bottle are permitted in the glove box weigh station at a time. The combined volume of the containers is considerably less than 4.5 liters, the safe fully reflected volume for UO_2 from Figure 2,TID 7016 Rev. 1. The material is moved in this closed container to the dissolver hood, posing no nuclear safety problem.

The dissolver is four inches in diameter by 30 inches long and it is therefore of safe geometry for the reasons given in paragraph 9.7. The dissolver jacket is a six inch schedule 40 pipe which normally contains no uranium but it is safe in the event solution leaked into it because it meets the conditions of item 5 in Figure 9.4. As back-up against loss of fissile material to unrestricted areas the cooling and heating system is a closed system with a three inch diameter tube and

shell heat exchanger 02-1 spaced 27 inches on center from the dissolber. The dissolver operates at atmospheric pressure, whereas the cooling system is maintained under 15 psig so that a leak would result in a flow into the reactor. The heating-cooling system pressure and the liquid level in its expansion tank are both read and recorded before uranium is introduced into the dissolver for each dissolution. If either are found to be low, they are corrected. The dissolver is then inspected and a determination is made that it does not leak before proceeding with dissolution. The solution filter 06-2A or 2B measures four inches in diameter and is therefore safe. The uranium solution is stored in three five inch PVC pipe columns which are bare and which are located in one plane on 27 inch centers. To protect against distortion of these tanks, should the dissolver solution inadvertently be introduced into a tank while still hot, a steel sleeve surrounds each of the three tanks.

(b) Radiation Safety.

The system is a closed solution system except for the introduction of urania powder into the top of the dissolver. To minimize dusting in transferring the powder from the bottle to the dissolver, the bottle is conical in shape at one end and this cone is inserted into the small part in the top of the dissolver thus open pouring is avoided. The top of the dissolver is inside a small box with a sliding window front. This window is normally closed. The face velocity with the window open exceeds 100 fpm. This enclosure is vented through a small absolute filter into the process ventilation system.

up the column. Dry particles are thus formed in this six inch diameter column which tapers to two inches at the bottom, and they collect in the smaller lower section. The wet solvent passes through small solids removal filters, then to a water scrubber column. At this point it contains no uranium. It is sent through a still by way of a backup hexanol-water separator column where it is dried for reuse.

(a) Nuclear Safety.

The two particle columns are six inch schedule 40 pipe. They have no close fitting reflectors and they are five feet or more from any massive reflectors; therefore nominal reflection equivalent to one inch of water or less may be assumed.

The uranium sol is insoluble in the drying agent and the particles have a density at least twice that of the drying agent; therefore they collect at the bottom of the column which is tapered down to two inches in diameter. This lower section is glass so that the presence of particles may be observed. The particles are removed several times each shift. From Figure 3, of TID 7016 Rev. 1, these columns would be safe with nominal reflection to concentrations approaching 200 g/l U-235. The residence time of the particles dropping through the column is relatively short being a very few minutes at most; therefore the fissile concentration is extremely small considering that if the entire 24-hour throughput were uniformly distributed throughout the column, which could not possibly occur, the U-235 concentration would only be 50 g/l so, in fact, a large safety factor exists. The collected particles have a bulk density of about 2 g/cc and they should not be permitted to build up in the tapered section above

(b) Radiation Safety.

This system is a completely closed liquid system which poses no new problems.

(c) Safeguards.

Material leaves the system as product from the column which is handled as discussed in the next paragraph and a very small quantity may find its way to the cartridge filter which material is eventually accounted for as scrap.

10.5 Particle Washing and Drying--The small beaker of particles taken from the column is transferred to one of the four inch wash containers which is drained of drying agent. The drying agent is piped by way of a cartridge filter to the redrying system. The particles are rinsed with an aqueous solution and placed in a two inch deep tray. Two trays may be placed in the vacuum furnace and the particles are dried. Alternatively a smaller one inch thick slab container may be used for this operation. The aqueous wash passes through the particulate filter and to the waste water collection tanks.

(a) Nuclear Safety.

The particles are maintained in safe geometry containers of four inch diameter, or in safe volume slabs. The maximum volume in one location is two trays in the furnace. Each tray has a volume of less than 1.5 liters. The material is not densified appreciably in the dryer but the moderator is removed thus decreasing reactivity. The safe volume for reactivity. The safe volume for these salts in the slab configuration encountered is more than the 4.5 liters given in Figure 2, TID 7016 Rev. 1.

The filter on the wash solution outlet prevents inadvertant loss should a hole develop in the collector screen. The wash water is collected in the fixed six inch glass columns to permit drying agent separation and then it is routed to poisoned tanks 10-42A or 42B.

(b) Radiation Safety.

This is the only operation in which fissile material is routinely handled in the open and with small quantities of wet material no dust problem is anticipated but the operation will be carefully monitored. After the particles are dried, covers are placed upon the trays and they are immediately transferred to the closed system glove box.

(c) Safeguards.

Essentially all material remains together at this point and it is not removed from the process.

10.6 Sintering--The dried particles are placed in the three inch diameter sintering furnace in quantities of about three kilograms. They are heated under reducing atmosphere and densification takes place. They are cooled and removed from the furnace in the standard canister and transferred to an inert atmosphere glove box where they are weighed.

(a) Nuclear Safety.

One three kilogram batch at a time is processed through this operation. Safety is maintained by the geometry of the equipment which is less than $3\frac{1}{2}$ inches in diameter, as discussed in paragraph 9.8.

(b) Radiation Safety.

The charge is placed in a loading device and sealed in the glove box. The transfer device is attached to the furnace for loading so the particles are not exposed and airborne activity from dusting is avoided. The use of argon purging with H_2 prevents an explosive mixture in the furnace. The off-gases pass through a clean gas dust filter then a primary high efficiency filter and into the ventilation duct. The normal air flow through the duct dilutes the H_2 to a factor of 100 below the minimum explosive limit of 4% in air and no explosion hazard exists.

(c) Safeguards.

At this point each sintered batch is carefully weighed and sampled for uranium analysis and a material balance is maintained accross the wet end of the process by comparing these measurements to the input measurements.

10.7 Dry-end Processing--A number of physical operations are performed upon the unmoderated spheres. These operations are performed in glove boxes which are ventilated as discussed in Section 12. No liquid or other moderating material is permitted in these glove boxes. Good physical specimens are coated in an essentially unmoderated system in that the only moderator being one atmosphere or less of H_2 gas. All transfers and storage is done in $3\frac{1}{2}$ inch diameter containers and the coating equipment does not exceed this diameter.

(a) Nuclear Safety.

Hydrogenous materials are excluded from the glove boxes permitting the safe use of unmoderated limits set forth in Table 9.4, Item 2. Except when the operations in the glove boxes are actually being performed upon the particles they are contained in geometrically safe cylinders as specified in Table 9.4, Item 7, which cylinders are properly spaced and nuclear safety is maintained.

(b) Radiation Safety.

Transfers are made only in closed canisters and furnace loading is performed using the sealed system loading device. All other operations are performed in closed system glove boxes which are exhausted through high efficiency filters which are discussed in Section 12; therefore, there is no unusual radiation hazard in these operations.

(c) Safeguards.

Both scrap and product are carefully weighed before they leave the system and records are maintained of the quantities of each, and a material balance on these operations is kept.

