

JAN 16 1973

W. R. Grace and Company
Attention: Mr. G. E. Ashby,
Vice President
Research Division
Washington Research Center
Clarksville, Maryland 21029

Docket No. 70-456

Gentlemen:

This refers to the inspection conducted by Mr. Epstein of this office on December 12-14, 1972 of activities authorized by AEC License No. SNM-840 and to the discussions of our findings held by Mr. Epstein with Mr. G. E. Ashby and Dr. R. J. Herbst of your staff at the conclusion of the inspection.

Areas examined during this inspection included: stack particulate effluents; liquid effluent releases; exposure of employees to external radiation; contamination surveys; training; management controls; and solid waste disposals for the period from March 15 to October 30, 1972. Within these areas, the inspection consisted of selective examinations of procedures and representative records, interviews with personnel, and observations by the inspector.

Our inspector also examined the circumstances of the overexposures reported in your letter to the Directorate of Regulatory Operations dated November 7, 1972, which you designated an interim report. After receipt and review of a final report concerning this incident, we will inform you if we have any questions.

During this inspection, it was found that certain of your activities appeared to be in violation of AEC requirements, and other activities appeared to raise questions concerning the safety of operations. The items and references to the pertinent requirements and to generally accepted guidance are listed in the enclosure to this letter. This letter constitutes a notice sent to you pursuant to the provisions of Section 2.201 of the AEC's "Rules of Practice," Part 2, Title 10, Code of Federal Regulations. Section 2.201 requires you to submit to this office within 20 days of your receipt of this notice, a written

ITEM # 249

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OFFICE ▶	GRESS. I.				
SURNAME ▶	Epstein:dw	Smith	Nelson	CARLSON	
DATE ▶	1-11-73	1-12-73	1/15/73		

5

statement of explanation in reply, including: (1) corrective steps which have been or will be taken by you, and the results achieved; (2) corrective steps which will be taken to avoid further violations; and (3) the date when full compliance will be achieved.

Should you have any questions concerning this inspection, we will be pleased to discuss them with you.

Sincerely,

James P. O'Reilly
Director

Enclosures:

1. Description of Violations
2. Description of Safety Items

bcc: RO Chief, Materials & Fuel Facilities Branch
RO:HQ (4)
L:D/D for Fuels & Materials
DR Central Files
PDR
NSIC
State of Maryland

ENCLOSURE I

DESCRIPTION OF VIOLATIONS

W. R. Grace and Company
Research Division
Washington Research Center
Clarksville, Maryland 21029
Docket No. 70/456

Certain activities under your license appear to be in noncompliance with AEC regulations and license requirements as indicated below:

1. License Condition 8(B), License Application dated April 8, 1970, Page 36(A), Paragraph 8.6, requires decontamination of restricted areas when contamination levels exceed stated action guides.

Contrary to this requirement, fixed contamination in the vicinity of the dialysis and dissolver unit constantly exceeded the action guide of 10,000 cpm alpha activity and had not been decontaminated.

2. License Condition 8(B), License Application dated April 8, 1970, Page 10 and 11, Paragraph 6.15, requires that operating personnel take prompt action to correct any hazardous condition or noncompliance noted by the Radiation Safety Officer.

Contrary to this requirement, operating personnel did not correct the conditions causing the high contamination existing around process equipment, nor did they take any action to decontaminate these areas. They also did not correct the conditions noted in monthly audits made by the Nuclear Safety Committee.

3. 10 CFR 20.201(b), "Surveys," requires you to make such surveys as may be necessary for you to comply with all sections of Part 20.

Contrary to this requirement, you failed to make such surveys as were necessary to assure compliance with 10 CFR 20.103, "Exposure of individuals to concentrations of radioactive materials in restricted areas."

- a. Specifically, no surveys had been made to determine the concentrations in air to which employees were exposed when containment was broken approximately once each week of a dialysis

unit or when containment was broken on the particle formation unit.

- b. Specifically, such surveys as were performed in other areas were inadequate in that the devices used collected air at waist level and not in the breathing zones of persons performing operations.
 - c. Specifically, the evaluation of the exposure that eleven persons received as a result of a reported incident involving the release of radionuclides to a restricted area was inadequate in that the results of air particulate surveys taken twenty to twenty five feet away from the source of the release were included and averaged to give the final result. Also the samples of feces and urine were of too small a quantity and submitted too late to provide an analysis for an adequate evaluation.
4. License Condition 8(B), License Application dated April 8, 1970, Page 31, Table 7.23 describes the equipment to perform continuous air sampling. Page 36 also states that continuous air sampling is performed.

Contrary to this requirement continuous air sampling of air in the production area had not been performed from March 15, 1972 to December 14, 1972.

5. License Condition 8(B), License Application dated April 8, 1970, Page 9, Paragraph 6.10, requires that verbal or written instructions be issued to those persons not performing normal operations.

Contrary to this requirement, two persons on October 6, 1972, broke containment on a gas fluidized bed reactor releasing contained materials to the immediate restricted area without verbal or written instructions having been provided.

ENCLOSURE II

DESCRIPTION OF SAFETY ITEMS

W. R. Grace and Company
Research Division
Washington Research Center
Clarksville, Maryland 21029
Docket No. 70/456

Certain items appear to raise questions concerning the safety of operations as identified below:

1. Accepted radiological and nuclear safety practices dictate that those individuals responsible for health and safety be notified when nonstandard operations are to be performed, so that a proper assessment of safety hazards may be made.

Contrary to the above, the person responsible for assessing the health and safety of operations was not notified when nonstandard operations were performed, such as rodding to relieve the pressure buildup on the fluidized bed reactor; removal of membranes from the dialysis unit; and the breaking of containment on the particle formation unit.

2. Prudent radiological safety control practices dictate that when SNM processing equipment deficiencies are encountered, appropriate modifications and a comprehensive evaluation of the functional characteristic effects of the modifications and a preoperational test to verify the evaluations be made.

Contrary to the above, operations personnel proceeded to process 1500 gms of enriched uranium in a fluidized bed reactor when pressurization problems had been encountered with this apparatus during the processing of 50 gms. The processing of 1500 gms of enriched uranium resulted in a reported incident involving excessive concentrations of uranium in air.

U. S. ATOMIC ENERGY COMMISSION
DIRECTORATE OF REGULATORY OPERATIONS

REGION I

RO Inspection Report No.: 70-456/73-01 Docket No.: _____
Licensee: W. R. Grace and Company License No.: SNM-840
Grace/Nuclear Division Priority: I
Washington Research Center Category: (A)-1
Location: Clarksville, Maryland 21029

Type of Licensee: Fuel Fabrication
Type of Inspection: Management Meeting
Dates of Inspection: January 8, 1973
Dates of Previous Inspection: December 12-14, 1972

Principal Inspector: H. W. Crocker 1/16/73
H. W. Crocker, Senior Fuel
Facilities Inspector Date

Accompanying Inspectors: R. H. Smith Jan. 16, 1973
R. H. Smith, Acting Senior
Facilities Radiological Safety Section Date

E. E. Epstein Jan 16, 1973
E. E. Epstein, Radiation
Specialist Date

Other Accompanying Personnel: _____

Reviewed By: _____
R. T. Carlson, Chief
Facility Operations Branch

Date

ITEM # 250

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(3)

SUMMARY OF FINDINGS

Enforcement Action

None

Licensee Action on Previously Identified Enforcement Items

Not applicable

Design Changes

Not applicable

Unusual Occurrences

Not applicable

Other Significant Findings

Not applicable

Management Meeting

The management meeting was conducted in the offices of Region I, Directorate of Regulatory Operations.

W. R. Grace and Company Representatives

G. E. Ashby, Vice President and General Manager
R. J. Herbst, Manager, Operations Services

Region I Representatives

J. P. O'Reilly, Director
R. T. Carlson, Chief, Facility Operations Branch
H. W. Crocker, Senior, Fuel Facilities Section
R. H. Smith, Senior, Facilities Radiation Protection Section
E. E. Epstein, Radiation Specialist

Items discussed are summarized below:

- A. The Director, Region I, stated that the purpose of the meeting was to discuss with corporate management the current methods by which the Directorate of Regulatory Operations enforces the federal regulations, the findings of our inspectors during recent inspections, the relation of their findings to those found during previous inspec-

tions, the position of management with respect to the findings of our inspectors, and management's plans to correct the violations.

- B. It was stated by Region I representatives that the numerous violations in criticality and radiological safety controls in their SNM processing and storage operations indicate that additional emphasis should be placed on their management control program. The violations noted during the inspections of November 29 to December 1, 1972 and December 12-14, 1972, were discussed.
- C. The licensee acknowledged the violations reported by our inspectors. They presented, in general form, their plans for correction of these items. They recognized the fact that reports and letters will be sent to their company on the specific findings of the inspections. Formal responses to all violations will, of course, be requested by Region I.
- D. The Director stated that increased emphasis will be placed on the inspection of the management control system employed by W. R. Grace and Company to assure that licensed activities are safely conducted.

JAN 17 1973

G. W. Roy, Chief, Materials & Fuel Facilities Branch
Division of Compliance, HQ

RO INSPECTION REPORT NO. 70-456/73-01
W. R. GRACE AND COMPANY
GRACE/NUCLEAR DIVISION
WASHINGTON RESEARCH CENTER
CLARKSVILLE, MARYLAND

I believe this management meeting was very beneficial. The licensee appears to be making a real effort to bring their facility back into compliance in a timely manner.

During the meeting, Mr. Ashby stated that the future of their operations is somewhat uncertain. Due to recent requirements imposed by their customer, Knolles Atomic Power Laboratory, the uncertainty of future contracts and new security requirements of significant expense, they may be forced to terminate their nuclear activities. The nuclear activities at the Washington Research Center represent only a small fraction of the company's business.

Mr. Ashby's remarks were made to provide our office with the current status of their operations and were not to be construed as an indication that there would be any reduction in efforts to bring their operations into compliance.

H. W. Crocker
Fuel Facilities Section

Enclosure:
RO Inspection Report No. 70-456/73-01

cc: RO Chief, Materials & Fuel Facilities Branch
RO:HQ (4)
L:D/D for Fuels & Materials
DR Central Files
PDR
NSIC
State of Maryland

ITEM #

251 B/250

OFFICE ▶	CRESS: I					
SURNAME ▶	Crocker: pac					
DATE ▶	1/16/73					

JAN 17 1973

W. R. Grace and Company, Grace/Nuclear Division
Attention: Mr. G. E. Ashby
Vice President, Manager
Washington Research Center
Clarksville, Maryland 21029

Docket No. 70-456

Gentlemen:

This refers to the meeting which was held at our request at the Region I, Regulatory Operations office, Newark, New Jersey, on January 8, 1973. This meeting, which related to the inspections of AEC License SNM-840 conducted on November 29 to December 1, 1972 and December 12 - 14, 1972, was attended by Mr. O'Reilly and other members of the Region I staff and by Mr. G. E. Ashby and another member of your company's staff.

The matters discussed at this meeting related to the violations which were noted by our inspectors during the referenced inspections and your plans to correct the violations observed by our inspectors. In addition we discussed our intent to increase our inspection emphasis on your management controls which relate to activities licensed by the Atomic Energy Commission.

It is our view that these discussions were helpful, and that our understanding of your plans and systems has been enhanced. Furthermore, we believe that the discussions relating to your Management Control Systems and our increasing inspection attention in this broad area, should prove to be mutually beneficial to our organizations.

In accordance with Section 2.790 of the AEC's "Rules of Practice", Part 2, Title 10, Code of Federal Regulations, a copy of this letter and the enclosed inspection report will be placed in the AEC's Public Document Room. If this report contains any information that you believe to be proprietary, it is necessary that you make a written application within 20 days to this office to withhold such information from public disclosure. Any such application must include a full statement of the reasons on the basis of which it is claimed that the information is proprietary, and should be prepared so that proprietary information identified in the application is contained in a separate part of the document. If we do not hear from you in this regard within the specified period, the report will be placed in the Public Document Room.

ITEM # 252

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OFFICE ▶	CRESS: I					
SURNAME ▶	<i>W. R. Grace</i> Crocker: pac	<i>Carlson</i>	<i>RAS</i> SMITH			
DATE ▶	1/10/73		1/15/73			

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Should you have any questions concerning this meeting, we will be pleased to discuss them with you.

Sincerely,

James P. O'Reilly
Director

Enclosure:
Inspection Report
No. 70-456/73-01

bcc: RO Chief, Materials & Fuel Facilities Branch
RO:HQ (4)
L:D/D for Fuels & Materials
DR Central Files
PDR
NSIC
State of Maryland

MEMO ROUTE SLIP Form AEC-95 (Rev. May 14, 1947) AEC.M 0240		See me about this. Note and return.	For concu For signature.	For action. For information.
TO (Name and unit) Gen W. Roy, Chief (2)	INITIALS DATE	REMARKS W.R. GRACE AND COMPANY WASHINGTON RESEARCH CENTER CLARKSVILLE, MD. RO REPORT NO. 70-456/72-03		
TO (Name and unit) cc: RO:HQ (4) DR Central Files Licensing	INITIALS DATE	REMARKS Attached for your information is the subject inspection report. Also, a management meeting was held in the RO:I office on January 8, 1973.		
TO (Name and unit)	INITIALS DATE	REMARKS		
FROM (Name and unit) Raymond H. Smith, Acting Senior Radiation RO:I	REMARKS			
PHONE NO. 201 645-2370	DATE 01-18-73			

USE OTHER SIDE FOR ADDITIONAL REMARKS

GPO : 1971 O - 445-469

ITEM # 253

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(12)

U. S. ATOMIC ENERGY COMMISSION
DIRECTORATE OF REGULATORY OPERATIONS
REGION I

RO Inspection Report No.: 70-456/72-03

Docket No.: 70-456

Licensee: W. R. Grace and Company

License No.: SNM-840

Research Division

Priority: 1

Washington Research Center

Category: A(1)

Clarksville, Maryland 21029

Location: _____

Type of Licensee: Fuel Processing

Type of Inspection: Special - Announced

Dates of Inspection: December 12 - 14, 1972

Dates of Previous Inspection: November 29, 30; December 1, 1972

Principal Inspector: E. Epstein
E. Epstein, Radiation Specialist

Jan 16, 1973
Date

Accompanying Inspectors: H. W. Crocker
H. W. Crocker, Senior Fuel Facilities
Inspector

1/16/73
Date

Date

Other Accompanying Personnel: NONE

Reviewed By: R. H. Smith
R. H. Smith, Acting Senior, Facilities Radiological
Protection Section

Jan 16, 1973
Date

SUMMARY OF FINDINGS

Enforcement Action

A. Violations

1. Failure to maintain fixed contamination below license limits. (Report Details, Paragraph 2)
2. Failure of operations personnel to correct noted hazards and non-compliance. (Report Details, Paragraph 3)
3. Failure to perform air particulate surveys when containment was broken on process equipment. (Report Details, Paragraph 4)
4. Failure to perform adequate air particulate surveys. (Report Details, Paragraph 4(a))
5. Failure to perform adequate evaluations and surveys to determine the exposure to employees as a result of a reported incident. (Report Details, Paragraphs 8(a)(b)(c)(d)(j))
6. Failure to perform continuous air sampling in the Production area. (Report Details, Paragraph 5)
7. Failure to provide persons who vented and removed the head of the fluidized bed reactor with written or verbal instructions. (Report Details, Paragraph 6)

B. Safety Items

1. Failure to inform the Radiation Safety Officer of non-standard operations in the Production area. (Report Details, Paragraph 7)
2. Failure to perform proper safety evaluations prior to using a fluidized bed reactor. (Report Details, Paragraph 6 and 8(a)(b)(c)(d)(j))

Licensee Action on Previously Identified Enforcement Items

Not applicable

Design Changes

Stack height Change. (Report Details, Paragraph 9)

Unusual Occurrences

Licensee letter to Directorate of Regulatory Operations dated November 7, 1972, reporting exposure of eleven persons to excessive concentrations of uranium-235 between October 3 and 6, 1972. (Report Details, Paragraph 8)

Other Significant Findings

A. Current Findings

None

B. Status of Previously Reported Unresolved Items

Not applicable

Management Interview

The following persons attended a management interview held on December 14, 1972.

Mr. G. E. Ashby, Divisional Vice-President and Manager of Nuclear Operations
Dr. R. J. Herbst, Manager, Operation Services

The following subjects were discussed:

- A. The current AEC policy of providing the licensee with a copy of the inspection report for their review to define proprietary information prior to release of the report to the Public Document Room.
- B. The presence of fixed contamination in the Production Facility in excess of license limits. (Report Details, Paragraph 2)
- C. The submission of reports showing fixed contamination to the Operations Group and no corrective action being taken. (Report Details, Paragraph 3)
- D. Failure to perform required particulate air surveys in the Production Facility, particularly when containment was broken on production equipment. (Report Details, Paragraph 4)

- E. The inadequacy of the air sampling that was performed. (Report Details, Paragraph 4(a))
- F. The inadequate evaluation performed to determine the exposure to eleven employees during a release of uranium-235. (Report Details, Paragraph 8(a)(b)(c)(d)(j))
- G. Failure to perform constant air particulate monitoring in the Production Facility. (Report Details, Paragraph 5)
- H. The failure to issue verbal or written instructions to persons performing non-standard operations. (Report Details, Paragraph 6)
- I. The failure of operating personnel to notify the Radiation Safety Officer in advance of non-standard operations. (Report Details, Paragraph 7)
- J. The failure to evaluate the hazards associated with the use of a fluidized bed reactor. (Report Details, Paragraphs 6 and 8(a)(b)(c)(d)(j))

DETAILS

1. Persons Contacted

Mr. G. E. Ashby, Divisional Vice-President and Manager of Nuclear Operations

Dr. R. J. Herbst, Manager, Operation Services

Mr. D. L. Sillyman, Health and Safety Officer

Mr. C. T. Lamberth, Foreman, Nuclear Production

Mr. G. Widner, Operator

Mr. L. Wilcox, Operator

Mr. S. Porter, Consultant

Mr. S. L. Reese, Consultant

2. Contamination Surveys

A review was made of the licensee's smear and direct survey data since March 15, 1972. Examination of these records indicated the following:

10/19/72 - Fixed contamination was found in 20 areas. 18 of these areas had contamination in excess of 25,000 cpm/100 cm², with the floor at the dialysis and dissolver units showing fixed contamination from 200,000 - 300,000 cpm/100 cm² of alpha activity.

10/9/72 - Similar surveys and similar results noted.

9/25/72 - The floor area at the dissolver unit had fixed contamination from 3,000 - 125,000 cpm/100 cm² alpha activity.

3. A licensee representative stated that after each contamination survey a written report was made to the person responsible for production, but that no corrective action was taken. He stated that the same contamination existed on December 14, 1972. In addition, the results of monthly audits and inspections which showed noncompliance were submitted to the same person and no corrective action was taken.

4. Particulate Air Surveys in Restricted Areas

- a. A review was made of particulate air surveys for the restricted Production Facility of Building 16-A for the period from March 15 to December 1, 1972. The review indicated and licensee representatives stated that all surveys were made using an air sampler collecting particulates at the rate of 2 cfm and the intake

of this air sampler is at waist level. All air samples were taken at waist level and not in the breathing zones of persons performing operations. The licensee representative stated that air sampling was intermittent and varied from 15 minutes to 24 hours per sample.

- b. The inspector noted a dialysis unit which contains a semi-permeable membrane. Licensee representatives stated that this device was taken apart approximately once each week to replace the membrane. They also stated that no particulate air surveys were taken in this area during this disassembly of the apparatus. The inspector also observed the repair of a particulate formation column; two persons were working at the top of the column removing needles, which caused loss of containment. Licensee representatives also stated that no air surveys had been performed in this area during this operation.
- c. Records of particulate air surveys and statements made by licensee representatives, revealed that on October 5 and 6, 1972, two persons continuously vented a fluidized bed reactor in which 1.5 Kg of 97% enriched uranium had been processed for three days. They were reported to have opened a release valve and at each opening, smoke and dust were observed emerging from the open valve. On October 6, 1972, one of these persons, was reported to have removed the flanged head of the apparatus and smoke and dust were reported to have emerged during this operation. Licensee representatives stated that standard air sampling was performed during the removal of the apparatus head and that the air intake was at waist level and two feet from the work position. The reported air concentration during this operation was 8.9×10^{-11} uCi/ml, which is less than the MPCa of 1×10^{-10} uCi/ml.

5. In-Plant Air Monitoring

Licensee personnel stated that since March 15, 1972, they had not performed continuous particulate air sampling in the Production Facility. They stated that such sampling had been intermittent, using portable air samplers. The inspector noted and licensee representatives stated that equipment is not available to perform continuous air particulate monitoring.

6. Operating Instructions

Licensee representatives stated the following:

The persons who vented the fluidized bed reactor on October 6, 1972, did so without verbal or written instructions being provided by the

Nuclear Safety Committee or the Radiation Safety Officer; that there had been a standard operating procedure (SOP) for this operation when the operation was performed inside an enclosed ventilated hood; that an SOP had not been issued for the venting operation of the present fluidized bed reactor which is larger and contains up to 1.5 Kg of enriched uranium; and that the present fluidized bed reactor was used without a ventilated hood. Licensee representatives also stated that instructions were not provided regarding radiological safety during the breaching of containment on the dialysis unit and the particle formation unit.

7. Non-Standard Operations

A review was made of the organizational structure and the function of the Radiation Safety Officer. The licensee stated that the Radiation Safety Officer had not been informed of non-standard operations in Building 16-A, thus the required surveys during non-standard operations, such as breaching containment on operating equipment, were not performed.

8. Unusual Occurrence

- a. Licensee representatives stated that on ten to twelve occasions prior to October 3, 1972, 50 gms of 97% enriched uranium had been processed in the fluidized bed reactor and at each time, the material in the reactor had solidified which caused a pressure build-up. The practice developed to alleviate this was the insertion of a wire rod to open an orifice into the tightly packed material. Licensee representatives stated that particulate air surveys had not been made during these operations.
- b. Licensee representatives stated that the amount of material was increased from 50 gms to 1.5 Kg on October 3, 1972 and the material within the apparatus solidified with an increase in pressure.

The operators believed this could be relieved by the rodding operation but when a valve was opened to insert the wire rod, a puff of white smoke emerged with some visible dust.

- c. Licensee representatives stated that the operation continued for 36 hours and that air particulate surveys were performed from 3:30 p.m. on October 3, to 11:30 a.m. on October 4, 1972. These surveys were noted to have been conducted in the

vicinity of the Change Room, approximately 25 feet from the fluidized bed reactor. These samples resulted in a concentration of 1.86×10^{-13} uCi/ml.

- d. The licensee stated that at noon on October 4, 1972, the pre-heater for heating incoming gases failed and the apparatus was shutdown. The preheater was repaired and licensee representatives stated that the reactor was started up between 8:00 and 9:00 a.m. on October 5, 1972. Licensee representatives stated that at 20:00 hours on October 5, 1972, an operator vented the apparatus by opening a valve and smoke and visible dust were released. Particulate air sampling was performed from 11:30 a.m. October 4, to 12:30 p.m. October 5, 1972. According to survey records this sampler was located at the sintering furnace, approximately twelve feet from the fluidized bed reactor. These concentrations averaged 1.93×10^{-10} uCi/ml. A sample was taken in the same area between 5:18 p.m. on October 5, and 8:35 a.m. on October 6, 1972, and concentrations averaged 5.76×10^{-11} uCi/ml.
- e. Records and statements made by licensee representatives indicated that operations were halted by the Radiation Safety Officer on October 6, 1972, when the sample taken on October 5, 1972 was counted. Survey records also indicated that the first particulate air sample taken in the vicinity of the fluidized bed reactor was taken between 5:45 and 6:38 p.m. on October 6, 1972 and concentrations were 15.6×10^{-10} uCi/ml. A second sample was taken from 9:15 p.m. to 10:54 p.m. on October 6, 1972 in the vicinity of the fluidized bed reactor and concentrations were 37.8×10^{-10} uCi/ml.
- f. Survey records indicated that there was contamination, in excess of 1×10^6 cpm/100 c m², alpha activity, on the surface of the apparatus and in the immediate vicinity. It was noted that persons had been assigned to decontaminate the apparatus and the surrounding area and that the Nuclear Safety Committee issued a written SOP prior to the decontamination. A review of the SOP was made and it was noted that wearing of a full face (demand type) respirator, gloves, protective clothing and the taking of nasal swabs at the conclusion of the decontamination were required. Particulate air monitoring performed during decontamination and in the immediate vicinity showed concentrations of 37.8×10^{-10} uCi/ml. Nasal swab activity after mask removal was 12 to 14 dpm alpha.

- g. Particulate air concentrations in the vicinity of the fluidized bed reactor after decontamination decreased to 6.7 and 8.3×10^{-12} uCi/ml. When fluidized bed operations resumed on October 10, 1972 particulate air concentrations were between 2.5 and 1.9×10^{-10} uCi/ml during October 10 and 11, 1972. The last air survey in this area taken on October 16, 1972, showed concentrations of 2.39×10^{-11} uCi/ml with the apparatus shutdown.
- h. The licensee stated that a consultant had been obtained to evaluate the exposure to personnel as a result of this incident. They stated that the consultant requested urine and fecal samples from all persons working in the Production Facility during the incident and that these persons be sent to the consultant's facility for whole body counting.
- i. The results of bioassay and whole body counting indicated that the person who performed the rodding operation on October 3, 1972, and the person who continuously vented and removed the head of the fluidized bed reactor on October 6, 1972, possibly had body burdens of from $10 - 15$ nCi uranium-235. The consultant had recommended that these two persons be sent to ORNL for more intensive whole body counting. Four of the twelve persons were reported to have burdens of less than 4 nCi. Urine samples submitted initially were between two and six days post incident and were only of one voiding, from $100 - 300$ ml. Fecal samples were submitted between two and six days post incident and were only $20 - 30$ gms. The consultant stated that he could not estimate the exposure from the bioassay samples submitted.
- j. The inspector reviewed the licensee's evaluation of the incident with the consultant and the licensee's representatives and noted that the employees were reported to have been exposed to approximately $6.2 \times \text{MPCa}$ for 40 hours. The inspector noted and the licensee's representatives confirmed that this exposure was determined by including the concentrations of 2×10^{-13} uCi/ml for eight hours on October 2 and 3, 1972. It was noted that these concentrations existed at the Change Room a distance of 20 to 25 feet from the fluidized bed reactor where personnel were working. The inspector also noted that confirming air samples were taken in the immediate area of the fluidized bed reactor on October 6, 1972 which was three days post incident and based on these results, 15.6 and 37.8×10^{-10} uCi/ml the exposures may have been between 15.6 and 37.8 times MPC.

k. Corrective action was described by licensee representatives as follows:

- (1) Install a rupture disc in the gas supply line to rupture at 15 psi.
- (2) Tie the exhaust into the air effluent exhaust system.
- (3) Use smaller quantities.

9. Design Change

A review of design changes, showed that the stack for exhausting air from the Production Facility of Building 16-A had its height increased from 32 inches to 13.2 feet above the roof surface. The licensee stated that five isokinetic probes have been ordered and will be installed to provide representative stack samples. The change occurred during the period from October 30 to November 6, 1972.

10. Stack Particulate Effluent Releases

The results of stack monitoring were reviewed for the period from March 15 to October 30, 1972. The exhaust air from the facilities passes through three banks of rough and absolute type filters, according to a plan of the exhaust system and the results showed that air concentrations had not exceeded 1×10^{-14} uCi/ml.

11. Liquid Effluent Releases

Water effluent records were examined for a similar period and records indicated that all effluent is analyzed for gross alpha activity prior to disposal. It was noted that the licensee observed license limits and did not dispose of liquid whose activity was greater than 2.4×10^{-5} uCi/ml. Such liquids were noted to have been sent to the boil-down unit for further processing. --

12. Solid Waste Disposal

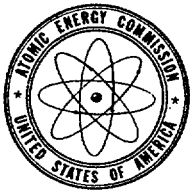
Licensee representatives stated that they accumulate solid waste within a boil-down unit. The sediment from this unit is packaged and sent to a contractor for reprocessing. Records were noted to have been maintained showing each transfer on proper forms including kind, quantity and dates of transfer.

13. Film Badge Monitoring

A review was made of the film badge processor reports from March 15 to October 30, 1972 and the results entered on Forms AEC-5. These records indicated that film badges were used on a bi-weekly basis and that neutron, as well as beta-gamma exposures were monitored. These records showed no neutron exposure and beta gamma exposures had not exceeded 200 mrem in any calendar quarter year.

14. TLD Area Monitoring

The Production Facility was noted to have at least six TLD devices affixed at locations on the mezzanine and the walls of the main floor. Licensee representatives stated that the film badge processor also processes these TLDs. The results, between March 15 and October 30, 1972 were also reviewed and showed a maximum exposure of 6.9 mrem/week.



UNITED STATES
ATOMIC ENERGY COMMISSION
DIRECTORATE OF REGULATORY OPERATIONS
REGION I
970 BROAD STREET
NEWARK, NEW JERSEY 07102
JAN 18 1973

RAS
R. H. Smith, Acting Senior, Facilities Radiological Protection Section
Directorate of Regulatory Operations, Region I

INSPECTOR'S EVALUATION
W. R. GRACE AND COMPANY
CLARKSVILLE, MARYLAND
DOCKET NO. 70-456

An inspection, which was performed from December 12 - 14, 1972 revealed seven violations and two safety items. All the violations and safety items reveal a total loss of management control of the program and a disregard for health and safety. The licensee does not have any person on his staff trained to appreciate the hazards concerned with health and safety and relies on outside consultants only when they themselves consider it necessary. In addition, supervision of operations and radiation safety coverage exists only on the day shift, although the licensee operates three shifts daily.

It is believed that unless corrective action is taken regarding the violations and safety items noted, a serious health hazard will occur. The licensee has been invited to attend a management conference to be held on January 8, 1973, and has indicated an intention to be present.

The licensee reports activity in liquid effluent in terms of total alpha content. The need for beta counting to determine thorium activity as well was discussed.

E. Epstein
E. Epstein
Radiation Specialist

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ITEM # 254



UNITED STATES
ATOMIC ENERGY COMMISSION
DIRECTORATE OF REGULATORY OPERATIONS
REGION I
970 BROAD STREET
NEWARK, NEW JERSEY 07102

JAN 18 1973

G. W. Roy, Chief, Materials & Fuel Facilities Branch
Directorate of Regulatory Operations, HQ

RO INSPECTION REPORT NO. 70-456/72-02
W. R. GRACE AND COMPANY
RESEARCH DIVISION
CLARKSVILLE, MARYLAND

The subject inspection report is forwarded for your information.

Numerous criticality safety violations were observed during this inspection. Some of these violations have continued uncorrected for two to three months even though they previously had been observed and reported to management by the licensee's nuclear safety committee. The licensee's failure to take proper corrective actions in these matters demonstrates the inadequacy of their management control system.

One operation, involving the transfer, dilution and loadout of highly enriched U-235 solutions from a waste boil down operation was being conducted without provision of operating procedures or administrative controls. Licensee management terminated this operation during the inspection and stated that the operation will not be resumed until procedures are provided and license authorization is received for that activity.

The licensee's continued operation in noncompliance with license conditions, even though repeatedly informed of these conditions by their nuclear safety committee, represents gross disrespect for the federal regulations.

Just prior to this inspection, top management made managerial changes in their organization to initiate a strengthening of their management control system.

This licensee depends heavily upon consultants for both criticality and radiological safety. Their in-house safety personnel act as servicing personnel and do not provide a dynamic safety activity.

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A majority of the processing equipment used in their operations is safe geometry equipment. The processes used do not present any unique safety problems. With good management control, this facility could be brought back into full compliance within thirty days.

As a result of this inspection and a second inspection conducted on December 12 - 14, 1972, we invited Mr. G. E. Ashby, Vice President, W. R. Grace and Company, to our office to discuss their corrective actions and plans to strengthen their management control system for surveillance of plant activities. That meeting was held on January 8, 1973. A copy of the report for that meeting will follow.

The safety items noted in this inspection were discussed with George Bidinger on January 9, 1973, and he provided RO:HQ concurrence on those matters.


H. W. Crocker, Senior
Fuel Facilities Inspector

Enclosure:

Subject Inspection Report No. 70-456/72-02

cc: RO Chief, Materials & Fuel Facilities Branch (2)
RO:HQ (4)
L:D/D for Fuels & Materials
DR Central Files
PDR
NSIC
State of Maryland

U. S. ATOMIC ENERGY COMMISSION
DIRECTORATE OF REGULATORY OPERATIONS
REGION I

RO Inspection Report No.: 70-456/72-02

Docket No.: 070-00456

Licensee: W. R. Grace and Company

License No.: SNM-840

Research Division

Priority: I

Clarksville, Maryland

Category: A(1)

Facility: Washington Research Center

Location: Clarksville, Maryland

Type of Licensee: Fuel Fabrication

Type of Inspection: Routine - unannounced

Dates of Inspection: November 29 - 30, December 1, 1972

Dates of Previous Inspection: March 20 - 23, 1972

Principal Inspector: *W. J. Cooley*

W. J. Cooley, Fuel Facilities Inspector

1/14/73
Date

Reporting Inspectors: _____

Date

Date

Other Accompanying Personnel: G. H. Bidinger, Senior Fuel

Facilities Inspector

Reviewed By: *H. W. Crocker*

H. W. Crocker, Senior Fuel Facilities Inspector

1/14/73
Date

SUMMARY OF FINDINGS

Enforcement Action

A. Violations

1. Failure of the Nuclear Safety Committee, as a body, to investigate the high airborne concentration incident that was reported to the Commission by letter dated November 7, 1972. (Report Details, Paragraph 20)
2. Failure to provide approved written procedures and instructions for the SNM waste dilution operation and failure to enforce procedures for storage of materials in the incoming material storage cage. (Report Details, Paragraphs 37, 38, 40, 42, and 44)
3. Failure to prepare and maintain written procedures and/or instructions in the areas of criticality and radiological safety. (Report Details, Paragraph 7)
4. Failure to transfer fissile solutions from the boil down unit directly into DOT special permit packages. (Report Details, Paragraph 45)
5. Unauthorized storage of containers of fissile solution on the floor of the fabrication laboratory. (Report Details, Paragraph 43)

B. Safety Items

1. Storage of flammable materials, wooden frames and papers, with fissile material containers in the incoming materials storage cage. (Report Details, Paragraph 40)
2. Use of unsecured, unstable, free standing fissile material storage rack. (Report Details, Paragraph 39)

3. Use of fissile material storage rack which was not provided with a physical barrier or other control to maintain positive retention of stored materials. (Report Details, Paragraph 41)

Licensee Action on Previously Identified Enforcement Items

At the previous inspection, the licensee was found in noncompliance with Condition 8, Section 8.11 of his April 8, 1970 application in that he failed to label containers in the processing area.

During this inspection it was observed that the deficiency had been corrected. (Report Details, Paragraph 46)

Unusual Occurrences

By letter dated November 7, 1972, the licensee reported a high airborne activity incident (10 CFR 20.405). The circumstances and corrective action taken by the licensee were reviewed. The licensee had not completed their evaluation and corrective action at the time of this inspection. (Report Details, Paragraphs 13 - 20)

Other Significant Findings

A. Current Findings

The licensee possessed approximately 50 kilograms of highly enriched uranium. That material was being used in fuel fabrication and process development utilizing various forms, including solutions. Equipment and operations are relatively standard, although some design changes have occurred and are contemplated.

Organization and personnel changes have occurred since the last inspection. The licensee depends heavily upon consultants in the areas of health physics, nuclear safety, and nuclear materials management.

B. Status of Previously Reported Unresolved Items

There were no unresolved items noted during the previous inspection.

Management Interview

An exit interview was conducted at the conclusion of the inspection, on December 1, 1972. The following persons were present:

W. R. Grace

G. E. Ashby, Manager, Grace/Nuclear Division (GND)
R. J. Herbst, Manager, Operation Services (GND)
S. Reese, Nuclear Safety Consultant
J. Blouin, Supervisor, Engineering (GND)
D. L. Sillyman, Health and Safety Officer

AEC

W. J. Cooley, Fuel Facilities Inspector

- A. Licensee management was informed of the scope of the inspection and of the following violations and safety items:
1. Violation - Failure of the Nuclear Safety Committee, as a body, to investigate the high airborne concentration incident that was reported to the Commission by letter dated November 7, 1972. (Report Details, Paragraph 20)
 2. Violation - Failure to provide approved written procedures and instructions for the SNM waste dilution operation and failure to enforce procedures for storage of materials in the incoming material storage cage. (Report Details, Paragraphs 37, 38, 40, 42, and 44)
 3. Violation - Failure to prepare and maintain written procedures and/or instructions in the areas of criticality and radiological safety. (Report Details, Paragraph 7)
 4. Violation - Failure to transfer fissile solutions from the boil down unit directly into DOT special permit packages. (Report Details, Paragraph 43)

5. Violation - Unauthorized storage of containers of fissile solution on the floor of the fabrication laboratory. (Report Details, Paragraph 43)
 6. Safety Item - Storage of flammable materials, wooden frames and papers, with fissile material containers in the incoming materials storage cage. (Report Details, Paragraph 40)
 7. Safety Item - Use of unsecured, unstable, free standing fissile material storage tank. (Report Details, Paragraph 39)
 8. Safety Item - Use of fissile material storage rack which was not provided with a mechanical or other type buffer to maintain retention of stored materials. (Report Details, Paragraph 41)
- B. The licensee representative gave assurance that the waste dilution operation had been terminated until, as a minimum, detailed operating procedures had been written and approved and license approval had been obtained.
- C. Details of the AEC's method of correspondence with licensees and the requirement of replies to deficiencies were outlined. Additionally, the licensee's representatives were informed of the Commission's policy of placing inspection reports in the Public Document Room and of the provisions of 10 CFR, Part 2, and 10 CFR, Part 9, which permit the withholding from public disclosure proprietary information.

REPORT DETAILS

1. Persons Contacted

G. E. Ashby, Manager, Grace/Nuclear
R. J. Herbst, Manager, Operations & RSO
J. J. Blouin, Supervisor, Engineering
D. L. Sillyman, Health and Safety Officer
H. Davis, Acting Foreman, Nuclear Production
S. L. Reese, Nuclear Safety Consultant

2. Organization

Changes in organization and personnel have occurred since the last inspection. The organizational name of the licensee's nuclear effort is now Grace/Nuclear managed by G. E. Ashby who reports to T. G. Gibian. Reporting to Ashby are R. J. Herbst, Manager, Operations Services; D. L. Sillyman, Health and Safety Officer and R. Bevill, Security Officer. Also reporting to Ashby are the positions of Quality Assurance Engineer, Vacant, and Accountability Officer, R. J. Herbst (Acting). In a line organization separate from the above and reporting to Ashby are J. J. Blouin, Supervisor, Engineering; N. H. Weissert, Supervisor, Analytical; C. Lamberth, Foremen, Nuclear Production; and G. N. Zeleznik, Foreman, Fine size Production. D. R. Telesca is no longer a part of the nuclear organization.

3. The licensee stated that consultants are used in the areas of nuclear safety, radiation physics, and material accountability. Dr. Herbst is presently the contact for those consultants.
4. Mr. Telesca's responsibilities have been divided among several persons notably C. Lamberth who is presently in charge of the fabrication facility operation and J. Blouin who is presently responsible for equipment and procedures modification. Additional consultation is available from other groups at the Grace Washington Research Center.
5. Approximately ten additional individuals support the nuclear effort as operators and laboratory personnel.

6. Nuclear Safety Committee

The licensee maintains a Nuclear Safety Committee whose membership has varied since it became active. Members of the committee have been Herbst, Reese, J. H. Baird, Telesca, Lamberth, and Sillyman. Reese and Baird provide independence in that they are respectively, consultant and management representative outside the licensed organization. Herbst and Sillyman represent the radiation safety function. Blouin and Lamberth represent fabrication operations.

7. Functions of the Nuclear Safety Committee include monthly facility audits with written reports of audit results, definition of problems and requests for corrective action and review and approval by signature of all standard operating procedures.. It was noted that the licensee does not maintain written procedures and instructions in the areas of criticality and radiological safety.

8. Nuclear Safety Committee Audit Reports

Nuclear Safety Committee inspection reports for the months of August through November 1972 were reviewed. Reported observations and recommendations by the Committee were heavily oriented toward nuclear safety. Observations recorded by the Committee include operations performed in a manner contrary to AEC license commitments and contrary to accepted practices in nuclear work.

9. Written replies to committee recommendations were made by the licensee's nuclear management and indicated an effort to correct deficiencies. Management's written response to the committee's inspection recommendations dated September 19, 1972 was a directive to shutdown certain fissile solution operations until they met license requirements or until AEC-approved license changes had been made.
10. Subsequent Committee inspection reports dated October and November 1972 indicate that those operations were not suspended and, for the most part, recommended corrective action was not accomplished.
11. The last in the series of Nuclear Safety Committee inspection reports which was dated November 21, 1972, listed five uncorrected items carried from previous reports dating to the original inspection in August 1972.
12. The November 21 report listed four additional items which gave the committee concern in the area of safe practices. Most of the Committee's concerns were observed independently by the AEC inspector and are listed as items of noncompliance and safety items in this report under the heading Enforcement Action.

13. Details of Unusual Occurrence and Corrective Action Taken by Licensee

The licensee's report dated November 7, 1972, presented proposed corrective action but did not relate the incident circumstances. The licensee's representatives gave the following details of the incident.

14. The incident occurred at a fluidized bed reactor which, at the time, was not equipped with local ventilation. Loading of that reactor with fissile material and process gases began about 7:00 p.m. on October 3, 1972. Between October 3 and October 4, reactor startup difficulties were encountered including an observed rise in reactor operating pressure. On October 4, the reactor was "plug rodded" by the supervisor responding to that pressure rise. The "plug rodding" operation appears to be common and is performed to remove input material plugs at the base of the reactor. The operation is accomplished by venting the reactor at its top and inserting a long, metal rod. On October 5, additional plugging at the reactor input was experienced and relieved. Further reactor pressure rise was also experienced and the system was vented about 10:00 a.m. at which time smoke and dust was observed coming from the system. The reactor was again vented at about 11:00 p.m. with the accompaniment of dust and smoke. The operators waited approximately 45 minutes, donned half-face respirators and vented the reactor repeatedly, observing dust and smoke each time.
15. The cycle was repeated until no further dust-venting was noted at which time the "plug rodding" operation was attempted again. In that attempt the operators encountered a plug near the top of the reactor accounting for the anomalous pressure rise. The operator thereupon opened the reactor noting further smoke and dusting. A vacuum exhaust hose was added in the vicinity of the reactor flange and the reactor was disassembled and cleaned.
16. Five air samples were obtained over portions of the operations described above. The results of those samples are included in the licensee's report and indicate an average exposure of approximately 6 X MPCa.
17. Licensee management recapitulated the incident by noting that an unusual reactor vessel plug occurred downstream during operation. Operations personnel responded by venting the vessel, an operation which is not included in the reactor operating procedure. Management added that proper final design of the vessel should have removed the manual vent or should have provided a ventilation exhaust hood.

18. Engineering corrections which had been made at the time of this inspection were explained by engineering personnel. The one inch diameter reactor off-gas line had been replaced with a two inch diameter line to reduce downstream plugging. An elephant truck ventilation line had been installed to be used during operations. The reactor input loading had been reduced to prevent overloading the system. A "Swagelok" seal on the rod used to clean plugs had been installed to permit the plug rodding operations without the need for venting the reactor. Those engineering corrections were observed by the inspector to have been accomplished.
19. Licensee representatives stated that full face masks had been procured for use in the event of suspected airborne contamination. At the time of this inspection the licensee had not yet ordered personal air sample equipment to augment this air sampling program as indicated in his report dated November 7. Steps had been taken, by reference to equipment catalogs, to select that equipment.
20. Much of the incident details presented above, including the engineering corrections were obtained in conversations with licensee's employees who were depending upon their memories for that information. The only recorded information regarding the health aspects of the incident was the raw air sample data and an attempt at correlation of that data with the sequence of operations which may have caused the high airborne activity. Specifically, there was no apparent, concerted effort on the part of the licensee's Nuclear Safety Committee to investigate, evaluate, or document the incident details.
21. Inplant Air Sample Program

The licensee has four, portable air samplers available. Three of the samplers are located in the fabrication facility and are used to monitor specific operations.
22. Records of air sample results are maintained on forms which indicate, by diagram, the location of the sampler. Those records also include the raw data and sampling results in terms of concentration and per cent of MPCa.
23. A review of air sampling results dating from approximately March 1972 to the date of this inspection indicated that approximately five air samples of relatively short time duration are obtained each week. Records indicate that samples are obtained at sintering and finishing operations, during the addition of fissile material to the dissolver,

during filter changes at certain equipment and during a floor vacuuming operation. Records indicated that occasional, short-term high airborne concentrations are experienced during those operations. Airborne concentrations ranging from $1 - 3 \times 10^{-10}$ microcuries per cc were noted but did not appear to be in excess of the MPCa of 1×10^{-10} microcuries/cc when averaged over a 40-hour week. The concentrations referred to are those routinely experienced and do not include the high airborne concentrations listed by the licensee in his unusual incident report.

24. According to licensee representatives operations are conducted on three shifts while health physics surveillance is available only on the day shift. It was indicated that on occasion (particularly during the reported incident) health physics assistance has been made available during off shift hours.
25. It was observed that air samples are often counted shortly after being obtained and counted only once, thus not providing for radon decay. Licensee representatives indicated they had not appreciated the radon decay problem until the reported incident and that they had not established counting procedures to that end.

26. Exhaust Air Monitoring

The licensee monitors the fabrication laboratory exhaust air. Samples are normally collected and evaluated once each week. Raw data and calculated exhaust air concentrations are recorded on an air sample data sheet similar to that used for implant monitoring data. A review of that monitoring record from approximately March, 1972 to the date of the inspection indicated that exhaust concentrations ranged from 10^{-15} uCi/cc to 10^{-14} uCi/cc. The laboratory air effluent passes through a system of absolute filters.

27. No exhaust air sample results were available for the week of October 1, 1972 (week of the reported incident). Licensee representatives stated that no samples had been obtained for that week because the air pump connection to the sample line was found parted when the sample filter paper was collected. Moreover, the licensee reported that no exhaust air samples had been obtained for approximately two weeks prior to this inspection and would not be obtained until approximately the end of 1972 because of ongoing exhaust stack and sampling system design changes. The licensee indicated that stack height, sample line port and sample line routing were being changed to provide iso-kinetic effluent sampling.

28. Health Physics Contamination Survey Program

Both smear and direct reading surveys of the fabrication laboratory areas are made daily by the licensee. Separate areas are surveyed each day with the entire facility being surveyed once per week. Smears are for an estimated one square foot area with the results reported in terms of activity per 100 cm². A copy of survey records is supplied to the fabrication laboratory supervisor, and on occasion to the facility manager. Those copies indicated the location of contamination which requires cleanup based on an internally generated action level of 2500 dpm/100 cm² for working area and .250 dpm/100 cm² for clean areas. A review of those records and licensee statements indicated some delay on the part of operation personnel accomplishing decontamination. It was indicated that a maximum of one week delay in cleanup had been experienced apparently due to the pressure of work and the limited number of personnel available for decontamination.

29. A review of contamination survey records dating from approximately March 1972 through November 13, 1972 usually indicated results less than 500 dpm/100 cm² with occasional spots ranging to a 1000 dpm/100 cm². Cleanup efforts at a level of 2500 dpm/100 cm² were indicated on the survey records. Fixed contamination on the order of 10k (10,000) to 15k counts per minute and removable contamination on the order of 100k cpm (direct reading) were encountered and were cleaned in an extensive effort about September 20, 1972.

30. According to licensee representatives much of the contamination found has been from liquids except at the location of sintering operations. In an effort to control liquid contamination, the licensee has installed new valves on chemical equipment, painted trays under vessels with a stripable coating material and assigned more janitorial cleaning time.

31. Bioassay Program

The licensee conducts a urinalysis bioassay program with analytical work performed by an independent laboratory. Approximately 20 people participate in the program with samples collected at a monthly frequency. Management and maintenance personnel participating in the program are sampled on a quarterly basis.

32. Instructions on sampling procedure accompany the sampling test provided by the analytical laboratory. The licensee's action level is set at 25 dpm/liter as determined by radiometric analysis.

33. The licensee urinalysis bioassay records in the form of analytical laboratory reports were reviewed for the period of approximately December, 1971 through the report dated November 6, 1972. The maximum bioassay activity observed in that review was 25 dpm/liter.
34. The review included the results for samples collected on October 28, 1972, which post-dates the high airborne concentrations reported by the licensee on November 7, 1972. Nine of the eleven individuals potentially exposed during the incident were sampled at that time. Volume of the sample ranged from 200 to 450 cc. The maximum bioassay activity indicated was 20 ± 8 dpm/liter. Of the nine individuals sampled, four indicated positive results. The licensee representatives indicated that, for some reason, two individuals had been missed in the sampling procedures.
35. With regard to the timeliness of bioassay sampling, the licensee representative stated that their health physics consultant requested three additional urine samples each on two potentially exposed individuals. That request had been made approximately one week prior to the presently reported inspection.
36. The consultant also requested that those two individuals be lung counted for uranium-235 at the Oak Ridge National Laboratory for confirmation. At the time of this inspection, those additional samples had not been collected and arrangements for the lung count had not been made.
37. Physical Inspection of Fabrication Laboratory

Incoming and some in-process fissile material is stored in a locked cage located on the mezzanine of Building 16 A. The licensee's Standard Operating Procedure No. 1 which is addressed to that storage of fissile material was posted at that cage. A review of the procedure indicated that it required fissile storage be in safe racks and that it prohibited the storage of fissile solutions in that area.
38. It was observed that several containers of fissile material including 10, 30 and 55 gallon drums, as well as smaller containers, were stored on the floor of the storage cage rather than in safe racks. The fissile content of those containers was estimated by the licensee to range between 40 and 60 grams uranium-235 each. Additional laboratory samples were stored in a box on the floor.

39. The storage cage also contained a slender storage rack measuring approximately four feet tall by 25 square inch base area. That rack contained approximately 400 grams uranium-235 in containers on several shelves. That rack was not fastened to any other structure and was quite unstable.
40. A nominal 11 liter, 5 inch diameter polyethylene bottle containing fissile solution at an estimated 150 grams per liter concentration was stored in a wooden safe storage rack located in the storage cage. That solution was described as recycle material by a licensee representative. The cage was also being used for storage of several boxes of paper clerical supplies.
41. An additional fissile material storage rack similar in design to that described above was located outside the storage cage on the mezzanine of the laboratory. That rack contained cans of fissile material which were oversized for the rack cubicles and obviously not intended for storage in the racks. Those containers were resting on the rack restraining lips. That storage rack was bolted to the floor and appeared stable. The rack was not provided with a physical barrier or any other control to maintain positive retention of stored materials.
42. On the main floor of the fabrication laboratory the inspector observed an operator performing a waste fissile solution diluting operation. The operation as described, begins with the transfer of concentrated solution from the boil down unit to geometrically safe polyethylene bottles. The waste concentration varies to a maximum of about 150 grams U-235 per liter. Two analyses are obtained to determine the fissile concentration and the material is then pumped from the safe bottle to a large glass graduate in a predetermined quantity. The graduate is subcritical by volume. The contents of the graduate are then poured into a non-geometrically safe, five gallon polyethylene container and subsequently diluted with water to a concentration less than 5 grams uranium-235 per liter. Two five-gallon containers of that description are placed in a 55-gallon drum along with vermiculite, the drum sealed and used as a shipping container.
43. The licensee had constructed a number of waste solution in-process storage containers. Those containers were 55-gallon drums provided with internal, sheet-metal bracing to accommodate and centralize 11 liter bottles of concentrated waste from the boil down unit. At the time of this inspection, approximately 18 in-process storage containers of that design were observed in an array located near the loading dock door of the laboratory. The array included containers of concentrated fissile material along with shipping containers loaded with the diluted fissile solutions.

44. The licensee representative stated that no written standard operating procedure existed for the waste dilution operation and that laboratory floor storage of solutions was not authorized by the subject license.
45. Section 11.1 of the licensee's April, 1970 application describes fissile solutions as being concentrated in the boil down system and packaged directly from that system into DOT Special Permit packages. A licensee representative stated that approximately 80 shipping containers containing a total of approximately 800 gallons of dilute fissile solution has been prepared by the methods above and transferred for waste reprocessing.
46. The inspector observed that the noncompliance noted in the previous inspection, concerning labeling of containers has been corrected.

JAN 18 1973

W. R. Grace and Company, Grace/Nuclear Division
Attention: Mr. G. E. Ashby
Vice President, Manager
Washington Research Center
Clarksville, Maryland 21029

Docket No. 70-456

Gentlemen;

This refers to the inspection conducted by Mr. Cooley of this office on November 29 - 30, and December 1, 1972, of operations authorized by AEC License No. SNM-840 and to the discussion of our findings held by Mr. Cooley with Mr. Ashby of your staff at the conclusion of the inspection.

Areas examined during this inspection included: organization; use of consultants; chemical and physical processes; facilities and equipment; Nuclear Safety Committee activities including reports for the period from August 1 to November 30, 1972; in-plant air monitoring, effluent air monitoring, and contamination control records for the period from March 1 to November 30, 1972; and bioassay records for the period from December 1, 1971 to November 30, 1972. Within these areas, the inspection consisted of selective examinations of procedures and representative records, interviews with personnel and observations by the inspector.

This inspection also included an examination of the circumstances of the airborne activity incident which you reported to the Commission by letter dated November 7, 1972, and the steps you have taken to prevent its recurrence. With regard to your corrective action, we note that you are ordering additional air sampling equipment with which to augment your health physics program. That equipment and its use, as well as your complete evaluation of the incident, will be a subject of the next inspection.

During this inspection it was found that certain of your activities appeared to be in violation of AEC requirements and not in accordance with appropriate safety practices. The items and references to the pertinent requirements are

ITEM # 256

B/255
(5)

OFFICE ▶	CRESS:I					
SURNAME ▶	<i>Howe</i> Crocker:ss	<i>Carlson</i>	<i>Nelson</i> O'Reilly			(copy) NELSON
DATE ▶	1/11/73					

listed in the enclosures to this letter. This notice is sent to you pursuant to the provisions of Section 2.201 of the AEC "Rules of Practice," Part 2, Title 10, Code of Federal Regulations. Section 2.201 requires you to submit to this office within 20 days of your receipt of this notice a written statement or explanation in reply including: (1) corrective steps which have been taken by you, and the results achieved; (2) corrective steps which will be taken to avoid further violations; and (3) the date when full compliance will be achieved. In addition to the need for corrective action regarding specific deficiencies, we are concerned about the implementation of your management control system that permitted these deficiencies to occur. Consequently, in your reply, you should describe, in particular, those actions taken or planned to improve the effectiveness of your management control system.

We note that the liquid waste dilution operation referred to in item No. 2 of Enclosure No. 1 was suspended on November 30, 1972. It is our understanding that the operation will not be resumed until detailed written procedures have been established and license approval has been obtained.

Should you have any questions concerning this inspection, we will be glad to discuss them with you.

Sincerely,

James P. O'Reilly
Director

Enclosures:
As Stated

bcc: RO Chief, Materials & Fuel Facilities Branch (2)
RO:HQ (4)
L:D/D for Fuels & Materials
DR Central Files
PDR
NSIC
State of Maryland

ENCLOSURE NO. 1

Description of Violations

W. R. Grace and Company
Clarksville, Maryland
Docket No. 70-456

Certain activities under your license appear to be in noncompliance with license requirements and AEC regulations as indicated below:

1. License Condition 8B incorporates Section 6.9 dated August 9, 1972, of your license application which requires that the Nuclear Safety Committee will stand ready to aid in the solution or correction of incidents and emergencies involving special nuclear material.

Contrary to that requirement, the high airborne concentration incident reported to the AEC by your letter dated November 7, 1972, had not been investigated, evaluated, or documented by your Nuclear Safety Committee acting as a body.

2. License Condition 8B incorporates Section 6.10 dated August 9, 1972, of your license application which requires that all operations at the site involving special nuclear material be performed only in accordance with written procedures which have been reviewed and approved.

Contrary to that requirement, approved written procedures and instructions were not prepared for the liquid waste dilution operation used in preparing fissile solution for shipment.

Moreover, contrary to the requirement of adherence to your procedures:

- a. at the time of the inspection, quantities of fissile material ranging from 40 to 60 grams uranium 235 were stored on a floor of the incoming materials storage cage, and not in racks as required by your Standard Operation Procedure No. 1 and
- b. a fissile solution was stored in the incoming material storage cage contrary to your Standard Operating Procedure No. 1.

3. License Condition 8B incorporates Sections 6.10 and 6.11 dated August 9, 1972, of your license application which requires detailed, specific procedures involving safety.

Contrary to that requirement, standard operating procedures, operating manuals, or specific instructions had not been prepared in the areas of criticality and radiation safety.

4. License Condition 8B incorporates Section 11.1 dated August 9, 1972, of your license application which requires that fissile solutions will be concentrated in the boil down system and packaged directly from that system into DOT special permit packages.

Contrary to that requirement, at the time of the inspection fissile solution were being transferred from the boil down unit to the non-specification containers which were arranged in an array on the floor of the fabrication laboratory.

5. 10 CFR 70-41(a) "Authorized use of special nuclear material," requires that possession and use of special nuclear materials be limited to the locations and purposes authorized in this license.

Contrary to this requirement, at the time of the inspection both concentrated and dilute fissile solutions, in a common array of both DOT specification and internally-designed containers were stored on the floor of the fabrication laboratory, without authorization under AEC License No. SNM-840.

ENCLOSURE NO. 2

Description of Safety Items

W. R. Grace and Company
Clarksville, Maryland
Docket No. 70-456

Certain items appear to raise questions concerning the safety of operations as identified below:

1. Prudent nuclear safety control practices dictate that the use of flammable materials be minimized in areas where fissile materials are handled or stored.

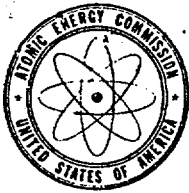
Contrary to the above, at the time of the inspection, wooden storage frames and several large boxes of clerical papers were observed stored with fissile material in the incoming materials storage cage located on the mezzanine of Building 16 A.

2. Prudent nuclear safety control practices dictate that fissile material storage racks be adequately secured in place to prevent displacement of the storage array.

Contrary to the above, at the time of the inspection, the incoming material storage cage was equipped with an unsecured, free standing fissile storage rack which was very unstable because of its large height to width ratio.

3. Prudent nuclear safety control practices dictate that fissile storage equipment be designed to provide positive retention of fissile materials.

Contrary to the above, at the time of the inspection, the fissile material storage rack located outside the storage cage was not provided with a physical barrier or other control to provide positive retention of stored materials.



UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

L:FFRB:JCD
70-456

JAN 9 1973

W. R. Grace & Co.
ATTN: Mr. R. J. Herbst
Radiation Protection Officer
Washington Research Center
Clarksville, Maryland 21029

Gentlemen:

Your letter dated December 11, 1972, requests authorization to determine and limit personnel exposure to airborne radioactive contamination by sampling only respirable size particles using the National Environmental Instruments, Inc. Model C-115 Personnel Monitor and Lapel Sampler or its equivalent.

According to Section 20.103(c)(2) the Commission may authorize a licensee to expose an individual in a restricted area to airborne concentrations in excess of the limits specified in Appendix B, Table I, 10 CFR 20, upon receipt of an application demonstrating that the concentration is composed in whole or in part of particles of such size that such particles are not respirable; and that the individual will not inhale in excess of the limits established in Appendix B, Table I.

Before we may further review your application you should submit the demonstration required by Section 20.103(c)(2).

Include data establishing the particle size distribution of the contamination prevailing in the atmosphere of the pertinent work spaces and explain how the respirable fractions as evaluated by the proposed sampler, compares to the respirable fraction that was utilized in establishing the concentration values in Column 1, Table 1, Appendix B, 10 CFR 20.

Describe the Model C-115 instrument and any acceptable alternate which you claim will not detect non-respirable particles. Provide data on its sampling characteristics and identify what fraction of inhalable particles it will detect.

ITEM # 257

B/256

(2)

W. R. Grace & Co.

- 2 -

JAN 8 1973

What correlation have you experienced running samples simultaneously in atmospheres characteristic of the proposed work space, separated, by a distance comparable to that between a worker's nose and his monitoring instrument?

Establish that inhalation of a radioactive material by employees' will be as low as practicable when taking credit for non-respirable size particles.

Establish the calibration frequency and method you will use to verify sampler performance and the respirable component of the atmosphere to which workers may be subject.

Sincerely,

R. B. Chitwood, Chief
Fuel Fabrication and Reprocessing
Branch

Distribution:
Public Document Room Directorate of Licensing

Docket File

Branch R/F

L:FM R/F

RO, HQ (2)

JCDelaney:FFRB

RBChitwood, L:FFRB

FEB 1

L:FFRB:JCD

70-456

SNM-840, Amendment No. 3 ✓

W. R. Grace & Company
ATTN: Mr. G. E. Ashby
Vice President, Nuclear
Washington Research Center
Clarksville, Maryland 21027

Gentlemen:

Pursuant to Title 10, Code of Federal Regulations, Part 70, Special Nuclear Material License No. SNM-840 is hereby amended to incorporate in Item 8B the revised pages 23, 23A, 29, 50, 55, 56, 66A and 66B, dated November 6, 1972, and submitted with your application dated December 11, 1972.

All other conditions of this license shall remain the same.

Your request that the revisions to pages 23 and 23A be withheld from public disclosure pursuant to Section 2.790 of 10 CFR 2 is under review. We will advise you when a final determination has been made regarding the request for withholding.

The review of your October 4, 1972, application for renewal is not complete. However, you will be requested to identify all effluents and all inplant operations that release radioactivity and demonstrate that the procedures and equipment being used to control releases are such that the releases are as low as practicable.

FOR THE ATOMIC ENERGY COMMISSION

Distribution:

Public Document Room

State Health Official

Docket File HJMcAlduff, OR

L:FM R/F RGPPage, LLMP

FFRB R/F ACabell, DRAR. B. Chitwood, Chief

CR, HQ (2) BBrooks, GM Fuel Fabrication and Reprocessing

VJD'Amico, RO RBChitwood

ITEM #

258-1

B/257

(2)

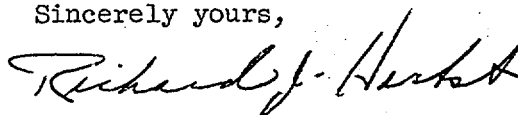
W. A. GRACE & CO.
Research Division
WASHINGTON RESEARCH CENTER

CONTINUATION

We believe that the one-time shipment by motor express and exclusive use of vehicle of this quantity of material in the shipping assembly described above in no way endangers life or property or the common defense and security.

The container does not comply with ICC specifications, and we have asked the DOT for special permission to use it. I have also attached a copy of my letter to DOT. I am certain that your authorization or concurrence in our plan will help our case. If you have any questions, call me at (301) 531-5711, extension 550. Thank you.

Sincerely yours,



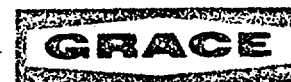
Richard J. Herbst

RJH/par
attachments

DOCKET NO. 70-456

REGULATORY OPERATIONS

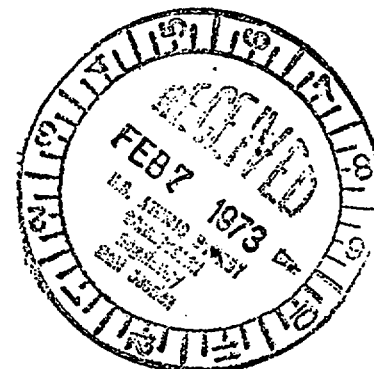
W. R. GRACE & CO.



RESEARCH DIVISION

Washington Research Center, Clarksville, Maryland 21029

5 February 1973



R. B. Chitwood, Chief
Directorate of Licensing
Fuel Fabrication and Reprocessing Branch
U. S. Atomic Energy Commission
7920 Norfolk Avenue
Bethesda, Maryland 20014

Ref: (1) Docket 70-456
(2) Special Nuclear Material License, SNM 840
(3) Letter: R. J. Herbst to USAEC (11 Dec 1972)
(4) L:FFRB:JCD (31 Jan 1973)

Dear Sir:

W. R. Grace & Co. withdraws its request for authorization to determine and limit personnel exposure to airborne radioactivity on the basis of air sampling respirable size particles only.

Thank you for considering our request.

Sincerely,

R. J. Herbst
Radiation Protection Officer

RJH/cal

ITEM # 259

942

ROI

L:TB:RMO
70-456
SNM-840, Amendment No. 71-1

FEB 16 1973

W. R. Grace & Co.
ATTN: Mr. G. E. Ashby
Washington Research Center
Clarksville, Maryland 21029

Gentlemen:

Enclosed is Amendment No. 71-1 to Special Nuclear Material License No. SNM-840 authorizing delivery of special nuclear material to a carrier for transport in the Model No. WRG-10 C1 package.

Note that this amendment does not authorize the transport of special nuclear material. Such transport is normally subject to regulation by the Department of Transportation (DOT). Questions regarding their requirements should be directed to DOT.

Sincerely,

Original Signed by
Charles E. MacDonald

Charles E. MacDonald, Chief
Transportation Branch
Directorate of Licensing

Enclosure:
As stated

cc: Mr. Alfred W. Grella, DOT

Mr. Stan Reese
Nuclear Safety Associates
1055-R Rockville Pike
Rockville, Maryland 20852

Distribution: w/o encl
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Document Room
State Health (License only)
RO:HQ (2) ✓
HJMcAlduff, OROO
VJD'Amico, RO
BBrooks, GM
ACabell, DRA
CEMacDonald, L:TB
RHodegaarden, L:TB
FRinaldi, L:TB
Branch R/F
L:F&M R/F

ITEM # 260

B/259

OFFICE >	L:TB	L:TB				
SURNAME >	RHodegaarden/vjh CEMacDonald					
DATE >	2/15/73	2/ /73				

15

UNITED STATES
ATOMIC ENERGY COMMISSION

FEB 16 1973

LICENSE AMENDMENT
for
DELIVERY OF RADIOACTIVE MATERIAL
to a
CARRIER FOR TRANSPORT

Pursuant to the Atomic Energy Act of 1954 and Title 10, Chapter 1, Code of Federal Regulations, Part 30, "Rules of General Applicability to Licensing of Byproduct Material", Part 70, "Special Nuclear Material", as appropriate, and Part 71, "Packaging of Radioactive Material for Transport", the following amendment to the license identified below is hereby issued, authorizing the licensee to deliver radioactive material to a carrier for transport, and is subject to the conditions specified in that license and to the conditions specified below:

LICENSEE	
1. Name:	W. R. Grace & Co.
2. Address:	Washington Research Center Clarksville, Maryland 21029
3. License No.	SNM-840
Amendment No.	71-1
Docket No.	70-456

CONDITIONS

4. (a) Packaging

WRG-10 C1

(1) Model number

Nominal 12 liter polyethylene bottle contained in a 5-inch stainless steel pressure vessel, supported by tubular steel structure, insulated with vermiculite, enclosed in double-high 55-gallon drums, constructed in accordance with NFS Drawings CAPE-1170-15, CAPE-1170-35 through CAPE-1170-37.
Alternate details of construction approved:

(2) Description

- (i) The specification for the material used in the stainless steel pressure vessel (Drawing CAPE-1170-36) may be changed from "Type 304" to "Type 304L". When the material is "Type 304L", the heat treatment specification may be deleted.

COPY

LICENSEE: W. R. Grace & Co.

PAGE NO: 2

FEB 16 1973

LICENSE NO: SNM-840

AMENDMENT NO: 71-1

4. (a) (2) Description (Cont'd.)

- (ii) Welds in stainless steel chamber may be dye penetrant checked where it is not feasible to X-ray.
- (iii) The vented polyethylene cap shown on Drawing CAPE-1170-37 is authorized for use.
- (iv) The polyethylene bottle shipping container as shown in Nuclear Fuel Services, Inc. Drawing 5B-U-740 is authorized for use.
- (v) The specification for the steel in the NFS-10LI supporting structure shown in Drawing CAPE-1170-35 may be changed from "steel" to "Grade MT 1015 steel seamless tubular" for the tubular structure.
- (vi) Steel parts welded to the tubular structure may be specified as "SAE No. 1010, 1012 or 1015 steel" to be compatible with the tubular steel.
- (vii) The annealing requirement on Drawing CAPE-1170-35 may be deleted.

(b) Contents

- (1) Type and form of material

Uranyl chloride solutions having a concentration of U-235 not exceeding 350 grams per liter and an H/U-235 atomic ratio not less than 80.

- (2) Maximum quantity of material per package

10.5 liters of solution.

(c) Fissile Class

II and III

- (1) Minimum transport index to be shown on label for Class II 1.5

- (2) Maximum number of packages per shipment for Class III

68

COPY

LICENSEE: W. R. Grace & Co.

PAGE NO: 3

LICENSE NO: SNM-840

AMENDMENT NO: 71-1

5. A restraining device shall be placed between the cap assembly of the polyethylene bottle and the closure flange of the pressure vessel to assure that the polyethylene bottle will vibrate at the same frequency as the pressure vessel during transport.
6. In addition to the requirements of Subpart D of 10 CFR 71;
 - a. A hydrostatic test shall be performed on each pressure vessel once each year at 300 psig. Any chamber that fails to pass the test will be withdrawn from service and repaired to meet the test.
 - b. The tubular structure of each birdcage shall be inspected once each year for cracking and weld failure. Any failure shall be examined to determine the cause and shall be repaired prior to additional use.
 - c. Prior to use, each polyethylene bottle of the type shown in NFS Drawing 5B-U-740 and loaded after the effective date of this amendment shall pass a hydrostatic test at 25 psig without leakage.
 - d. Prior to use, each "Duo Vent" cap assembly shall pass a test whereby the valve will vent at not less than 3 psig or more than 5 psig.
7. Closure seal used for both the pressure vessel and the polyethylene bottle cap closure shall be a fluorelastomer (Viton-A) material.
8. The use of these containers shall be dedicated to the material contents identified above. The container shall not be re-designated and used for the shipment of other material contents.

REFERENCES

Licensee's application dated December 21, 1972 as amended February 1, 1973, requesting approval to deliver special nuclear material to a carrier for transport in the WRG-10 C1 container.

Previous submittals by Nuclear Fuel Services, Inc., West Valley, New York (Docket No. 70-959) dated August 27, 1965; January 27, February 23, July 12, September 26, and December 7, 1966; June 15 and December 12, 1967; August 12, 1969; and October 28, 1971.

FOR THE ATOMIC ENERGY COMMISSION

FEB 16 1973

Date of Amendment _____

Original Signed by
Charles E. MacDonald

Charles E. MacDonald
Directorate of Licensing

COPY

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W. R. GRACE & CO.
RESEARCH DIVISION

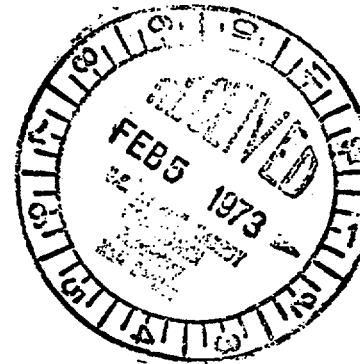
REGULATORY OPERATIONS



Washington Research Center, Clarksville, Maryland 21029

February 1, 1973

Mr. C. E. McDonald
Chief, Transportation Branch
Directorate of Licensing
USAEC
Washington, D. C. 20545



Dear Mr. McDonald:

Re: Docket No. 70-456

In response to your questions relative to our December 21, 1972 request for permission to use the SP-5061 packaging for solutions containing chloride, we agree to limit the use of the packages to the solutions described and not to release the packages for use by others for use with different solutions. The package will be designated as the WRG-10 C1 packaging and each package will be so marked.

We propose to use the Viton-Fluorelastomer or equivalent gasket in the polyethylene cap closure. This material is recommended by the manufacturer, the DuPont Company, for use at 230 F or less in 20% hydrochloric acid. The solutions to be shipped are much less corrosive than 20% HCl, and are therefore compatible with the gaskets to be used.

We trust that this answers your questions satisfactorily and that you will forward your approval promptly.

Sincerely,

G. E. Ashby (by RJA)
G. E. Ashby
Vice President
Nuclear

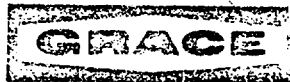
GEA:srh

cc: Office of Hazardous Materials - DOT

877

W. R. GRACE & CO.

RESEARCH DIVISION



Washington Research Center, Clarksville, Maryland 21029

December 21, 1972

Mr. R. B. Chitwood
Chief, Fuel Fabrication and
Reprocessing Branch
Directorate of Licensing
USAEC
Washington, D. C.

REGULATORY OPERATIONS

Dear Mr. Chitwood:

Re: Docket No. 70-456

W. R. Grace & Co. requests that its License SNM-840 as amended be further amended to permit the use of NFS-10 LI type package (DOT Special Permit No. 5061 as revised) for the shipment of chloride and nitrate solutions of uranium. These solutions shall not exceed 350 grams U-235 per liter and they shall be contained in the polyethylene inner bottle, all as specified in SP-5061.

The SP-5061 packaging has not been previously used for shipping concentrated solutions containing uranium chloride ion. The solutions to be transported herein are obtained by concentration in a still. Three potential materials of construction for the pressure vessel were tested by exposing samples of these materials to solution from the still at the maximum temperatures to which they could be expected to be exposed under normal transport conditions (130°F) and under accident conditions (200°F, the maximum solution temperature expected after the package has been exposed to 1475°F radiant heat for 30 minutes).

COPY SENT REGION I

The data are presented in the following table:

<u>Material</u>	<u>Surface Area cm²</u>	<u>Temperature °F</u>	<u>Time at Temperature hrs</u>	<u>Weight Loss grams</u>	<u>Corrosion rate mil/year</u>
304 SS	79.68	130	78	0.0023	0.136
316 SS	102.89	130	78	0.0039	0.177
iron pipe	50.53	130	78	8.8987	998
304 SS	82.62	200	4	0.0076	10.16
316 SS	102.9	200	4	0.0201	21.6

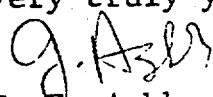
From the table it is apparent that a pressure vessel constructed of either 304 or 316 stainless steel is suitable for continuous service with this solution at a temperature of 130°F whereas it will be exposed to the solution only in the event of failure of the inner polyethylene bottle. The corrosion rate is a fraction of a mil per year. It is also apparent that a vessel constructed of either 304 or 316 SS would retain its integrity from contact with this solution in the event of accident involving a standard fire.

An inspection, testing, and loading procedure regarding the use of this package will be developed, approved, and placed into effect in the manner provided in the license for all operating procedures.

Your prompt consideration and approval of this amendment is earnestly requested.

We are simultaneously sending a copy of this request to the Department of Transportation Office of Hazardous Materials requesting that SP-5061 be revised to permit the use of this packaging as proposed herein.

Very truly yours,


G. E. Ashby
Vice President
Nuclear

GEA:srh
Attachment



DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS REGULATIONS BOARD
WASHINGTON, D.C. 20590

SPECIAL PERMIT NO. 5061
FOURTEENTH REVISION

Pursuant to 46 CFR 146.02-25 of the U.S. Coast Guard (USCG) Dangerous Cargo Regulations and 49 CFR 170.15 of the Department of Transportation (DOT) Hazardous Materials Regulations, as amended, Special Permit No. 5061 is hereby amended as follows:

1. Paragraph (1a) is amended to read as follows:

"1. * * *

a. For contents as limited by paragraph 5(a) - USAEC license SNM-984 (71-11), dated November 11, 1969, or USAEC license SNM-1138 (71-1), dated May 26, 1969, as amended April 15 and May 7, 1971; or USAEC, Richland Operations Office approval dated October 18, 1966."

2. In paragraph (3), the last two sentences are changed to read,

"This version of the package is identified as the Model ASDA-10LI. The provisions of paragraph (4), except for the exemption from the provisions of §173.268 of the Department of Transportation Regulations, do not apply to this version."

3. In paragraph (4), line 3, "30 days" is changed to read "90 days."

All other terms of this permit, as revised, remain unchanged. The complete permit currently in effect consists of the Thirteenth and Fourteenth Revisions.

Issued at Washington, D.C.:

R.G. Schwing
R.G. Schwing, Capt.
For the Commandant
U.S. Coast Guard

6 December 1971
(DATE)

W.R. Fiste
W.R. Fiste
For the Administrator
Federal Highway Administration

8 DEC 1971
(DATE)

Mac E. Rogers
Mac E. Rogers
For the Administrator
Federal Railroad Administration

DEC 15 1971
(DATE)

Ellis C. Langford
Ellis C. Langford
For the Administrator
Federal Aviation Administration

107 DEC 1971
(DATE)

Address all inquiries to: Secretary, Hazardous Materials Regulations Board, U.S. Department of Transportation, Washington, D.C. 20590.
Attention: Special Permits.

Dist: a, b, c, d, e, h, i

Nuclear Fuel Services, Incorporated, West Valley, New York
The Dow Chemical Company, Golden, Colorado
Idaho Nuclear Corporation, Idaho Falls, Idaho
Kerr-McGee Corporation, Oklahoma City, Oklahoma
Nuclear Materials & Equipment Corporation, Apollo, Pennsylvania
U.S. Atomic Energy Commission, Richland, Washington
North American Rockwell Corporation, Canoga Park, California
N.Y. State Atomic & Space Development Authority, New York, New York
Consolidated Edison Co. of New York, Incorporated, New York, New York
Argonne National Laboratory, Argonne, Illinois
Edlow International, Washington, D.C.



DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS REGULATIONS BOARD
WASHINGTON, D.C. 20590

SPECIAL PERMIT NO. 5061
FIFTEENTH REVISION

Pursuant to 46 CFR 146.02-25 of the U. S. Coast Guard (USCG) Dangerous C Regulations and 49 CFR 170.15 of the Department of Transportation (DOT) Hazardous Materials Regulations, as amended, and on the basis of the May 24, 1972 petition by Aerojet Nuclear Company, Idaho Falls, Idaho.

Special Permit No. 5061 is hereby amended as follows:

1. Paragraphs 1(d) and 5(d) are added to read:

"1(d). For the contents as limited by paragraph 5(d) - Idaho Operations Office approval dated May 19, 1972.

"5(d) Uranyl nitrate, plutonium nitrate, or neptunium nitrate, or any mixture thereof limited to not more than 10.5 liters, wherein the total concentration of uranium, plutonium, and neptunium does not exceed 250 grams per liter."

2. Paragraph 6 is changed by the addition of a fourth listing for Fissile Class II transport index assignment, as follows:

"Paragraph 5d contents - 1.5."

All other terms of this permit, as revised, remain unchanged. The compl permit currently in effect consists of the Thirteenth, Fourteenth, and Fifteenth Revisions.

Issued at Washington, D. C.:

for B.R. Milster
 W. R. Fiste
 For the Administrator
 Federal Highway Administration

16 JUN 1972

(DATE)

Mac E. Rogers
 Mac E. Rogers
 For the Administrator
 Federal Railroad Administration

JUN 20 1972

(DATE)

Ellis C. Langford
 Ellis C. Langford
 For the Administrator
 Federal Aviation Administration

26 June 1972

(DATE)

R. G. Schwing
 R. G. Schwing
 For the Commandant
 U. S. Coast Guard

12 June 1972

(DATE)

Address all inquiries to: Secretary, Hazardous Materials Regulations Board
 U. S. Department of Transportation, Washington, D. C. 20590
 Attention: Special Permits.

Dist: a, b, c, d, e, h, i

Nuclear Fuel Services, Incorporated, West Valley, New York
 The Dow Chemical Company, Golden, Colorado
 Idaho Nuclear Corporation, Idaho Falls, Idaho
 Kerr-McGee Corporation, Oklahoma City, Oklahoma
 Nuclear Materials & Equipment Corporation, Apollo, Pennsylvania
 U. S. Atomic Energy Commission, Richland, Washington
 North American Rockwell Corporation, Canoga Park, California
 N. Y. State Atomic & Space Development Authority, New York, New York
 Consolidated Edison Co. of New York, Incorporated, New York, New York
 Argonne National Laboratory, Argonne, Illinois
 Edlow International, Washington, D.C.



DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS REGULATIONS BOARD
WASHINGTON, D.C. 20590

SPECIAL PERMIT NO. 5061
THIRTEENTH REVISION
(COMPLETE)

This special permit is reissued pursuant to 46 CFR 146.02-25 of the U.S. Coast Guard (USCG) Dangerous Cargo Regulations and 49 CFR 170.15 of the Department of Transportation (DOT) Hazardous Materials Regulations, as amended, and on the basis of the March 22, 1971, petition by Nuclear Fuel Services, Inc., West Valley, New York; and the previous petitions on file with this Board.

1. Shipments of large quantities of fissile radioactive materials, n.o.s., are hereby authorized in the packaging as described in this special permit. This packaging, when constructed and assembled as prescribed herein, with the contents as authorized herein meets the standards prescribed in the DOT regulations, Sections 173.395(c)(2), 173.396(c)(3) and 173.398(c). Shipments must be in accordance with the provisions of either of the following USAEC approvals, or equivalent approvals thereto:
 - a. For contents as limited by paragraph 5a--USAEC license SNM-984 (71-10) dated September 22, 1969, or USAEC license SNM-1138, (71-1) dated May 26, 1969; or USAEC, Richland Operations Office approval dated October 18, 1966.
 - b. For contents as limited by paragraph 5b--USAEC, Richland Operations Office approval dated March 7, 1967.
 - c. For contents as limited by paragraph 5c--USAEC, San Francisco Operations Office approval dated June 8, 1969.
2. Each shipper, under this permit, other than the petitioner named above, and the other petitioners previously identified by this Board, shall register his identity with this Board prior to his first shipment, and shall have a copy of this permit in his possession before making any shipment.
3. The packaging authorized by this permit consists of a nominal 12-liter polyethylene bottle, contained in a 5-inch inside diameter stainless steel pressure vessel, with flanged, bolted closure. The pressure vessel is centered and supported by a welded tubular steel structure, insulated with vermiculite, within an overpack of welded double-high, 55 gallon drums which are equivalent to DOT Specification 6J or 17H. The outer container closure shall conform to §178.103-5. The package is identified as the Dow L-10 or NFS-10 LI Type. The NFS-10 LI package is described on NFS Drawings No. CAPE-1170-15, 35, 36, and 37. As an alternate gasket material for the pressure vessel closure,

a flat gasket of fluorelastomer (Viton "A") as described in Atlantic Richfield Hanford Company's drawing number SK-2-21001, may be used in lieu of the gas-filled stainless-steel "O" ring gasket. As an alternate, the product containers may be a stainless steel capsule, as prescribed in paragraph 5a, 3, and 7 of USAEC license SNM-1138 (71-1). This version of the package is identified as the Model ASDM-10 LI. The provisions of paragraph (4) do not apply to this version.

