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SUMMARY OF ENVIRONMENTAL CONTAMINATION INCIDENTS AT HANFORD 1952 - 1957

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HANFORD LABORATORIES OPERATION

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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SUMMARY OF ENVIRONMENTAL CONTAMINATION INCIDENTS AT HANFORD, 1952 - 1957

I. INTRODUCTION

This reports was written to provide a summary of information on incidents, which have resulted in ground deposition of radioactive materials at Hanford. An effort was made to include all incidents of possible interest which occurred between December, 1951, and December, 1957. The information was obtained from monitoring reports, maps, and incident investigation reports.

II. ABSTRACT

100 Areas

Six of eleven incidents reported for the 100 Areas from 1954 to 1957 were the result of an overflow, break, or dryout at a basin. Dryouts led to the spread of contamination several miles downwind, while only a localized area was contaminated from a break or overflow. Four stack emissions reported here resulted from a ruptured or burning fuel element. The escaping activity in each case represented only a small fraction of the fuel element.

200 Areas

The 200 Area incidents reported are either stack emissions or the spread of contamination from a burial ground. The major problem, a series of significant ruthenium emissions from Redox, occurred from March, 1952, through 1954. Two emissions from other stacks resulted in only localized contamination. A number of instances of contamination spread from a burial ground have been recorded over the past several years. However, only three were felt to be significant enough to include in this report.

Miscellaneous Incidents

Two 300 Area burial ground fires, a fire in a research facility, and a uranium spill from an overturned tank truck are reported. Only localized contamination resulted from these four incidents.

III. TERMINOLOGY

Survey results were reported in terms of particle frequencies and radiation instrument readings. Portable GM Meter readings were recorded in units of counts per minute (c/m) per particle. GM meter response for energy ranges involved in this report was approximately 100 c/m per 5000 disintegrations per minute.

Instrument readings in units of mrad/hr per particle were obtained with Hanford type "C.P." meters. These were uncorrected surface readings, taken under field conditions, and do not represent true dosage rates.

The term "filterable gross beta", as used in this report, refers to beta particle emitters collected by drawing stack effluents through asbestos filter paper.

The reactor buildings at Hanford are designated 105, and in this report, the ventilation air exhaust stacks for these buildings are referred to as 105 stacks. The 107 basins are retention basins for reactor effluent cooling water.

IV. DISCUSSION

A. 100 Area Incidents

1. 107-B Basin

During February, 1954, a break occurred in the 107-B basin. A survey on February 25, of the area around the basin covered with water, disclosed a variation in readings from several hundred c/m to 13 mrad/hr. The amount of radioactive material in the water was comparable to that in normal reactor effluent water; beta radioactivity of the mud was 10^{-4} to 10^{-2} μc/gm. The contamination was confined to the immediate vicinity of the 107-B basin.

2. 107-C Basin

The 107-C basin was emptied overnight, March 10-11, 1954, to facilitate repairs. Extensive surveys of 100-B Area were made on March 25 and 26, following the discovery of ground contamination near the gatehouse on March 20. Widespread particulate contamination, covering 20 percent of 100-B Area, was found around the 107-C basin (Figure 1). The particles varied from a few hundred c/m to 50 mrad/hr inside the perimeter fence. No particles greater than 10 mrad/hr were found outside of the 100-B Area. Analysis of particulates indicated 30 percent rare earths plus yttrium, 5 percent $Ru^{103-106}$, and traces of Sr, U, and Pu.

3. 107-F Basin

Baffles in the 107-F basin broke loose and plugged the basin outlet on May 23, 1955. The overflow of the 107 water contaminated the immediate vicinity of the basin and a narrow path between the basin and the river (Figure 2). There was general contamination from 20,000 to 60,000 c/m, with a maximum of 350 mrad/hr. One of the baffle boards carried out by the water, read 14 rad/hr. Gamma spectrometer analysis of a chip from this board showed a high percentage of Sc^{46}, with some Cr^{51}.