10.8 Finished Material Washing and Drying--The coated particles are exposed to moderator once more when they are washed with inorganic acid, rinsed with water and then rinsed in alcohol. This operation is performed in a four inch diameter container of 2.5 liter capacity. Normally the coating is impervious to this treatment, however, the wash solutions are collected and analyzed to assure that this is indeed the case before they are discarded. Finally the product is placed in a tray and dried under vacuum at elevated temperature.

(a) Nuclear Safety.

A single container of this material is processed at one time and it holds a subcritical volume. The particles are dried in a slab of no greater volume. The washing acid solutions are collected in a three inch cylinder which is visually checked for particles. If it contains none, it is carried to the boildown feed pump and pumped by hose into the boildown feed system. It could only contain particles if the wash unit filter broke in which case, the unit would be replaced and the batch would be reworked. The alcohol and water washes which will not dissolve uranium and; therefore, cannot contain more than trace quantities are drained through a small cartridge filter which removes particulate and into a five inch pipe tank located beneath the glove box. This solution is drained into a five inch diameter container and carried directly to process waste tank 10-42A or 42B. Full bottles are not permitted to collect.

(b) Radiation Safety.

This operation is performed in a glove box as discussed in Section 12 and no unusual radiation problem exists.

(c) Safeguards.

Only possible loss of special nuclear material in this operation is in washing and it is insignificant; however wash solutions are checked before discarding to ascertain that significant quantities of uranium are not being discarded.

10.9 Particle Storage--There are a number of stages in the process in which particles are stored to await further processing. These particles are stored in the standard canister which measures 3.5 inches outside diameter by nine inches in length. The racks have locators to center the canisters on their supports into a vertical column of up to six canisters. In one case six of these racks are in line, which places the columns of canisters on 18 inch centers, in one plane. An identical plane is parallel to this plane with two feet between planes. A glove box is located at the end of the rack and it may contain the contents of one storage canister at a minimum distance of two feet from the nearest column of canisters in storage. If all 200 kg of U-235 authorized were in this storage rack, it would completely fill the rack with a U-235 density of 0.08 g/cc.

(a) Nuclear Safety.

These units are individually safe by the criteria of Item 7 in Table 9.4. The lack of reflectors provides decreased reactivity. An analysis of the interaction within the array shows the array to be safe (Table 9.13).

(b) Radiation Safety.

The canisters are covered with a sealing cover when in storage posing no dusting problems.

(c) Safeguards.

Each canister of material in the storage rack is carded to identify it.

10.10 Drying Agent Safety--Considerable care has been exercised in the design of the system for washing and drying the drying agent to minimize the fire hazard associated with the use of this flammable hydrocarbon. It has a flashpoint higher than that of kerosene. It has a very low vapor pressure at the temperature of operation. The ventilation exhausts at the bottom of the particle columns to remove any fumes. The drying agent is redried in the still room. This room is separated from the operating area by a concrete-block wall. It is provided with a blow-out wall to the outside as a safety feature and it is equipped with explosion proof electrical equipment and fixtures. It and the particle column area are the only ones sprinklered. As noted in section 12, the air is replaced 12 times an hour in this room. Thus it is apparent that any hazard associated with the use of this flammable liquid has been handled in a manner representing good industrial practice.

10.11 Sumps--There are two sumps in the 16A facility. One is in the floor of the change room and the showers, wash basins, fountains and laboratory sinks drain to this sump. Solutions are pumped from this sump to the shower waste holding tanks discussed in paragraph 11.2. The other sump is in the still room and provides a collection point for solution leaks in the still room.

(a) Nuclear Safety.

Neither of these sumps are accessable to any solution containing more than trace quantities of fissile material under any circumstances; consequently,

they need not be of restricted geometry. For any fissile solids to collect in the shower sump these solids would have to be dumped in the laboratory sink contrary to procedure. Solid fissile material could collect in the still room sump only by spillage in filter or draining particles from the water scrub column in the unlikely event of filter failure. To avoid the long term possibility of fissile solids buildup , the solids in the bottom of the sumps are sampled each six months and if uranium is found the sumps are cleaned out.

(b) Radiation Safety.

No radiation problem is associated with the sumps.

(c) Safeguards.

Significant quantities of fissile material are not likely to be found in these sumps.

10.12 Large Tanks--In addition to the tanks previously discussed, there are in the six large tanks associated with drying agent or chemical supply which are not of restricted geometry because fissile material cannot reach them. These tanks are as follows:

Tank Number	Description
10-21	Dried Solvent Receiver
10-22	Spent Solvent Tank
10-23	Clean Solvent Storage Tank
10-28	Aqueous Wash Solution Storage Tank
10-29A,29B	Wash Solution Feed Tanks

(a) Nuclear Safety.

The drying agent passes through the washing system described in paragraph 10.4 before it can reach tanks 10-21 or 10-22, and tank 10-23 contains only new drying agent without provision for recycle; therefore, no fissile material can reach these tanks. The aqueous solution tanks 10-28, 10-29A and 29B are all located at a higher elevation than the systems they feed, so that siphoning cannot occur and they are not equipped for recirculating solution; therefore, no fissile material can reach these tanks either.

(b) Radiation Safety.

No radioactive material involved.

(c) Safeguards.

No fissile material involved.

11.0 WASTE TREATMENT AND DISPOSAL

11.1 Scrap Recovery--The scrap generated in the facility consists of liquids; solids consisting principally of non-specification products; and contaminated clothing and materials. Non-specification product may in some instances be recycled directly to dissolution. All other solid scrap will be packaged in DOT specification 6L containers and shipped to a licensee qualified to receive and recover the uranium in the scrap. The liquid wastes will also be sent out for recovery. These solutions are concentrated by distillation in the boildown system and after analysis for uranium they are packaged either in 55 gallon drums, in the case of dilute solutions which will not precipitate, or which would be safe in total mass as set forth in Table 9.4, if they did not precipitate; or they are packaged in cylinders of safe diameter and shipped to recovery in DOT special permit packages.

11.2 All liquid process wastes that are expected under normal circumstances to contain in excess of 5×10^{-6} microcuries of U/ml are routed directly to the boildown feed tanks 10-37A or 37B. All other aqueous process wastes go directly to poisoned tanks 10-42A or 42B.

The showers, wash basins, fountains and the laboratory sinks drain to the shower room sump from which they are pumped up to one of the shower waste holding tanks. The laboratory sinks are used for washing apparatus and hand washing. All analytical

solutions that may contain uranium are poured into five inch diameter bottles and the container is rinsed into the bottle thus no detectable uranium will normally be found in this solution.

When tank 10-42A, 42B or either of the shower waste holding tanks become full, flow is switched to the alternate. The solution in the full tank is cycled by pump for thirty minutes to mix the solution thoroughly and a sample is taken. If the uranium content of the sample exceeds $5x10^{-6}$ microcuries of U/ml, the solution is routed to 10-37A or 37B for further treatment in the boildown. Solutions containing $5x10^{-6}$ microcuries of U per ml or less are discharged directly to the sewer without further treatment.

Under normal conditions the distillate from the boildown contains no uranium and it will be discharged directly to the sewer unless the activity exceeds $2.5x10^{-5}$ microcuries per ml. During the infrequent occasions (estimated at not more than one week each year) when the boildown may become inoperative, solutions containing up to $3x10^{-5}$ microcuries per ml of activity, the limit set forth in 12 CFR paragraph 20.106, may be discharged to the sewer.