4. For shipment of nitrate solutions, no polyethylene bottle may be used which has also been used as a storage vessel for nitrate solutions for more than 30 days. Any internal pressure within the polyethylene bottle must have been relieved within 48 hours prior to shipment. An "O"-ring seal (Viton-Fluorelastomer, or approved equivalent) must be used as part of the cap closure. The cap must be subjected to at least 15 foot-pounds of torque during closure. Venting is authorized. Bottles must conform to the requirements of DOT Specification 34, except for §§178.19-2(b), 178.19-6, and 178.19-7(c)(2). The package is not authorized for nitrate solutions exceeding 6 molar. The package is exempted from the provisions of §173.268 of the DOT regulations.

5. The contents of each package authorized by this permit consist of fissile radioactive material, including large quantities, as either of the following:

a. Uranyl nitrate or plutonium nitrate solutions, limited to not more than 10.5 liters of either of the following:

1. Uranyl nitrate solutions having a concentration of Uranium-235 not exceeding 350 grams per liter and an H/U-235 atomic ratio not less than 80, provided that the combined U-233 and plutonium content is not more than 1% of the U-235 content; or

2. Uranyl nitrate solution having a combined concentration of Uranium-233 and Uranium-235 not exceeding 250 grams per liter and a hydrogen/fissile material atomic ratio not less than 80, provided (1) that the U-233 content is not greater than 20 per cent of the combined U-233 and U-235 content and (2) that the plutonium content is not more than one per cent of the combined U-233 and U-235 content; or

3. Plutonium nitrate solutions having a concentration not exceeding 250 grams of Pu-239 per liter.

b. Not more than 4.5 Kilograms of dry plutonium-uranium compounds and mixtures.

c. Not more than 450 grams of Uranium-235 in the form of 93.137% U-235 enriched uranyl sulfate solution (UO_2SO_4).

6. The packaging authorized by this permit meets the requirements for shipment as Fissile Class II with the transport indices as follows to be assigned to each package (unless, however, external radiation levels dictate a higher assignment):

Paragraph 5a contents - 1.5

Paragraph 5b contents - 0.5

Paragraph 5c contents - 1.5.

7. The packaging authorized by this permit with the contents as limited by paragraph 5(a) meets the requirements for shipment as Fissile Class III with not more than 68 packages per transport vehicle or stowage area. Shipments by cargo-only aircraft must conform to §173.396(g)(1).

8. The authorized package described herein is hereby certified as meeting the specific requirements of the International Atomic Energy Agency's (IAEA) "Regulations for the Safe Transport of Radioactive Material," Safety Series No. 6, 1967 edition, as follows:

a. Marginal C-6.2.3 - The package design meets the requirements for Type B packaging for large quantity (source) radioactive materials.

b. Marginal C-6.2.4 - The package design meets the requirements for Fissile Class II and III shipments.

c. Marginal C-2.4.3 - The packaging design is based on the ambient conditions.

d. Marginal C-6.5 - No special transport controls are necessary during carriage and no special arrangements have been prescribed, except as specified herein.

9. The outside of each package must be plainly and durably marked "USA DOT SP 5061" and "TYPE B", in connection with and in addition to the other markings and labels prescribed by the DOT regulations. Each shipping paper issued in connection with shipments made under this permit must bear the notation "DOT SPECIAL PERMIT NO. 5061", in connection with the commodity description thereon.

10. Each package must have its gross weight plainly and durably marked on the outside of the package.

11. This permit authorizes shipments only by vessel, cargo-only aircraft, motor vehicle and rail.

12. For shipments by water or air, a copy of this permit, kept current, must be carried aboard any vessel or aircraft transporting radioactive material under these terms.

13. For shipments by water:

The shipper or agent shall notify the USCG Captain of the Port in the port area through which the shipment is to be made, of the name of the vessel on which the shipment is to be made, and of the time, date, and place of loading or unloading. When the initial notification is given in a port area, it must be accompanied by a copy of this permit, addressed to the attention of that Captain of the Port.

14. Prior to each shipment authorized by this permit, the shipper shall notify the consignee and, for export shipments, the competent authority of any country into or through which the package will pass, of the dates of shipment and expected arrival.

15. Any incident involving loss of contents of the package must be reported to this Board at the earliest feasible moment.

16. The permit does not relieve the shipper or carrier from compliance with any requirement of either the DOT regulations, including 46 CFR Parts 146 to 149 of the USCG regulations, except as specifically provided for herein, or the regulations of any foreign government into or through which the package will be carried.

17. This permit expires on June 30, 1973.

Issued at Washington, D.C.:

R.G. Schwing
R.G. Schwing, Capt.
For the Commandant
U.S. Coast Guard

12 May 1971
(DATE)

W.R. Fiste
W.R. Fiste
For the Administrator
Federal Highway Administration

14 MAY 1971
(DATE)

Mac E. Rogers
Mac E. Rogers
For the Administrator
Federal Railroad Administration

MAY 18 1971
(DATE)

S. Schneider
S. Schneider
For the Administrator
Federal Aviation Administration

25 MAY 1971
(DATE)

DISTRIBUTION:
Public Document Room
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RO, HQ, (2)
JCDelaney, L:FFR
RBChitwood, L:FFR
DANussbaumer, L:FC
SHSmiley, L:FM

FEB 16 1973

L:FFR:JCD
70-456

W. R. Grace & Co.
ATTN: Mr. G. E. Ashby
Vice President, Nuclear
Washington Research Center
Clarksville, Maryland 21029

Gentlemen:

Your application dated December 11, 1972, requested that pages 23 and 23A of the enclosure thereto, be withheld from public inspection pursuant to 10 CFR 2.790(b).

After reviewing this information, we have determined that disclosure of the information contained therein is not required in the public interest nor by the provision of 10 CFR 9 and would adversely affect the interest of W. R. Grace and Company. Accordingly, we are withholding from public inspection the information contained in the above referenced pages pursuant to 10 CFR 2.790(b). Withholding of this information from public inspection shall not, however, affect the rights, if any, of persons properly and directly concerned to inspect these documents.

Sincerely,

Original Signed by
S. H. Smiley

S. H. Smiley, Deputy Director
for Fuels and Materials
Directorate of Licensing

ITEM # 261

B/260

OFFICE ▶	L:FFR	L:FFR	OGC	L:FC	L:FM	
SURNAME ▶	JCDelaney/ slm	RBChitwood		DANussbaumer	SHSmiley	
DATE ▶	1/ /73	1/ /73	1/ /73	1/ /73	1/ /73	

In reply refer to:
RO:RPB
SNM-840

MAR 7 1973

W. R. Grace & Company
Washington Research Center
ATTN: Mr. G. E. Ashby
Vice President
Nuclear
Clarksville, Maryland 21029

Gentlemen:

This will acknowledge your letter dated February 13, 1973, with the attached Final Report on the October 1972 exposure of several employees to radioactive material. We have no further questions at this time.

Very truly yours,

Original signed by
F. E. Kruesi

F. E. Kruesi, Director
of Regulatory Operations

bcc: PDR
NSIC
L:AEB
L:BMB
C. F. Eason, AWCRR, AGMES
License Files
Incident Files
DR Central Files

RO:I
DR Reading Files

ITEM # 262

B/261

OFFICE ▶	RO:RPB	RO	RO	RO		
SURNAME ▶	GHBidinger:ef X-7347	GWRoy	RHEngelken	FEKruesi		
DATE ▶	3/5/73					

MAR 13 1973

W. R. Grace and Company, Grace/Nuclear Division
Attention: Mr. G. E. Ashby
Vice President, Manager
Washington Research Center
Clarksville, Maryland 21029

Docket No. 70-456

Reference: Your letters of February 8, 28, 1973
In response to our letter of January 18, 1973

Gentlemen:

Thank you for your letters informing us of the action you have taken to correct the violations of AEC requirements and the items that were not in accordance with appropriate safety practices, which we brought to your attention following our recent inspection of your licensed program. Your corrective action will be verified during our next inspection of your program.

In accordance with Section 2.790 of the AEC's "Rules of Practice," Part 2, Title 10, Code of Federal Regulations, a copy of this letter and the enclosed inspection report will be placed in the AEC's Public Document Room. If this report contains any information that you (or your contractors) believe to be proprietary, it is necessary that you make a written application within 20 days to this office to withhold such information from public disclosure. Any such application must include a full statement of the reasons on the basis of which it is claimed that the information is proprietary, and should be prepared so that proprietary information identified in the application is contained in a separate part of the document. If we do not hear from you in this regard within the specified period, the report will be placed in the Public Document Room.

Your cooperation with us is appreciated.

Sincerely,

James P. O'Reilly
Director

Enclosure:

RO Inspection Report No. 70-456/72-02

ITEM # 263 B/262

OFFICE ▶	CRESS: I					
SURNAME ▶	<i>Handwritten: Crocker:pc</i>	<i>Handwritten: Carlson</i>	O'Reilly		<i>Handwritten: Smith</i>	<i>Handwritten: NELSON</i>
DATE ▶	3/12/73					3/13/73

- 2 -

bcc: RO Chief, Materials & Fuel Facilities Branch (2)
RO:HQ (4)
L:D/D for Fuels & Materials
DR Central Files
PDR
NSIC
State of Maryland

W. R. GRACE & CO.

RESEARCH DIVISION



Washington Research Center, Clarksville, Maryland 21029

February 8, 1973

Mr. James P. O'Reilly
Director
U. S. Atomic Energy Commission
Directorate of Regulatory Operations
Region 1
970 Broad Street
Newark, New Jersey 07102

Dear Mr. O'Reilly:

The attachment is our reply to your letter of January 18, 1973, in which you list the violations found by Mr. Cooley's inspection on November 29-30 and December 1, 1972, of activities authorized by AEC License No. SNM 840.

Should you have questions concerning this reply, we will be pleased to discuss them with you.

Sincerely,

A handwritten signature in dark ink, appearing to read "G. Ashby".

G. E. Ashby
Vice President
Nuclear

GEA:srh
Attachment

Explanation in Reply to Violations Reported from
the November 29-30, and December 1, 1972, Inspection
of Activities Authorized by AEC License No. SNM-840

Violation 1 - License Condition 8B incorporates Section 6.9 dated August 9, 1972, of your license application which requires that the Nuclear Safety Committee will stand ready to aid in the solution or correction of incidents and emergencies involving special nuclear material.

Contrary to that requirement, the high airborne concentration incident reported to the AEC by your letter dated November 7, 1972, had not been investigated, evaluated, or documented by your Nuclear Safety Committee acting as a body.

The incident referred to has been investigated and evaluated by the Nuclear Safety Committee acting as a body. Hereafter, each incident or other emergency will be referred to the committee without delay.

Violation 2 - License Condition 8B incorporates Section 6.10 dated August 9, 1972, of your license application which requires that all operations at the site involving special nuclear material be performed only in accordance with written procedures which have been reviewed and approved.

Contrary to that requirement, approved written procedures and instructions were not prepared for the liquid waste dilution operation used in preparing fissile solution for shipment.

Moreover, contrary to the requirement of adherence to your procedures:

- a. at the time of the inspection, quantities of fissile material ranging from 40 to 60 grams uranium 235 were stored on a floor

of the incoming materials storage cage, and not in racks as required by your Standard Operation Procedure No. 1 and

- b. a fissile solution was stored in the incoming material storage cage contrary to your Standard Operating Procedure No. 1.

The personnel responsible for the dilution operation have been reinstructed with emphasis that operations can only be performed in accordance with written procedures that have been approved by the Nuclear Safety Committee.

All solutions have been removed and are not permitted in the incoming materials storage cage. All solid materials in the incoming materials storage cage have been stored in racks or birdcages in compliance with AEC License No. SNM-840.

Violation 3 - License Condition 8B incorporates Sections 6.10 and 6.11 dated August 9, 1972, of your license application which requires detailed, specific procedures involving safety.

Contrary to that requirement, standard operating procedures, operating manuals, or specific instructions had not been prepared in the areas of criticality and radiation safety.

All operating personnel are required to comply with written standard operating procedures which have been reviewed and approved by the Nuclear Safety Committee. This review considered the areas of criticality and radiation safety. New or special situations which may develop and if not covered by existing standard operating procedures are considered on an item by item basis by our consultant, Mr. Reese, in the criticality area or by our Radiation Protection Officer, Dr. Herbst, and new standard operating procedures are written and approved by the Nuclear Safety Committee for those cases. Operating personnel are not permitted to make decisions based upon guidelines or

manuals, but only are allowed to follow approved standard operating procedures dealing with the specific operation or situation.

Violation 4 - License Condition 8B incorporates Section 11.1 dated August 9, 1972, of your license application which requires that fissile solutions will be concentrated in the boil down system and packaged directly from that system into DOT special permit packages.

Contrary to that requirement, at the time of the inspection fissile solution were being transferred from the boil down unit to the non-specification containers which were arranged in an array on the floor of the fabrication laboratory.

The AEC License No. SNM-840 has been amended so that fissile solutions from the boildown unit can be transferred and stored in storage tanks 10-42A and 10-42B. Further the license has also been amended so that the fissile waste solutions may also be stored in the interim storage area on the laboratory floor in polyethylene bottles supported inside 55 gallon drums.

As there are no DOT special permit packages authorized for solutions of the type handled in our laboratory, we have applied to DOT and the AEC for authorization to use a shipping container specifically specified for our type of solution. We have not received such authorizations to date and accordingly all waste fissile solutions are being stored in either tanks 10-42A and 10-42B or in the interim storage area. Operations that generate waste solutions have been terminated in the plant pending approval of the shipping containers by DOT and the AEC.

Violation 5 - 10 CFR 70-41(a) "Authorized use of special nuclear material," requires that possession and use of special nuclear materials be limited to the locations

and purposes authorized in this license.

Contrary to this requirement, at the time of the inspection both concentrated and dilute fissile solutions, in a common array of both DOT specification and internally-designed containers were stored on the floor of the fabrication laboratory, without authorization under AEC License No. SNM-840.

AEC License SNM-840 has been amended to permit storage in tanks 10-42A and 10-42B and in an internally designed container in the interim storage area. Fissile solutions now are only stored in approved locations and for purposes authorized by AEC License No. SNM-840.

W. R. GRACE & CO.
RESEARCH DIVISION



Washington Research Center, Clarksville, Maryland 21029

February 28, 1973

Mr. James P. O'Reilly
Director
USAEC
Directorate of Regulatory Operations
Region 1
970 Broad Street
Newark, New Jersey 07102

Dear Mr. O'Reilly:

This is an additional response to your letters of January 16 and 18, 1973. You will find attached to this letter responses to the safety items brought to our attention from Mr. Epstein's inspection of December 12-14, 1972, and from Mr. Cooley's inspection of November 29-30 and December 1, 1972.

Should you have questions concerning these responses, we will be pleased to discuss them with you.

Sincerely,

A handwritten signature in dark ink, appearing to read "G. E. Ashby", is written over the typed name.

G. E. Ashby
Vice President
Nuclear

GEA:srh

Attachments

Response to Safety Items Noted in
Enclosure II of AEC Letter Dated 1/16/73
Docket No. 70-456

1. Grace has established as a formal requirement that the Radiation Protection Officer be notified immediately when a non-standard operation is to be performed. If such an operation is not covered by an approved SOP or if containment is to be breached or might be breached in a manner not covered by an SOP, a temporary procedure will be written and approved by the Nuclear Safety Committee before the operation will be started. In all cases of non-standard operations, the activity will be monitored by radiation safety personnel.
2. Our procedure is to present to the Nuclear Safety Committee all instances of equipment deficiencies for analysis and all proposed equipment modifications for approval. If conditionally approved by the Committee, the equipment modifications are made and preoperational tests are conducted. During the preoperational tests those parameters considered critical are measured or monitored to determine if the design parameters or the SOP's used meet the health and safety requirements. Final approval by the Nuclear Safety Committee will be based upon the results from the preoperational tests.

GEA
2/28/73

Response to Safety Items Noted in
Enclosure No. 2 of AEC Letter Dated 1/18/73
Docket No. 70-456

1. All flammable materials have been removed from areas where fissile materials are stored.
2. All storage racks have been firmly secured against displacement or in one case when this was not feasible the rack has been removed from the facility.
3. The storage racks have been inspected to determine if positive retention of fissile material is provided. In some cases, design changes of the storage racks were necessary. All storage racks now provide positive retention of fissile material.

MAR 13 1973

W. R. Grace and Company
Attention: Mr. G. E. Ashby,
Vice President
Research Division
Washington Research Center
Clarksville, Maryland 21029

Docket No. 70-456

References: Your letters dated February 7, 1973 and February 28, 1973
In response to our letter dated January 16, 1973

Gentlemen:

Thank you for your letters informing us of the action you have taken to correct the violations of AEC requirements and the items that were not in accordance with appropriate safety practices which we brought to your attention following our inspection of your licensed program. Your corrective action will be verified during our next inspection of your program.

In accordance with Section 2.790 of the AEC's "Rules of Practice," Part 2, Title 10, Code of Federal Regulations, a copy of this letter and the enclosed inspection report will be placed in the AEC's Public Document Room. If this report contains any information that you (or your contractors) believe to be proprietary, it is necessary that you make a written application within 20 days to this office to withhold such information from public disclosure. Any such application must include a full statement of the reasons on the basis of which it is claimed that the information is proprietary, and should be prepared so that proprietary information identified in the application is contained in a separate part of the document. If we do not hear from you in this regard within the specified period, the report will be placed in the Public Document Room.

Your cooperation with us is appreciated.

Sincerely,

James P. O'Reilly
Director

Enclosure:
RO Inspection Report

ITEM # 264

OFFICE ▶	CRESS I					
SURNAME ▶	Epstein:dw	Smith	Carlson	Nelson	O'Reilly	
DATE ▶	3-12-73	3-12-73		3/13/73		

- 2 -

bcc: RO Chief, Materials & Fuel Facilities Branch, (2)
RO:HQ (4)
L:D/D for Fuels & Materials
DR Central Files
PDR
NSIC
State of Maryland

W. R. GRACE & CO.

RESEARCH DIVISION



Washington Research Center, Clarksville, Maryland 21029

February 7, 1973

Mr. James P. O'Reilly
Director
USAEC
Directorate of Regulatory Operations
Region 1
970 Broad Street
Newark, New Jersey 07102

Dear Mr. O'Reilly:

The attachment is our reply to your letter of January 16, 1973, in which you list the violations found by Mr. Epstein's inspection on December 12-14, 1973, of activities authorized by AEC License No. SNM 840.

Should you have questions concerning this reply, we will be pleased to discuss them with you.

Sincerely,

G. E. Ashby
Vice President
Nuclear

GEA:srh
Attachment

Explanation in Reply to Violations
Reported from the December 12-14, 1972, Inspection
of Activities Authorized by AEC License No. SNM-840

Violation 1 - License Condition 8(B), License Application dated April 8, 1970, page 36(A), paragraph 8.6, requires decontamination of restricted areas when contamination levels exceed stated action guides.

Contrary to this requirement, fixed contamination in the vicinity of the dialysis and dissolver unit constantly exceeded the action guide of 10,000 cpm alpha activity and had not been decontaminated.

The fixed contamination in the vicinity of the dialysis and dissolver units has been decontaminated to below the action guide of 10,000 cpm alpha activity.

The following corrective actions have also been taken:

- (1) Personnel have been reinstructed and procedural changes have been made to assure that if contamination levels exceed the action guide of 10,000 cpm alpha activity at any location, the location will be isolated immediately and decontaminated. Operating personnel will not be permitted to use the area until decontamination is completed and the area released by the Radiation Protection Officer for use.
- (2) The Engineering Department will review each instance of contamination to determine the probable cause and to determine if equipment or procedural changes are required to avoid contamination in the future.
- (3) For routine operations the Radiation Safety Services personnel will monitor

2/7/73
GEA

for contamination in frequent intervals. For infrequent operations or for any operation where the potential for breaching of containment has been identified, operating personnel are now required to notify the Radiation Protection Officer in advance of the operation and in sufficient time so that appropriate monitoring will be in use during that specific operation.

Violation 2 - License Condition 8(B), License Application dated April 8, 1970, page 10 and 11, paragraph 6.15, requires that operating personnel take prompt action to correct any hazardous condition or noncompliance noted by the Radiation Safety Officer.

Contrary to this requirement, operating personnel did not correct the conditions causing the high contamination existing around process equipment, nor did they take any action to decontaminate these areas. They also did not correct the conditions noted in monthly audits made by the Nuclear Safety Committee.

As indicated above, we have reinstructed our personnel and made procedural changes to assure that if contamination levels exceed the action level of 10,000 cpm alpha activity at any location that location will be isolated immediately and decontaminated. No use of the equipment or the area around the equipment will be permitted until decontamination has been completed and the Radiation Protection Officer has released the area for use by operating personnel.

With regard to the monthly audits of the Nuclear Safety Committee, an action plan will be implemented by the Engineering Department after each audit. This action plan will deal with each condition noted by the Committee on an item-by-item basis. The action plan will be in writing within two working days after the committee report is issued. Implementation of the action plan will begin as soon as possible and a written progress report will be submitted to the Nuclear Safety Committee for review at the Committee's next monthly meeting.

Violation 3 - 10 CFR 20.201(b), "Surveys," requires you to make such surveys as may be necessary for you to comply with all sections of Part 20.

Contrary to this requirement, you failed to make such surveys as were necessary to assure compliance with 10 CFR 20.103, "Exposure of individuals to concentrations of radioactive materials in restricted areas."

- a. Specifically, no surveys had been made to determine the concentrations in air to which employees were exposed when containment was broken approximately once each week of a dialysis unit or when containment was broken on the particle formation unit.
 - b. Specifically, such surveys as were performed in other areas were inadequate in that the devices used collected air at waist level and not in the breathing zones of persons performing operations.
 - c. Specifically, the evaluation of the exposure that eleven persons received as a result of a reported incident involving the release of radionuclides to a restricted area was inadequate in that the results of air particulate surveys taken twenty to twenty-five feet away from the source of the release were included and averaged to give the final result. Also the samples of feces and urine were of too small a quantity and submitted too late to provide an analysis for an adequate evaluation.
-
- a. Since Mr. Epstein's inspection in December, surveys have been made of the potential employee exposures for those operations (1) when containment is broken at the dialysis unit and (2) when containment is broken at the particle formation unit. No hazard was found.
 - b. The air sampling device we have used in the past has a telescopic attachment for adjusting the position of the

samples to variable breathing zone heights. To the best of our knowledge and belief these adjustments were made correctly whenever the devices were used and no samples were collected at waist level. We note that the units are stored in the "telescoped" position and might be observed in that configuration when in stand-by status. Our records were inadequate, however, as they did not reveal as a written record the height of the samples tube when airborne samples were collected. Accordingly, our procedures have been changed so that a written record is made of all sample heights when airborne samples are taken.

In addition, our air monitoring capability has been improved by adding personal air monitors to our equipment complement. These devices will be used to resurvey the operations previously surveyed using the telescopic sampling tube.

- c. The inadequacies of the evaluation of the reported incident have been considered in detail. As a result, radiation safety personnel have been issued written instructions describing the investigative and diagnostic actions to be taken when hazardous amounts of airborne contamination are suspected to be present. These new procedures are believed to be more than adequate for evaluation of exposure, if such an exposure should be encountered in a future incident. These procedures assure proper air particulate surveys as well as proper feces and urine samples.

As a general comment, we are now placing greater emphasis on airborne contamination and operating experience when making our surveys. In addition, we are requiring as part of all surveys a review by the Nuclear Safety Committee with approval by the Committee contingent upon the Committee's decision that the survey meets the requirements of 10 CFR 20.

Violation 4 - License Condition 8(B), License Application dated April 8, 1970, page 31, Table 7.23 describes the equipment to perform continuous air sampling. Page 36 also states that continuous air sampling is performed.

Contrary to this requirement continuous air sampling of air in the production area had not been performed from March 15, 1972 to December 14, 1972.

Continuous sampling of air in the restricted area of the Nuclear Facility was established on December 14, 1972. Samplers are situated to sample air in the vicinity of the breathing zone for personnel who are doing process operations. When processing is not in progress, these samplers are used to measure the activity in the ambient air of the Facility at breathing-zone level as specified in our SNM License.

No activity in excess of the applicable MPC_a has been detected since continuous sampling was begun on 14 December 1972. The maximum concentration which we have measured occurred during a sintering operation and equaled 48% MPC_a. The average of 61 determinations of air activity concentration (24 hour samples) made at various points in the restricted area of the Nuclear Facility since 14 December 1972 equaled 5.3% MPC_a.

Violation 5 - License Condition 8(B), License Application dated April 8, 1970, page 9, paragraph 6.10, requires that verbal or written instructions be issued to those persons not performing normal operations.

Contrary to this requirement, two persons on October 6, 1972, broke containment on a gas fluidized bed reactor releasing contained materials to the immediate restricted area without verbal or written instructions having been provided.

The SOP's used during processing instruct the operators to consult their supervisor if a problem is encountered. On October 6 the operators contacted the Facility Foreman by telephone prior to breaking containment and received verbal instructions from the Foreman. The Foreman did not understand that the verbal instructions which he had given might lead to airborne contamination.

The equipment involved has now been redesigned so that breaking of containment is not possible when following the same instructions. Further, we have established a policy of avoiding verbal instructions wherever possible. The present SOP's are being revised to minimize the occasions where verbal instructions might be required. We have also instructed the operators to make a written note of all verbal instructions in the shift log book in order to retain a permanent record of verbal instructions.

W. R. GRACE & CO.



RESEARCH DIVISION

Washington Research Center, Clarksville, Maryland 21029

February 28, 1973

Mr. James P. O'Reilly,
Director
USAEC
Directorate of Regulatory Operations
Region 1
970 Broad Street
Newark, New Jersey 07102

Dear Mr. O'Reilly:

This is an additional response to your letters of January 16 and 18, 1973. You will find attached to this letter responses to the safety items brought to our attention from Mr. Epstein's inspection of December 12-14, 1972, and from Mr. Cooley's inspection of November 29-30 and December 1, 1972.

Should you have questions concerning these responses, we will be pleased to discuss them with you.

Sincerely,

G. E. Ashby
Vice President
Nuclear

GEA:srh

Attachments

COPY

Response to Safety Items Noted in
Enclosure II of AEC Letter Dated 1/16/73
Docket No. 70-456

1. Grace has established as a formal requirement that the Radiation Protection Officer be notified immediately when a non-standard operation is to be performed. If such an operation is not covered by an approved SOP or if containment is to be breached or might be breached in a manner not covered by an SOP, a temporary procedure will be written and approved by the Nuclear Safety Committee before the operation will be started. In all cases of non-standard operations, the activity will be monitored by radiation safety personnel.

2. Our procedure is to present to the Nuclear Safety Committee all instances of equipment deficiencies for analysis and all proposed equipment modifications for approval. If conditionally approved by the Committee, the equipment modifications are made and preoperational tests are conducted. During the preoperational tests those parameters considered critical are measured or monitored to determine if the design parameters or the SOP's used meet the health and safety requirements. Final approval by the Nuclear Safety Committee will be based upon the results from the preoperational tests.

COPY

Response to Safety Items Noted in
Enclosure No. 2 of AEC Letter Dated 1/18/73
Docket No. 70-456

1. All flammable materials have been removed from areas where fissile materials are stored.
2. All storage racks have been firmly secured against displacement or in one case when this was not feasible the rack has been removed from the facility.
3. The storage racks have been inspected to determine if positive retention of fissile material is provided. In some cases, design changes of the storage racks were necessary. All storage racks now provide positive retention of fissile material.

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COPY

Elwood

five
5/15/74

APR 18 1973

To the Files

APRIL 16 CONFERENCE WITH ASHBY AND HERBST OF W. R. GRACE AND COMPANY, CLARKSVILLE, MARYLAND - DOCKET 70-456

This meeting, proposed by W. R. Grace and Company and scheduled by FFRB commenced at 10:00 a.m. in Room 100 of the Woodmont Building. In attendance were G. E. Ashby, Vice President, and R. J. Herbst, SS Representative, who represented W. R. Grace & Co., and J. C. Delaney, R. J. Dube, and E. J. Frederick, who represented FFRB. The subject of the meeting was the termination of Special Nuclear Material License No. SNM-840.

Ashby summarized the current status of the Clarksville Operation as follows:

All fuel fabrication operations have been terminated, and the uranium removed from the system. There is, at the present time, 70 kg. U-235 in storage on the site. Of this quantity, 60 kg. is in the form of scrap. Bids have been received from NFS, NUMEC, and United Nuclear for recovery of the SNM; NFS appears to be the low bidder. Grace expects to have the scrap removed from the site by mid-May. The remaining 10 kg. will be shipped to KAPL at about the same time.

The process equipment has measurable contamination on both the internal and external surfaces.

Grace is hopeful that they can sell the process equipment to another licensee. United Nuclear, NFS, NUMEC, Westinghouse, Astro Nuclear, and Electro-Nuclear have expressed an interest. United Nuclear appears to be the best prospect at this time. If a sale is consummated with them, the equipment will most likely be installed

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SURNAME >						
DATE >						
ITEM #			<u>265</u>			

To the Files

- 2 -

Distribution:

CRouse

RJDube

JCDelaney

✓EJFrederick

L:FM R/F Docket File

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at their Woodriver Junction Facility. If the equipment cannot be sold, it may be crated up and sent to a licensed burial ground for disposal. It's likely that the fate of the process equipment won't be known until sometime in July or August.

Grace was instructed that in order to terminate their license they would have to meet the contamination limits set forth in "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material" dated April 22, 1970. If contamination levels cannot be reduced to this level, the existing license can be amended, upon request, to cover only storage of SNM material. The quantity of material remaining on-site in the form of contamination will probably be low enough to permit licensing by the state. However, it was recommended by us that a possession limit in excess of 350 gms. be requested in order that the license remains under Fuel Fabrication and Reprocessing Branch control. Another option that can be considered in the event it becomes desirable to amend the license after the SNM material is removed from the site but before the equipment removal and/or decontamination is complete, is to write an amendment to cover decontamination operations and storage of special nuclear material.

The existing license permits a possession limit of 25 gm. Pu. Grace indicated that they have received but one shipment of Pu; the shipping container was never opened and has since been removed from the site. Accordingly, they have conducted no work with Pu.

Grace has a source materials license for depleted uranium and thorium with the State of Maryland. They were instructed that in order to terminate that license they would have to satisfy the requirements of the State of Maryland.

The annual application fees were paid in November 1972. As a result, there is adequate time for Grace to pursue the course of action they consider most beneficial.

13/
E. J. Frederick
Fuel Fabrication and Reprocessing
Branch

OFFICE ▶	L:FFR	Directorate of Licensing			
SURNAME ▶	EJFrederick:slm				
DATE ▶	4/ /73				

U.S. ATOMIC ENERGY COMMISSION
REGULATORY OPERATIONS - STATISTICAL DATA

A F	A. DOCKET NUMBER (9) (1-8) 70000456	B. REPORT NUMBER (10-13) 7203	C. PRIORITY/ CATEGORY (14) 1	D. INQ/INSPECTION/INVESTIGATION DATES (15) FROM (16-21) TO (22-27) 121272 121472	F. REGION CONDUCTING ACTIVITY: (28) 1
LICENSEE/VENDOR W.R. Grace and Company			FACILITY Clarksville, Maryland		LICENSE NUMBER SNM-840
G. ACTIVITY CONDUCTED: (29) 1 <input checked="" type="checkbox"/> INSPECTION 2 <input type="checkbox"/> INQUIRY 3 <input type="checkbox"/> INVESTIGATION 4 <input type="checkbox"/> VENDOR INSPECTION 5 <input type="checkbox"/> MANAGEMENT VISIT 6 <input type="checkbox"/> INQUIRY-NON LICENSEE					
H. INSPECTION/INVESTIGATION RESULTS: (30) 1 <input type="checkbox"/> 591 2 <input checked="" type="checkbox"/> REGIONAL OFFICE LETTER 3 <input type="checkbox"/> REFERRED TO HQS FOR ACTION 4 <input type="checkbox"/> REGIONAL OFFICE LETTER & REFERRED TO HQS FOR ACTION					
J. INSPECTION/INVESTIGATION FINDINGS: (31) 1 <input type="checkbox"/> CLEAR 2 <input type="checkbox"/> SAFETY ITEM 3 <input checked="" type="checkbox"/> NONCOMPLIANCE 4 <input type="checkbox"/> NONCONFORMANCE					
K. FIELD ACTION AS A RESULT OF INQUIRY (32) 1 <input type="checkbox"/> CONDUCT INVESTIGATION 2 <input type="checkbox"/> REVIEW NEXT INSPECTION 3 <input type="checkbox"/> REFER TO OTHER REGION 4 <input type="checkbox"/> REFER TO NON-REG. AUTH. 5 <input type="checkbox"/> REFER TO OTHER REG. OFFICE 6 <input type="checkbox"/> HQS FOR ACTION 7 <input type="checkbox"/> NO FURTHER ACTION					
L. REASON INSP. FINDINGS REFERRED TO HEADQUARTERS FOR ACTION: (33-34)		M. SUBJECT OF INQUIRY OR INVESTIGATION (35-36)		N. HEADQUARTERS ACTION ON INSPECTION AND INVESTIGATION (37-38)	
01 <input type="checkbox"/> IMMEDIATE THREAT TO HEALTH AND SAFETY COMPLEX ITEM INVOLVING: 02 <input type="checkbox"/> NONCOMPLIANCE/NONCONFORMANCE 03 <input type="checkbox"/> LICENSING PROBLEM 04 <input type="checkbox"/> POLICY MATTER 05 <input type="checkbox"/> INTERPRETATION 06 <input type="checkbox"/> SAFETY ITEM 07 <input type="checkbox"/> MANAGEMENT DEFICIENCY 08 <input type="checkbox"/> INADEQ. REPLY TO LETTER 09 <input type="checkbox"/> NO REPLY TO LETTER 10 <input type="checkbox"/> NO CORRECTIVE ACTION PLANNED 11 <input type="checkbox"/> INADEQUATE CORRECTIVE ACTION PLANNED 12 <input type="checkbox"/> HQS LETTER REQUIRED 13 <input type="checkbox"/> HQS REVIEW REQUIRED 14 <input type="checkbox"/> UNREVIEWED SAFETY MATTER 15 <input type="checkbox"/> DESIGN CHANGE 16 <input type="checkbox"/> OTHER 17 <input type="checkbox"/> 18 <input type="checkbox"/> 19 <input type="checkbox"/>		01 <input type="checkbox"/> TYPE A INT. OVEREXPOSURE 02 <input type="checkbox"/> TYPE A EXT. OVEREXPOSURE 03 <input type="checkbox"/> TYPE A RELEASE 04 <input type="checkbox"/> TYPE A LOSS OF FACILITY 05 <input type="checkbox"/> TYPE A PROPERTY DAMAGE 06 <input type="checkbox"/> TYPE B INT. OVEREXPOSURE 07 <input type="checkbox"/> TYPE B EXT. OVEREXPOSURE 08 <input type="checkbox"/> TYPE B RELEASE 09 <input type="checkbox"/> TYPE B LOSS OF FACILITY 10 <input type="checkbox"/> TYPE B PROPERTY DAMAGE 10 CFR 20.405 11 <input type="checkbox"/> INTERNAL OVEREXPOSURE 12 <input type="checkbox"/> EXTERNAL OVEREXPOSURE 13 <input type="checkbox"/> EXCESSIVE RADIATION LEVELS 14 <input type="checkbox"/> EXCESSIVE CONCENTRATION LEVELS 15 <input type="checkbox"/> CRITICALITY 16 <input type="checkbox"/> LOSS OR THEFT 17 <input type="checkbox"/> CONTAMINATION 18 <input type="checkbox"/> UNSAFE OPERATION 19 <input type="checkbox"/> FIRE, EXPLOSION 20 <input type="checkbox"/> HUMAN (OPERATOR) ERROR 21 <input type="checkbox"/> COMPLAINT 22 <input type="checkbox"/> PUBLIC INTEREST 23 <input type="checkbox"/> LEAKING SOURCE 24 <input type="checkbox"/> TRANSPORTATION 25 <input type="checkbox"/> EXPIRED LICENSE 26 <input type="checkbox"/> EXPOSURE REPORTED AND FOUND INVALID. 27 <input type="checkbox"/> CONSTRUCTION/EQUIP. DEFICIENCY 28 <input type="checkbox"/> EQUIPMENT FAILURE 29 <input type="checkbox"/> EXCEED LIC/TECH SPEC REQ'S 30 <input type="checkbox"/> DEPARTURE FROM FSAR/TS'S 31 <input type="checkbox"/> OTHER		01 <input type="checkbox"/> NO ACTION REQUIRED 02 <input type="checkbox"/> LETTER-CLEAR 03 <input type="checkbox"/> LETTER-NONCOMPLIANCE 04 <input type="checkbox"/> LETTER-SAFETY ITEM 05 <input type="checkbox"/> PART 2 NOTICE 06 <input type="checkbox"/> PART 2 NOTICE AS RESULT OF FOLLOWUP TO REGIONAL OFFICE LETTER 07 <input type="checkbox"/> ORDER 08 <input type="checkbox"/> REFER TO RL FOR RESOLUTION 09 <input type="checkbox"/> REFER TO RL FOR INFORMATION 10 <input type="checkbox"/> REFER TO ML FOR RESOLUTION 11 <input type="checkbox"/> REFER TO ML FOR INFORMATION 12 <input type="checkbox"/> REFER TO REGION TO CLOSE OUT 13 <input type="checkbox"/> OTHER	
O. REGIONAL OFFICE ACTION DATES (39-44) 011873					
P. REPORT SENT TO HEADQUARTERS (45-50) 011773					
Q. DATE LETTER, NOTICE, ORDER ISSUED (51) 011773					
R. REPLY NOT REQUIRED (52) 030573					
S. LICENSEE REPLY RECEIVED (53) 021273					
T. REPLY INADEQUATE (54) 1 <input type="checkbox"/>					
U. DATE LICENSEE REPLY RECEIVED (55-60)					
V. REPLY NOT REQUIRED (61) 1 <input type="checkbox"/>					
W. CARD CODE (62) 1 <input type="checkbox"/>					

E. Epstein

A. DOCKET NUMBER (1-8) <div style="border: 1px solid black; width: 100px; height: 20px; margin-top: 5px;"></div> (9) <div style="border: 1px solid black; width: 20px; height: 20px; float: right; margin-top: -20px;"></div>	B. REPORT NUMBER (10-13) <div style="border: 1px solid black; width: 60px; height: 20px; margin-top: 5px;"></div>
W. CIVIL PENALTY IMPOSED (14) 1 <div style="border: 1px solid black; width: 20px; height: 20px; margin-left: 10px;"></div>	X. TOTAL AMOUNT OF FINE (15-20) <div style="border: 1px solid black; width: 100px; height: 20px; margin-top: 5px;"></div>
G. ACTIVITY CONDUCTED (29) <div style="display: flex; justify-content: space-between; font-size: small;"> 1 <input type="checkbox"/> INSPECTION 2 <input type="checkbox"/> INQUIRY 3 <input type="checkbox"/> INVESTIGATION 4 <input type="checkbox"/> VENDOR INSPECTION 5 <input type="checkbox"/> MANAGEMENT VISIT 6 <input type="checkbox"/> INQUIRY-NON-LICENSEE </div>	
Y. SPECIFIC VIOLATIONS (1st ten listed by code no.) (30-52) <div style="display: grid; grid-template-columns: repeat(5, 1fr); gap: 10px;"> <div style="border: 1px solid black; width: 40px; height: 20px;"></div> <div style="border: 1px solid black; width: 40px; height: 20px;"></div> <div style="border: 1px solid black; width: 40px; height: 20px;"></div> <div style="border: 1px solid black; width: 40px; height: 20px;"></div> <div style="border: 1px solid black; width: 40px; height: 20px;"></div> <div style="border: 1px solid black; width: 40px; height: 20px;"></div> <div style="border: 1px solid black; width: 40px; height: 20px;"></div> <div style="border: 1px solid black; width: 40px; height: 20px;"></div> <div style="border: 1px solid black; width: 40px; height: 20px;"></div> <div style="border: 1px solid black; width: 40px; height: 20px;"></div> </div> <div style="margin-top: 10px;"> <input type="checkbox"/> (Check if more than 10 violations) </div>	
<p><i>Viol.</i></p> <p>Lic Card B(B). Lic Appl. 4/8/70 pg 36 A (Excessive contamination)</p> <p>Lic Card B(B) " " " 10 E 11 (failure to correct noncompliance)</p> <p>Lic Card B(B)</p> <p>20.201(b) re 20.103</p> <p>Lic Card B.B. Lic Appl. 4/8/70 Pg 9 TP 6.10</p> <p style="text-align: center;"><i>INSTRUCTIONS TO PERSONS PERFORMING NON-ROUTINE FUNCTIONS</i></p> <p>Safety Items</p> <p style="margin-left: 40px;">Notification trans. Health & Safety when non routine operations are to be performed</p> <p style="margin-left: 40px;">failure to appreciate or evaluate deficiencies in process equipment.</p>	
CARD CODE (80) 2 <div style="border: 1px solid black; width: 20px; height: 20px; margin-left: 10px;"></div>	

In reply refer to:
RO:MPPB
70-456

MAY 21 1973

W. R. Grace & Company
Washington Research Center
ATTN: Dr. G. E. Ashby, Vice President
Research Division
Clarksville, Maryland 21029

Gentlemen:

This refers to the inspection conducted by Messrs. H. Bartz and E. Woltner from our Region I Office, Directorate of Regulatory Operations, on January 2-4, 1973, of the safeguards control provided by your company over the special nuclear material possessed pursuant to AEC License Nos. SNM-840. This also refers to the discussion of our findings held by Mr. Bartz with Dr. R. J. Herbst of your staff at the conclusion of the inspection.

During the inspection it was found that certain of your activities were not conducted in full compliance with the conditions of the safeguards amendment to your license and the physical protection requirements of the AEC's "Physical Protection of Special Nuclear Material," Part 73, Title 10, Code of Federal Regulations.

The activities and reference to the pertinent requirements of 10 CFR 73 are listed in the enclosure to this letter. Since the enclosure discusses security measures used for the physical protection of your facility, it is being withheld from public disclosure pursuant to 10 CFR 2.790(d). The activities and references to the pertinent conditions of the safeguards amendment to your license are as indicated below:

1. License Condition No. 3.2 requires that you maintain a program of standardizations and calibrations of measurement equipment and analytical procedures in order to provide data to substantiate the limits of error associated with all measurements required for safeguards purposes.

Contrary to the above, you failed to maintain a calibration program for the scales and balances used for safeguards measurements.

ITEM # 266

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MAY 21 1973

2. License Condition No. 3.5 requires that you promptly notify the AEC if the quantity of the material unaccounted for (MUF) exceeds the associated limits of error. Also this same condition requires that you investigate the MUF and submit a written report to the AEC within thirty (30) days after the initial notification specifying the probable reasons for the MUF and the corrective action taken or planned.

Contrary to the above, you failed to submit a written report of the significant MUF determined as a result of the physical inventory taken on January 1, 1973.

3. License Condition No. 7.3 requires that you submit a monthly report of all intentional discards and material unaccounted for to the AEC within fifteen (15) days after the end of the month the discard was made or MUF determined.

Contrary to the above, you failed to submit intentional discard and MUF reports as required.

This notice is sent to you pursuant to the provisions of §2.201 of the AEC's "Rules of Practice," Part 2, Title 10, Code of Federal Regulations. Section 2.201 requires you to submit to this office within twenty (20) days of this notice, a written statement or explanation in reply including: (1) corrective steps which have been taken by you, and the results achieved; (2) corrective steps which will be taken to avoid further violations; and (3) the date when full compliance will be achieved.

Sincerely,

[Signature]
Donald F. Knuth, Deputy Director
for Field Operations
Directorate of Regulatory Operations

Enclosure:
As Stated

bcc: M&PPB Reading, w/encl
M&PPB File, w/encl
DFKnuth, w/encl
RO-I, w/encl
WGMartin, RO-I, w/encl

SHSmiley, L, w/encl
PDR, w/o encl
Docket No. 70-456, w/encl
ELM File, w/encl

OFFICE ▶	M&PPB:RO	M&PPB:RO	RO	RO		
SURNAME ▶	ELMay:leg	WJD'Amico	JGDavis	DFKnuth		
DATE ▶	5/15/73	5/16/73	5/17/73	5/18/73		

ENCLOSURE

Materials and Plant Protection Findings
W. R. Grace and Company
(Docket No. 70-456)

As a result of the inspection conducted on January 2-4, 1973, it was found that one of your activities was not conducted in full compliance with the physical protection requirements of the AEC's "Physical Protection of Special Nuclear Material," Part 73, Title 10, Code of Federal Regulations, as indicated below:

10 CFR 73.31(a), "Physical Protection of Special Nuclear Material in Transit," requires in part that all shipments of special nuclear material subject to 10 CFR 73 be transported in the continuous personal custody of an authorized individual or under established procedures of a common or contract carrier which provides a system for the physical protection of valuable material in transit and requires an exchange of hand-to-hand receipts at origin and destination and at all points en route where there is a transfer of custody. 10 CFR 73.31(b) requires that you notify the consignee of the time of departure of the shipment and confirm with the consignee the method of transportation and the estimated time of arrival of the shipment at its destination.

Contrary to the above, shipments identified as ZXM-ZQM-1, ZXM-ZWT-3, and ZXM-ZWT-4 were not protected in transit as required.

W. R. GRACE & CO.

GRACE

RESEARCH DIVISION

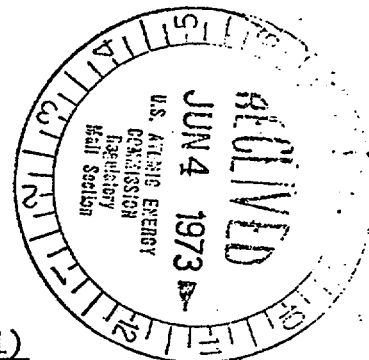
WASHINGTON RESEARCH CENTER
7379 ROUTE 32, COLUMBIA, MARYLAND 21044
Telephone 301 - 531-5711

May 30, 1973

Director, Division of Materials
Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Sir:

Re: Notification per 10 CFR 71.7 (b) (iii)



Please register

W. R. Grace & Co.
Washington Research Center
7379 Route 32
Columbia, Maryland 21044

SNM License No. 840

as a user of shipping container, Model No. UNC 1484, which is
licensed [SNM 33 (71-25)] to be used for the delivery of licensed
material to a carrier for transport by

Gulf-United Nuclear Fuels Corp.
P. O. Box 107
Hematite, Missouri 63047

Thank you.

Very sincerely,

Richard J. Herbst
Richard J. Herbst

RJH:srh

ITEM # 267

3593

B/266

MEMO ROUTE SLIP Form AFC-92 (Rev. May 14, 1947) ITEM 0240		See me about this. Note and return.	For reference. For signature.	For action. For information.
TO (Name and unit)	INITIALS	REMARKS		
H. D. Thornburg, Chief, FS&EB		RO INSPECTION REPORT NO. 70-456/73-02		
	DATE	W. R. GRACE AND COMPANY		
		CLARKSVILLE, MARYLAND		
TO (Name and unit) cc: RO:IIQ (4) L:D/D for Fuels & Materials DR Central Files Regional Directors,	INITIALS	REMARKS		
		The subject inspection report is forwarded		
	DATE	for your information. Distribution will		
		be made by this office to the PDR, NSIC		
TO (Name and unit) RO:II, RO:III	INITIALS & RO:V	REMARKS		
		and State representatives after review by		
	DATE	the licensee for proprietary information.		
FROM (Name and unit)	REMARKS			
H. W. Crocker, RO:I				
PHONE NO.	DATE			
	6/8/73			

USE OTHER SIDE FOR ADDITIONAL REMARKS

GPO : 1971 O - 445-469

ITEM # 268

B/267

(12)

U. S. ATOMIC ENERGY COMMISSION

DIRECTORATE OF REGULATORY OPERATIONS

REGION I

RO Inspection Report No.: 70-456/73-02

Docket No.: 70-456

Licensee: W. R. Grace Company

License No.: SNM-840

Grace/Nuclear Division

Priority: 1

Category: A(1)

Location: Clarksville, Maryland

Type of Licensee: Fuel Fabrication

Type of Inspection: Routine - unannounced

Dates of Inspection: May 16-17, 1973

Dates of Previous Inspection: December 12-14, 1973

Reporting Inspector: H. W. Crocker

Sr. Fuel Facilities Inspector

June 5, 1973
Date

Accompanying Inspectors: _____

Date

Date

Other Accompanying Personnel: _____

Reviewed by: R. T. Carlson

R. T. Carlson, Chief
Facility Operations Branch

6/6/73
Date

SUMMARY OF FINDINGS

Enforcement Action

- A. Violation - Failure of the Nuclear Safety Committee to perform inspection of the plant operations in March and April, 1973.

Licensee Action on Previously Identified Enforcement Items

- A. Item No. 1 of the licensee's letter dated February 8, 1973, to Directorate of Regulatory Operations, RO:I, described corrective action relating to the requirement for the Nuclear Safety Committee investigation of incident. The inspector verified the licensee's action. (Details, Paragraph 5e)
- B. Item No. 2 of the licensee's February 8 letter describes corrective action taken concerning the performance of uranium solution dilution operations without approved written procedures and improper storage fissile materials. The inspector verified that the dilution operation was terminated and that the storage violations have been corrected. (Details, Paragraphs 5a and 5c)
- C. Item No. 3 of the licensee's February 8 letter describes the licensee's actions concerning specific criticality and radiological safety procedures. The inspector verified the corrective action. (Details, Paragraph 5f)
- D. Item No. 4 of the licensee's February 8 letter describes corrective action concerning transfer of fissile solutions from the boil down system. The inspector verified the licensee's corrective action. (Details, Paragraph 5c)
- E. Item No. 5 of the licensee's February 8 letter describes corrective action concerning storage of fissile solutions. The inspector verified the corrective action. (Details, Paragraph 5d)
- F. Item No. 1 of the licensee's letter dated February 7, 1973, to Directorate of Regulatory Operations, RO:I, described corrective action relating to abnormally high levels of fixed contamination in the uranium processing area. The inspector verified the corrective action. (Details, Paragraph 5g)
- G. Item No. 2 of the licensee's February 7 letter describes corrective action concerning actions to correct hazardous conditions or non-compliance observed by the Radiation Safety Officer. The inspector verified the corrective action. (Details, Paragraph 5h)

- H. Item No. 3 of the licensee's February 7 letter describes corrective action concerning surveys of airborne uranium concentrations. The inspector verified the corrective action. (Details, Paragraph 5i)
- I. Item No. 4 of the licensee's February 7 letter describes corrective action concerning continuous air sampling in the uranium processing area. The inspector verified the corrective action. (Details, Paragraph 5j)
- J. Item No. 5 of the licensee's February 7 letter describes corrective action concerning instructions to persons performing non-routine operations. The inspector verified the corrective action. (Details, Paragraph 5k)
- K. Item No. 1 of Enclosure No. 1 to the licensee's letter dated February 28, 1973, to Directorate of Regulatory Operations, RO:I, describes corrective action relating to notification of the Radiation Protection Officer in cases of non-standard plant operations. The inspector verified the corrective action. (Details, Paragraph 5L)
- L. Item No. 2 of Enclosure No. 1 to the licensee's February 28 letter describes corrective action concerning resolution of processing equipment deficiencies. The inspector verified the corrective action. (Details, Paragraph 5m)
- M. Item No. 1 of Enclosure No. 2 to the licensee's February 28 letter describes corrective action concerning control of flammable materials in the uranium processing area. The inspector verified the corrective action. (Details, Paragraph 5a)
- N. Item No. 2 of Enclosure No. 2 to the licensee's February 28 letter describes corrective action concerning securing of fissile material storage racks to prevent displacement of the storage array. The inspector verified the corrective action. (Details, Paragraph 4b)
- O. Item No. 3 of Enclosure No. 2 to the licensee's February 28 letter describes corrective action concerning positive retention of fissile material within the storage rack. The inspector verified the corrective action. (Details, Paragraph 4c)

Unusual Occurrences

None

Other Significant Findings

A. Current Findings

The licensee has terminated uranium processing activities, is in the process of decommissioning the facility and expects to terminate all aspects of their nuclear work about July 31, 1973.

B. Status of Previously Unresolved Items

None

Management Interview

An exit interview was held with Mr. Ashby and Mr. Herbst at the conclusion of the inspection on May 17, 1973.

The gentlemen were informed of the scope of the inspection and of the violation regarding failure to make Nuclear Safety Committee inspections during March and April, 1973.

DETAILS

1. Persons Contacted

G. E. Ashby, Manager, Grace/Nuclear Division (GND)
R. J. Herbst, Manager, Operation Services (GND)
C. Lamberth, Foreman, Nuclear Production (GND)
J. J. Blouin, Supervisor, Engineering

2. Organization

The licensee's organization has been significantly modified as a result of their decision to terminate their licensed activities. Messrs. Ashby, Herbst, and Lamberth are the three remaining individuals involved in the nuclear program. Mr. Sillyman, the former Health and Safety Officer terminated for other employment. All other work force members have been assigned to other positions within the W. R. Grace Co. organization.

3. Schedules

The licensee anticipates that the remaining special nuclear material (SNM) will be shipped by June 15, 1973 and that all equipment removal and decontamination will be completed by July 30, 1973.

4. Examination of Processing and Storage Areas

- a. Examination of these areas confirmed that all SNM processing has been terminated. The licensee's processing equipment has been cleaned out and flushed with nitric acid to remove the SNM.
- b. The in-process storage racks were empty except for three appropriately stored containers. The floor storage solution array of eleven liter bottles, each centered in a 22 inch diameter drum was in accord with license conditions. Materials in the incoming storage vault were in birdcage shipping containers. Posting and labeling of materials was adequate.
- c. Criticality monitors were observed to be located according to license conditions and were operating.
- d. No new operations had been placed into service between the time of the last inspection and termination of uranium processing, based upon inspector observations and licensee statements.

5. Previously Identified Enforcement Items

- a. Examination of the incoming materials storage vault disclosed that the storage of SNM solutions and process compounds noted during the inspection of November 29 to December 1, 1972, was observed to have been terminated in accordance with the licensee statements in their letter of February 8, 1973. In addition, the unsecured fissile material storage rack and the flammable materials observed to be stored in this area during the referenced inspection have been removed.
- b. Examination of the in process storage racks confirmed that all of the racks are now equipped with positive retention devices. During the inspection of November 29 to December 1, 1972, it was noted that one such rack was not equipped with a retention device.
- c. During the inspection of November 29 to December 1, 1972, it was observed that the licensee was not packaging fissile solutions from the boil down column directly into DOT special permit packages as required by license conditions. Instead they were diluting the solutions without coverage by procedures. This practice was terminated immediately. The licensee obtained an amendment to their license on February 1, 1973 to allow transfer of boil down solution to tanks 10-42A and 10-42B for interim storage pending approval of shipping containers by the AEC and Department of Transportation (DOT). At the time of the current inspection, no such operations were being performed.
- d. During the inspection of November 29 to December 1, 1972, the licensee was observed to be storing concentrated and dilute fissile solutions on the floor of the process area without license authorization. The licensee obtained authorization for a floor storage array on February 1, 1973. At the time of the current inspection, the inspector observed that the fissile solutions were stored in accordance with the authorized license amendment.
- e. During the inspection of November 29 to December 1, 1972, the licensee was in noncompliance with license condition 8B, Section 6.9, in that the Nuclear Safety Committee did not, acting as a body, investigate and evaluate the airborne uranium occurrence reported in their letter to the Commission, dated November 7, 1972. By letter of February 8, 1973, the licensee stated that the committee had performed their function relating to the occurrence and that they will in the future without delay refer such matters to the committee. The inspector verified that no incidents requiring such action had occurred subsequent to the previous inspection.

- f. The licensee had not prepared special procedures in the areas of criticality and radiological safety at the time of the November 29 to December 2, 1972, inspection. In their letter of February 8, 1973, they described their policy which requires strict adherence to specific operational procedures which incorporate criticality and radiological safety considerations. The inspector verified that the procedures are authorized by the Nuclear Safety Committee, and do contain requirements relating to criticality and radiological safety.
- g. During the inspection of December 12 to 14, 1972, it was noted that fixed contamination in the vicinity of the dialysis and dissolver units consistently exceeded the licensee's action guide for decontamination of 10,000 cpm alpha activity, without being decontaminated. During the current inspection, the inspector's examination of the licensee's decontamination records confirmed that such levels of fixed contamination are appropriately being decontaminated and that the engineering personnel have reviewed the contamination cases to determine if equipment improvements can be provided to minimize such contamination. In addition, the records confirm that the Radiation Safety Services personnel are performing routine contamination monitoring.
- h. During the inspection of December 12 to 14, 1972, it was observed that licensee personnel did not take prompt action to correct hazardous conditions or noncompliance items noted by the Radiation Safety Officer or the Nuclear Safety Committee. The inspector verified that prompt corrective actions are taken as a result of these inspections and the information has been documented.
- i. During the December 12 to 14, 1972 inspection it was determined that no surveys of airborne uranium concentrations were made when process containment for the particle formation unit was breached, that surveys made on other occasions were not in the breathing zones of persons performing the operations, and that urine and feces samples submitted as a result of airborne uranium occurrence were too small in quantity and submitted too late to provide an analysis for adequate evaluation of personnel exposures. During the current inspection, air sampling records indicated that surveys have been made concerning recent occasions when process containment was breached. The licensee obtained breathing zone samplers for use by plant personnel. These units have now been returned to the supplier since plant operations have been terminated. The inspector observed that new instructions have been issued concerning air surveys and personnel bioassay sampling.

- j. During the inspection of December 12 to 14, 1972, it was determined that the licensee had not been performing the required continuous air sampling of the processing area during the period from March 15 to December 14, 1972. A review of the air sampling records confirmed that continuous air sampling has been provided since the December inspection.
- k. During the December 12 to 14, 1972 inspection it was determined that on October 6, 1972, two persons broke containment on a gas fluidized bed reactor releasing contained special nuclear material to the immediate restricted area without verbal or written instructions having been provided. According to the licensee's letter of February 7, 1973, the equipment was re-designed to preclude breaking of containment. At the time of the current inspection the equipment operation had been terminated and all special nuclear material removed.
- l. During the December 12 to 14, 1972 inspection it was determined that the Radiation Safety Officer was not informed when non-standard operations involving breaking of containment were performed on process equipment. During this inspection examination of process air sampling records subsequent to December 14, 1972, confirmed that the Radiation Safety Officer received notification of such operations and did provide special air sampling for the non-standard operations.
- m. During the December 12 to 14, 1972, inspection it was determined that SNM process equipment deficiencies related to the fluidized bed reactor which resulted in an incident involving excessive concentrations of airborne uranium, were not comprehensively evaluated and that appropriate equipment modifications and pre-operational tests were not provided. In their letter of February 28, 1973, the licensee stated that such evaluations and modifications will be made. The inspector's examination of modifications to operating procedures disclosed that the Nuclear Safety Committee was in the process of evaluating equipment and procedural modifications to several processing equipment pieces.

6. Facility Decommissioning Activities

- a. All processing operations were completed by the end of February, 1973. Special cleanup procedures were issued by the Nuclear Safety Committee on March 8, 1973, to govern the equipment cleanup and flushing operations. The inspector examined the procedures which were authorized and signed by the committee members. The procedures were observed to be detailed, step by step, instructions. Records indicate that the procedures were

reviewed with the concerned employees on March 9, 1973. The cleanout operations were started on March 12 and were completed by the end of the month. According to the licensee, no problems were encountered in the cleanup operations.

7. Decontamination Activities

- a. Records of smearable contamination sampling were reviewed for the period January 1 through April 26, 1973. Smear samples were taken at numerous locations in the plant at a frequency of every other day. Licensee goals were to maintain clean areas at less than 250 dpm/100 cm², and the process areas at less than 2500 dpm/100 cm². Examination of the records showed that the areas were decontaminated and maintained below these levels.
- b. Since the last inspection the licensee has given special emphasis to reducing the levels of fixed contamination around the equipment in the uranium processing areas. The licensee's action level for cleanup of such activity is 10,000 cpm/100 cm². Examination of the records for the period from January 1 through April 26, 1973, showed that the licensee has taken prompt action to decontaminate areas of excessive fixed contamination to levels below the referenced action point. Surveys for the equipment area were performed routinely on a two to three times a week basis.

8. In-Plant Air Sampling

- a. Records of in-plant, restricted area, air sampling were examined for the period from January 1 through April 26, 1973. Sampling was performed at selected areas of the processing area on a daily basis. In general the airborne concentrations were less than 5 per cent of the 1×10^{-10} uCi/cc limit. On February 13 and 16, 1973, during waste consolidation activities, work area samples of $1-1.77 \times 10^{-10}$ uCi/cc were experienced. Samples in nearby areas were normal. The occurrence was evaluated and documented. Bioassay results and air sampling data indicated that none of the employees exceeded the maximum permissible exposure level for 40 hours.
- b. Special air sampling studies were made in January to determine the levels of airborne uranium concentrations on operations at the dissolver, dialysis unit, and columns, which involved breaching of process equipment containment. No unusual levels of airborne activity were encountered.

9. Gaseous Effluents

Off gas stack sampling records were examined for the period from January 1 through April 26, 1973. The records showed that the required samples were taken and that the particulate effluent radioactivity concentrations were routinely less than ten percent of 10 CFR 20, Appendix B - Table II limits.

10. Liquid Effluents

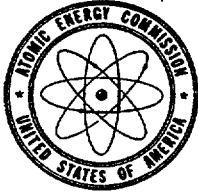
Records of liquid effluents were examined for the period from January 1 through April 26, 1973. The data showed that the effluent concentrations did not exceed ten percent of the 10 CFR 20, Appendix B - Table II limits.

11. Nuclear Safety Committee Inspections

- a. Records of the committee's inspections for the period from January 1 through May 2, 1973 were examined. The inspection records describe the scope, findings and recommendations of the committee. In the record of the February audit, the committee recommended further air surveys of specific operations involving breaching of equipment containment. These were not done because plant processing operations were terminated.
- b. The committed did not perform inspections during March and April. According to the licensee, this was an oversight, but no uranium processing was done during that period. The licensee assured the inspector that the committee inspections will be performed as required while special nuclear materials are possessed.

12. Incidents or Unusual Occurrences

There were no incidents or unusual occurrences since the last inspection according to licensee statements and the inspector's review of pertinent records.



UNITED STATES
ATOMIC ENERGY COMMISSION
DIRECTORATE OF REGULATORY OPERATIONS
REGION 1
970 BROAD STREET
NEWARK, NEW JERSEY 07102

JUN 8 1973

W. R. Grace and Company, Grace/Nuclear Division
Clarksville, Maryland
License No. SNM-840, Inspection No. 7302
Docket No. 70-456

Inspector's Evaluation

At the time of the inspection (May 16-17, 1973) the licensee had terminated their processing operations. They have about 70 kgs of U-235 in storage awaiting shipment. Disposal of the processing equipment has not been finalized. They still hope to sell the equipment to another nuclear company. Decontamination of the process area is essentially complete.

My examination of plant records convinced me that the licensee had put forth a concentrated effort to correct the violations and safety items observed during the November 29-December 1, 1972, and December 12-14, 1972, inspections.

Their failure to perform the Nuclear Safety Committee inspections during March and April, 1973 does not represent a significant hazard as all fissile materials were in storage containers and no actual processing operations were being performed. Mr. Ashby assured me that the inspections will be performed as required while fissile material is possessed.

A handwritten signature in cursive script, appearing to read "H. W. Crocker".

H. W. Crocker
Sr. Fuel Facilities Inspector

W. R. GRACE & CO.

LOCKET NO. 70-436

GRACE

RESEARCH DIVISION

WASHINGTON RESEARCH CENTER
7379 ROUTE 32, COLUMBIA, MARYLAND 21044
Telephone 301 - 531-5711

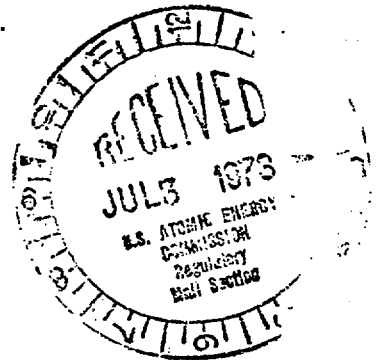
REGULATORY OPERATIONS

June 29, 1973

Director, Division of Materials
Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Sir:

Re: Notification per 10 CFR 71.7 (b) (iii)



Please register

W. R. Grace & Co.
Washington Research Center
7379 Route 32
Columbia, Maryland 21044

SNM License No. 840

as a user of shipping container, Model No. RMG-181-I, which
is licensed SNM 124(71-23) to be used for the delivery of
licensed material to a carrier for transport by

Nuclear Fuel Services, Inc.
Erwin, Tennessee 37650

Thank you.

Very sincerely,

Richard J. Herbst

RJH:srh

ITEM # 269

B/268

5178

W. R. GRACE & CO.

RESEARCH DIVISION

WASHINGTON RESEARCH CENTER
7379 ROUTE 32, COLUMBIA, MARYLAND 21044
Telephone 301 - 531-5711



July 10, 1973

United States Atomic Energy Commission
Directorate of Regulatory Operations
Region I
631 Park Avenue
King of Prussia, Pennsylvania 19406

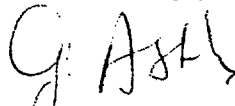
Attention: Mr. Robert T. Carlson, Chief
Facility Operations Branch

Dear Mr. Carlson:

This refers to Docket No. 70-456, specifically to the findings of an inspection of W. R. Grace & Co. facilities at Clarksville, Maryland, on May 16-17, 1973. We have reviewed your findings and have taken the corrective actions stated on the attached sheet.

Should you have any questions we will be glad to discuss them with you.

Sincerely,


G. E. Ashby

GEA:srh

Attachment

ITEM # 270

B/269

(2)

Corrective Actions Resulting from Inspection
on May 16-17, 1973 of Operation
Authorized by AEC License No. SNM-840

Description of Violation

1. License Condition 8B incorporates Section 6.7 dated July 1, 1972, of your license application which requires that the Nuclear Safety Committee will inspect the plant operations at least once in each month that operations involving special nuclear material are being performed.

Contrary to this requirement, no inspections were performed in March and April, 1973, during which time fissile storage operations were performed.

Corrective Actions

Prior to this inspection Grace had not intended nor understood that storage of special nuclear material would constitute a plant operation. From this date forward Grace will require inspections by the Nuclear Safety Committee at least once each month so long as License SNM-840 is operative. Full compliance will be achieved in July 1973.

7-26-73

W. R. Grace and Company, Grace/Nuclear Division
Attention: Mr. G. E. Ashby
Vice President, Manager
Washington Research Center
Clarksville, Maryland 21029

Docket No. 70-456

Reference: Your letter dated July 10, 1973
In response to our letter dated June 8, 1973

Gentlemen:

Thank you for your letter informing us of the action you have taken to correct the items of noncompliance which we brought to your attention following our recent inspection of your licensed program. Your corrective action will be verified during our next inspection of your program.

In accordance with Section 2.790 of the AEC's "Rules of Practice," Part 2, Title 10, Code of Federal Regulations, a copy of this letter and the enclosed inspection report will be placed in the AEC's Public Document Room. If this report contains any information that you (or your contractors) believe to be proprietary, it is necessary that you make a written application within 20 days to this office to withhold such information from public disclosure. Any such application must include a full statement of the reasons on the basis of which it is claimed that the information is proprietary, and should be prepared so that proprietary information identified in the application is contained in a separate part of the document. If we do not hear from you in this regard within the specified period, the report will be placed in the Public Document Room.

Your cooperation with us is appreciated.

Sincerely,

Robert T. Carlson, Chief
Facility Operations Branch

Enclosure:

1. RO Inspection Report No. 70-456/73-02

ITEM # 271

B/270
(2)

OFFICE ▶	GRESS: 1					
SURNAME ▶	<i>P. H. C.</i> Crocker/db	<i>RC</i> Carlson	<i>W</i> O'Reilly			
DATE ▶	7/23/73	7/25				

bcc: RO Chief, Field Support & Enforcement Branch, HQ (2)
RO:HQ (4)
L: D/D for Fuels & Materials
RO Files
DR Central Files
FDR
Local FDR
NSIC
State of Maryland

MONTHLY INSPECTION SUMMARY REPORT

SEP 25 1973

To: W. G. Martin

Fuel Facility

Report No. 70-456-WRG MAPF 74-1

W. R. Grace & Co.

License No. SNM-840 Docket No. 70-456

An inspection was performed on September 18 thru 21, 1973 covering the period of January 1, 1973 - September 18, 1973. This review was performed as a close out inspection since Grace has terminated their nuclear operation.

The final nuclear material (scrap) was shipped September 13, 1973 to NFB, Erwin, Tennessee. A walk-thru inspection was conducted on what previously had been the storage, process, and laboratory areas. There was no evidence of nuclear material on hand; disposal of the processing equipment had essentially been completed; and the area decontaminated.

The inspection covered records, reports, and a verification of the reconciliation to a -0- balance. The licensee had a book balance of 1.2 kgs U-235 after final shipment where as the audit amount was a negative 1.2 kg U-235. Posting adjustments are required which will result in an overall MUF loss of .9 kgs U-235 for the total operation between March 1972 and September 1973.

A MUF of 1.3 kgs in June 1973 was not reported to NRC and also the Material Status Report, Form 742 for the period ending June 30, 1973 requires corrections.

A final close out meeting is set for October 4, 1973 with the licensee requesting that Doug George, their independent nuclear materials auditor, be in attendance for close out of records.

Edward Woltner

GRESS

Woltner:ddb
9-25-73

Martin

ITEM # 272

10/2/73

XXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXX
631 Park Avenue
King of Prussia, Pennsylvania 19406

OCT 25 1973

W. R. Grace and Company
Attention: Mr. G. E. Ashby
Washington Research Center
Clarksville, Maryland 21029

Docket No. 70-456

Gentlemen:

This refers to the inspection conducted by Mr. Woltner of this office on September 18 - 21, 1973 of activities authorized by AEC License SNM-840 and to the discussions of our findings held by Mr. Woltner with Mr. R. J. Herbst at the conclusion of the inspection.

Areas examined during this inspection included: Records; reports; and a verification of the reconciliation to a zero balance of material and ledger accounts. Within these areas, the inspection consisted of selective examinations of procedures and representative records and observations by the inspector.

Within the scope of this inspection, no violations were observed.

No reply to this letter is required; however, if you should have any questions concerning this inspection we will be pleased to discuss them with you.

Sincerely,

Walter G. Martin

Walter G. Martin, Chief
Materials and Plant Protection
Branch

bcc: RO: Chief, Field Support & Enforcement Branch, HQ w/encls
RO: Chief, Materials and Plant Protection, HQ w/encls
RO:HQ (4) w/encls
Directorate of Licensing, HQ (4) encls
DR Central Files w/encls
PDR w/o encls
Local PDR w/o encls
State of Maryland w/o encls
RO:I Materials and Plant Protection Branch (2) w/encls
RO:HQ Files w/encls

ITEM # 273

B/272

OFFICE ▶	RO: I MAPP					
SURNAME ▶	Woltner:sc	Martin	O'Reilly			
DATE ▶	10-24-73	10-24-73	10-17-73			

OFFICIAL USE ONLY
NOT FOR PUBLIC DISCLOSURE

U. S. ATOMIC ENERGY COMMISSION
DIRECTORATE OF REGULATORY OPERATIONS
REGION I

RO Inspection Report No: RO:I 70-456 WRG-MAPP-74-1 Docket No: 70-456

Licensee: W. R. Grace & Co. License No: SNM-840

Priority: I

Category:

Location: Clarksville, Maryland

Type of Licensee: Fuel Fabrication Development

Type of Inspection: Announced

Dates of Inspection: September 18-21, 1973

Inspection Period Covered: January 1-September 18, 1973

Dates of Previous Inspection: January 2-5, 1973

Reporting Inspector: E. Woltner
E. Woltner

10-2-73
DATE

DATE

Accompanying Inspectors:

DATE

DATE

Other Accompanying Personnel:

DATE

Reviewed By: W. G. Martin
W. G. Martin, Chief

10/26/73
DATE

OFFICIAL USE ONLY

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NOT FOR PUBLIC DISCLOSURE

A. Summary of Findings

The inspection was directed towards a close out review since W. R. Grace and Co. has terminated their special nuclear material operation and all nuclear material has been removed from the premises.

The previous inspection report, No. RO:I-MAPP-76, cited W. R. Grace and Co. for noncompliance with License Conditions 3.2, 3.5 and 7.3. Also, certain activities were not conducted in full compliance with requirements of Title 10, Code of Federal Regulations, Part 73. W. R. Grace and Company's letter, dated June 11, 1973, responded with the corrective actions taken in regard to the above. The results of the corrective actions were acceptable and/or the condition eliminated due to termination of operation.

The licensee will be required to post adjustments to their records since they have a 1.2 kilograms U-235 high enriched uranium balance with a-o-physical inventory. The audited amount resulted in an overall MUF loss of .9 kilograms U-235 for the total operation between March 1972 and September 1973. These corrections will be required in order to file a final Material Status Report, AEC Form 742.

B. Report Details

1. Individual Contacted

R. J. Herbst, Manager, Operation Services

2. Introduction

W. R. Grace and Co., Washington Research Center has since our last prior inspection of January 1973, terminated their nuclear operations. The organization has been disbanded and the close out operation is administered by the former Manager, Operation Services. The final nuclear material shipment was completed September 13, 1973. The disposal of the processing equipment has essentially been completed and the areas decontaminated.

Scope

The inspection covered an audit of accounts, records, and reports from January 1, 1973 to September 18, 1973 and a verification of the reconciliation of the book balance to a-o-physical inventory. A walk through inspection was conducted on what previously had been the storage, process and laboratory areas in which there was no evidence of nuclear material on hand.

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- 2 -

Discussion of Findings

The licensee was informed that there were no items of noncompliance as a result of this inspection.

The Material Status Report, Form 742, filed for the period ended June 30, 1973 requires corrections which will be completed.

A final Form 742 will have to be completed for the activity subsequent to June 30, 1973 and for adjustment of material unaccounted for.

W. R. Grace and Co. will have to designate an authorized employee for any subsequent action required since there are open Nuclear Material Transfer Reports (Form 741) involving scrap recovery, and for any other items that may occur.

A final management interview is planned for October 11, 1973 at which time the licensee will have a member of their consulting firm, Nuclear Surveillance and Auditing Corporation present for close out of the record accounts.

A material status report will be issued with the final management interview report.

OFFICIAL USE ONLY

W. R. GRACE & CO.
RESEARCH DIVISION



WASHINGTON RESEARCH CENTER
7379 ROUTE 32, COLUMBIA, MARYLAND 21044
Telephone 301 - 531-5711

October 30, 1973

Director, Division of Materials Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Sir:

The attached data sheets summarize additional fixed and removable contamination estimates made regarding light fixtures and appurtenances near the ceiling of our 16A Nuclear Facility. These data supplement those already supplied in our report of September 1973.

The average levels of fixed and removal contamination on these surfaces is 2205 and 28 dpm/100 cm², respectively. No individual measurements of fixed contamination were in excess of the Guideline⁽¹⁾ limit of 25,000 dpm/100 cm². We believe these data further confirm the success of our decontamination efforts.

Data are also included showing the results of action taken to decontaminate the surfaces of the narrow ledge of the mezzanine outside the railing. This ledge was shown to be contaminated by measurements which Mr. P. German (USAEC - Region 1) made during this inspection and survey on 24 and 25 October 1973. Decontamination to below the Guideline limits was achieved. To the best of our knowledge, this is the only area wherein Mr. German's measurements failed to corroborate our own findings.

We hope submitting these data will enable the Commission to finally disposition our request for termination of our SNM

ITEM # 274

B/273
②

Director, Division of
Materials Licensing

- 2 -

October 30, 1973

License and release for unrestricted use of the premises
formerly relegated to our nuclear work.

Very sincerely,



R. J. Herbst

RJH/kh

Attachments

cc: Director, Directorate of Regulatory Operations - Region 1
U. S. Atomic Energy Commission
631 Park Avenue
King of Prussia, Pa. 19406

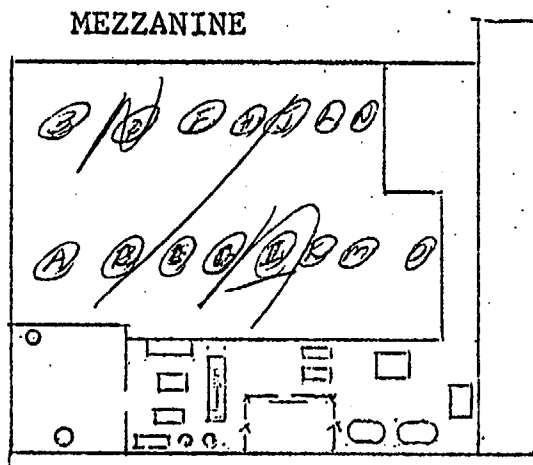
- (1) Guidelines for Decontamination of Facilities and Equipment
Prior to Release for Unrestricted Use or Termination of
Licenses for Byproduct, Source or Special Nuclear Material.
U. S. Atomic Energy Commission, 22 April 1970.