4. 105-H Stack

The 105-H stack emitted about 0.06 curie of filterable gross beta (calculated from ground deposition) on May 3, 1955, when two ruptured slugs were removed from the reactor. However, the emission was unnoticed until general contamination was found in the fan cells. A spot check was then made of the 100-H Area, and the few particles detected were thought to be from previous emissions. On May 25 and 26, after analysis of the particulates indicated the presence of short-lived isotopes, an extensive ground survey was made. Ground contamination was located in the northwest corner of 100-H Area, with concentrations as high as 20 particles per 100 square feet (Figure 3). The Meteorology Tower reported a wind from the northwest during the time of the stack emission; however, during periods of light winds, 100-H Area frequently experiences a different wind direction than is recorded at Meteorology. Six particles were detected in 10,000 square feet surveyed along the Wahluke Slope road opposite 100-H Area.

5. 105-H Stack

Another emission from the 105-H stack occurred on November 1, 1955, while a ruptured slug burned briefly during discharge from the reactor. Approximately 0.8 curie of filterable gross beta, mostly barium and rare earths plus yttrium, was emitted from the stack. An estimated 1,000 to 2,000 curies of radioactive material were released

5. 105-H Stack - contd

to the effluent water retention basins as a result of this incident. The south one-third portion of the 100-H Area was found contaminated with concentrations as high as 12 particles per 100 square feet (Figure 4). The contamination level was 1,000 to 10,000 c/m, with isolated particles as high as 100 mrad/hr. One particle, found near the 100-H Gatehouse, had a dose rate of 700 mrad/hr. The contamination was found to have spread south of 100-H Area, covering an area of approximately seven square miles (Figure 5).

6. 107-H Trench

Swallows were discovered making nests out of contaminated mud taken from the 107-H crib trench, after isolated cases of personnel and vehicle contamination were detected on May 15, 1956. The contaminated mud was being dropped around the 100-H water towers and at scattered locations over the flight path to the "white bluffs" across the river (Figure 6). Concentrations ranged from 0 to 6 particles per 100 square feet, with a maximum reading of 150 mrad/hr. This is the only documented occurrence of this nature found; however, spread of contamination by swallows is an annual problem.

7. 105-C Stack

A stack emission occurred at 105-C on September 17, 1956, when a slug burned for six minutes at the reactor discharge face. Maximum ground contamination of 5 particles per 100 square feet was found in a small area between the 105-C stack and the south fence of 100-B Area (Figure 7). Contamination levels were 5,000 to 30,000 c/m, with a maximum reading of 350 mrad/hr from one particle. The particulate contamination was primarily Np^{239}, with a small amount of mixed fission products.

8. 107-D Basin

The water level in the 107-D basin was lowered in February, 1957, so that work could be performed by Minor Construction forces. The basin became dry on February 21, and strong winds spread contamination to the surrounding ground. Concentrations inside the 100-D Area were 0 to 8 particles per 100 square feet, with a maximum reading of 40 mrad/hr. (Figure 8). No significant contamination was found outside of the 100-D Area or on Wahluke Slope.

9. 105-C Stack

A rupture of a special fuel element occurred at 105-C on March 23, 1957. After the fuel element was removed from the reactor, dosage rates from 30 to 200 mrad/hr were observed in adjacent buildings. Surveys revealed a maximum field reading of 800 mrad/hr outside the 105-C Building. These readings, due primarily to radioactive noble gases, were back to normal in approximately two hours. Radioactive noble gases have been detected around reactor buildings a number of times; however, the dosage rates reported above were the highest observed.

10. 107-C Basin

The 107-C basin was allowed to dry in early April, 1957, so that repair work could be completed. Contamination was blown out of the basin at some later date, and was first detected on the ground April 22. A survey of 100-B Area disclosed ground contamination

10. 107-C Basin - contd

from 5,000 to 10,000 c/m in a fan-shaped area extending from the 107-C basins toward the east perimeter fence. The edge of the contaminated area crossed the area fence at points 100 yards south and 300 yards north of the gatehouse. The frequency ranged from 7 particles per 1000 square feet, one mile east of the badgehouse, to 0 particle per 1000 square feet, six miles east of 100-B Area. the readings were from 5,000 to > 80,000 c/m, with a maximum of 50 mrad/hr. A high wind occurred later in the week and the area was re-surveyed on May 2, 3, and 6. Most of the contamination shifted to the northeast section of 100-B Area where frequencies ranged from < 10 particles per 100 square feet to 150 particles per 100 square feet (Figure 9). A majority of the particles were < 5,000 c/m, with very few active enough to read on a dose rate instrument.