11.3 The plant sanitary sewer and chemical sewer systems are treated separately to meet the general and specific water quality standards of the State of Maryland for the Middle Patuxent River into which they are finally released. They are combined prior to release to a creek on the property. Combined workday flow will

average 4×10^5 liters, dropping off to 2.4×10^5 per day on weekends. The 10^3 liters of process liquids to be discarded daily are thus subjected to dilution on the order of 100 or more prior to release.

11.4 In the course of the operation some disposable solid materials will undoubtedly become contaminated. For the most part these will consist of clothing, gloves and the like which will contain only trace quantities of fissile materials and which may be disposed of by burial at a licensed burial facility.

Material that could contain appreciable quantities of fissile materials such as filters will be monitored for activity. If the presence of a significant quantity of fissile material is indicated, the item will be packaged in DOT specification containers for shipment to scrap recovery. None of these materials pose a fire hazard.

11.5 The bottoms from the boildown are drained into a five inch diameter container which is poured directly into the five inch diameter shipping container bottle. This bottle is loaded while in the shipping package to assure safe spacing from other containers.

12.0 AUXILIARY SYSTEMS

12.1 Ventilation System--The ventilation system for the Building 16A Facility consists of a combination of blowers, filters, ducts, dampers and other control devices which work together to provide a clean and conditioned air supply to all areas wherein radioactive materials are handled, and to exhaust the air from these areas thru filtering devices which will assure that any release of airborne radioactivity downstream from these filters is within the acceptable release limits of 10 CFR 20.

12.2 The basic design guidelines are similar to those covering the ventilation of radioactive operations as set forth in the Manual of Recommended Practice for Industrial Ventilation, published by the Committee on Industrial Ventilation of the American Conference of Governmental Industrial Hygienists.

12.3 The flow of air is designed to be never from areas of higher contamination toward areas of lower contamination; all building exhaust air is directed to the filtered exhaust system for final discharge above the building roof. The areas of lesser contamination, such as the working areas of the rooms, are always maintained at levels which allow personnel occupancy.

12.4 The fresh supply air to all working areas of the radioactive facility is 62% fresh outside air and the balance is recycled cooled or heated room air. This air is filtered and tempered by heating or cooling before being discharged to the work spaces. The amounts

of supply air discharged to these spaces is sufficient to maintain any level of radioactivity present well below the acceptable maximum allowable of 10 CFR 20, and respiratory protective equipment for the personnel will not be required for normal operations. In the event of unexpected air contamination above acceptable work levels, authorization is requested to use respiratory protective equipment pursuant to 10 CFR 20.103(c)(3). The fissile material processed in this facility is not likely to cause contamination that cannot be cleaned up when wearing the usual work clothing plus respiratory protective equipment if airborne activity is associated with the activity. Health and Safety will rope off any seriously contaminated areas as defined in Section 8 hereof, and they will specify the protective clothing and respiratory devices required to enter the area. Contaminated materials, if solutions, are collected in five inch bottles and transferred to the waste solution system, or directly to the five inch DOT Special Permit shipping container for shipment to recovery if the solution contains appreciable uranium. Other contaminated materials are packaged directly in DOT specification drums for shipment to waste burial.

12.5 The air from the working areas is exhausted at a rate which maintains these areas at a slightly lower pressure than the surrounding areas and assures that any air leakage is inward toward

the areas of potential contamination and away from the non-contaminated areas. All of the exhaust air is passed through a bank of "absolute"type final filters which are greater than 99.9% efficient for 0.3 micron diameter particles. The filters are equipped with pressure drop measuring devices to indicate the amount of resistance developed due to particulate loading; the filters are factory tested to 10" w.g. pressure, and when the in-service pressure drop reaches 50% of the test value, the filters are discarded and replaced with new ones.

12.6 Within the work area, the radioactive material is processed in completely contained handling systems. In the solution form it is contained by closed tanks connected by a piping system. This system is kept and operated in a leak-tight condition; should any leaks inadvertently occur, chemically resistant floor pans are placed under all pieces of equipment so the liquid can be quickly recovered and not spread into difficult locations for retrieval; the fumes or vapors from any such occasional leakages are considered to be slight and they will be rapidly swept away by the copious quantities of fresh ventilation air supplied.

12.7 In the solids form, the radioactive materials are processed in a completely contained system of high-integrity glove boxes which are tested for leak-tightness before being placed in service. Whenever the materials are withdrawn from the glove boxes for storage or transfer, they are first placed in a small tightly sealed stainless steel flanged container or a screw top polyethylene bottle. These containers are wiped clean and passed from the glove boxes through two-door airlock entrances which effectively prevent the glove box atmosphere from contaminating the room atmosphere during the transfer operation. There are two hoods in the area with sliding doors, one at dissolver loading and one at needle cleaning. These have a face velocity of 100 feet per minute which velocity is checked at regular intervals under contract to an organization which tests and certifies the air flow to all hoods on site.

may be generated by the processing operations being carried on in this line of boxes. The inert gas inlet line is protected with an absolute type filter, and the withdrawal effluent is also passed through an absolute type filter. It is then directed into the main ventilation exhaust system, upstream from the final filters, thus ensuring that all ventilation effluents from the areas of high contamination within the glove boxes are filtered twice by absolute type filters before being released to the environment. A continuous air sampler is located in the ventilation exhaust duct (stack). It is placed sufficiently far into the duct to avoid eddy current effect of the duct walls and the flow rate is adjusted to be isokinetic with the normal exhaust velocity from the facility. Samples are taken weekly and analyzed whenever the facility is operating.

12.12 Other Systems--The only other auxiliary system that is of concern to nuclear safety is the Evacuation Alarm System. This system has an emergency wet battery power supply so that both the gamma detectors and the radiation alarm are operative in the event of a power failure. The modes of operation of the Evacuation Alarm Systems are described below:

Modes of Operation

1. An event is monitored at either of two places in Building 16-A. A monitored event would cause the monitor to sound and blink. System will operate indefinitely from 115V A.C. house power or 12 hours monitoring and 20 min. alarm from battery.

Building 16-A:	Siren sounds outside
Building 16, 16A:	Evacuation alarm inside
Building 20:	Siren sounds outside
Building 1:	Four sirens sound outside
Building 1, Civil Def. Rm:	Red light comes on indicating "Bldg. 16-A alarm"
Building 1, Civil Def. Rm:	Alarm silenced by key operated switch. Red light comes on indicating "Alarm Silenced"

2. An event is monitored at Bldg. 20. A monitored event would cause the monitor to sound and blink. System will operate indefinitely from 115V A.C. house power or 12 hours monitoring and 20 min. alarm from battery.

Building 16-A:	Siren sounds outside
Building 20:	Siren sounds outside
Building 20:	Evacuation alarm inside
Building 11:	Evacuation alarm inside
Building 16-A, Rm. 10:	Red light comes on indicating "Bldg. 20 alarm"
Building 16-A, Process Area:	Red light comes on indicating "Bldg. 20 alarm"
Building 1:	Four sirens sound outside
Building 1, Civil Def. Rm:	Red light comes on indicating "Bldg. 20 alarm"
Building 1, Civil Def. Rm:	Alarm silenced by key switch. Red light indicates "Alarm Silenced"

3. Test either of two monitors in Bldg. 16-A with a radiation source. Key switch in Bldg. 1, Civil Defense Room would be turned to "Alarm Silenced" position. The monitor will sound and blink.

Building 1, Civil Def. Rm:	Red light on indicating "Alarm Silenced"
Building 1, Civil Def. Rm:	Red light comes on indicating "Bldg. 16-A alarm"

4. Test monitor in Bldg. 20 with a radiation source. Key switch in Bldg. 1, Civil Def. Room would be turned to "Alarm Silenced" position. The monitor will sound and blink.