SMEAR SAMPLE DATA SHEET

DIAGRAM OF AREA

MEZZANINE

2560 = 48
3030



DATE

10/26/73

BUILDING OR AREA

16A - LIGHT Fixtures
+ Appurtenances
near Ceiling

SUSPECTED ACTIVITY

EU

SMEARED BY

C.T. Lamberth

COUNTED BY

R.J. Herbst

SUPERVISOR

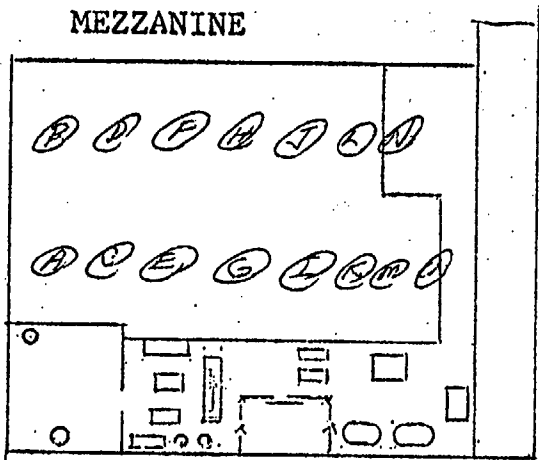
1	2	3	4	5	6	7	8	9	10	11
SAMPLE NUMBER	LOCATION	AREA OF SMEAR IN 100cm ²	ACTIVITY COUNTED	GROSS CPM	DNCHD. CPM	NET CPM	EFFI- CIENCY	DPM/ 100cm ² Total	GOAL DPM/100 cm ²	REMARKS
26.1	Light Fixture # A3	7.5	✓	15	3	12	6/48	6	1000	
26.2	do # B3	7.5	✓	30	3	27	6/48	12	"	
26.3	do # C3	7.5	✓	74	3	71	6/48	33	"	
26.4	do # D3	7.5	✓	14	3	11	6/48	5	"	
26.5	do # E3	7.5	✓	51	3	48	6/48	22	"	
26.6	do # F3	7.5	✓	75	3	72	6/48	35	"	
26.7	do # G3	7.5	✓	27	3	24	6/48	11	"	
26.8	do # H3	7.5	✓	28	3	25	6/48	11	"	
26.9	do # I3	7.5	✓	10	3	37	6/48	17	"	
26.10	do # J3	7.5	✓	224	3	221	6/48	102	"	
26.11	do # K3	7.5	✓	21	3	18	6/48	8	"	
26.12	do # L3	7.5	✓	67	3	61	6/48	28	"	
26.13	do # M3	7.5	-	22	3	19	6/48	9	"	
26.14	do # N3	7.5	✓	43	3	40	6/48	19	"	
26.15	do # O3	7.5	✓	12	3	9	6/48	4	"	

SMEAR SAMPLE DATA SHEET

PAC-4G Instrument

DIAGRAM OF AREA

MEZZANINE



DATE 10/25/73

BUILDING OR AREA 16A - Light Fixtures & Apparatuses in ceiling of Process Area

SUSPECTED ACTIVITY EU

SMEARED BY N/A

COUNTED BY C.T. Lamberth

SUPERVISOR R. J. [Signature] - 10/25/73

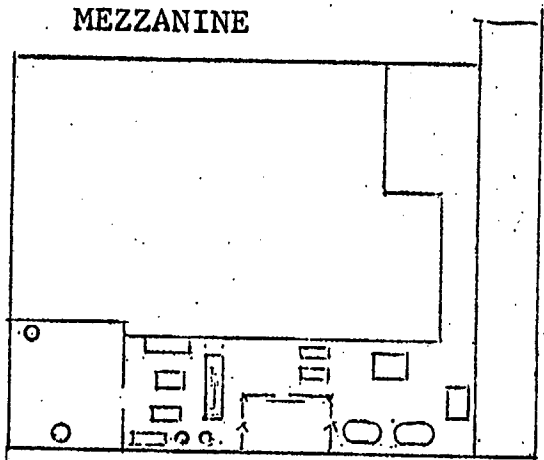
SAMPLE NUMBER	LOCATION	AREA OF SMEAR IN 100cm ²	ACTIVITY COUNTED		GROSS CPM	BKGD. CPM	NET CPM	EFFICIENCY	DPM/100cm ² Total	GOAL DPM/100cm ²	REMARKS
			α	β - γ							
A1	Light Fixture	0.6	✓		200	50		.51	500	5000/25,000	
A2	Light Fixture	0.6	✓		300	50		.51	800	"	
B1	Light Fixture	0.6	✓		1500	50		.51	4800	"	
B2	"	0.6	✓		2000	50		.51	6500	"	
C1	"	0.6	✓		200	50		.5	500	"	
C2	"	0.6	✓		200	50		.5	500	"	
D1	"	0.6	✓		300	50		.5	800	"	
D2	"	0.6	✓		400	50		.5	1300	"	
E1	"	0.6	✓		1500	50		.5	5800	"	
E2	"	0.6	✓		1000	50		.5	3200	"	
F1	"	0.6	✓		2000	50		.5	6500	"	
F2	"	0.6	✓		1500	50		.5	4800	"	
G1	"	0.6	✓		1000	50		.5	3200	"	
G2	"	0.6	✓		600	50		.5	1800	"	
H1	"	0.6	✓		2200	50		.5	7200	"	
H2	"	0.6	✓		1200	50		.5	4000	"	

SMEAR SAMPLE DATA SHEET

PAC-46 Instrument

DIAGRAM OF AREA

MEZZANINE



DATE

10/25/73

BUILDING OR AREA

Light Fixtures & 16A - Appurtenances nr Ceiling of Process Area

SUSPECTED ACTIVITY

EU

SMEARED BY

N/A

COUNTED BY

C. T. Lamberth

SUPERVISOR

R. J. Nicks - 10/28/73

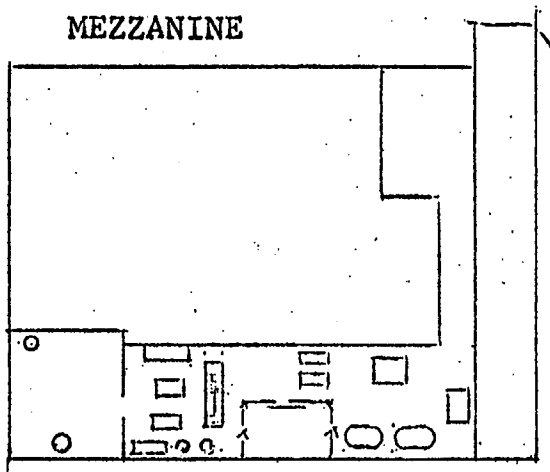
SAMPLE NUMBER	LOCATION	AREA OF SAMPLE IN 100cm ²	ACTIVITY COUNTED		GROSS CPM	BKGD. CPM	NET CPM	EFFICIENCY	DPM/100cm ² Total	GOAL DPM/100cm ²	REMARKS
			α	β - γ							
I1	Light Fixture	0.6	✓		100	≤50		.5	200	5000/25,000	
I2	Light Fixture	0.6	✓		300	"		.5	800	"	
J1	"	0.6	✓		800	"		.5	2200	"	
J2	"	0.6	✓		700	"		.5	2500	"	
K1	"	0.6	✓		<100	"		.5	200	"	
K2	"	0.6	✓		<100	"		.5	200	"	
L1	"	0.6	✓		1000	"		.5	3200	"	
L2	"	0.6	✓		1000	"		.5	3200	"	
M1	"	0.6	✓		<100	"		.5	200	"	
M2	"	0.6	✓		400	"		.5	1200	"	
N1	"	0.6	✓	400	500	"		.5	1200	"	
N2	"	0.6	✓	800	500	"		.5	2500	"	
O1	"	0.6	✓	<100	300	"		.5	200	"	
O2	"	0.6	✓		300	"		.5	800	"	
#8	Duct @ #8	0.6	✓		1000	"		.5	3200	"	
#9	Duct @ #9	0.6	✓			"		.5		"	

PAC-4G Instrument

DATE _____

10/25/73

MEZZANINE



BUILDING OR AREA 16A - Ductwork on Ceiling

SUSPECTED ACTIVITY EU

SMEARED BY W/a

COUNTED BY C. T. Lamberth.

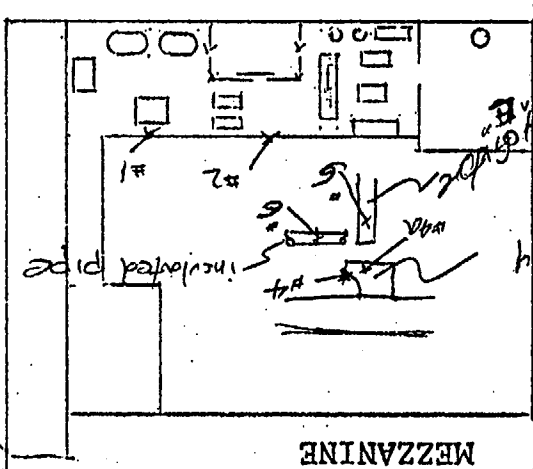
SUPERVISOR R. J. Lusk - 10/28/73

[illegible]

SMEAR SAMPLE DATA SHEET

DIAGRAM OF AREA

MEZZANINE



SUSPECTED ACTIVITY

EU

SMEARED BY

R. J. M. [Signature]

COUNTED BY

R. J. M. [Signature]

SUPERVISOR

BUILDING OR AREA *16A - Process Area @ Ceiling*

DATE

10/28/73

SAMPLE NUMBER	LOCATION	AREA OF SMEAR 100cm ²	a	b-y	GROSS CPM	BACKGND. CPM	NET CPM	EFFICIENCY	DPM/100cm ²	GOAL DPM/100cm ²	REMARKS
284	Outside of Mt supply unit	7.5	1		2843	5	2838	7.5/1	1059	2838	
284a	"	7.5	1		1869	5	1864	7.5/1	990		
285	Light fixture "E"	7.5	1		278	5	273	7.5/1	102		
286	Insulated pipe	7.5	1		726	5	721	5/51	376		
281	Mezzanine outside railing @	7.5	1		485	5	480	6/51	209		
28.2	" @ 2	7.5	1		102	5	97	6/51	42		
284	Outside of Mt supply duct	7.5	1		92	2	90	7.5/1	34	1050	after dem.
284a	"	7.5	1		70	2	68	7.5/1	35		
285	Light fixture "E"	5.0	1		72	2	70	7.5/1	40		
286	Insulated pipe	7.5	1		443	2	441	5/51	231		(wet)

11

10

9

8

7

6

5

4

3

2

1

JUN 8 1973

W. R. Grace and Company, Grace/Nuclear Division Docket No. 70-456
Attention: Mr. G. E. Ashby
 Vice President, Manager
Washington Research Center
Clarksville, Maryland 21029

Gentlemen:

This refers to the inspection conducted by Mr. Crocker of this office on May 16-17, 1973, of operations authorized by AEC License No. SNM-840 and to the discussion of our findings held by Mr. Crocker with Mr. Ashby of your staff at the conclusion of the inspection.

Areas examined during this inspection included: organization; facility decontamination and decommissioning activities; facility processing and storage areas; Nuclear Safety Committee activities including reports for the period from January 1 to May 2, 1973; and in-plant air monitoring, effluent air monitoring and contamination control, and liquid effluent monitoring records, all for the period from January 1 to April 26, 1973. Within these areas, the inspection consisted of selective examinations of procedures and representative records, interviews with personnel and observations by the inspector.

In addition to the above areas, the inspector verified the corrective actions described in your letters to this office dated February 7, 8, and 28, 1973. We have no further questions concerning these matters.

During this inspection it was found that one of your activities appeared to be in violation of AEC requirements. The item and reference to the pertinent requirement are listed in the enclosure to this letter. This notice is sent to you pursuant to the provisions of Section 2.201 of the AEC "Rules of Practice," Part 2, Title 10, Code of Federal Regulations. Section 2.201 requires you to submit to this office within 20 days of your receipt of this notice a written statement or explanation in reply including: (1) corrective steps which have been taken by you, and the results achieved; (2) corrective steps which will be taken to avoid further violations; and (3) the date when full compliance will be achieved.

ITEM # 275

OFFICE ▶	CRESS-I					
SURNAME ▶	<i>Crocker/mh</i>	<i>Carlson</i>	<i>NELSON</i>	<i>O'Reilly</i>		
DATE ▶	6/5/73	6/7	6/6/73	6/6/73		

③

- 2 -

Should you have any questions concerning this inspection, we will be glad to discuss them with you.

Sincerely,

Robert T. Carlson, Chief
Facility Operations Branch

Enclosure:
Description of Violations

bcc: RO, Chief, Field Support & Enforcement Branch, HQ
RO:HQ (4)
L:D/D for Fuels & Materials
DR Central Files
PDR
NSIC
State of Maryland

Enclosure

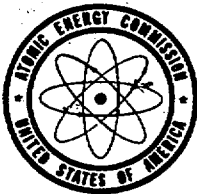
Description of Violation

W. R. Grace and Company, Grace/Nuclear Division
Clarksville, Maryland
Docket No. 70-456

One activity under your license appears to be in violation of AEC requirements as indicated below:

1. License Condition 8B incorporates Section 6.7 dated July 1, 1972, of your license application which requires that the Nuclear Safety Committee will inspect the plant operations at least once in each month that operations involving special nuclear material are being performed.

Contrary to this requirement, no inspections were performed in March and April, 1973, during which time fissile storage operations were performed.



UNITED STATES
ATOMIC ENERGY COMMISSION
DIRECTORATE OF REGULATORY OPERATIONS
REGION 1
631 PARK AVENUE
KING OF PRUSSIA, PENNSYLVANIA 19406

NOV 15 1973

W. R. Grace Company
Attention: Dr. G. E. Ashby
Vice President
Manager
Washington Research Center
Clarksville, Maryland 21029

Docket No. 70-456
License No. SNM-840

Gentlemen:

This refers to the inspection conducted by Mr. Jerman of this office on October 24, 25 and November 9, 1973 of activities authorized by AEC License No. SNM-840 and to the discussions of our findings held by Mr. Jerman with Dr. G. E. Ashby at the conclusion of the inspection, and to a subsequent telephone discussion between Mr. Jerman and Dr. Ashby on November 13, 1973.

Areas examined during this inspection are described in the Regulatory Operations Inspection Report which is enclosed with this letter. Within these areas, the inspection consisted of selective examinations of procedures and representative records, interviews with personnel, measurements made by the inspector, and observations by the inspector.

The effort of this inspection was to establish the validity of the survey report submitted with a letter from G. E. Ashby dated September 19, 1973. This letter stated that based on the report, buildings and facilities formerly utilized for work with special nuclear materials had been decontaminated to levels specified by the Directorate of Licensing as acceptable for unrestricted use. Many random checks made by the inspector confirmed the validity of this report.

A single isolated area of contamination in excess of acceptable limits was found by the inspector. We note that this contamination was reduced to acceptable levels during the inspection.

The inspector noted a sump tank and pump located in the floor of the change room under an iron grating. The tank was used for collecting lab sink, shower and wash basin drainage. You had not measured contamination levels in this tank and pump, and it appears it would not be possible to survey them for unconditional release. We note that you intend to remove the tank, pump and associated piping, to dispose of them as contaminated waste and to survey the surrounding area after removal. Notice of this action and the associated survey report should be furnished to the Directorate of Licensing in support of your request for license termination.

OFFICE	GRESS	JERMAN/JAA	KNAPP	MARTIN	NELSON	O'REILLY
SURNAME	PC8	PC8	MARTIN	NELSON	O'REILLY	
DATE	11-14-73	11-14-73	11/15/73	11/14/73	11/15	

ITEM # 276

17

W. R. Grace Company

In accordance with Section 2.790 of the AEC's "Rules of Practice", Part 2, Title 10, Code of Federal Regulations, a copy of this letter and the enclosed inspection report will be placed in the AEC's Public Document Room. If this report contains any information that you (or your contractor) believe to be proprietary, it is necessary that you make a written application within 20 days to this office to withhold such information from public disclosure. Any such application must include a full statement of the reasons on the basis of which it is claimed that the information is proprietary, and should be prepared so that proprietary information identified in the application is contained in a separate part of the document. If we do not hear from you in this regard within the specified period, the report will be placed in the Public Document Room.

No reply to this letter is required; however, should you have any questions concerning this inspection, we will be pleased to discuss them with you.

Sincerely,

Paul R. Nelson, Chief
Radiological and Environmental
Protection Branch

Enclosure:

RO Inspection Report No. 70-456/73-03

bcc:

RO Chief, FS&EB (2 w/encls.)
RO:HQ (4 w/encls.)
L:D/D for Fuels and Mat'l (1 w/encls.)
PDR (1 w/encls.)
NSIC (1 w/encls.)
RO Files (1 w/encls.)
DR Central Files (1 w/encls.)
State of Maryland (1 w/encls.)

OFFICE

SURNAME

DATE

U.S. ATOMIC ENERGY COMMISSION

DIRECTORATE OF REGULATORY OPERATIONS

REGION I

RO Inspection Report No.: 70-456/73-03

Docket No.: 70-456

Licensee: W. R. Grace Company
Grace/Nuclear Division

License No.: SNM-840

Priority: 1

Category: A (1)

Location: Clarksville, Maryland

Type of Licensee: Fuel Fabrication

Type of Inspection: Verification of Close Out Survey for License Termination - Announced

Dates of Inspection: October 24, 25 and November 9, 1973

Dates of Previous Inspection: May 16-17, 1973

Reporting Inspector:

Phillip C. Jerman
PHILLIP C. JERMAN, Radiation Specialist
NONE

November 14, 1973
Date

Accompanying Inspectors:

Date

Date

Date

Date

Other Accompanying Personnel:

NONE

Date

Reviewed by:

P. J. Knapp
P. J. Knapp, Senior, Facility Radiological and Environmental
Protection Section

11/14/73
Date

Date

SUMMARY OF FINDINGS

Enforcement Action

A. Violations

None

B. Safety Items

None

Licensee Action on Previously Identified Enforcement Items

Not applicable

Unusual Occurrences

None

Other Significant Findings

A. Current Findings

The inspection, consisting of a radiation survey to verify contamination levels at the facility, as reported by the licensee, showed that existing contamination levels appeared to meet the Directorate of Licensing guidelines for termination of License No. SNM-840, with the exception of a sump pump and tank which the licensee intends to dispose of as contaminated waste.

B. Status of Previously Reported Unresolved Items

None

Management Interview

The following individuals attended the management interview held at the conclusion of the inspection on October 25, 1973:

W. R. Grace Company

G. E. Ashby, Vice President, Manager

AEC

P. C. Jerman, Radiation Specialist

The following subject was discussed:

The inspector stated that his survey showed that contamination levels existing in those areas he had checked, appeared to verify the licensee's survey documentation. In a telephone conversation on November 13, 1973 the inspector pointed out that some action would

-2-

have to be taken with regard to the tank and sump pump in the floor
of the change room.

DETAILS

1. Persons Contacted

G. E. Ashby, Vice President, Manager

R. J. Herbst, Manager, Operation Services

C. T. Lamberth, Foreman, Nuclear Production

2. Material Possessed and Processed Under the License

A licensee representative stated that highly enriched uranium-235(97%) was used exclusively.

3. Facility Status

- a. By letter dated September 19, 1973, signed by G. E. Ashby, the licensee transmitted a document entitled, Decontamination of W. R. Grace and Company's Nuclear Facility for Decommissioning and Return to Unrestricted Use, to the Directorate of Licensing. The document included a report of surveys conducted by the licensee.
- b. The inspection was limited to a survey by the inspector of those areas identified in the survey report. The survey consisted of spot checks of surfaces employing portable survey meters ⁽¹⁾₍₂₎⁽³⁾ and wiping 100 cm² surfaces with #541 Whatman filter papers.
- c. The inspector verified the survey report submitted by the licensee. The inspector's survey report superimposed on the licensee's survey report is included as Attachment 1.
- d. Contamination levels were not measured in a sump tank and pump located in the floor of the change room under an iron grating. This tank was used for gathering lab sink, shower and wash basin drainage by the licensee. The inside of the tank and pump were not accessible to the inspector. A licensee representative stated that the tank, pump and associated piping would be removed and disposed of as contaminated waste and the surrounding area would be surveyed after removal. The inspector noted that certification this removal and survey would have to be supplied to the Directorate of Licensing.
- e. The licensee had not included results of surveys of the lighting fixtures and ventilation ducts in the original report. The results of these surveys, which were submitted to the AEC with a letter dated October 30, 1973, are included as Attachment 2. This report was in acceptable agreement with the inspector's findings.

(1) Eberline PAC 1SA

(2) Eberline E-120 with 7 mg/cm absorber

(3) Wipes were counted in an Eberline SAC-4 and an Eberline LCS-1 with RD-14 Beta Detector

PAC-46 INSTRUMENT SURVEY

DIAGRAM OF AREA

DATE 3/28/73

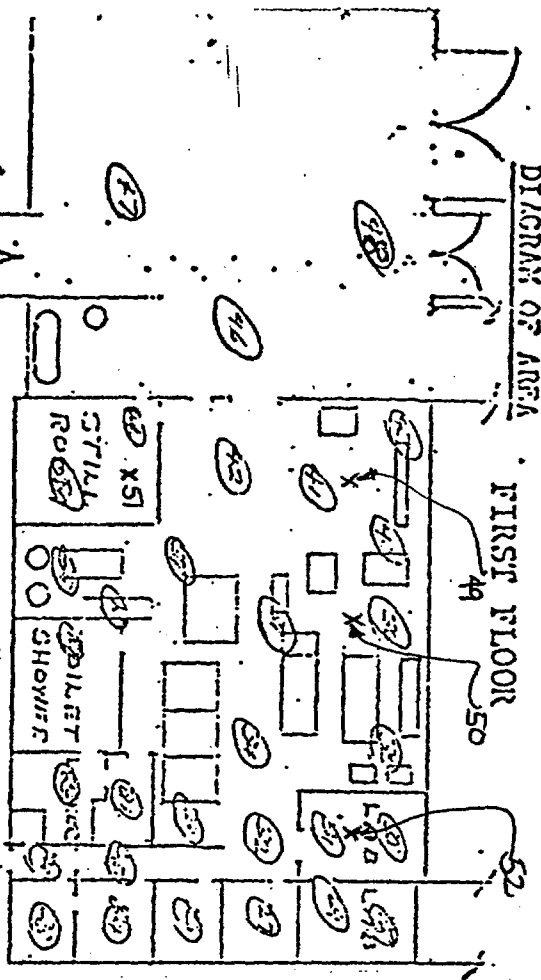
BUILDING OR AREA 16A - main Floor Floor-

SUSPECTED ACTIVITY EU

SUPERVISED BY R.L. MARR

COUNTED BY n/a

SUPERVISOR TC. J. H. 1-3/29/73.



SAMPLE NUMBER	LOCATION	AREA OF SIGNIF. 2	ACTIVITY CODE	GROSS CPM	NET CPM	EFF. CENCY	DPM/100cm ²	GOAL DPM/100cm ²	REMARKS
	18	2	β-γ	100	25	51	142	5000/25,000	
	19	2	β-γ	350	275	51	1160		
	20	2	β-γ	350	275	51	1160		
	21	2	β-γ	450	375	51	1500		
	22	2	β-γ	50	51	51	OK		
	23	2	β-γ	25	51	51	OK		
	24	2	β-γ	50	51	51	OK		
	25	2	β-γ	50	51	51	OK		
	26	2	β-γ	75	51	51	OK		
	27	2	β-γ	150	75	51	300		
	28	2	β-γ	75	51	51	OK		
	29	2	β-γ	150	75	51	300		
	30	2	β-γ	275	250	51	1000		

PAC INSTRUMENT SURVEY 10/21/73

49 2200 dpm/100cm²
 50 2200 dpm/100cm²
 51 2000 dpm/100cm²
 52 2000 dpm/100cm² (lab badge near sink)

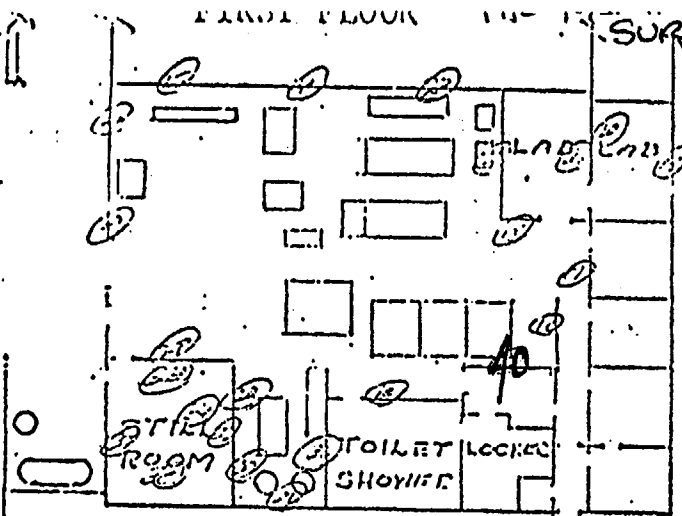
Floors 18 through 52 for 371
 < 0.1 mrad/hr through 7 m²/cm²

ATTACHMENT 1

①

FIRST FLOOR

SURVEY



BUILDING OR AREA 16A Main Floor - Walls

SUSPECTED ACTIVITY EU

SURVEYED
SUGGESTED BY R. L. Matr

COUNTED BY h/a

SUPERVISOR _____

SAMPLE NUMBER	LOCATION	AREA OF SHEAR 100cm ²	ACTIVITY COUNTED		GROSS CPM	BKGRD. CPM	NET CPM	EFFICIENCY	DPM/100cm ² TOTAL	GOAL DPM/100cm ²	REMARKS
			α	$\beta-\gamma$							
14		0.5	✓		50	<50	0	50	Blk	5000	AEC INSTRUMENT SURVEY 10/24/72 IN AREA DESIGNATED 40 IN NO AREA LARGER THAN 10 M ² The highest reading was 12,000 dpm/100cm ² and the Average Reading was 3000 dpm/100cm ² All other Areas < 500 dpm/100cm ² All walls 14 through 37 < 0.1 mrad/hr p/through 7mg/cm ²
15		0.5	✓		1000	<50	950	50	3800	"	
16		0.5	✓		200	<50	150	50	600	"	
17		0.5	✓		50	<50	0	50	Blk	"	
18		0.5	✓		50	<50	0	50	"	"	
19		0.5	✓		36	<50	0	50	"	"	
20		0.5	✓		100	<50	50	50	200	"	
21		0.5	✓		50	<50	0	50	Blk	"	
22		0.5	✓		150	<50	100	50	400	"	
23		0.5	✓		100	<50	50	50	200	"	
24		0.5	✓		150	<50	100	50	400	"	
25		0.5	✓		150	<50	100	50	400	"	
26		2.5	✓		100	<50	50	50	200	"	
27		2.5	✓		50	<50	0	50	0	"	
28		0.5	✓		50	<50	0	50	0	"	
29		0.5	✓		50	<50	0	50	0	"	

ATTACHMENT 1

③



國人

SUPERVISOR

SAMPLE NUMBER	LOCATION	AREA OF SURFACE 2	ACTIVITY COUNTED	NET CPM	GROSS CPM	NET CPM	EFFICIENCY	DEPT/GOAL	REMARKS
30		0.5	✓	100	450	50	20%	5000	
31		0.5	✓	150	450	100	50	100	
32		0.5	✓	3000	450	50	11.8%		
33	Floor - Shell 11 Km	0.5	✓	350	200	150	50	6.00	9/18/73
34	"	0.5	✓	1000	200	800	50	3000	9/18/73
35	"	0.5	✓	1000	200	800	50	3000	9/18/73
36	Wall - Shell 11 Km	0.5	✓	500	200	300	50	1200	9/18/73
37	"	0.5	✓	300	200	100	50	400	9/18/73
38	Floor - Bldg 20	100	✓	250	200	50	50	200	9/18/73
39	Wall - Bldg 20	100	✓	250	200	50	50	200	9/18/73

天下



LAO
BENCH
047

1/17 - Press Area

ME

140W 27

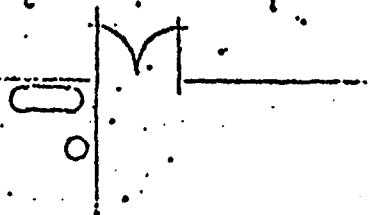
R. May

[Handwritten signature]

REC SMAR SURF 10-24-73

LOCATIONS 35 through 40
Highest smear was 2 dpm/100cm²

天下



[Handwritten signature]

1504 21

1104

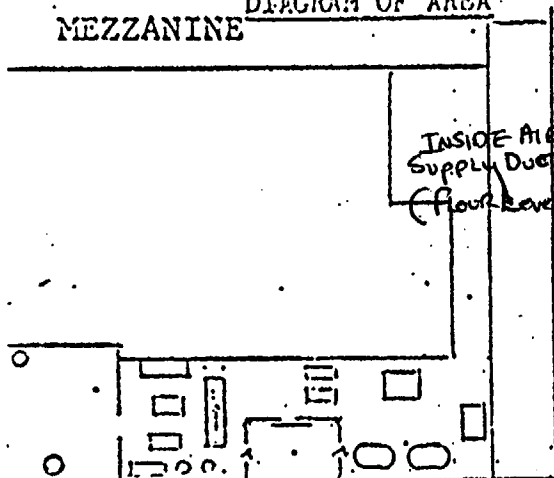
71

1617 - Police Area.

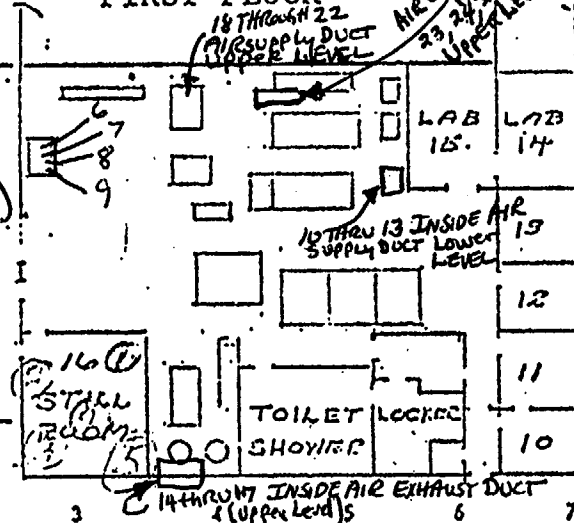
SAFETY	LOCATION	AREA OF SHEAR 100cm ²	ACTIVITY a 11-7	GROSS CPM	NET CPM	EFF. CENCY	DPM/ 100cm ²	REMARKS
27	Wall	7		329	2.9	96.1	183	
28	Wall	7		98	4.3	96.1	52	
29	Wall	7		154	2.9	96.1	85	
30	Wall	7		61	4.3	96.1	32	
31	Wall	7		78	2.9	96.1	42	
32	Wall	7		435	4.3	96.1	241	
33	Wall	7		371	2.9	96.1	206	
34	Stairs	5		48	4.3	96.1	24	108.1
								108.1
	Exhaust Alcove	3.0		423	2.9	96.1	549	108.1
	Wall - N Center	7		1144	2.9	96.1	1278	Dust on outlet box and conduit
	Exhaust Alcove	3.0		531	2.9	96.1	690	
		2.0		287	2.9	96.1	557	
	Exhaust Vent	3.0		497	2.9	96.1	696	

MEZZANINE

DIAGRAM OF AREA



FIRST FLOOR



DATE

9/18/73

BUILDING OR AREA

16A - Still Room

SUSPECTED ACTIVITY

EU

SAMPLED BY

R. L. Marr

FILTER PAPER USED

COUNTED BY

R. L. Marr

INSTRUMENT USED

PC-4

BOOK AND PAGE

SAMPLE NUMBER	LOCATION	FIXED VOLUME OF SMPL. IN 100 FT ³	ACTIVITY COUNTED		GROSS CPM	BKGD. CPM	NET CPM	EFFICIENCY	DPM/FT ³	REMARKS	REMARKS
			α	β-γ							
1	Floor	3			1	3.8	0	51.3	134	OK	1000
2	Floor	3			27	3.8	23	51.3	45	OK	"
3	Floor	3			35	3.8	31	51.3	68	OK	"
4	Wall	3			10	3.8	16	51.3	35	OK	"
5	Wall	3			3	3.8	0	51.3	134	OK	"

AEC SURVEY (SMEARS) 10/24/73

LOCATIONS 10 THROUGH 20; HIGHEST: 102 dpm/100cm², 136 dpm/100cm²

LOCATION	DESCRIPTION	dpm/100cm ²	dpm/100cm ²
21	Top Surface	756	534
22	Light Fixture	124	70
23	Inside Duct	832	454
24	Baffle of Duct	348	200
25	LIGHT Fixture	10	52

ATTACHMENT 1 (7)

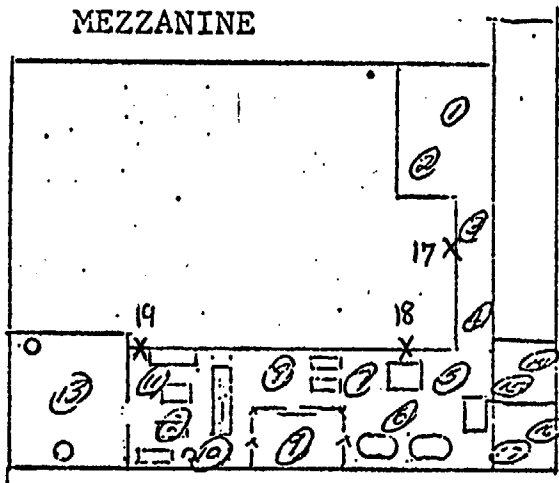
SMEAR SAMPLE DATA SHEET

PAC 46 INSTRUMENT SURVEY

DIAGRAM OF AREA

DATE 8/28/73

MEZZANINE



BUILDING OR AREA 16A - Mezzanine Floor

SUSPECTED ACTIVITY ELL

SURVEYED

SURVEYED BY

R. L. Marr

COUNTED BY

n/a

SUPERVISOR

R. J. Murphy - 8/29/73

SAMPLE NUMBER	LOCATION	AREA OF SMEAR 100cm ²	ACTIVITY COUNTED		GROSS CPM	BKGD. CPM	NET CPM	EFFI- CIENCY	DPM/ 100cm ² Total	GOAL DPM/100 cm ²	REMARKS
			α	β - γ							
1	①	0.5	✓		50	400	Bkgd	51	0L	5000/25000	INSTRUMENT AEC SURVEY 10/24/73 LOCATION 12 3400 dpm/100cm ² LOCATIONS 1 thru 11 & 13 thru 16 > 200 dpm/100cm ² ALONG FLOOR EDGE FROM 17 to 19 - 3000 to 7000 dpm/100cm ² ONE SPOT AT 18 READS 30,000 dpm/100cm ² THE FLOOR EDGE WAS CLEANED DURING THE INSPECTION AND RESURVEYED ALL LEVELS WERE REDUCED - Spot at 18 was reduced to 15,000 dpm/100cm ² β Survey: LOCATIONS 1 through 19 less than 0.1 mrad/hr through 7 mg/cm ²
2	②	0.5	✓		75	400	Bkgd		0L		
	③	0.5	✓		60	400	Bkgd		0L		
	④	0.5	✓		150	400	50	51	200		
	⑤	0.5	✓		475	400	400		1600		
	⑥	0.5	✓		450	400	400		1500		
	⑦	0.5	✓		600	400	500		2200		
	⑧	0.5	✓		400	400	350		1200		
	⑨	0.5	✓		200	400	150		650		
	⑩	0.5	✓		150	400	100		400		
	⑪	0.5	✓		260	400	150		600		
	⑫	0.5	✓		350	400	200		1200		
	⑬	0.5	✓		400	400	200		1400		

ATTACHMENT 1

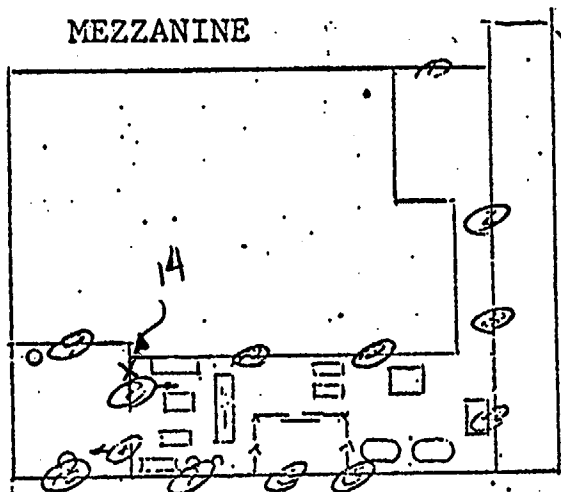
⑧

SURFACE SAMPLE DATA SHEET
PAC-46 INSTRUMENT SURVEY

DIAGRAM OF AREA

DATE 8/29/73

MEZZANINE



BUILDING OR AREA 16A Mezzanine Walls

SUSPECTED ACTIVITY EU

SURVEYED
 INITIATED BY R.L. Marr

COUNTED BY n/a

SUPERVISOR _____

1	2	3	4	5	6	7	8	9	10	11
SAMPLE NUMBER	LOCATION	AREA OF MEASUREMENT 100cm ²	ACTIVITY COUNTED α β-γ	GROSS CPM	BRKNO. CPM	NET CPM	EFFICIENCY	DPM/ 100cm ² Total	GOAL DPM/100 cm ²	REMARKS
1	Wall	0.5	✓	50	<50	0	50	Brknl	5000/25000	INSTRUMENT
2	Wall	0.5	✓	50	<50	0	50	"		AEC SURVEY 10-24-73
3	Wall	0.5	✓	50	<50	0	50	"		LESS THAN 200 dpm/100cm ² locations
4	Wall	0.5	✓	25	<50	0	50	"		1 through 13
5	Wall	0.5	✓	25	<50	0	50	"		8000 dpm/100cm ² on wall at location
6	Wall	0.5	✓	25	<50	0	50	"		14
7	Wall	0.5	✓	50	<50	0	50	"		
8	Wall	2.5	✓	100	<50	50	50	200		All locations 1 through 14 less than
9	Wall	0.5	✓	25	<50	0	50	Brknl		through 7 mg/cm ²
10	Wall	0.5	✓	50	<50	0	50	"		
11	Wall	2.5	✓	50	<50	0	50	"		
12	Rail	0.5	✓	50	<50	450	50	1800		
13	Rail	2.5	✓	450	<50	400	50	1600		

ATTACHMENT 1

(10)

DATE _____

8/31/67

BUILDING OR AREA

16A - mezzanino

SUSPECTED ACTIVITY

EU

SMEARED BY

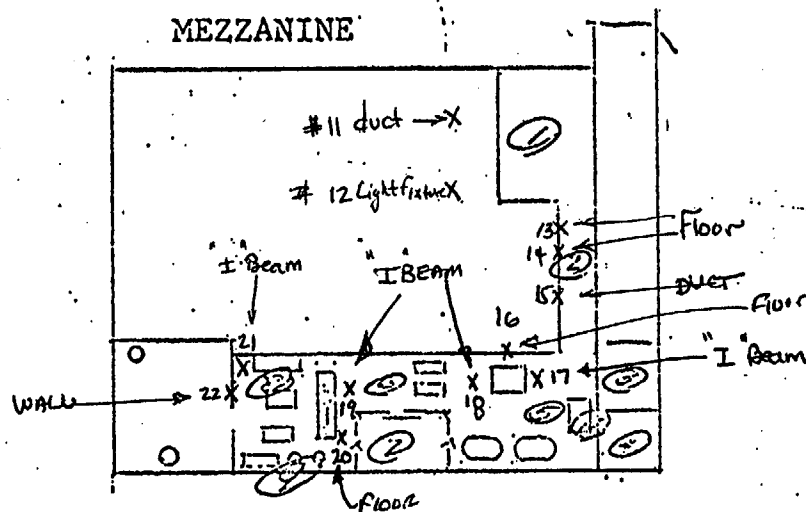
R. Mart

COUNTED BY

R. Mart

SUPERVISOR

R. J. Herbert



SAMPLE NUMBER	LOCATION	AREA OF SHEAR 100cm ²	ACTIVITY COUNTED		GROSS CPM	BKGRD. CPM	NET CPM	EFFICIENCY	DPM/100cm ² Total	GOAL DPM/100cm ²
			a	B-7						
1	Floor	7	✓		34	2.9	51	75/51	13	100
2	Floor	7			36	2.9		79/51	13	"
3	Floor	7			58	4.3		79/51	22	"
4	Floor	7			29	2.9		79/51	10	"
5	Floor	7			81	4.3		79/51	31	"
6	Floor	7			28	2.9		79/51	10	"
7	Floor	7			80	4.3		79/51	30	"
8	Floor	7			32	2.9		79/51	12	"
9	Wall	7			157	4.3		59/51	86	"
10	Wall	7			30	2.9		59/51	15	"
5	Floor	7			65	2.9		79/51	25	"

REL SMEAR SURVEY
10-24-73

LOCATIONS 11 THROUGH 22

Highest: # 16 160 dpm/100cm²

OF THE REMAINING LOCATIONS NONE EXCEEDED 96 dpm/100cm²

— 0 — 0 — 0 —

LOCATIONS 11 THROUGH 22

Highest: # 17 52 dpm/100cm²

OF THE REMAINING LOCATIONS NONE EXCEEDED 48 dpm/100cm²

(11)

PL ST 4

ATTACHMENT

L:FFRB:EJF
Docket 70-456

DEC 17 1973

W. R. Grace & Company
ATTN: Dr. G. E. Ashby
Vice President
Washington Research Center
Clarksville, Maryland 21029

Gentlemen:

In accordance with your application dated September 19, 1973,
and supplements dated October 30, 1973 and December 3, 1973,
and pursuant to Title 10, Code of Federal Regulations, Part 70,
Special Nuclear Material License No. SNM-840 is hereby terminated.

FOR THE ATOMIC ENERGY COMMISSION

Original Signed by
Leland C. Rouse

L. C. Rouse, Chief
Fuel Fabrication and Reprocessing
Branch
Directorate of Licensing

Distribution
PDR
State Health Official
Docket File
Branch R/F
L:FM R/F
~~RO~~, HQ (2)
HWerner, RO
RCPage, L
ACabell, DRA
BBrooks, L
LCRouse
RJDube
WTCrow
EJFrederick

ITEM # 277 B1276
5

OFFICE	L:FFRB	L:FFRB	L:FFRB			
SURNAME	EJFrederick:lk	RJDube	LCRouse			
DATE	12/12/73	12/17/73	12/17/73			

ORNL SITES - SUMMARY

License No.: SNM-00840 ORNL Score: 2,267
Docket No.: 070-00456
Licensee: W.R Grace and Company Review Status: Complete
Site Address(es): Washington Research Center
Clarksville, Maryland 21029
Site Contact: Robert Costello, Mgr, Safety, Hygiene & Reg Compliance
Telephone No.: 410-531-4000/ direct 410-531-4659
SDMP Site: no
Related License(s): [SNM-00417: NOT ON LIST]
NRC Reviewer: Stephen W. Holmes, David Limroth
Review Abstract: License No. SNM-00840 superseded License No. SNM-00417 which had been issued on October 18, 1960 and authorized nuclear fuel manufacturing between December 64 and December 73 at the Washington Research Center. A termination survey by the licensee in 1973 and a confirmatory survey by the AEC demonstrate that most of the facility is suitable for unrestricted use. A site visit and survey conducted by the NRC on November 4, 1994 determined that the site is suitable for release for unrestricted use.
Recommendations: None.

Summary: The licensee manufactured enriched uranium reactor fuel under License No. SNM-00417 and then License No. SNM-00840 at the Washington Research Center, Clarksville, MD until September 1973. Letters dated September 19, 1973 and October 30, 1973 describe decontamination procedures, initial surveys following decontamination, and additional decontamination and post-decon surveys. An AEC confirmatory survey on October 24 and 25, 1973 identified further contamination in a sump tank. A licensee letter dated December 3, 1973 states that the tank, pump, and associated piping had been removed and disposed of at an authorized burial site.

A technical review of licensee's termination survey dated September 1973 with supplemental survey of October 30, 1973 and AEC close-out survey dated October 5, 1972 was performed to determine if the termination surveys were adequate to determine that the facility is suitable for unrestricted use based on present guidelines.

Prior to performing the initial contamination survey the whole facility was decontaminated, the floor was striped and surveyed, and, where necessary, the floor covering excised and disposed as radwaste. Additionally, cleaning and decontamination of the process equipment and piping was performed according to a written procedure. The procedures for the decontamination and the packaging and shipping of radioactive waste were good.

The surveys covered both use and non-use areas to including outside storage areas. Survey points included the floor, walls, and ceiling light fixtures, appurtenances, and ducting, as well as other horizontal and vertical surfaces. The smear and radiation area surveys consisted of approximately 90 and 120 points,

ITEM # 278

January 23, 1995

B/277
70

respectively, at appropriate locations. Based on the total area, surfaces and items surveyed, this number swipe and survey points would not meet present standards. The instruments used for both analyses met regulatory guidance criteria and industry standards of practice. Region I laboratory staff confirmed that the survey and counting instruments and their parameters, as described in the report, were reasonable and would have been able to measure/detect the radiation levels reported.

The limits used for fixed uranium contamination were 5,000 dpm/100cm² average and 25,000 dpm/100cm² maximum taken from the 1970 AEC guideline. Areas of fixed contamination which exceeded those limits were decontaminated to below the limit and resurveyed. The average activity measured on the floor and walls was less than 675 dpm/100cm² with a maximum activity identified by the licensee of less than 12,000 dpm/100cm² (this was a very localized area). The average on ceiling ducts and light fixtures was 2,205 dpm/100cm² with a maximum of 7,200 dpm/100cm².

The limit used for removable uranium contamination was 1,000 dpm/100cm². Areas of removable contamination which exceeded this limit were decontaminated to below the limit and resurveyed. The average removable activity measured on the floor and walls was less than 110 dpm/100cm² with a maximum activity of less than 241 dpm/100cm². The average on ceiling ducts and light fixtures was 28 dpm/100cm² with a maximum of 209 dpm/100cm².

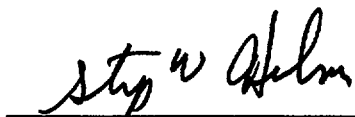
Limited information was available on the liquid and gaseous effluent system other than the \approx 15 smear and survey points in the report.

The AEC survey was extensive and identified only one spot of fixed contamination which was decontaminated to 15,000 dpm/cm². Beta/gamma readings were < 0.1 mrad/hr with a 7mg/cm² absorber. Smear and survey results confirmed the licensee's survey findings for the floor, wall, lighting fixtures, and ventilation ducts. The inspector identified a sump tank and pump in the change room that had not been surveyed. The licensee removed them and the associated piping, disposed of them as radwaste, and surveyed the sump areas. Although the survey indicated no removable and minimal fixed contamination it consisted of only four smears and three survey points.

With the exception of the relative small number of smears and survey points, and the limited information available on the liquid and gaseous effluent systems, the termination and confirmatory surveys were adequate to release the facility for unrestricted use based on present guidelines.

In order to assure that the facility is suitable for unrestricted use, a site visit and survey were conducted on November 4, 1994. The survey was performed at Building 16 to determine that radiation levels on the roof, ventilation system, and other areas where radioactive material was used were below NRC guidelines for release for unrestricted use and to determine the disposition of a contaminated sump tank, pump, and associated piping. No radiation levels above background were detected and a smear survey of the roof fan showed no removable contamination. Therefore, based on the NRC survey and the previous termination and confirmatory surveys, the site is suitable for release for unrestricted use.

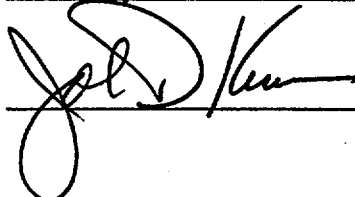
Reviewed by:



Date

01/23/95

Approved by:



Date

1/23/95

W. R. GRACE & CO.

RESEARCH DIVISION

WASHINGTON RESEARCH CENTER, CLARKSVILLE, MARYLAND 21029

Telephone 301 - 531-5711

September 19, 1973



NEW POSTAL ADDRESS

7379 ROUTE 32
COLUMBIA, MARYLAND
21044

Director
Division of Materials Licensing
U. S. Atomic Energy Commission
Washington, D.C. 20545

Dear Sir:

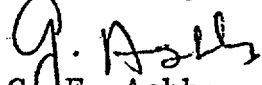
W. R. Grace & Co. has terminated further work with special nuclear material at its Washington Research Center in central Howard County, Maryland. All special nuclear material has been removed from the premises. Contaminated equipment has been transferred to other licensees, disposed to authorized burial sites, or decontaminated and committed to alternate uses. Buildings and facilities formerly utilized exclusively for work with special nuclear materials have been decontaminated to levels acceptable for use for unrestricted purposes. The attached report summarizes our surveys of these premises in this regard.

W. R. Grace & Co. advises the Commission that the buildings and facilities heretofore restricted for exclusive use for work with special nuclear materials will be released for unrestricted use on 1 October 1973. Current plans are to utilize these premises for the development of equipment for air and water pollution control.

W. R. Grace & Co. also requests termination of its special nuclear materials license, SNM-840, effective 1 October 1973.

Inasmuch as the availability of the subject building and facilities are important to the progress and success of other work, W. R. Grace & Co. ask that the Commission promptly consider these requests.

Yours very truly,


G. E. Ashby
Vice President

GEA/RJH/et
Attachment

cc: Director, U. S. Atomic Energy Commission
Directorate of Regulatory Operations--Region I
631 Park Avenue, King of Prussia, Pa. 19406

W. R. GRACE & CO.



RESEARCH DIVISION

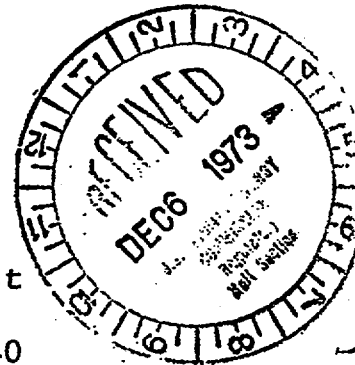
WASHINGTON RESEARCH CENTER
7379 ROUTE 32, COLUMBIA, MARYLAND 21044
Telephone 301 - 531-5711

December 3, 1973

Director, Division of Material Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Sir:

Subject: SNM License 840 Termination Request
Re: Additional Radiological Survey
Ref: Docket 70-456 License No. SNM-840



Please be advised that the sump tank and pump used to collect lab sink, shower and wash basin drainage in our Nuclear Facility have been disconnected, removed and disposed of by burial at an authorized burial site. The results of our radiological survey of the cellar used to house the sump and accessible pipe used to conduct the waste are attached. We conclude that there is no lingering radiological hazard associated with this space.

It is our understanding that disposition of the sump is the only open item impeding termination of our license. We believe this letter and the attached data will remove this obstacle and allow the Commission to act affirmatively on our request.

Very truly yours,

Richard J. Herbst

RJH:srh
Attachment

cc: Director, Directorate of
Regulatory Operations - Region I

8340
H

SMEAR SAMPLE DATA SHEET

DIAGRAM OF AREA

DATE _____

11/28/75

BUILDING OR AREA

16A - Sanitary Sump

SUSPECTED ACTIVITY

~~UE~~

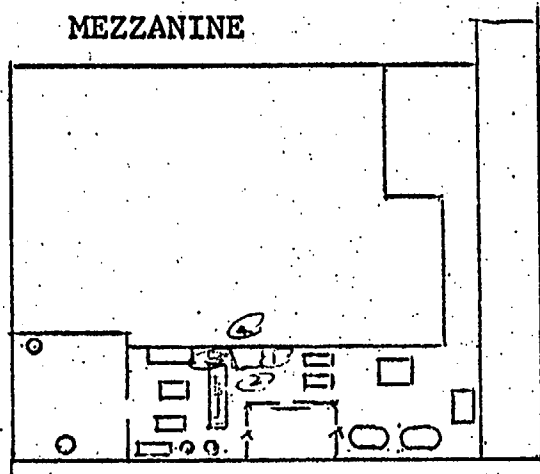
SMEARED BY

R. J. Herbst

COUNTED BY

R. V Herbst

SUPERVISOR



2967
3030

[illegible]

W. R. GRACE & CO.

RESEARCH DIVISION



WASHINGTON RESEARCH CENTER
7379 ROUTE 32, COLUMBIA, MARYLAND 21044
Telephone 301 - 531-5711

October 30, 1973

Director, Division of Materials Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Sir:

The attached data sheets summarize additional fixed and removable contamination estimates made regarding light fixtures and appurtenances near the ceiling of our 16A Nuclear Facility. These data supplement those already supplied in our report of September 1973.

The average levels of fixed and removal contamination on these surfaces is 2205 and 28 dpm/100 cm², respectively. No individual measurements of fixed contamination were in excess of the Guideline(1) limit of 25,000 dpm/100 cm². We believe these data further confirm the success of our decontamination efforts.

Data are also included showing the results of action taken to decontaminate the surfaces of the narrow ledge of the mezzanine outside the railing. This ledge was shown to be contaminated by measurements which Mr. P. German (USAEC - Region 1) made during this inspection and survey on 24 and 25 October 1973. Decontamination to below the Guideline limits was achieved. To the best of our knowledge, this is the only area wherein Mr. German's measurements failed to corroborate our own findings.

We hope submitting these data will enable the Commission to finally disposition our request for termination of our SNM

Director, Division of
Materials Licensing

- 2 -

October 30, 1973

License and release for unrestricted use of the premises
formerly relegated to our nuclear work.

Very sincerely,

R. J. Herbst

RJH/kh

Attachments

cc: Director, Directorate of Regulatory Operations - Region 1
U. S. Atomic Energy Commission
631 Park Avenue
King of Prussia, Pa. 19406

- (1) 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. Atomic Energy Commission, 22 April 1970.

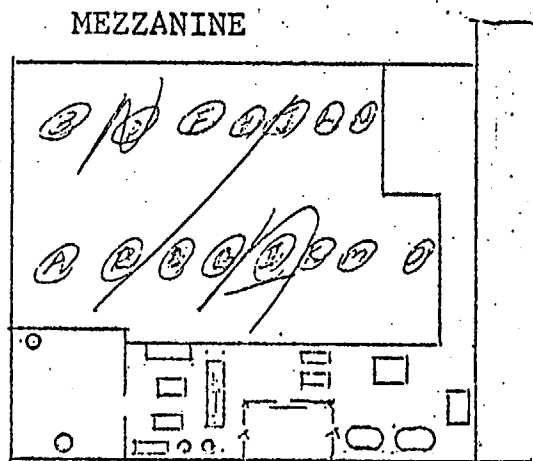
SMEAR SAMPLE DATA SHEET

DIAGRAM OF AREA

DATE 10/26/73

MEZZANINE

$\frac{2560}{3030} = 48$



BUILDING OR AREA 16A - LIGHT FIXTURES + REPAIRS
near ceiling

SUSPECTED ACTIVITY EL

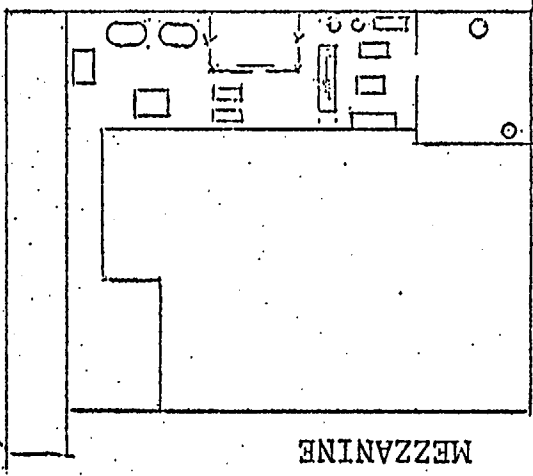
SMEARED BY C.T. Lamberth

COUNTED BY R.J. Herklot

SUPERVISOR _____

1	2	3	4	5	6	7	8	9	10	11	
SAMPLE NUMBER	LOCATION	AREA OF SMEAR 100cm ²	ACTIVITY COUNTED		GROSS CPM	BKGD. CPM	NET CPM	EFFI- CIENCY	DPM/ 100cm ² Total	GOAL DPM/100 cm ²	REMARKS
			α	β - γ							
26.1	Light Fixture #13	7.5	✓		15	3	12	6/48	6	1000	
26.2	do #33	7.5	✓		30	3	27	6/48	12	"	
26.3	do #03	7.5	✓		74	3	71	6/48	33	"	
26.4	do #03	7.5	✓		14	3	11	6/48	5	"	
26.5	do #E3	7.5	✓		51	3	48	6/48	22	"	
26.6	do #F3	7.5	✓		75	3	72	6/48	35	"	
26.7	do #G3	7.5	✓		27	3	24	6/48	11	"	
26.8	do #H3	7.5	✓		28	3	25	6/48	11	"	
26.9	do #I3	7.5	✓		10	3	37	6/48	17	"	
26.10	do #J3	7.5	✓		224	3	321	6/48	102	"	
26.11	do #K3	7.5	✓		21	3	18	6/48	8	"	
26.12	do #L3	7.5	✓		64	3	61	6/48	28	"	
26.13	do #M3	7.5	✓		22	3	19	6/48	9	"	
26.14	do #N3	7.5	✓		43	3	40	6/48	19	"	
26.15	do #O3	7.5	✓		12	3	9	6/48	4	"	

DIAGRAM OF AREA



MEZZANINE

DATE

10/26/01

BUILDING OR AREA 167 - Duffield nr. Collins

SUSPECTED ACTIVITY

73

SWEARED BY

C. T. Lombardy

COUNTED BY

25.10.1973

SUPERVISOR

[illegible]

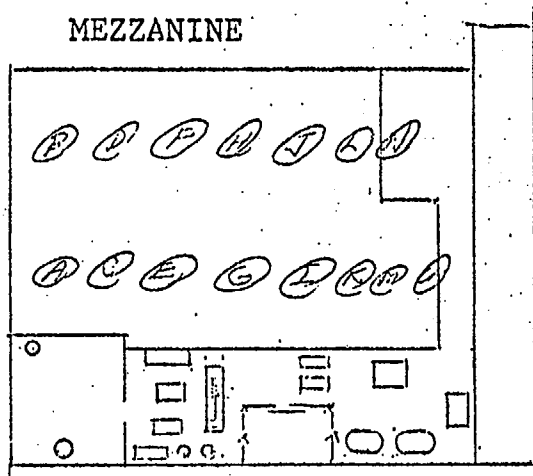
SMEAR SAMPLE DATA SHEET

PAC-4G Instrument

DIAGRAM OF AREA

DATE 10/25/73

MEZZANINE



BUILDING OR AREA 16A - Light Fixtures & Apparatuses on ceiling of Process Area

SUSPECTED ACTIVITY EV

SMEARED BY N/A

COUNTED BY C.T. Lamberth

SUPERVISOR R.J. [Signature] - 10/25/73

SAMPLE NUMBER	LOCATION	AREA OF SMEAR IN 100cm ²	ACTIVITY COUNTED		GROSS CPM	BKGD. CPM	NET CPM	EFFICIENCY	DPM/100cm ² Total	GOAL DPM/100cm ²	REMARKS
			a	β-γ							
A1	Light Fixture	0.6	✓		200	50		.51	500	5000/25000	
A2	Light Fixture	0.6	✓		300	50		.51	800	"	
B1	Light Fixture	0.6	✓		1500	50		.51	4800	"	
B2	"	0.6	✓		2000	50		.51	6500	"	
C1	"	0.6	✓		200	50		.5	500	"	
C2	"	0.6	✓		200	50		.5	500	"	
D1	"	0.6	✓		300	50		.5	800	"	
D2	"	0.6	✓		400	50		.5	1200	"	
E1	"	0.6	✓		1700	50		.5	5800	"	
E2	"	0.6	✓		1000	50		.5	3200	"	
F1	"	0.6	✓		2000	50		.5	6500	"	
F2	"	0.6	✓		1500	50		.5	4800	"	
G1	"	0.6	✓		1000	50		.5	3200	"	
G2	"	0.6	✓		600	50		.5	1800	"	
H1	"	0.6	✓		2200	50		.5	7200	"	
H2	"	0.6	✓		1300	50		.5	4200	"	

SETUP SHEET FAC-46 Instrument

DATE 10/25/73

Light fixtures & Building or area 1619 - apartments in ceiling of process area

SUSPECTED ACTIVITY EU

SMOARED BY N/A

COUNTED BY D. T. Kamberth.

SUPERVISOR *[Signature]* 10/25/73

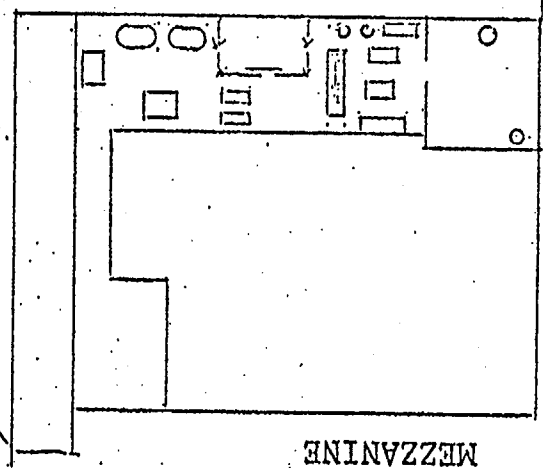


DIAGRAM OF AREA

SAMPLE NUMBER	LOCATION	AREA OF 100cm ²	ACTIVITY COUNTED	α	β-γ	GROSS CPM	BRGND. CPM	NET CPM	EFF. CPM	DPM/100cm ² GOAL	REMARKS
I1	Light fixture	100	✓	0.6		450				5	
I2	Light fixture	300	✓	0.6		300				5	
J1	"	800	✓	0.6		800				5	
J2	"	700	✓	0.6		700				5	
K1	"	<100	✓	0.6		<100				5	
K2	"	<100	✓	0.6		<100				5	
L1	"	1000	✓	0.6		1000				5	
L2	"	1000	✓	0.6		1000				5	
M1	"	<100	✓	0.6		<100				5	
M2	"	400	✓	0.6		400				5	
N1	"	<100	✓	0.6		<100				5	
N2	"	300	✓	0.6		300				5	
O1	"	<100	✓	0.6		<100				5	
O2	"	300	✓	0.6		300				5	
#8	Duff #8	1000	✓	0.6		1000				5	
#9	Duff #9	200	✓	0.6		200				5	
Total 5000/25,000											

1 2 3 4 5 6 7 8 9 10 11

PAC-4G Instrument

DATE _____

10/25/73

BUILDING OR AREA 16A - Ductwork on Ceiling

SUSPECTED ACTIVITY

FL

SMEARED BY

N/a

COUNTED BY

C. T. Lamberth

SUPERVISOR

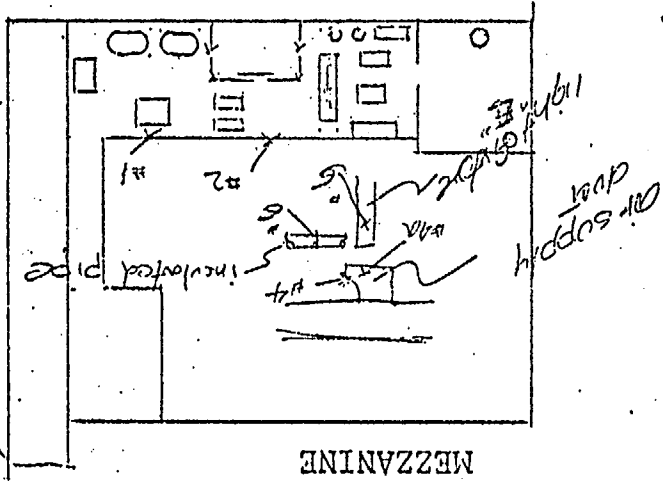
R. J. Hunt - 10/28/73

[illegible]

SMEAR SAMPLE AT A SHEET

DIAGRAM OF AREA

MEZZANINE



SUPERVISOR

COUNTED BY

SMEARED BY

SUSPECTED ACTIVITY

EU

BUILDING OR AREA

16A - Process Area @ Ceiling

DATE

10/28/73

SAMPLE NUMBER	LOCATION	AREA OF SMCAR 100cm ²	ACTIVITY COUNTED a. b-7	GROSS CPM	BACKG. CPM	NET CPM	EFF. CPM	DPM/100cm ²	GOAL DPM/100cm ²	REMARKS
284	Outside of Air supply duct	7.5	1	2843	5	2838	7.5	1059	1000	
284a	"	7.5	1	1869	5	1864	7.5	1090		
285	Light fixture "E"	7.5	1	278	5	273	7.5	102		
286	Insulated Pipe	7.5	1	726	5	721	5.5	376		
281	MEZZANINE outside railing "E"	7.5	1	485	5	480	6.5	209		
282	" " " " " "	7.5	1	102	5	97	6.5	42		
284	Outside of Air supply duct	7.5	1	92	2	90	7.5	34	1000	after demon.
284a	"	7.5	1	70	2	68	7.5	35		"
285	Light fixture "E"	5.0	1	72	2	70	7.5	40		"
286	Insulated Pipe	7.5	1	443	2	441	5.5	231		" (wet)

DECONTAMINATION
OF
W. R. GRACE & CO.'s NUCLEAR FACILITY
FOR DECOMMISSIONING AND RETURN TO
UNRESTRICTED USE

W. R. Grace & Co.
7379 Route 32
Columbia, Maryland 21044

September 1973

TABLE OF CONTENTS

1. DESCRIPTION OF THE NUCLEAR FACILITY AND
RESTRICTED AREA
2. DESCRIPTION OF DECONTAMINATION PROCEDURES
3. SURVEY PROCEDURES
4. SURVEY RESULTS

REFERENCE

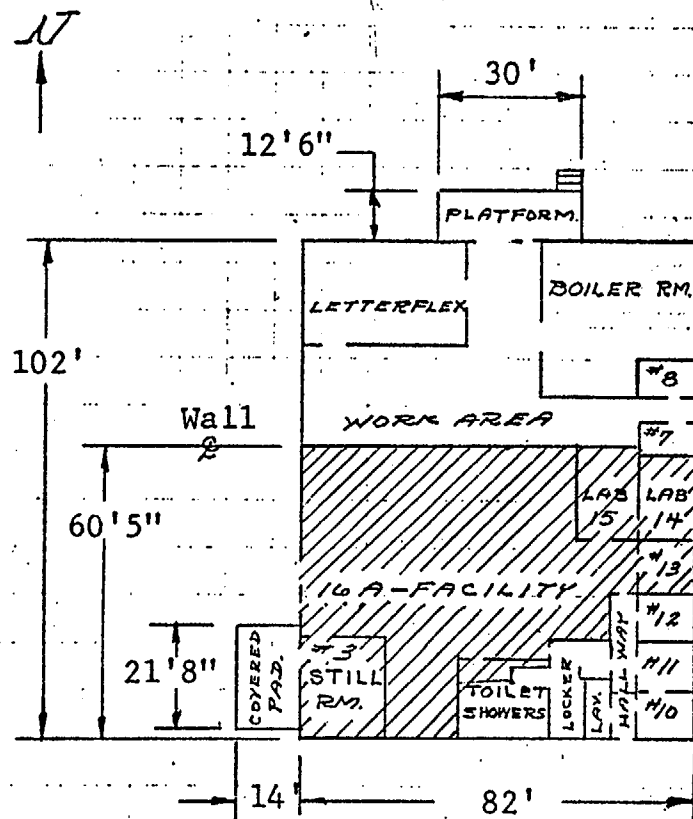
APPENDIX A: DESCRIPTION OF NUCLEAR FACILITY
FROM SNM 840 LICENSE APPLICATION

APPENDIX B: SPECIAL INSTRUCTIONS FOR WET-END
CLEAN-UP AND LIQUID SCRAP/WASTE
DISPOSAL

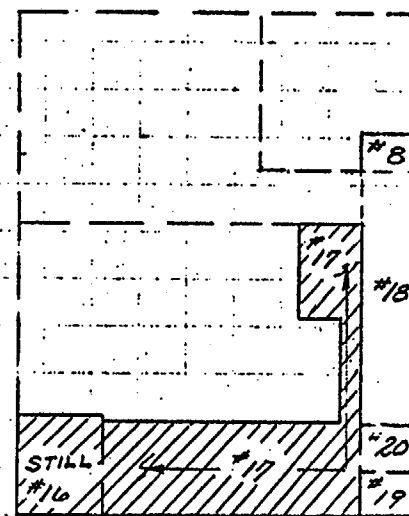
APPENDIX C: TOTAL AND REMOVABLE CONTAMINATION
IN RESTRICTED AREA AFTER DECONTAMINATION

1. DESCRIPTION OF THE NUCLEAR
FACILITY AND RESTRICTED AREAS

W. R. Grace & Co.'s NUCLEAR FACILITY at Clarksville, Maryland, is comprised of the portions of the two buildings identified in Figure 1 and known locally as Buildings 16-A and 20. Building 16-A houses all research and development activity with special nuclear material (SNM). The Restricted Area of Building 16-A consists of a central high-bay Process Area - main floor and mezzanine, three laboratory rooms used for chemical and physical testing, a solvent recovery or still room and a security-fenced, outdoor, storage area for shipping and the temporary storage of ordinary materials and waste. Also included in the Building 16-A complex but outside the Restricted Area are four offices, a change area and a lunch room. The Restricted Area of Building 20 consists of a security fenced portion used only for the storage of packaged, as-received raw material or product. These buildings are described in more detail in Figures 2 and 3 and Appendix A which has been excerpted from our SNM License Application.



Main Floor



Mezzanine

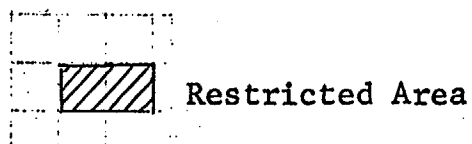


FIGURE 2. Restricted Areas in Building 16A

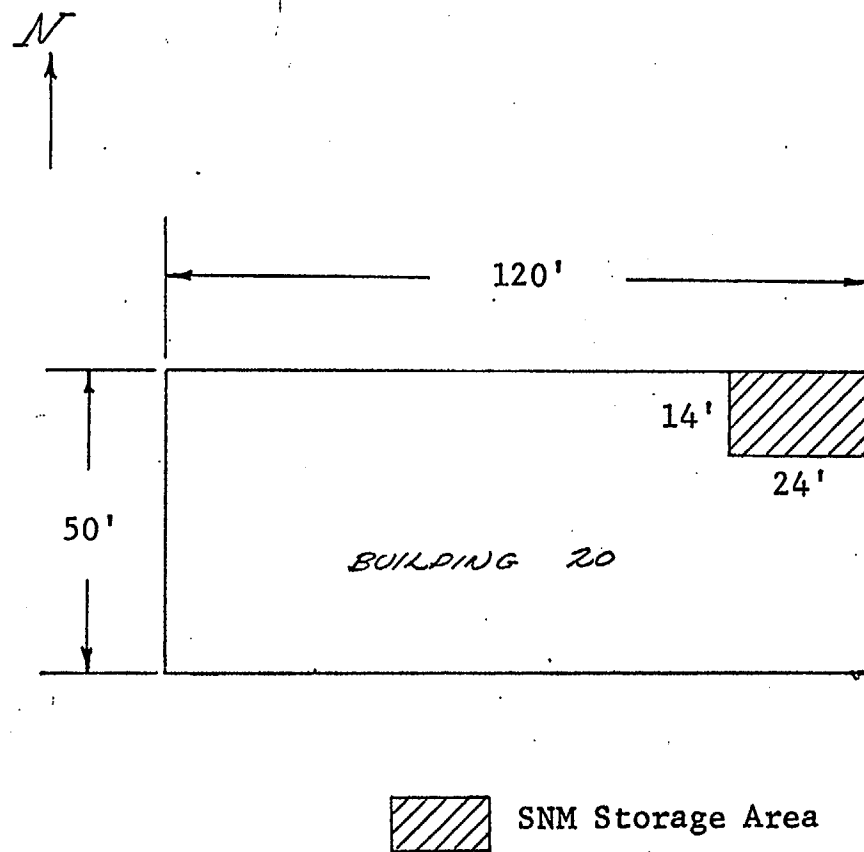


FIGURE 3. Restricted (SNM Storage) Area in Building 20

2. DESCRIPTION OF DECONTAMINATION PROCEDURES

The decontamination of the NUCLEAR FACILITY proceeded in four stages.

- (1) decontamination of all liquid processing apparatus - pipes and containers,
- (2) consolidation and transfer of all SNM,
- (3) decontamination and disposal of service facilities and equipment, and
- (4) decontamination of walls and floors.

Written procedures were prepared to cover all operations in Stages 1 and 2. These are included in this report as Appendix B. The operations in Stages 3 and 4 largely involved the washing and disposing of low specific activity waste. The operations in Stages 3 and 4 were done on a case by case basis without written procedures but with close surveillance by management and radiation safety personnel.

The decontamination procedures in Stages 3 and 4 consisted primarily of washing every accessible surface with an ordinary industrial, high sudsing detergent* and hot water

*WEDAC, West Chemical Products, Inc.

mixture and then rag wiping. Painted surfaces which resisted decontamination by this procedure were scoured with the same mixture and an ordinary abrasive cleansing agent. This procedure was effective on painted metal and masonry surfaces in all but one instance. In this instance, a wet abrasive grinder was required to reduce the contamination on a portion of the masonry floor to below the limits recommended in the Guidelines.⁽¹⁾ All wash water was sorbed on vermiculite and shipped to an authorized disposal site for burial*. Contaminated buckets, sponges, rags, etc., were similarly disposed. All surfaces were presumed contaminated initially. They were monitored for fixed and removable contamination after decontamination.

Following decontamination of the walls and appurtenances above the floor lines, the floor itself was decontaminated by stripping the wax from the vinyl floor covering. Wherever this procedure failed to reduce the contamination level to below the Guideline limits, the floor covering material was excised and discarded. All waste water from the floor cleaning was sorbed on vermiculite and along with buckets, sponges, rags, etc., was shipped to an authorized disposal site for burial.

*All LSA waste was consigned to Hittman Nuclear and Development Corp.

3. SURVEY PROCEDURES

Subsequent to decontamination the entire facility was surveyed to determine the presence and amount of any remaining contamination. An Eberline Model PAC-4G portable, gas-flow proportional counter was used to monitor for the total contamination remaining on the walls and floors. The count rate indicated by the survey instrument was calibrated to compensate for back reflection using Eberline Model S94-3 Calibration Standards. The meter indication was corrected manually for background geometry and probe area to obtain the measured activity in disintegration per minute per 100 cm².

Removable contamination was estimated by taking smear samples with filter paper and counting the transferred activity using a Nuclear Measurements Corporation, Model PC-4 gas-flow proportional counter. The measured count rate was manually corrected for background and counting and transfer efficiency.

The same monitoring techniques were used to estimate the contamination present on equipment released for unrestricted use, for equipment scrapped and disposed and in air ducts and waste lines.

4. SURVEY RESULTS

The average total activity on the walls and floor of the Restricted Area was less than 675 dpm per 100 cm². The maximum total activity measured was less than 12,000 dpm per 100 cm². This occurred in only a very localized area on one wall.

The average level of removable activity in the Restricted Area was less than 110 dpm per 100 cm². The maximum amount of removable contamination detected was 241 dpm per 100 cm².

The results of all the instrument and smear measurements are included as Appendix C to this Report.

REFERENCE

- (1) U.S.A.E.C., Division of Materials Licensing, "Guidelines for Decontamination of Facility and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source or Special Nuclear Material", 22 April 1970.

APPENDIX A

DESCRIPTION OF NUCLEAR FACILITY

FROM

SNM 840 LICENSE APPLICATION

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, Simpsenville is two miles to the east. Howard County is substantially rural, the principal urban area in the county is Columbia (with a population of 18,000) 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 processes are located in authorized areas in Bldg. 16-A and Bldg. 20 shown on Figure 3.2. Small quantities, such as waste may be stored in steel drums for a period not to exceed 72 hours, in the enclosed yard area, outside of Bldg. 16-A.
- 3.4 The Medical Department, First Aid Room and Health and Safety Department are located in Bldg. 2 shown in Figure 3.2. The assembly area for the Bldg. 16 complex is located in the Lobby Conference Room of Bldg. 2, where the emergency cache is located. Emergency equipment is located in these various offices.
- 3.5 The normal SRM samples are analyzed in the analytical laboratories, see Figure 3.2. Special samples are run in supporting laboratories.

FIGURE 3.2

BOUNDARY AND TOPOGRAPHIC SURVEY

WASHINGTON RESEARCH CENTER

CLARKSVILLE, MARYLAND

Docket No. _____ Date _____ Revision No. _____ Date _____

page 4

3.6

Special nuclear material may be found in one other location on the site and that location is the storage area in Building 20. This caged area is used primarily for the storage of bird cages of various scrap materials containing special nuclear material and also product in bird cages. The building and the caged area are both locked to prevent unauthorized intrusion.

APPENDIX B

SPECIAL INSTRUCTIONS FOR WET-END CLEAN-UP

AND

LIQUID SCRAP/WASTE DISPOSAL

SPECIAL INSTRUCTIONS
FOR
CLEAN UP OF THE NUCLEAR FACILITY

SPECIAL INSTRUCTIONS

for

WET END CLEAN-UP

1. GENERAL

All process piping and vessels will be cleaned by flushing with 3 N. nitric acid and then rinsing twice with deionized water. The adequacy of this procedure will be checked by analyzing a sample of liquid from the second rinse cycle. The process piping will be modified to permit the transfer of wash and rinse liquids directly to the Boildown apparatus Feed Tanks 10-37A or 10-37B from tank 10-11.

3. SPECIFIC INSTRUCTIONS

CAUTION: All solutions drained from the equipment during the execution of these instructions must be collected in critically safe, less than five inch diameter containers.

No solution may be drained from the critically safe geometry system unless specifically instructed to be by these instructions or authorized by the Foreman.

3.1 Drain all "heels" from the process lines and charge the drained liquids to the Boildown apparatus.

3.2 Clean the Dissolver assembly.

3.2.1 Carefully charge the Dissolver (13-1) with 2 ± 0.2 liters of deionized water and 3 ± 0.2 liters of concentrated HNO_3 .

3.2.2 Turn on the agitator and circulating pump. Circulate the acid wash solution through the Dissolver assembly piping for a minimum of 30 minutes.

3.2.3 Drain from 0.5 to 1 liter of acid wash solution through each drain or sampling valve and return the drained wash liquid to the Dissolver.

3.2.4 Stop the agitator and transfer the acid wash solution to tank 10-3A.

3.2.5 Repeat 3.2.1 through 3.2.4 eight more times until a total of 45 liters of acid and water has been charged.

- 3.2.6 Add 5 liters of deionized water to the Dissolver (13-1).
- 3.2.7 Start the agitator and circulating pump:
Circulate the rinse water for a minimum of 30 minutes as in 3.2.2.
- 3.2.8 Drain from 0.5 to 1 liter of rinse liquid through each drain or sampling valve and return the drained rinse liquid to the Dissolver.
- 3.2.9 When tank 10-3A is empty, stop the agitator and then transfer the rinse liquid to tank 10-3A.
- 3.2.10 Repeat the rinse procedure steps 3.2.6 to 3.2.9. Remove a 100 ± 10 ml sample of the rinse liquid from the second rinse cycle before transfer to 10-3A and request analysis for uranium.
- 3.3 Clean dilution tanks: 10-3A, 10-3B, and 10-3C.
 - 3.3.1 Circulate the acid wash solution in 10-3A through 10-3A for a minimum of 30 minutes. During the circulating period, drain 0.5 to 1 liter of the acid wash through each drain and sampling valve. Return the wash liquid to tank 10-3A.

- 3.3.2 Transfer the acid wash liquid from 10-3A to 10-3B.
- 3.3.3 Circulate the acid wash in 10-3B for a minimum of 30 minutes. During the circulating period, drain 0.5 to 1 liter of acid wash through each drain and sampling valve. Return the drained wash solution to tank 10-3B.
- 3.3.4 Transfer the acid-wash from 10-3B to 10-3C and repeat step 3.3.4 in 10-3C.
- 3.3.5 Transfer the acid wash solution from tank 10-3C to tank 10-4.
- 3.3.6 Fill tank 10-3A to a height of 140 to 145 inches with deionized rinse water.
- 3.3.7 Circulate the rinse water in tank 10-3A for a minimum of 30 minutes. During the circulation period, drain 0.5 to 1 liter of rinse water from each drain and sampling valve and return the drained rinse water to tank 10-3A.
- 3.3.8 Transfer the rinse solution in 10-3A to 10-3B and circulate and drain valves as described in 3.3.7 for tank 10-3A.
- 3.3.9 Transfer the rinse solution from 10-3B to 10-3C and circulate and drain valves as described in 3.3.7 for tank 10-3A.

3.3.10 When 10-3C has been cleared of rinse water, refill 10-3A with deionized water as described in 3.3.6 and repeat the procedures described in 3.3.7, 3.3.8 and 3.3.9. Remove a 100 to 125 ml sample from this second rinse charge after circulation in each tank and request an analysis of this sample for U-content.

3.4 Clean the catholyte system of the dialysis apparatus.

3.4.1 Bypass the dialysis cell and circulate the acid wash solution in tank 10-4 through the Heat Exchanger (02-3) and the Aerator (10-5) assemblies for a minimum of 60 minutes.

During the circulating period, drain 0.5 to 1 liter of acid wash solution through each drain and sample valve. Return the drained acid wash solution to tank 10-4.

3.4.2 Periodically open the by-pass lines around the Heat Exchanger and Aerator assemblies and flush these lines with the acid wash solution.

3.4.3 At the end of the circulating period, transfer the acid wash solution to tank 10-10A.

3.4.4 Transfer the rinse water in tank 10-3C to tank 10-4.

3.4.5 Circulate the rinse water through the catholyte system as described in steps 3.4.1 and 3.4.2 for the acid wash solution.

3.4.6 Transfer the rinse water to tank 10-10A as soon as this tank is cleared of acid wash solution following the same procedure used in step 3.4.4.

3.4.7 Transfer the second charge of rinse water from 10-3C to 10-4 and process as described in steps 3.4.5 and 3.4.6 for the first rinse. Remove a 100 to 125 ml sample from the second rinse at the conclusion of the circulating period and request analysis of the sample for U-content.

3.5 Clean the sol storage tanks 10-10A and 10-10B.

3.5.1 Circulate the acid wash in tank 10-10A for a minimum of 30 minutes using pump 03-9. During the circulation period, drain 0.5 to 1 liter of acid wash solution through each drain or sampling valve. Return the drained solution to 10-10A.

3.5.2 Transfer the acid wash solution to tank 10-10B using pump 03-9 and repeat the procedure described in 3.5.1 in tank 10-10B.

apparatus feed tanks 10-37A or 10-37B using 03-10 and a temporary line connected between the filter assembly (06-5B) and the discharge side of the feed pump on the Boildown apparatus.

3.6.4 Drain the Constant Overflow Tank (10-12) through the line to the sol feed pump as instructed in 3.6.2. Add the solution drained from 10-12 to the Waste Receiving Funnel on the Boildown apparatus.

3.6.5 Repeat 3.6.1 to 3.6.4 with each volume of rinse water as it is transferred to 10-11. Remove a 100 to 125 ml sample from the second rinse and request analysis of the sample for U-content.

3.6.6 Operate the Boildown apparatus as per SOP #11 except for the instruction in par. 8.B.9. Instead continue to operate the apparatus until the concentration of uranium in the bottoms is between 125 to 150 gs/l and then unload.

SPECIAL INSTRUCTIONS
FOR
CATEGORIZING AND DISPOSITIONING
LIQUID WASTES

LIQUID WASTE CATEGORIES

Liquid wastes generated and presently stored in the Nuclear Facility may be divided into three categories for the purposes of processing for recovery or disposal as follows:

Category 1

This category of waste liquids includes all waste liquids that are highly concentrated with respect to uranium and can be packaged for shipment for recovery without further processing.

Category 2

This category includes all waste liquids that are dilute with respect to uranium and are contaminated with other liquids so as to preclude economic recovery of the contained uranium. Waste liquids in this category can be packaged by SOP and disposed of by burial at authorized disposal sites.

Category 3

Waste liquids in this category are of intermediate concentrations with respect to uranium and will be converted to Category 1 waste before being packaged and shipped for recovery. The conversion to Category 1 waste will be done by concentrating using the boildown apparatus. Waste liquids in this category are of two types:

Type A - liquid without sludge

Type B - liquid with a precipitate or sludge

Special Instructions have been prescribed for the disposition of all waste liquids in each of these categories.

SPECIAL INSTRUCTIONS
for
PACKAGING Category 1 LIQUID WASTES

I. GENERAL

Category 1 liquid wastes in nominal 12 liter, polyethylene bottles (NFS, Inc. Drawing #5B-U-740) may be loaded directly into Model WRG-10 C1 packaging for transport after they have been sampled and reweighed.

III. DETAILED INSTRUCTIONS

CAUTION: Do not remove the storage containers from their bird-cage assemblies except to place them in the shipping container in the Packaging Area.

- A. Select one (1) storage container of Category 1 liquid waste and transfer it to the Packaging Area.
- B. Open the storage container and remove a 25 ± 5 ml sample representative of the container's contents. Complete an Analytical Request and Material Transfer form and obtain an analysis of the sample for U-content.
- C. Close the storage container and redetermine its gross weight.
NOTE: The "gross weight" equals the weight of the closed container, labels and contents.
- D. Remove the old label and relabel with the revised information.
- E. Transfer one (1) Model WRG-10 C1 package to the Packaging Area and load the nominal 12 liter, polyethylene bottle storage container into the package per SOP #18.
- F. Close and seal the completed package and store it in the MBA #1 cage until transport arrangements are completed.

SPECIAL INSTRUCTIONS

for

PACKAGING Category 2 LIQUID WASTES

I. GENERAL

Category 2 waste liquids may be absorbed on vermiculite in DOT Specification 6J, 17C or 17H, 55 gallon capacity containers per SOP #17 after they have been sampled and the U-Content has been confirmed by analysis.