11. 105-C Stack

On September 27, 1957, the 105-C stack emitted an estimated 4 curies of filterable gross beta when a ruptured slug burned for ten minutes at the reactor discharge face. Some locations in the 105-C Building were contaminated to a maximum of 500 rad/hr at a few inches; however, no deposition of radioactivity on the ground outside 105-C Exclusion Area was found. The detection of particulate contamination was hampered by rain and fallout from bomb tests.

12. 107-C Basin

A number of people working near the 107-C basin on December 6, 1957, were found to have contaminated clothing. Winds as high as 37 mph had occurred during the day while the basin was dry for repair. A survey in 100-B Area on December 7, revealed general contamination of 2,000 to 6,000 c/m in a fan-shaped area to the east and southeast of the basin, with a maximum of 65 mrad/hr. During the week beginning December 9, surveys of the area surrounding 100-B Area revealed a contaminated zone of 1 to 3 particles per 100 square feet between the northeast corner of the area and the river (Figure 10). Only two particles were detected across the river during numerous surveys.

B. 200 Area Incidents

1. Redox Stack Emissions

This section is a brief review of surveys performed to define ground contamination resulting from Redox stack emissions. No attempt was made to include an evaluation of the hazards from radioactive ruthenium particles. Several reports covering experimental work with ruthenium particles are included in the bibliography (1-11). Correlation between instrument readings and radioactive ruthenium content of particles was obtained in the laboratory. "C.P." meter readings of isolated particles were approximately 200 mrad/hr per microcurie. This ratio was useful in estimating ground deposition from field readings.

Operation of the Redox facility was started in January, 1952, and by March of that year, ruthenium emission problems had developed. High levels of air contamination were noticed in the Redox Area on March 8, 1952. Subsequent investigation revealed that off-gas clean-up equipment was not functioning properly, and greater quantities of radio-ruthenium than anticipated, were being released from the stack. Air concentrations were back to normal within a few hours and there was no indication of ground contamination.

1. Redox Stack Emissions - contd

Shoe contamination at Redox on April 29 lead to the discovery of spots of contamination outside of the building. Surveys on May 2 and 3 revealed an area 1000 feet x 1500 feet around the Redox stack which had concentrations of 200 to 400 particles per 100 square feet (Figure 11). Readings of radioactive particles ranged from 200 c/m to a maximum of 800 mrad/hr inside of the Redox Area. Outside of this area, concentrations of 100 to 200 particles per 100 square feet, with readings of 200 to 1000 c/m were found. The ruthenium contamination was found to be closely associated with ammonium nitrate crystals.

The Redox stack sample removed on May 24, 1952, was found to contain unusually large amounts of radioactive material. Surveys, downwind and just outside of the Redox Area, revealed small white flakes at a frequency of 30 to 300 per 100 square feet (Figure 12). These particles ranged from 1 to 600 mrad/hr, with an isolated maximum of 4 rad/hr. Laboratory analysis revealed the particles were predominantly ammonium nitrate containing small amounts of Ru^{103} and Ru^{106}.

The daily emission of ruthenium from the Redox stack remained low from August, 1952, until April, 1953 (Table I). Surveys in March and April revealed a maximum ground contamination of 25 mrad/hr in the vicinity of Redox stack (Figure 13). Ruthenium emission steadily increased throughout August. On August 14, 1953, routine ground surveys revealed the presence of large flakes, several inches in length and width and up to 3/4 inch thick, in a pattern extending in a southeast direction from the stack. Laboratory analyses indicated the bulk of the material was ammonium nitrate and the radioactivity was due primarily to ruthenium. Concentrations of 200 to 400 particles per 100 square feet, reading from 100 to 600 mrad/hr, were found on the east side of Redox and around the stack. Readings on the roads, east and southeast of the stack, were from 1,000 to 8,000 c/m. Re-surveys on August 17 and 18 were necessary because of continued emission. Results showed readings up to 20 rad/hr around the stack, and 1,000 c/m to 20 mrad/hr on the roads east and southeast of Redox (Figure 14).

The average stack emission (Table I) in September, 1953, increased when 5.3, 5.2, 5.4, 34, 84, and 3.1 curies of ruthenium per day were emitted on September 2, 3, 4, 5, 6, and 7, respectively. During September, surveys of areas downwind from Redox revealed no appreciable amounts of ground contamination. Ruthenium emission decreased after September, and remained low until January, 1954. Wide-spread contamination of HAPO and environs resulted from the emission of approximately 230 curies from the Redox stack during the period January 2 to 3, 1954. Surveys on the third of January revealed extensive local ground contamination and, by early January 4, contamination had been found extending considerably beyond the local area. Surveying and sampling of vegetation was performed as far north as Spokane, Washington. Highest vegetation contamination detected outside of the project boundary was 10^{-2} μc Ru per gram of vegetation (Figure 15). Normally, off-project vegetation contains 10^{-5} to 10^{-4} μc of beta emitters per gram of vegetation.