Building 1, Civil Def. Rm:	Red light on, indicating "Alarm Silenced"
Building 1, Civil Def. Rm:	Red light comes on indicating "Bldg. 20 alarm"

5. In case of a non-nuclear event at any one of Buildings 1, 1A, 2, 3,4,16,16-A and 20, the evacuation alarm would be manually tripped. Each local evacuation alarm would operate independently from house power in this mode.

Each radiation alarm is tested with a radiation source by Health and Safety and the emergency power supply is checked for charge once each month. Each unit is tagged with the date of the last inspection and the initials of the inspector. Action will be taken to repair faulty equipment immediately upon detection.

12.13 Building 20 Storage--Building 20 is a storage warehouse and inside of it, an area 16 feet by 20 feet square has been fenced with chain link fence which reaches to the ceiling. The area is used for storage of material in DOT approved shipping packages only. Packages are moved in and out of this area which is secured by lock in the manner specified in the accountability manual. No operations are performed in this area which could violate the safety inherent in the shipping packages; however a radiation alarm sensor is located on the wall at one side of the storage area. The operation of this alarm and its relation to the alarm system is described in paragraph 12.12.

The difference is 8.46-8.12 = 0.34 cm and in percent, the diameter is reduced only 4% by increasing the enrichment from 93.2% to 97% U-235.

The minimum critical diameter for water reflected solutions of 93.2% U-235 in infinite cylinders is 5.4 inches. Reduced by 4% for increased enrichment of 97% U-235 results in a minimum critical fully reflected cylinder of 5.2 inches. The uranium containing columns in the facility are 5 inches in diameter so they would be subcritical even if fully reflected. The columns are, in fact, bare and they are spaced well apart from each other and from reflecting structures, which reduces their reactivity substantially.

of the canisters will contain unmoderated material, but since it is not desirable to restrict the storage area to unmoderated material, the reactivity determination here assumes optimum moderation. The area is not subject to flooding and the canisters have 0.083-inch thick stainless steel walls.

Reflector savings varies inversely as the U-235 density and are reported to be 2.15 cm for full density metal and 2.55 cm for bare stainless steel cylinders of UO_2F_2 solution at 0.538 g/cc (DP 532 Fig. 2.7 and Table IV.5). The density of the fissile material stored in the rack is intermediate; therefore, since neutrons that are reflected are not available for interaction for the purpose of interaction computation it is conservative to use S=2.55 cm.

The largest buckling occurs at the greatest density so the U-235 density for fully dense particles which is 6.52 g/cc is used. The six canisters in the rack are all considered to be one continuous unit 54 inches in length in this calculation.

The critical diameter of an infinite cylinder from Figure 10--TID 7028 for metal at 6.5 g/cc is 6.2 inches. Using 6.2 inches reduced by 4% to account for the 97% enrichment discussed above a buckling may be calculated.

$$B^2 = \frac{(2.405)^2}{(R + S)^2}$$

$R = 7.56$ cm

$S = 2.55$ cm

$$B^2 = 0.0566 \text{ cm}^{-2}$$

The buckling for the rack taken as a 3.33 inch inside diameter by 54 inch long column is

$$B_g^2 = \frac{(2.405)^2}{(R + S)^2} + \frac{\pi^2}{(x + 2S)^2}$$

where

$R = \frac{3.33}{2} \times 2.54 = 4.23$ cm

x = length = $54 \times 2.54 = 137.2$ cm

$S = 2.55$ cm

$$B_g^2 = 0.1258 + 0.0005$$

$$= 0.1263 \text{ cm}^{-2}$$

K_{eff} may then be computed as follows:

$$K_{eff} = \frac{1 + M^2 B_m^2}{1 + M^2 B_g^2}$$

letting

$M^2 = 38$ cm which is applicable to a highly moderated system

then

$$K_{eff} = \frac{1 + 38 \times 0.0566}{1 + 38 \times 0.1263} = 0.54$$

M^2 increases with decreasing moderation and K_{eff} decreases, therefore:

$$K_{eff} \leq 0.54$$

The permissable interaction solid angle for a K_{eff} of 0.54 is 3.7 steradians (Figure 26--TID 7016 Rev. 1).

C. Solid Angle Interaction in the Array

By inspection of the Storage Area layout it can be seen that the distances to the glove boxes is so great at 5 feet from the nearest box to any storage unit that the most central unit of the array should be the most reactive by reason of interaction with its much closer neighbors. This interaction is computed using the formula of TID 7016 Rev.1 where $\sim = (2d/h) \sin \theta$

No. of Neighbors Seen	Distance inches	Solid angle per Neighbor	Total Solid Angle
2	16.5	0.344	0.688
1	22.5	0.227	0.227
2	28.8	0.158	0.316
2	42.5	0.084	0.168
		Total	1.399

say, 1.4 steradians
Total permissable 3.7 steradians

Such other units as there are in the room contribute less than 0.005 steradians each and may therefore be neglected.

II Liquid Storage Interaction

A. Configuration

All uranium solutions in the process other than waste solutions are stored or treated in a series of 5 inch schedule 40 PVC columns which are located in one vertical plane. The individual tanks are separated from each other by 24 inches on center and any one column sees only its adjacent neighbors. These columns vary in length from 140 to 160 inches and they may therefore be treated as infinite.

There are no other containers or tanks containing more than 5 g/l fissile material at any time sufficiently close to subtend a solid angle greater than 0.005 steradians.

B. Single Unit Reactivity

The solution concentration in the columns is about 2 molar in uranium. As a maximum, the material buckling for a UO_2F_2 solution of 93.5% U-235 at 2.14 molar is given in Table IV.15 of DP-532 as $Bm^2 = 0.03166\ cm^{-2}$. If this buckling is increased by 4%, it will approximate the buckling of 97% enrichment and $Bm^2_{97} = 0.03293\ cm^{-2}$.

The bare column of 5.047 inch inside diameter has a 1/4 inch wall and a reflector savings S = 4.0 cm fairly represents the reflection experienced by the column.

then:

$$R = 6.41\ cm$$

$$Bg^2 = \frac{(2.405)^2}{(r + S)^2} = \frac{(2.405)^2}{(6.41 + 4.0)^2} = 0.05337\ cm^{-2}$$

$$Keff = \frac{1 + M^2Bm^2}{1 + M^2Bg^2} = \frac{1 + 38 \times 0.03295}{1 + 38 \times 0.0534}$$

Keff = 0.74

The permissable solid angle from Figure 26 TID 7016 Rev. 1 is 1.5 steradians.

7.7 The solution in which the uranium is in the form of UO_2Cl_2 is adjusted in uranium and acid concentrations in the dilution tank to that desired for the next step (dialysis).

7.8 Dialysis-- The adjusted UO_2Cl_2 solution is next transferred on a batch basis to the dialysis feed tank (10-4) which is a five inch diameter PVC tank, to which is attached a sight glass to permit observation of the color of the solution. The solution is then circulated to one side of the dialysis cell 13-2. The dialysis cell is separated into two compartments by a semi-permeable membrane. Water is circulated through the second (anolyte) side of the cell. In this cell, the chloride ion is essentially removed from the UO_2Cl_2 leaving the UO_2 in the form of a sol. Some of the chloride goes off as chlorine gas and is neutralized in NaOH in Tank 10-8. Some is transferred through the membrane into the anolyte as HCl; this is also neutralized with NaOH in Tank 10-8 and the resulting solution is sent to hold-up tank 10-42A or 42B. Hydrogen gas is also given off from the dialysis cell. This is diluted with sufficient air in aerators 10-5 or 10-7 to lower the hydrogen concentration well below the lower explosive limit. This mixture is vented to the laboratory ventilation system--where additional dilution of the hydrogen will occur placing it even farther below the explosive limit. The dialyzed sol is collected in storage tanks 10-10A or 10B made of five inch PVC pipe.

to spent solvent tank 10-22. The wastes from the entire process and their treatment is shown pictorially in Figure 7.12.