SPECIAL INSTRUCTIONS

for

CONCENTRATING Category 3A and 3B LIQUID WASTES

I. GENERAL

Category 3A and 3B liquid wastes presently stored in nominal 12 liter, polyethylene bottles will be charged to the Boildown apparatus and concentrated to convert them to Category 1 liquid wastes which then can be packaged and shipped for recovery.

III. DETAILED INSTRUCTIONS

A. Category 3A waste liquid. (NOTE: Category 3A liquid wastes include all Category 3 waste liquids in storage containers which do not also contain a visible precipitate or sludge.)

1. Transfer the Category 3A waste liquid from the storage torpedo (nominal 12 liter, polyethylene bottle) or 5 gal. plastic carboy to the Waste Receiving Funnel on the Boildown apparatus.

- (a) Construct a transfer assembly comprised of one (1) Master-flex pump, a length of 3/8 inch diameter Tygon tubing sufficient to reach from the torpedo dip tube to the pump and then the Waste Receiving Funnel on the Boildown apparatus and a length of stainless steel tubing sufficient to reach the bottom of a standard torpedo.
- (b) Select a storage container of Category 3A waste liquid and move the container to the vicinity of the Boildown apparatus and transfer assembly. CAUTION: Do not remove the torpedoes from the bird-cage assemblies.
- (c) Open the torpedo start the pump on the transfer assembly and use the stainless steel dip tube to remove the waste liquid and transfer it to the Boildown apparatus. Periodically operate the Boildown apparatus feed pump to move waste liquid accumulating in the receiving funnel to the feed tank 10-37A or 10-37B.

- (d) Rinse the outside of the dip tube and the inside of the storage container twice with 1 to 2 liters of deionized water. Transfer the rinse liquid to the boildown apparatus as described in III.A.1(c).
 - (e) When all the waste and rinse liquid has been transferred from the storage container, remove the SS-10 and special label, close the container, wipe the outside clean of any contamination and return the container to the Interim Storage or shipping container as required.
- 2. Repeat III.A.1(a) to III.A.1(e) until all of the Category 3A waste has been transferred to the boildown apparatus feed tanks 10-37A or 10-37B.
 - 3. Operate the boildown apparatus per SOP #11 except for the instruction in par. 8.B.9. Instead, continue operation until the concentration of uranium in the bottoms equals 125-150 gs/l and then unload.

B. Category 3B waste liquid. (NOTE: Category 3B liquid waste is liquid wastes in containers which also contain a visible sludge or precipitate.)

- 1. Transfer the supernatant liquid from a Category 3B liquid waste from the storage container to the boildown apparatus using the procedure described in III.A.1(a) to III.A.1(e). Retain as much of the sludge as possible in the storage container. Do not transfer the sludge to the boildown apparatus. Label the storage container "#1".

2. Repeat III.B.1 with a second container of Category 3B liquid waste.
3. Slurry the sludge in the bottom of the second container with added deionized water and then transfer the slurry to storage container #1 using the transfer assembly.
4. Inspect the container and assure that all of the sludge has been transferred.
5. Rinse the outside of the dip tube and the inside of the storage container with 1 to 2 liters of deionized water. Transfer the rinse water to the Boildown apparatus per the procedure described in III.A.1(c).
6. After inspection to assure that all of the sludge and rinse water has been emptied from the storage container, remove the SS-10 and special labels, close the container, wipe the outside clean of contamination and return the empty container in its birdcage assembly to the Liquid Waste Storage Area.
7. Remove a 20 to 25 ml representative sample from the contents of storage container #1 and request analysis of the sample for U-content.
8. CAUTION: The contents of storage container #1 must contain less than 350 g/l of uranium as shown by the results of the sample analyzed in step III.B.7. If the analysis indicates a U-content greater than 350 g/l, no further sludge additions to storage container #1 shall be made. Repeat III.B.2 and III.B.5 with each remaining container

of Category 3B liquid waste until all of the supernatant liquid has been charged to the Boildown apparatus and all of the sludge has been accumulated separately.

9. Operate the Boildown apparatus per SOP #11 except for the instruction in par. 8.B.9. Instead, continue to operate the apparatus until the concentration of uranium in the bottoms equals between 125 and 150 g/l and then unload.

W. R. GRACE & CO.

RESEARCH DIVISION



WASHINGTON RESEARCH CENTER
7379 ROUTE 32, COLUMBIA, MARYLAND 21044
Telephone 301 - 531-5711

Approvals for Standard Operating Procedures

SOP, Dated July 9, 1973

PACKAGING OF LIQUID WASTES

S. Reese 7/9/73 Nuclear Criticality Safety
Signature Date (S. Reese - Nuclear Safety Associates)

R. Herbst 7/10/73 Radiation Safety
Signature Date (R. Herbst)

J. H. Baird 7/11/73 Process Safety
Signature Date (J. H. Baird)

J. J. Blouin 7/10/73 Operation Safety
Signature Date (J. J. Blouin)

PACKAGING OF LIQUID WASTES

1. Purpose

To establish the procedure for packaging liquid wastes for shipment.

2. Area

All packaging of liquids are to be at the west end of Building 16-A.

3. General

A quantity of liquid waste is transferred from a storage container into a tared container. After the transfer the container is weighed, capped and sealed, and sealed in a plastic bag. The sealed container is placed into an approved shipping container. The shipping container is closed and made ready for shipment.

4. Health & Safety

4.1 Wear protective gloves, safety glasses and protective clothing.

4.2 Report all spills and follow the cleanup SOP.

4.3 Monitor for airborne contamination throughout the operation.

July 9, 1973

4.4 No hazardous chemicals are involved.

5. Materials

For each shipping container.

- 5.1 Two 1/2 gallon plastic bottles and caps.
- 5.2 Plastic tape for sealing the bottle caps.
- 5.3 Labels for the plastic bottles (SS-10).
- 5.4 Plastic bags for each plastic bottle.
- 5.5 One cork, round-bottom, flask holder.
- 5.6 Two wooden discs; 1 inch thick, 4-3/4 inch in diameter.

6. Major Equipment

- 6.1 Masterflex pump in a shallow tray (1-1/4" max. depth)
with inlet and outlet hoses.
- 6.2 Weighing scale with check-weight.
- 6.3 Approved shipping containers.

7. Analytical

None.

8. Procedure

A. Equipment Checks

- 1. Leak check the Masterflex pump and hoses. Record
the results of the check on the data sheet.

2. Check the weighing scale by placing the check-weight on the scale. Record the actual weight of the check-weight and the measured weight of the check-weight on the data sheet.
3. Inspect the inside of the shipping container for cracks or other potential sources for leaks. Record the results of this inspection on the data sheet.
Also record the number of the shipping container.

B. Filling the Inner Container

NOTE: These operations are to be completed for each shipping container.

1. Place the storage container adjacent to the Masterflex pump. Record the container number, weight of contents, and U concentration on the data sheet. These data are to be taken from the label of the storage container.
2. Label and number a 1/2 gallon plastic bottle and then tare weigh the empty bottle and cap. Record the number and tare weight on the label and on the data sheet. Place this bottle in a shallow tray.
3. Insert the Masterflex inlet and outlet hoses into the storage container and circulate the waste for

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a minimum of 30 minutes for mixing.

4. After mixing, shutoff the pump and transfer the outlet tube to the tared plastic bottle.
5. Start the pump and fill the plastic bottle, controlling the flow to avoid overflow by means of the valve in the outlet hose.
6. When the plastic bottle is filled, shutoff the pump and transfer the outlet hose to the next tared plastic bottle.
7. Weigh the filled plastic bottle (including cap) and record the weight on the data sheet.
8. If the storage container empties before a plastic bottle is full, weigh the partially filled bottle (including cap) and record the weight on the data sheet. Then start on a new storage container and repeat Steps A-3 and B-1 through B-7
9. When the plastic bottle is filled, cap the bottle tightly.

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10. Request that Accountability complete the label on the plastic bottle based upon the information on the data sheet.
11. Torque the cap of the plastic bottle to 15 foot pounds and seal it with tape. Place the plastic bottle inside a plastic bag and seal the bag with tape. Load the bottle into the approved shipping container as described in C below.
12. Repeat Steps B-2 through B-11 until two plastic bottles are sealed in plastic bags and loaded into the shipping container.

C. Loading the Shipping Container

1. Open the shipping container.
2. Examine all parts of the container and be certain each is in good repair. Carefully inspect the 5-inch diameter-pipe, inner container walls. There must be no evidence of corrosion or thinning.

CAUTION: Do not use any container that is clearly damaged or which is suspected to be defective. Note any observations in this regard on the data sheet

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and have Engineering review and recommend action regarding the disposition of any suspect parts.

3. Place one of the 1-inch by 4-3/4 inch diameter wood discs in the bottom of the 5-inch diameter pipe inner or primary container.
4. Place one of the filled and bagged plastic bottles into the inner container on top of the wood disc. Be careful to place the taped portion of the plastic bag to one side of the neck of the bottle.
5. Locate one of the cork, round-bottom, flask supports on top and around the neck of the plastic bottle in the inner container.
6. Place a second filled and bagged plastic bottle in the inner container on top of the first.
7. Place one (1) 1-inch by 4-3/4 inch wood disc on top of the second plastic bottle.
8. Cap the inner container tightly. NOTE: The 5-inch pipe inner container is the primary containment in the event one of the plastic bottles should open or

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break. This cap must be tightly fastened to prevent leakage in the event of such an occurrence.

9. Pack vermiculite level with the top of the drum.
10. Place the 1/8 inch asbestos sheet on top.
11. Close the drum.
12. Record on the data sheet the date that the drum was closed.
13. Repeat the complete procedure for each shipping container.
14. Not more than 18 shipping containers are permitted in one location.

D. Empty Bottles

1. Upend each empty storage container over a 1/2 gallon plastic collecting bottle and let it drain for at least 30 minutes.
2. Pour the contents of the collecting bottle into the 1/2 gallon plastic bottle to be filled for shipping.

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3. Inspect each empty storage container carefully to be sure it is free of solids particularly in the bottom. If solids are present, rinse with a small quantity of solution. Add the rinse solution to the contents of the collecting bottle.
4. Place the drained storage containers into plastic bags for disposal.

E. Shutdown Procedure

Wash the pump and hoses with water and dispose of the water as directed by Health & Safety.

PACKAGING OF LIQUID WASTE FOR SHIPPING

DATA SHEET - SHIPPING CONTAINER NO. _____

INSPECTIONS: (1) Leak Check Pump & Tubing: Results _____
(2) Scale Check: Results _____
(3) Check of Shipping Container: Results _____

IDENTIFICATION OF STORAGE CONTAINERS: From which waste is transferred

DATA FROM CONTAINER LABEL

Container Number
Wt. of Contents
U Concentration of Contents

SC-1	SC-2	SC-3

	Inner Container No.	Tare	Wt. After Receiving From SC-1	Wt. After Receiving From SC-2	Wt. After Receiving From SC-3	Net Wt. Contents
1st Inner Container						
2nd Inner Container						
3rd Inner Container						

DATE SHIPPING CONTAINER CLOSED _____

OPERATOR'S NAME _____

APPENDIX C

TOTAL AND REMOVABLE CONTAMINATION
IN RESTRICTED AREA AFTER DECONTAMINATION

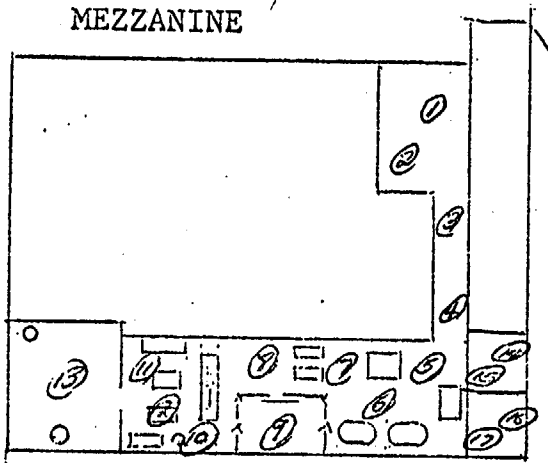
SMEAR SAMPLE DATA SHEET

PAC 46 INSTRUMENT SURVEY

DIAGRAM OF AREA

DATE 8/28/73

MEZZANINE



BUILDING OR AREA 16A - Mezzanine Floor

SUSPECTED ACTIVITY EU

SURVEYED

SMOURED BY R. L. Marr.

COUNTED BY n/a

SUPERVISOR

R. J. [Signature] - 8/29/73

1	2	3	4	5	6	7	8	9	10	11
SAMPLE NUMBER	LOCATION	AREA OF SMEAR 100cm ²	ACTIVITY COUNTED α β-γ	GROSS CPM	BACKGND. CPM	NET CPM	EFFI- CIENCY	DPM/ 100cm ² Total	GOAL DPM/100 cm ²	REMARKS
1	①	0.5	✓	50	<100	Bkgd	51	0L	5000/25000	
2	②	0.5	✓	75	<100	Bkgd		0L		
	③	0.5	✓	60	<100	Bkgd		0L		
	④	0.5	✓	150	<100	50	51	200		
	⑤	0.5	✓	475	<100	400		1600		
	⑥	0.5	✓	450	<100	400		1600		
	⑦	0.5	✓	600	<100	550		2200		
	⑧	0.5	✓	400	<100	350		1400		
	⑨	0.5	✓	200	<100	150		600		
	⑩	0.5	✓	150	<100	100		400		
	⑪	0.5	✓	200	<100	150		600		
	⑫	0.5	✓	350	<100	300		1200		
	⑬	0.5	✓	400	<100	350		1400		
	⑭	0.5	✓	50	<100	Bkgd		0L		
	⑮	0.5	✓	75	<100	Bkgd		0L		
	⑯	0.5	✓	25	<100	Bkgd		0L		

RAC 4G Instrument Survey

DATE _____

8/28/73

MEZZANINE

BUILDING OR AREA 16A Mezzanine Floor

SUSPECTED ACTIVITY

EU

SURVEYED

PREPARED BY

R. L. Matt

COUNTED. BY

 $\cdot h/a$

SUPERVISOR

R. L. L. D. - 2/22/73

[illegible]

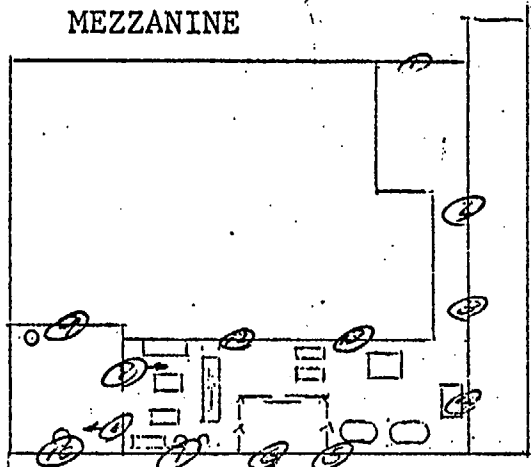
SHEAR SAMPLE DATA SHEET

PAC-46 INSTRUMENT SURVEY

DIAGRAM OF AREA

DATE 8/29/73

MEZZANINE



BUILDING OR AREA 16A Mezzanine Walls

SUSPECTED ACTIVITY ELL

SURVEYED
SHEARED BY R.L. Marr

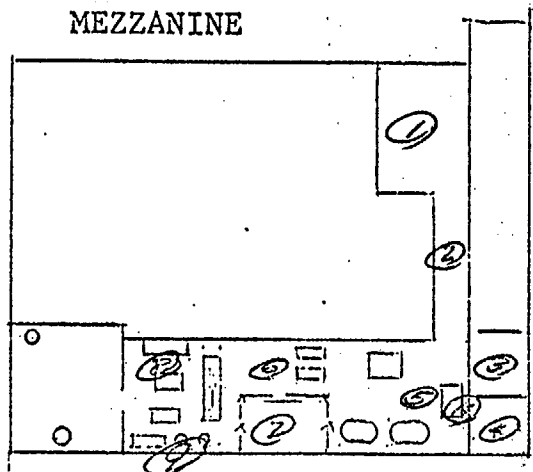
COUNTED BY n/a

SUPERVISOR _____

SAMPLE NUMBER	LOCATION	AREA OF SHEAR 100cm ²	ACTIVITY COUNTED		GROSS CPM	BKGD. CPM	NET CPM	EFFI- CIENCY	DPM/ 100cm ² Total	GOAL DPM/100 cm ²	REMARKS
			α	$\beta-\gamma$							
1	Wall	0.5	✓		50	<50	0	50	Bkgd	5000/25,000	
2	Wall	0.5	✓		50	<50	0	50	"		
3	Wall	0.5	✓		50	<50	0	50	"		
4	Wall	0.5	✓		25	<50	0	50	"		
5	Wall	0.5	✓		25	<50	0	50	"		
6	Wall	0.5	✓		25	<50	0	50	"		
7	Wall	0.5	✓		50	<50	0	50	"		
8	Wall	0.5	✓		100	<50	50	50	200		
9	Wall	0.5	✓		25	<50	0	50	Bkgd		
10	Wall	0.5	✓		50	<50	0	50	"		
11	Wall	0.5	✓		50	<50	0	50	"		
12	Rail	0.5	✓		500	<50	450	50	1800		
13	Rail	0.5	✓		450	<50	400	50	1600		
									277		Alg.

S M E A R S A M P L E D A T A S H E E T

DIAGRAM OF AREA



DATE _____

BUILDING OR AREA

SUSPECTED ACTIVITY

SMEARED BY

COUNTED BY

SUPERVISOR

1	2	3	4	5	6	7	8	9	10	11
SAMPLE NUMBER	LOCATION	AREA OF SHEAR in cm ²	ACTIVITY COUNTED α $\beta - \gamma$	GROSS CPM	BKGND. CPM	NET CPM	EFFICIENCY	DPM/ Total 100cm ²	GOAL DPM/100 cm ²	REMARKS
1	Floor	7	✓	34	2.9	31	70/51	13	1100	
2	Floor	7		36	2.9	-	70/51	13	"	
3	Floor	7		58	4.3	-	70/51	22	"	
4	Floor	7		29	2.9	-	70/51	10	"	
5	Floor	7		81	4.3	-	70/51	31	"	
6	Floor	7		28	2.9	-	70/51	10	"	
7	Floor	7		80	4.3	-	70/51	30	"	
8	Floor	7		32	2.9	-	70/51	12	"	
9	Wall	7		157	4.3	-	80/51	86	"	
10	Wall	7		30	2.9	-	80/51	15	"	
5	Floor	7		65	2.9	-	70/51	25	"	PC ST 4
							N/A	17.6	wall	

SUGAR SAMPLE TA SHEET
PAC-4G INSTRUMENT SURVEY

DIAGRAM OF AREA

FIRST FLOOR

DATE 8/28/73

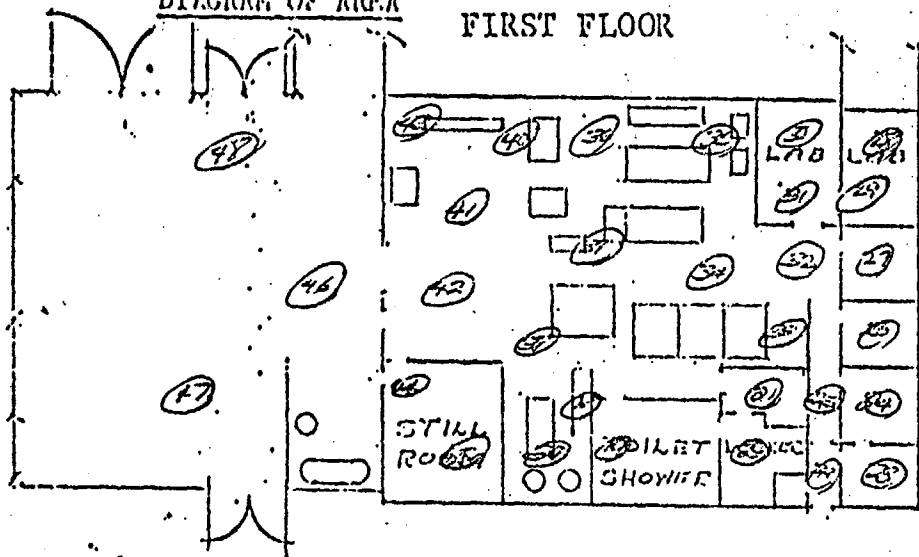
BUILDING OR AREA 16A - main Floor Floor

SUSPECTED ACTIVITY EW

SURVEYED
SHOWN BY R.L. Marr

COUNTED BY n/a

SUPERVISOR R. J. Huel - 8/29/73.



SAMPLE NUMBER	LOCATION	AREA OF SUGAR 100cm ²	ACTIVITY COUNTED		GROSS CPM	BGND. CPM	NET CPM	EFFICIENCY	DPM/100cm ² TOTAL	GOAL DPM/100cm ²	REMARKS
			a	β-γ							
	(18)		✓		100	<100	25	51	100	5000/25,000	
	(19)		✓		350	<100	275	51	1100		
	(20)		✓		350	<100	275	51	1100		
	(21)		✓		450	<100	375	51	1500		
	(22)		✓		50	<100	Bld	51	OK		
	(23)		✓		25	<100	Bld	51	OK		
	(24)		✓		50	<100	Bld	51	OK		
	(25)		✓		50	<100	Bld	51	OK		
	(26)		✓		75	<100	Bld	51	OK		
	(27)		✓		150	<100	75	51	300		
	(28)		✓		75	<100	Bld	51	OK		
	(29)		✓		150	<100	75	51	300		
	(30)		✓		275	<100	200	51	800		
	(31)		✓		450	<100	400	51	1600		
	(32)		✓		300	<100	225	51	900		

CONFIDENTIAL PAGE 46 INSTRUMENT SURVEY

DATE 8/28/73

BUILDING OR AREA 16A MAIN, Floor Floor

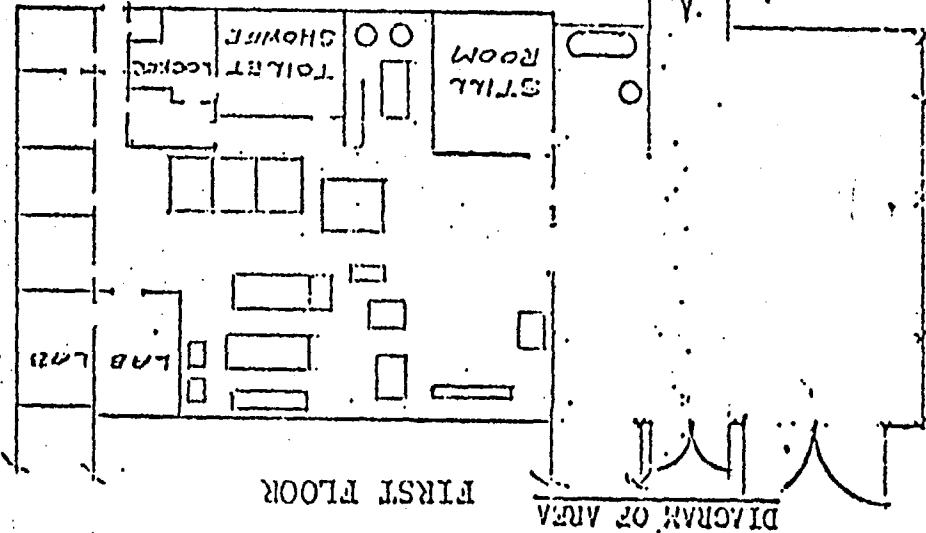
SUSPECTED ACTIVITY

अथवा

BY STANDARD

COUNTY BY

SUPERVISOR



SAMPLE NUMBER	LOCATION	AREA OF SHEAR 100cm ²	ACTIVITY COUNTED	a	B-7	GROSS CPM	BACKGND. CPM	NET CPM	EFF. CENCY	DPM/100cm ²	GOAL DPM/100cm ²	REMARKS
(33)		0.5	✓			100	100	25	51	100	5000/25.000	
(34)		0.5	✓			450	100	375	51	1500		
(35)		0.5	✓			400	100	305	51	1300		
(36)		0.5	✓			2000	100	1925	51	7700		
(37)		0.5	✓			500	100	425	51	1700		
(38)		0.5	✓			1000	100	925	51	3700		
(39)		0.5	✓			750	100	675	51	2700		
(40)		0.5	✓			1500	100	1425	51	5700		
(41)		0.5	✓			500	100	375	51	1700		
(42)		0.5	✓			150	100	75	51	300		
(43)		0.5	✓			1000	100	925	51	3700		
(44)		0.5	✓			100	100	25	51	100		
(45)		0.5	✓									
(46)		0.5	✓			400	100	305	51	1300		
(47)		0.5	✓			150	100	75	51	300		
(48)		0.5	✓			200	100	25	51	100		

A SHEET

PAC 46 INSTRUMENT SURVEY

DIAGRAM OF AREA

FIRST FLOOR

DATE 8/29/73

BUILDING OR AREA 16A Main Floor - Walls

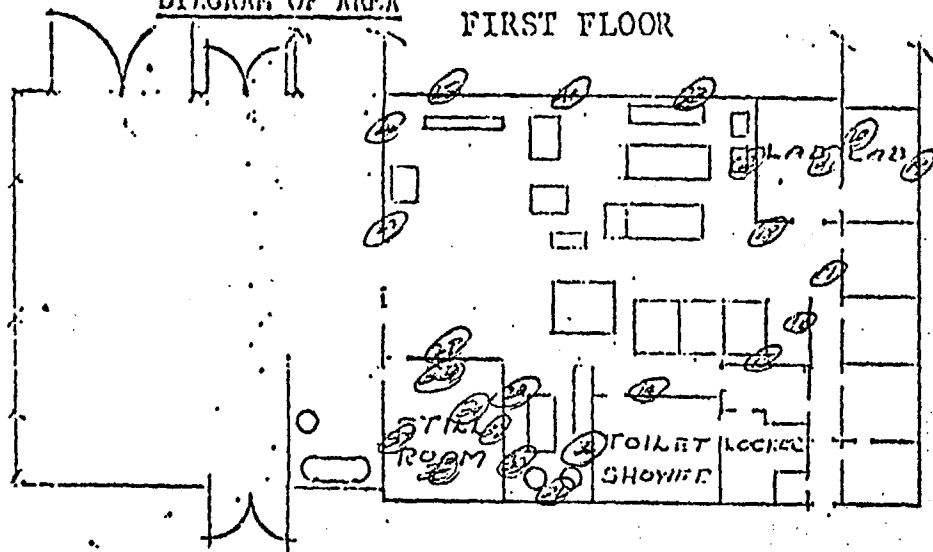
SUSPECTED ACTIVITY EU

SURVEYED

SURVEYED BY R. L. Mott

COUNTED BY h/a

SUPERVISOR _____



SAMPLE NUMBER	LOCATION	AREA OF SHEAR 100cm ²	ACTIVITY COUNTED		GROSS CPM	BKGND. CPM	NET CPM	EFFICIENCY	DPM/100cm ² TOTAL	GOAL DPM/100cm ²	REMARKS
			α	$\beta-\gamma$							
14		0.5	✓		50	<50	0	50	Bld	5000	25,000
15		0.5	✓		1000	<50	950	50	3800	"	
16		0.5	✓		200	<50	150	50	600	"	
17		0.5	✓		50	<50	0	50	Bld	"	
18		0.5	✓		50	<50	0	50	"	"	
19		0.5	✓		36	<50	0	50	"	"	
20		0.5	✓		100	<50	50	50	200	"	
21		0.5	✓		50	<50	0	50	Bld	"	
22		0.5	✓		150	<50	100	50	400	"	
23		0.5	✓		100	<50	50	50	200	"	
24		0.5	✓		150	<50	100	50	400	"	
25		0.5	✓		150	<50	100	50	400	"	
26		0.5	✓		100	<50	50	50	200	"	
27		0.5	✓		50	<50	0	50	0	"	
28		0.5	✓		50	<50	0	50	0	"	
29		0.5	✓		450	<50	400	50	1500	"	

WORK SAMPLE SHEET
PAC 46 INSTRUMENT SURVEY

DIAGRAM OF AREA

FIRST FLOOR

DATE 8/29/73

BUILDING OR AREA 16A Main Floor - Walk

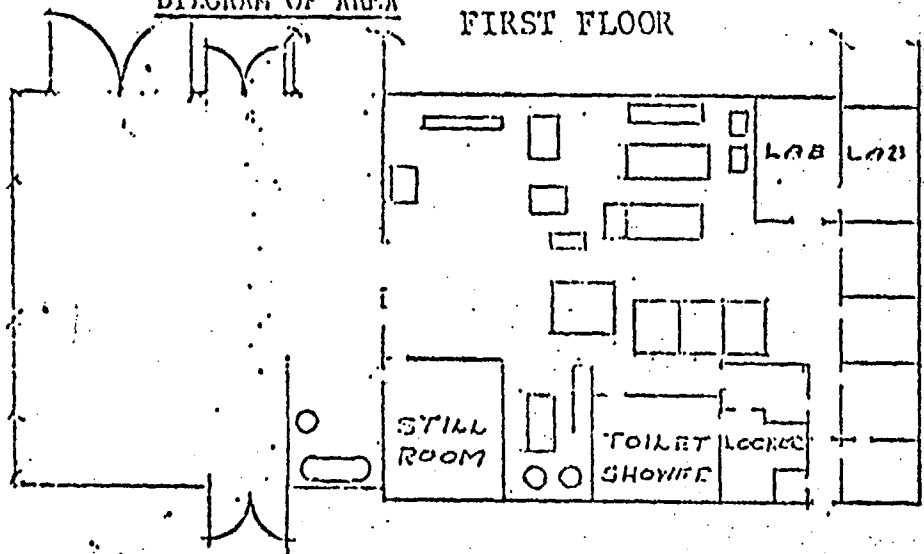
SUSPECTED ACTIVITY EU

SURVEYED

SHOWN BY R-L. Marr

COUNTED BY W.A.

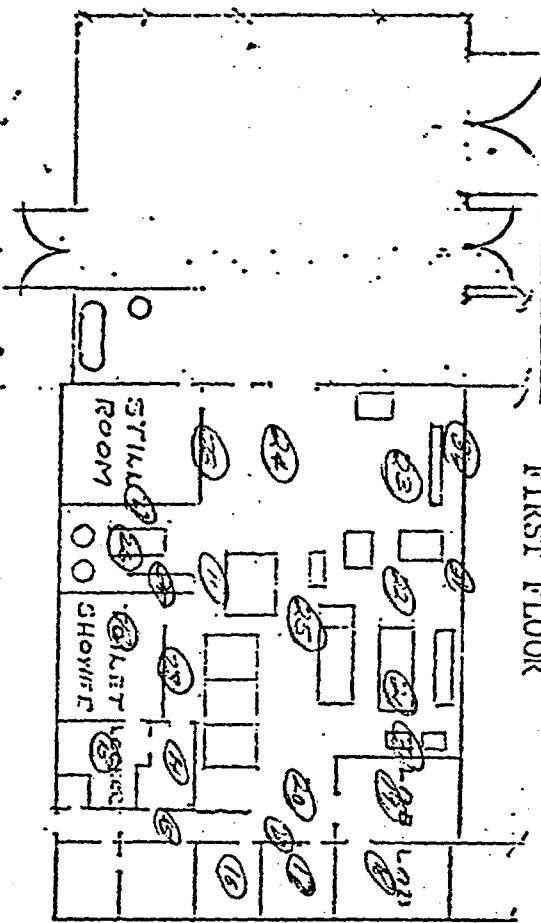
SUPERVISOR _____



SAMPLE NUMBER	LOCATION	AREA OF SHEAR 100cm ²	ACTIVITY COUNTED		GROSS CPM	BKCHO. CPM	NET CPM	EFFICIENCY	DPM/100cm ² TOTAL	GOAL DPM/100cm ²	REMARKS
			a	B-γ							
30		0.5	✓		100	450	50	50	200	5000/25000	
31		0.5	✓		150	450	100	50	100	"	
32		0.5	✓		3000	450	2950	50	11,800	"	
33	Floor - Still Rm	0.5	✓		350	200	150	50	600	5000/25000	9/18/73
34	"	0.5	✓		1000	200	800	50	3200	"	9/18/73
35	"	0.5	✓		1000	200	800	50	3200	"	9/18/73
36	Wall - Still Rm	0.5	✓		500	200	300	50	1200	"	9/18/73
37	"	0.5	✓		300	200	100	50	400	"	9/18/73
38	FLOOR - Bldg 20	AVG	✓		250	200	50	50	200	5000/25000	9/18/73
39	Wall - Bldg 20	AVG	✓		250	200	50	50	200	"	9/18/73

DIAGRAM OF AREA

FIRST FLOOR



DATE 8/31/67

BUILDING OR AREA 1619 - PROCESS AREA

SUSPECTED ACTIVITY ELU

SHEARED BY R. MATH

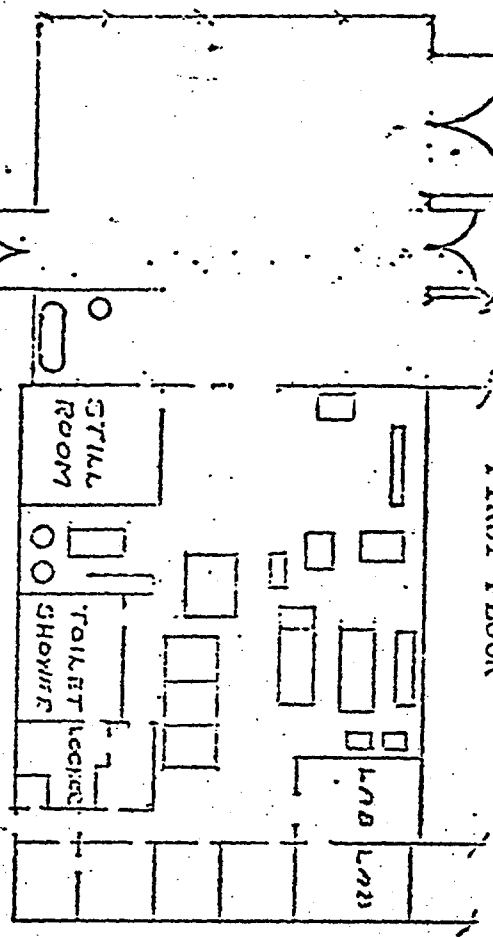
COUNTED BY R. MATH

SUPERVISOR R. MATH

SAMPLE NUMBER	LOCATION	AREA OF SHEAR	ACTIVITY COUNTERED	GROSS CPM	NET CPM	EFF. CENCY	DPM/100CM ² TOTAL	GOAL DPM/100CM ²	REMARKS
11	Floor	2	✓	18	2.9	70/51	6	1000	
12	Floor	✓		7	2.9	70/51	2	"	
13	Floor	✓		16	2.9	70/51	5	"	
14	Floor	✓		25	4.3	70/51	8	"	
15	Floor	✓		11	2.9	70/51	3	"	
16	Floor	✓		31	4.3	70/51	11	"	
17	Floor	✓		11	2.9	70/51	3	"	
18	Floor	✓		17	4.3	70/51	5	"	
19	Floor	✓		50	2.9	70/51	19	"	
20	Floor	✓		30	4.3	70/51	10	"	
21	Floor	✓		150	2.9	70/51	59	"	
22	Floor	✓		26	4.3	70/51	9	"	
23	Floor	✓		31	2.9	70/51	11	"	
24	Floor	✓		34	4.3	70/51	12	"	
25	Floor	✓		41	2.9	70/51	15	"	
26	Floor	✓		45	2.9	70/51	15	"	ALMA = 12.1

DIAGRAM OF AREA

FIRST FLOOR



DATE 9/31/67

BUILDING OR AREA 1619 - Process Area

SUSPECTED ACTIVITY EU

SHEARED BY R. Marr

COUNTED BY R. Marr

SUPERVISOR R. Marr

SAMPLE NUMBER	LOCATION	AREA OF SHEAR 2	ACTIVITY	GROSS CPM	NET CPM	EFF. CPM	DPM/100CM	GOAL DPM/100CM	REMARKS
27	Wall	7	18-7	329	2.9	50/51	183	1000	
28	Wall	7		98	4.3	50/51	52	"	
29	Wall	7		154	2.9	50/51	85	"	
30	Wall	7		61	4.3	50/51	32	"	
31	Wall	7		78	2.9	50/51	42	"	
32	Wall	7		435	4.9	50/51	241	"	
33	Wall	7		371	2.9	50/51	206	"	
34	Stairs	5		48	4.3	50/51	24	"	
	Exhaust Alcove	3.0		423	2.9	50/51	549	"	
	Wall - N Center	7		1144	2.9	50/51	1278	"	Dust on outlet box and conduit
	Exhaust Alcove	3.0		531	2.9	50/51	690	"	
	"	2.0		287	2.9	50/51	557	"	
	Exhaust Vent	3.0		497	2.9	50/51	646	"	

SAMPLE DATA SHEET

FIRST FLOOR



BUILDING OR AREA

SUSPECTED ACTIVITY

SAMPLED BY

FILTER PAPER USED

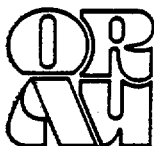
COUNTED BY

INSTRUMENT USED

BOOK AND PAGE

[illegible]

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Prepared by
Oak Ridge Associated
Universities

Prepared for
Division of Fuel
Cycle and
Material Safety

U.S. Nuclear
Regulatory
Commission

RADIOLOGICAL SURVEY OF SHEFFIELD BROOK WAYNE, NEW JERSEY

P. W. FRAME

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

PRELIMINARY REPORT

July 1982

ITEM # _____

ITEM #

279

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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

P.W. Frame

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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 acquired 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

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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 μ rem/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 Assessment 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.

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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.

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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.

Measurement of Direct Radiation

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

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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-penetrating 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.

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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.

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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 $\mu\text{R/h}$; surface beta-gamma dose rates ranged from 16 to 38 $\mu\text{rad/h}$.

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 $\mu\text{R/h}$ (background) to 423 $\mu\text{R/h}$. The highest levels were noted in two general areas. The first was a strip, approximately 5 m wide and 200 m

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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 $\mu\text{R/h}$ and 365 $\mu\text{R/h}$, 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 $\mu\text{R/h}$ 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 $\mu\text{R/h}$, 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 $\mu\text{R/h}$, 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 $\mu\text{R/h}$ to 173 $\mu\text{R/h}$, averaging 51 $\mu\text{R/h}$. At 5 m from the brook the exposure rates ranged from 9 $\mu\text{R/h}$ to 269 $\mu\text{R/h}$, averaging 58 $\mu\text{R/h}$; at 10 m from the brook the range was from 8 $\mu\text{R/h}$ to 250 $\mu\text{R/h}$, with an average value of 38 $\mu\text{R/h}$. 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.

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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 $\mu\text{rad/h}$. 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,

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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 upstream 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.

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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 guideline⁴ 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

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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 μ R/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.

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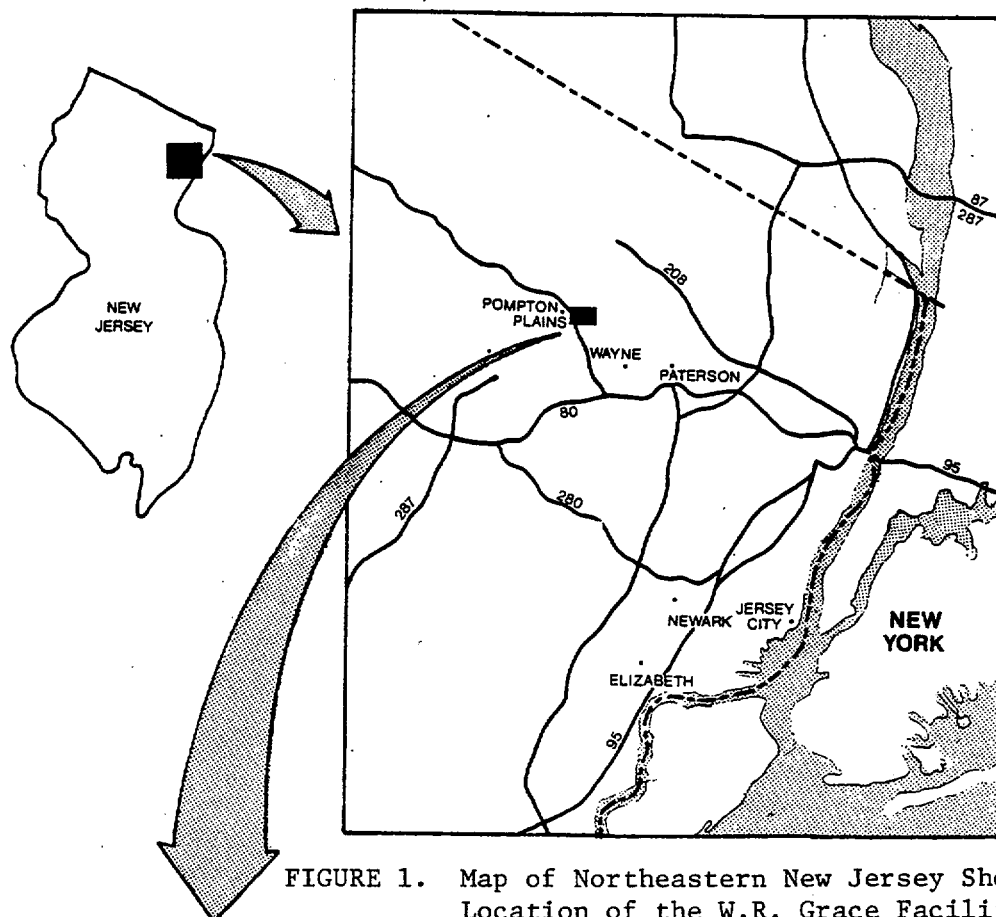


FIGURE 1. Map of Northeastern New Jersey Showing the Location of the W.R. Grace Facility.

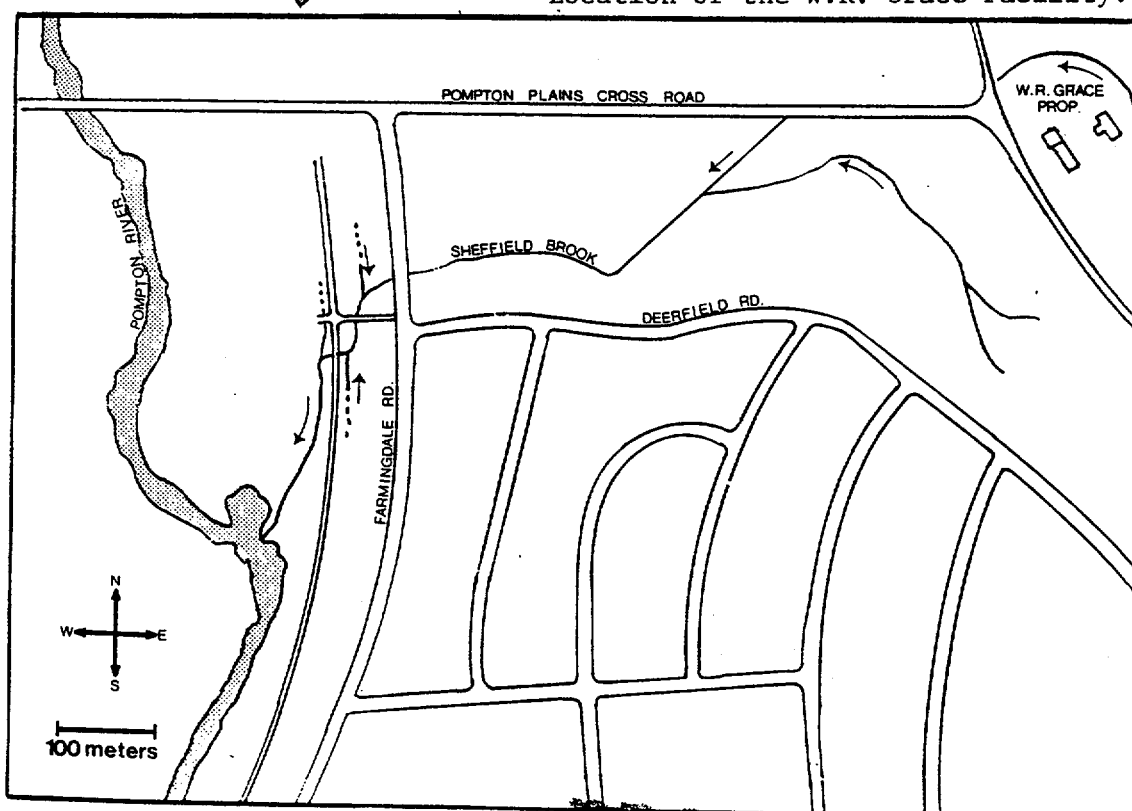


FIGURE 2. Portion of Wayne, New Jersey, Indicating the Locations of the W.R. Grace Property, Sheffield Brook and Associated Streams.

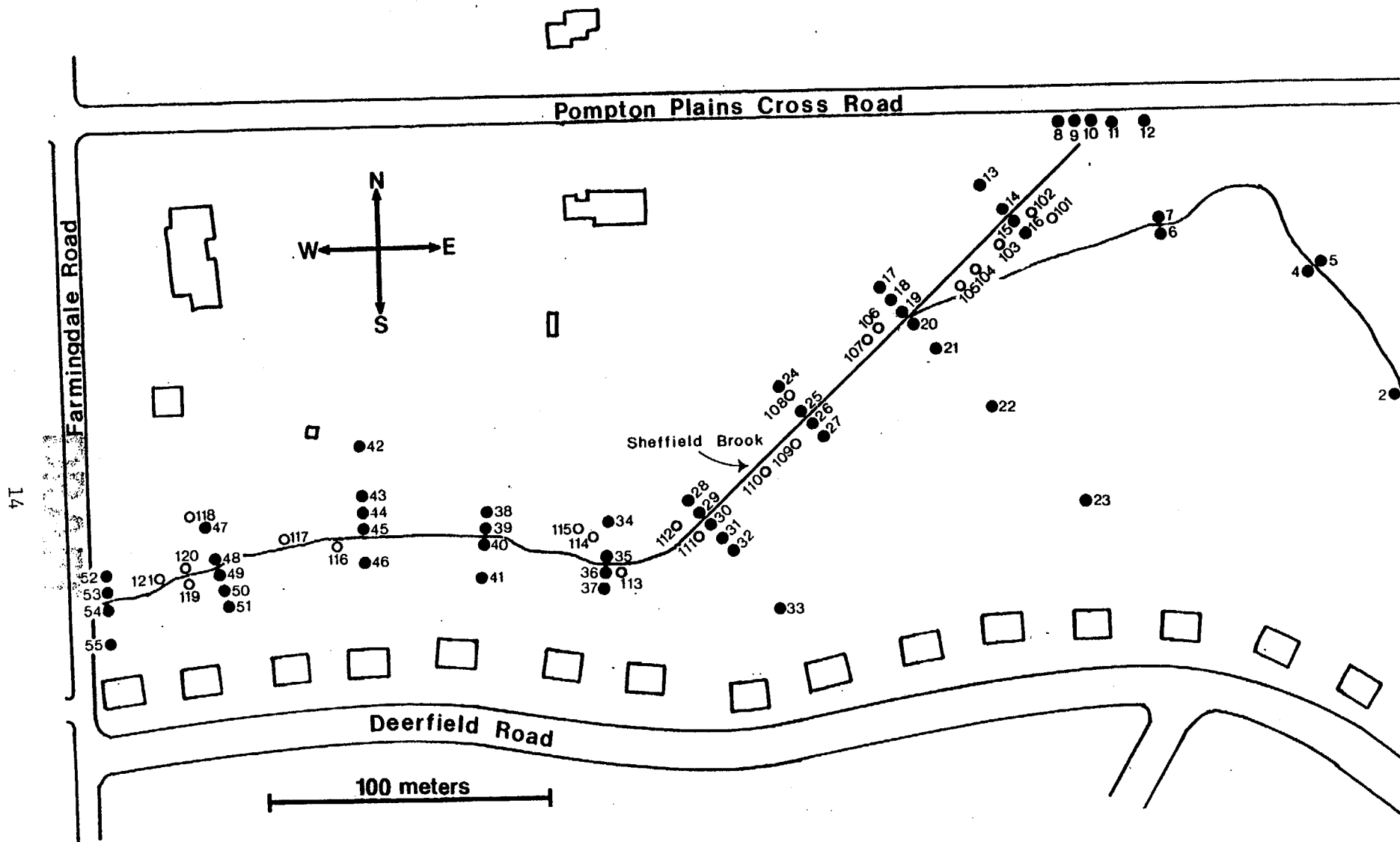


FIGURE 3. Map of Sheffield Brook, East of Farmingdale Road, Indicating Locations of Soil Samples.

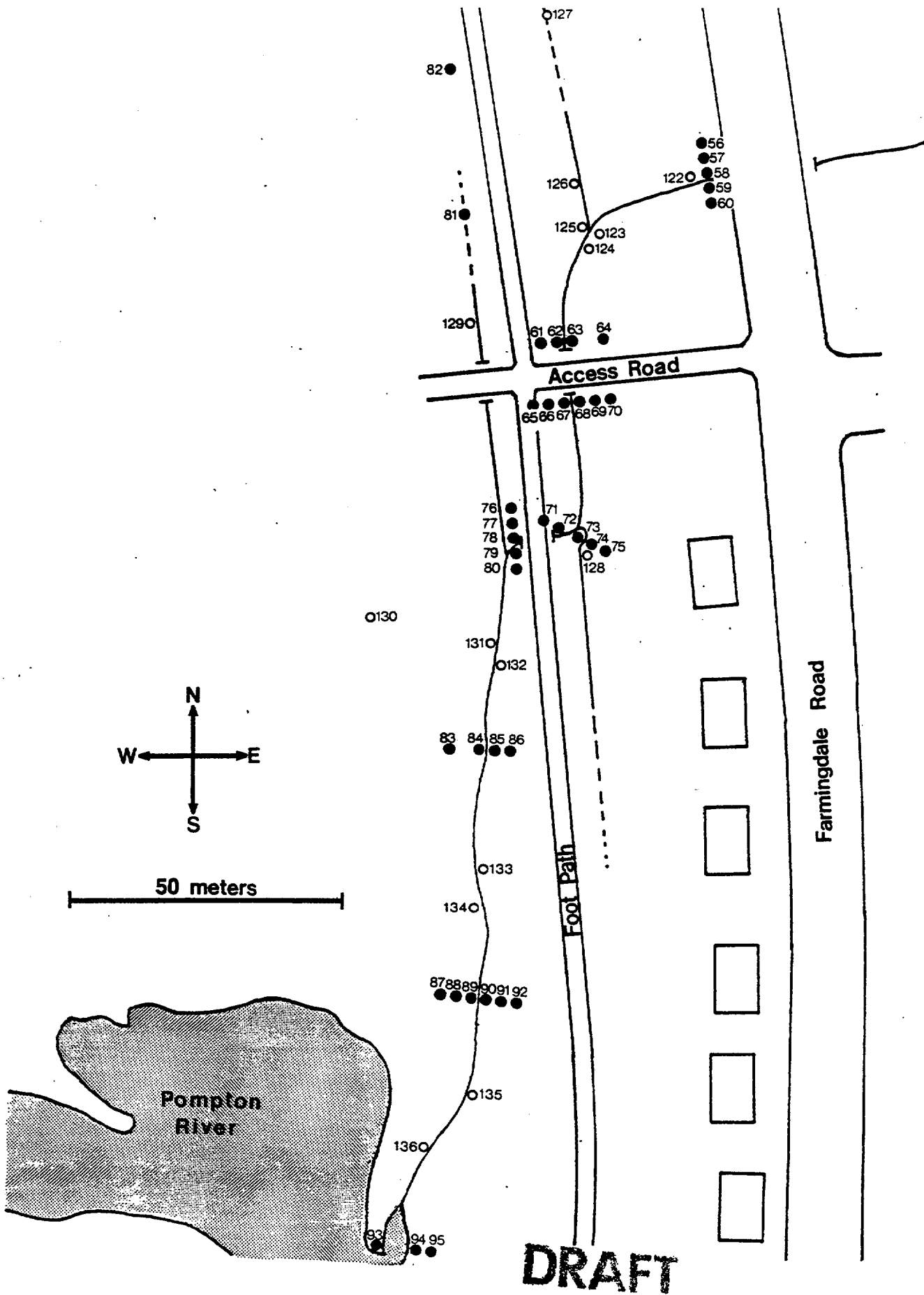


FIGURE 4. Map of Sheffield Brook, West of Farmingdale Road, Indicating Locations of Soil Samples.

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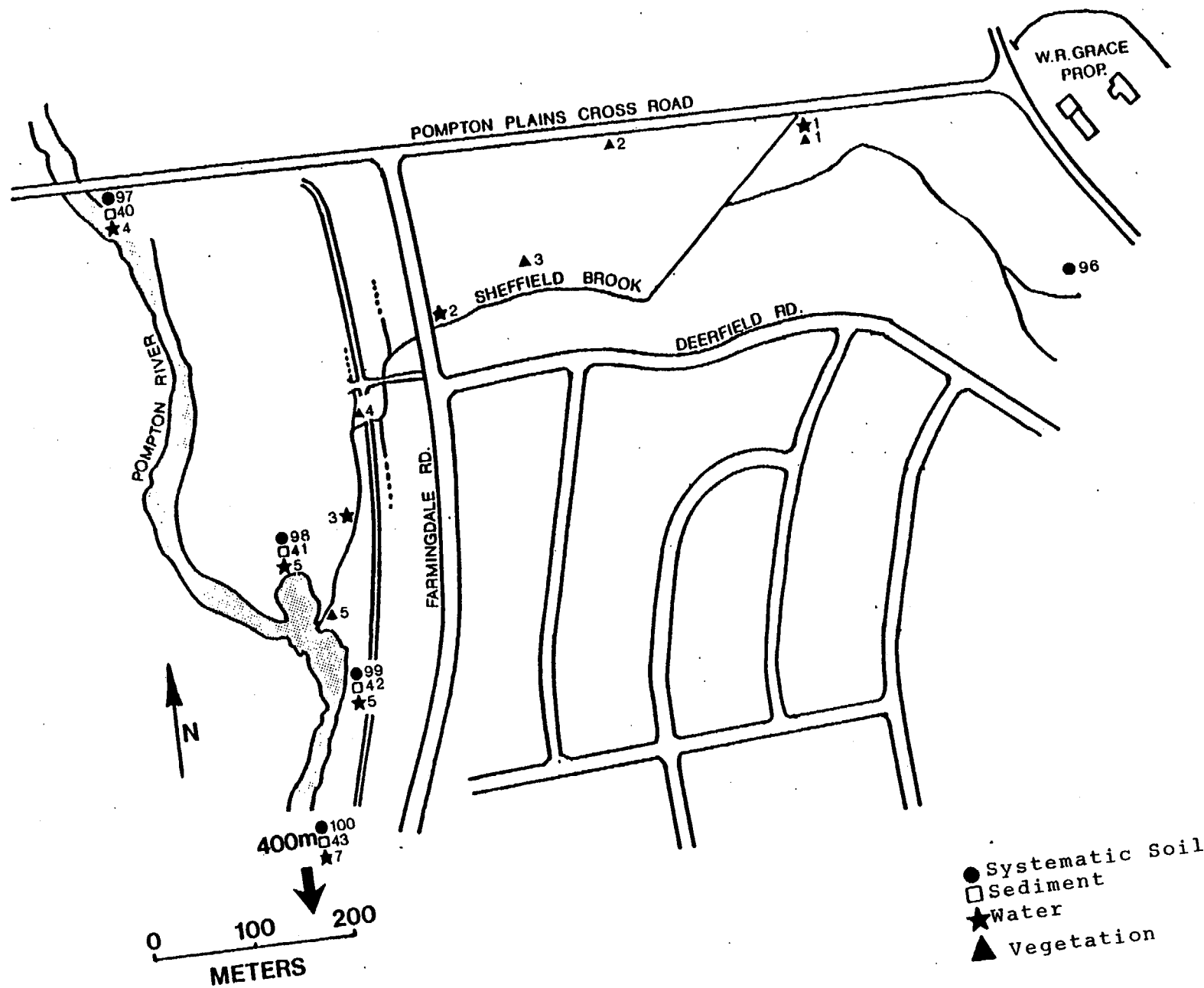


FIGURE 5. Map of Sheffield Brook and Vicinity Indicating Locations of Soil, Sediment, Water, and Vegetation Samples.

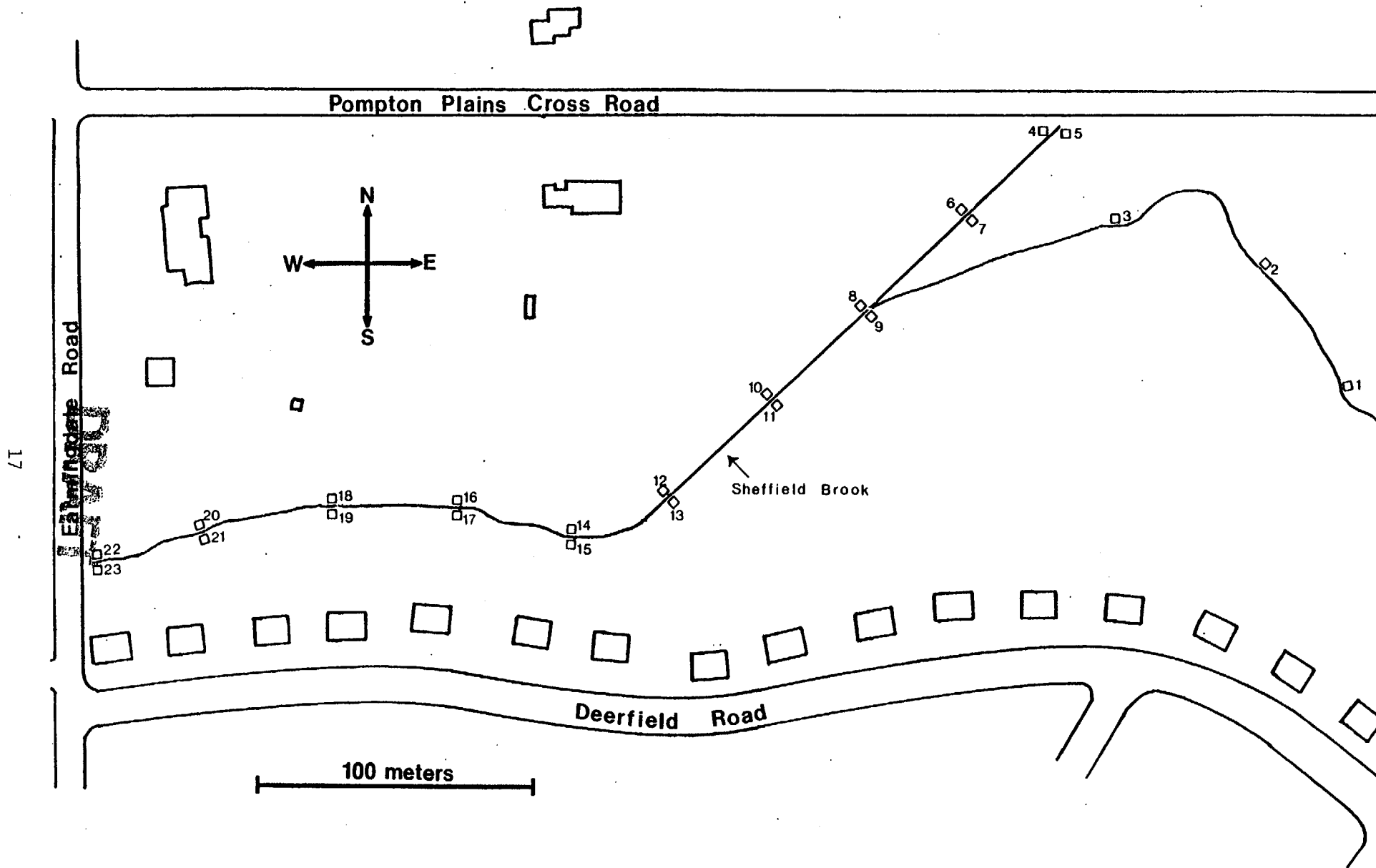


FIGURE 6. Map of Sheffield Brook, East of Farmingdale Road, Indicating Locations of Sediment Samples.

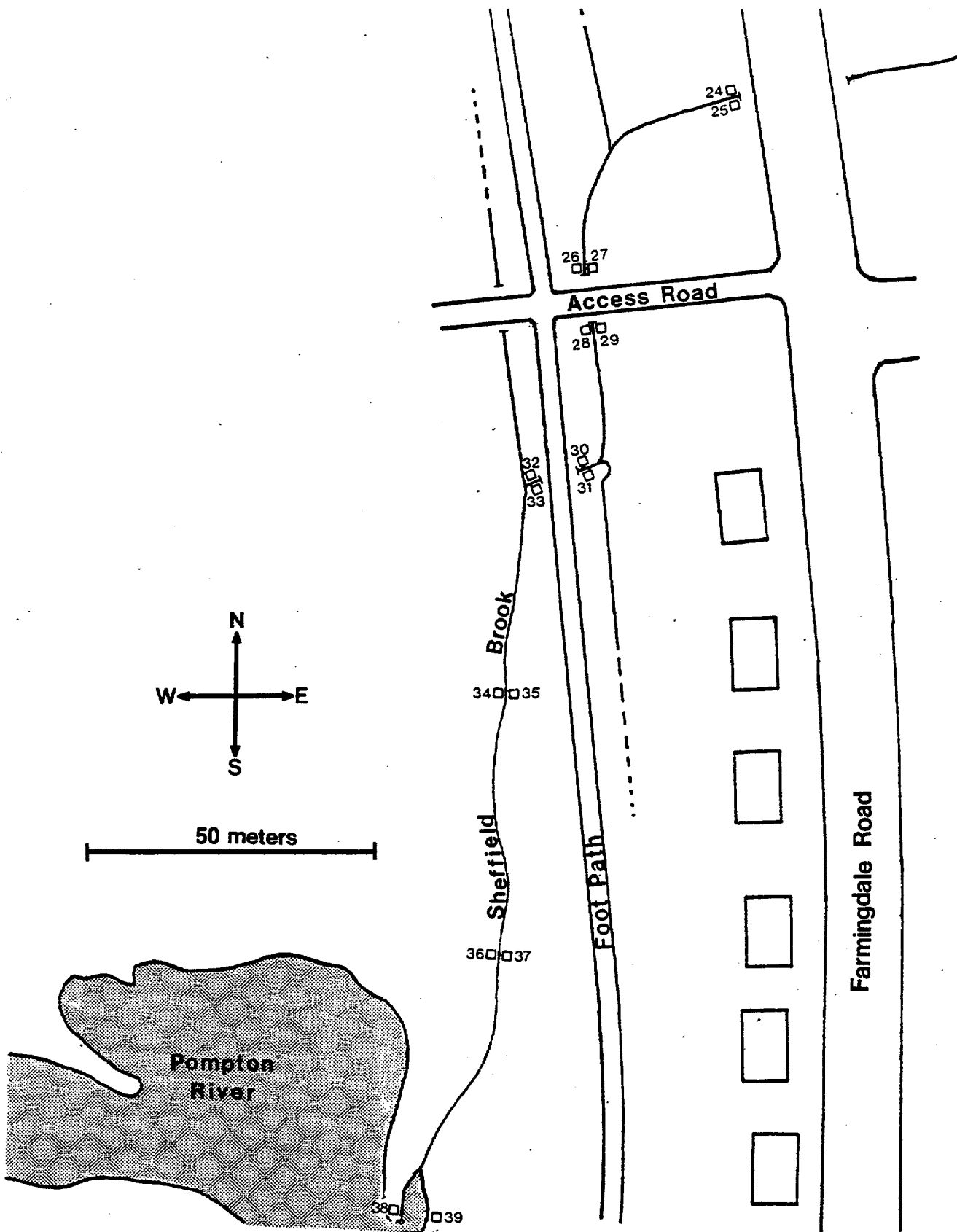


FIGURE 7. Map of Sheffield Brook, West of Farmingdale Road, Indicating Locations of Sediment Samples.

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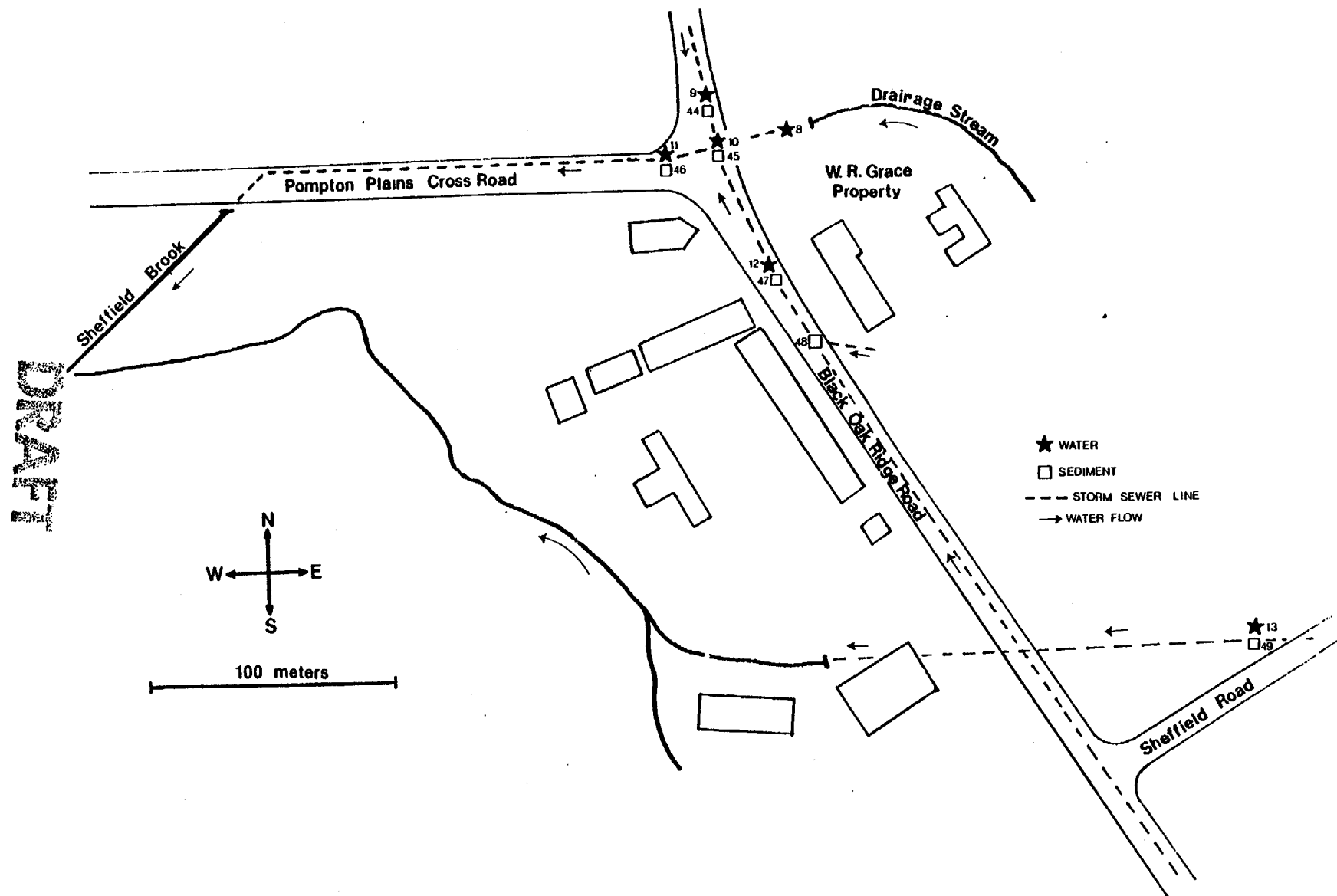


FIGURE 8. Plan View of Storm Sewer System Feeding Sheffield Brook, Indicating Locations of Sediment and Water Samples.

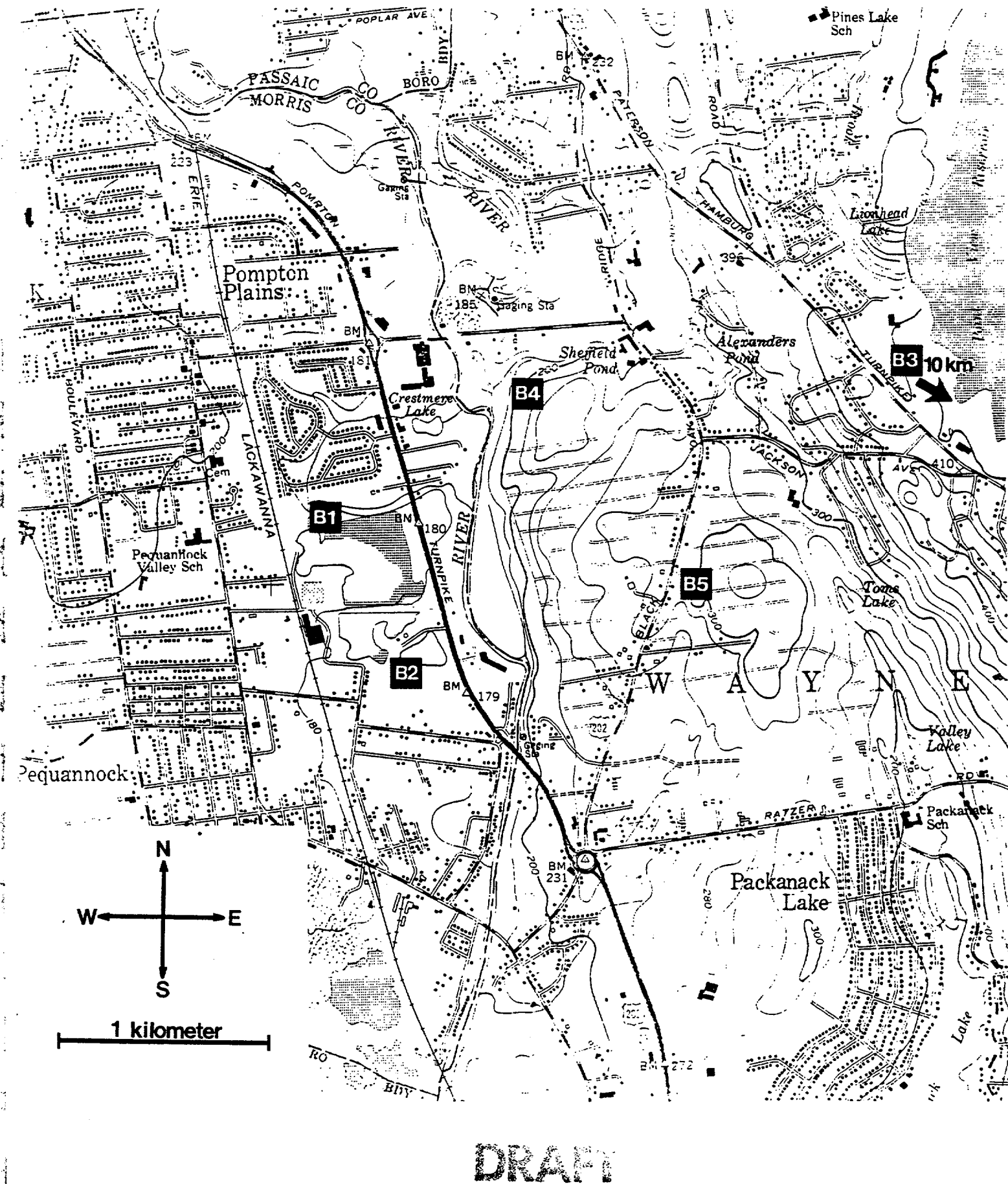


FIGURE 9. Locations of Background Measurements and Baseline Samples in the Wayne-Pompton Plains Area.

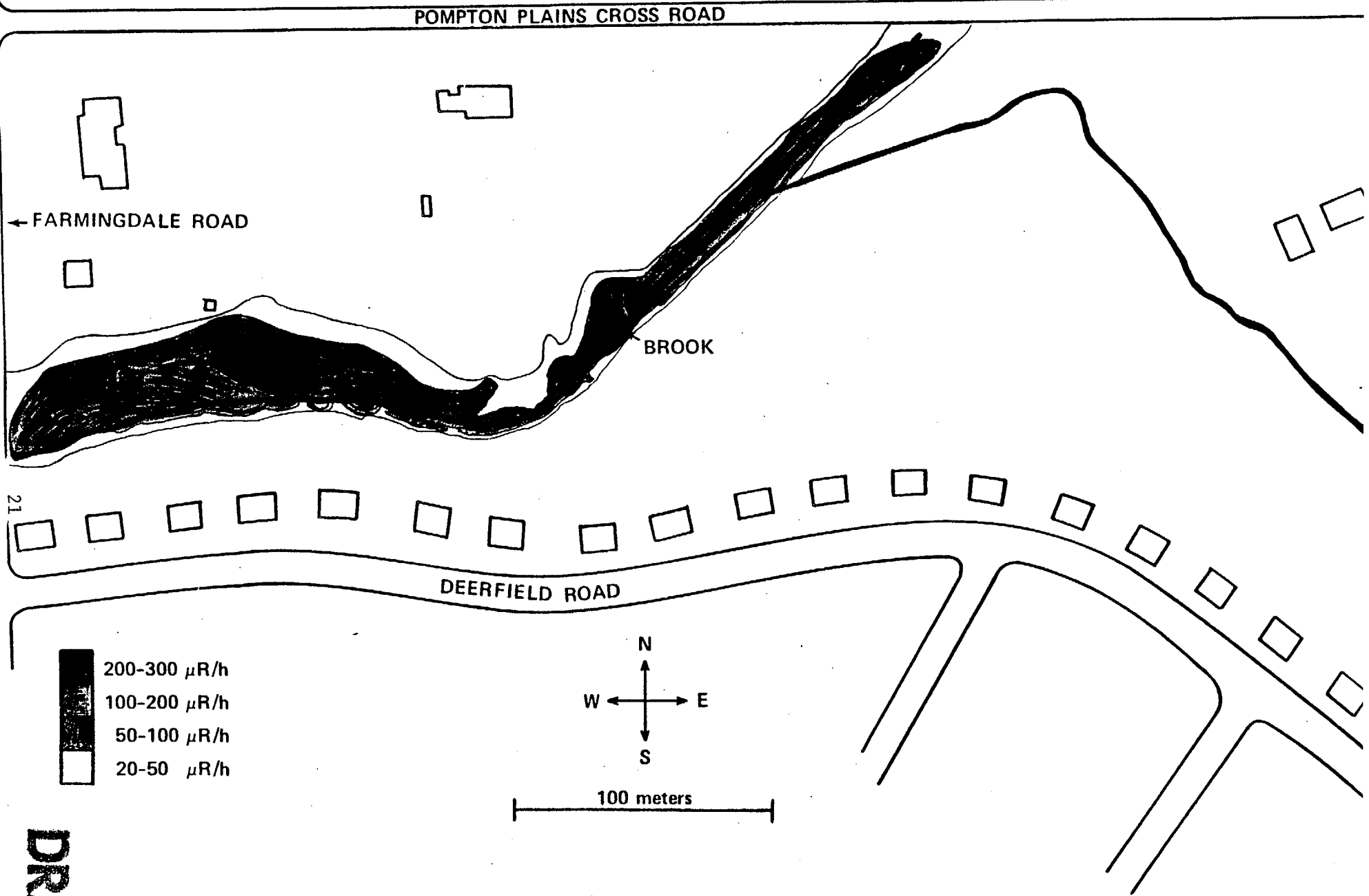


FIGURE 10. Surface Exposure Rates ($\mu\text{R/h}$) Along Sheffield Brook East of Farmingdale Road.

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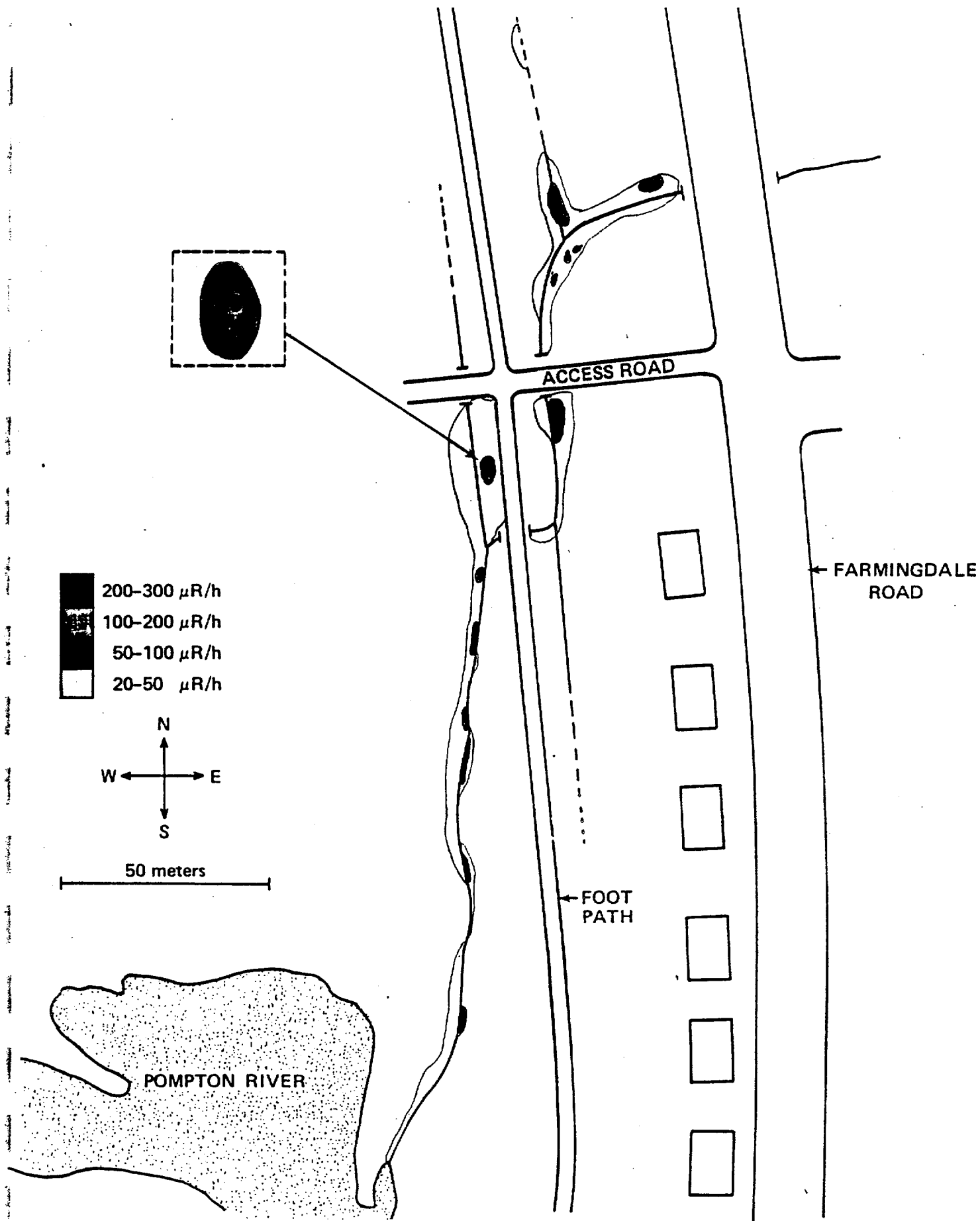


FIGURE 11. Surface Exposure Rates ($\mu\text{R/h}$) Along Sheffield Brook West of Farmingdale Road.

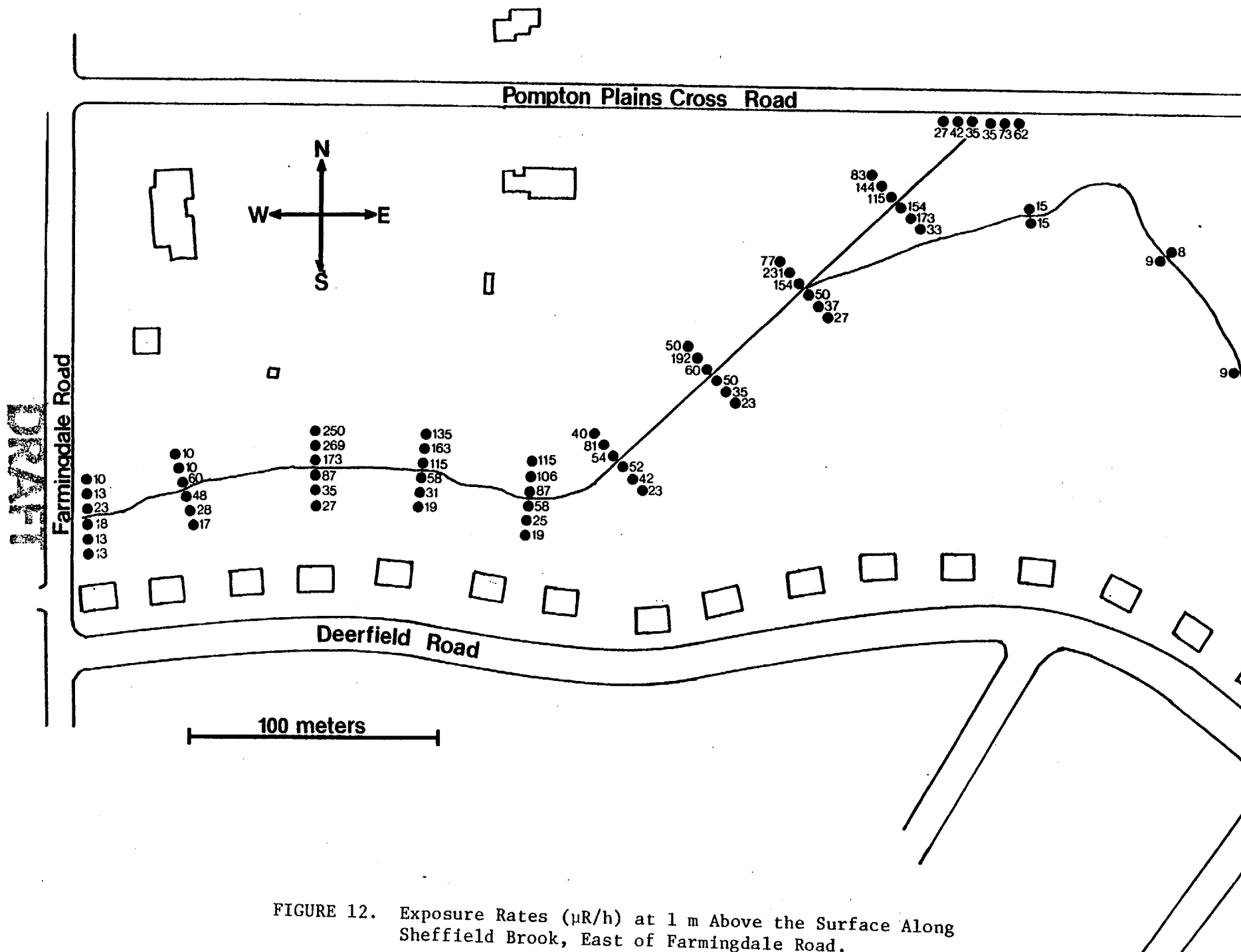


FIGURE 12. Exposure Rates ($\mu\text{R/h}$) at 1 m Above the Surface Along Sheffield Brook, East of Farmingdale Road.