TABLE I

REDOX STACK EMISSION
APRIL, 1952 - DECEMBER, 1953

Month	Average Curies/day	Maximum Curies/day
April, 1952	0.01	0.95
May	0.2 *	> > 0.07 **
June	0.2	1.7
July	0.6	4.1
August	0.06	0.3
September	0.07	0.58
October	0.07	0.58
November	0.09	0.36
December	0.02	0.55
January, 1953	0.01	0.05
February	0.01	0.02
March	0.01	0.02
April	0.02	0.09
May	0.4	1.3
June	0.2	3.1
July	0.7	3.0
August	0.8 *	> > 3.0 **
September	6.0	84
October	1.0	3.2
November	0.1	0.44
December	1.0	1.8

* Average does not include samples not analyzed.

** Maximum sample contained too much activity to permit analysis.

1. Redox Stack Emissions - contd

As ground surveys progressed through January 5 and 6, additional deposition was observed, indicating a new emission (Figure 16). Analysis of stack samples revealed that approximately 70 curies of ruthenium were emitted between January 5 and 6. Readings on radioactive particles inside of 200 West Area were from 100 to 500 mrad/hr, with a maximum of 1.3 rad/hr; readings of 5,000 c/m were found on Wahluke Slope. Re-surveys of 200 West Area in February, March, and May, 1954, (Figures 17 through 20) traced the decrease in ground contamination.

Forty curies of ruthenium (calculated from ground deposition) emitted from the Redox stack on May 24, 1954, traveled in the direction of 100-B Area. Particle frequencies in the path were 25 to 1000 particles per 100 square feet inside of 200 West Area, and 30 particles per 100 square feet in 100-B Area. The maximum readings on particles were 15 rad/hr in 200 West Area, 1.6 rad/hr in 100-B Area, and 250 mrad/hr on Wahluke Slope. Surveys in late May and early June showed extensive contamination between 200 West Area and 100-B Area, and also indicated a contamination spread from this or previous emissions toward 200 East Area (Figure 21). An average of 2 particles per 100 square feet was found in 200 East Area, with an isolated maximum reading of 2 rad/hr.

Because of wide-spread ground contamination from the previous Redox emissions, extensive surveys of the entire project and the surrounding country were performed from June to September, 1954. Only four particles were found in a casual survey of 50,000 square feet of the 100-K Construction Area. Surveys around the buildings and main roads in 100-H Area disclosed 74 particles, with readings from 2,000 c/m to 250 mrad/hr. A total of 14 particles were found in two surveys performed in 100-D Area, with a maximum reading of 200 mrad/hr. A survey of the entire 300 Area revealed an average of 0.1 particle per 1000 square feet, with readings from 500 c/m to 500 mrad/hr. Army camp surveys showed frequencies of 0.2 to 1.0 particle per 1000 square feet, with a maximum reading of 310 mrad/hr. A total of 45 particles were found in a survey of 114,000 square feet of the 700 Area. An average of 1 particle per 1000 square feet was found in surveying 20,000 square feet of school lawns in Richland. Particle frequencies ranged from 0.05 to 0.1 particle per 1000 square feet in North Richland. A survey of five orchards just west of the project, near Midway, showed there were approximately 127 particles in 8×10^6 square feet. Twelve orchards east of the project, near Ringold, had approximately 300 particles in 8×10^6 square feet. Only one particle of a few hundred c/m was found in surveys of each peach in a ton of peaches purchased from a Ringold orchard. Sixty-four particles were located in a survey of 107,000 square feet of Wahluke Slope. The maximum frequency was 10 particles per 1000 square feet, and the maximum reading was 1.5 rad/hr.