7.13 When the glass wash bottle system is used the drained bottle containing the particles is removed from the stand and carried to the table on the opposite side of the vacuum dryer 08-7 where the particles are poured into a metal tray measuring 8-7/8 inches long by 5 inches wide by 1 inch deep. The cavity in the drying oven is such that six trays may be placed in the oven at one time. The oven is evacuated and heated to about 250 C to assure complete removal of moisture from the particles. The dryer is cooled and a cover is placed upon each tray of dried particle which is then carried to the glove box transfer station 14-13. When the slab collector is used it is already in a furnace where it was placed for washing. The screened end is valved to vacuum. It is evacuated and heated to about 250 C. After cooling it is removed to transfer station 14-13, as are the trays described above.

7.14 The weigh station is connected to a series of glove boxes and in this complex, which is under inert gas, the particles are weighed and particles with undesirable physical characteristics are separated out and returned to dissolution. Good particles are stored in one of the standard canisters--04-8 which measure 3.5 inches outside diameter by nine inches in length.

7.15 The standard canister with a three kg sintering charge in it is moved to the sintering furnace 01-1 which is a three inch vertical pipe. The contents of the container are emptied into the furnace and the particles are subjected to high temperature in the presence of hydrogen. The furnace is allowed to cool and the densified particles are removed from the furnace into a storage canister using reactor unloading device 04-11. They are then returned to the weigh station.

to spent solvent tank 10-22. The wastes from the entire process and their treatment is shown pictorially in Figure 7.12.

7.13 When the glass wash bottle system is used the drained bottle containing the particles is removed from the stand and carried to the table on the opposite side of the vacuum dryer 08-7 where the particles are poured into a metal tray measuring 8-7/8 inches long by 5 inches wide by 1 inch deep. Each tray is filled to a depth of about 3/4 inch. The cavity in the drying oven is such that six trays may be placed in the oven at one time. The oven is evacuated and heated to about 250°C to assure complete removal of moisture from the particles. The dried particle density may approach 35% of theory for UO_2 or 3.8 g/cc. The U-235 density with random packing in the tray could then approach 2.1 g/cc. Average bulk density experienced is 1.5 g/cc. The dryer is cooled and a cover is placed upon each tray of dried particle which is then carried to the glove box transfer station 14-3. When the slab collector is used it is already in a furnace where it was placed for washing. The screened end is valved to vacuum. It is evacuated and heated to about 250°C. After cooling it is removed to transfer station 14-13, as are the trays described above. In this box the material is transferred to a standard canister.

7.14 The standard canister is then moved to the weigh station where it is weighed. These canisters measure 3.5 inches outside diameter by 9 inches in length. This weigh station is also used for weighing the sintering charge, the sintered product and the physically defective material separated in the adjoining glove boxes. These boxes are all maintained under inert atmosphere. Water is not permitted nor is there any mechanism by which it can enter this system of boxes.

7.15 The standard canister with a three kg sintering charge in it and a furnace charging cover on it is moved to the sintering furnace 01-1 which

is a three inch vertical pipe. The contents of the container are emptied into the furnace and the particles are subjected to high temperature in the presence of hydrogen. The furnace is allowed to cool under intert gas and the densified particles are removed from the furnace into a storage canister using reactor unloading device 04-11. They are then returned to the weigh station.

release

7.16 Screening, Sampling, and Blending--At this point approximately 200-gram quantities of the particles are weighed into stainless steel beakers. Material is removed from the glove boxes in standard canisters only.

7.17 One at a time, charges of particles are placed in a set of eight inch diameter Rotap screens and the product is sized. Off-size material is bottled and transferred to scrap or recycle storage. Material which meets product size requirements is next tested for shape on an inclined plane. Again product which does not meet specifications is bottled and sent to scrap or recycle storage. Samples are taken of material which has met all of the size and shape requirements to determine the density of the product.

7.18 A number of individual batches of satisfactory product are next blended and split, and additional samples taken. Larger lots are again blended, split, and sampled, and finally bottled in the standard canister in approximately three kg lots, for storage until finishing is to be carried out. All particle blending is performed in a blender which is bare wall and housed in a glove box under inert gas. All of the glove boxes have cartridge type replaceable filters on the exhaust outlet.

7.19 Finishing the Particles--Next approximately three kg batches of UO_2 particles which meet product specifications are placed in the finishing reactor 01-3. This unit is a three inch diameter tube about forty inches long installed inside a furnace. The particles are fluidized with a mixture of argon and hydrogen. Part of the hydrogen passes over

7.22 Liquid Waste Concentration-- Any liquid wastes from the process that may contain uranium are sampled, and if the activity is above the limits for discharge to the sewer without dilution, they are sent to boildown feed tanks 10-37A or 37B. From here the solution is concentrated in a small thermosiphon evaporator 02-10. The overheads are condensed and collected in condensate receivers 10-11A or 11B. This solution is sampled and analyzed for activity to be sure it meets MPC for discharge to the sewers before it is discharged to the plant sewer. Should the condensate be above MPC, it will be recycled to the boildown feed tank for redistillation.

7.23 Radiation Protection Facilities and Equipment-- The nuclear facilites at the Washington Research Center are equipped and operated in a manner that affords a high degree of safety against the possibility of serious exposure to radioactivity either on site or in the surrounding area. The safety equipment and supplies available on the site are discussed in the following paragraphs, and the monitoring equipment is listed in Table 7.22.

Personnel regularly working in the facility are provided with the following protective clothing:

1) coveralls

2) shoes or disposable shoe covers

The regular staff is required to wear the above clothing. Visitors and casual entrants into these working areas are provided with lab coats and shoe covers.

TABLE 7.23

RADIATION PROTECTION EQUIPMENT

FUNCTION	EQUIPMENT PROVIDED	NUMBER	LOCATION	REMARKS
To Sample Air:				
Continuous Air Sampling	Air Sampler, MCI Inc., Model HD-28 Constant Flow Sampler with Gast Pump and Gelman Filters	3	1-in Lab Metallographic Area 1-in Process area near 14-2 1-in Mezzanine near 14-1	Sample Head at breathing level in each room
Spot Air Sampling	Air Sampler, Staplex Model TFIA, Hi-volume	1	Portable	
Final Effluent Air Sampling	Gast Pump and Gelman Filter	1	In exit duct downstream of final filter	Samples taken intermittantly
Counting Air Filter Samples	Liquid scintillation counter Nuclear-Chicago Mark 1--Model 6860	1	Laboratory in Building 2	Samples counted daily
To Survey Surfaces:				
Monitoring Floors	Alpha Floor Monitor, Eberline Instrument Corp. Model FM-3G, 3 Scale 10^3,10^4 and 10^5 cpm	1	Portable	
Monitoring Other Surfaces	Alpha Survey Meter, Eberline Instrument Corp. Model PAC-3G 0-1000 cpm Alpha	1	Portable	
	Survey Meter, Victoreen Instrument Co. Model Thyac III, with Alpha, Beta, Gamma Probe 0-8 cpm Alpha, 0.2,2,20 and 200 mr/hr scales for Beta-Gamma	2	Portable	Used for more inaccessible areas and if Beta-Gamma Survey should be required