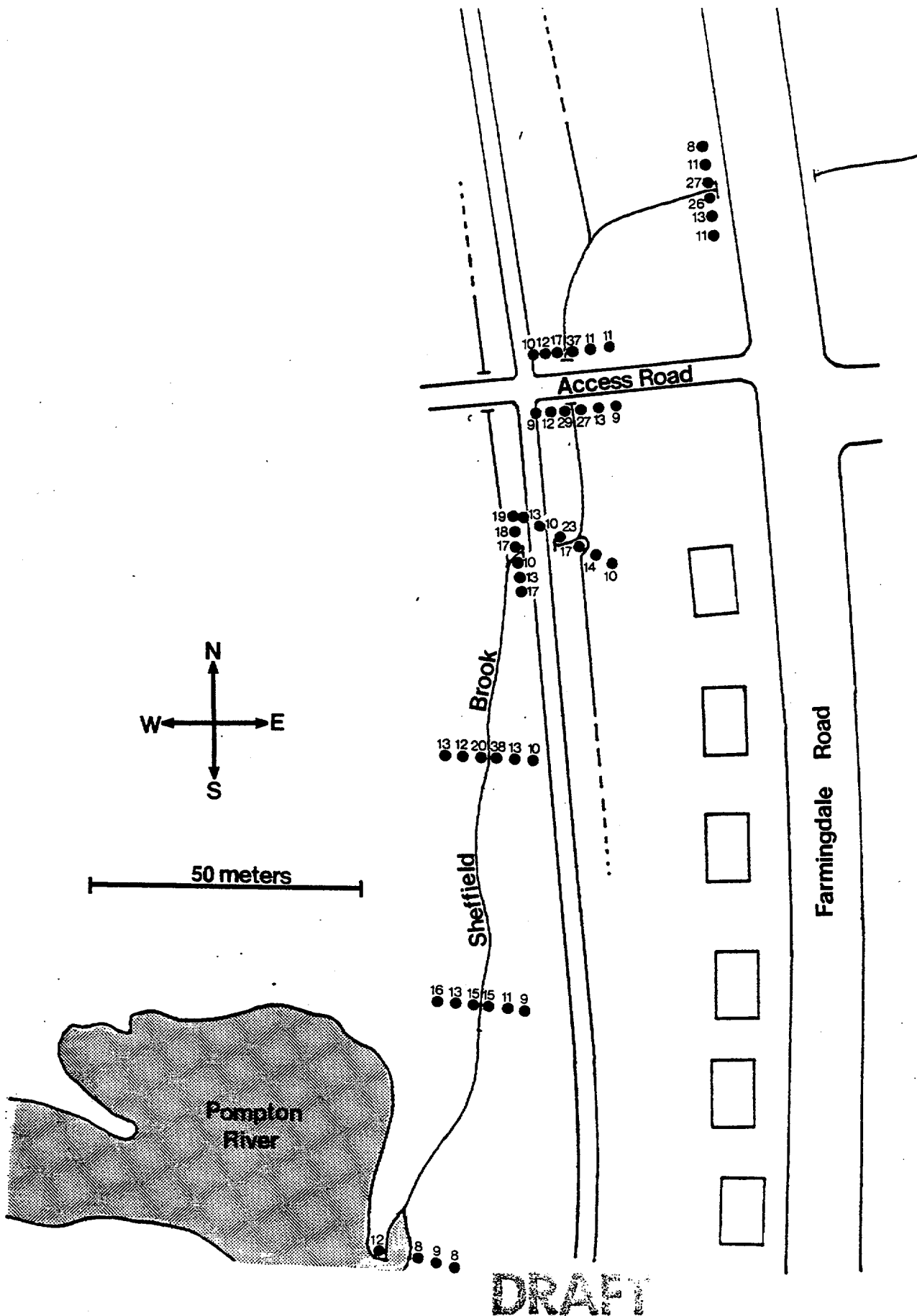


FIGURE 13. Exposure Rates ($\mu\text{R/h}$) at 1 m Above the Surface Along Sheffield Brook, West of Farmingdale Road.

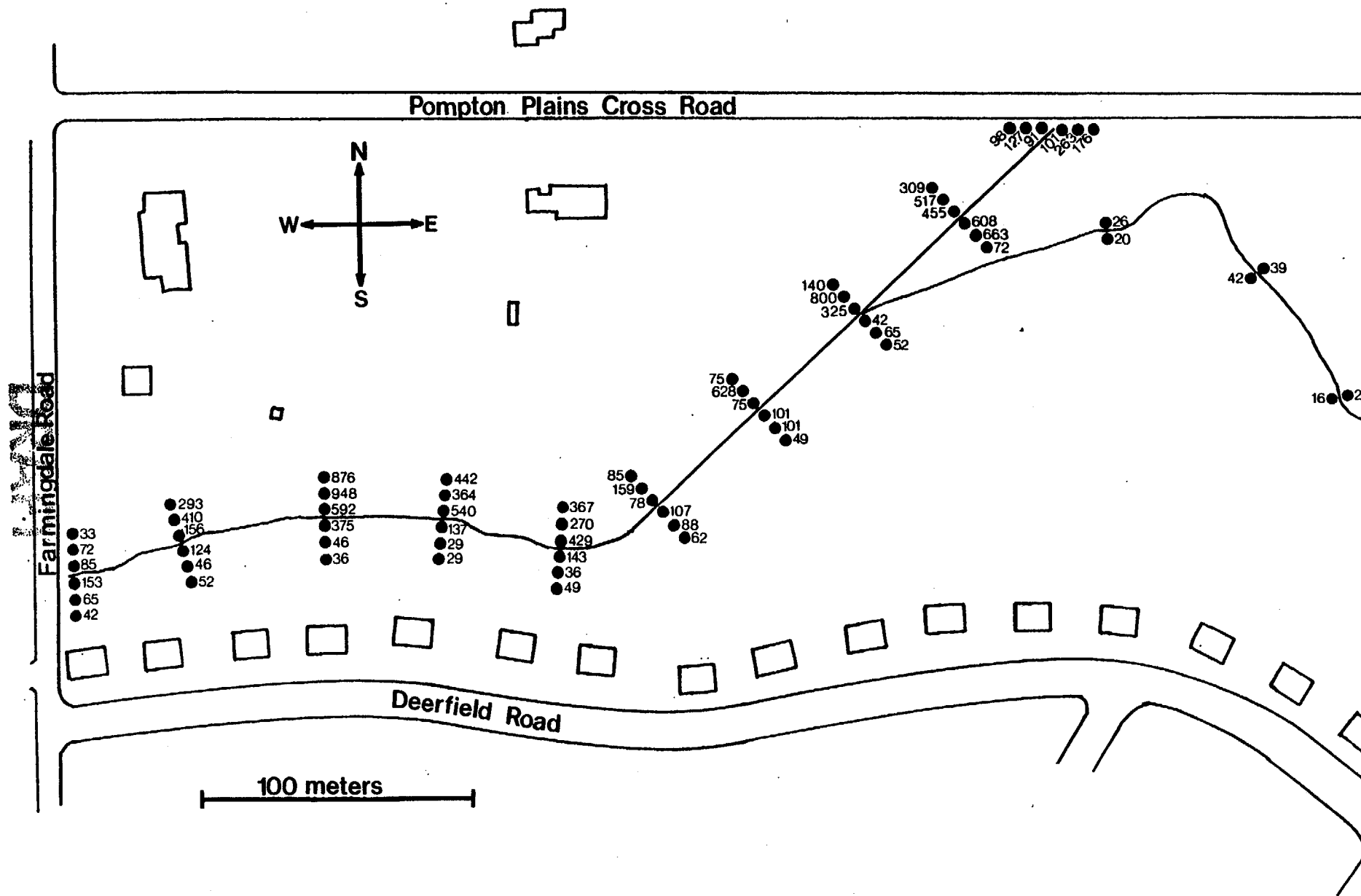


FIGURE 14. Surface Beta-Gamma Dose Rates ($\mu\text{rad/h}$) Along Sheffield

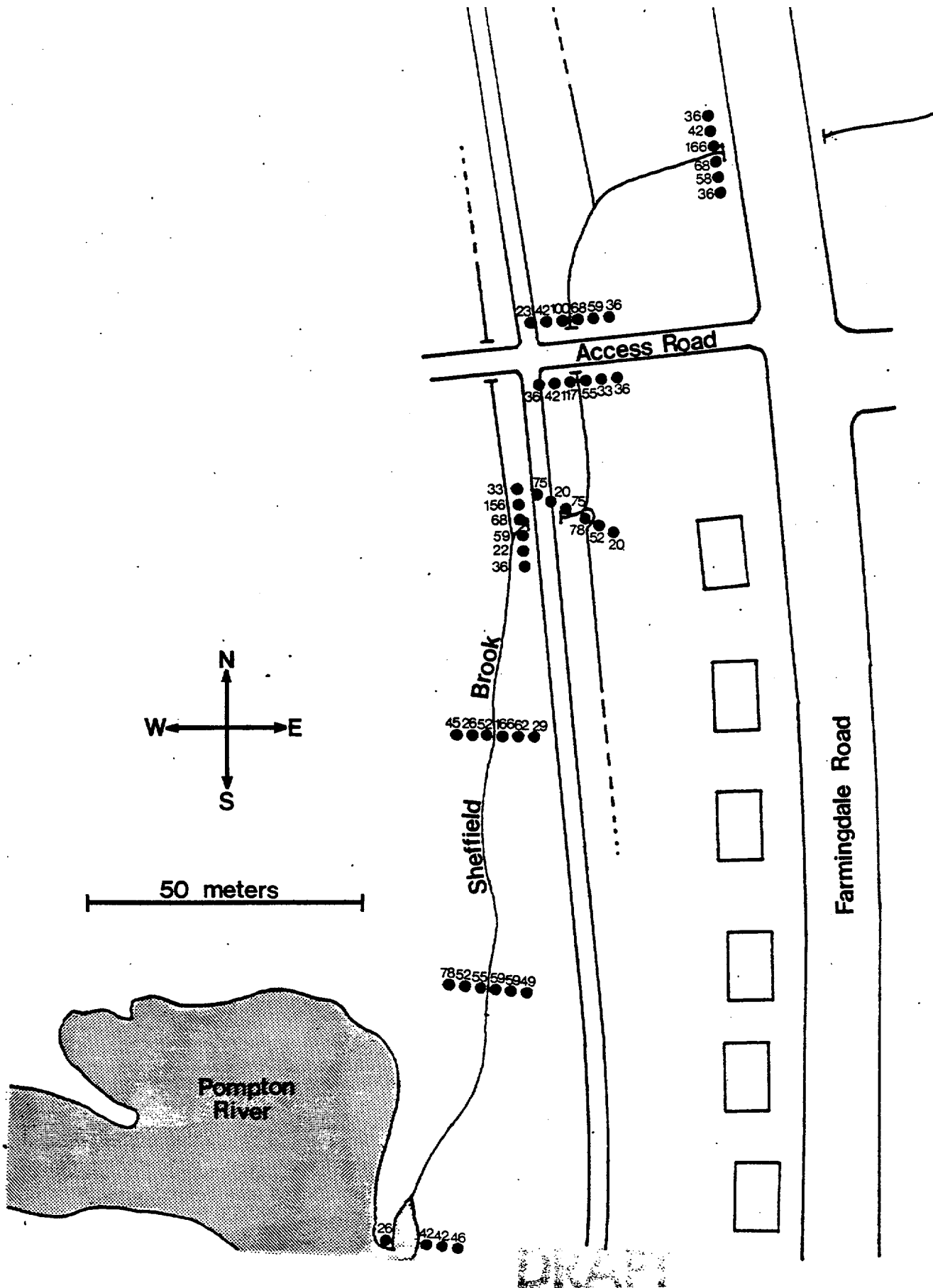


FIGURE 15. Surface Beta-Gamma Dose Rates ($\mu\text{rad/h}$) Along Sheffield Brook, West of Farmingdale Road.

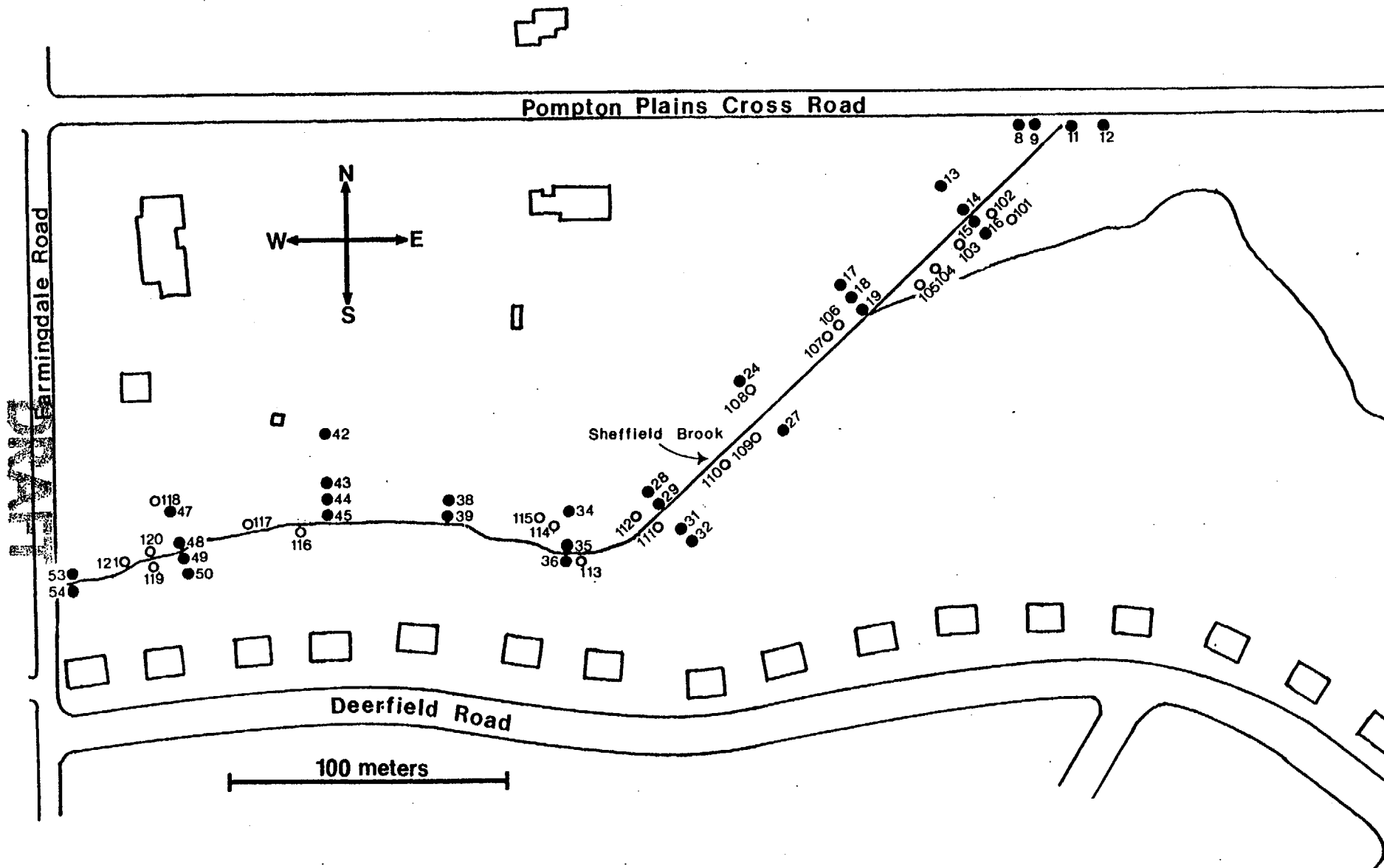


FIGURE 16. Distribution of Thorium Contaminated Soil Along Sheffield Brook, East of Farmingdale Road.

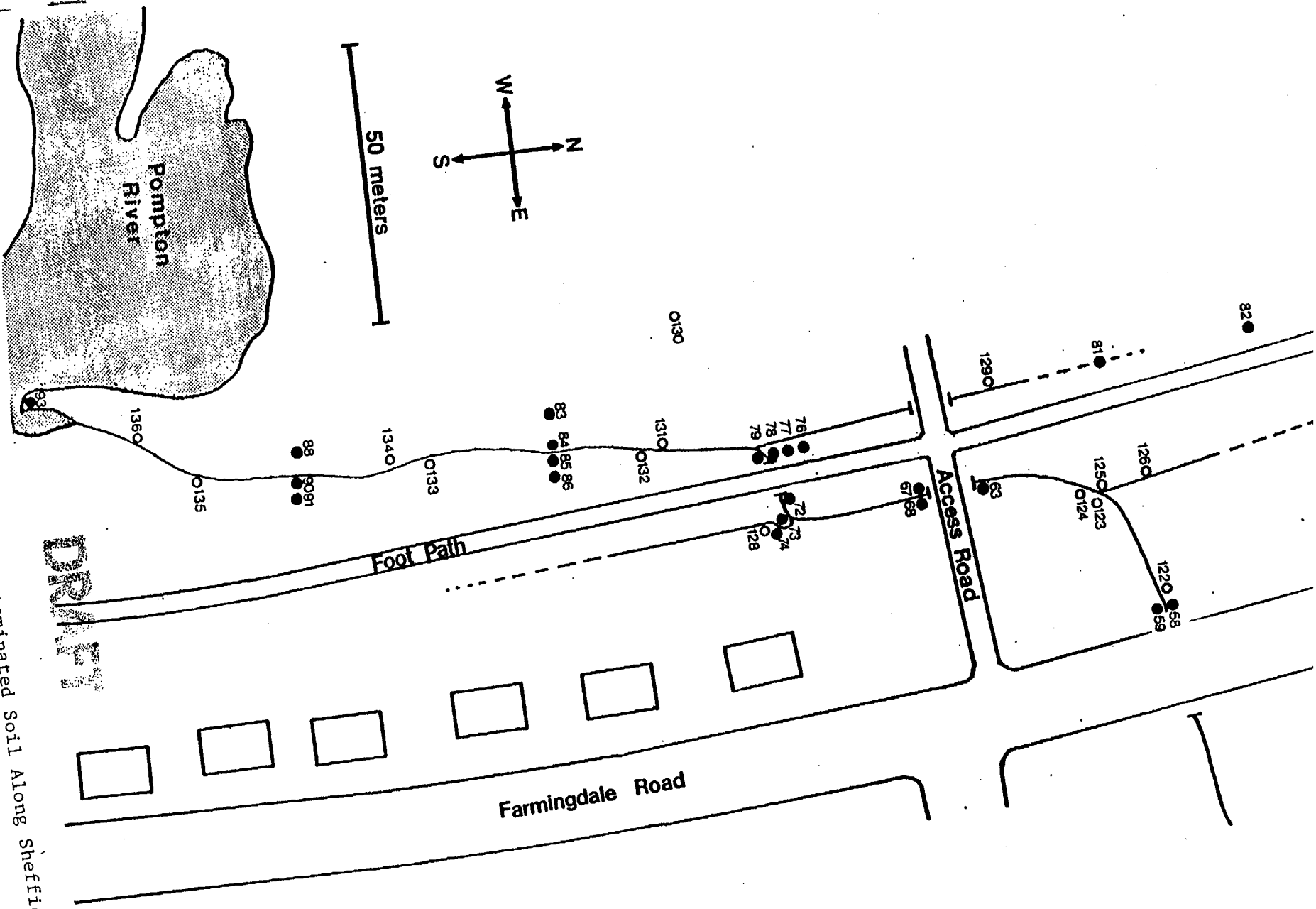


FIGURE 17. Distribution of Thorium Contaminated Soil Along Sheffield Brook, West of Farmingdale Road.

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
<u>Soil^a</u>				
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
<u>Vegetation^d</u>				
2		0.17 ± 0.23	0.28 ± 0.18	0.36 ± 0.15

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TABLE 1 (cont.)

RADIONUCLIDE CONCENTRATIONS IN BASELINE SOIL,
VEGETATION, AND WATER SAMPLES

Sample ^a Location	Radionuclide Concentrations in Water (pCi/l or $\times 10^{-9}$ μ Ci/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 equilibrium with Th-232.

^c Error is 2σ based on counting statistics only.

^d Refer to Figure 5.

* Other analyses not yet completed.

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TABLE 2

RADIONUCLIDE CONCENTRATIONS IN SYSTEMATIC SOIL SAMPLES

Location ^a	Distance from Brook or Stream (m)	Depth (cm)	Radionuclide Concentrations (pCi/g) ^b		
			Ra-228b	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)	Radionuclide 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 ± 0.39	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

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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 2σ based on counting statistics.

* Other analyses not yet completed.

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TABLE 3

RADIONUCLIDE CONCENTRATIONS IN BIASED SOIL SAMPLES

Location ^a	Depth (cm)	Radionuclide Concentrations (pCi/g)*		
		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

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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

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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) _±		
	Ra-228 ^b	Th-228	Ra-226
1	0.54 ± 0.36 ^c	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

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TABLE 4 (cont.)

RADIONUCLIDE CONCENTRATIONS IN SEDIMENT SAMPLES

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

^a Refer to Figures 5, 6, 7, and 8.

^b Assumed to be in equilibrium with Th-232.

^c Error is 2 σ based on counting statistics only.

* Other analyses not yet completed.

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TABLE 5
RADIONUCLIDE CONCENTRATIONS IN WATER SAMPLES

Sample Location ^a	Radionuclide Concentrations (pCi/l or $\times 10^{-9}$ μ Ci/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 \pm 9	
7 Pompton River - 500 m downstream	0.8 ± 1.1	
8 Storm Sewer	29 \pm 4	
9 Storm Sewer	19 \pm 8	
10 Storm Sewer	12 \pm 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	

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TABLE 5 (cont.)

RADIONUCLIDE CONCENTRATIONS IN WATER SAMPLES

Sample ^a Location	Radionuclide Concentrations (pCi/l or $\times 10^{-9}$ μ Ci/ml)	
	Gross Alpha*	
19 Well water - Wendt Lane	<2.2	
20 Well water - Deerfield Road	6.8 \pm 5.8	
21 Well water - Farmingdale Road	12 \pm 6	

^a Refer to Figures 5 and 8.

^b Error is 2σ based on counting statistics only.

* Other analyses not yet completed.

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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.

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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.

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APPENDIX A
MAJOR ANALYTICAL EQUIPMENT

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APPENDIX A

Major Analytical Equipment

The display or description of a specific product is not to 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)

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APPENDIX B
ANALYTICAL PROCEDURES

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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 ($\mu\text{R/h}$) using a factor of $520 \text{ cpm} = 1 \mu\text{R/h}$. 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 ($\mu\text{rad/h}$) 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 $0.63 \text{ cpm} = 1 \mu\text{rad/h}$.

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:

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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 equilibrium 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 μ m 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.*

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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

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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*			
	^a 1	^b 2	^c 3	^d 4
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 μ R/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

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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.

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**EG&G SURVEY REPORT
EP-F-006
OCTOBER 1982**

**THE
REMOTE
SENSING
LABORATORY**

**OPERATED FOR THE U.S.
DEPARTMENT OF ENERGY BY EG&G**

AN AERIAL RADIOLOGICAL SURVEY OF
WAYNE TOWNSHIP,
NEW JERSEY
AND SURROUNDING AREA

DATE OF SURVEY: SEPTEMBER 1982

ITEM # 280

8/279

⑨

AN AERIAL RADIOLOGICAL SURVEY OF
WAYNE TOWNSHIP, NEW JERSEY

AND SURROUNDING AREA

PROJECT SCIENTISTS: E.L. FEIMSTER
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1.0 SUMMARY OF RESULTS

An aerial radiological measuring system was used to survey the area surrounding the former W. R. Grace property located in Wayne Township, New Jersey, during the month of September 1982. This site formerly contained a facility to extract rare earths and thorium from monzanite sands. The survey was conducted for the U.S. Department of Energy's (DOE) Office of Operational Safety by the Department's Remote Sensing Laboratory, operated for the DOE by the Energy Measurements Group of EG&G.

The highest radiation exposure rates were measured over the site. Average radiation levels of 30 to 60 microroentgens per hour ($\mu\text{R/h}$), normalized to 3 feet above the ground, were inferred from the aerial data. Elevated radiation levels ranging from 20 to 30 $\mu\text{R/h}$ were also observed over a stream (Sheffield Brook) extending approximately 1/2 mile west of the site as well as over the quarry area located to the west of Pompton Lakes. The source of the elevated activity in each case was thorium.

Natural background radiation exposure rates measured by the airborne system within the survey area typically ranged from 6 to 10 $\mu\text{R/h}$ with an average value of approximately 8 $\mu\text{R/h}$.

2.0 INTRODUCTION

An aerial radiological survey was flown over a 5½-mile by 10-mile area surrounding the former W. R. Grace property located in Wayne Township, New Jersey. This survey was conducted for the Department of Energy's (DOE) Office of Operational Safety (OOS) by the Energy Measurements Group of EG&G. The OOS conducts radiological surveys at sites and facilities where nuclear operations were formerly conducted for the government.

An MBB BO-105 helicopter, equipped with aerial radiological detection systems, was used for the survey. The helicopter altitude above ground level was 300 feet with 300-foot line spacings. A previous survey covering an area of 3 miles by 4 miles surrounding this site was flown in May 1981 utilizing this system.¹ The purpose of the present survey was to expand the coverage to include all of Wayne Township.

Aerial radiological detection systems average the radiation levels produced by gamma-emitting radionuclides existing over an area of several acres. These detection systems are capable of determining specific radionuclides causing radiological anomalies. However, because of averaging, airborne systems, as compared to ground-based measurements, tend to underestimate the magnitude of localized sources. Details of the systems and procedures employed in obtaining and processing aerial radiation data are presented in References 2 and 3.

In aerial radiological surveys, the gamma ray energies, source concentrations, and relative distribution are measured by specialized instrumentation. The results are reported as radiation exposure rates

in $\mu\text{R/h}$ at 3 feet above the ground. The maximum annual radiation dose that could be absorbed through continuous exposure (24 hours a day for 365 days to a constant exposure rate), expressed in millirem per year (mrem/y) is approximated by multiplying the exposure rate in micro-roentgen per hour ($\mu\text{R/h}$) by 8.76*. These results apply to external radiation only and do not account for inhalation or ingestion of radioactive materials. The actual amount of radiation absorbed depends on the duration and circumstances of exposure.

3.0 BACKGROUND RADIATION

Background gamma radiation originates from naturally occurring radioactive elements present in the earth (terrestrial radiation) and cosmic rays entering the earth's atmosphere from space. The terrestrial gamma rays originate primarily from the uranium decay chain, the thorium decay chain, and radioactive potassium. Variable concentrations of these nuclides produce estimated annual radiation doses ranging from 15 to 140 mrem/y ($1.7\text{--}16 \mu\text{R/h}$) at the surface of the earth in the United States. The higher background radiation dose levels (up to 140 mrem/y) are typically found in the western states, primarily in the Colorado Plateau area, and are a result of high uranium and thorium concentrations in surface minerals and increased cosmic radiation because of higher elevation.

The uranium decay chain includes radium-226 and its daughter, radon, which is a noble gas, i.e., it will not combine chemically with other elements. The radionuclide radon can both diffuse through the

$$* \frac{\mu\text{R}}{\text{h}} \times \frac{24 \text{ h}}{\text{day}} \times \frac{365 \text{ day}}{\text{y}} \times \frac{1}{1000} \frac{\text{mrem}}{\mu\text{R}} = \frac{\text{mrem}}{\text{y}} \quad \left(\text{using the approximate conversion from } \mu\text{R to mrem} \right)$$

soil and move through the air to other locations. Thus, the level of radiation contributed by this noble gas depends upon the meteorological conditions, mineral and moisture content and permeability of the soil, and other physical conditions existing at each location at any particular time. Airborne radon typically contributes from 1 to 10 percent of the natural background radiation levels.

Cosmic rays, the space component of the natural radiological background, interact in a complex manner with the elements of the earth's atmosphere and soil. These cosmic ray interactions produce additional background radiation dose rates which vary slightly with latitude and directly with altitude, increasing from 26 mrem/y ($3 \mu\text{R/h}$) at sea level in Florida to 107 mrem/y ($12 \mu\text{R/h}$) at 10,000 feet above sea level at some locations in Colorado. The cosmic ray dose rate in Denver, Colorado (1 mile above sea level), contributes about 50 mrem/y to the total background dose rate of about 125 mrem/y.

The aerial survey results include the terrestrial gamma radiation measured throughout the surveyed area and an estimated cosmic ray exposure rate, but the results do not include the contribution from airborne radon.

4.0 SURVEY BOUNDARIES

This survey covered an area of approximately 55 square miles including all of Wayne Township, New Jersey. The boundaries of the survey are shown in Figure 1.

5.0 SURVEY RESULTS

The results of this aerial survey are presented in Figure 1 as closed contour curves of total radiation exposure rates (isoradiation contours) overlaid on an aerial photograph of Wayne Township, New Jersey.

The results are reported in units of $\mu\text{R/h}$ at 3 feet above ground and include a cosmic ray contribution estimated at $3.7 \mu\text{R/h}$.

The highest radiation exposure rates were measured over the site. Average radiation levels ranging from 30 to $60 \mu\text{R/h}$ were inferred from the aerial data. Elevated radiation levels ranging from 20 to $30 \mu\text{R/h}$ were also observed over a stream (Sheffield Brook) extending approximately $1/2$ mile west of the site and over the quarry area located to the west of Pompton Lakes.

A special data processing technique (details of which are given in References 2 and 3) was used to help identify areas containing thorium concentrations greater than that present in typical background soils. The results of this special analysis are also shown in Figure 1. The green area includes the site and the stream west of the site. The other areas, shown in yellow, appear to be the result of natural anomalies. Elevated exposure rates were associated with the excess thorium over the site, over the stream, and over the quarries north of the site. The other areas did not show elevated exposure rates, and appear to be due to slight perturbations in the relative amount of thorium within these areas compared to the rest of the survey area.

A similar technique was used to search for possible areas containing excess radium-226, normally associated with uranium ore and tailings. No positive indications were observed.

Natural background radiation exposure rates within the survey area typically ranged from 6 to $10 \mu\text{R/h}$ with an average value for Wayne Township of approximately $8 \mu\text{R/h}$.

6.0 COMPARISON WITH PREVIOUS SURVEYS

The results of the September 1982 survey compare quite well with the results of the May 1981 aerial survey except directly over the site and along the stream west of the site. The previous survey inferred exposure rate levels greater than 120 $\mu\text{R/h}$ over the site and maximum levels between 60 and 120 $\mu\text{R/h}$ along the stream. The present survey indicated levels between 30 and 60 $\mu\text{R/h}$ over the site and between 20 and 30 $\mu\text{R/h}$ along the stream. These differences result from the different survey altitudes flown in the two surveys (150 feet in 1981 versus 300 feet in 1982), and indicate that the source of the activity within the site and along the stream is highly localized. At the higher survey altitude the airborne system averages over a larger area and will infer a lower exposure rate for a localized source. Due to terrain limitations it was not possible to fly the large area survey lower than 300 feet.

A ground-based radiological survey was conducted April 26 to May 1, 1982 along the stream west of the site by the Radiological Site Assessment Program of Oak Ridge Associated Universities (ORAU), Oak Ridge, Tennessee.⁴ This survey indicated the presence of thorium contaminated soil and sediment along the stream. The survey findings also showed that the thorium contamination was generally limited to a narrow strip, approximately 30 feet maximum, on either side of the stream. Elevated radium-226 was also detected but at levels much lower (5 to 10%) than the thorium concentrations. Exposure rate levels measured 3 feet above ground were highly variable, ranging from 8 to 269 $\mu\text{R/h}$, with an average value along the stream of 50 $\mu\text{R/h}$. These results are consistent with those obtained from the aerial data after taking into consideration the large area averaging property of the airborne system.

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1. Dahlstrom, T.S. November 1981. An Aerial Radiological Survey of the W.R. Grace Property, Wayne Township, New Jersey (1981). Report No. NRC-8113. Las Vegas, Nevada: EG&G.
2. Boyns, P.K. July 1976. The Aerial Radiological Measuring System (ARMS): Systems, Procedures, and Sensitivity (1976). Report No. EGG-1183-1691. Las Vegas, Nevada: EG&G.
3. Jobst, J.E. 1979. "The Aerial Measuring Systems Program." Nuclear Safety 29:136-47.
4. Frame, P.W. July 1982. Radiological Survey of Sheffield Brook, Wayne, New Jersey. Preliminary Report. Oak Ridge, TN: Oak Ridge Associated Universities, Radiological Site Assessment Program.



Figure 1. GAMMA EXPOSURE RATE CONTOURS DERIVED FROM AERIAL SURVEY DATA OBTAINED OVER WAYNE TOWNSHIP, NEW JERSEY AND THE SURROUNDING AREA.

September 10, 1982

MEMO

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

FROM: M. Resnikoff, Township consultant on thorium contamination

RE: Radiation Levels in Park, west of Farmingdale Road

According to the NRC Preliminary Report, thorium contamination, west of Farmingdale Road, resides along Sheffield Brook. Except for one sampling location near where the access road to the athletic fields crosses a culvert (#76, fig. 17), the contamination is localized to within 15' of the Brook. The contamination levels along Sheffield Brook, west of Farmingdale Road (called "Sheffield Brook, west"), are several times higher than the interim EPA cleanup limits (5pCi/g) all the way to the Pompton River. I recommend that this area be cleaned up when decontamination efforts along Sheffield Brook, east are undertaken. Without more extensive core drillings, one cannot estimate the total volume of earth along Sheffield Brook, west which will have to be removed, but it is probably a fraction of the 5,000 to 10,000 cubic yards estimated by the NRC for Sheffield Brook, east. In comparison to Sheffield Brook, east, the radiation levels west of Farmingdale Road along the Brook are lower and the contamination band is narrower.

Regarding the soccer fields, while I would have preferred additional readings by the NRC since this is a low-lying area, prone to flooding, the levels appear quite low. The one core drilling which was taken shows radiation levels lower at the surface than below ground indicating that the surface was scraped and top soil added. The surface reading is near EPA interim standards. Results of a radiation survey by Concerned Citizens of Wayne also show quite low levels in the field and higher levels along Sheffield Brook.

I recommend that the area on both sides of Sheffield Brook, west, be temporarily fenced off and posted with warning signs such as, "Keep Out, Contaminated Area", signed by the Township of Wayne. The fencing can be removed when the brook area is scraped. With this temporary fencing of the Brook, I believe the field area can be opened, with little hazard to the users of the Park.

I have not yet consulted with the NRC or DEP on these recommendations. I intend to do that Monday, September 13 and will keep you informed if they strongly disagree with the above.

ITEM # 281

B/280

6

September 22, 1982

MEMO

TO: Mayor W. Jasinski, Town Council, A. Bartolozzi
FROM: M. Resnikoff, Town Consultant on Thorium Contamination
RE: Sheffield Park Hazard

The background radiation readings for the Township of Wayne are 8 to 10 microroentgens per hour (μ R/h), or 87 millirems per year. This is measured at a 3' height and is due to natural radiation in the soil, particularly potassium-40. Additional natural radiation arises from cosmic rays and other sources.

The radiation levels measured by the Health Department, at a 10" to 12" height, show background radiation levels on line "A", the west side of Sheffield Park paralleling Farmingdale Road and furthest from Sheffield Brook, but rise as one moves closer to Sheffield Brook. The levels on the east side of soccer field #1 are twice background levels and, in isolated cases, run as much as 3 times background. This is consistent with the radioactivity washing from Sheffield Brook during flood periods. The readings taken by the Wayne Health Department are higher than those taken by the Nuclear Regulatory Commission and Concerned Citizens, though many more of them were taken. In case of dispute, I have some confidence in the measurement methods and techniques of the NRC, though I differ with them on other matters.

To put these radiation readings into perspective, the radiation emanating from the ground is primarily gamma rays which behave similar to X rays but are more energetic. There is no safe levels of radiation; the greater the radiation dose, the more likely it is that cancers and genetic and health effects can occur. No one can certify that the levels are safe, but the Town can make a decision based on the costs in terms of health effects versus the benefits of using the fields.

What are the costs? One must estimate the number of hours of use and the number of persons who use Sheffield Park. Assuming 100 persons use the Park 12 hours per day, 365 days per year (this must be a high estimate) and assuming that the average dose above background is 10 μ R/h, the total additional dose to all persons due to thorium contamination would be

$$100 \text{ persons} \times 12 \text{ hours/day} \times 365 \text{ days/year} \times 10 \mu\text{R/h} = 4.38 \text{ person-rems/y}$$

This is a direct radiation dose to the whole body. How many cancers are expected from this whole body dose? Rather than choose one number in this controversial area of the health effects due to low level ionizing radiation, I would prefer a range. The number employed in numerous references is 125 cancers per million person-rems. Some would argue lower. On the high side, based on a study of radiation workers at Hanford, WA, is an estimate of 3770 cancers per million person-rems. Therefore, one expects 0.00055 to 0.0165 additional cancers to occur for each year's exposure, for the number of person-hours mentioned above. More or less people may be in the Park, but the expected number of additional cancers is clearly low. There are some caveats. These radiation doses will occur year after year and are additive, as are the number of projected cancers. Further, genetic effects will also occur, probably at the same levels.

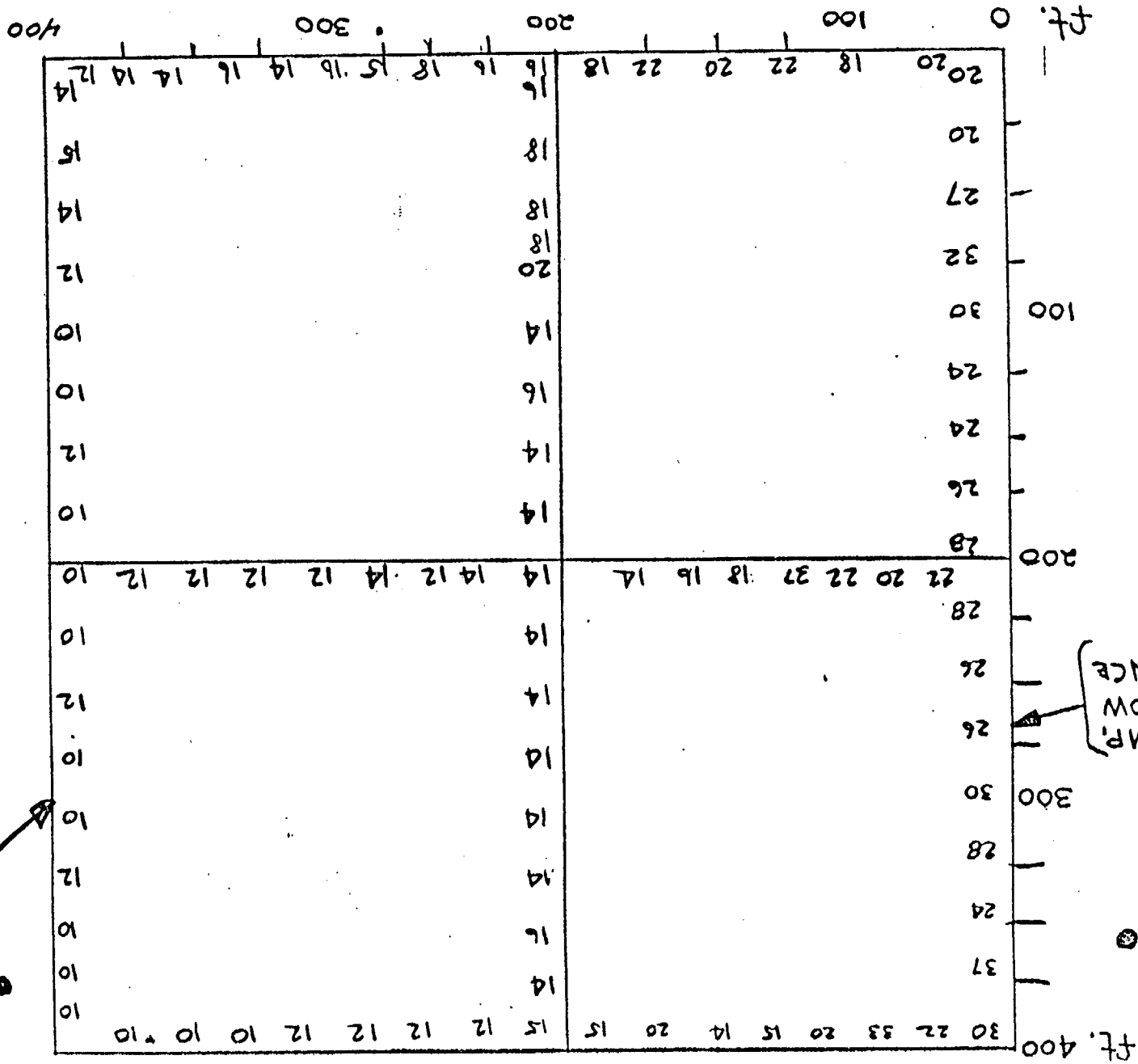
Other radiation pathways are through inhalation and ingestion. I consider these pathways lesser hazards at the ball field area, but there are not complete radiation readings here. The inhalation hazard is not due to radon gas, in the case of Sheffield Park, because radon gas in the thorium-232 chain is short-lived (55 sec) and would primarily stay in the ground. I believe that the radiation readings which the NRC has taken on the Grace & Co. site will bear this out. The hazard is due primarily to inhaling dust contaminated with thorium, bismuth, polonium, thallium and lead. Depending on the particle size, this radioactivity could reside in one's lungs for many years, providing a continual lung dose, possibly leading to lung cancer. I believe that this is a lesser hazard because even for uranium miners, lung cancers primarily arose from radon (which has a recognizable and distinctive cancer) and not from particulates.

The other radiation pathway is through ingestion, by drinking radioactively contaminated water, for example. My primary concern here is soluble radium in water, but perhaps ball players may eat contaminated dirt. Soil sample measurements were not fully taken by the NRC, but I expect that they would run roughly proportional to the beta-gamma readings. Without further information, it is impossible to be more specific. Radium, in soluble form, when ingested, is a bone seeker and would lead to leukemias. In uranium mining areas, such as Grand Junction, CO, it is not lung cancers, but leukemias which are much above the national average. Based on the radiation beta gamma readings on the field, I would expect this to be the least of the three hazards at the playing field.

I should add, after talking to several members of Concerned Citizens, that I am sympathetic to their concern about having temporary solutions, such as fencing off the Brook, become permanent ones. The radiation levels along Sheffield Brook run much higher, particularly on the east side of Farmingdale Road, and for several reasons, I consider the Brook hazard much greater. I support cleanup of Sheffield Brook and consider fencing a temporary expedient.

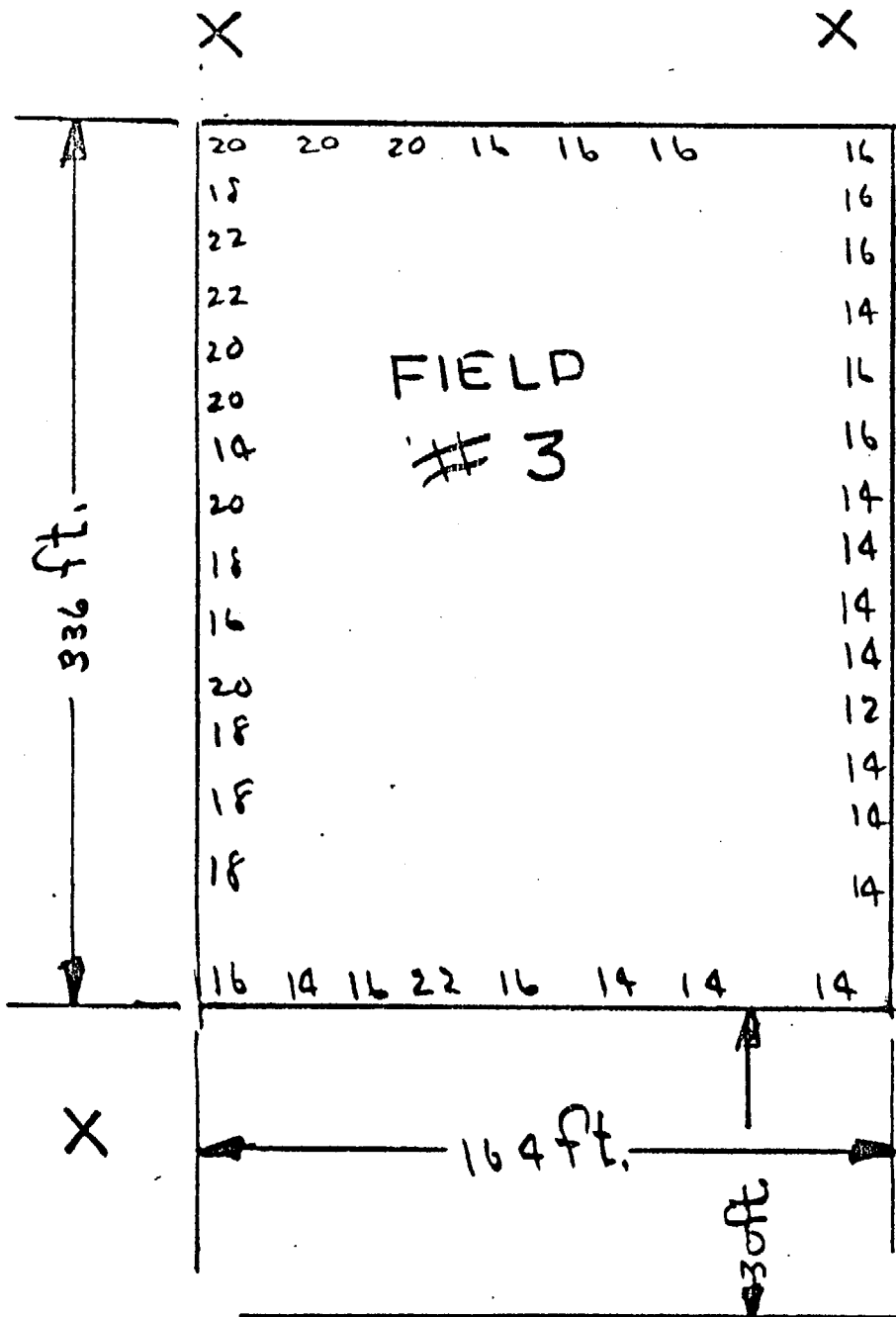
FARMINGDALE ROAD

ACCESS ROAD



Perimeter of
Sheffield Park.

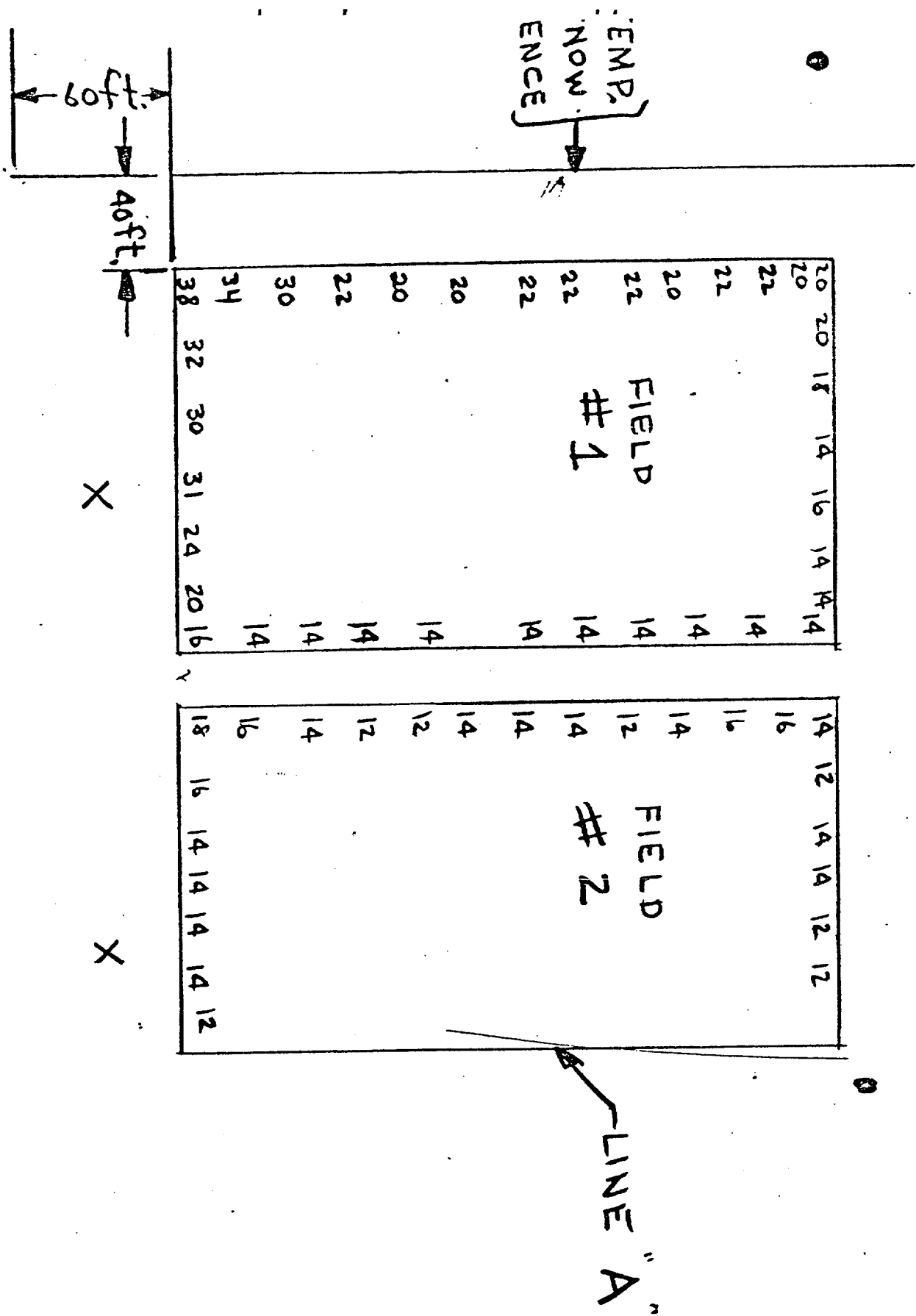
LINE "A"



Soccer/Baseball
Field
Sheffield Park

FENCE TO
SEWAGE TREATMENT
PLANT.

Soccer Fields Sheffield Park



RADIOLOGICAL SURVEY
OF
SHEFFIELD BROOK
WAYNE, NEW JERSEY

OCTOBER, 1982

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

ITEM # 282

B/281

(41)

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

Jeanette Eng
Joseph Morris
Frederick Rauch
Kent Tosch
Duncan White

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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 affiliated 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. Measurement 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.

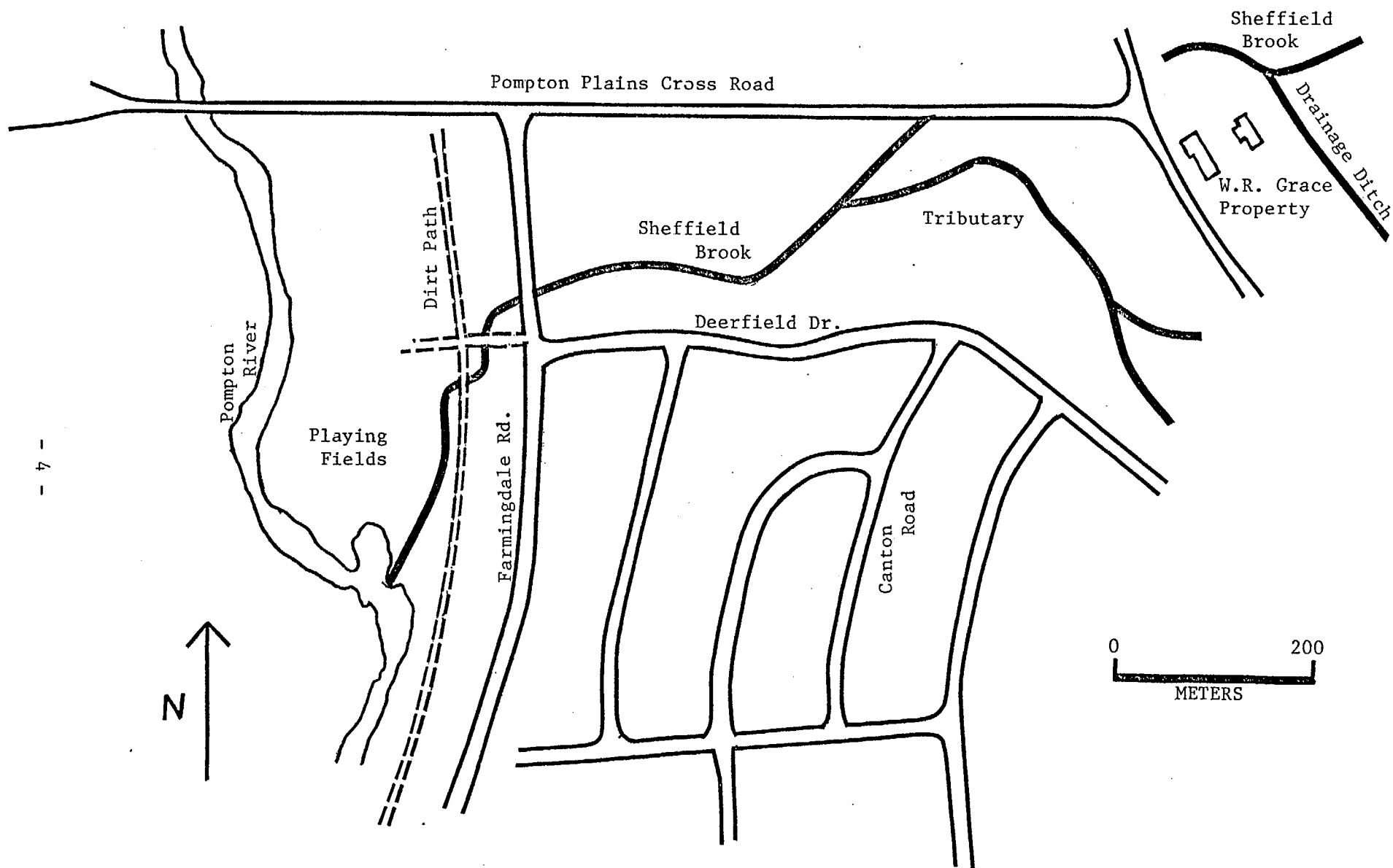


FIGURE 1: MAP OF SHEFFIELD BROOK AND VICINITY

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 m² 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 ($\mu\text{R/hr}$). The conversion factor is 113 cpm = 1 $\mu\text{R/hr}$.

Field Survey Results

Ground level exposure rates ranged from 7 to 354 $\mu\text{R/hr}$. Higher readings (a maximum of 354 $\mu\text{R/hr}$) were found east of Farmingdale Road. Lower exposure rates (a maximum at 151 $\mu\text{R/hr}$) were found in areas west of Farmingdale Road.

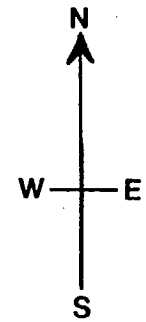
In Figure 2A, the region with a maximum ground level rate of 354 $\mu\text{R/hr}$ was found along a narrow berm on the west bank. This berm appears to have resulted from dredging operation at the brook. Exposure rates over 40 $\mu\text{R/hr}$ are generally confined to the first ten meters on either side 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 $\mu\text{R/hr}$. 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 $\mu\text{R/hr}$. 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 $\mu\text{R/hr}$ 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 $\mu\text{R/hr}$ at Sheffield Brook to 17 $\mu\text{R/hr}$ 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 $\mu\text{R/hr}$ 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 $\mu\text{R/hr}$ 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 $\mu\text{R/hr}$ was measure.

POMPTON PLAINS CROSS ROAD



50 meters

Ground Level Exposure Rate

	270 - 350 uR/hr
	180 - 270 uR/hr
	90 - 180 uR/hr
	40 - 90 uR/hr
	20 - 40 uR/hr
	7 - 20 uR/hr

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

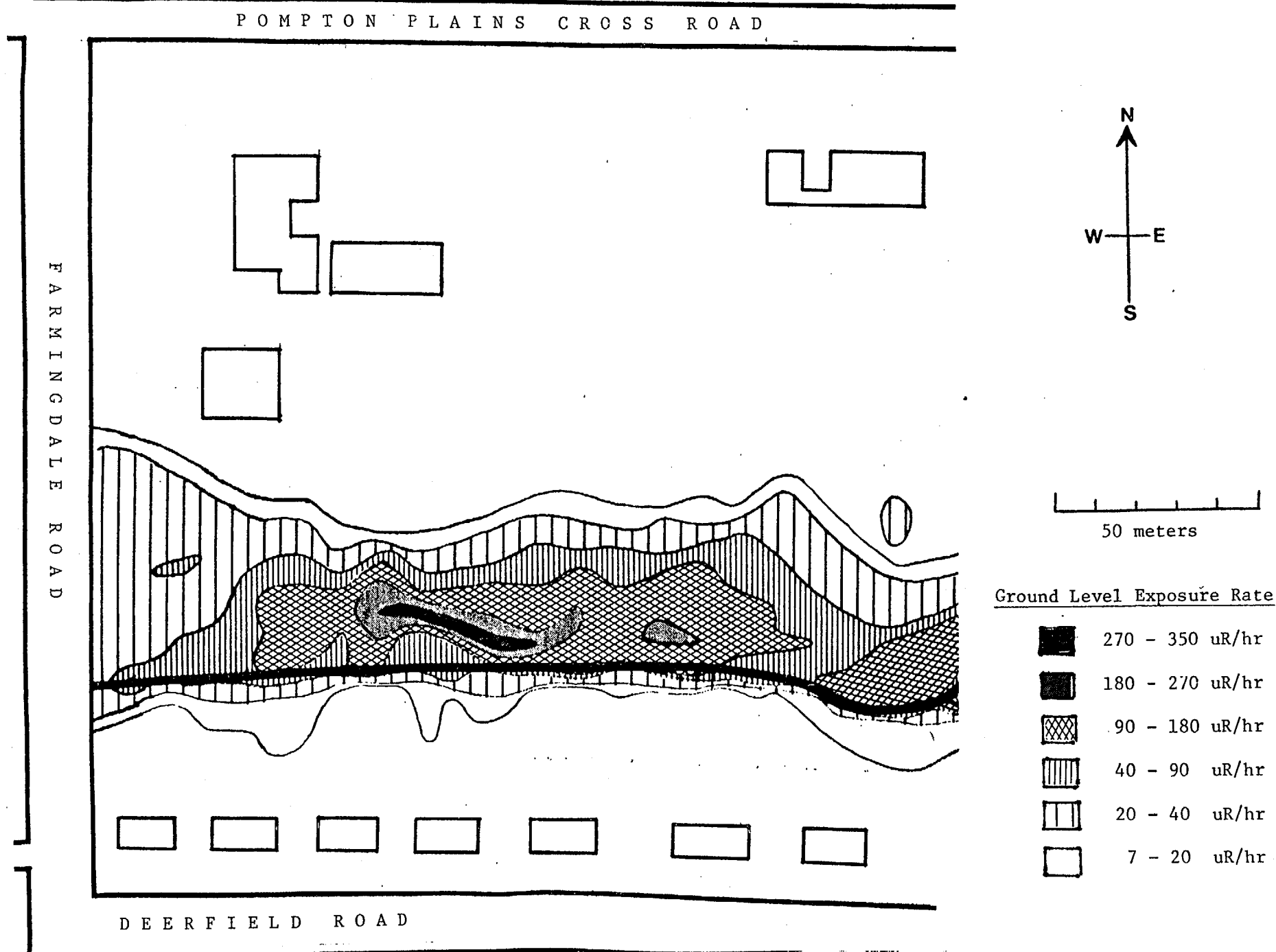
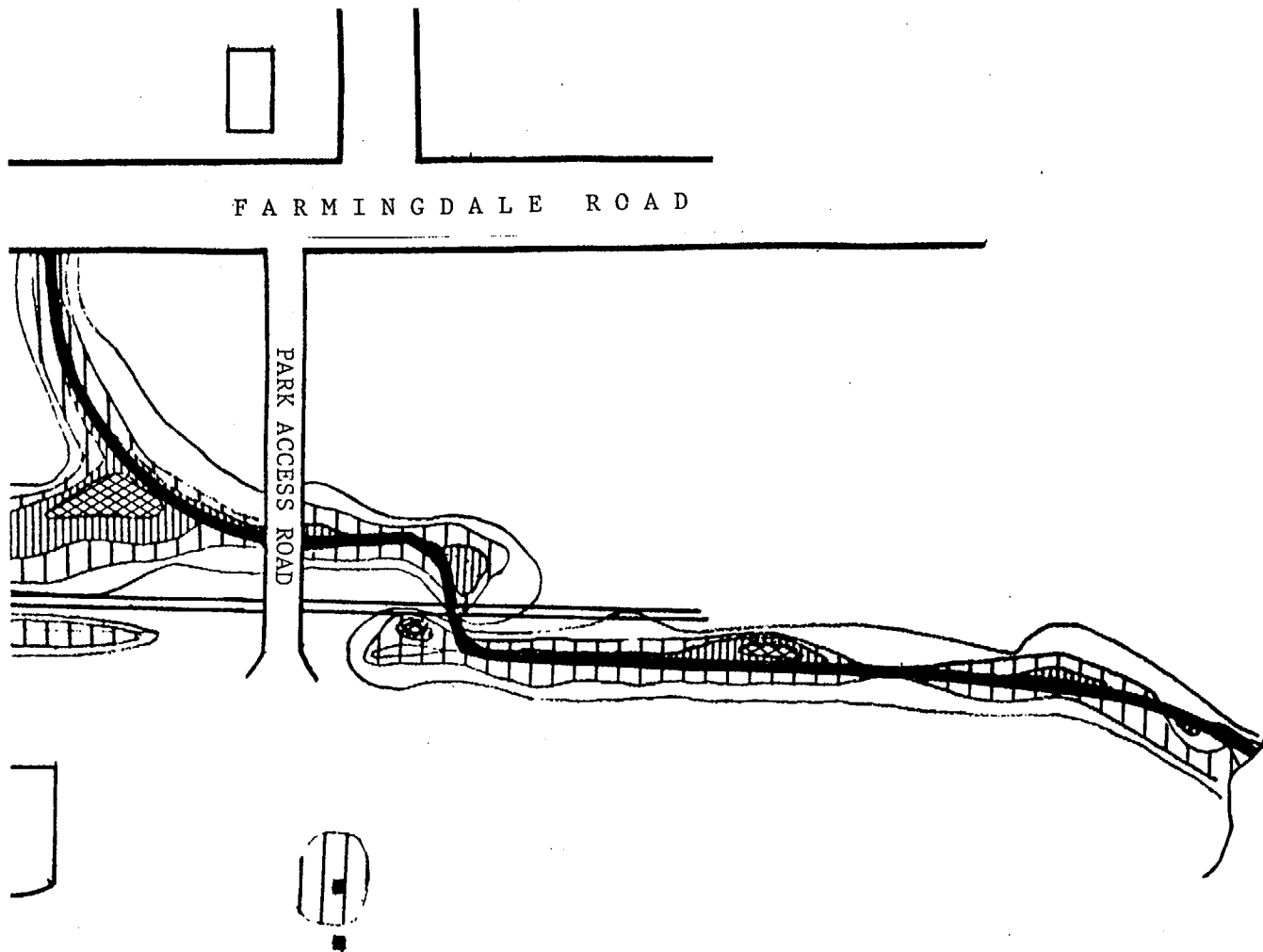


FIGURE 2B: FIELD SURVEY OF GAMMA RADIATION. GROUND LEVEL EXPOSURE RATE IN uR/HR., INCLUDING BACKGROUND.



Ground Level Exposure Rate







	270 - 350 uR/hr
	180 - 270 uR/hr
	90 - 180 uR/hr
	40 - 90 uR/hr
	20 - 40 uR/hr
	7 - 20 uR/hr

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

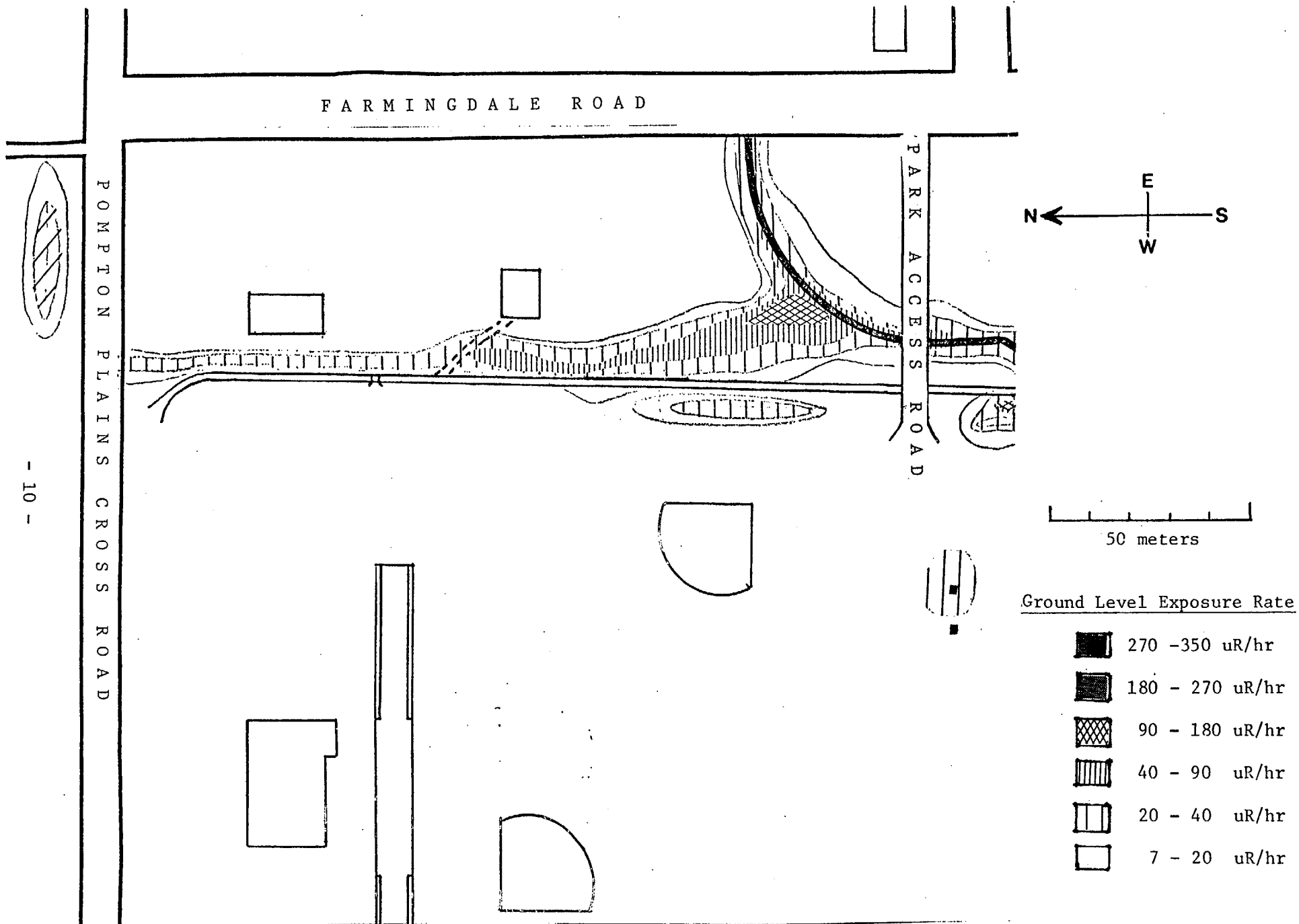


FIGURE 2D: FIELD SURVEY OF GAMMA RADIATION. GROUND LEVEL EXPOSURE RATE IN $\mu\text{R}/\text{hr}.$, INCLUDING BACKGROUND.

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° 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 intrinsic 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 ± 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 ± 7 and 549 ± 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 ± 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 correlated with the thorium concentration, but were lower by a factor of 20 to 50. The highest radium-226 concentration of 39.5 ± 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 ± 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.

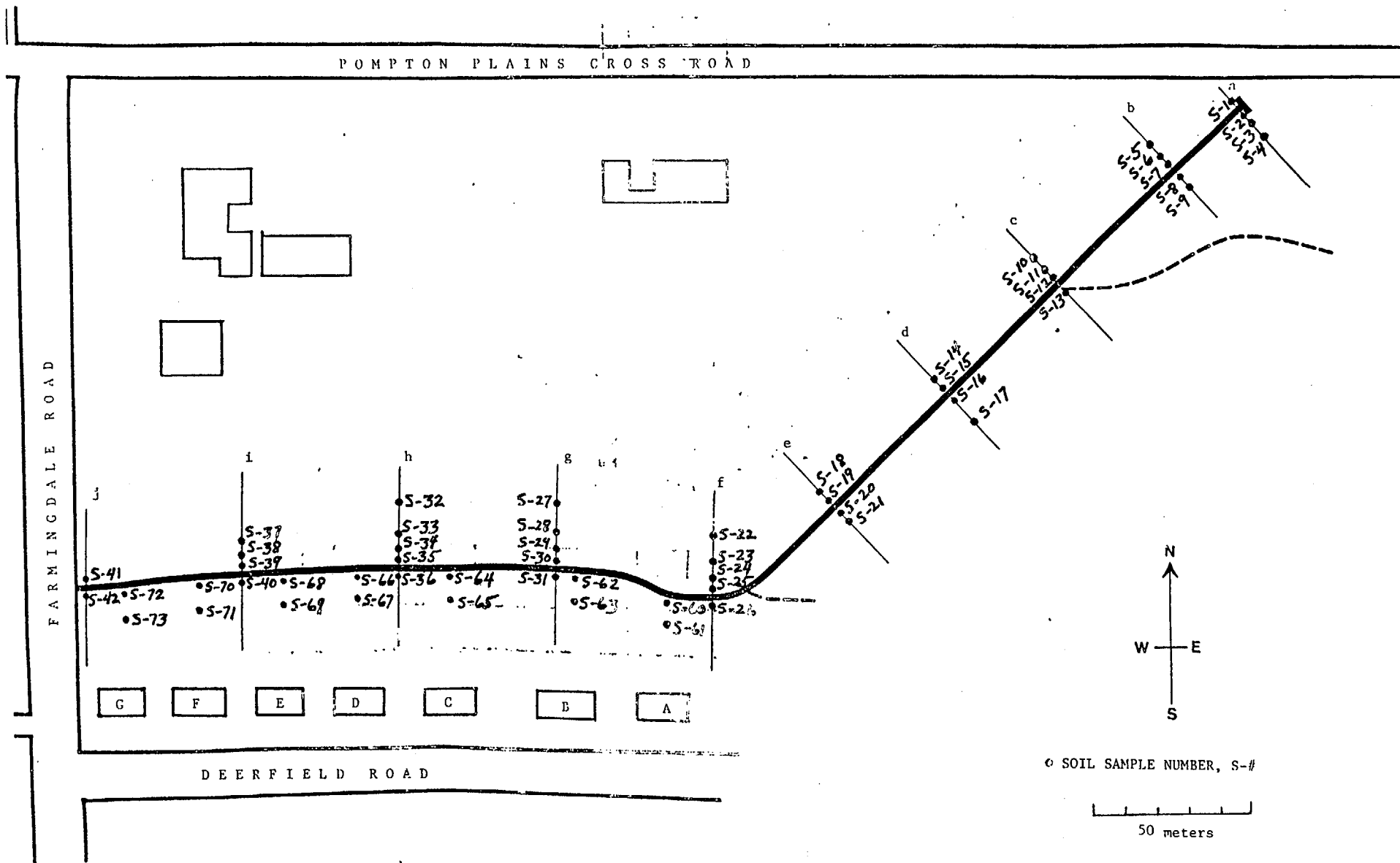
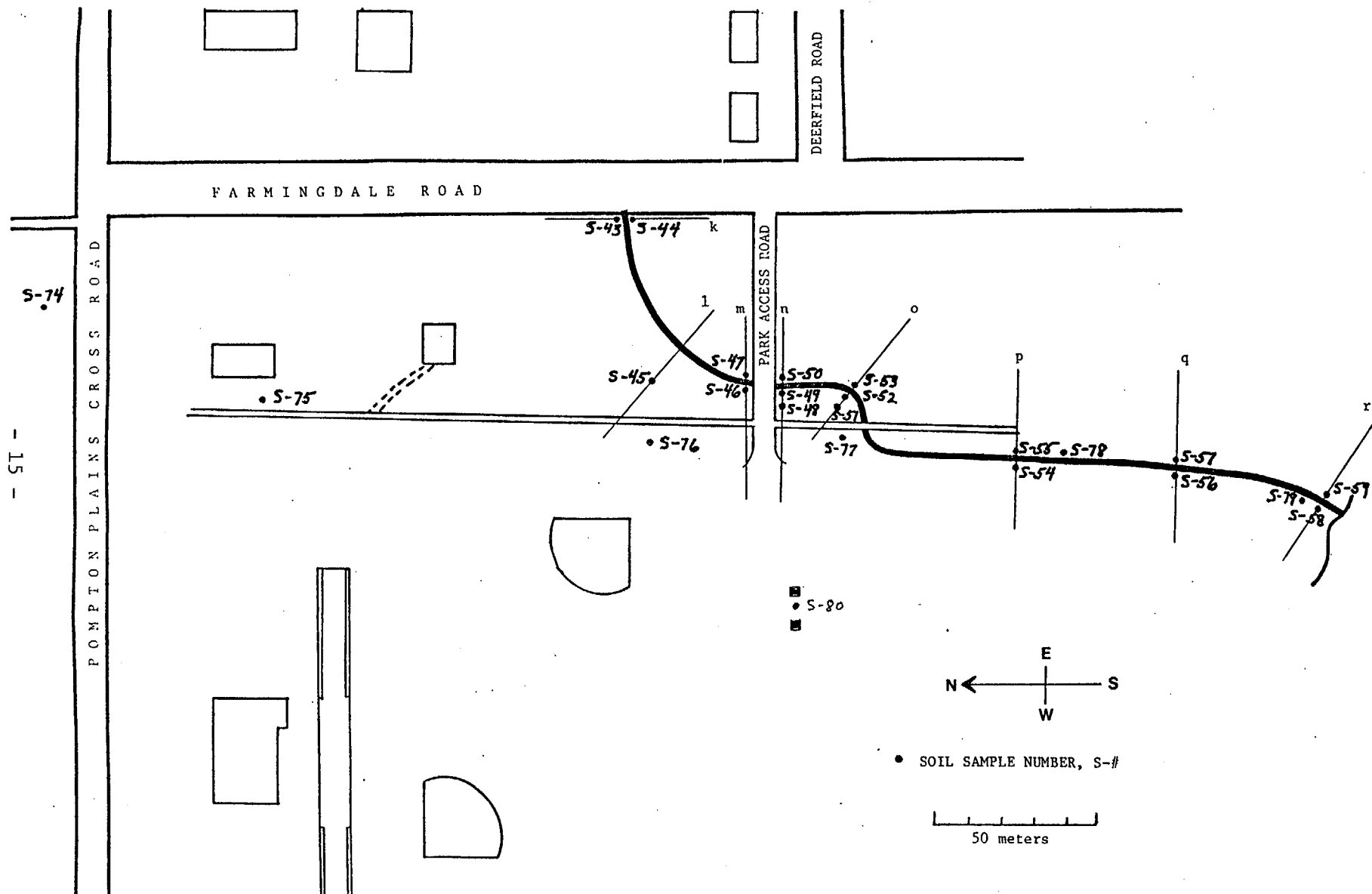


FIGURE 3A: SOIL SAMPLING LOCATIONS
EAST OF FARMINGDALE ROAD



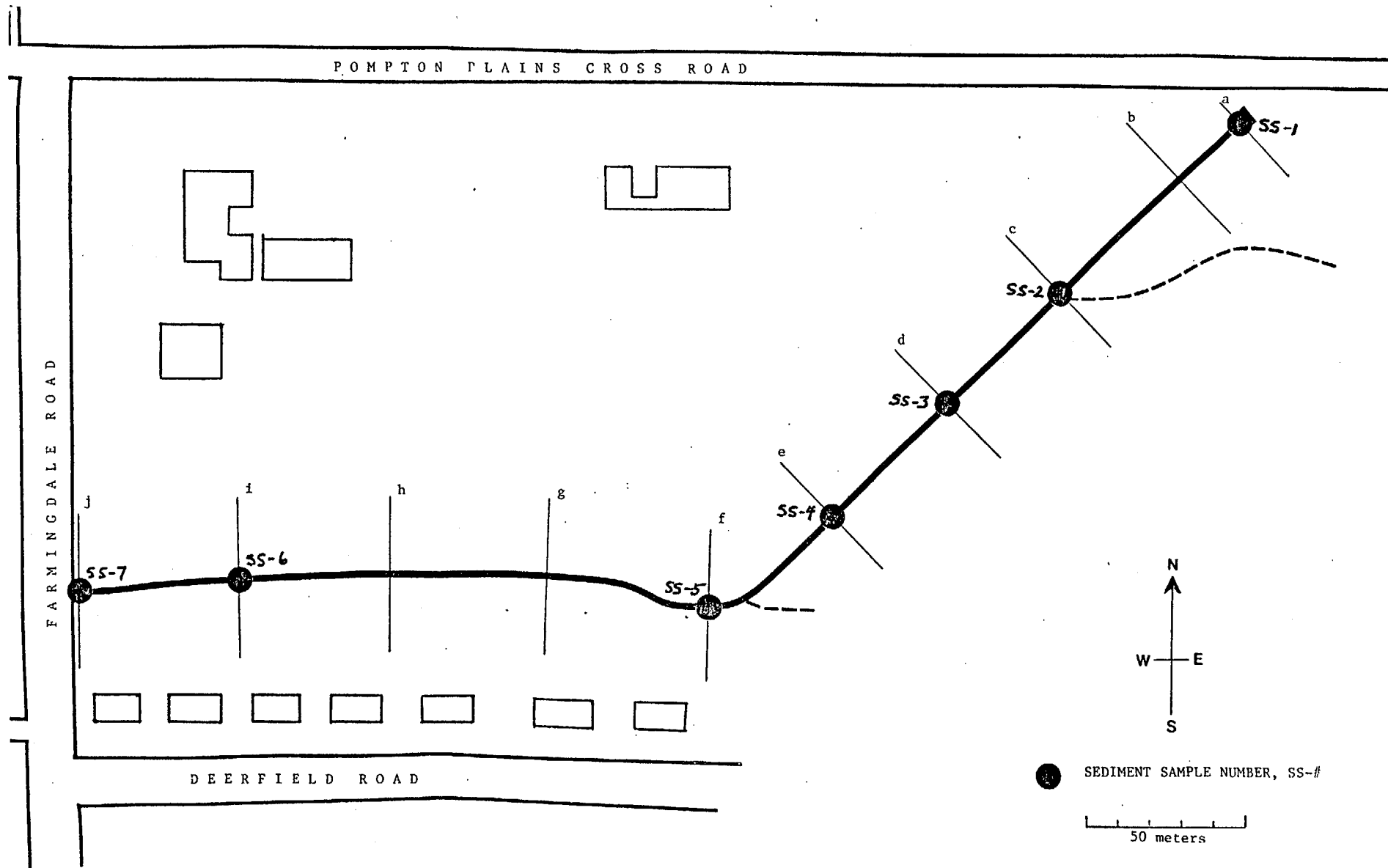


FIGURE 4A: SEDIMENT SAMPLING LOCATIONS
EAST OF FARMINGDALE ROAD

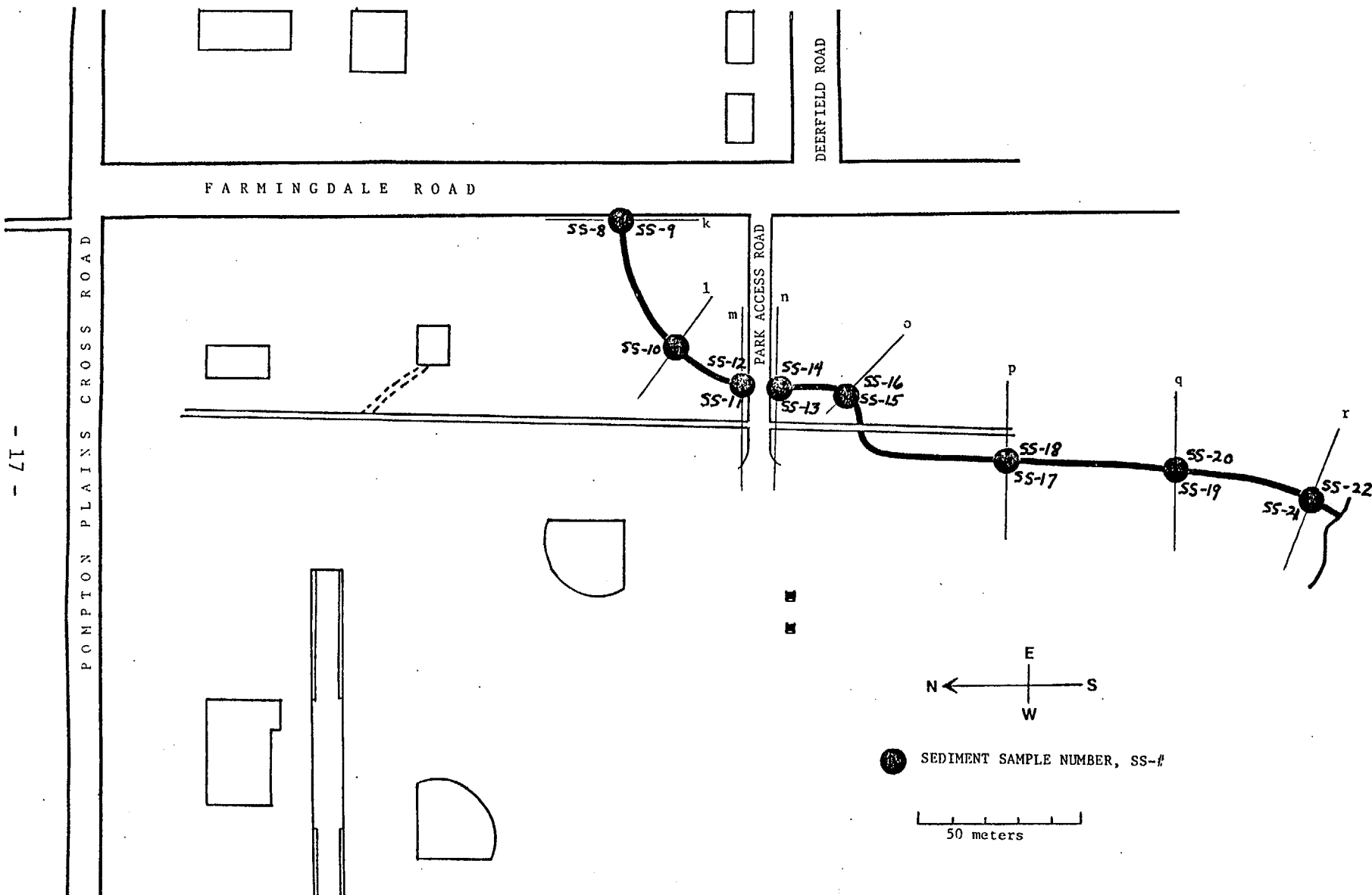


FIGURE 4B: SEDIMENT SAMPLING LOCATIONS
WEST OF FARMINGDALE ROAD

TABLE 1
RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
(Concentration in pCi/g)

<u>Sample No.</u>	<u>Location</u>	<u>Th-232</u>	<u>Ra-226</u>
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	$2.8 \pm 0.8^{(2)}$
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	$0.8 \pm 0.25^{(1)}$
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)

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

TABLE 1 - contd.
RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
(Concentration in pCi/g)

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

TABLE 1 - contd.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
(Concentration in pCi/g)

<u>Sample No.</u>	<u>Location</u>	<u>Th-232</u>	<u>Ra-226</u>
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	$0.9 \pm 0.2^{(1)}$

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

<u>Sample No.</u>	<u>Location</u>	<u>Th-232 (pCi/g)</u>	<u>Ra-226 (pCi/g)</u>
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	$1.8 \pm 0.5^{(2)}$
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	$2.8 \pm 0.1^{(1)}$	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	$0.7 \pm 0.1^{(2)}$
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)

<u>Location</u>	<u>Th-232</u>	<u>Ra-226</u>	<u>K-40</u>
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).