Surveys of 1000 square feet at 0.1 mile intervals along the road from Pasco to Ringold were performed. Fifty-four particles were found in the 414,000 square feet surveyed. Surveys of 1000 square feet at five mile intervals were made along highways between Wallula, Washington; Lewiston, Idaho; LaGrande, Oregon; Baker, Oregon; Pendleton, Oregon; and back to Wallula. Only five particles were found with a maximum reading of 500 mrad/hr. A re-survey of 200 West in November, 1954, and of 200 East Area in January, 1955, revealed little change in particle frequency from those found in previous surveys (Figures 22 and 23).

A series of locations selected in mid-1954 were used to obtain reproducible particle survey data for the entire project. Results of monthly surveys at these locations are shown in Figures 24 through 37. Trends in particle data, evident from these maps, are shown graphically in Figure 38. Increased particle deposition from other incidents is indicated by irregularities in the latter portion of the curve.

[redacted]

2. Other 200 Area Incidents

A fire occurred in the 200 West Area dry waste burial ground on July 9, 1952. Surveys after the fire did not reveal any contamination spread to personnel or equipment; however, appreciable alpha contamination was found on the ground (Figure 39). The maximum reading was 200,000 disintegrations per minute in the burial ground and 30,000 disintegrations per minute outside the burial ground. The affected areas were either hosed down in an attempt to settle and fix the contamination, or the contamination was removed. There was no significant spread of contamination outside of the areas shown on the map.

A spread of ruthenium contamination occurred at the burial ground in 200 West Area on January 27, 1956, when a wooden box containing contaminated equipment collapsed during burial. The contamination was undetected at the burial ground because of the high background; however, a gamma scan of air filters in 200 East and West Areas revealed the presence of ruthenium contamination.

Ground surveys were performed near U-plant on June 4, 1956, following the discovery of large radioactive flakes of paint (1/4" to 18" long, by several inches wide). Readings of 40,000 c/m to 450 mrad/hr were observed, with a maximum frequency of 100 particles per 100 square feet (Figure 40). The paint apparently flaked off of duct work in the U-plant ventilation system downstream from the sand filter.

After several occurrences of shoe contamination, follow-up surveys on July 4, 1957, revealed depositions of radioactive particles outside of the Purex Building. Ground contamination, apparently from the Purex stack, extended 1500 feet north and northwest of the stack. The readings in the contaminated area ranged from 2,000 to 20,000 c/m, with a maximum reading of 430 mrad/hr near the stack.

Approximately four square miles, in and around the 200 West Area, were contaminated with ruthenium following the burial of grossly contaminated equipment on November 6, 1957. Extensive surveys revealed frequencies from 5 to 100 particles per square feet. A majority of the readings were from 10,000 to > 80,000 c/m, with a maximum of 1100 mrad/hr (Figure 41). Since there was no wind during the burial, it is thought that thermal convection currents initiated the release of ruthenium. High winds on following days were responsible for extensive spread of the contamination.

3. Miscellaneous Incidents

A fire occurred in the contaminated waste storage area of a remotely located research facility on December 4, 1951. [12,13] The fire spread to the chemical laboratory and exhaust filters before it was extinguished. An estimated one to four grams of plutonium contamination was confined to the immediate vicinity of the research laboratory. Contaminated ground was covered with sand to prevent the spread of plutonium by the wind. Vegetation samples, collected around the facility, contained $< 4 \times 10^{-7}$ μc of plutonium per gram of vegetation. These results were below the level then existing in the vicinity of the 200 Areas.

A fire occurred in the 300 Area solid waste burial ground on February 17, 1954. One small area, immediately east of and up to 20 feet from the burial ground fence, contained widely scattered contamination from 2,000 c/m to 300 mrad/hr.

3. Miscellaneous Incidents - contd

A uranium solution spill occurred on December 30, 1954, when a tank truck overturned. General contamination of 60 mrad/hr was found on the road and shoulder. Readings were reduced to a maximum of 20,000 c/m by adding a thin layer of blacktop to the road and covering the shoulder with dirt.

A fire in the 300 North Burial Ground on August 16, 1955, caused particulate matter to be spread out to 1500 feet from the burial ground in a northeast direction. Particle frequencies ranged from 0.5 per 100 square feet to > 4 per 100 square feet. Instrument readings were from 35,000 to > 80,000 c/m, with an isolated maximum of 4.5 rad/hr.

IV. ACKNOWLEDGEMENTS

Extensive use was made of monthly and quarterly reports of Regional Monitoring Operation, Hanford Laboratories Operation. The Radiation Incident Investigation Files, maintained by Radiation Protection Operation, Hanford Laboratories Operation, were reviewed for supplementary data.