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TABLE 7.23 (cont'd)

RADIATION PROTECTION EQUIPMENT

FUNCTION	EQUIPMENT PROVIDED	NUMBER	LOCATION	REMARKS
To Monitor Liquid Effluents:	Holdup Tank	2	Mezzanine level and ground floor	Samples counted on liquid scintillation counter estimated level of detection, 3 CPM
To Detect Criticality Event:				
Alarm	Victoreen Instrument Co. Model 715 detectors or other approved sensors	3	1-in wall between lab rooms 1-in North wall with view of entire process 1-in Bldg. 20 storage	Alarm loud enough to alert entire Research Center
	Model 712 Control Panel with Evacuation Alarm or similar approved system	1	Control Panel at entrance in room 10; Claxon outside Building	
Record Event	Eberline Instrument Co. Thermoluminescent (TLD) Area Badges, room temp. self-annealing	24	At various points in Bldg 16A	Would be read in case of an event to develop iso-dose lines and estimate exposures to personnel
Personnel Monitoring: Hands, Clothes etc.	Eberline Instrument Co. Monitor Model RM-3C with AC-3 Alpha Probe 0-500 cpm	3	At clothes change area	
Film Badges	From commercial supplier such as R. S. Landauer & Co., Tracerlab or other Company approved		Worn on person	Read once each month

6.2 Mr. T. G. Gibian, a Vice President of W. R. Grace & Co. has overall responsibility for all research activities at the Center.

6.3 Dr. M. G. Sanchez, Vice-President of the Technical Group, is General Manager of the Research Division. Dr. Sanchez is very much involved in the nuclear activities at the Center and as General Manager he carries the responsibility for all aspects of the facilities involving special nuclear material.

6.4 Mr. G. E. Ashby, Divisional Vice-President has overall responsibility for nuclear operations and the nuclear processes, just as Mr. W. K. O'Loughlin, Divisional Vice-President has overall responsibility for the administrative aspects of carrying on operations involving special nuclear material.

6.5 Mr. D. R. Telesca is Plant Manager under whom the operations involving special nuclear material are carried out. The organization established to carry out the work is shown in Figure 6.5.

6.6 Nuclear Safety Committee-- In addition to the usual line and staff functions essential to the safe operation in the facility, the General Manager has established a Nuclear Safety Committee. This Committee is composed of individuals experienced in all aspects of nuclear safety and operations involving special nuclear material.

Mr. Reese is 45. He did his undergraduate work in Chemical Engineering at the University of Cincinnati and at the University of Alabama the latter as a part of his service in the U. S. Army during World War II. During that service he earned three battle stars in Germany and was decorated with the Silver and Bronze Stars. He left the service with the rank of Captain.
He is a member of ANS, AIF, INMM, ASM, and AIMME. He has been and is active on numerous working committees of each.

6.29 Training-- Prior to working with fissile materials, each employee who is to work in the nuclear area will attend a four hour basic course covering nuclear criticality, safety, radiation safety, and the use and maintenance of safety equipment. These will be followed monthly with safety meetings, each of about one hour duration, on pertinent safety matters including the above.

8.12 Waste Disposal

The wastes generated in the facility are either liquid or solid. Procedures are established whereby:

a) Solid radioactive wastes are packaged in DOT approved packages for shipment to disposal.

b) Airborne solid radioactive wastes are removed by way of the ventilation system. Radioactive dust is evolved primarily in ventilated glove boxes. Each box or closed train has a prefilter which may either be disposed of as above when the pressure differential indicates that it is plugged, or it may be packaged and sent out for recovery of uranium values. All ventilation gases finally exhaust through filters designed to remove 99.9% of particulate 0.3 microns in size. When contaminated, these filters are shipped to disposal in packages that comply with DOT regulations.

c) Liquid wastes include overheads from evaporation and various wash solutions. These solutions are monitored and any solution that contains 0.01 grams of uranium per liter or less is released to the sewer. More concentrated solutions are retained for recovery or disposal at an approved burial site.

9.9 Under each grouping of equipment containing fissile material in solution is a chemically resistant tray which is sized at 1 1/2 inches depth to hold the contents of the largest single container or group of containers that could drain or siphon out together. These are compared individually in Table 9.9. Assuming full reflection from the floor and practically no reflection from the open top, this depth which would be subcritical for a fully reflected slab has ample safety.

9.10 Neutron Poisons--Poisons are not used in the process. Fixed poison in the form of borosilicate raschig rings which contain 12.5% natural B_2O3 and are sized to uniformly occupy 23% of the tank volume are used in the waste solution collection tanks 10-42A and 42B. The waste entering these tanks normally contain only traces of special nuclear material. The fixed poison in these tanks provide back-up protection against a failure elsewhere in the system. When the tanks are full, the solution is analyzed for special nuclear material. It is discarded to the sewer if found to be below MPC, otherwise it is retained for recovery via the boildown system. No precipitants are routed to this tank.

9.11 Concentration Limits-- Throughout the process the solutions are, for the most part, confined such that they are safe by reason of features other than the concentration of fissionable material. Solutions such as waste solutions for scrap recovery which contain by analysis, 5 g/l or less U^{235} may be safely stored in containers of any size. Precipitants are carefully excluded to avoid concentration by settling. The containers of these solutions are

stored above the freezing temperature of the solution to preclude the possibility of selective crystallization of the uranium compound.

9.12 Neutron Reflection-- Process vessels containing solutions of fissile materials have been located at least 5 radii from building walls to minimize neutron reflection, and for operating convenience. Fox, Gilley and Calihan of ORNL determined that a close fitting concrete wall adjacent to one side of a container was equivalent to 0.2 inches of water reflection (ORNL-2367). At 6 inches separation its influence is reduced by several factors and its contribution as a reflector for practical purposes is negligible. This process system as designed has lower reactivity and enjoys increased safety by reason of reduced reflection.

10.0 SAFETY ANALYSIS

10.1 General-- In this section each process step is discussed relative to (a) Nuclear Safety, (b) Radiation Safety and (c) Safeguarding of Special Nuclear Material.

10.2 Dissolution-- A known quantity of uranium oxide powder containing a kilogram or two of U-235 is poured into the top of the dissolver. An inorganic acid is introduced to the dissolver, the system is agitated and heated to effect solution. After dissolution is completed the system is cooled and the uranium containing solution is drawn off through a small filter to storage.

(a) Nuclear Safety.

The dissolver is four inches in diameter by 30 inches long and it is therefore of safe geometry for the reasons given in paragraph 9.7. The dissolver jacket is a bare, six inch pipe which normally contains no uranium but it is safe in the event solution leaked into it for the same reasons. As back-up, in the event of a leak this cooling and heating system is a closed system with a three inch diameter tube and shell heat exchanger 02-1 spaced 27 inches on center from the dissolver. The dissolver operates at atmospheric pressure, whereas the cooling system is maintained under 15 psig so that a leak would result in a flow into the reactor. The heating-cooling system pressure and the liquid level in its expansion tank are both read and recorded before uranium is introduced into the dissolver for each dissolution. If either are found to be low they are corrected. The dissolver is then inspected and a determination is made that it does not leak before proceeding with dissolution. The solution filter 06-2A or 2B measures four inches in diameter and is therefore safe. The uranium solution stored in three five inch PVC pipe columns which are bare and which are located in one plane on 27 inch centers. To protect against distortion of these tanks, should the dissolver solution inadvertently be introduced into a tank while still hot, a steel sleeve surrounds each of the three tanks.