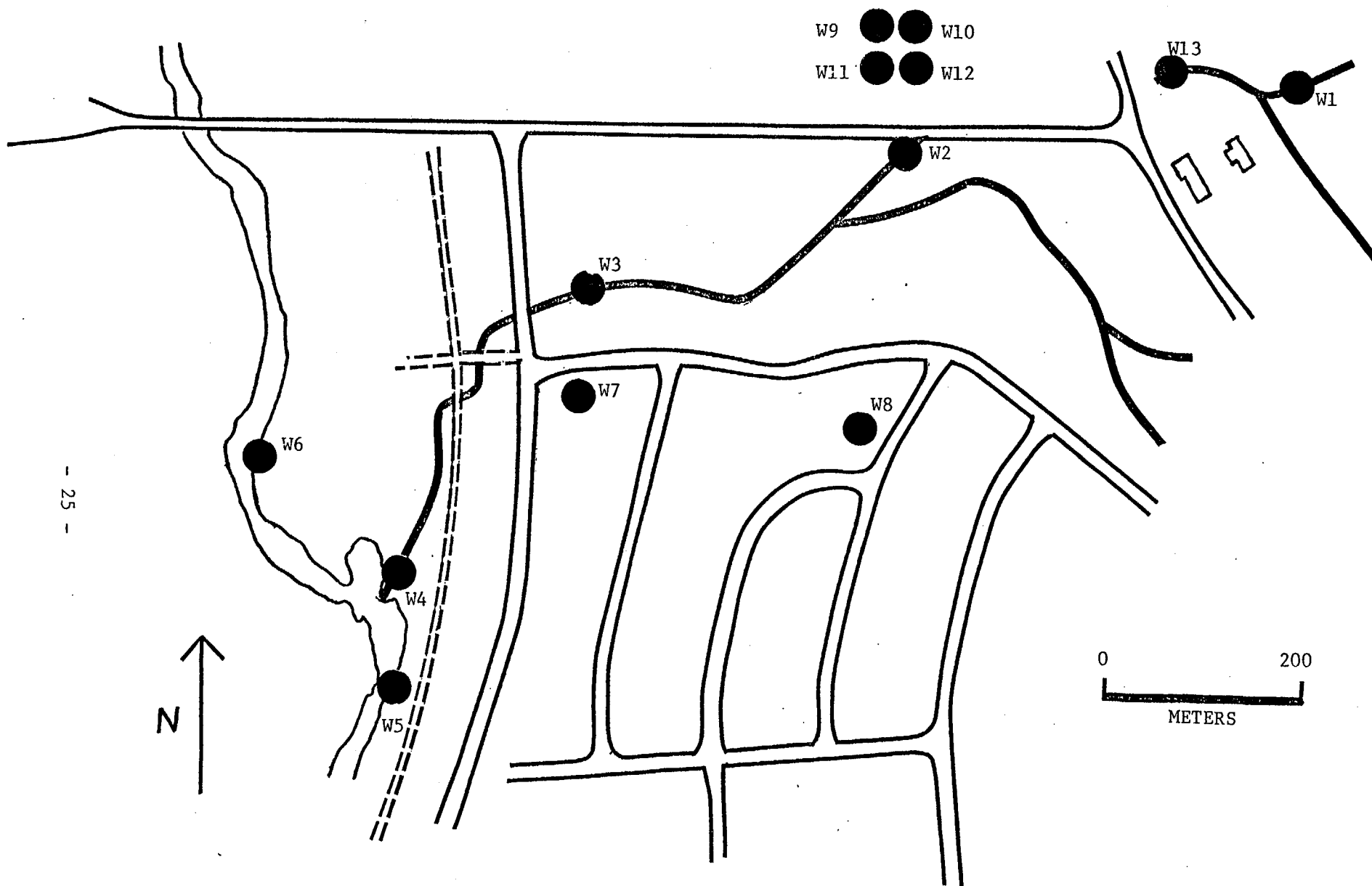


FIGURE 5: WATER SAMPLING LOCATIONS

TABLE 4
RADIONUCLIDE CONCENTRATION IN WATER SAMPLES
(Concentrations in pCi/l)

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

<u>Potable Water Sources</u> ⁴	<u>Gross Alpha</u>	<u>Gross Beta</u>
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

<u>Location</u>	<u>pCi/l \pm 2 sigma</u>
line n, RB + 20 meters	0.6 \pm 0.2
Center of Soccer Field	0.4 \pm 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 soil, 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 $\mu\text{R/hr}$ to 354 $\mu\text{R/hr}$.

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 μ R/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 μ R/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 μ R/hr above background for external exposure rate and 5 pCi/g above background for thorium-232, show that about 18,000 m² 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.

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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 photomultiplier 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 manufacturer 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 (microroentgens 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 intrinsic 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 - Counters 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.

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

Nuclide	Historical name	Half-life	Major radiation energies (MeV) and intensities		
			α	β	γ
^{40}K		$1.26 \cdot 10^9 \text{ y}$	—	1.32 (89%)	1.46 (11%)
<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> ^{40}Ar 10.7% </div> <div style="text-align: center;"> ^{40}Ca 89.3% </div> </div>		Stable	—		
^{232}Th	Thorium	$1.41 \cdot 10^{10} \text{ y}$	3.95 (24%) 4.01 (76%)	—	—
^{228}Ra	Mesothorium I	5.8 y	—	0.055 (100%)	—
^{228}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}Th	Radiothorium	1.910 y	5.34 (28%) 5.43 (71%)	—	0.084 (1.6%) 0.214 (0.3%)
^{224}Ra	Thorium X	3.64 d	5.45 (6%) 5.68 (94%)	—	0.241 (3.7%)
^{220}Rn	Emanation Thoron (Tn)	55 s	6.29 (100%)	—	0.55 (0.07%)
^{216}Po	Thorium A	0.15 s	6.78 (100%)	—	—
^{212}Pb	Thorium B	10.64 h	—	0.346 (81%) 0.586 (14%)	0.239 (47%) 0.300 (3.2%)
^{212}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%)
^{212}Po	Thorium C'	304 ns	8.78 (100%)	—	—
^{208}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}Pb	Thorium D	Stable	—	—	—

RADIOACTIVE DECAY PROPERTIES OF THE ^{238}U SERIES³

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

Docket No. 40-00086

OCT 27 1982

License No. STA-422

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

Gentlemen:

Subject: Radiological Surveys of Sheffield Brook, Final Report

Enclosed for your information are three (3) copies of the subject report. This report does not include the results of measurements made on your property on Black Oak Ridge Road in Wayne, New Jersey. Those results will be contained in a separate report.

In accordance with Section 2.790 of the NRC's "Rules of Practice," Part, 2, Title 10, Code of Federal Regulations, a copy of this letter and the enclosure will be placed in the Public Document Room.

No reply to this letter is required; however, should you have any questions, we will be pleased to discuss them with your.

Sincerely,

Original Signed By:
John D. Kinneman

for Thomas T. Martin, Director
Division of Engineering and
Technical Programs

Enclosure:
Radiological Surveys of Sheffield Brook, Final Report (3 copies)

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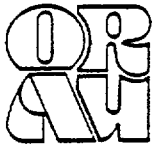
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Prepared by
Oak Ridge Associated
Universities

Prepared for
Division of Fuel
Cycle and
Material Safety

U.S. Nuclear
Regulatory
Commission

**RADIOLOGICAL SURVEY
OF
SHEFFIELD BROOK
WAYNE, NEW JERSEY**

P. W. FRAME

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

FINAL REPORT

October 1982

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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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FINAL REPORT

October 1982

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Along Sheffield Brook, Wayne, New Jersey

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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 acquired by the Davison Chemical Division of W.R. Grace and Co. in 1957; thorium ore processing activities continued until July 1971 when the plant was permanently closed. In 1974, Applied Health Physics Inc. decontaminated the buildings and the property was released by the Nuclear Regulatory Commission (NRC) for unrestricted use in January 1975. The buildings are currently under lease to, and occupied by, Electro-Nucleonics, Inc.

Solid wastes containing low (less than approximately 5%) concentrations of thorium were disposed of by on-site shallow land burial. These wastes included thorium-containing residues and slightly contaminated debris. Detailed records of quantities and compositions of waste and their exact burial locations were destroyed in a fire at the facility May 1977. Potentially contaminated liquid wastes were discharged into a small drainage stream 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. The State of New Jersey was represented at this survey and requested, through the U.S. Environmental Protection Agency, an aerial radiological survey of the site. In May 1981, the aerial survey was conducted by EG & G. This aerial survey identified elevated radiation levels

on the W.R. Grace site and west of the site, along Sheffield Brook.¹ The NRC performed confirmatory measurements along the brook in November 1981 and noted radiation levels up to 200 μ R/h and elevated concentrations of thorium in bank soil and stream sediment.²

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 Assessment Program of Oak Ridge Associated Universities (ORAU), Oak Ridge, Tennessee. Supplemental measurements and sampling were performed during the period of August 8-15, 1982. This report presents the findings of those surveys.

A glossary of technical and nuclear terms and schematic representations of the naturally-occurring thorium and uranium radioactive decay series have been provided in Appendices A and B, respectively, to aid the reader in interpreting this report.

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 on the west bank of the Pompton River and the W.R. Grace property and Wayne are located east of the river. The site occupies approximately 2.6 hectares most of which is 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 and heavy brush and weeds grow along a small drainage stream. The land generally slopes toward the west and northwest.

Figure 2 shows the location of Sheffield Brook and associated drainage streams. A small drainage stream enters the W.R. Grace

site near its southeast corner. This stream flows north, then west, and prior to leaving the property, enters a conduit. This conduit carries the water into a tank where it is mixed with the overflow from an on-site artesian well. The water then flows under the company's north parking lot to Black Oak Ridge Road where it combines with two storm sewer lines. It resurfaces approximately 150 m west of Black Oak Ridge Road, along the southern edge of Pompton Plains Cross Road. From this point, it flows southwesterly in a straight channel for approximately 100 m. There it joins with Sheffield Brook, another storm drainage stream originating about 100 m southwest of the W.R. Grace property. (Sheffield Brook was initially the overflow from Sheffield Pond, which was located just north of the brook's present origin. This pond was filled in approximately 10-20 years ago.)

The combined flow of Sheffield Brook and the W.R. Grace drainage stream continues in the straight ditch channel for another 100 m then turns west and continues in that direction until it passes under Farmingdale Road. 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.

East of Farmingdale Road, along the straight channel portion of the W.R. Grace drainage stream and Sheffield Brook, the land is relatively level. There are, however, small mounds of soil scattered along the banks in this area, apparently from periodic dredging of the ditch. Dense brush on both sides of the bank make access to this section of the stream and brook difficult. Beyond about 5 m from the ditch the land becomes open field containing scattered trees and tall grass. After the straight channel section, the brook flows from east to west and the bank on the south side of the brook becomes steeper, rising sharply for approximately 5 m. These banks are covered by brush and trees. North of the brook in this section the land is primarily low, soggy, open field, subject to periodic flooding. Along the portion of the brook west of Farmingdale Road the east bank is overgrown with brush and trees,

while the western bank is comparatively accessible from the park property. An aerial photograph of the Sheffield Brook area is provided as Figure 3.

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. Exposure rate measurements at 1 m above the surface for selected points along Sheffield Brook and associated streams.
2. Dose rate measurements at 1 cm above the surface for each of the locations where gamma measurements at 1 m were taken.
3. Monitoring of gamma radiation levels at the surface along Sheffield Brook and associated streams.
4. Collection of surface soil and subsurface soil from along Sheffield Brook, associated streams, and adjacent properties.
5. Collection of sediment samples along Sheffield Brook, its associated streams, and from the storm sewer system between W.R. Grace and Sheffield Brook.

6. Collection of water samples from streams, storm sewers, and local wells.
7. Collection of vegetation samples along the brook.
8. Sampling and measurements at off-site locations to provide baseline and background data for comparison.

Measurement of Direct Radiation

The brook was divided into 50 m intervals between the Pompton River and the juncture with the small drainage stream. Fifty meter intervals were also established along the drainage stream from the juncture to the point of emergence at Pompton Plains Cross Road. At each of these intervals, exposure rates at 1 m above the surface were systematically measured at the edges of the brook and at 5 and 10 m from the edges. Measurements were also taken where the brook entered or exited conduits. NaI(Tl) scintillation ratemeters, field-calibrated using a pressurized ionization chamber, were used to measure exposure rates.

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-penetrating radiations the measurements were made with the probes in both the open- and closed-shield configurations.

Three 50 m intervals were established along Sheffield Brook, upstream from its juncture with the drainage ditch from the W.R. Grace site. Exposure and dose rates were measured at 1 m and 1 cm, respectively, above the surface at these intervals along the stream bank.

Using NaI(Tl) gamma scintillation ratemeters, walkover surface scans were performed to a minimum of 10 m on either side of Sheffield Brook and associated streams from Pompton Plains Cross Road to the Pompton River. General radiation levels and locations of significantly elevated levels were noted.

Soil Sampling

At 50 m intervals along the W.R. Grace drainage stream and Sheffield Brook, surface (0-5 cm) soil samples were collected from both banks and at 5 or 10 m (alternating) from the water's edge. Sampling at these intervals was also extended to 100 m from the stream in the area east of Farmingdale Road. Surface samples were also collected from the banks at 50 m intervals along the upper section of Sheffield Brook and from one of the drainage streams west of Farmingdale Road. Subsurface (30 cm, 60 cm, and 90 cm) samples were collected at about 20% of these 50 m interval locations where surface samples were obtained. Additional subsurface and/or surface soil samples were collected at locations where direct measurements identified elevated radiation levels, and on other properties in the vicinity of the Sheffield Brook site. Soil sampling locations are indicated in Figures 4, 5, and 6.

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.

Sediment Sampling

Two sediment samples were collected at each of the 50 m intervals along Sheffield Brook and the W.R. Grace drainage stream. Samples were obtained using a garden trowel and traversing the bottom of the stream from its center toward the edge. Thus a sample was collected for each side of the stream at each interval. Sediment samples were collected at four locations in Sheffield Brook upstream of the

junction with the W.R. Grace drainage ditch and at four locations in the Pompton River - two upstream and two downstream of the junction with Sheffield Brook. Samples were also obtained at five locations in the storm sewer system servicing the W.R. Grace site. Locations of these sediment samples are indicated on figures 6, 7, 8, and 9.

Water Sampling

Surface water samples were collected from the drainage ditch on the W.R. Grace property and at four locations along Sheffield Brook. Samples were also collected from the Pompton River both 100 m and 500 m upstream and downstream of the junction with Sheffield Brook. Samples of water were obtained from five locations in the storm drain system feeding Sheffield Brook. Two samples of surface water and seven well water samples were obtained from the vicinity of Sheffield Brook and from local residents.

Locations of these water samples are indicated on Figures 6 and 9.

Due to questionably high gross alpha and gross beta concentrations measured in sample 6 from 100 m downstream on the Pompton River, this location was resampled.

Vegetation Sampling

On the original visit to the site, April 26 - May 1, 1982, vegetation samples were collected at five locations in the vicinity of Sheffield Brook (see Figure 6). These samples were analyzed without prior washing. Additional samples were collected from four of these locations as well as three new locations during the second visit to the site, August 8-15. These samples were washed before analysis to remove any surface contamination.

Baseline and Background Measurements

Five soil samples, two water samples, and two vegetation samples were collected at locations 0.3 to 10 km from the W.R. Grace and Sheffield Brook sites. Direct background radiation levels were measured at the locations of the soil samples. Figure 10 indicates the locations of these baseline samples and background measurements.

Equipment and Analytical Procedures

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

RESULTS

Background Radiation and Baseline Concentrations

Background exposure rates in the Wayne-Pompton Plains, NJ, area ranged from 6-12 $\mu\text{R/h}$; surface beta-gamma dose rates ranged from 10 to 24 $\mu\text{rad/h}$.

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

Direct Radiation Levels

Exposure Rates at 1 Meter Above the Surface

Exposure rates measured systematically at 1 m above the ground at the edge of the stream/brook ranged from 8 $\mu\text{R/h}$ to 170 $\mu\text{R/h}$, averaging 51 $\mu\text{R/h}$. At 5 m from the edge the exposure rates ranged from 9 $\mu\text{R/h}$ to 270 $\mu\text{R/h}$, averaging 58 $\mu\text{R/h}$; at 10 m the range was from 8 $\mu\text{R/h}$ to

250 $\mu\text{R/h}$, with an average value of 38 $\mu\text{R/h}$. Levels had decreased to approximately background at greater than 25 m from the stream/brook. These 1 m exposure rates are presented on Figures 11 and 12.

Beta-Gamma Surface Dose Rates

Surface beta-gamma dose rates ranged between 10 and 600 $\mu\text{rad/h}$ (see Figures 13 and 14). Differences between the open- and closed-shield measurements were less than 20%, indicating a relatively small contribution from beta and low-energy photon radiations.

Surface Walkover Survey

Surface exposure rates measured during the walkover scan of Sheffield Brook and associated drainage streams ranged from 6 $\mu\text{R/h}$ (background) to 420 $\mu\text{R/h}$. These exposure levels are presented graphically on Figures 15 and 16. Higher levels were noted in two general areas. One was a narrow strip, approximately 10 m wide and 150 m long, centered near the juncture of the drainage ditch with Sheffield Brook. This region of elevated radiation levels extended on either side of the straight channel portion of the drainage stream and brook for most of its length. Highest levels were mainly near small mounds of earth along the bank, believed to be material from dredging of the channel. Maximum contact radiation levels measured in this area were 420 $\mu\text{R/h}$ and 365 $\mu\text{R/h}$, both associated with mounds of earth. The other generally elevated area was centered approximately 100 m east of Farmingdale Road on the north side of Sheffield Brook. This elevated region is approximately 150-200 m long and 20-40 m wide. It is in a flat low area, subject to flooding. The maximum surface level measured in this area was 405 $\mu\text{R/h}$.

Surface radiation levels were considerably lower along the portion of the brook west of Farmingdale Road. Only one area, immediately west of the footpath and about 15 m south of the park access road, had contact levels above 100 $\mu\text{R/h}$. The maximum level measured here was 270 $\mu\text{R/h}$ at a small localized point. The slope of

the banks at this location is quite prominent, and it is therefore unlikely that the thorium contamination is attributable to direct deposition from the brook, even under flooding conditions.

Of the small drainage streams feeding Sheffield Brook, only the one north of the brook between Farmingdale Road and the footpath, had notably elevated exposure levels. The highest level along this stream, 120 μ R/h, was noted in a small area approximately 5 m north of the brook.

Minor discrepancies between the surface exposure rate and dose rate levels are probably the result of slight differences in the distances of the detectors from the surface during measurements.

Radionuclide Concentrations in Soil Samples

Radionuclide concentrations in surface and subsurface soils collected along Sheffield Brook and the associated drainage streams are presented in Table 2. Elevated levels of radium-228 and thorium-228 are present in surface soil over the entire length of the W.R. Grace drainage stream and Sheffield Brook following its juncture with this drainage stream. Another drainage stream adjacent to the township park also has elevated radionuclide concentrations in the bank soils. Following the pattern of the direct radiation levels, elevated concentrations in the soil were more frequent east of Farmingdale Road. In general there is a pattern of decreasing radionuclide concentrations with distance from the W.R. Grace property and from the edge of the brook. Exceptions to this pattern were areas of small mounds of dredging debris and at several other locations. For example, samples 131 and 135, collected close to the Pompton River, both contained radium-228 and thorium-228 concentrations exceeding 100 pCi/g. The maximum radium-228 and thorium-228 concentrations measured in surface soil were 734 and 722 pCi/g, respectively, at sample location 105. Samples obtained along the portion of Sheffield Brook upstream of the juncture with the drainage stream from the W.R. Grace property, and along the Pompton River, did

not contain radionuclide concentrations significantly different from the baseline levels.

Concentrations in subsurface soils obtained along the brook and drainage streams generally decreased with depths below 30 cm. Only two samples, from locations 112 and 113, contained significant radionuclide concentrations at the 90 cm depth; levels of radium-228 and thorium-228 at these locations exceeded 100 pCi/g. Elevated radionuclide concentrations below a 30 cm depth were often associated with the mounds of dredged material.

Surface soil at locations 130 and 153, from the area of the park soccer field having slightly elevated direct exposure levels, contained the following levels of radium-228 and thorium-228 respectively: 9.08 and 41.4 pCi/g, radium-228, and, 5.56 and 324 pCi/g, thorium-228. The sample taken from a depth of 30 cm at location 130 contained a radium-228 concentration of 24.1 pCi/g and a thorium-228 concentration of 21.8 pCi/g. The surface soil sample from location 154, an area of the soccer field with direct exposure levels comparable to the background levels, contained radionuclide levels in the range of the baseline samples. Samples 142 and 143, from the John Baum property on the southeast corner of Farmingdale and Pompton Plains Cross Roads, also had radionuclide concentrations in the range of the baseline samples.

Table 3 lists the concentrations of radionuclides measured in soil from the Kuehm and Baum properties north of Pompton Plains Cross Road. All of the samples from the Kuehm farm and all but one from the Baum property had concentrations comparable to the baseline levels. The exception, surface soil from location 160 on the Baum property, contained a radium-228 concentration of 112 pCi/g and a thorium-228 concentration of 113 pCi/g. This location was an isolated spot determined by a walkover survey to have direct radiation levels considerably above those characteristic of the remainder of the property. The location of this small elevated area was such that it was not accessible for subsurface sampling.

The average ratio of radium-228 and thorium-228 concentrations, measured in soils by gamma spectrometry is near 1. Alpha spectroscopy on three soil samples indicates an average thorium-232 to thorium-228 ratio of approximately 1.1. These ratios confirm that the thorium decay series is essentially in secular equilibrium. This equilibrium state allows the use of the radium-228 level as representative of the thorium-232 concentration present.

Elevated concentrations of uranium-238 and radium-226 were also measured in samples containing high concentrations of thorium. The source of these radionuclides is the natural uranium, which was present in the monazite sand - the major raw material for the Rare Earths, Inc., and W.R. Grace operations. The maximum radium-226 level, 46.8 pCi/g, was measured in sample 105. Radium-226 concentrations were generally less than 5% of the total thorium (thorium-232 plus thorium-228) levels in the soil samples. Radon-222, a radioactive noble gas, is produced by the decay of radium-226. This radon and its daughter products may be a large contributor to radiation doses from soils containing radium-226. The soils along Sheffield Brook, however, contain much higher concentrations of thorium than radium-226. Radiation contributed by radon-222 will, therefore, be much less than the levels of direct gamma radiation. For this reason radon and radon daughter concentrations in air were not measured as part of this survey. The maximum uranium-238 concentration was 247 pCi/g, measured in sample 44. When high enough to be detected, the uranium-238 concentrations in soil were typically 10-35% of the total thorium levels.

Radionuclide Concentrations in Sediment Samples

Radionuclide concentrations in sediment samples are presented in Table 4. Although no consistent pattern in the distribution of elevated levels in sediment was observed, concentrations were generally higher along the W.R. Grace drainage stream and the portion

of Sheffield Brook between the juncture with the drainage stream and Farmingdale Road. Elevated sediment levels were also frequently associated with sudden changes in flow rate due to severe bends, constrictions, expansions, or obstacles in the stream bed. The maximum concentrations of radium-228 and thorium-228 (61.0 and 53.9 pCi/g respectively) were measured at sample location 16. At locations 8 and 9, where the drainage stream joins Sheffield Brook, the radionuclide concentrations are considerably lower. Physical or chemical conditions may be inhibiting the deposition in or enhancing the clearance of radionuclides from the sediment at that location. West of Farmingdale Road the maximum thorium concentrations were noted at locations 24 and 31.

Levels in sediment from Sheffield Brook upstream of its juncture with the W.R. Grace drainage stream were in the range of baseline soil samples. Samples collected from the Pompton River upstream and downstream of Sheffield Brook were also in this baseline range; however, the downstream concentrations were slightly higher than those in upstream samples.

Sediment from the storm sewer system also contained thorium contamination. The maximum levels, 15.1 pCi/g of radium-228 and 14.9 pCi/g of thorium-228, were measured in sample location 45, the first sample collected in the drainage system after it leaves the site.

Radium-226 concentrations in sediment did not exceed 5 pCi/g. Where elevated levels were measured, they were generally less than 5% of the thorium concentrations. As with the soil samples, the uranium-238 levels in sediment were consistently lower than the thorium concentrations. Sediment from location 20 had the highest uranium-238 concentration, 20.1 pCi/g.

Water Samples

Radionuclide concentrations measured in water samples are presented in Table 5 and 6. Table 5 includes samples from Sheffield Brook, the associated drainage streams, and the Pompton River. Samples from residential wells in the Wayne area and other sources of surface water are presented in Table 6.

The maximum gross alpha concentration, 29 pCi/l (with the exception of 39 pCi/l originally measured in sample 6), was measured in sample 8, from the drainage stream on the W.R. Grace property. Samples 9 and 10 from the storm sewer also had elevated gross alpha concentrations. Samples 8 and 13 (also from the storm sewer system) contained elevated radium-228 levels. Other specific radionuclides were not measured at significant levels in samples from the storm drainage system.

With the exception of samples 2 and 6, surface water from the remainder of the brook and drainage system, contained levels in the range of the baseline water samples. Because of the unusually high alpha level of 39 pCi/l originally determined for sample 6, instrument malfunction or sample cross-contamination was suspected. This location was resampled and the results indicate an alpha concentration in the baseline range. The reason for the elevated gross alpha level in sample 2 is unexplained. Sample 2 contained a relatively high (compared to other samples) concentration of thorium-230; the reason for this is also unknown. Specific radionuclides in other samples from the surface drainage system are comparable to baseline levels.

Of the other water samples collected from the Wayne area, significant gross alpha concentrations were only measured in samples 20 and 21 (6.8 pCi/l and 12 pCi/l respectively). The unexpectedly high gross alpha concentration measured in sample 21, as well as its gross beta concentration of 60 pCi/l, raised the possibility of an analytical problem similar to that encountered with sample 6. Two

separate reanalyses of sample 21 were performed and both indicated gross alpha and beta concentrations in the range of the baseline levels. Sample 16 from one of the farm wells contained a radium-228 level of 3.07 pCi/l. All other radionuclide concentrations in these water samples were comparable to the baseline levels.

Vegetation Samples

Table 7 presents the results of vegetation sample analysis. With the exception of sample 2, elevated concentrations of radium-228 and thorium-228 were measured in the unwashed vegetation from the vicinity of the brook. The highest levels, 12.8 pCi/g of radium-228 and 10.1 pCi/g of thorium-228, occurred in sample 3; sample 4 contained 6.96 pCi/g and 4.11 pCi/g of radium-228 and thorium-228, respectively. These two samples were from regions of high surface soil levels. Washed samples from these same locations had much lower concentrations, indicating that the activity measured in the unwashed samples is primarily due to external surface contamination. Sample 2 and vegetation samples 6, 7, and 8 from the nearby farm had radionuclide levels comparable to those of the baseline samples.

Comparison of Results with Guidelines

Guidelines for levels of radiation and radioactive materials in the environment are established by federal regulatory agencies such as the Nuclear Regulatory Commission (NRC) and Environmental Protection Agency (EPA). These guidelines are usually based on conservative factors of land use and occupancy, potential intake by inhalation and ingestion, biological retention times, relative hazard of the radionuclide and potentially exposed population groups. Such guidelines are, therefore, for highly restrictive situations that may not be representative of the actual conditions at a specific site. For this reason these federal guidelines are often used as target criteria with site specific limits established on a case-by-case basis.

The Nuclear Regulatory Commission's Standards for Protection Against Radiation (10CFR20.105) limits the annual radiation dose to an individual in the general population to 500 millirem.³ Assuming continual exposure, i.e. 168 h/wk, this is equivalent to an average exposure rate of approximately 60 μ R/h. There are numerous locations along Sheffield Brook and the drainage streams which exceed this level; however, these locations are not in areas of continual occupancy.

Guidelines for concentrations of radionuclides in soil have not been specifically developed for the Sheffield Brook site. The NRC Branch Technical Position on storage and disposal of uranium and thorium wastes provides an example of soil concentration limits which have been proposed for other sites⁵. In this document, the most restrictive level for both natural thorium (i.e. thorium-232 plus thorium-228 with daughters in equilibrium) and natural uranium (uranium-238 plus uranium-234 with daughters, including radium-226, in equilibrium) in soil is 10 pCi/g. Guideline levels for these radionuclides in soils at the Sheffield Brook site may be higher than that value. The following volumes of soil exceeding various concentration levels of thorium have been estimated for the property in the vicinity of Sheffield Brook:

<u>Thorium Concentration Limit (pCi/g)</u>	<u>Soil Volume (m³)</u>
10	13,000
20	11,000
50	5,000

There are no established criteria for acceptable levels of radioactivity in ground water; however, the EPA has established the following levels for radioactive contaminants in community drinking water systems⁶:

Combined radium-226 and radium-228	5 pCi/l
Gross alpha (including radium-226 but excluding radon and uranium)	15 pCi/l
Gross beta	50 pCi/l

A water sample obtained from the W.R. Grace property and one from the storm sewer exceeded the gross alpha limit. All other samples were below the gross alpha and gross beta limits. None of the samples exceeded 5 pCi/l of combined radium-226 and radium-228. It should be noted that although these EPA levels have been used for comparison purposes, they are intended only for control of larger drinking water systems and are not applicable to surface drainage water or residential wells.

Most of the activity associated with the vegetation collected from the vicinity near the brook appears to be the result of surface contamination rather than radionuclides assimilated by the plants. After washing, radionuclide concentrations in the plants were low, most samples were in the range of baseline levels. Vegetation from the nearby farm also had radionuclide concentrations in the baseline range.

An evaluation of the current radiation exposures at this site is presented in Appendix E.

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 survey findings indicate thorium contamination of soils and streambed sediments in certain areas along this brook and the associated drainage streams. Smaller quantities of radionuclides from the natural uranium decay series, e.g. uranium-235, uranium-238, and radium-226 are also present.

The contamination apparently originated on the 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 by Rare Earths, Inc., and, later, W.R. Grace and Co., the present owner of the property. It is believed that some of the wastes from these operations entered the drainage system via liquid effluent discharges and storm runoff over an extended time period. This drainage system flowed off-site in a storm sewer line beneath Pompton Plains Cross Road. The flow surfaced about 150 m west of the facility to enter a drainage ditch into which Sheffield Brook subsequently flowed. The contaminants were deposited along the streambed and banks of the drainage ditch and portions of Sheffield Brook. Periodic dredging and occasional flooding of the brook have resulted in a spread of the contamination beyond the original areas of deposition. Several locations of soil contamination also are suggestive of prior earth-moving and grading activities and use of contaminated soils for "fill."

The contamination is concentrated in the immediate area of the drainage stream from the W.R. Grace property and portions of the brook. It is primarily limited to the upper 30-60 cm of soil. Low radionuclide concentrations in surface water, well water, and vegetation from the area confirms the low solubility of the material. It would therefore appear that the primary mode of exposure in the vicinity of the contaminated properties is external gamma radiation.

The levels of direct radiation and radionuclide concentrations in soil and sediment at many locations along Sheffield Brook and the associated drainage streams exceed target criteria proposed by the NRC for uncontrolled use by the general public. These criteria were developed by the NRC using highly restrictive assumptions. These assumptions may or may not be applicable to the Sheffield Brook property.

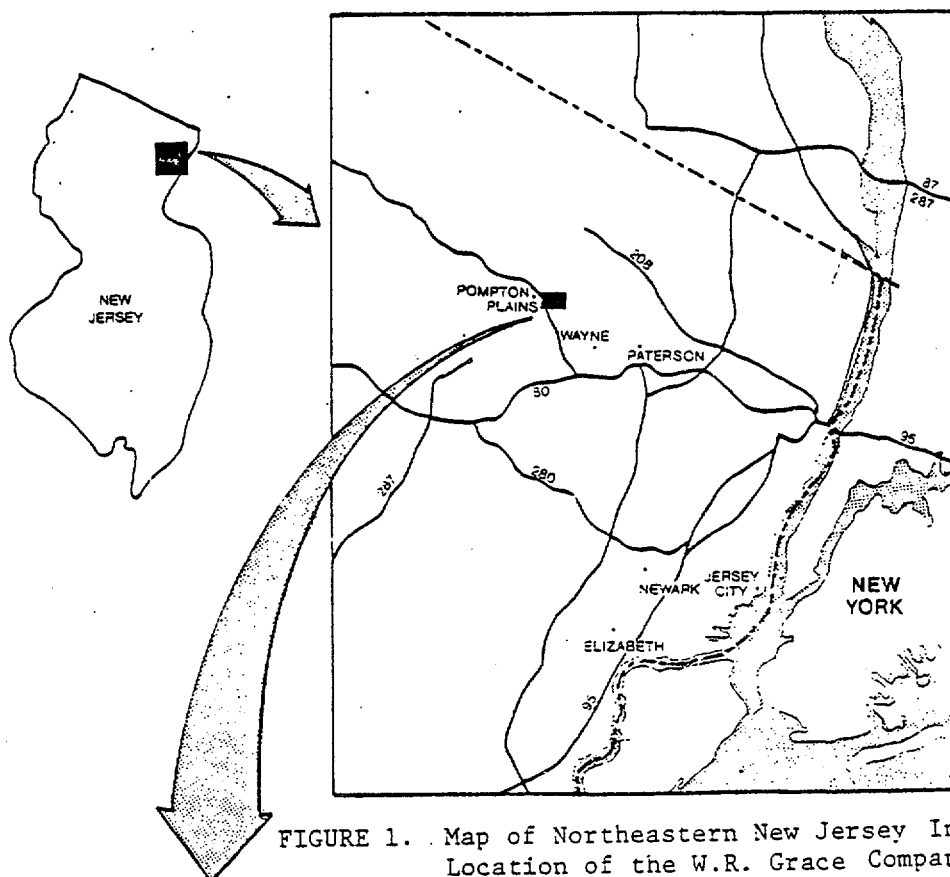


FIGURE 1. Map of Northeastern New Jersey Indicating the Location of the W.R. Grace Company.

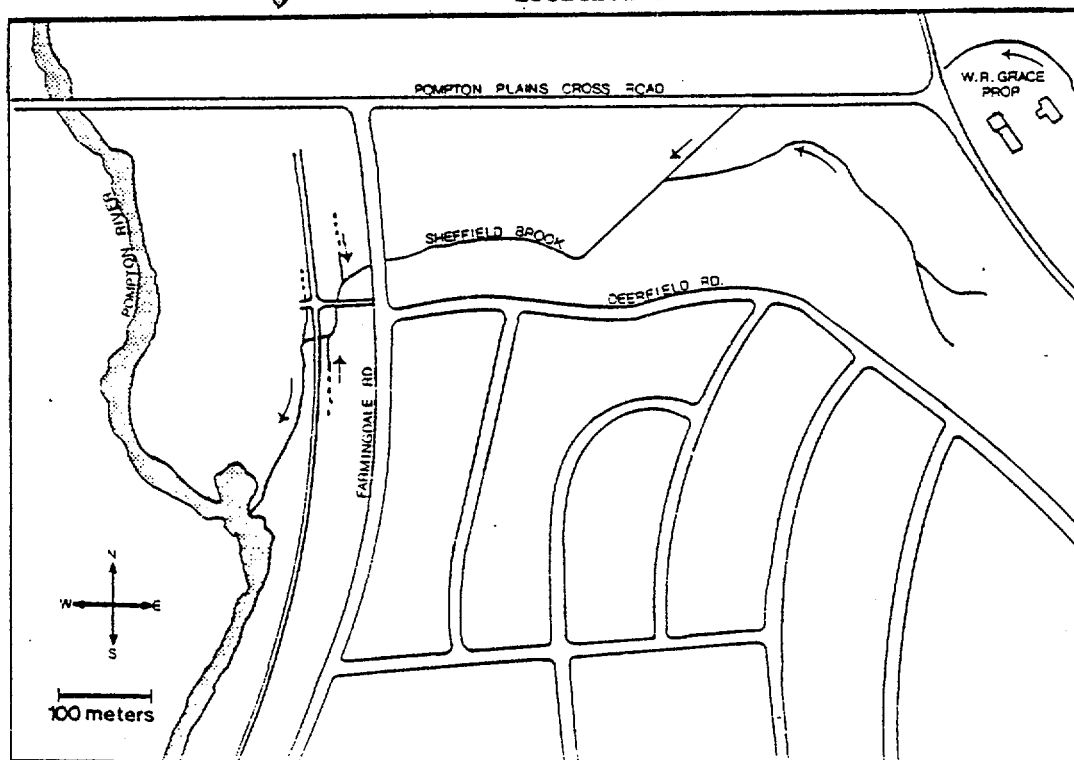


FIGURE 2. Portion of Wayne, NJ, Indicating the Location W.R. Grace Property, Sheffield Brook and Associated Streams.

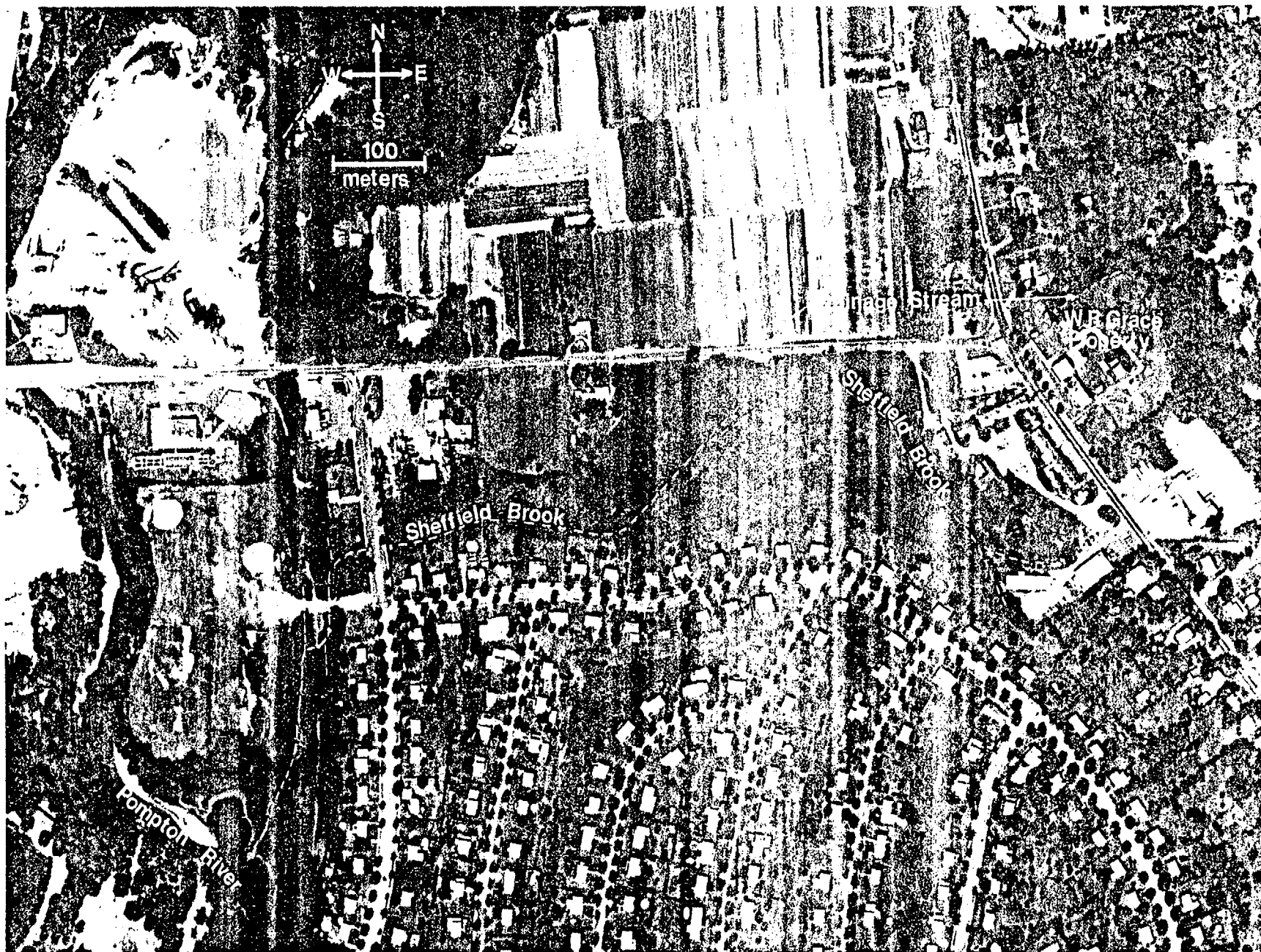


FIGURE 3. Aerial Photograph of Portion of Wayne, NJ, Indicating the Locations of the W.R. Grace Property, Sheffield Brook, and Associated Streams.

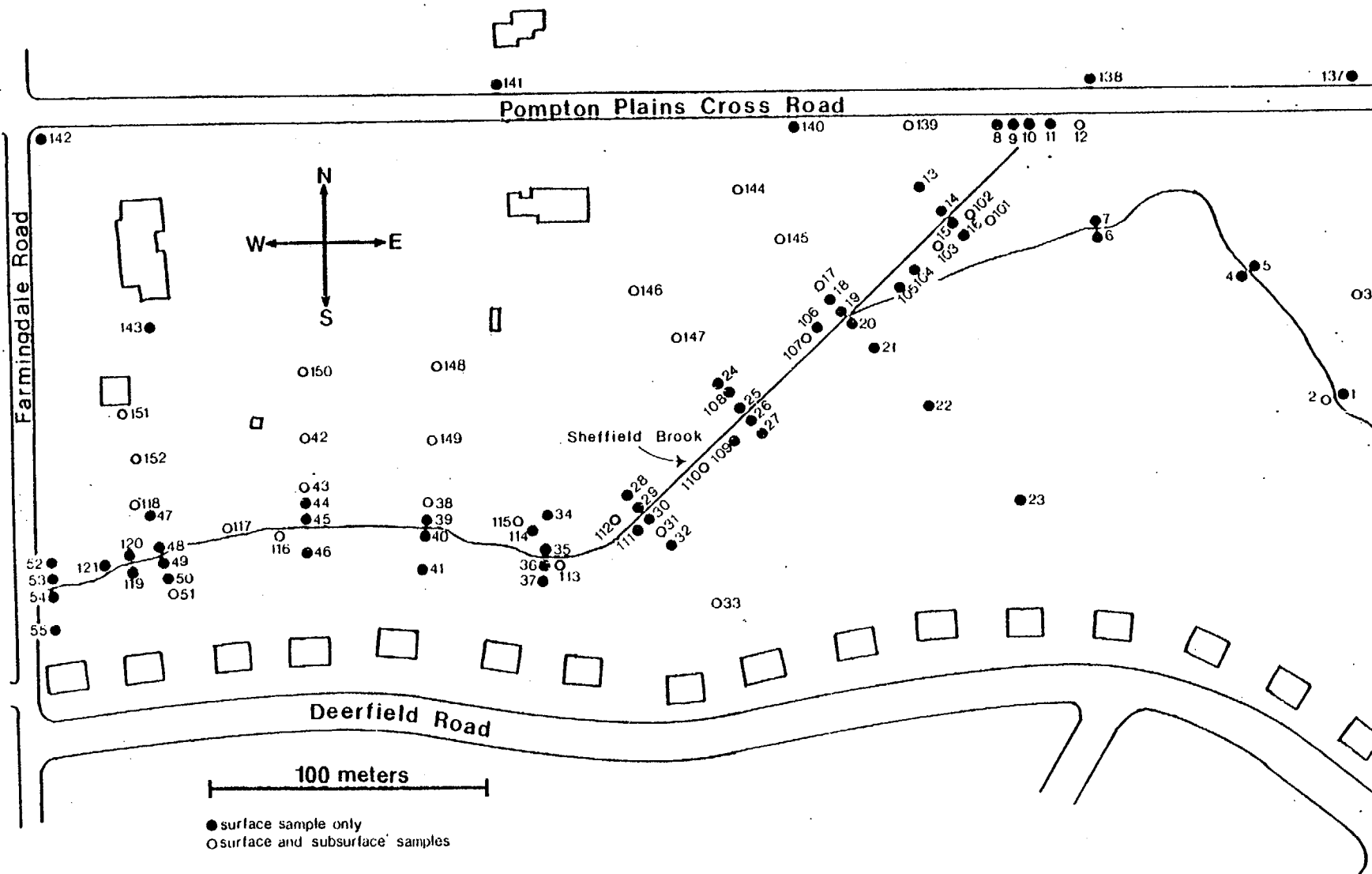


FIGURE 4. Map of Sheffield Brook, East of Farmingdale Road, Indicating Locations of Soil Samples.

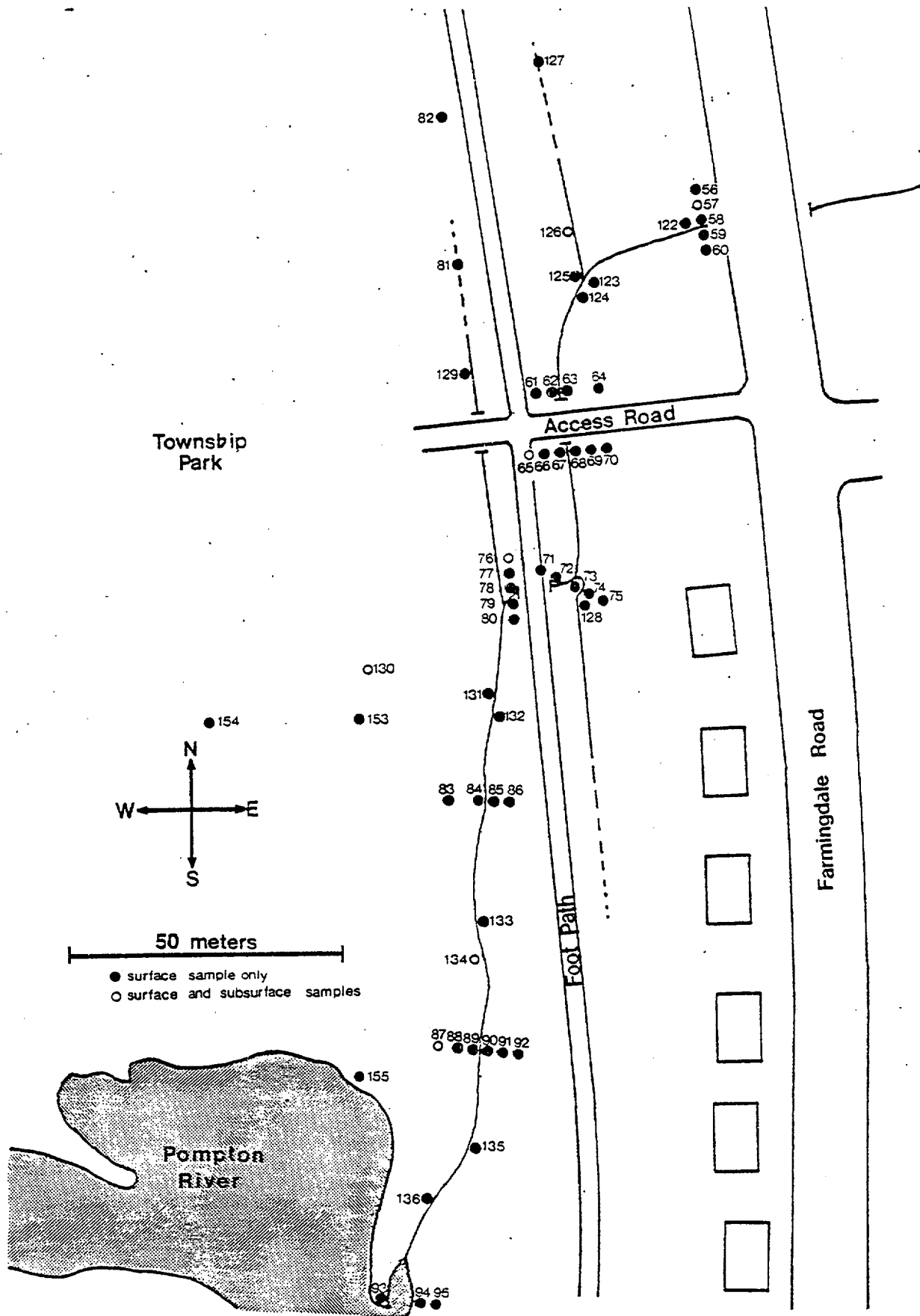


FIGURE 5. Map of Sheffield Brook, West of Farmingdale Road, Indicating Locations of Soil Samples.

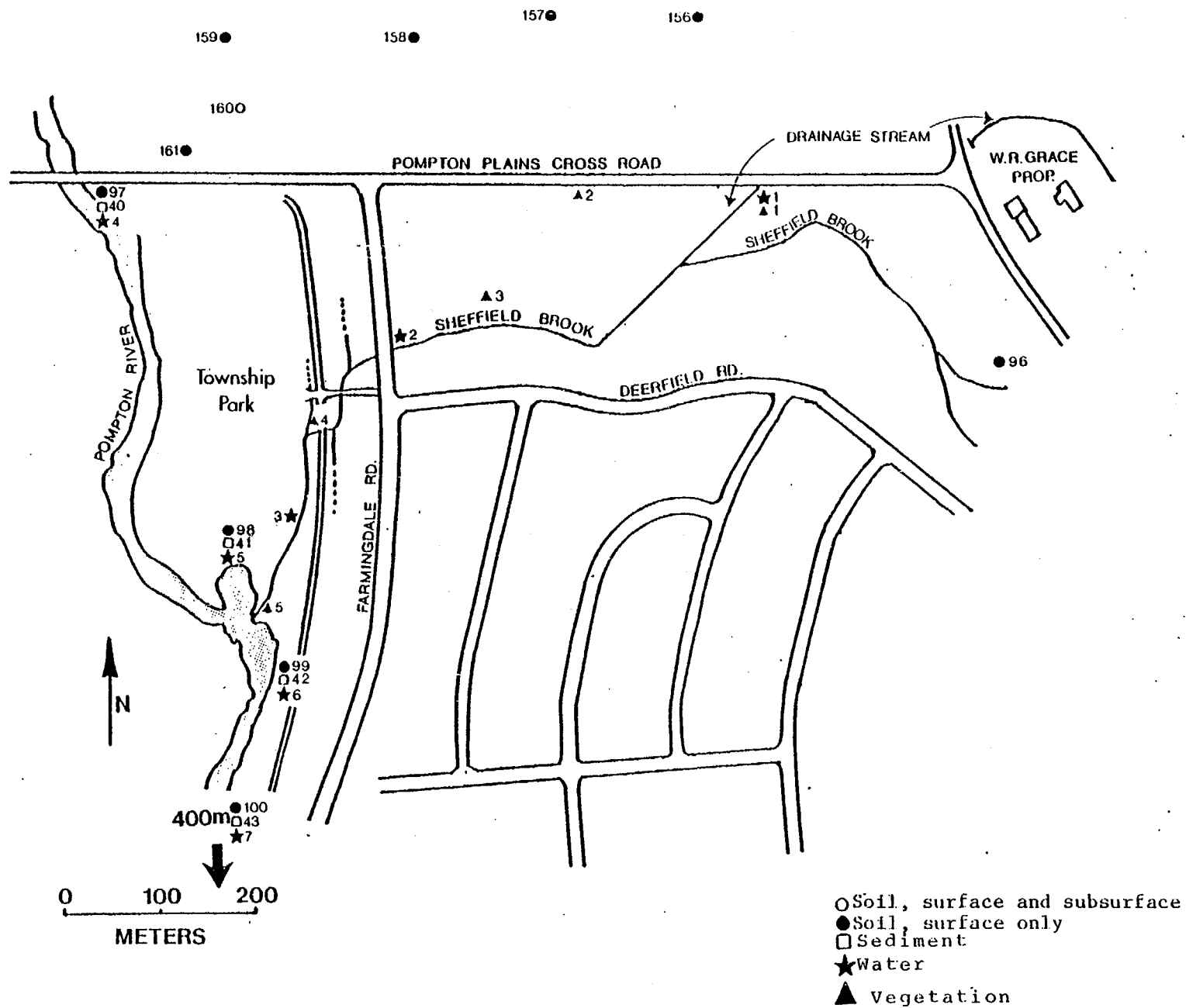


FIGURE 6. Map of Sheffield Brook and Vicinity Indicating Locations of Soil, Sediment, Water, and Vegetation Samples.

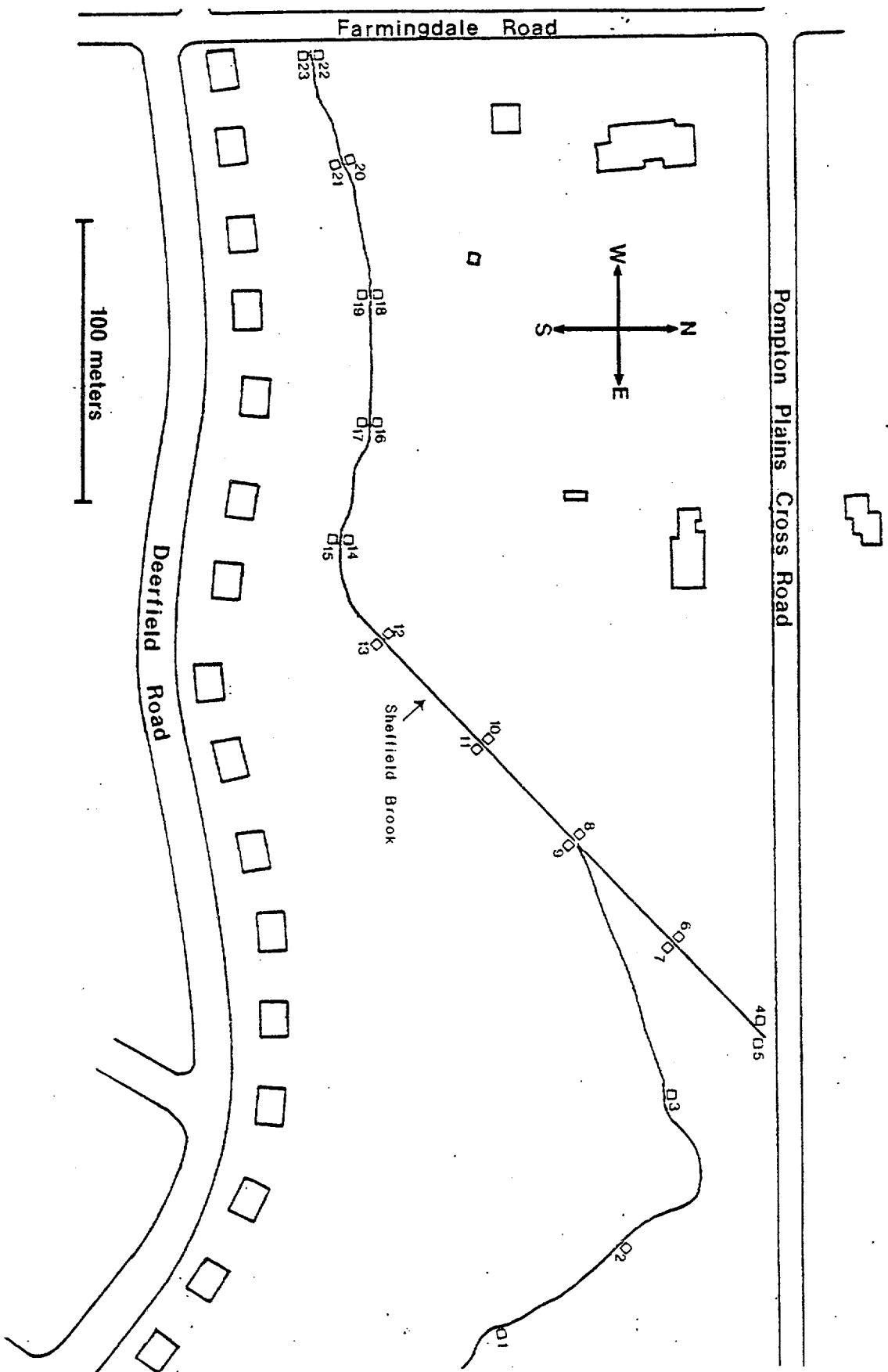


FIGURE 7. Map of Sheffield Brook, East of Farmingdale Road, Indicating Locations of Sediment Samples.

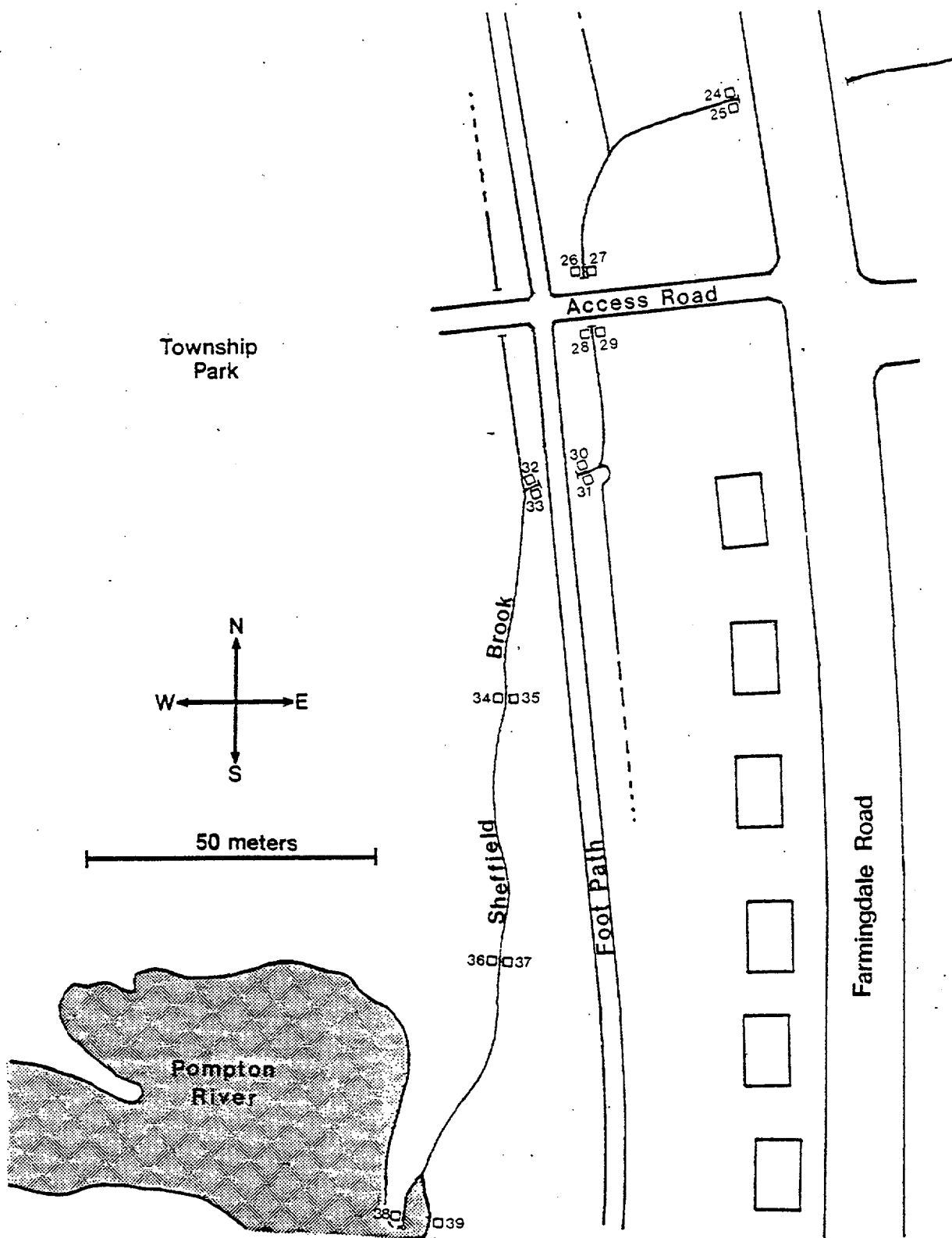


FIGURE 8. Map of Sheffield Brook, West of Farmingdale Road, Indicating Locations of Sediment Samples.

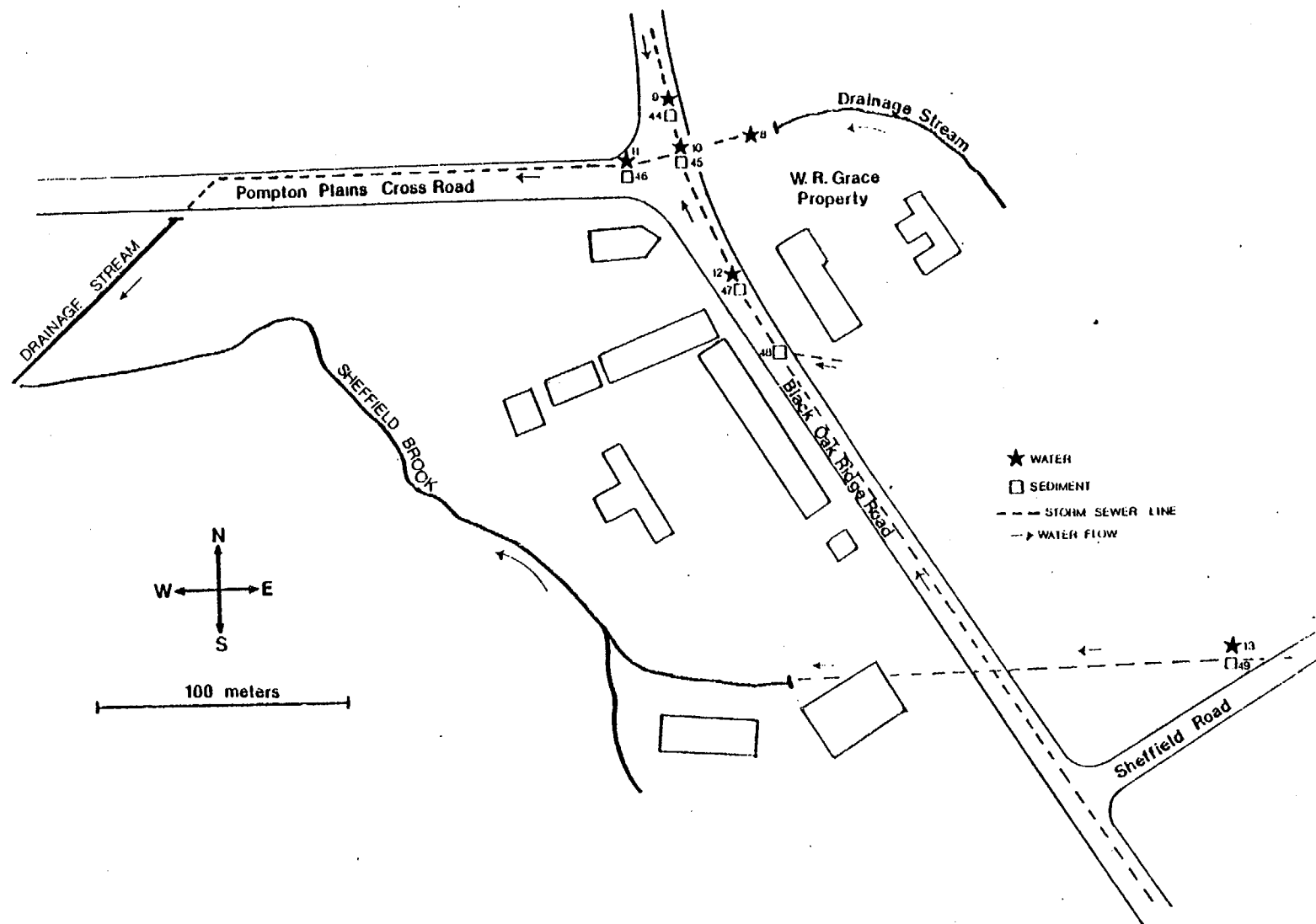


FIGURE 9. Plan View of Storm Sewer System Feeding Sheffield Brook, Indicating Locations of Sediment and Water Samples.

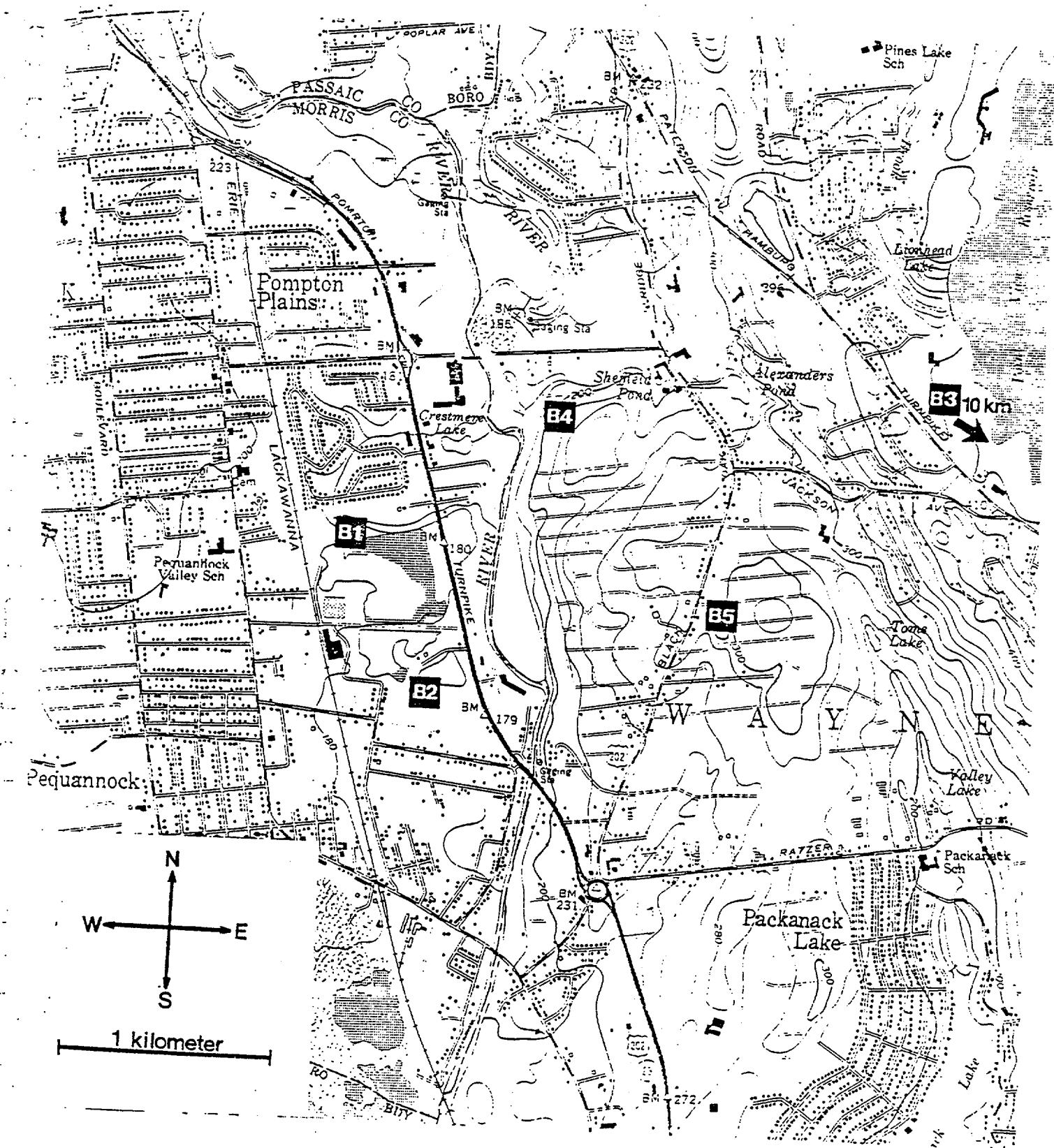


FIGURE 10. Locations of Background Measurements and Baseline Samples in the Wayne-Pompton Plains Area.

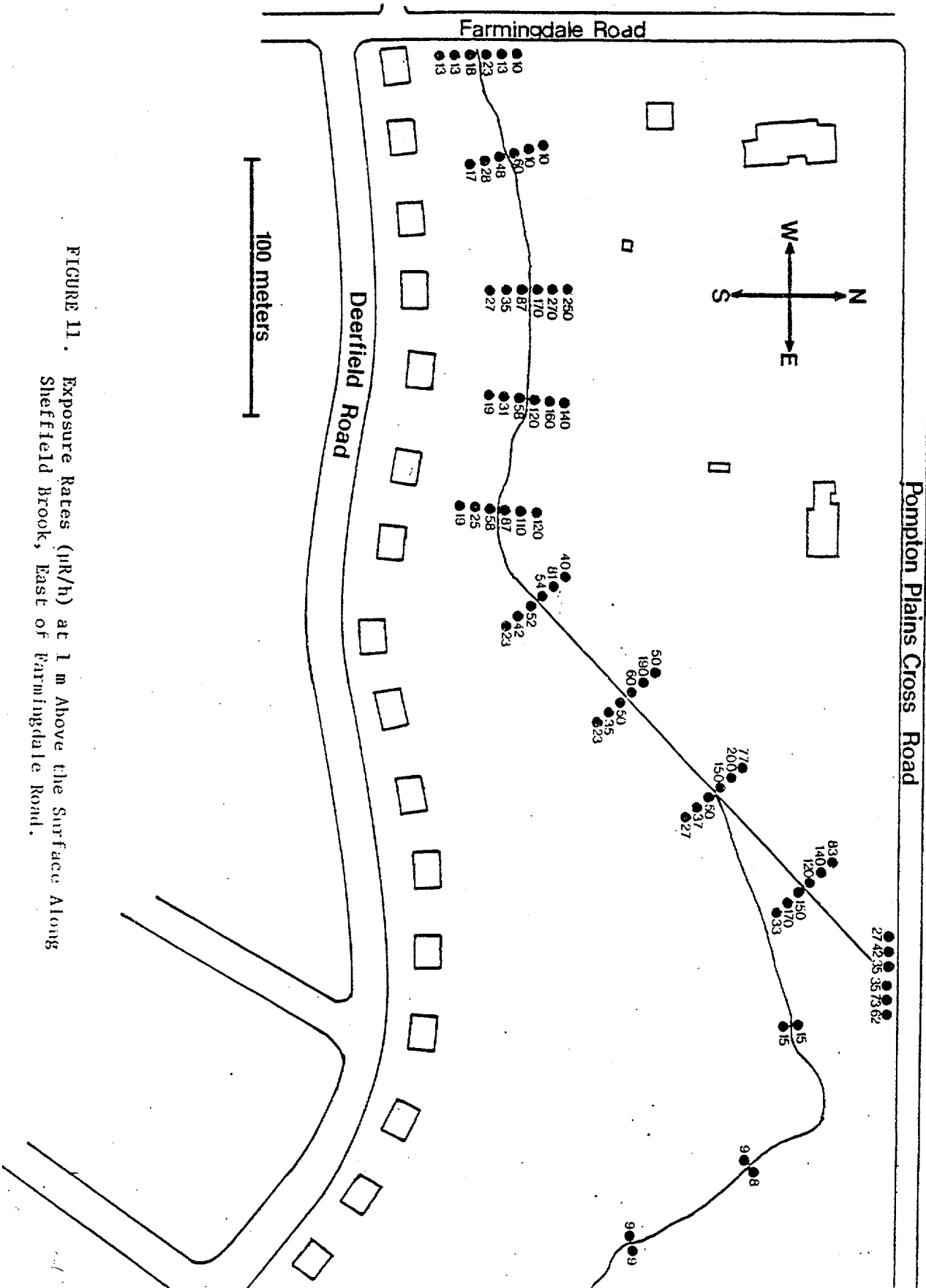


FIGURE 11. Exposure Rates ($\mu\text{R/h}$) at 1 m Above the Surface Along Sheffield Brook, East of Farmingdale Road.

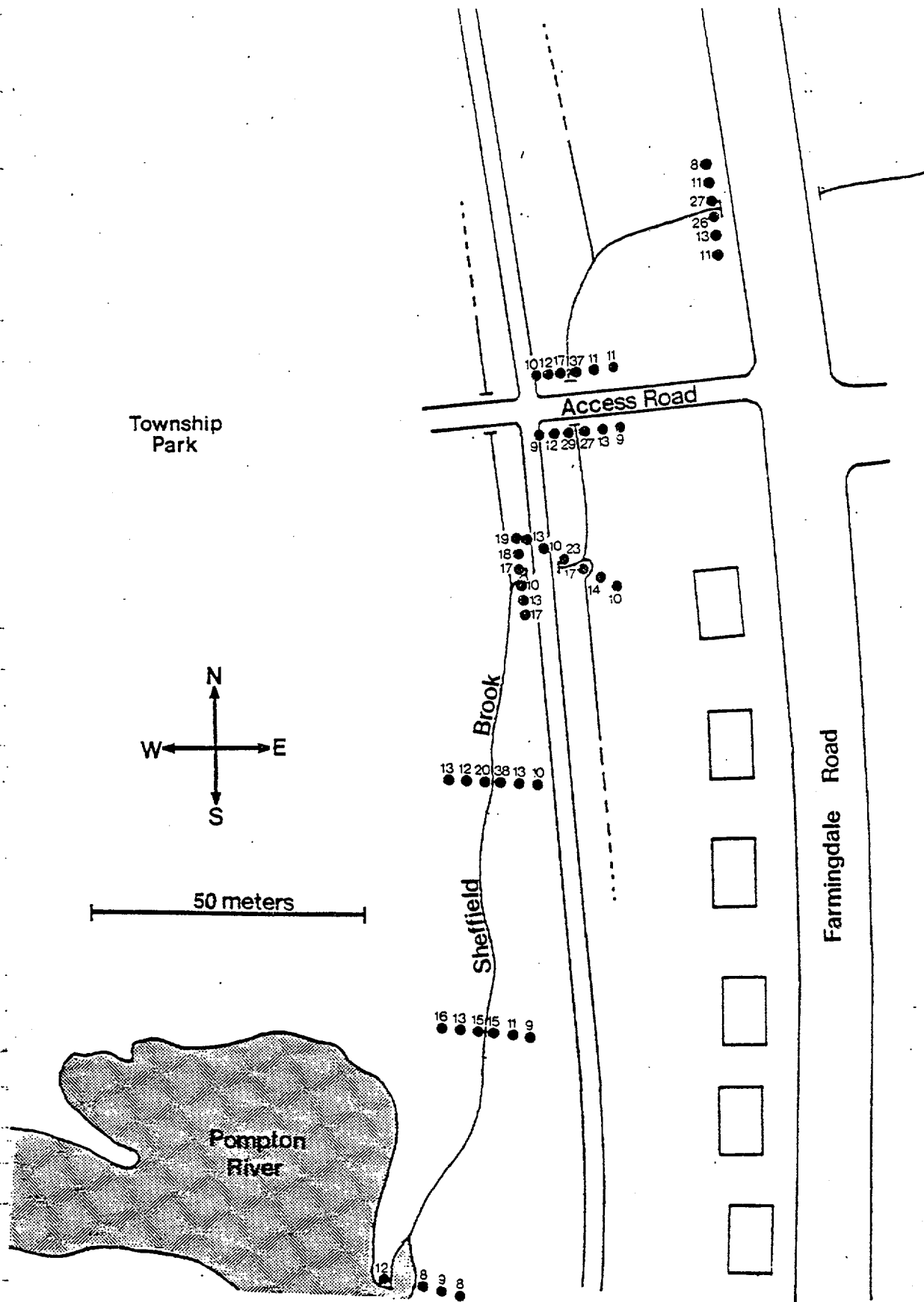


FIGURE 12. Exposure Rates ($\mu\text{R/h}$) at 1 m Above the Surface Along Sheffield Brook, West of Farmingdale Rd.

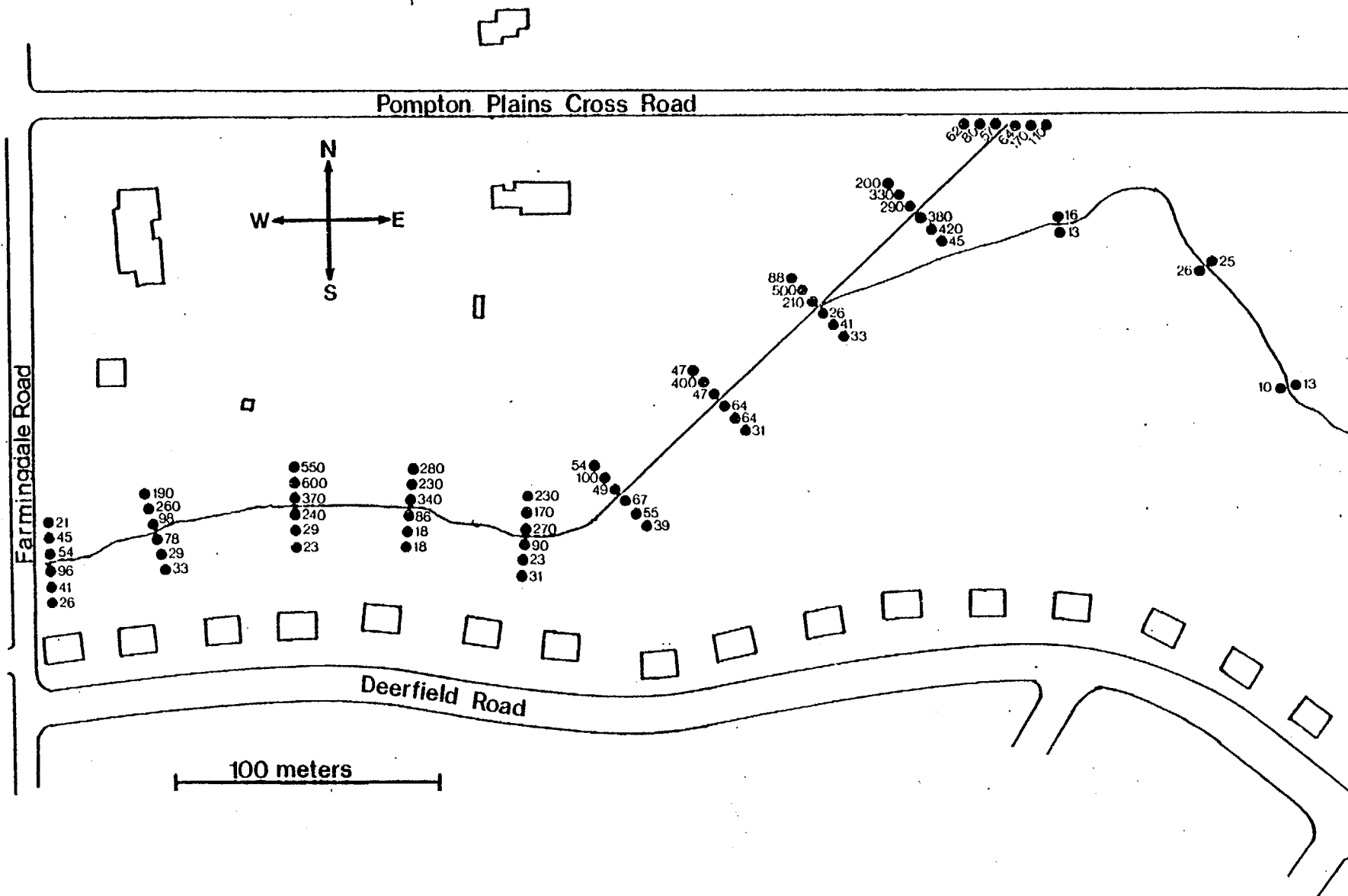


FIGURE 13. Surface Beta-Gamma Dose Rates ($\mu\text{rad/h}$) Along Sheffield Brook, East of Farmingdale Road.