(b) Radiation Safety

The system is a closed solution system except for the introduction of urania powder into the top of the dissolver. This possible source of airborne particulate is hooded and this hood is exhausted through a high efficiency filter.

(c) Safeguards

Since the uranium oxide loses its identity at this point of introduction into the system, the quantities introduced are carefully measured and a record is made of the weights.

10.3 Dialysis--Approximately 40 liter batches of dissolver solution is converted to a sol by circulating it through a dialysis cell. The finished sol is transferred to the sol storage tanks. The non-uranium bearing products of dialysis are taken into the anolyte solution This waste solution is treated by way of the boildown system. The product gases are scrubbed with caustic in tank 10-8. This solution is barren in uranium and when spent, it is discarded by way of the waste tank system 10-42A or 42B.

(a) Nuclear Safety

All of the tanks in this system are five inch bare pipe and all except 10-8, the scrub tank, which tank does not contain uranium, are in the same plane as the dissolver product tanks and these tanks are spaced 27 inches on center. This arrangement is safe for the reasons given in paragraph 9.13. The dialysis cell itself is a slab with a total capacity of less than six liters and half of that is

anolyte solution. The unit measures 22 inches by 22 inches outside and it is essentially isolated by in excess of six feet of space between it and any unit containing uranium. The waste anolyte which contains a small quantity of uranium is sent to the waste boildown tank which is six inches in diameter, bare and safe for t reasons presented in paragraph 9.7 and 9.11.

(b) Radiation Safety

This is a closed system and it poses no undue radiation problems;however, employees are instructed to come in close proximity to these units, only as needed to perform the required operations.

(c) Safeguards

No special nuclear material measurements are made at this point in the process and the only special nuclear material leaving the process proper is that which goes to the boildown system where it is concentrated and the uranium content is measured at that point.

10.4 Particle Formation-- A batch of sol is pumped to the particle column feed tank. The sol in this tank is continuously circulated through a four inch diameter by eighteen inch long constant overflow tank which feeds the top of the column through proportioning pumps. The sol flows down the column and is dehydrated by an imiscible drying agent which flows up the column. Dry particles are thus formed in this six inch bare column which tapers to two inches at the bottom, and they collect in the smaller lower section. The wet solvent passes through

small solids removal filters, then to a water scrubber column and then finally through a backup glass column particulate trap. At this point it contains no uranium. It is sent through a still where it is dried for reuse.

(a) Nuclear Safety

The two six inch particle columns are bare and they have very low uranium density as the small particles pass down the columns through the drying agent liquid. The diameter is reduced in the section where the particles collect. They reach a bulk density of about two g/cc when they settle in the lower column section which is less than four inches in diameter. The particles are removed after a few hundred grams have collected by draining into a four inch diameter collector, thus column safety is assured. The two columns are spaced 36 inches apart on center and no other vessels of uranium are found in the area.

The drying agent, as it leaves the column, normally contains no uranium since it is insoluble in this solution; however, a surge or malformed particle connected to a gas bubble could carry out with the drying agent. Any such material is removed by four inch diameter cartridge filters. The agent is then scrubbed with water in a six inch bare column to remove chemicals and as final backup the drying agent passes through a six inch glass column particulate trap on its way to redrying. These two columns are spaced 27 inches on center from each other. They pose no nuclear safety problem.

(b) Radiation Safety.

This system is a completely closed liquid system which poses no new problems.

(c) Safeguards.

Material leaves the system as product from the column which is handled as discussed in the next paragraph and a very small quantity may find its way to the cartridge filter which material is eventually accounted for as scrap.

10.5 Particle Washing and Drying--The small beaker of particles taken from the column is transferred to one of the four inch wash containers which is drained of drying agent. The drying agent is piped by way of a cartridge filter to the redrying system. The particles are rinsed with an aqueous solution and placed in a drying tray. These one inch deep trays are placed in the vacuum furnace and the particles are dried. Alternatively a one inch thick slab container may be used for this operation. The aqueous wash passes through the particulate filter and to the waste water collection tanks.

(a) Nuclear Safety.

The particles are maintained in safe geometry containers of four inch diameter, or in safe volume slabs. The maximum volume in one location is 4.4 liters of total tray capacity in the furnace. No other trays are permitted in the area and the furnace opening is fitted to accomodate only these trays. The material is not densified appreciably in the dryer but the moderator is removed thus decreasing reactivity. The safe volume for these salts in the slab configuration encountered is more than the 4.5 liter spherical volume adjusted for higher enrichment from Figure 2, TID 7016 Revision 1.

(b) Radiation Safety

This system is a completely closed liquid system which poses no new problems.

(c) Safeguards

Material leaves the system as product from the column which is handled as discussed in the next paragraph and a very small quantity may find its way to the cartridge filter which material is eventually accounted for as scrap.

10.5 Particle Washing and Drying-- The four inch container of particles taken from the column is drained of drying agent which agent is piped by way of a cartridge filter to the redrying system. The particles are rinsed with an aqueous solution and placed in a one inch deep tray. The tray is then placed in the vacuum furnace and dried. The aqueous wash passes through the particulate filter and to the waste hold tank.

(a) Nuclear Safety

The particulate is maintained in safe geometry containers of four inch diameter or one inch slab thickness throughout and the filter prevents inadvertant loss to an unsafe system, should a hole develop in the collector screen.

(b) Radiation Safety

This operation with small quantities of wet material poses no dust problem until the particles are dried and at that point the

10.7 Dry-end Processing-- A number of physical operations are performed upon the unmoderated spheres. These operations are performed in glove boxes which are ventilated as discussed in section 12. No liquid or other moderating material is permitted in these glove boxes. Good physical specimens are coated in an essentially unmoderated system. All transfers and storage is done in $3\frac{1}{2}$ inch diameter containers and the coating equipment does not exceed this diameter.

(a) Nuclear Safety

Hydrogenous materials are excluded from the glove boxes permitting the safe use of unmoderated limits set forth in Table 9.4, Item 2. Except when operations are actually being performed upon the particles they are contained in geometrically safe cylinders as specified in Table 9.4, Item 7 which cylinders are properly spaced and nuclear safety is maintained.

(b) Radiation Safety

Transfers are made only in closed canisters and all operations are performed in closed system glove boxes which are exhausted through high efficiency filters and discussed in Section 12; therefore, there is no unusual radiation hazard in these operations.

(c) Safeguards

Both scrap and product are carefully weighed before they leave the system and records are maintained of the quantities of each, and a material balance on these operations is kept.

11.0 WASTE TREATMENT AND DISPOSAL

11.1 Scrap Recovery-- The scrap generated in the facility consists of liquids which exceed the MPC prescribed by 10 CFR Part 20 for release to the sewer and solids consisting principally of non-specification product. Non-specification product may in some instances be recycled directly to dissolution. All other solid scrap will be packaged in safe diameter containers and shipped in approved bird cages to a licensee qualified to receive and recover the uranium in the scrap. The liquid wastes will also be sent out for recovery. These solutions are concentrated by distillation in the boildown system and after analysis for uranium they are packaged either in 55 gallon drums in the case of dilute solutions which will not precipitate, or which would be safe in total mass as set forth in Table 9.4, if they did precipitate; or they are packaged in cylinders of safe diameter and shipped to recovery in approved bird cages.

11.2 Contaminated liquids are collected in safe diameter cylinders or in the collection tanks which are poisoned with borosilicate glass raschig rings. Each batch of solution is monitored for uranium and if it is found to be below MPC for such discharge the solution is sent to the general sewer. No dilution by other activities on the site is assumed and the concentration must be below MPC at the initial point of discharge. Those solutions which exceed MPC are handled as described in paragraph 11.1.

In the course of the operation some disposable solid materials will undoubtedly become contaminated. For the most part these will consist of clothing, gloves and the like which will contain only trace quantities of fissile materials and which may be disposed of by burial at a licensed burial facility.

Material that could contain appreciable quantities of fissile materials such as filters will be monitored for activity. If the presence of a significant quantity of fissile material is indicted, the item will be packaged for shipment to scrap recovery.

amounts of supply air discharged to these spaces is sufficient to maintain any level of radioactivity present well below the acceptable maximum allowable of 10 CFR 20, and respiratory protective equipment for the personnel will not be required for normal operations.

12.5 The air from the working areas is exhausted at a rate which maintains these areas at a slightly lower pressure than the surrounding areas and assures that any air leakage is inward toward the areas of potential contamination and away from the non-contaminated areas. All of the exhaust air is passed through a bank of "absolute" type final filters which are greater than 99.9% efficient for 0.3 micron diameter particles. The filters are equipped with pressure drop measuring devices to indicate the amount of resistance developed due to particulate loading; the filters are factory tested to 10" w.g. pressure, and when the in-service pressure drop reaches 50% of the test value, the filters are discarded and replaced with new ones.

may be generated by the processing operations being carried on in this line of boxes. The inert gas inlet line is protected with an absolute type filter, and the withdrawal effluent is also passed through an absolute type filter. It is then directed into the main ventilation exhaust system, upstream from the final filters, thus ensuring that all ventilation effluents from the areas of high contamination within the glove boxes are filtered twice by absolute type filters before being released to the environment.

12.12 Other Systems-- The only other auxiliary system that is of concern to nuclear safety is the criticality alarm system. This system has an emergency wet battery power supply system so that both the gamma detectors and the nuclear criticality alarm are operative in the event of a power failure.

GSM

To: Paul L Wilson Sr. Radiation Specialist.

From: Eugene Epstein Radiation Specialist COI.

Subject: Trench Fill

Evaluation Re WR Grace Washington Research Center

Gaithersburg MD License ~~[illegible]~~ SNM-840.

There has been no use of materials at this under license SNM-840. A completely ~~[illegible]~~ remodeled glove box facility has been erected to process experimental fuel elements ~~[illegible]~~ but has not been started due to a problem of getting large sized machinery into the glove boxes. The license is properly categorized as A-II and will be scheduled for reinspection during 2/70.

REGION I, DIVISION OF COMPLIANCE
NEWARK, NEW JERSEY

SPECIAL LIMITED INSPECTION

1. Name and address of licensee:

W. R. Grace and Company
Research Division
Washington Research Center

2. Date of Inspection: August 20, 1968

3. Type of Inspection: Initial - announced

4. License number(s), docket number(s), number and date of last amendment for each license. Category and Priority of each license:

SNM-840
A-II
70-456

5. Date of previous inspection: None

6. Is "Company Confidential," or proprietory, or classified information contained in report?

Yes _____ No ✓

(Specify paragraphs)

7. Scope of inspection:

use of materials.

8. Eugene Gratton
Inspector

Sept 6, 1968.
Date of Report

Reviewer

9/30/68
Date of Review

Licensee: W R Grace SNM-840

Summary

Licensee has constructed an elaborate complete stainless steel glove box facility to process U^{235} for experimental fuel production. No use of materials has been made to date pending arrival of machinery to be installed in the ventilated glove box.

Noncompliance and Safety Items

None

Unusual Occurrences

None

Status of Previously Reported Noncompliance or Safety Items

None

Management Interview

~~Dr~~ James Baird ~~Assistant Mgr~~ Manager Analytical Services and Dr. L V Trigiani Mgr. Fuel Facility notified of results of inspection and Form AEC 591 discussed

Licensee: W R Grace SNM 840

DETAILS

A. Participants

Dr Joseph D. Moyer R.P.O.
Roy McCandless Rad. ~~Prot~~ Protection Branch State of Md.
Dr L V Tuggiani - ~~State of~~ Nuclear Fuels Manager.

B. Scope of Licensee Program

Lic allows possession and use of 25 gms Pu^{239} and 1 Kg U^{235}.

C. Organization

Separate Nuclear Fuels Facility headed by Dr L V Tuggiani who reports directly to the Director at Clarksville Dr. Gale Sanchez, Moyer who is the RPO also reports to Sanchez

D. Administrative Control

~~Tuggi~~ No use of materials to date.

E. Use of Material

No use of materials 25 gms P^{235} and 215 gms U^{235} on hand in sealed separate locked lead pigs inside locked unmanned Fuels room.

Licensee: _____

F. **Facilities**

As described in license back up.

G. **Equipment**

PAC Hand Eberline alpha ~~beta gamma~~ lab counter with extension to allow monitoring of hands and clothing

PAC Eberline alpha scintillation ~~beta~~ survey meters

H. **Radiological Safety Procedures**

as outlined in application for license

I. **Personnel Monitoring and Exposure to External Radiation**

None to date to use of materials

Licensee: W R Grace SNM-846

J. Exposure of Employees to Concentrations of Radioactive Materials

None

K. Effluents to Unrestricted Areas

None

L. Disposals

None

M. Miscellaneous Surveys, Evaluations and Records

None None needed.

Licensee: _____

N. **Special License Conditions**

#8 No use to date.
10 - Place of use as indicated in item 2 of license.
12 - No use wipe indicate no detectable alpha contamination in storage room

O. **Posting and Labeling**

Room and be posted Caution Radioactive Materials w symbol.
Lead pigs - to similarly labeled with kind and quantity as well

P. **Independent Measurements**

none

Q. **Operations Observed**

none

R. **Incidents, Overexposures, Theft or Loss, Equipment Malfunction**

none

Licensee: W. R Grace SNM-840

S. Other Information or Continuation from Previous Paragraphs

None

to the oven based upon trays filled 3/4 inch full on the average would be approximately 7 kg of U-235. The trays actually form two separate slabs each having a capacity of 2.2 liters. Optimum moderation is assumed as is full reflection because the furnace is water cooled and flooding although unlikely is possible. The safe volume for a sphere with optimum water moderation after adjustment for increased enrichment is 4.5 liters from Fig. 2 TID 7016 Revision 1. The volume of all the fissile material containers in the slab array encountered here is less than 4.5 liters, and the array is less reactive due to lower neutron economy from the much greater surface area present. The filter on the wash solution outlet prevents inadvertent loss should a hole develop in the collector screen. The wash water is collected in the fixed six inch glass columns to permit drying agent separation and then it is routed to poisoned tanks 10-42A or 42B.

(b) Radiation Safety.

This is the only operation in which fissile material is routinely handled in the open and with small quantities of wet material no dust problem is anticipated but the operation will be carefully monitored. After the particles are dried, covers are placed upon the trays and they are immediately transferred to the closed system glove box.

(c) Safeguards.

Essentially all material remains together at this point and it is not removed from the process.