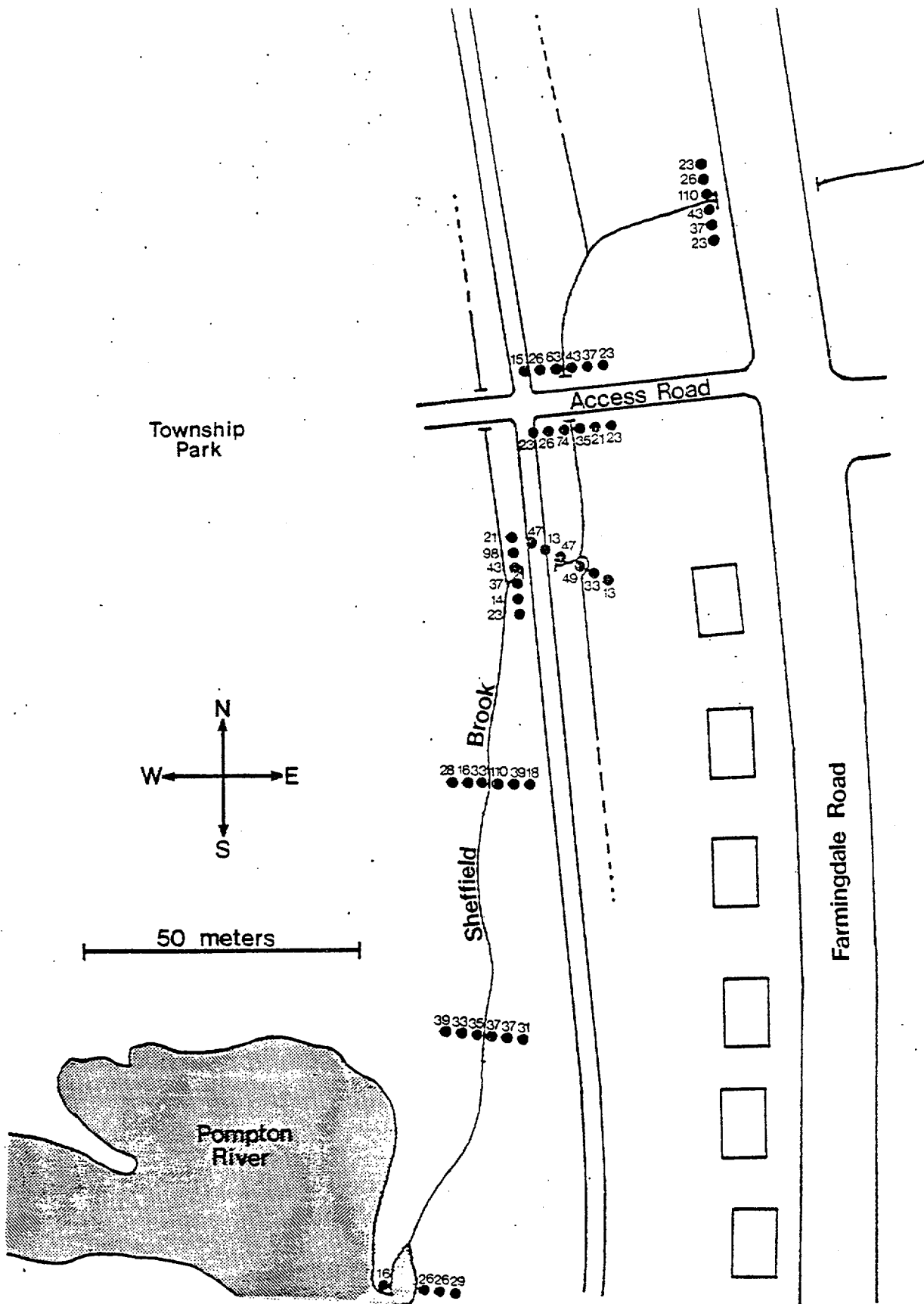


FIGURE 14 . Surface Beta-Gamma Dose Rates (μrad/h) Along Sheffield Brook, West of Farmingdale Road.

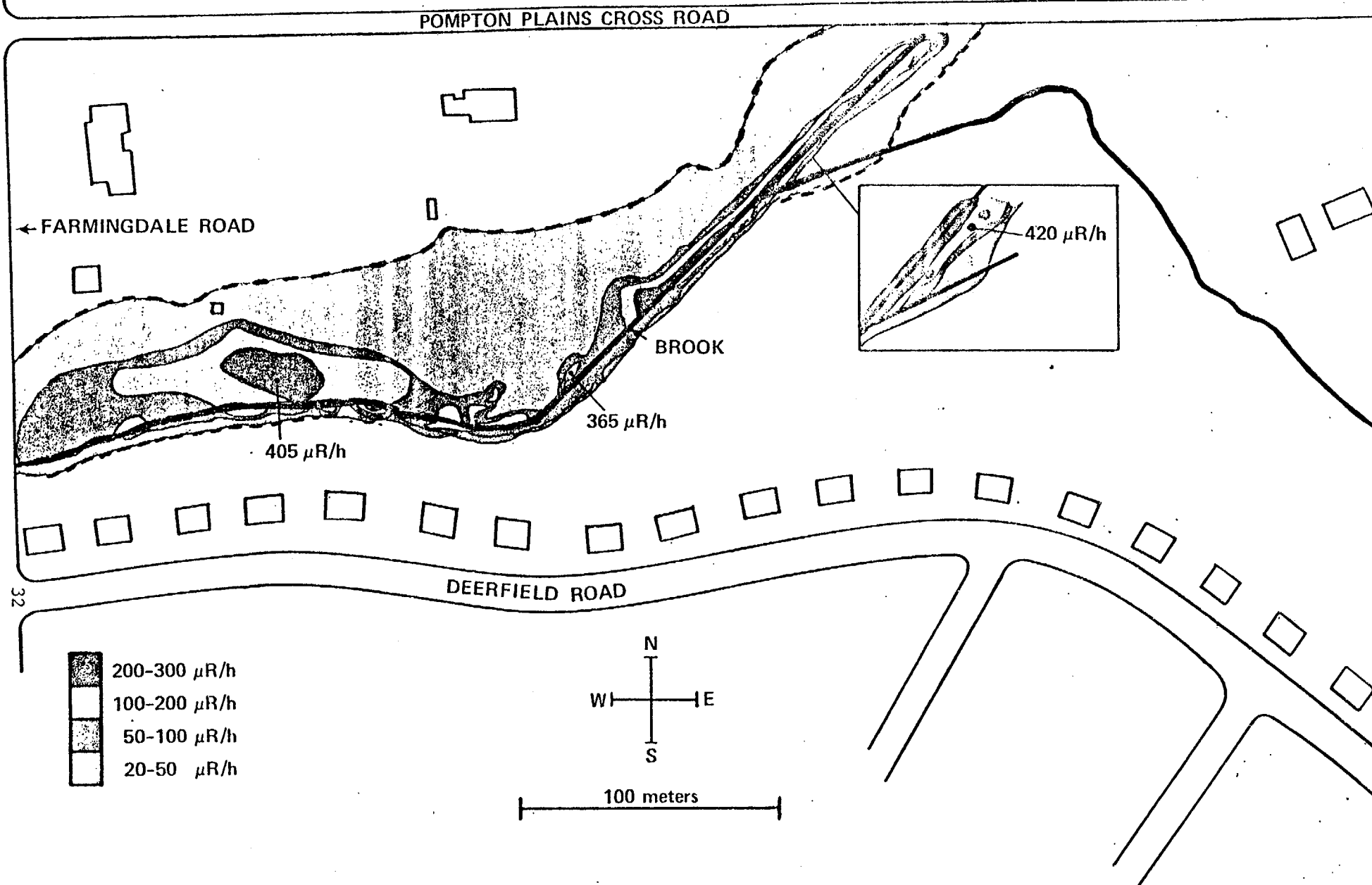


FIGURE 15. Surface Exposure Rates ($\mu\text{R/h}$) Along Sheffield Brook, East of Farmingdale Road.

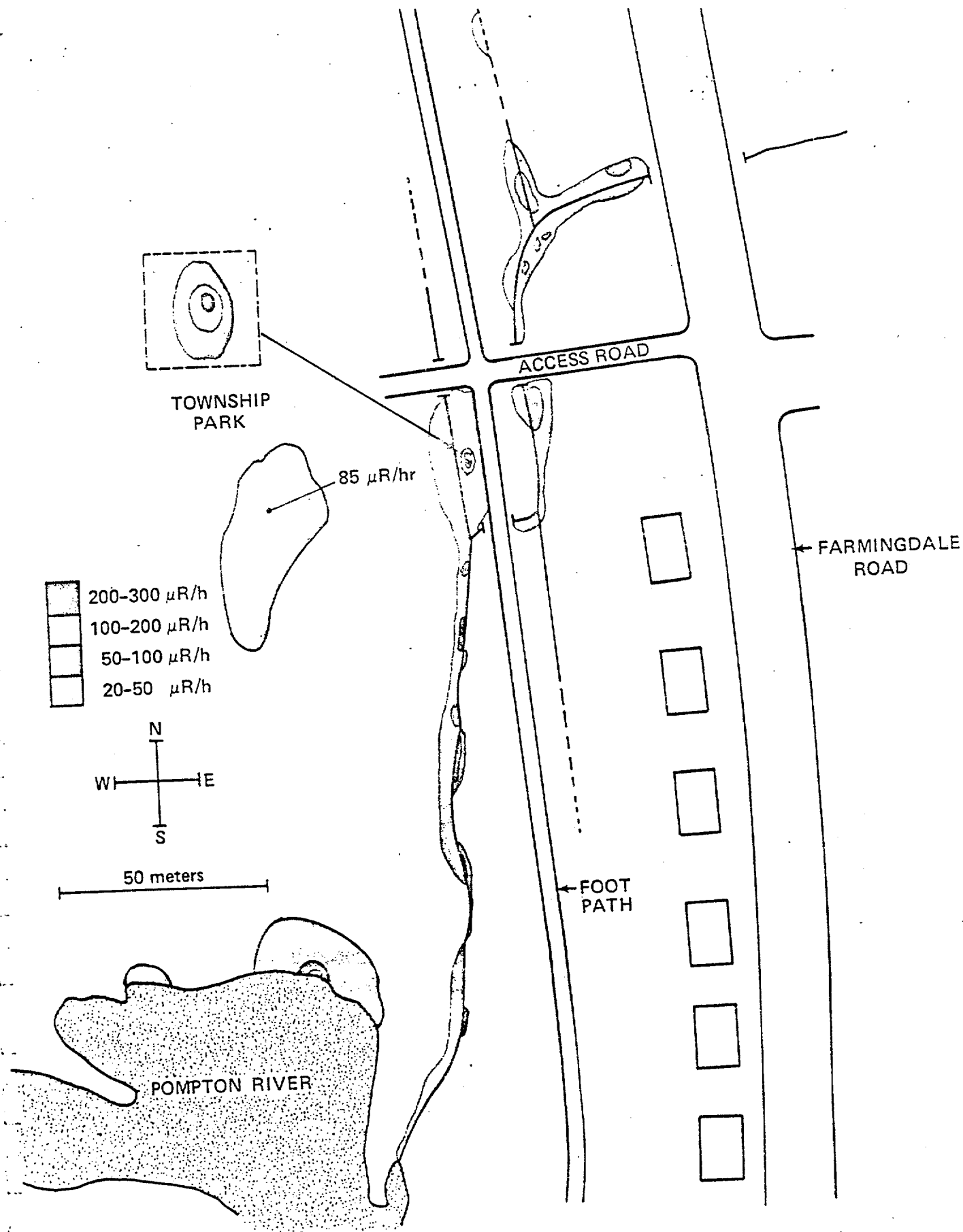


FIGURE 16. Surface Exposure Rates ($\mu\text{R/h}$) Along Sheffield Brook, West of Farmingdale Road.

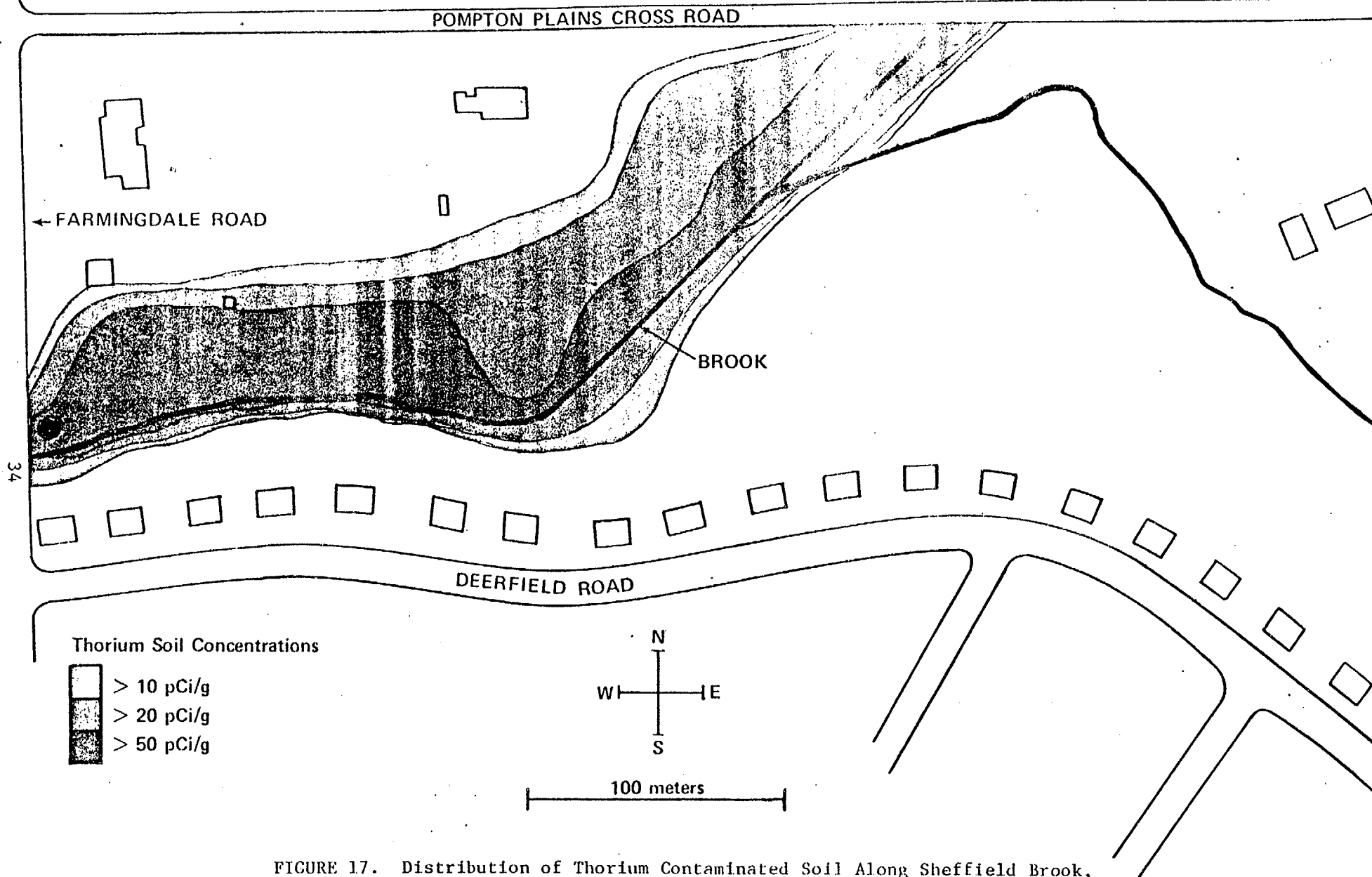


FIGURE 17. Distribution of Thorium Contaminated Soil Along Sheffield Brook, East of Farmingdale Road.

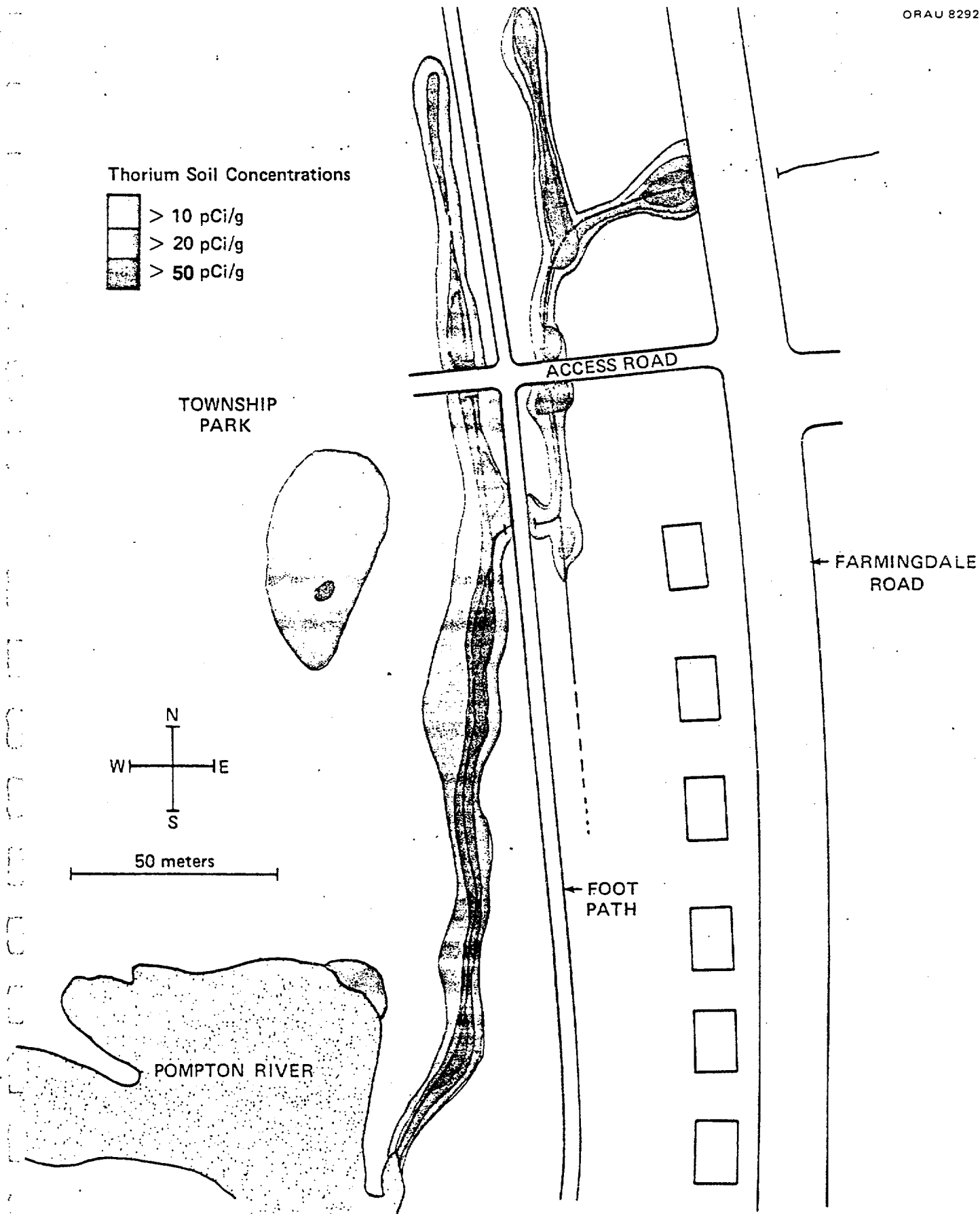


FIGURE 18. Distribution of Thorium Contaminated Soil Along Sheffield Brook, West of Farmingdale Road.

TABLE 1
RADIONUCLIDE CONCENTRATIONS IN BASELINE SOIL,
VEGETATION, AND WATER SAMPLES

Sample Location ^a	Depth (cm)	Radionuclide Concentrations (pCi/g)			
		Ra-228 ^b	Th-228	Ra-226	U-238
<u>Soil:</u>					
B1 - P.V. Park	surface	0.51 ± 0.23 ^c	0.58 ± 0.27	0.47 ± 0.15	<MDA ^d
	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 - 1.36	0.54 - 1.60	0.37 - 1.34	"
<u>Vegetation:</u>					
B1 - P.V. Park		<0.10	0.29 ± 0.13	<0.06	"
B2 - McDonald Park		0.39 ± 0.18	0.31 ± 0.14	0.21 ± 0.15	"

TABLE 1, cont.

RADIONUCLIDE CONCENTRATIONS IN BASELINE SOIL,
VEGETATION, AND WATER SAMPLES

Sample Location ^a	Gross Alpha	Gross Beta	Radionuclide Concentrations in Water (pCi/l or $\times 10^{-9}$ pCi/ml)							
			Th-228	Th-230	Th-232	Ra-226	Ra-228	U-234	U-235	U-238
B1 P.V. Park	0.95 \pm 1.20	<1.3	0.10 \pm 0.07	0.07 \pm 0.03	<0.05	0.09 \pm 0.08	<0.63	0.19 \pm 0.03	<0.05	0.13 \pm 0.03
B2 McDonald Park	<2.28	<3.6	<0.05	<0.05	<0.05	--- ^e	---	0.12 \pm 0.03	<0.05	0.09 \pm 0.02
B6 City Water	<1.56	<3.7	<1	<1	<1	<0.07	1.12 \pm 0.65	<1	<1	<1

^a Refer to Figure 10.^b Assumed to be in equilibrium with Th-232.^c Error is 2 σ based on counting statistics only.^d MDA values generally ranged between 2 to 5 pCi/g.^e Dash indicates analysis not performed.

TABLE 2

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

Location ^a	Distance from Brook or Stream (m)	Depth (cm)	Radionuclide Concentrations (pCi/g)			
			Ra-228 ^b	Th-228	Ra-226	U-238
1	0 (edge)	surface	0.84 ± 0.29^c	0.85 ± 0.22	0.56 ± 0.17	<MDA ^d
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	11.0 ± 0.4
9	5	surface	18.4 ± 0.9	17.4 ± 0.8	1.47 ± 0.44	11.6 ± 0.4
10	0	surface	1.74 ± 0.32	2.18 ± 0.29	0.87 ± 0.22	<MDA
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	10.3 ± 0.4
		60	5.16 ± 0.59	4.40 ± 0.43	0.75 ± 0.25	2.7 ± 0.3
		90	2.14 ± 0.42	2.05 ± 0.31	0.94 ± 0.22	<MDA
13	10	surface	52.6 ± 1.5	51.5 ± 1.3	4.92 ± 0.68	20.1 ± 0.4
14	0	surface	71.4 ± 1.7	69.9 ± 1.6	5.34 ± 0.72	17.7 ± 0.4
15	0	surface	132 ± 2	132 ± 2	11.4 ± 1.1	27.6 ± 0.5
16	5	surface	116 ± 2	113 ± 2	7.49 ± 0.94	32.9 ± 0.5
17	10	surface	29.6 ± 1.9	26.9 ± 1.5	1.42 ± 0.68	9.42 ± 0.41
		30	12.4 ± 0.9	12.2 ± 0.7	1.43 ± 0.34	<MDA
		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 SOIL SAMPLES

Location	Distance from Brook or Stream (m)	Depth (cm)	Radionuclide Concentrations (pCi/g)			
			Ra-228	Th-228	Ra-226	U-238
18	5	surface	153 \pm 3	144 \pm 3	8.25 \pm 1.12	39.1 \pm 0.5
19	0	surface	89.0 \pm 2.0	83.1 \pm 1.9	5.00 \pm 0.90	21.5 \pm 0.4
20	0	surface	4.78 \pm 0.53	4.77 \pm 0.48	0.81 \pm 0.32	<MHA
21	10	surface	0.84 \pm 0.36	0.65 \pm 0.24	0.53 \pm 0.20	"
22	50	surface	1.05 \pm 0.39	1.47 \pm 0.47	1.36 \pm 0.28	"
23	100	surface	1.24 \pm 0.44	1.36 \pm 0.38	0.81 \pm 0.32	"
24	10	surface	5.49 \pm 0.57	5.82 \pm 0.55	0.99 \pm 0.30	"
25	0	surface	1.64 \pm 0.34	2.18 \pm 0.31	0.55 \pm 0.18	"
26	0	surface	3.38 \pm 0.55	3.69 \pm 0.44	0.77 \pm 0.25	"
27	5	surface	13.9 \pm 1.1	13.6 \pm 1.0	1.74 \pm 0.49	"
28	5	surface	18.7 \pm 1.2	18.9 \pm 0.9	1.89 \pm 0.41	"
29	0	surface	12.7 \pm 0.8	13.2 \pm 0.7	1.38 \pm 0.36	"
30	0	surface	4.45 \pm 0.53	5.00 \pm 0.52	0.78 \pm 0.27	"
31	5	surface	8.94 \pm 0.99	8.91 \pm 0.92	1.58 \pm 0.46	"
		30	6.76 \pm 0.67	5.93 \pm 0.59	1.94 \pm 0.33	"
		60	1.29 \pm 0.40	1.21 \pm 0.25	0.69 \pm 0.19	"
		90	1.53 \pm 1.21	1.33 \pm 0.29	0.69 \pm 0.18	"
32	10	surface	6.99 \pm 1.06	6.95 \pm 0.74	1.10 \pm 0.40	"
33	50	surface	4.86 \pm 1.18	3.98 \pm 1.17	1.23 \pm 0.58	"
		30	0.97 \pm 6.39	1.18 \pm 0.29	0.94 \pm 0.23	"
		60	1.07 \pm 0.29	1.06 \pm 0.24	0.85 \pm 0.17	"
		90	0.91 \pm 0.25	0.93 \pm 0.22	0.76 \pm 0.18	"
34	10	surface	36.9 \pm 1.2	32.4 \pm 1.2	1.92 \pm 0.55	14.2 \pm 0.4
35	0	surface	40.2 \pm 1.5	34.4 \pm 1.2	2.67 \pm 0.60	"
36	0	surface	18.6 \pm 1.1	16.5 \pm 0.9	1.29 \pm 0.44	"

TABLE 2, cont.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

Location	Distance from Brook or Stream (m)	Depth (cm)	Radionuclide Concentrations (pCi/g)			
			Ra-228	Th-228	Ra-226	U-238
37	5	surface	1.50 \pm 0.41	1.48 \pm 0.36	1.00 \pm 0.21	<HDA
38	5	surface	34.4 \pm 1.8	27.7 \pm 1.3	1.68 \pm 0.58	"
		30	102 \pm 2	88.4 \pm 2.0	6.38 \pm 0.96	26.9 \pm 0.5
		60	17.8 \pm 1.1	15.8 \pm 0.9	1.83 \pm 0.40	5.92 \pm 0.37
		90	5.79 \pm 0.88	7.98 \pm 0.75	0.64 \pm 0.38	<HDA
39	0	surface	20.8 \pm 1.3	19.4 \pm 1.0	1.49 \pm 0.52	"
40	0	surface	2.31 \pm 0.44	2.43 \pm 0.38	0.74 \pm 0.22	"
41	10	surface	1.31 \pm 0.30	1.09 \pm 0.30	0.94 \pm 0.22	"
42	30	surface	29.5 \pm 1.6	29.8 \pm 1.4	2.18 \pm 0.66	14.2 \pm 0.5
		30	1.22 \pm 0.35	1.25 \pm 0.27	0.72 \pm 0.18	<HDA
		60	1.03 \pm 0.24	0.98 \pm 0.22	0.61 \pm 0.19	"
		90	0.79 \pm 0.24	0.79 \pm 0.18	0.69 \pm 0.16	"
43	10	surface	84.3 \pm 2.7	71.7 \pm 2.2	2.79 \pm 0.90	58.0 \pm 0.8
		30	17.8 \pm 1.0	16.1 \pm 0.9	1.27 \pm 0.42	9.41 \pm 0.41
		60	7.06 \pm 0.65	13.6 \pm 0.6	0.92 \pm 0.28	5.99 \pm 0.38
		90	6.29 \pm 0.58	5.49 \pm 0.50	0.82 \pm 0.25	5.98 \pm 0.36
44	5	surface	573 \pm 7	472 \pm 5	7.87 \pm 2.42	247 \pm 2
45	0	surface	18.8 \pm 1.1	16.7 \pm 0.9	1.38 \pm 0.47	7.39 \pm 0.37
46	5	surface	1.41 \pm 0.33	1.31 \pm 0.30	0.86 \pm 0.18	<HDA
47	10	surface	143 \pm 3	87.3 \pm 2.6	3.40 \pm 1.14	"
48	0	surface	24.8 \pm 1.4	23.2 \pm 2.4	1.71 \pm 0.49	"
49	0	surface	21.8 \pm 1.2	16.5 \pm 0.9	1.37 \pm 0.48	"
50	5	surface	5.23 \pm 0.56	5.73 \pm 0.51	0.95 \pm 0.26	"
51	10	surface	1.04 \pm 0.30	1.18 \pm 0.26	0.61 \pm 0.21	"
		30	1.05 \pm 0.30	1.19 \pm 0.26	0.67 \pm 0.17	"
		60	0.90 \pm 0.27	0.93 \pm 0.24	0.58 \pm 0.16	"
		90	1.47 \pm 0.33	1.02 \pm 0.25	0.61 \pm 0.17	"
52	5	surface	1.00 \pm 0.28	1.16 \pm 0.28	0.62 \pm 0.19	"

TABLE 2, cont.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

Location	Distance from Brook or Stream (m)	Depth (cm)	Radionuclide Concentrations (pCi/g)			
			Ra-228	Th-228	Ra-226	U-238
53	0	surface	27.5 \pm 1.5	27.4 \pm 1.2	2.24 \pm 0.52	9.73 \pm 0.38
54	0	surface	30.5 \pm 1.5	28.9 \pm 1.2	1.62 \pm 0.52	10.9 \pm 0.4
55	10	surface	0.93 \pm 0.34	0.87 \pm 0.32	0.69 \pm 0.23	<MDA
56	10	surface	0.77 \pm 0.39	0.96 \pm 0.26	0.68 \pm 0.24	"
57	5	surface	0.78 \pm 0.21	0.93 \pm 0.26	0.70 \pm 0.19	"
		30	1.01 \pm 0.28	1.09 \pm 0.28	0.67 \pm 0.16	"
		60	0.62 \pm 0.25	0.70 \pm 0.25	0.65 \pm 0.16	"
		90	1.01 \pm 0.30	0.90 \pm 0.20	0.56 \pm 0.15	"
58	0	surface	50.1 \pm 2.2	48.2 \pm 1.8	2.56 \pm 0.73	"
59	0	surface	26.2 \pm 1.5	24.3 \pm 1.3	1.69 \pm 0.60	"
60	5	surface	1.51 \pm 0.37	1.70 \pm 0.31	0.87 \pm 0.22	"
61	5	surface	0.86 \pm 0.42	1.03 \pm 0.27	1.40 \pm 0.60	"
62	0	surface	3.16 \pm 0.43	3.01 \pm 0.41	0.66 \pm 0.29	"
63	0	surface	45.9 \pm 2.1	44.5 \pm 1.4	2.60 \pm 0.65	23.6 \pm 0.5
64	10	surface	0.97 \pm 0.39	0.93 \pm 0.25	0.76 \pm 0.20	<MDA
65	10	surface	0.79 \pm 0.49	1.04 \pm 0.38	0.76 \pm 0.24	"
		30	0.98 \pm 0.29	0.92 \pm 0.21	0.11 \pm 0.14	"
		60	0.84 \pm 0.33	0.99 \pm 0.26	0.57 \pm 0.25	"
		90	1.02 \pm 0.30	0.94 \pm 0.22	0.67 \pm 0.17	"
66	5	surface	0.94 \pm 0.29	1.03 \pm 0.29	0.74 \pm 0.16	"
67	0	surface	56.0 \pm 2.3	43.1 \pm 1.8	2.42 \pm 0.80	29.0 \pm 0.5
68	0	surface	44.2 \pm 2.1	33.1 \pm 0.8	2.53 \pm 0.74	17.1 \pm 0.5
69	5	surface	0.88 \pm 0.40	1.06 \pm 0.23	0.64 \pm 0.18	<MDA
70	10	surface	1.20 \pm 0.35	0.98 \pm 0.28	0.95 \pm 0.21	"
71	5	surface	1.03 \pm 0.43	2.56 \pm 0.23	0.15 \pm 0.19	"

TABLE 2, cont.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

Location	Distance from Brook or Stream (m)	Depth (cm)	Radionuclide Concentrations (pCi/g)			
			Ra-228	Th-228	Ra-226	U-238
72	0	surface	20.2 \pm 1.0	22.7 \pm 0.90	1.39 \pm 0.48	11.4 \pm 0.4
73	0	surface	18.4 \pm 1.3	15.6 \pm 1.1	1.20 \pm 0.53	6.96 \pm 0.39
74	5	surface	7.23 \pm 0.83	5.85 \pm 1.21	0.47 \pm 0.35	<MDA
75	10	surface	1.44 \pm 0.30	1.59 \pm 0.67	0.87 \pm 0.48	"
76	10	surface	150 \pm 3	133 \pm 3	7.91 \pm 1.31	"
		30	66.2 \pm 1.9	58.5 \pm 1.6	3.72 \pm 0.74	"
		60	13.5 \pm 0.8	13.9 \pm 0.66	1.45 \pm 0.33	"
		90	8.17 \pm 0.67	8.14 \pm 0.60	1.19 \pm 0.34	"
77	5	surface	38.6 \pm 1.7	34.7 \pm 1.3	2.85 \pm 0.64	"
78	0	surface	12.5 \pm 0.9	10.4 \pm 0.7	1.22 \pm 0.33	"
79	0	surface	7.01 \pm 0.63	5.61 \pm 0.57	0.89 \pm 0.28	"
80	5	surface	1.36 \pm 0.31	1.35 \pm 0.24	0.65 \pm 0.18	"
81	0	surface	5.10 \pm 0.74	4.75 \pm 0.64	1.01 \pm 0.38	"
82	0	surface	9.96 \pm 0.92	10.3 \pm 0.8	1.13 \pm 0.39	5.99 \pm 0.46
83	10	surface	5.55 \pm 0.67	5.75 \pm 0.64	0.83 \pm 0.34	<MDA
84	0	surface	6.43 \pm 0.67	6.32 \pm 0.61	1.23 \pm 0.31	"
85	0	surface	30.6 \pm 1.5	31.5 \pm 1.4	2.82 \pm 0.69	14.6 \pm 0.4
86	5	surface	7.01 \pm 0.74	6.68 \pm 0.33	1.09 \pm 0.34	<MDA
87	10	surface	1.12 \pm 0.51	1.06 \pm 0.27	0.88 \pm 0.23	"
		30	1.59 \pm 0.39	1.63 \pm 0.29	0.89 \pm 0.22	"
		60	0.85 \pm 0.24	0.92 \pm 0.23	0.57 \pm 0.14	"
		90	0.34 \pm 0.20	0.46 \pm 0.16	0.51 \pm 0.14	"
88	5	surface	8.57 \pm 0.93	7.38 \pm 0.71	1.09 \pm 0.41	"
89	0	surface	1.85 \pm 0.52	1.47 \pm 0.38	1.01 \pm 0.25	"

TABLE 2, cont.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

Location	Distance from Brook or Stream (m)	Depth (cm)	Radionuclide Concentrations (pCi/g)			
			Ra-228	Th-228	Ra-226	U-238
90	0	surface	10.6 \pm 1.0	10.3 \pm 0.8	1.07 \pm 0.45	<MDA
91	5	surface	7.33 \pm 0.83	7.57 \pm 0.66	1.41 \pm 0.38	"
92	10	surface	4.33 \pm 0.67	3.74 \pm 0.58	0.83 \pm 0.31	"
93	0	surface	7.61 \pm 0.43	6.52 \pm 0.65	0.92 \pm 0.31	"
94	0	surface	2.20 \pm 0.54	1.74 \pm 0.37	1.09 \pm 0.26	"
95	5	surface	3.55 \pm 0.66	3.85 \pm 0.51	0.76 \pm 0.27	"
96	20	surface	2.76 \pm 0.40	2.68 \pm 0.33	0.62 \pm 0.22	"
97	0	surface	5.60 \pm 0.37	4.36 \pm 0.38	0.59 \pm 0.21	"
98	0	surface	0.60 \pm 0.34	0.66 \pm 0.20	0.54 \pm 0.16	"
99	0	surface	1.04 \pm 0.36	1.09 \pm 0.26	0.72 \pm 0.11	"
100	0	surface	0.71 \pm 0.30	0.97 \pm 0.24	0.83 \pm 0.19	"
101	8	surface	91.4 \pm 3.2 ^c	86.5 \pm 2.6	3.38 \pm 1.10	24.7 \pm 0.5
		30	182 \pm 4	163 \pm 4	9.61 \pm 1.63	<MDA
		60	44 \pm 2	41.9 \pm 1.9	3.43 \pm 0.88	19.7 \pm 0.5
		90	31.2 \pm 1.8	27.8 \pm 1.5	1.81 \pm 0.78	11.3 \pm 0.4
102	3	surface	32.4 \pm 1.6	32.3 \pm 1.4	2.19 \pm 0.63	24.0 \pm 0.4
		30	50.2 \pm 2.2	44.1 \pm 1.8	2.59 \pm 0.88	19.1 \pm 0.4
		60	41.2 \pm 1.9	41.8 \pm 1.6	3.04 \pm 0.72	24.4 \pm 0.4
		90	51.3 \pm 2.1	50.8 \pm 1.9	2.73 \pm 0.82	23.1 \pm 0.4
103	4	surface	275 \pm 6	201 \pm 4	13.6 \pm 2.3	38.6 \pm 0.6
		30	102 \pm 3	98.6 \pm 2.9	7.16 \pm 1.40	28.8 \pm 0.5
		60	87.8 \pm 2.9	64.0 \pm 2.2	4.08 \pm 1.00	14.8 \pm 0.4
		90	30.9 \pm 1.9	29.4 \pm 1.6	2.29 \pm 0.78	12.1 \pm 0.4
104	4	surface	191 \pm 5	187 \pm 5	9.95 \pm 2.18	42.9 \pm 0.7
105	5	surface	734 \pm 8	722 \pm 8	46.8 \pm 3.8	52.6 \pm 0.7

TABLE 2, cont.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

Location	Distance from Brook or Stream (m)	Depth (cm)	Radionuclide Concentrations (pCi/g)			
			Ra-228	Th-228	Ra-226	U-238
106	4	surface	235 ± 6	227 ± 5	12.6 ± 2.3	44.8 ± 0.6
107	4	surface	307 ± 7	287 ± 6	11.9 ± 2.6	65.7 ± 0.8
		30	37.9 ± 2.4	35.5 ± 1.8	3.26 ± 0.83	11.9 ± 0.4
		60	28.9 ± 18.1	28.0 ± 1.5	2.06 ± 0.78	8.6 ± 0.4
		90	9.93 ± 0.94	10.0 ± 0.7	1.47 ± 0.32	3.8 ± 0.4
108	7	surface	507 ± 8	479 ± 7	28.1 ± 3.4	47.1 ± 0.7
109	0	surface	9.11 ± 1.59	8.34 ± 1.02	1.21 ± 0.58	<MDA
110	3	surface	19.4 ± 1.5	16.9 ± 1.3	1.58 ± 0.64	5.29 ± 0.42
		30	75.5 ± 4.0	60.4 ± 3.1	5.07 ± 1.52	17.7 ± 0.5
		60	76.4 ± 3.3	62.6 ± 2.9	3.17 ± 0.99	20.2 ± 0.6
		90	6.06 ± 0.86	4.44 ± 0.76	0.71 ± 0.42	<MDA
111	3	surface	19.1 ± 2.3	18.0 ± 1.9	1.31 ± 0.94	"
112	5	surface	345 ± 4	310 ± 4	20.9 ± 1.7	76.7 ± 0.9
		15	247 ± 5	230 ± 5	24.0 ± 2.4	42.9 ± 0.7
		30	273 ± 5	260 ± 5	18.3 ± 2.3	48.7 ± 0.7
		60	289 ± 5	261 ± 5	24.0 ± 2.5	<MDA
		90	151 ± 4	139 ± 3	10.9 ± 1.6	29.0 ± 0.6
113	0	surface	23.7 ± 1.7	21.7 ± 1.5	1.03 ± 0.65	8.36 ± 0.44
		30	152 ± 3	144 ± 3	6.88 ± 1.14	48.4 ± 0.8
		60	57.7 ± 1.6	53.0 ± 1.5	2.71 ± 0.67	21.0 ± 0.6
		90	136 ± 2	130 ± 2	7.49 ± 1.06	48.6 ± 0.7
114	5	surface	163 ± 2	139 ± 1	3.88 ± 0.93	28.4 ± 0.6
115	5	surface	170 ± 2	152 ± 4	9.46 ± 1.82	76.0 ± 0.9
		30	20.9 ± 0.9	19.0 ± 0.9	2.11 ± 0.41	7.89 ± 0.44
		60	7.28 ± 7.60	5.87 ± 0.61	1.24 ± 0.39	<MDA
116	0.5	surface	163 ± 6	111 ± 5	2.59 ± 1.69	66.0 ± 1.1
		30	13.3 ± 1.3	13.6 ± 1.1	1.13 ± 0.29	8.87 ± 0.45
		60	10.2 ± 0.9	6.88 ± 0.13	1.24 ± 0.38	<MDA
		90	2.97 ± 0.44	2.18 ± 0.39	0.62 ± 0.11	"

TABLE 2, cont.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

Location	Distance from Brook or Stream (m)	Depth (cm)	Radionuclide Concentrations (pCi/g)			
			Ra-228	Th-228	Ra-226	U-238
117	0	surface	90.8 \pm 3.8	79.6 \pm 3.2	3.94 \pm 0.70	52.7 \pm 0.8
		30	27.2 \pm 1.9	24.7 \pm 1.4	1.82 \pm 0.64	7.29 \pm 0.42
		60	8.11 \pm 0.69	6.58 \pm 0.57	1.09 \pm 0.35	<MHA
		90	4.84 \pm 0.49	4.00 \pm 0.43	0.80 \pm 2.40	2.62 \pm 0.37
118	15	surface	172 \pm 5	124 \pm 4	4.89 \pm 1.80	88.6 \pm 1.0
		30	13.4 \pm 0.8	10.5 \pm 0.6	1.43 \pm 0.35	8.56 \pm 0.45
		60	4.17 \pm 0.54	3.32 \pm 0.41	0.85 \pm 0.26	<MHA
		90	5.65 \pm 0.73	5.05 \pm 0.62	0.94 \pm 0.35	3.89 \pm 0.38
119	3	surface	56.1 \pm 2.74	43.6 \pm 2.0	2.33 \pm 0.88	25.0 \pm 0.7
120	0	surface	45.6 \pm 2.9	35.7 \pm 2.2	2.66 \pm 1.06	19.4 \pm 0.5
121	0	surface	10.3 \pm 0.8	10.4 \pm 0.6	1.19 \pm 0.34	<MHA
122	0	surface	57.1 \pm 1.7	43.1 \pm 1.6	1.92 \pm 0.66	35.5 \pm 0.6
123	0	surface	13.4 \pm 0.8	10.5 \pm 6.4	1.43 \pm 0.35	12.2 \pm 0.5
124	2	surface	31.3 \pm 1.8	23.2 \pm 1.4	2.23 \pm 0.69	14.8 \pm 0.5
125	0	surface	68.9 \pm 3.0	51.1 \pm 2.3	3.19 \pm 1.06	36.2 \pm 0.6
126	15	surface	126 \pm 3	112 \pm 2	3.97 \pm 0.98	70.7 \pm 0.8
		30	24.8 \pm 1.0	22.3 \pm 1.1	2.25 \pm 0.48	<MHA
		60	120 \pm 4	114 \pm 4	3.50 \pm 1.48	56.9 \pm 0.7
		90	8.08 \pm 0.93	8.14 \pm 0.67	1.25 \pm 0.42	4.59 \pm 0.42
127	75	surface	30.7 \pm 2.1	29.2 \pm 1.7	2.13 \pm 0.83	16.6 \pm 0.5
128	3	surface	44.7 \pm 2.1	40.9 \pm 1.8	2.29 \pm 0.82	23.5 \pm 0.7
129	0	surface	26.2 \pm 1.8	25.6 \pm 1.7	1.62 \pm 0.78	13.8 \pm 0.5
130	25	surface	9.08 \pm 0.72	5.56 \pm 0.63	0.93 \pm 0.27	<MHA
		30	24.1 \pm 1.9	21.8 \pm 1.4	1.69 \pm 0.69	13.6 \pm 0.5
		60	6.09 \pm 0.59	5.58 \pm 0.47	0.76 \pm 0.32	3.17 \pm 0.38
		90	0.90 \pm 0.26	0.75 \pm 0.17	0.42 \pm 0.16	<MHA
131	0	surface	105 \pm 3	90.4 \pm 3.1	6.05 \pm 1.46	21.3 \pm 0.5
132	0	surface	57.3 \pm 3.3	50.8 \pm 2.4	2.77 \pm 1.00	14.2 \pm 0.5

TABLE 2, cont.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

Location	Distance from Brook or Stream (m)	Depth (cm)	Radionuclide Concentrations (pCi/g)			
			Ra-228	Th-228	Ra-226	U-238
133	0	surface	17.9 \pm 1.0	15.3 \pm 0.8	1.07 \pm 0.41	10.5 \pm 0.4
134	0	surface	18.6 \pm 1.2	17.1 \pm 0.9	1.05 \pm 0.46	6.33 \pm 0.38
		30	5.25 \pm 0.50	4.65 \pm 0.43	0.64 \pm 0.23	2.41 \pm 0.37
		60	1.79 \pm 0.32	1.67 \pm 0.25	0.45 \pm 0.16	<MHA
		90	0.54 \pm 0.24	0.72 \pm 0.17	0.33 \pm 0.15	"
135	0	surface	126 \pm 2	119 \pm 2	4.41 \pm 1.02	27.5 \pm 0.6
136	0	surface	12.8 \pm 1.0	10.3 \pm 0.8	1.29 \pm 0.39	7.45 \pm 0.41
137	100	surface	1.01 \pm 0.24	1.06 \pm 0.22	0.77 \pm 0.15	<MHA
138	20	surface	1.07 \pm 0.29	1.07 \pm 0.23	0.57 \pm 0.18	"
139	30	surface	1.18 \pm 0.32	1.06 \pm 0.27	0.57 \pm 0.20	"
		50	2.22 \pm 0.37	1.76 \pm 0.31	0.76 \pm 0.22	"
		100	1.54 \pm 0.37	1.33 \pm 0.30	0.64 \pm 0.24	"
140	60	surface	0.80 \pm 0.27	0.84 \pm 0.22	0.61 \pm 0.16	"
141	150	surface	0.80 \pm 0.30	1.04 \pm 0.24	0.78 \pm 0.19	"
142	150	surface	0.62 \pm 0.31	0.75 \pm 0.27	0.60 \pm 0.22	"
143	125	surface	0.80 \pm 0.28	0.85 \pm 0.22	0.55 \pm 0.21	0.63 \pm 0.30
144	60	surface	10.9 \pm 1.0	8.52 \pm 0.67	1.33 \pm 0.34	<MHA
		50	11.0 \pm 0.8	8.28 \pm 0.63	1.03 \pm 0.34	"
		100	3.56 \pm 0.42	2.30 \pm 0.32	0.81 \pm 0.21	"
145	30	surface	12.3 \pm 0.96	9.72 \pm 0.75	1.03 \pm 0.41	"
		50	1.86 \pm 0.34	1.44 \pm 1.14	0.73 \pm 0.22	"
		100	2.67 \pm 0.48	1.98 \pm 0.35	0.78 \pm 0.31	"
146	60	50	1.08 \pm 0.32	0.98 \pm 0.20	0.70 \pm 0.15	"
		100	0.98 \pm 0.28	0.92 \pm 0.23	0.73 \pm 0.20	"
147	30	surface	13.6 \pm 0.96	9.09 \pm 0.79	1.09 \pm 0.35	6.51 \pm 0.40
		50	4.44 \pm 0.44	2.82 \pm 0.41	0.49 \pm 0.21	<MHA
		100	2.00 \pm 0.38	1.28 \pm 0.30	0.77 \pm 0.24	"

TABLE 2, cont.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

Location	Distance from Brook or Stream (m)	Depth (cm)	Radionuclide Concentrations (pCi/g)			
			Ra-228	Th-228	Ra-226	U-238
148	60	surface	1.93 \pm 0.37	1.65 \pm 0.31	0.62 \pm 0.19	"
		50	0.68 \pm 0.23	0.85 \pm 0.20	0.57 \pm 0.14	"
		100	0.74 \pm 0.26	0.85 \pm 0.21	0.56 \pm 0.14	"
149	30	surface	37.0 \pm 1.9	33.5 \pm 1.7	2.52 \pm 0.71	"
		50	1.33 \pm 0.40	1.49 \pm 0.36	0.66 \pm 0.21	"
		100	7.81 \pm 0.71	7.57 \pm 0.61	0.92 \pm 0.30	"
150	60	surface	1.77 \pm 0.43	1.62 \pm 0.34	0.70 \pm 0.20	"
		50	0.94 \pm 0.16	0.79 \pm 0.25	0.70 \pm 0.20	"
151	50	surface	9.89 \pm 0.90	8.26 \pm 0.72	0.61 \pm 0.34	"
		50	0.88 \pm 0.29	0.74 \pm 0.18	0.49 \pm 0.14	"
		100	1.23 \pm 0.30	0.96 \pm 0.28	0.44 \pm 0.22	"
152	30	surface	66.5 \pm 0.3	57.5 \pm 2.1	3.06 \pm 0.93	38.8 \pm 0.7
		50	8.41 \pm 0.70	6.53 \pm 0.64	0.73 \pm 0.34	<MDA
		100	2.03 \pm 0.45	1.92 \pm 0.57	0.53 \pm 0.22	"
153	50	surface	41.4 \pm 1.6	32.4 \pm 1.2	1.49 \pm 0.58	18.3 \pm 0.5
154	100	surface	0.96 \pm 0.29	0.83 \pm 0.24	0.62 \pm 0.18	<MDA
155	50	surface	9.25 \pm 0.89	7.70 \pm 0.62	0.92 \pm 0.46	"

a Refer to Figures 4 and 5.

b Assumed to be in equilibrium with Th-232.

c Errors are 2 σ based on counting statistics only.

d MDA values generally ranged between 2 and 5 pCi/g.

TABLE 3

RADIONUCLIDE CONCENTRATIONS IN ADDITIONAL SOIL SAMPLES
FROM THE VICINITY OF SHEFFIELD BROOK

Location ^a	Depth (cm)	Radionuclide Concentrations (pCi/g)			
		Ra-228 ^b	Th-228	Ra-226	U-238
156 Kuehn Farm	surface	0.54 ± 0.23^c	0.65 ± 0.21	0.47 ± 0.17	<MDA
157 Kuehn Farm	surface	0.66 ± 0.22	0.77 ± 0.18	0.60 ± 0.20	"
158 Kuehn Farm	surface	0.75 ± 0.29	0.68 ± 0.26	0.67 ± 0.84	"
159 J. Baum Prop.	surface	0.68 ± 0.26	0.62 ± 0.22	0.63 ± 0.19	"
160 J. Baum Prop.	surface	0.66 ± 0.32	0.78 ± 0.21	0.74 ± 0.17	"
	30	0.70 ± 0.26	0.88 ± 0.20	0.63 ± 0.14	"
	60	1.00 ± 0.26	0.96 ± 0.24	0.57 ± 0.18	"
	90	0.44 ± 0.36	0.61 ± 0.18	0.25 ± 0.15	"
161 J. Baum Prop.	surface	112 ± 4	113 ± 3	10.7 ± 1.5	44.8 ± 0.6

a Refer to Figure 6.

b Assumed to be in equilibrium with Th-232.

c Error is 2σ based on counting statistics.

TABLE 4
RADIONUCLIDE CONCENTRATIONS IN SEDIMENT SAMPLES

Location ^a	Radionuclide Concentrations (pCi/g)			
	Ra-228 ^b	Th-228	Ra-226	U-238
1	0.54 ± 0.36 ^c	0.57 ± 0.12	0.48 ± 0.10	<MDA ^d
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	4.24 ± 0.38
5	5.56 ± 0.57	5.39 ± 0.46	0.95 ± 0.24	<MDA
6	44.3 ± 2.1	42.7 ± 1.8	3.72 ± 0.90	11.1 ± 0.4
7	26.7 ± 1.9	24.5 ± 1.6	2.86 ± 0.80	10.4 ± 0.5
8	0.88 ± 0.26	0.75 ± 0.24	0.55 ± 0.14	<MDA
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	16.7 ± 0.4
15	7.07 ± 0.57	7.04 ± 0.48	0.90 ± 0.31	<MDA
16	61.0 ± 1.4	53.9 ± 1.3	4.16 ± 0.61	13.0 ± 0.4
17	4.44 ± 0.41	3.69 ± 0.34	0.58 ± 0.19	<MDA
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	1.79 ± 0.30
20	32.0 ± 1.31	25.1 ± 1.0	1.99 ± 0.49	20.1 ± 0.5
21	6.06 ± 0.51	5.75 ± 0.43	0.76 ± 0.21	<MDA
22	16.4 ± 0.9	17.6 ± 0.8	0.67 ± 0.41	7.57 ± 0.37
23	9.13 ± 0.63	7.31 ± 0.49	0.70 ± 0.25	3.24 ± 0.31
24	21.2 ± 1.1	19.5 ± 1.0	1.15 ± 0.43	<MDA
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	6.61 ± 0.35
27	8.26 ± 0.65	8.48 ± 0.54	0.68 ± 0.20	<MDA
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	3.58 ± 0.33
31	17.5 ± 1.1	17.2 ± 0.89	1.17 ± 0.42	<MDA
32	8.91 ± 0.68	9.83 ± 0.61	0.98 ± 0.38	6.02 ± 0.39
33	6.14 ± 0.53	6.26 ± 0.49	0.84 ± 0.24	<MDA
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	U-238
44	1.23 ± 0.38	1.38 ± 0.28	0.48 ± 0.20	<MDA
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 6, 7, 8, and 9.

^b Assumed to be in equilibrium with Th-232.

^c Error is 2σ based on counting statistics only.

^d MDA values generally ranged between 2 and 5 pCi/g.

TABLE 5

RADIONUCLIDE CONCENTRATIONS IN WATER SAMPLES

Sample Location ^a	Gross Alpha	Gross Beta	Radionuclide Concentrations (pCi/l or 10 ⁻⁹ pCi/ml)							
			Th-228	Th-230	Th-232	Ra-226	Ra-228	U-234	U-235	U-238
<u>Stream, Brook, River</u>										
1 Drainage Stream	4.8 ± 1.8 ^b	2.1 ± 1.9	<1.0	<1.0	<1.0	<0.07	<0.63	<1.0	<1.0	1.1 ± 0.8
2 Sheffield Brook	6.5 ± 1.7	2.5 ± 1.9	<1.0	1.7 ± 0.6	<1.0	0.20 ± 0.23	<0.63	<1.0	<1.0	1.1 ± 0.6
3 Sheffield Brook	<2.2	<3.6	<1.0	<1.0	<1.0	---	---	<1.0	<1.0	1.0 ± 0.7
4 Pompton River, 500 m upstream	1.1 ± 1.4	<1.3	0.09 ± 0.07	<0.05	0.10 ± 0.34	0.10 ± 0.10	<0.63	0.10 ± 0.02	<0.05	0.13 ± 0.02
5 Pompton River, 100 m upstream	<0.7	<1.3	<1.0	<1.0	<1.0	<0.07	<0.63	<1.0	<1.0	<1.0
6 Pompton River, 100 m downstream	39 ± 9	877 ± 32	<0.05	0.06 ± 0.03	<0.05	---	---	<0.05	<0.05	0.06 ± 0.02
^d Pompton River 100 m downstream	0.9 ± 1.0	1.6 ± 1.6	---	---	---	---	---	---	---	---
7 Pompton River, 500 m downstream	0.8 ± 1.1	2.9 ± 1.9	<1.0	<1.0	<1.0	<0.07	<0.63	<1.0	<1.0	<1.0
<u>Storm Sewer</u>										
8	29 ± 4	10.4 ± 2.3	0.32 ± 0.07	0.08 ± 0.02	0.06 ± 0.02	0.12 ± 0.11	3.25 ± 0.84	0.76 ± 0.04	<0.05	0.79 ± 0.06
9	19 ± 8	8.8 ± 5.3	<0.05	<0.05	<0.05	0.18 ± 0.11	<0.63	0.19 ± 0.03	<0.05	0.11 ± 0.02
10	12 ± 6	4.2 ± 5.7	0.25 ± 0.09	<0.05	<0.05	0.08 ± 0.09	<0.63	1.02 ± 0.07	0.05 ± 0.01	0.98 ± 0.07
11	<2.8	6.6 ± 6.0	0.55 ± 0.08	0.14 ± 0.03	0.06 ± 0.03	0.08 ± 0.07	<0.63	0.52 ± 0.04	<0.05	0.56 ± 0.04
12	1.6 ± 1.3	8.4 ± 2.1	<0.05	<0.05	<0.05	0.25 ± 0.10	<0.63	0.23 ± 0.03	<0.05	0.21 ± 0.03
13	<2.3	<3.7	0.11 ± 0.10	<0.05	0.23 ± 0.11	<0.07	2.16 ± 0.59	0.19 ± 0.06	<0.05	0.34 ± 0.07

^a Refer to Figures 6 and 9.^b Error is 2σ based on counting statistics only.^c Dash indicates analysis not performed.^d Resampled 7/26/82 due to questionable gross alpha and gross beta concentrations in initial sample.

TABLE 6

RADIONUCLIDE CONCENTRATIONS IN ADDITIONAL
WATER SAMPLES FROM THE VICINITY OF SHEFFIELD BROOK

Sample location ^a	Radionuclide Concentrations (pCi/l or $\times 10^{-9}$ pCi/ml)									
	Gross Alpha	Gross Beta	Th-228	Th-230	Th-232	Ra-226	Ra-228	U-234	U-235	U-238
14 Surface Water Kuehn Farm	3.5 ± 4.0	4.9 ± 5.6^b	<1	<1	<1	<0.07	<0.63	<1	<1	<1
15 Surface Water Kuehn Farm	<2.3	<3.6	<0.05	<0.05	<0.05	2.17 ± 0.02	<0.63	0.19 ± 0.03	<0.05	0.13 ± 0.03
16 Well Water Kuehn Farm	<2.8	<3.7	<1	<1	<1	<0.07	3.07 ± 2.06	<1	<1	<1
17 Well Water Kuehn Farm	1.6 ± 1.4	<1.3	<1	<1	<1	<0.07	<0.63	<1	<1	<1
18 Well Water Wendt Lane	<2.2	14.7 ± 6.5	<1	<1	<1	<0.07	<0.63	<1	<1	<1
19 Well water Wendt Lane	<2.2	<3.6	<1	<1	<1	<0.07	<0.63	<1	<1	<1
20 Well Water Deerfield Rd.	6.8 ± 5.8	<3.8	<1	<1	<1	<0.07	<0.63	<1	<1	<1
21 Well Water Farmingdale Rd. 12	± 6	60 ± 10	<1	<1	<1	0.42 ± 0.04	<0.63	<1	<1	<1
21d Well Water Farmingdale Rd.	1.3 ± 2.3	<2.3	--	--	--	--	--	--	--	--
21d Well Water Farmingdale Rd.	3.7 ± 2.8	3.1 ± 3.5	--	--	--	--	--	--	--	--
22 Well Water Black Oak Ridge Rd.	1.2 ± 1.1	1.3 ± 1.6	-- ^c	--	--	--	--	--	--	--

^a Sample location not indicated in Figures.

^b Errors are 2 σ based on counting statistics only.

^c Dash indicates analysis not performed.

^d Reanalyzed due to questionable gross alpha and gross beta concentrations.

TABLE 7

RADIONUCLIDE CONCENTRATIONS IN VEGETATION SAMPLES

Location ^a	Radionuclide Concentrations (pCi/g)				
	Ra-228	Th-228	Ra-226	U-235	U-238
1 Unwashed	2.04 ± 0.47 ^b	0.99 ± 0.21	0.34 ± 0.15	<MDA ^c	<MDA
Washed	0.31 ± 0.12	0.09 ± 0.11	0.04 ± 0.06	"	"
2 Unwashed	0.17 ± 0.23	0.28 ± 0.18	0.36 ± 0.15	"	"
3 Unwashed	12.8 ± 0.4	10.1 ± 0.3	0.71 ± 0.16	"	"
Washed	0.69 ± 0.61	0.15 ± 0.12	0.10 ± 0.10	"	"
4 Unwashed	6.96 ± 0.36	4.11 ± 0.24	0.44 ± 0.13	"	"
Washed	2.38 ± 2.06	0.28 ± 0.12	0.14 ± 0.19	"	"
5 Unwashed	1.87 ± 0.19	1.83 ± 0.16	0.39 ± 0.10	"	"
Washed	1.25 ± 0.16	0.89 ± 0.12	0.14 ± 0.07	"	"
6 Washed	0.37 ± 0.13	0.14 ± 0.12	0.08 ± 0.11	"	"
Kuehn Farm:					
Kale	<0.08	0.21 ± 0.12	0.10 ± 0.09	"	"
Zucchini	0.25 ± 0.12	0.14 ± 0.08	0.16 ± 0.07	"	"
Dill	<0.05	<0.03	0.04 ± 0.06	"	"

a Refer to Figure 6.

b Error is 2σ based on counting statistics only.

c MDA = minimum detectable activity

Uranium-235: 0.05 - 0.10 pCi/g

Uranium-238: 1.2 - 2.3 pCi/g

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5. Nuclear Regulatory Commission, Branch Technical Position, Disposal or On-Site Storage of Thorium or Uranium Wastes from Past Operations, Docket 81-30808, Federal Register, Oct. 23, 1981.
6. Title 40, Code of Federal Regulations, Part 141. Interim Primary Drinking Water Regulations. Federal Register, July 1976.

APPENDIX A

GLOSSARY OF TERMS

Glossary

Activation:	The process of making a material radioactive by bombardment with neutrons, protons, or other nuclear particles.
Activity:	Radioactivity, the spontaneous emission of radiation, generally alpha or beta particles, often accompanied by gamma rays, from the nuclei of an unstable nuclide. As a result of this emission, the radioactive material is converted (or decays) into a different nuclide (daughter), which may or may not be radioactive. Ultimately, as a result of one or more stages of radioactive decay, a stable (nonradioactive) nuclide is formed.
Aerial survey:	A search for sources of radiation by means of sensitive instruments mounted in a helicopter or airplane. Generally, the instrumentation records the intensity, location, and spectral analysis of the radiation.
Alpha particle:	A positively charged particle emitted by certain radioactive materials. It is made up of two neutrons and two protons bound together, and hence is identical with the nucleus of a helium atom. It is the least penetrating of the three common types of radiation (alpha, beta, gamma) emitted by radioactive material, and can be stopped by a sheet of paper.
Background radiation:	The radiation in man's natural environment, including cosmic rays and radiation from the naturally radioactive elements. It is also called natural radiation. The term may also mean radiation that is unrelated to a specific experiment. Levels vary, depending on location.
Baseline concentration:	The concentration of a given substance typically encountered in the area under consideration, i.e. the normal or naturally occurring level.
Beta particle:	An elementary particle emitted from a nucleus during radioactive decay, with a single electrical charge and a mass equal to 1/1837 that of a proton. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron.
Contamination:	Undesired radioactive materials that have been deposited on surfaces, are internally ingrained into structures or equipment, or that have been mixed with another material.

Curie: A special unit of activity. One curie equals 3.7×10^{10} nuclear disintegrations per second. Several fractions of the curie are in common usage:

- Millicurie - one thousandth of a curie. Abbreviated as mCi.
- Microcurie - one millionth of a curie. Abbreviated as μ Ci.
- Nanocurie - one billionth of a curie. Abbreviated as nCi.
- Picocurie - one trillionth of a curie. Abbreviated as pCi.

Daughter: The product of radioactive decay of a nuclide. (also see Parent).

Decay, radioactive: The spontaneous transformation of one nuclide into a different nuclide or into a different energy state of the same nuclide. The process results in a decrease, with time, of the number of original radioactive nuclides in a sample. It involves the emission from the nucleus of alpha particles, beta particles, or gamma rays; or the nuclear capture or ejection of orbital electrons; or fission. Also called radioactive disintegration.

Decontamination: Those activities employed to reduce the levels of contamination.

Dose: A measure of the quantity of radiation absorbed in a unit mass of a medium. The unit of dose is the rad.

Dose rate: The radiation dose delivered per unit time and measured, for example, in rads per hours.

Exposure: A measure of the ionization produced in air by x or gamma radiation. It is the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of the air in the volume element. The special unit of exposure is the roentgen.

Exposure rate: The radiation exposure per unit time. Measured, for example, in roentgens per hour.

Gamma radiation: High-energy, short-wave length electromagnetic radiation of nuclear origin (radioactive decay). Gamma rays are

the most penetrating of the three common types of radiation.

Half-life:	The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years.
Microrad (μ rad):	A submultiple of the rad, equal to one-millionth of a rad. (see rad).
Microroentgen (μ R):	A submultiple of the roentgen, equal to one-millionth of a roentgen. (see roentgen).
Millirem (mrem):	A submultiple of the rem, equal to one-thousandth of a rem. (see rem).
Natural uranium:	Uranium as found in nature, containing 0.7 percent of uranium-235, 99.3 percent of uranium-238. It is also called normal uranium.
Natural thorium:	Thorium as found in nature. Natural thorium contains equal activity level of thorium-232 and thorium-228.
Parent:	A radionuclide which disintegrates or decays to produce another nuclide which is also radioactive. This second radionuclide is known as the daughter product.
Picocurie (pCi):	One-trillionth (10^{-12}) of a curie.
Rad:	The unit of absorbed dose. The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. One rad equals 0.01 joules/kilogram of absorbing material.
Radiation:	Energetic nuclear particles including neutrons, alpha particles, beta particles, x-rays, and gamma rays (nuclear physics). Also includes electromagnetic waves (radiation) of any origin.
Radioactivity:	The property of certain nuclides of spontaneously emitting particles, or gamma radiation. Often shortened to "activity."
Radionuclide:	A general term applicable to any radioactive form of the elements, a radioactive nuclide.
Radium (Ra):	A radioactive metallic element with atomic number 88. As found in nature, the most common isotope has an atomic weight of 226. It occurs in minute quantities associated with uranium in pitchblende, carnotite, and other minerals; the uranium decays to radium in a series

of alpha and beta emissions. By virtue of being an alpha- and gamma-emitter, radium is used as a source of illuminescence and as a radiation source in medicine and radiography. The isotope of radium with an atomic weight of 228 is found in the thorium decay series.

Radon (Rn): The heaviest element of the noble gases, produced as a gaseous emanation from the radioactive decay of radium. Its atomic number is 86. All isotopes are radioactive. Rn-222 is an isotope with a half-life of 3.82 days.

Rare earths: A group of 15 chemically similar metallic elements, including elements 57 through 71 on the Periodic Table of the Elements, also known as the Lanthanide Series.

Rem: The unit of ionizing radiation that produces the same biological damage to man as a unit of absorbed dose (1 roentgen) of high voltage x-rays.

Roentgen (R): A unit of exposure to ionizing radiation. It is that amount of gamma or x-rays required to produce ions carrying one electrostatic unit of electrical charge (either positive or negative) in one cubic centimeter of dry air under standard conditions.

Secular Equilibrium: The state which prevails when the rate of formation of a radioactive material equals the material's rate of decay. Although, by theory, this condition is never completely achieved, it is essentially established in the thorium decay series as it occurs in nature.

Survey: An evaluation of the radiation hazards incidental to the production, use, or existence of radioactive materials or other sources of radiation under a specific set of conditions.

Thorium (Th): A naturally occurring radioactive element with atomic number 90 and, as found in nature, an atomic weight of approximately 232.

Thorium series: The series (sequence) of nuclides resulting from the radioactive decay of thorium-232. Many man-made nuclides decay into this sequence. The end product of the sequence in nature is lead-208.

Uranium (U): A radioactive element with the atomic number 92 and, as found in natural ores, an average atomic weight of approximately 238. The two principal natural isotopes are uranium-235 (0.7 percent of natural uranium) and uranium-238 (99.3 percent of natural uranium). Natural uranium also includes a minute amount of uranium-234.

Uranium series: The series (sequence) of nuclides resulting from the radioactive decay of uranium-238. The end product of the series is lead-206.

EXPLANATION OF SYMBOLS AND UNITS

Symbols	Unit	English Equivalents
cm	centimeter ($\times 10^{-2}$ meters)	0.394 inches
g	gram	0.032 ounces
h	hour	-----
kg	kilogram ($\times 10^3$ grams)	2.2 pounds
km	kilometer ($\times 10^3$ meters)	0.622 miles
l	liter	0.264 gallons
m	meter	3.28 feet
ml	milliliter ($\times 10^{-3}$ liters)	0.061 cubic in.
mrem	millirem ($\times 10^{-3}$ rem)	-----
pCi	picocurie ($\times 10^{-12}$ curies)	-----
Ra	Radium	-----
U	Uranium	-----
Th	Thorium	-----
μ Ci	microcurie ($\times 10^{-6}$ curies)	-----
μ rad	microrad ($\times 10^{-6}$ rads)	-----
μ R	microroentgen ($\times 10^{-6}$ roentgens)	-----

APPENDIX B

THORIUM AND URANIUM DECAY SERIES

THORIUM DECAY SERIES

Parent	Half-Life	Major Decay Products	Daughter
Thorium-232	14 billion years	alpha	Radium-228
Radium-228	5.8 years	beta	Actinium-228
Actinium-228	6.13 hours	beta, gamma	Thorium-228
Thorium-228	1.91 years	alpha	Radium-224
Radium-224	3.64 days	alpha	Radon-220
Radon-220	55 seconds	alpha	Polonium-216
Polonium-216	0.15 seconds	alpha	Lead-212
Lead-212	10.6 hour	beta, gamma	Bismuth-212
Bismuth-212	60.6 minutes	alpha (1/3)* beta (2/3)*	Thallium-208 Polonium-212
Thallium-208	3.1 minutes	beta, gamma	Lead-208
Polonium-212	0.0000003 seconds	alpha	Lead-208
Lead-208	stable	none	none

* Two decay modes are possible for Bismuth-212.

URANIUM DECAY SERIES

Parent	Half-life	Major Decay Products	Daughter
Uranium-238	4,500,000,000 yrs.	alpha	Thorium-234
Thorium-234	24 days	beta, gamma	Protactinium-234
Protactinium-234	1.2 minutes	beta, gamma	Uranium-234
Uranium-234	250,000 years	alpha	Thorium-230
Thorium-230	80,000 years	alpha	Radium-226
Radium-226	1,600 years	alpha	Radon-222
Radon-222	3.8 days	alpha	Polonium-218
Polonium-218	3 minutes	alpha	Lead-214
Lead-214	27 minutes	beta, gamma	Bismuth-214
Bismuth-214	20 minutes	beta, gamma	Polonium-214
Polonium-214	2/10,000 second	alpha	Lead-210
Lead-210	22 years	beta	Bismuth-210
Bismuth-210	5 days	beta	Polonium-210
Polonium-210	140 days	alpha	Lead-206
Lead-206	stable	none	none

APPENDIX C

MAJOR ANALYTICAL EQUIPMENT

APPENDIX C

Major Analytical Equipment

The display or description of a specific product is not to 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)

25 mg Californium-252 Source with
Flexo-Rabbit Pneumatic Transfer system
(Reactor Experiments, Inc., San Carlos, CA)

Multichannel Analyzer
Model TN-7200
(Tracor Northern, Middleton, WI)

APPENDIX D
ANALYTICAL PROCEDURES

APPENDIX D

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 ($\mu\text{R/h}$) using a factor of $520 \text{ cpm} = 1 \mu\text{R/h}$. 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 ($\mu\text{rad/h}$) 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 natural thorium source. The conversion factor determined was $1.0 \text{ cpm} = 1 \mu\text{rad/h}$.

Soil and Sediment Sample Analysis

Soil and sediment samples were sifted to remove rocks (the fraction removed constituted <5% of the total), 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 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 approximately equal concentrations of Th-232 and Th-228, confirming that the thorium series is in equilibrium in the off-site residues.

All soil and sediment samples were analyzed for U-238 and U-235 by gamma spectrometry. Samples with detectable levels of uranium were subsequently analyzed for U-238 by neutron activation. Approximately 19-20 g of soil were irradiated for 15 minutes in a neutron flux of 10^8 n/cm²/sec. After a one minute wait time, the U-239 peak (74.6 keV) was counted for 10 minutes and the U-238 concentration calculated.

Water Samples

Water samples were rough filtered through Whatman No. 2 filter paper. Remaining suspended solids were removed by a filtration through 0.45 μ m 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 and Gross Beta 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.

Radium-226/228 Analysis

Samples were analyzed for Ra-226 and 228 using the standard technique EPA 600/4-75-008 (Revised).

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.

APPENDIX E

EVALUATION OF RADIATION EXPOSURES
ALONG SHEFFIELD BROOK
WAYNE, NEW JERSEY

Appendix E

Evaluation of Radiation Exposures Along Sheffield Brook Wayne, New Jersey

The survey of Sheffield Brook indicates that the streambeds and bank soils of the brook and two drainage streams contain radioactive material in concentrations exceeding the normal background levels. Elevated concentrations of this material are also present on some of the adjacent properties.

The radionuclides present are from the thorium and uranium decay series. These are naturally occurring substances, believed to have been created when the earth was formed, and present today in small quantities throughout our environment. They occur in soil, air, water, food, etc., and are the sources of a portion of the background exposure each person receives daily. Soils in the United States typically have thorium (Th-228 and Th-232) and uranium (U-234 and U-238) levels of 2 pCi/g and 1.2 pCi/g, respectively.¹ Thorium concentrations in igneous rock are typically 2.6 pCi/g.² Uranium concentrations in Florida phosphate rock and Tennessee bituminous rock average 80 pCi/g and 30-50 pCi/g respectively. Radiation exposures arising from these radioactive substances in their natural state are not the result of man's activities and, to a large extent, can be controlled only by relocating to regions of lower background levels.

Thorium is the principal radioactive substance present along Sheffield Brook. It is present in its natural form with all daughter products in equilibrium (refer to Appendices A and B). Radionuclides from the uranium decay series are present in lower concentrations than the thorium, e.g. the average concentration of radium-226, one of the decay products in the uranium series, is less than 5% of the thorium levels. Evaluations of various exposure pathways for thorium have determined that the primary pathway is direct exposure to the gamma radiation associated with this decay series.^{3,4} Although additional exposures may be received through ingestion of contaminated food or water or through inhalation of airborne radioactive materials, contributions from the pathways are very small compared to that from direct radiation.

The National Council on Radiation Protection and Measurements has recommended a maximum annual whole-body dose equivalent of 500,000 microrem (μrem) per year to an individual in the general population.⁵ This is equivalent to a continuous level of approximately 57 microrem per hour ($\mu\text{rem/h}$). The maximum exposure level measured at one meter above the ground along Sheffield Brook is 270 microroentgens per hour ($\mu\text{R/h}$); the average exposure level is 49 $\mu\text{R/h}$. To calculate the annual exposure which might be received it is necessary to first estimate the amount of time that would be spent in the areas where these radiation levels occur. This is referred to as the "occupancy factor"; an occupancy factor of 10% - an average of 16.8 hours per week, 52 weeks per year - was selected for this purpose. It is felt that this is an overestimate of the occupancy time and will therefore lead to a conservative overestimate of the radiation exposure and potential health effects. If an individual were to spend 10% of his or her time in the maximum and average radiation levels at this site, the annual dose equivalent above background would be approximately 201,000 μrem and 31,400 μrem respectively. The latter value, based on the average exposure level, is more likely representative of the radiation an individual might receive at this site. This value can be compared with the annual natural background radiation of approximately 70,000 μrem which residents of the Wayne-Pompton Plains area receive from direct external exposures or the approximately 20,000 μrem per year received from the radionuclides (e.g. K-40) normally present in the human body. Also, for comparison, a typical chest x-ray (according to data from the Department of Health and Human Services) might yield an exposure of about 27,000 μR .

The primary health effect associated with radiation exposure is an increased risk of cancer. In this connection, an individual exposed continually for 70 years to the estimated average dose rate of 31,400 $\mu\text{rem}/\text{year}$ would receive a dose of approximately 2.2 rem over the entire period. Based on a lifetime risk estimate of 100 fatal cancers per million people exposed to 1 rem of radiation*, the estimated increased risk of fatal cancers from 2.2 rem of radiation exposure is 0.22 deaths per 1000 total deaths. This may be compared with the cancer death rate in Passaic County, according to the 1977 vital statistics (not age adjusted), of 222.3 cancer deaths per 1000 total deaths.

* Calculated from risk estimates provided in the 1980 National Academy of Sciences report, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," and the 1977 report by the U.S. Scientific Committee on Effects of Atomic Radiation.

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2. M. Eisenbud, Environmental Radioactivity. 2nd ed. Academic Press, New York (1973).
3. J.W. Healy et al., Interim Soil Limits for D & D Projects. Los Alamos Laboratory, Los Alamos, NM. LA-UR-79-1865 rev. (Sept. 1979).
4. Gorman S. Hill, Doses for Various Pathways to Man Based on Unit Concentrations of Radionuclides Pertinent to Decontamination and Decommissioning of Properties. Oak Ridge National Laboratory, Oak Ridge, TN. ORNL/OEPA-7 (March 1979).
5. National Council on Radiation Protection and Measurements, Basic Radiation Protection Criteria, NCRP Report 39 (1971).

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 offered 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 proffered 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-

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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 μ R/h (background levels) up to 420 μ R/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 μ R/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 μ R/h. According to DEP, this latter value is exceeded in an area greater than 18,000 m² 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 μ R/h above background. The levels along Sheffield Brook greatly exceed these levels. DEP estimates that a surface area of 18,000 m² 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 Tennessee (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

<u>Sample No.</u>	<u>Location Description</u>	<u>Gross Alpha (pCi/l)</u>	<u>Comments</u>
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

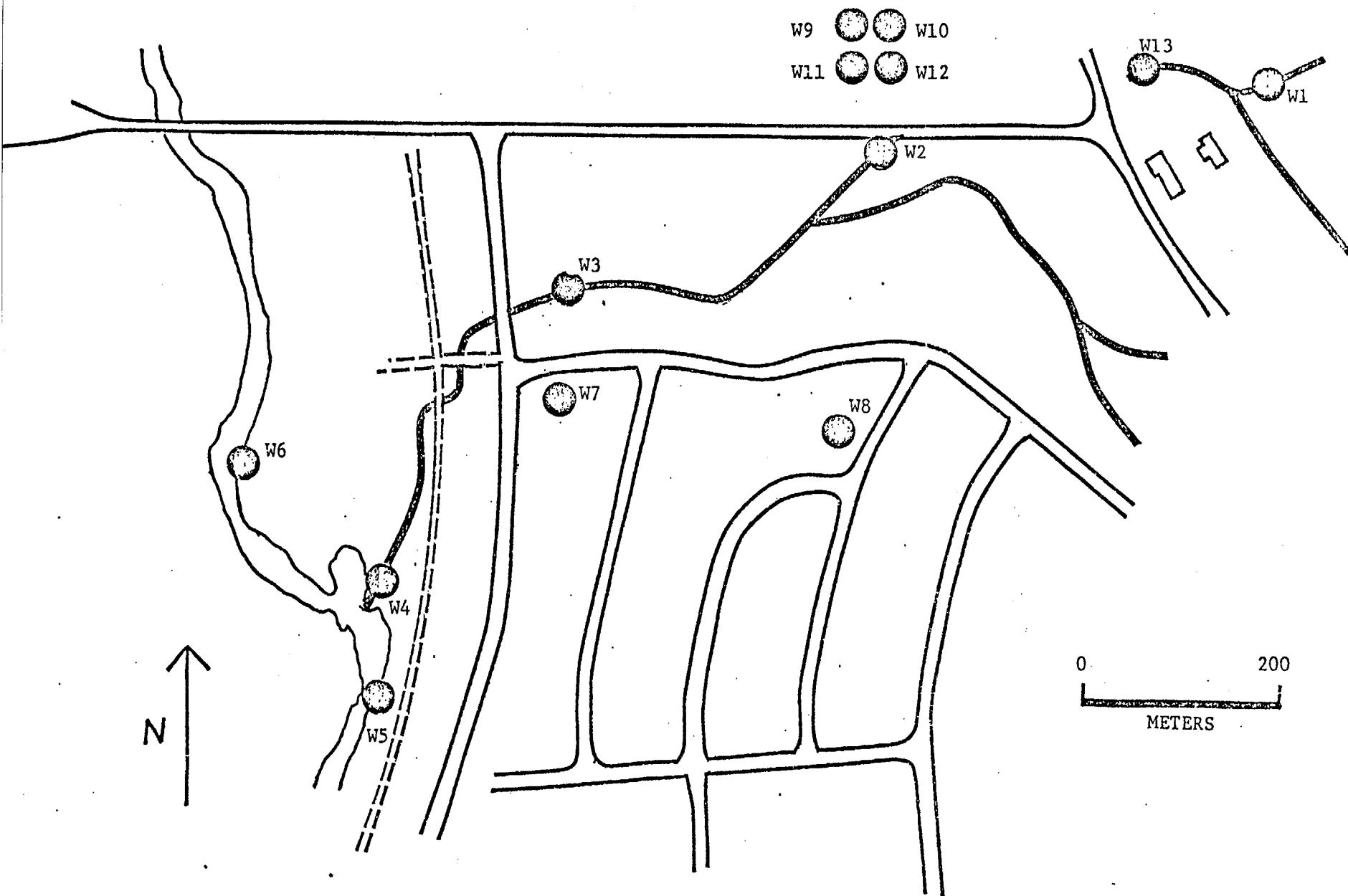


FIGURE 1: WATER SAMPLING LOCATIONS
From DEP radiological survey



Department of Energy
Washington, D.C. 20545

DEC 13 1982

Mr. John Kinneman, Chief
Materials Radiological
Protection Section
NRC - Region I
631 Park Avenue
King of Prussia, Pennsylvania 19406

Dear Mr. Kinneman:

As requested during our telephone conversation on December 8, 1982, I am enclosing a copy of the Wayne Township, New Jersey, aerial radiological survey report.

Sincerely,

A handwritten signature in dark ink, appearing to read "Arthur J. Whitman", written over a horizontal line.

Arthur J. Whitman
Public Safety Division
Office of Operational
Safety (EP-323)

Enclosure

ITEM # 285

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The Aerial Measuring Systems Program

By J. E. Jobst*

Abstract: EG&G, Inc., has developed for the Department of Energy (DOE) an Aerial Measuring Systems (AMS) program dedicated to environmental research at facilities of interest to DOE, the Nuclear Regulatory Commission (NRC), and other federal agencies. The AMS was originally created to measure nuclear radiation; the program scope has been broadened dramatically to include a wide variety of remote sensors: multispectral and mapping cameras, optical and infrared multispectral scanners, air-sampling systems, and meteorological sensors. The AMS maintains seven aircraft as survey platforms, both fixed-wing aircraft and helicopters. Photography, scanner imagery, and radiation data are processed in dedicated, modern laboratories and used for a broad range of environmental impact studies. A graphic overview system has been developed for effective presentation of all types of remotely sensed data obtained at a facility of interest.

The Aerial Measuring Systems (AMS) program has been developed by the Department of Energy (DOE) and its predecessors, the Atomic Energy Commission (AEC) and the Energy Research and Development Administration (ERDA), to ensure that all energy "programs and operations are conducted in a manner that will protect the public, ensure occupational safety and health, and preserve the environment in accordance with nationally accepted norms."¹

Much of the AMS expertise is the fruit of experience gained empirically—results from research and development in support of the Environmental Health and Safety Program of the Department of Energy. A primary goal of the Environmental Health and Safety Program is to conduct balanced health and safety research in methods to protect against potentially harmful effects of all energy systems—from raw materials to final energy use.

The AMS is a tool useful for both emergency nuclear safety problems and long-range environmental impact measurement, evaluation, and control. This article describes early systems development, the

present hardware and subsystems, the data analysis process, and the special overall nonnuclear environmental measurement capability and its relation to health and safety when unsuspected nuclear contamination arises.

SYSTEM DEVELOPMENT

Aerial measurements of surface radioactivity were made in the United States as early as 1948. Their original purpose was to determine the feasibility of airborne prospecting for radioactive ore deposits.² The U.S. Geological Survey (USGS) and the Oak Ridge National Laboratory (ORNL) cooperated with the Division of Biology and Medicine of the AEC in these early efforts.³ Experimental and theoretical studies led to the development of appropriate instrumentation. This equipment was used in 1950 to carry out the first systematic aerial survey of a large area (over 4100 km²). In the mid-1950s, a series of events spurred the development of this aerial radiological measuring system by the USGS and ORNL. These events included the United Kingdom Windscale reactor accident, the release of radioactive clouds from nuclear weapon tests in Nevada, and the emergence of commercial power reactors.

The Windscale accident involved a partial core meltdown and subsequent release of radioactive gases for several days. These gases and particulates blanketed a large area surrounding the Windscale facility and severely taxed the health physicists charged with monitoring the affected areas. No airborne capability existed in England at the time to provide a rapid, large-area assessment of the problem.

The radiological measuring system developed to aid in locating uranium deposits in the western United States was temporarily called on to track several radioactive clouds released by the Weapons Test Program at the Nevada Test Site. The system proved very useful in the cloud-tracking operation, but the USGS asked the AEC to relieve them of the cloud-tracking activity. In 1959 the AEC asked EG&G, Inc., to develop a second-generation system.

The aerial monitoring system that EG&G designed⁴ was primarily for theoretical and experimental studies of (1) the radiation environment, (2) detector

*Joel E. Jobst received the B.S. degree in physics and mathematics from Marquette University in 1959 and the Ph.D. degree in nuclear physics from the University of Wisconsin in 1966. Since then he has worked at the Las Vegas Office of EG&G, the last 10 years in the Division of Aerial Measurement Operations. He has major responsibilities for the planning, execution, analysis, and reporting of aerial radiological surveys conducted throughout the United States and in the mid-Pacific.

response, (3) operational procedures, and (4) methods for rapid acquisition, analysis, and presentation of survey data.

The AMS, as the program is now known, became operational in November 1960; the first large-area survey was conducted in 1961. Since that time a growing remote-sensing capability has been developed and operated for the U. S. government. It now incorporates a wide range of remote-sensing instrumentation and a variety of aerial platforms, performing both routine and accident-response functions.

Several aerial programs are currently served by EG&G under the direction of DOE's Nevada Operations Office. These programs share the support of a staff of 110 full-time personnel, seven aircraft, data-acquisition systems, and analysis hardware and software.

The objectives of AMS missions concern safety and environmental assessment and include (1) accident response, (2) baseline documentation, (3) accurate definition of man-made contribution to the radiation environment at sites of interest to DOE, and (4) integrated remote-sensing capability to support DOE-related programs.⁵ The AMS also provides routine radiological surveys of nuclear reactors and other licensed facilities for the Nuclear Regulatory Commission (NRC). One of the primary purposes of AMS is fast response to a major accident or natural disaster. Fixed-wing and rotary aircraft, fully equipped with remote-sensing systems, are based on both the East and West Coasts to permit rapid response. The main operational base of AMS is in Las Vegas, Nev.; a smaller permanent staff is maintained at Andrews Air Force Base in Washington, D. C. The AMS supports the Interagency Radiological Assistance Program (IRAP).

In a radiological emergency, all AMS assets, personnel, and equipment become a major element of NEST, the Nuclear Emergency Search Team. Other groups from the Los Alamos Scientific Laboratory, Lawrence Livermore Laboratory, Sandia Laboratories, and elsewhere join forces to search for and assess the radiological emergency and perform any necessary decontamination.

AMS sensor systems include large-volume gamma scintillator arrays, neutron detectors, meteorological sensors, large-format aerial mapping cameras, multi-spectral aerial cameras, a multichannel scanner, air-sampling equipment, and extensive ground support equipment, including dedicated computers for data processing and a sophisticated multimode communication system. When not responding to an emergency or disaster situation, AMS is routinely used

to provide background hydrological, geological, ecological, and radiological baseline data on sites of interest to DOE. These include all operating nuclear power plants, radioactive waste storage facilities, and all DOE nuclear and energy development sites. Formal reports are prepared for each of the DOE and NRC surveys. These reports are useful for routine environmental impact statements and provide the basis for future detailed accident assessment, should that ever be necessary. Their preparation constantly maintains proficiency for accident response.

AERIAL SURVEY EQUIPMENT

In Las Vegas, AMS maintains four aircraft: a Convair 580-T, a Beechcraft Twin Bonanza E-50, a Hughes H-500 helicopter, and a Boeing BO-105 helicopter. A Beechcraft King Air A-100, a Hughes H-500, and a Boeing BO-105 are stationed at Andrews Air Force Base. These aircraft are shown in Fig. 1. As mission requirements change, various sensor systems are mounted aboard an appropriate aircraft. Sometimes

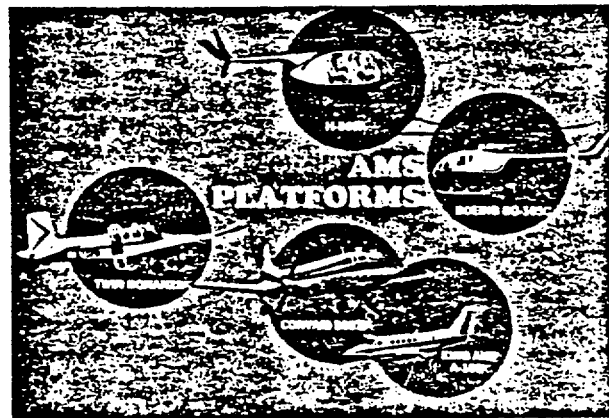


Fig. 1 Seven aircraft are maintained by EG&G as AMS aerial survey platforms. This fleet is supplemented by various military aircraft for special purposes.

more than one system is used on a given mission. Since the aircraft performance capabilities are fairly well-known, the special emphasis here will be placed on the sensor systems, their performance specifications, and how the data are applied to a specific problem.

Radiological Sensors

The AMS relies primarily on arrays of sodium iodide crystals to detect gamma radiation from aerial

platforms. Crystals of various sizes and arrays of various weights and configurations are assembled as required.

For relatively small areas, AMS relies heavily on a pair of detector pods, each containing ten 12.7-cm-diameter by 5.1-cm-thick sodium iodide [NaI(Tl)] detectors. These are attached to the outside of the H-500 helicopter fuselage. Even though the H-500 has a limited range (500 km), its variable speed (0 to 200 km/hr) and low altitude capability provide a very flexible platform for precision radiation surveys. Survey patterns are regularly flown at an altitude of 30 m, with a speed of 110 km/hr and a line spacing of 30 m. In a typical day of survey work, the H-500s are airborne approximately 4 hr. By operating from a support base at the site, which is easily accomplished, this system can fly over 400 km of survey line and complete a 10-km² site within 1 day.

Gamma counts from all 20 detectors are summed. Count rates, gamma spectral data, aircraft position information, clock time, live time, radar altitude, and meteorological data are recorded on magnetic tape for subsequent analysis. Several real-time displays keep the two-man crew abreast of survey progress.

Special importance is attached to the vertical and horizontal position of the aircraft at all times. Since the source signal drops sharply with increasing altitude, radar altimeter readings that are accurate to ± 0.6 m are recorded every second. During processing, count rates are corrected for altitude variations.

Fixed reference points are established at each site by positioning a pair of transponders from a microwave ranging system (MRS). The master unit, in the helicopter, interrogates the slaves and calculates aircraft position to better than ± 3 m. These data are recorded each second. A computer, also linked to the ranging system, drives a steering indicator in the cockpit. By "flying the needle," the pilot can fly programmed survey lines with great accuracy. This, in turn, assures complete coverage of the site and provides maximum assurance that even weak radioactive sources will be detected.

All data from radiological and meteorological sensors, as well as time and position information, are automatically recorded by the Radiation and Environmental Data Acquisition and Recording (REDAR) system shown in Fig. 2. REDAR is highly interactive, allowing the operator to select and display several

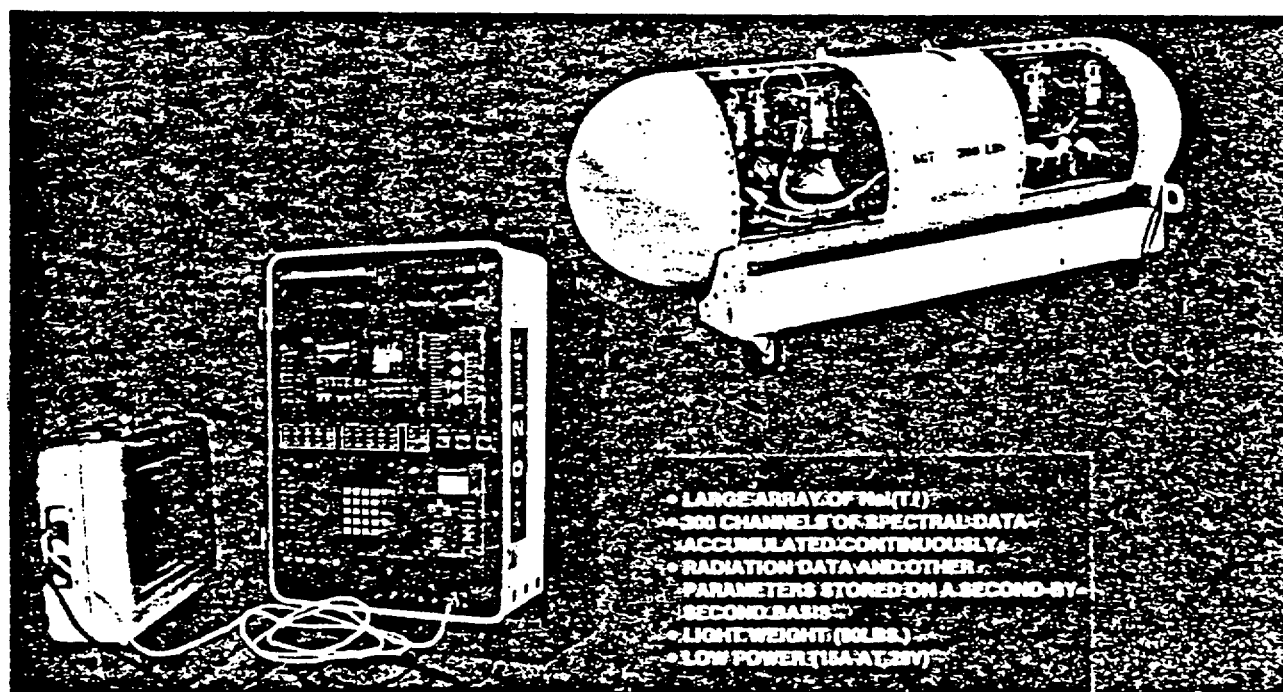


Fig. 2 The REDAR system consists of a power supply (11 kg), a processing and recording unit (33 kg), and various detector modules. The 170-kg detector pod shown at the upper right is half of the large array discussed under the heading Radiological Sensors. The processing unit handles input from many types of sensors simultaneously.

Table 1 Large-Array Conversion Factors

Isotope	Relaxation length, cm	Sample depth, cm	Detector response		
			nCi/m ² counts/sec	nR/hr* counts/sec	fCi/g counts/sec
¹³⁷ Cs	5	3	0.94	3.4	9.4
¹³⁷ Cs	5	10	0.94	3.4	5.4
¹³⁷ Cs	15	3	1.8	3.2	7.4
¹³⁷ Cs	15	10	1.8	3.2	6.0
⁶⁰ Co	5	3	0.51	7.65	5.1
⁶⁰ Co	5	10	0.51	7.65	3.0
⁶⁰ Co	15	3	0.94	7.24	3.8
⁶⁰ Co	15	10	0.94	7.24	3.1
²⁴¹ Am	5	3	8.3		83.0
²⁴¹ Am	5	10	8.3		48.0
²⁴¹ Am	15	3	2.0		81.0
²⁴¹ Am	15	10	2.0		65.0

*Measured at 1 m above ground.

portions of the gamma spectrum simultaneously. Spectra can be added, and background can be subtracted. Its great flexibility permits the real-time analysis required for aerial search activity. REDAR is used in all radiological surveillance, except snow surveys, for which a different system has been developed.

The sensitivity of various AMS detector systems is a complicated function of crystal volume, survey altitude, gamma-ray energy, source distribution, aircraft speed, and other variables. No point is served here by presenting all the results of elaborate experiments and computations that have been made to express AMS results accurately, in meaningful units, for all these variables. Table 1, however, shows typical response parameters for a large array of crystals (40 detectors, 12.7 by 5.1 cm) flown at an altitude of 30 m by a helicopter.

Typical values of air density, soil density, and soil composition were assumed. The gamma-ray relaxation length in the soil is a function of energy and soil composition. The last three columns convert counts per second in the gamma photopeak window to nCi/m² (nanocuries per square meter), to nR/hr (nanoroentgens per hour, measured at a distance of 1 m above ground), or to fCi/g (femtocuries of isotope per gram of soil). Sample depths for a ground survey must be accurately known if these aerial survey results are to be compared with ground survey results. The dramatic difference between the ⁶⁰Co and ²⁴¹Am results, for comparable conditions, is due to the large difference in their gamma-ray energies (1.17321 and

1.33248 vs. 0.0595 MeV). The H-500 system response is half of that shown in Table 1, since it uses 20 of the same type of crystals.

Most nuclear power reactors are surveyed with the A-100 King Air from an altitude of 152 m at a velocity of approximately 77 m/sec. Table 2 shows the response from 28 detectors (10.2 cm in diameter by 10.2 cm high), again assuming typical air and soil conditions.

Table 2 King Air Detector Array Conversion Factors*

Distribution, cm	¹³⁷ Cs		⁶⁰ Co	
	CF, nR/hr counts/sec	MDA, μ R/hr	CF, nR/hr counts/sec	MDA, μ R/hr
Surface	41.6	3.2	73.2	4.6
0.1	37.4	2.9	66.5	4.2
1.0	28.8	2.2	50.3	3.2
2.0	26.9	2.1	45.5	2.9
3.0	26.0	2.0	44.3	2.8
10.0	25.1	2.0	40.2	2.5
Volume	25.1	2.0	38.9	2.5

*CF, conversion factor (nanoroentgens per hour per count per second).

MDA, minimum detectable activity, in units of microroentgens per hour at the 99% confidence level.

Surface, infinite planar source with no vertical distribution.

Volume, source is uniformly distributed from the surface to infinity.

Note: Other distributions are expressed in terms of relaxation depths for an exponentially distributed source. The indicated exposure rates are to be measured at a distance 1 m above the soil surface.

The minimum detectable activity (MDA) for this system was calculated by measuring the statistical variations in signal strength after background had been stripped away from data obtained over typical survey sites containing variable concentrations of natural isotopes producing exposure rates of 4 to 6 $\mu\text{R/hr}$. The MDA (the minimum signal that would indicate a source of interest) was set at +3 standard deviations for terrain devoid of the isotopes being sought. Hence less than 1% of strictly background data should yield erroneous ^{60}Co or ^{137}Cs indications. Because of statistical fluctuations superimposed on the signal plus background, a source corresponding to the minimum signal would be detected 50% of the time.

In addition to the gamma-ray detector systems, AMS has also developed sensitive neutron detector arrays for aerial deployment. The detector is a 7-cm-diameter by 188 cm-long tube filled with ^3He under high pressure and surrounded by a polyethylene moderator. An array of 24 tubes with appropriate power supply and counting electronics can be quickly mounted on the H-500 or other helicopter. These arrays are useful for neutron sources, some of which emit gamma rays of such low intensity that they are nearly undetectable with sensitive NaI detector arrays.

Camera Systems

AMS employs several camera systems, primarily on fixed-wing aircraft (Twin Bonanza, Convair 580-T, and King Air A-100). Occasionally, military aircraft are used as aerial platforms. One system consists of four Hasselblad 500 EL/M cameras mounted closely and aligned to yield identical fields of view. Synchronous framing provides multispectral photography on 70-mm film; 10 to 80% overlap between frames provides full coverage. By proper selection of film sensitivity and optical filter combinations, this system can be used to cover any four wavelength bands in the spectrum from visible to near-infrared (400 to 900 nm). Typical choices are shown in Table 3.

Imagery obtained with this system is of very high quality and extremely useful when comparative information regarding the spectral properties of surface objects is required. Either 80- or 50-mm lenses are used. With the latter, each frame covers 18 by 18 km, centered on the nuclear reactor or other site of interest.

The Hasselblad multispectral system is routinely used for documentary photographic studies near nuclear power plants. When provided with a photographic data base recorded at the time of plant startup, a photo

Table 3 Multispectral-Band Photography (Hasselblad)

Film type	Filter	Band, nm
Kodak Aerocolor Negative Film 2445	Wratten 2A (haze)	400-700
Kodak Aerochrome Infrared Film 2443	Wratten 12 (yellow)	500-900
Kodak Plus-X Aerographic Film 2402	Wratten 25	600-700
Kodak Infrared Aerographic Film 2424	Wratten 89B	700-900

interpreter can detect changes in vegetation type or growth stress in existing vegetation by comparing these with similar imagery obtained after the plant has been in operation for some time. Such changes may be related to power-plant operation. Changing land use and demographic studies are made possible because complete coverage of each power plant is provided every few years by AMS.

The AMS program also depends on large-format aerial mapping cameras for many projects. Large color photographs of sites are frequently used as base maps for radiological surveys. The Convair is equipped with twin Wild-Heerbrugg RC-10 aerial mapping cameras with a periscope viewfinder and camera control system. The King Air accepts just one such camera, as shown in Fig. 3. The RC-10 produces 23- by 23-cm vertical aerial photographs of mapping quality. The system is normally operated at altitudes between 3 and 9 km, with normal aerial color film (Kodak Aerocolor Negative Film 2445), at 60% forward overlap to provide imagery suitable for stereo viewing. Such photographs are used wherever geometrical accuracy, high resolution, and normal color presentation are desirable. Other films, such as Infrared Color Type 2443, are also used. Two lenses are used: a 153-mm focal length with a resolving power of 60.1 cycles/mm and an 89-mm lens with a resolving power of 42.2 cycles/mm. The former has a field of view 1.5 times the aircraft altitude; at 3 km a single frame covers 4.5 by 4.5 km.

Each site for a radiological survey is usually photographed with the RC-10 a few days before the survey starts. Prints are used immediately for survey planning and again as a base map for radiation isopleth contours in the survey report.

Multispectral Scanner

The Convair is also equipped with a Daedalus multispectral scanner system. The spatial resolution is



Fig. 3 The Wild-Heerbrugg RC-10 is shown here in the King Air A-100. The operator guides the pilot directly over target. The control system automatically adjusts the framing rate to produce a preset overlap between frames.

not as good as either camera system, but spectral selection is better and covers a much greater wavelength range. Direct measurements of thermal emission can be made in the infrared band as well as in the visible and ultraviolet bands. There are 10 optical channels, completely covering the range 0.38 to 1.10 μm . Two thermal channels cover the 4.5 to 5.5 and 8.5 to 11 μm bands. In operation, the Daedalus scanner views a ground scene in up to 11 bands simultaneously (10 optical plus 1 of the 2 thermal) measuring reflected and emitted radiation in the ultraviolet, visible, and infrared. Line-by-line imagery is constructed, similar to a television raster, to provide a photograph-like image of the overflowed area. The lines are roll-corrected to remedy distortion caused by rotation of the aircraft about the longitudinal axis of the fuselage. Other system specifications are shown in Table 4.

Table 4 Daedalus Multispectral Scanner Parameters

Parameter	Symbol	Specification
Instantaneous field-of-view on the ground	IFOV	2.5 mradians
Noise equivalent temperature difference	NE ΔT	$\leq 0.1^\circ\text{K}$
Noise equivalent reflectance difference	NE $\Delta\rho$	1–2% (ultraviolet); $<1\%$ (visible and reflecting infrared)
Wavelength coverage		
optical (10 channels)		0.38 to 1.1 μm
thermal (2 channels)		4.5–5.5, 8.5–11 μm
Roll correction		$\pm 15^\circ$

Multispectral scanner imagery neither supports nor complements radiological survey data. Its imagery is a dynamic branch of remote-sensing technology which makes a distinct contribution to AMS capabilities. Personnel, aircraft, and other support equipment are shared among AMS groups.

Other Systems

The Twin Bonanza and King Air are equipped with gas- and particulate-sampling systems to permit real-time sampling of airborne contaminants. The King Air system permits isokinetic sampling with 13-cm-diameter filters at 24 liters/sec. For high-efficiency gamma spectroscopy, the filters are analyzed on board with a sodium iodide detector. Filters are counted immediately after exposure and at carefully selected intervals thereafter to separate and identify the short- and long-lived isotopic contaminants. For high resolution, GeLi or high-purity Ge detectors are employed. These systems include various ports for whole gas sampling or the addition of other instruments, such as a nephelometer or a multistage Lundgren cascade impactor. Particles are collected on thin mylar films which can be analyzed by alpha-particle-induced X-ray fluorescence or by inductively coupled plasma optical spectroscopy.

AMS fixed-wing aircraft are equipped with various meteorological sensors for special applications. Absolute barometric pressure, outside air temperature, dew point, wind speed, wind direction, turbulence, and other parameters are often required background data for remote-sensing missions. The REDAR system records these along with radar altitude, exact aircraft position, and clock time to provide complete documentation for special missions as they occur.

DATA ANALYSIS

Computer Processing

Data from radiation surveys are initially processed on site within a NOVA 840 computer, which has a 32,000-word core memory and an additional 1.2×10^6 word disk memory. Accessories include two data tape drives, two plotters, a cathode-ray tube (CRT) display, and a hard copier. The system, shown schematically in Fig. 4, is called REDAC (Radiation and Environmental Data Analyzer and Computer).

Many software routines are available. Gamma spectral windows can be selected from any portion of the spectrum between 50 keV and 3 MeV. Weighted combinations of such windows can be summed or subtracted; by proper selection of such windows, it is possible to extract photopeak count rates for radioisotopes deposited on the terrain by human activity. The count rates are converted to isotope concentrations or exposure rates and plotted as a function of position. The resulting isopleth contour map is superposed on a

recent color photograph of the site. A typical radiation contour map is shown in Fig. 5.

In most cases, preliminary copies of a radiation isopleth map are presented to the facility manager immediately after the survey and before the crew leaves the site. Two mobile computer laboratories have been built into 5-ton step vans, as shown in Fig. 6. One mobile laboratory accompanies the aircraft to each survey site. Even greater speed and adaptability is being pursued; a third computer laboratory was recently built into an airline cargo container of the type normally used by wide-bodied jets. The AMS can now airlift a fully operational magnetic tape data-processing laboratory to any major city in the world just as conveniently as passenger luggage.

Photographic Processing

AMS maintains a complete photo processing laboratory equipped with modern, high-speed processing and printing equipment. A scientific photographer directs a full-time staff of 15 photographers and photo technicians. In addition to the Wild-Heerbrugg RC-10 and Hasselblad cameras mentioned previously, the photo staff uses many 35-mm cameras for documentary work, such as the Olympus OM-1 and Nikon F2AS. Hand-held Hasselblad cameras are also used frequently for documentary work.

Nearly all photo processing, color as well as black and white, is performed in dedicated AMS support facilities. A wide variety of development processes is used for rolls 60 m long or more. Contact prints and enlargements up to 1.3 by 3 m are routinely provided. Other services include slide and viewgraph production and prints from slides (Cibachrome or internegative). Nine graphic artists work with the photo laboratory and the scientific staff to produce radiation isopleth maps, reports, and data displays.

Image Processing

AMS has recently acquired [from ESL, Inc. (formerly Electromagnetic Systems Laboratories, Inc.) of Sunnyvale, Calif.] a state-of-the-art, interactive data-processing system, designed and dedicated to the processing and analysis of image-related data. All types of imagery can be analyzed once it has been converted to digital form. The system is presently dedicated full time to the processing of scanner imagery.

The system hardware consists of an HP-3000II minicomputer, 350 megabytes of disk storage, a Comtal Vision One display and microprocessor unit,

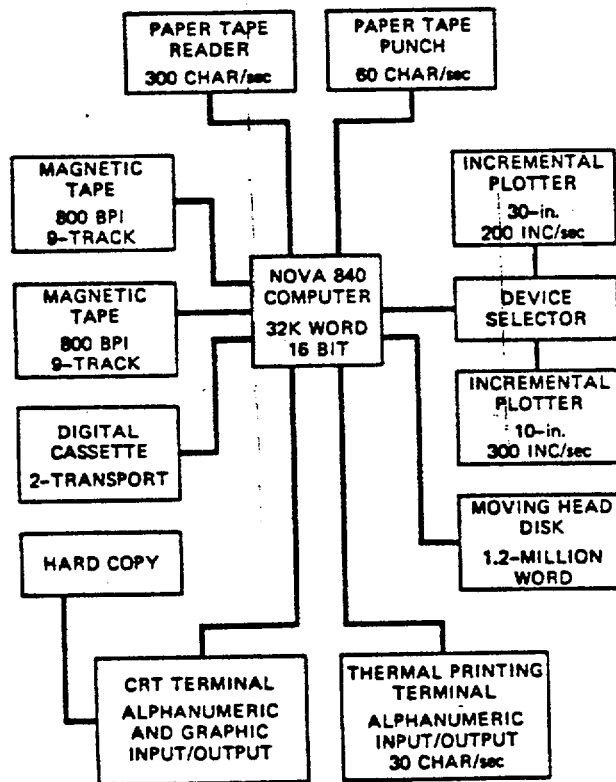


Fig. 4 A block diagram of the REDAC (Radiation and Environmental Data Analyzer and Computer) system.

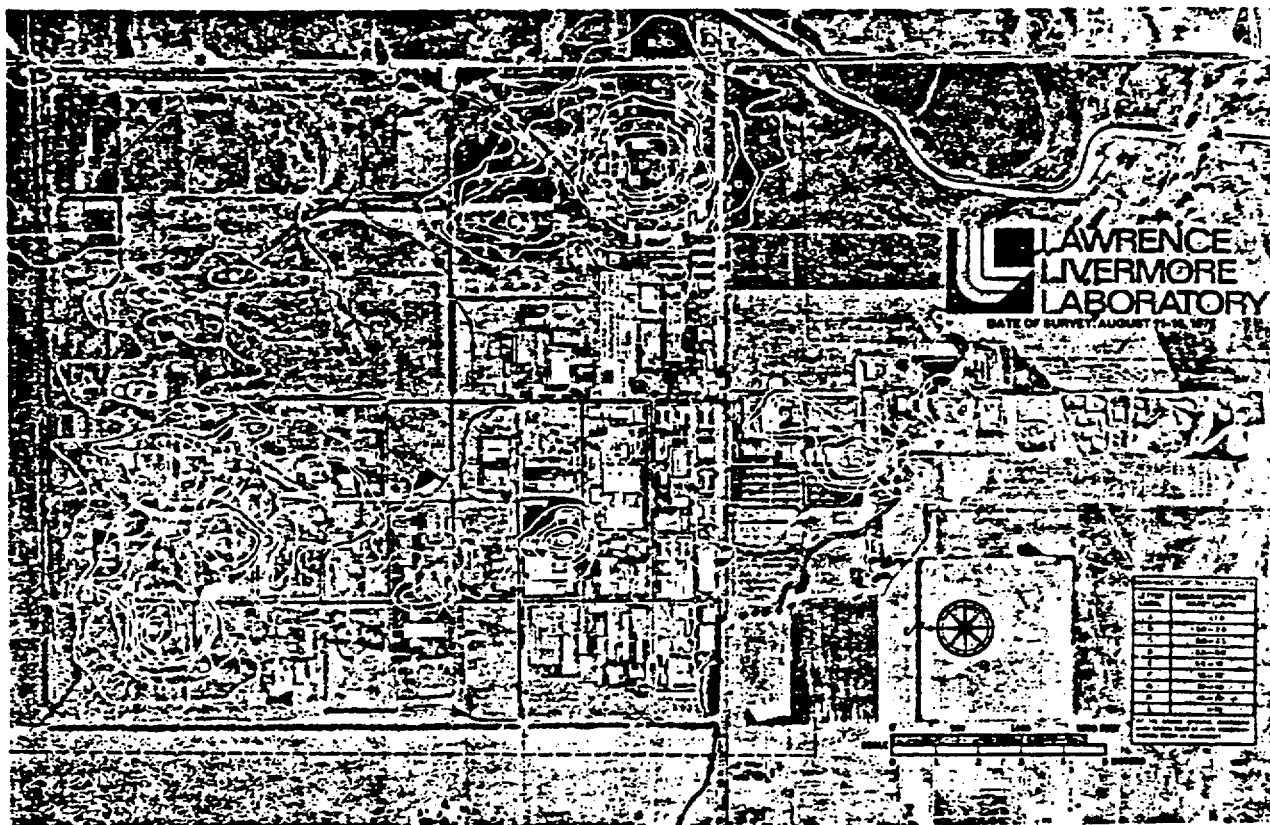


Fig. 5 This typical gamma-radiation isopleth was obtained over Lawrence Livermore Laboratory. Forty NaI(Tl) detectors (12.7 cm in diameter by 5.1 cm thick) were flown at an altitude of 45 m. The survey work was completed on Aug. 13, 1975.



Fig. 6 The REDAC system processes magnetic tapes recorded by REDAR. Gamma spectra may be obtained immediately after the aircraft returns from a flight. Sophisticated software permits preparation of radiation isopleth contours in the field.

and a number of input-output devices. The accompanying software was specifically developed to take advantage of the characteristics of the hardware. Over 100 specially designed algorithms and enhancement functions are accessible to process and analyze the imagery. Included are transforms, maximum-likelihood classification, statistical analysis, ratioing, and many more capabilities ideally suited to the analysis and interpretation of a broad range of remotely sensed data.

APPLICATION OF NUCLEAR SURVEYS

The primary objectives of AMS radiological surveys were stated earlier, viz., to provide baseline documentation, to define any man-made contributions to the natural radiation environment, and to assess a radiological accident or disaster. Many AMS surveys are completed before a new reactor or nuclear facility begins operation.

Reactor surveys, before or during operations, are typically flown with a fixed-wing aircraft, such as the King Air, at an altitude of 150 m and a speed of 80 m/sec. A 46- by 46-km square, centered on the facility, is flown with 0.93-km (0.5 nautical mile) spacing. Five flights of 3 to 4 hr each are required to accumulate the survey data. Generally, such surveys are completed in 1 week because of presurvey calibration work and MRS setup and postsurvey data analysis. Preliminary analysis is done with the REDAC system (Fig. 6) on site. The facility operators are invited to review the results as they are processed in the field. If anomalies are observed, gamma spectra at points of interest can be examined and isotopes can be identified. Much of the data required for remedial action can be provided immediately at the site. A final report is prepared after complete analysis, evaluation, and review by the AMS senior staff. Depending on the urgency and the priorities established by NRC, DOE, or other agencies that commission AMS surveys, the report is published within a few weeks or as long as a year or more after the survey.

Large facilities, such as the Hanford Reservation or the Idaho National Engineering Laboratory, may require survey crews, aircraft, and the computer processing laboratory to be on site for as long as 5 weeks. Such reports are generally quite complex and require considerably more time to prepare.

As indicated in an earlier section, the REDAC system can be programmed to select the photopeak of a given isotope. Background and the Compton tails of other prominent isotopes can be stripped from the detector response; the resulting isopleth map for a specific isotope is invaluable for assessing the environmental impact of multiple sources at a single facility. Considerable interaction with facility operators is required in some cases, so that the aerial survey flight pattern will complement the radiation monitoring and soil sample program established at the facility.

For large facilities where detailed, low-altitude data are required, 40 NaI detectors are usually flown on a large helicopter such as the BO-105 or on military helicopters such as the UH-1N or SH-3. For smaller areas the H-500 has proved to be an excellent vehicle, as indicated under the heading Radiological Sensors.

One very interesting application of the radiation survey techniques should be mentioned. Since 1969, AMS has cooperated with the National Weather Service in a research and development program. Airborne radiological measurements are used to determine the attenuation of terrestrial gamma rays caused by snow

accumulated on the ground: these data can be used to calculate the water equivalent of the snow cover. The Twin Bonanza is flown over carefully identified survey lines before and after the snow has accumulated. Background counts due to (1) radon gas in the air, (2) cosmic rays, and (3) detector and aircraft sources are subtracted in each case. The difference in the net count rates reflects the attenuation by the snow. Calibration against traditional methods has demonstrated that this system can determine the water equivalence of snow to an accuracy of ± 1 cm. This technique can be the heart of an important flood safety alert in heavy snow years.

The AMS has frequently been called on to locate lost radioactive materials. In 1968, a 330-mCi ^{60}Co source was lost in interstate shipment between Salt Lake City and Kansas City.⁶ An AMS aircraft was dispatched to look for the source along a 1930-km stretch of highway. In 2 days the source was recovered. A more difficult search occurred in 1970 when a U. S. Air Force Athena missile, with an 800-mCi ^{57}Co source aboard, accidentally strayed 650 km into Mexico.⁷ Radar tracking provided a 5- by 15-km footprint for the target area. Over 50 military personnel had combed the area for 3 weeks when AMS was requested to support the search. With a single 2½-hr search, the source was located.

Routine aerial surveys of the Nuclear Fuel Service reprocessing facility at West Valley, N.Y., triggered extensive supplementary effort on the ground.⁸ Increasing levels of off-site radionuclide deposition were discovered. Survey data showed, for example, ^{137}Cs buildup of as much as 30% per year at locations as much as 2 to 8 km off site in the plant watershed.

Over the years, aerial surveys of all the major DOE nuclear facilities and operating nuclear power plants have repeatedly identified potential problems that the site personnel had missed through existing monitoring programs. Those surveyed include such highly controlled areas as the Savannah River Plant,⁹ Hanford Reservation,¹⁰ Oak Ridge facilities,¹¹ Idaho National Engineering Laboratory,¹² Nevada Test Site,¹³ and Rocky Flats Plant.¹⁴

The most dramatic application of AMS resources occurs when a radiological emergency requires deployment of NEST. This occurred most recently in the early months of 1978 when NEST was sent to the Northwest Territories of Canada. The AMS and groups from other agencies assisted the Canadian Combined Forces in the location and recovery of hundreds of fragments of Cosmos 954, a nuclear-powered Russian satellite which reentered the atmosphere and disintegrated over Canada on Jan. 24, 1978 (Ref. 15).

APPLICATIONS OF PHOTO-OPTICAL REMOTE-SENSING CAPABILITIES

The photo-optical remote-sensing capabilities of the AMS are a more recent development, providing a comprehensive site survey to those responsible for assessing and planning health protection and safety at specialized sites.

Aerial photography with precisely engineered modern cameras, such as the Wild-Heerbrugg RC-10, has proved to be invaluable, especially for radiological surveys. For many recent survey sites, the available USGS maps were inadequate because of dramatic changes in land use. For some areas the only maps available are 50 to 75 years old. When AMS surveyed the Idaho National Engineering Laboratory in 1974, most of the site had never been mapped by the USGS.

In September 1978, AMS completed aerial photography of the Northern Marshall Islands in the mid-Pacific. Included were perhaps 350 to 400 islands, most of them in atolls such as Bikini and its neighbors which may have been contaminated by bomb testing in the forties and fifties. The most recent marine charts of these areas were prepared during World War II. Some of the islands have disappeared and others have drastically changed because of natural wind and wave action. With these new aerial photographs as base maps, AMS conducted a 3-month radiological survey of the entire Northern Marshall Islands at 30-m altitude using the large detector array discussed under the heading Radiological Sensors.

For nearly all radiation surveys, AMS obtains aerial photographs, at several altitudes, of each site a few days before the survey team arrives. Prints are rectified in the AMS photo laboratory, if possible, by matching the negative with maps prepared with traditional civil survey techniques. These prints are used by the project scientist to lay out all survey lines. Often the assistance of site personnel is sought to ensure complete coverage. This planning map is used in the aircraft so that correct flight line numbers can be assigned to "mag-tape" records in the mission log. Finally, rectified prints are used as a base map in preparing the report: radiation isopleth contours are drawn directly on the print, as shown in Fig. 5. Data interpretation is vastly improved by the marriage of these two remote-sensing disciplines.

The AMS personnel have also found that multi-spectral photography and scanner imagery provide a wealth of complementary data which often reveal unforeseen health and safety risks. These sensors

provide an important contribution to the following study areas:

Ecological Systems

- Detection of the effects of drift from cooling towers, ponds, etc.
- Detection of the effects of spills.
- Biomass inventory.
- Habitat mapping.
- Detection of stress effects on plants.
- Population census of large animals.

Water Quality

- Measurement of thermal plumes in the water system.
- Mapping of changes in size and location of wet areas.
- Detection of leakage effects from production and reinjection pipes.
- Detection of effects from water-table changes.
- Mapping surface spills.

Subsidence and Seismicity

- Detection and mapping of changes in shorelines.
- Detection of effects of drainage tile damage.
- Detection of the effects of changed hydrology.
- Mapping the location of fault escarpments, ancient shorelines, and stream beds.

Air Quality

- Measurement of vertical and horizontal profiles of particulates and gases, such as O_3 , NO_x , and SO_x .

Overt Health Effects

- Detection of toxic plumes or other effluent streams by sampling, photography, or use of the scanner.

Socioeconomic Factors

- Determination of full land-use relations.
- Measurement of population distribution.
- Cataloging of new construction.

Integrated Assessment

- Baseline documentation.
- Information transfer.

Photo-optical survey capability has been steadily improved over the years. The AMS conducts surveys of DOE facilities to measure any effects which might have an impact on the surrounding environment.

The Daedalus scanner is useful for characterizing the total land mass according to basic land-use criteria. The first AMS application of this system was at the Idaho National Engineering Laboratory where

thermal-emission data were recorded to quantitatively reveal the heat loss from laboratory facilities. These data were then used to remedy unnecessary heat loss.

A scanner has also been used over the Salton Sea area of Southern California, as part of the Imperial Valley Environmental Project.¹⁶ It has been proposed that the vast geothermal water resources there be tapped for commercial generation of electricity. The scanner was flown to determine the long-term and short-term environmental effects of heat and salt on the ecology of the area, which is dominated now by heavy agricultural usage. Multispectral photography, performed in conjunction with the scanner imagery, showed that land surrounding a new geothermal test well suffered crop damage shortly after operations commenced. One farmer was already preparing litigation for damages. The government promptly agreed to settle out of court because of the AMS data.

During another mission, scanner data near the Rocky Flats Plant revealed potential leaks and seepage from settling ponds.¹⁷

The AMS has also completed several multispectral scanning missions over DOE's Laramie Energy Research Center pilot projects in Wyoming, Colorado, and Utah. Coal gasification and extraction of oil from shale are test processes at these sites. Scanner data are used to monitor the effects of conversion processes. The results will be an important part of the environmental impact statements required by both state and federal governments.

Since the continued strength and vigor of the energy development programs in the United States require prompt, intelligent application of environmental controls, the future of the AMS program appears certain. New energy sources have been tapped in major programs in the past few years, and no source of energy is free, i.e., free of potentially serious environmental impact. The AMS has broadened its scope and its technology to meet our burgeoning demands for energy.

However, the wealth of data provided by AMS remote-sensing systems must be used effectively. For the past 2 years, AMS has been developing a graphic overview system for all DOE facilities. The presentation format is uniform to facilitate intercomparison. For each facility, detailed aerial photographs of the site are used as base maps. All environmental data are presented at the same scale on transparent overlays. Hence the viewer can quickly observe many interactive factors such as prevailing winds, watershed drainage, and waste burial sites. Subsequent survey results are

plotted to the same scale so that, by overlapping transparencies, the viewer can graphically observe the trend of changes between surveys.

This graphic overview system can accommodate all the requirements of the U. S. Environmental Protection Agency Environmental Impact Statement. For this purpose the environmental overlays are supplemented by transparencies showing population, land use, demographic data, and even social information. The overview method thus provides DOE management with an effective tool for highlighting major environmental problem areas. It gives focus to the effort required to correct the deficiencies in any control program.

CONCLUSION

The AMS program is a multipurpose nuclear safety and environmental monitoring resource. It provides aerial photography, multispectral scanning, air sampling, radiation measurements, and other environmental data for licensed and government facilities. The AMS provides routine professional environmental monitoring and many of the imperative requirements for response to a nuclear threat or emergency. Most recently, in Operation Morning Light (a joint effort by the United States and Canada to recover the Russian nuclear satellite Cosmos 954), AMS assisted the nuclear community in its responsibility to protect the health and safety of threatened populations. Continuous research is conducted in the detection and analysis of gamma and neutron signatures; hence AMS is making a strong contribution to nuclear safety in the United States.

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SYMPOSIUM ON SAFEGUARDS AND NUCLEAR MATERIALS MANAGEMENT

Brussels, Belgium, Apr. 25-26, 1979

The European Safeguards Research and Development Association (ESRDA) is sponsoring this first of a projected annual series on Safeguards and Nuclear Materials Management. The Joint Research Center of the Commission of the European Communities is organizing the symposium to be held in the Ravenstein Congress Hall, Brussels, Belgium, Apr. 25-26, 1979. The purpose of the meeting is to stimulate discussion about safeguards implementation problems in the European Communities between nuclear plant operators, safeguards authorities, and research organizations. Nuclear plant operators, safeguards authorities, and research organizations of all countries will present papers on the following subjects:

- Safeguards concepts and regulations.
- System analysis.
- Nondestructive assay methods and instruments.
- Destructive analysis.
- Physical standards (reference materials) and normalization samples.
- Interlaboratory tests.
- Containment and surveillance.
- Data recording, processing, and reporting in nuclear installations.
- Isotopic correlations.
- Statistical methods for nuclear safeguards.

Papers must be written in Danish, Dutch, English, French, German, or Italian, and an abstract in English should also be provided. Simultaneous translation will be organized at the symposium.

For additional information, write to one of the following members of the scientific secretariat of the symposium: A. S. Adamson, NMACT, AERE HARWELL, Didcot OXON; OX11 0RA, England; C. Beets, CEN/SCK, B-2400 Mol/Donk, Belgium; or L. Stanchi, JRC, 21020 Ispra (Varese) Italy.

EG&G
ENERGY MEASUREMENTS GROUP

EG&G SURVEY REPORT
EP-F-006
OCTOBER 1982

THE
REMOTE
SENSING
LABORATORY

OPERATED FOR THE U.S.
DEPARTMENT OF ENERGY BY EG&G

AN AERIAL RADIOLOGICAL SURVEY OF
WAYNE TOWNSHIP,
NEW JERSEY
AND SURROUNDING AREA

DATE OF SURVEY: SEPTEMBER 1982

AN AERIAL RADIOLOGICAL SURVEY OF
WAYNE TOWNSHIP, NEW JERSEY
AND SURROUNDING AREA

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1.0 SUMMARY OF RESULTS

An aerial radiological measuring system was used to survey the area surrounding the former W. R. Grace property located in Wayne Township, New Jersey, during the month of September 1982. This site formerly contained a facility to extract rare earths and thorium from monzanite sands. The survey was conducted for the U.S. Department of Energy's (DOE) Office of Operational Safety by the Department's Remote Sensing Laboratory, operated for the DOE by the Energy Measurements Group of EG&G.

The highest radiation exposure rates were measured over the site. Average radiation levels of 30 to 60 microrentgens per hour ($\mu\text{R/h}$), normalized to 3 feet above the ground, were inferred from the aerial data. Elevated radiation levels ranging from 20 to 30 $\mu\text{R/h}$ were also observed over a stream (Sheffield Brook) extending approximately 1/2 mile west of the site as well as over the quarry area located to the west of Pompton Lakes. The source of the elevated activity in each case was thorium.

Natural background radiation exposure rates measured by the airborne system within the survey area typically ranged from 6 to 10 $\mu\text{R/h}$ with an average value of approximately 8 $\mu\text{R/h}$.

2.0 INTRODUCTION

An aerial radiological survey was flown over a 5½-mile by 10-mile area surrounding the former W. R. Grace property located in Wayne Township, New Jersey. This survey was conducted for the Department of Energy's (DOE) Office of Operational Safety (OOS) by the Energy Measurements Group of EG&G. The OOS conducts radiological surveys at sites and facilities where nuclear operations were formerly conducted for the government.

An MBB BO-105 helicopter, equipped with aerial radiological detection systems, was used for the survey. The helicopter altitude above ground level was 300 feet with 300-foot line spacings. A previous survey covering an area of 3 miles by 4 miles surrounding this site was flown in May 1981 utilizing this system.¹ The purpose of the present survey was to expand the coverage to include all of Wayne Township.

Aerial radiological detection systems average the radiation levels produced by gamma-emitting radionuclides existing over an area of several acres. These detection systems are capable of determining specific radionuclides causing radiological anomalies. However, because of averaging, airborne systems, as compared to ground-based measurements, tend to underestimate the magnitude of localized sources. Details of the systems and procedures employed in obtaining and processing aerial radiation data are presented in References 2 and 3.

In aerial radiological surveys, the gamma ray energies, source concentrations, and relative distribution are measured by specialized instrumentation. The results are reported as radiation exposure rates

in $\mu\text{R}/\text{h}$ at 3 feet above the ground. The maximum annual radiation dose that could be absorbed through continuous exposure (24 hours a day for 365 days to a constant exposure rate), expressed in millirem per year (mrem/y) is approximated by multiplying the exposure rate in micro-roentgen per hour ($\mu\text{R}/\text{h}$) by 8.76*. These results apply to external radiation only and do not account for inhalation or ingestion of radioactive materials. The actual amount of radiation absorbed depends on the duration and circumstances of exposure.

3.0 BACKGROUND RADIATION

Background gamma radiation originates from naturally occurring radioactive elements present in the earth (terrestrial radiation) and cosmic rays entering the earth's atmosphere from space. The terrestrial gamma rays originate primarily from the uranium decay chain, the thorium decay chain, and radioactive potassium. Variable concentrations of these nuclides produce estimated annual radiation doses ranging from 15 to 140 mrem/y (1.7-16 $\mu\text{R}/\text{h}$) at the surface of the earth in the United States. The higher background radiation dose levels (up to 140 mrem/y) are typically found in the western states, primarily in the Colorado Plateau area, and are a result of high uranium and thorium concentrations in surface minerals and increased cosmic radiation because of higher elevation.

The uranium decay chain includes radium-226 and its daughter, radon, which is a noble gas, i.e., it will not combine chemically with other elements. The radionuclide radon can both diffuse through the

$$* \frac{\mu\text{R}}{\text{h}} \times 24 \frac{\text{h}}{\text{day}} \times 365 \frac{\text{day}}{\text{y}} \times \frac{1}{1000} \frac{\text{mrem}}{\mu\text{R}} = \frac{\text{mrem}}{\text{y}} \quad \left(\text{using the approximate conversion from } \mu\text{R to mrem} \right)$$

soil and move through the air to other locations. Thus, the level of radiation contributed by this noble gas depends upon the meteorological conditions, mineral and moisture content and permeability of the soil, and other physical conditions existing at each location at any particular time. Airborne radon typically contributes from 1 to 10 percent of the natural background radiation levels.

Cosmic rays, the space component of the natural radiological background, interact in a complex manner with the elements of the earth's atmosphere and soil. These cosmic ray interactions produce additional background radiation dose rates which vary slightly with latitude and directly with altitude, increasing from 26 mrem/y ($3 \mu\text{R/h}$) at sea level in Florida to 107 mrem/y ($12 \mu\text{R/h}$) at 10,000 feet above sea level at some locations in Colorado. The cosmic ray dose rate in Denver, Colorado (1 mile above sea level), contributes about 50 mrem/y to the total background dose rate of about 125 mrem/y.

The aerial survey results include the terrestrial gamma radiation measured throughout the surveyed area and an estimated cosmic ray exposure rate, but the results do not include the contribution from airborne radon.

4.0 SURVEY BOUNDARIES

This survey covered an area of approximately 55 square miles including all of Wayne Township, New Jersey. The boundaries of the survey are shown in Figure 1.

5.0 SURVEY RESULTS

The results of this aerial survey are presented in Figure 1 as closed contour curves of total radiation exposure rates (isoradiation contours) overlaid on an aerial photograph of Wayne Township, New Jersey.

The results are reported in units of $\mu\text{R/h}$ at 3 feet above ground and include a cosmic ray contribution estimated at $3.7 \mu\text{R/h}$.

The highest radiation exposure rates were measured over the site. Average radiation levels ranging from 30 to $60 \mu\text{R/h}$ were inferred from the aerial data. Elevated radiation levels ranging from 20 to $30 \mu\text{R/h}$ were also observed over a stream (Sheffield Brook) extending approximately 1/2 mile west of the site and over the quarry area located to the west of Pompton Lakes.

A special data processing technique (details of which are given in References 2 and 3) was used to help identify areas containing thorium concentrations greater than that present in typical background soils. The results of this special analysis are also shown in Figure 1. The green area includes the site and the stream west of the site. The other areas, shown in yellow, appear to be the result of natural anomalies. Elevated exposure rates were associated with the excess thorium over the site, over the stream, and over the quarries north of the site. The other areas did not show elevated exposure rates, and appear to be due to slight perturbations in the relative amount of thorium within these areas compared to the rest of the survey area.

A similar technique was used to search for possible areas containing excess radium-226, normally associated with uranium ore and tailings. No positive indications were observed.

Natural background radiation exposure rates within the survey area typically ranged from 6 to $10 \mu\text{R/h}$ with an average value for Wayne Township of approximately $8 \mu\text{R/h}$.

6.0 COMPARISON WITH PREVIOUS SURVEYS

The results of the September 1982 survey compare quite well with the results of the May 1981 aerial survey except directly over the site and along the stream west of the site. The previous survey inferred exposure rate levels greater than 120 $\mu\text{R/h}$ over the site and maximum levels between 60 and 120 $\mu\text{R/h}$ along the stream. The present survey indicated levels between 30 and 60 $\mu\text{R/h}$ over the site and between 20 and 30 $\mu\text{R/h}$ along the stream. These differences result from the different survey altitudes flown in the two surveys (150 feet in 1981 versus 300 feet in 1982), and indicate that the source of the activity within the site and along the stream is highly localized. At the higher survey altitude the airborne system averages over a larger area and will infer a lower exposure rate for a localized source. Due to terrain limitations it was not possible to fly the large area survey lower than 300 feet.

A ground-based radiological survey was conducted April 26 to May 1, 1982 along the stream west of the site by the Radiological Site Assessment Program of Oak Ridge Associated Universities (ORAU), Oak Ridge, Tennessee.⁴ This survey indicated the presence of thorium contaminated soil and sediment along the stream. The survey findings also showed that the thorium contamination was generally limited to a narrow strip, approximately 30 feet maximum, on either side of the stream. Elevated radium-226 was also detected but at levels much lower (5 to 10%) than the thorium concentrations. Exposure rate levels measured 3 feet above ground were highly variable, ranging from 8 to 269 $\mu\text{R/h}$, with an average value along the stream of 50 $\mu\text{R/h}$. These results are consistent with those obtained from the aerial data after taking into consideration the large area averaging property of the airborne system.

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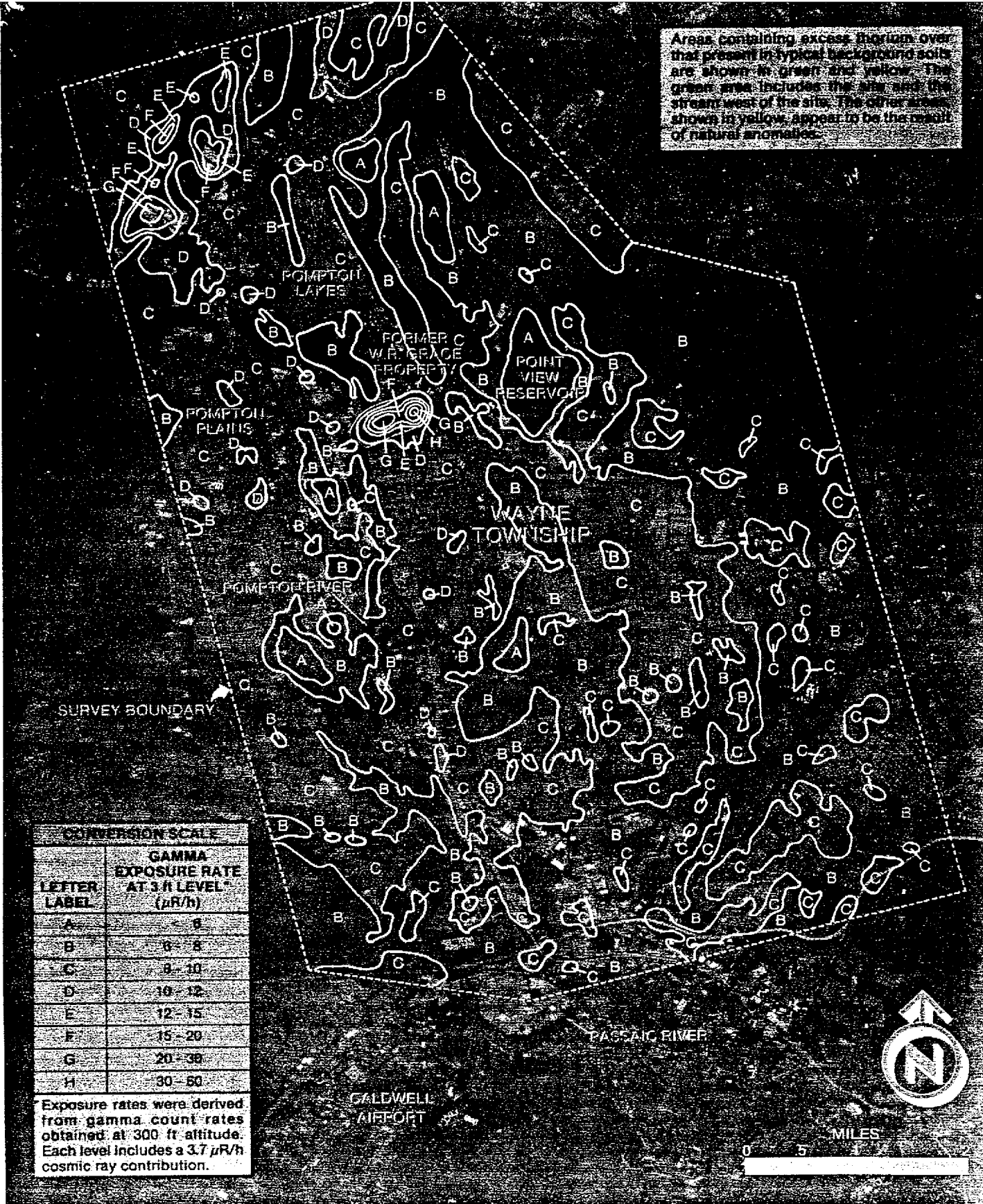


Figure 1. GAMMA EXPOSURE RATE CONTOURS DERIVED FROM AERIAL SURVEY DATA OBTAINED OVER WAYNE TOWNSHIP, NEW JERSEY AND THE SURROUNDING AREA.

Contract No. W-7405-eng-26

Health and Safety Research Division

RESULTS OF THE MOBILE GAMMA SCANNING ACTIVITIES AT
WAYNE, NEW JERSEY, AND SURROUNDING COMMUNITIES*

January 1983

Work performed
as part of the
REMEDIAL ACTION SURVEY AND
CERTIFICATION ACTIVITIES PROGRAM

OAK RIDGE NATIONAL LABORATORY
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RESULTS OF THE MOBILE GAMMA SCANNING ACTIVITIES AT WAYNE, NEW JERSEY, AND SURROUNDING COMMUNITIES

INTRODUCTION

The former W. R. Grace property, located at 868 Black Oak Ridge Road in Wayne, New Jersey, has^{1,2} been the focus of several investigations over the past several years. The site, presently occupied by Electro-Nucleonics, Inc., is known to have thorium residues and contaminated debris buried onsite. Samples of soil and stream sediment from along Sheffield Brook between the site and its confluence with the Pompton River have also been found to contain elevated thorium concentrations.¹

At the request of the Department of Energy's (DOE) Office of Operational Safety (OOS), the Energy Measurements Group of EG&G conducted an aerial radiological survey over all of Wayne Township and surrounding areas in October 1982.³ Results of this survey indicated elevated exposure rates associated with excess thorium over the W. R. Grace site, Sheffield Brook west of the site, and over quarries located approximately three miles northwest of the W. R. Grace site. Several other areas were recognized by the aerial survey which showed excess thorium concentrations with no associated elevated radiation exposure rates and appear to be due to slight perturbations in the relative amount of thorium within these areas compared to the rest of the survey area.

In order to further define the excess thorium anomalies found on the EG&G aerial survey, a mobile gamma scanning survey was conducted by personnel from Oak Ridge National Laboratory (ORNL) during the period of November 11-13, 1982. This report summarizes the results of the mobile survey.

SURVEY METHODS

The following is a brief description of the scanning methods utilized for the mobile scanning of the Wayne, New Jersey, area. Details of the system description and operation have been provided in Reference 4.

Instrumentation

The gamma radiation detection system employed in the ORNL scanning van consists of three 4 x 4 x 16-in. NaI(Tl) log crystals housed in a lead-shielded steel frame to provide a 12 x 16-in. detector surface area for acceptance of gamma radiation through one side of the survey van. The detector and shield height can be varied with a hydraulic lift mechanism to optimize the detector field-of-view. The detector output

* The survey was performed by members of the Remedial Action Survey and Certification Activities Group of the Health and Safety Research Division at Oak Ridge National Laboratory under DOE contract W-7405-eng-26.

is transferred to a computer-controlled, eight-channel discriminator and interface, which provides for continuous analysis of data inputs for correlation of system location with count rate information. Six separate energy regions-of-interest are analyzed and a ^{226}Ra -specific algorithm is employed to identify locations containing residual radium-bearing materials. Changes in the multichannel analysis capabilities of the system were made for additional qualitative thorium identification prior to conducting the survey in the Wayne area.

Mobile Scanning Methods

The data analysis method employed on the ORNL van is based on computations involving background count rates in specific energy regions. These background levels are normally obtained within small (10 square block) survey areas, based on coverage of at least 75% of the accessible streets in that area. Scanning of these areas are conducted at a slow speed (<5 mph), which maximizes response of the detectors at anomalous subject properties. Anomaly locations are highlighted by the computer system when the preset hit criteria are exceeded during the scan.

SURVEY RESULTS

Scope of Activities

The purpose of this survey was primarily to verify the excess thorium anomalies found on the EG&G aerial survey. Areas with indicated anomalous thorium and several background areas to further characterize the survey area were scanned.

Scan Results

As the basis for analysis of the mobile scan data, background radiation levels were measured in eight areas in the Wayne Township and surrounding communities. Count rates in the regions of interest were found to vary between these areas. To illustrate this variability, the values for three background radiation levels are given as follows:

	<u>Background 1</u>	<u>Background 2</u>	<u>Background 3</u>
Average total Ra Count rate (cps)	217 ± 15	245 ± 16	565 ± 24
Average Th count rate (cps)	16 ± 4	29 ± 5	78 ± 9
Average K count rate (cps)	82 ± 9	116 ± 11	224 ± 15
Average Ra/Th ratio	13 ± 3	8 ± 1	7 ± 1

This range indicates that the background levels in the Wayne area show considerable variation. The observed variations are a direct result of the geologic setting found in the Wayne area. Three major bedrock types are represented within the survey area (Fig. 1).

Background 1 represents areas underlain by Triassic Age [approximately 200 million years before present (mybp)] basalts.⁵ Basalt is an extrusive (volcanic) rock composed primarily of calcic plagioclase feldspar, pyroxene, and olivine.⁵ The relatively large atomic radii of the naturally-occurring radionuclides U(Ra), Th, and K tends⁷ to exclude them from the composition of the minerals present in basalt.⁷ Packanack Mountain and Second Watchung Mountain are two roughly north-south trending ridges composed of basalt within the survey area.

Background 2 represents the typical radiation levels found in areas underlain by Triassic Age (~200 mybp) sedimentary rocks. These rocks are shales and sandstones which underlie the lowlands between the basalt ridges in the survey area.⁵ Considering the more heterogeneous composition of the sedimentary rocks when compared to basalt, the observed increase in the background radiation levels is to be expected.

Both the Triassic basalts and sedimentary rocks are within the Triassic Lowlands of the Piedmont Physiographic Province. Northwest of Pompton Lakes, rocks of the New Jersey Highlands section of the New England Physiographic Province are present.⁵ The Highlands are underlain by granites and granitic gneisses of Precambrian (>800 mybp) age. Granitic magmas are enriched in potassium, silicon, and aluminum, and cool very slowly. During the late stages of the cooling process, potassium feldspar crystallizes out of the magma, leaving the leftovers, the trace element suite, to form minor minerals which often contain thorium and uranium.

Background 3 was taken at a granite quarry and reflects the higher concentrations of naturally-occurring radionuclides in the granitic rocks of the New Jersey Highlands.

SIGNIFICANCE OF FINDINGS

Based on the results of the ORNL scanning activities, 20 properties or areas in the Wayne Township and surrounding area were found to contain excess thorium anomalies above the background levels for their respective areas. Three properties are recommended for future comprehensive onsite surveys because of their proximity to previously-surveyed (Reference 1) areas related to the former W. R. Grace property, or because no natural cause for the observed anomaly was observed (Table 1). Four properties with observed excess thorium anomalies have already been surveyed (Table 2).

The remaining 13 locations are the New Jersey Highlands' "granite" quarries, or areas where there was probable use of the "granite" as roadbase or in asphalt (Table 3). Since these properties are probably unrelated to the W. R. Grace property, they are not recommended for comprehensive onsite surveys by DOE contractors.

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SEDIMENTARY ROCKS

CENOZOIC

Quaternary - Recent - deposits of Sandy Hook and the offshore bar shown in white. Pleistocene deposits not shown.

Tertiary

MESOZOIC

Cretaceous

Triassic

PALEOZOIC

Devonian

Silurian

Ordovician

Cambrian

PRE-CAMBRIAN

Franklin Ls.

IGNEOUS ROCKS

TRIASSIC

Diorite

Basalt

POST-ORDOVICIAN

Serpentine (s)
Nepheline-Syenite (n)

PRE-CAMBRIAN

Gneiss, Granite, Gabbro,
and metamorphic rocks

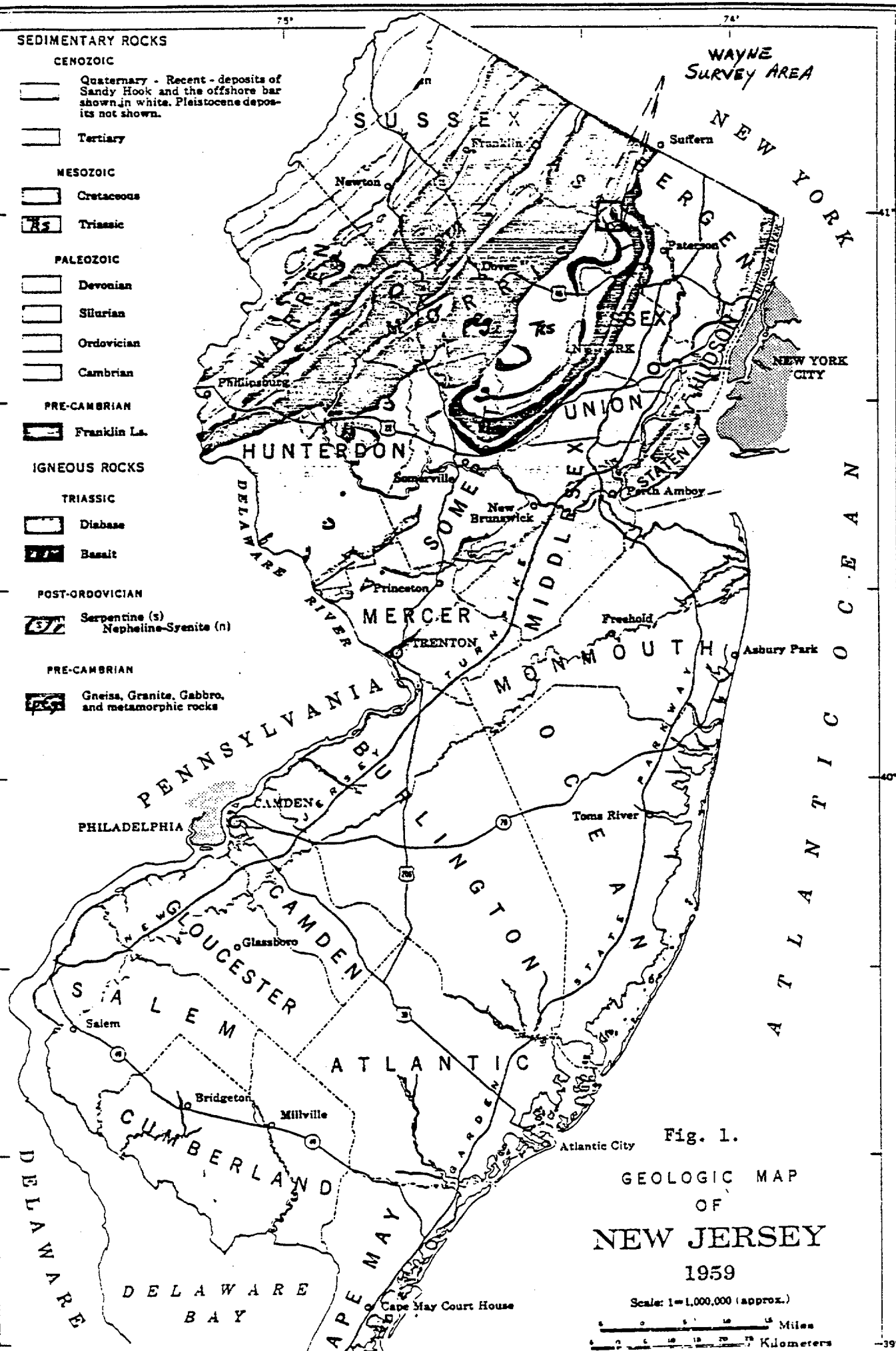


Fig. 1.
GEOLOGIC MAP
OF
NEW JERSEY
1959

Scale: 1=1,000,000 (approx.)

0 1 2 3 4 Miles
0 2 4 6 8 10 Kilometers

Explanation for Geologic Map of New Jersey with unit codes for rocks found in the Wayne, New Jersey, survey area.

ap
des

SEDIMENTARY ROCKS

Cenozoic

Quaternary—Recent deposits of the last 10,000 years are chiefly beach sands forming Sandy Hook and the offshore bars. Pleistocene or ice age starting 1,000,000 years ago. Widespread thin deposits of till and outwash covering older formations are not shown on this map. Mineral production—peat moss, sand, and gravel.

Tertiary—Starting 70,000,000 years ago. Unconsolidated sands, gravels, and clays. Forms the outer Coastal Plain. Marked by three different periods of invasion by sea, separated by erosional periods of dry land. Mineral production—brick and terracotta clays; glass sands; ilmenite (titanium ore).

Mesozoic

Cretaceous—Starting 125,000,000 years ago. Unconsolidated sands, clays, and greensand marls. Forms the inner Coastal Plain. Appalachian Province uplifted and coast depressed; fast moving rivers deposited sediments in marine environment. Mineral production—fireclay, brick clay, greensand marls.

Triassic—Starting 200,000,000 years ago. Shales, argillites, sandstone, and some conglomerates. Forms Piedmont Plain. Appalachian Mts. uplifted and long thin depressed basins formed between ridges; fast moving rivers deposited sediments in these basins. Mineral production—Stockton sandstone (brownstone) for building stone; negligible amounts of copper found in some shales.

Paleozoic

Devonian—Starting 330,000,000 years ago. Sediments occur in two areas, 1) fossiliferous, calcareous shales and limestones in Appalachian Plateau, 2) sandy shales, sandstones, and conglomerates in valley south of Greenwood Lake in Highlands. No significant mineral production.

Silurian—Starting 360,000,000 years ago. Coarse conglomerates, sandstone, shale and, limestone. Occur to the southeast of Devonian sediments. From early Devonian, when sea receded to early Upper Silurian, N.J. was dry land. In late Silurian, the sea receded for a very short period and then re-invaded land. No significant mineral production.

Ordovician—Starting 420,000,000 years ago. Limestone, shales, and slates. Found in the Highlands and Appalachian Plateau. Three different invasions of land by sea, with erosional periods of dry land in between. Mineral production—cement rock and slate.

Cambrian—Starting 500,000,000 years ago. Quartzite followed by limestone. Found in the Highlands and Appalachian Plateau. During first and last parts of Cambrian time N.J. was covered by seas, while in Middle Cambrian time it was dry land.

Precambrian—Franklin limestone—more than 500,000,000 years old. Typically a white crystalline limestone. Found in a narrow belt and a few isolated masses in the Highlands. Mineral production—zinc deposits at Franklin and Ogdensburg; limestone for flux and cement rock.

IGNEOUS ROCKS

Triassic—Diabase and Basalt—The same basic rock formed from cooling molten material. Differ in texture. Diabase is coarse grained due to slow cooling beneath the surface while basalt is fine grained due to quick cooling of lava at the surface. Diabase forms the Palisades and its extensions to the south in the Princeton area. Basalt forms the Watchung Mts. and the two small masses at New Germantown and Sand Brook. Diabase and basalt are extensively quarried for concrete, road metal, and railroad ballast.

Precambrian—Gneiss and Granite. Granite is a coarse grained igneous rock characterized by predominant alkali feldspar and quartz. Gneiss is a crystalline rock with a secondary rough foliation developed as a result of pressure on the solidified rock; bands or lenses in gneisses are commonly unlike. Metamorphic rocks are included in this zone, some of them having been derived from sediments. These rocks form "The Highlands of New Jersey". Mineral production—magnetite (iron ore), crushed stone and prospects for uranium, monazite, and

Rbs

PCg

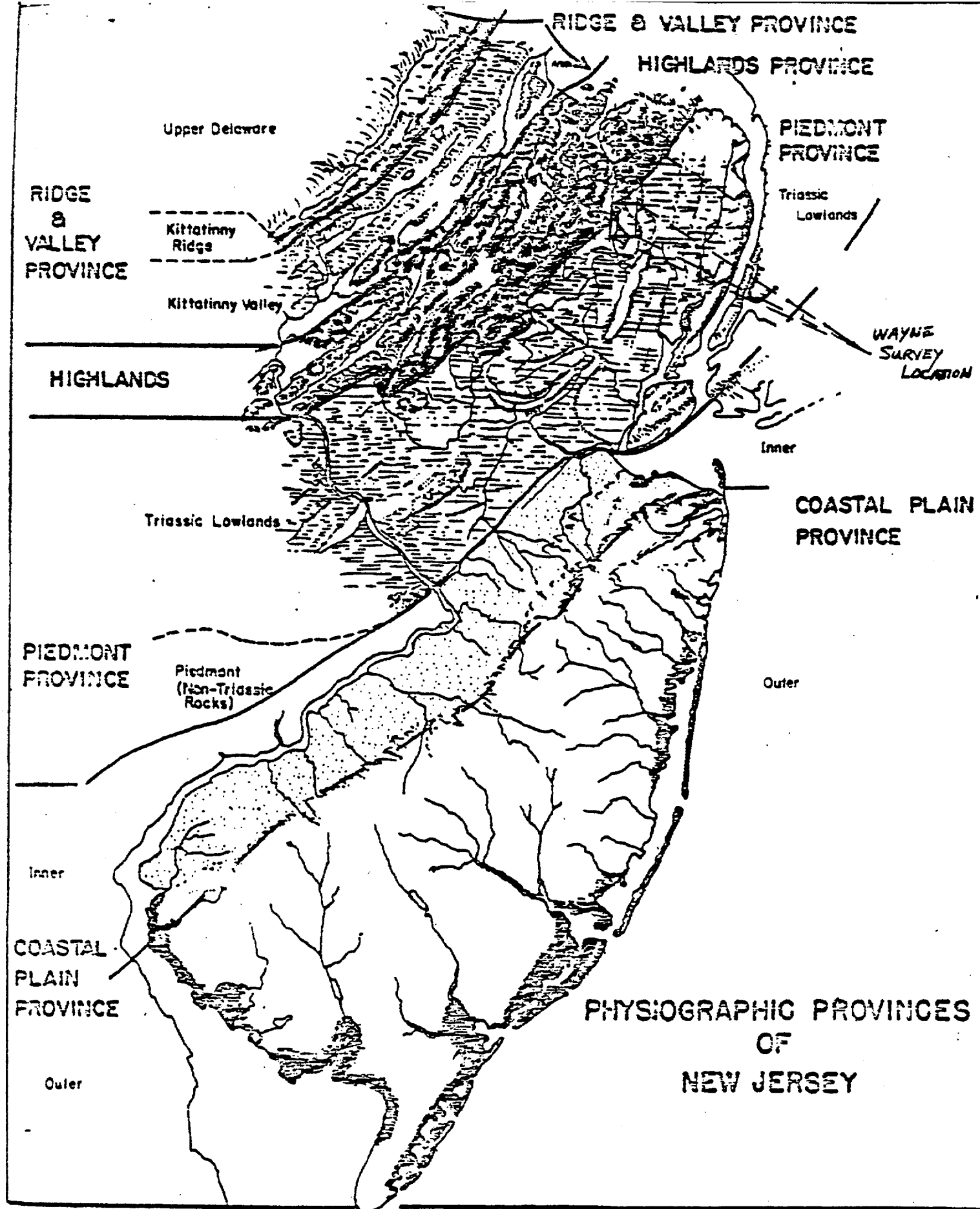


Fig. 2. Physiographic province map of New Jersey with location of Wayne survey location.



Approximate Scale: 1 inch ~ 2600 feet

Numbers indicate locations of samples analyzed by Oak Ridge National Laboratory (ORNL). See Table 4 for results.

*Areas where onsite radiological surveys have been conducted by Oak Ridge Associated Universities (ORAU).

Fig. 3. Detailed map of Wayne, New Jersey, and surrounding area.

Table 1. Listing of Wayne, New Jersey, vicinity properties recommended for comprehensive onsite surveys

Property Location	Property Description
Last house at the east end of Peck Avenue, north side of street (across from railroad tracks), Pompton Plains, New Jersey.	Residential property.
15 Peck Avenue, Pompton Plains, New Jersey, last house on East end of Peck Avenue, south side of street.	Residential property.
Reinhardt Road, Wayne, New Jersey.	Southwest lawn of Passaic Technical and Vocational School property. Approximately 200-m ² area of landscaped lawn at new building construction site (soil sample WNJ6).

Table 2. Listing of Wayne, New Jersey, vicinity properties which have been part of a previous radiological survey (Reference 1)

Property Location	Property Description
868 Black Oak Ridge Road.	Electro-Nucleonics, Inc. (Former W. R. Grace property).
East end of Peck Avenue, Pompton Plains, New Jersey.	Railroad tracks and abandoned earthen loading dock. ^a
South side of Pompton Plains Crossroad, Wayne, New Jersey.	Vacant land along Sheffield Brook.
21 Pompton Plains Crossroad, Wayne, New Jersey, southwest of W. R. Grace property across from Black Oak Ridge Road.	American Carving School (asphalt parking lot) and within ORAU survey area.

^aOnsite survey of this area has been completed and a report of results is presently in preparation by Oak Ridge Associated Universities (ORAU).

Table 3. Listing of Wayne, New Jersey, vicinity properties where excess thorium anomalies were found related to New Jersey Highlands granite or use of granites in asphalt or road base material

Property Location	Property Description
125 Hamburg Turnpike, Riverdale, New Jersey.	Riverdale Quarry Company, large "granite" quarry and asphalt paving contractor, northwest most EG&G "quarry anomaly" (samples WNJ1 and WNJ2).
West end of Broad Street, Pompton Lakes, New Jersey.	Passaic Crushed Stone Co., Inc., large "granite" quarry and paving contractor (EG&G "quarry anomaly").
Pierson Miller Lane, Pompton Lakes, New Jersey.	"Granite" outcrops along street (northeastern most EG&G anomaly area).
Southeast corner of Pompton Plains cross road and New Jersey Rt. 23, Pompton Plains, New Jersey.	Plains Plaza Shopping Mall, new asphalt at main entrance to mall off Rt. 23 (soil sample from planter at mall entrance WNJ5).
Longport Road from Haddon Road to Black Oak Ridge Road.	New asphalt on street.
827 Black Oak Ridge Road.	SFE Printed Circuit Compay (new asphalt parking lot).
West end of West Parkway, Pequannock, New Jersey.	Mountainside Park asphalt parking lot (sample WNJ4) also a background soil sample (WNJ3) was taken from the area south of the asphalt parking lot.
West Parkway, Pequannock, New Jersey.	General Foods Distribution Center, large new asphalt parking lot on south side of building.
Riverdale Road, Riverdale, New Jersey.	A&A Concrete Products Co., large asphalt parking lot and crushed rock "granite" yard area.

Table 3. Continued

Property Location	Property Description
11 Lucas Lane, Wayne, New Jersey.	Residential property with new asphalt driveway.
7 Lucas Lane.	Residential property with new asphalt driveway.
Northeast corner lot at Kurland Street and Ferrara Avenue, Mountain View area of Wayne (EG&G area west of Rt. 23).	Residential property with new asphalt driveway on crushed "granite" base fill material. Area also showed slightly depressed Ra/Th ratio, i.e., excess thorium, but not over statistical "hit" criteria.
New Jersey Rt. 23 at U.S. Hwy. 202, Mountain View, New Jersey.	New asphalt used for highway resurfacing presently under construction.

Table 4. Results of sample analyses from Wayne, New Jersey,
and surrounding communities

Sample Number	Location	Sample Description	Radionuclide Concentrations (pCi/g)			
			^{226}Ra	^{238}U	^{232}Th	^{40}K
WNJ1	Upper level of Riverdale Quarry, Riverdale, New Jersey.	Granitic rock frag- ments insitu.	2.9	3.4	8.6	38
WNJ2	Lower level of Riverdale Quarry, Riverdale, New Jersey.	Crushed granitic rock from aggregate stockpile.	2.6	3.5	8.1	34
WNJ3	Mountainside Park, Pequannock, New Jersey.	Sandy glacial soil from area south of parking lot.	0.46	0.5	0.8	16
WNJ4	Mountainside Park, Pequannock, New Jersey.	Asphalt from parking lot.	0.48	0.53	3.7	30
WNJ5	Plains Plaza, Pomp- ton Plains, New Jersey.	Soil from flower planter at Rt. 23 entrance to shopping mall.	0.53	0.67	0.39	6.8
WNJ6	Passaic County Technical and Voca- tional School, Reinhardt Road, Wayne, New Jersey.	Soil from landscaped lawn area on southeast side of Reinhardt Road at the southwestern- most building on the school property.	4.7	3.5	40	10