The authors wish to acknowledge the cooperation of B. V. Andersen, H. E. Book, J. W. Healy, J. M. Prewett, H. F. Soule, R. E. Trumble, and R. H. Wilson during the preparation of this report.

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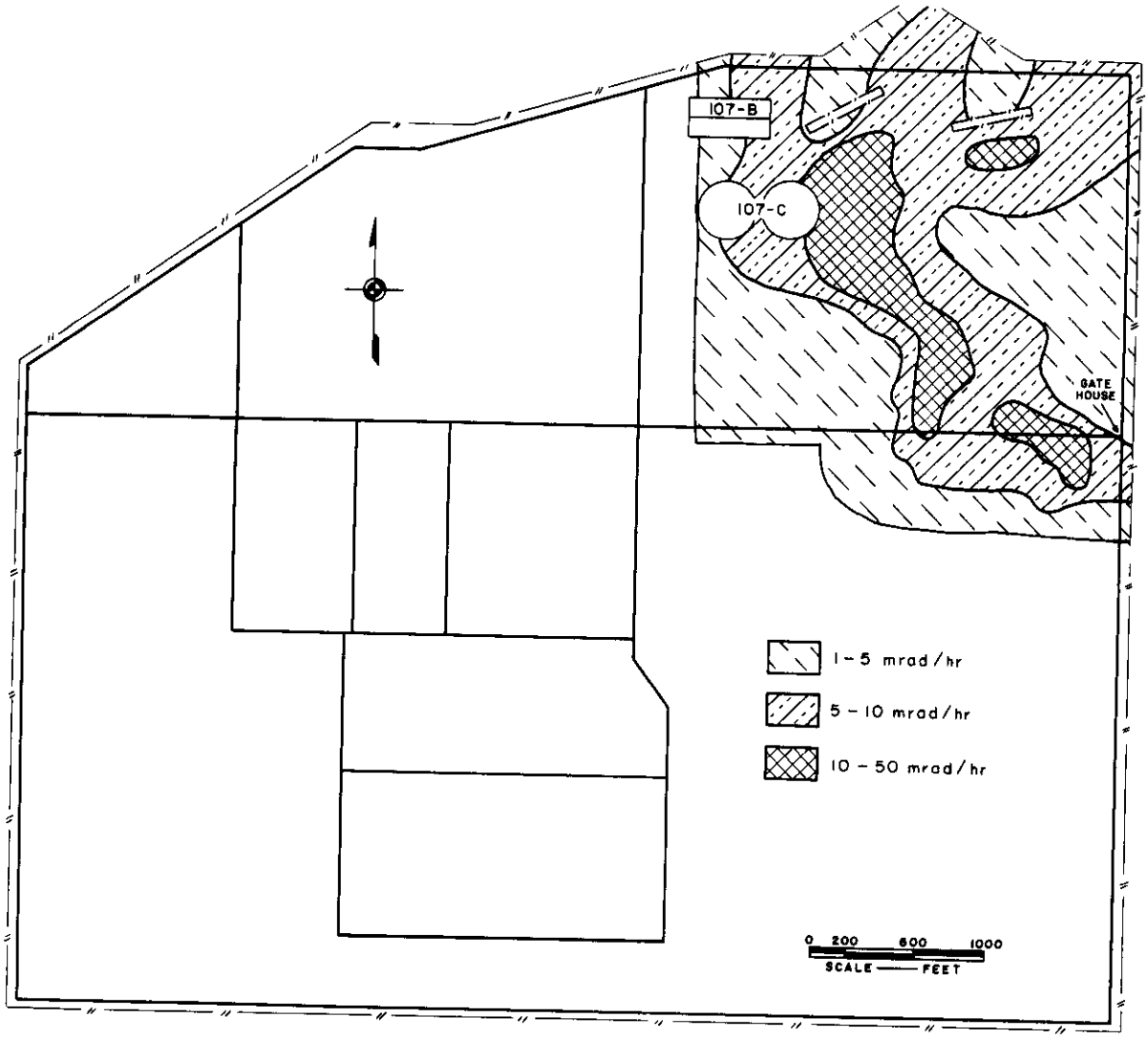

FIGURE – 1
GROUND CONTAMINATION PATTERN
100 – B
MARCH 26, 1954

AEC-GE RICHLAND, WASH.

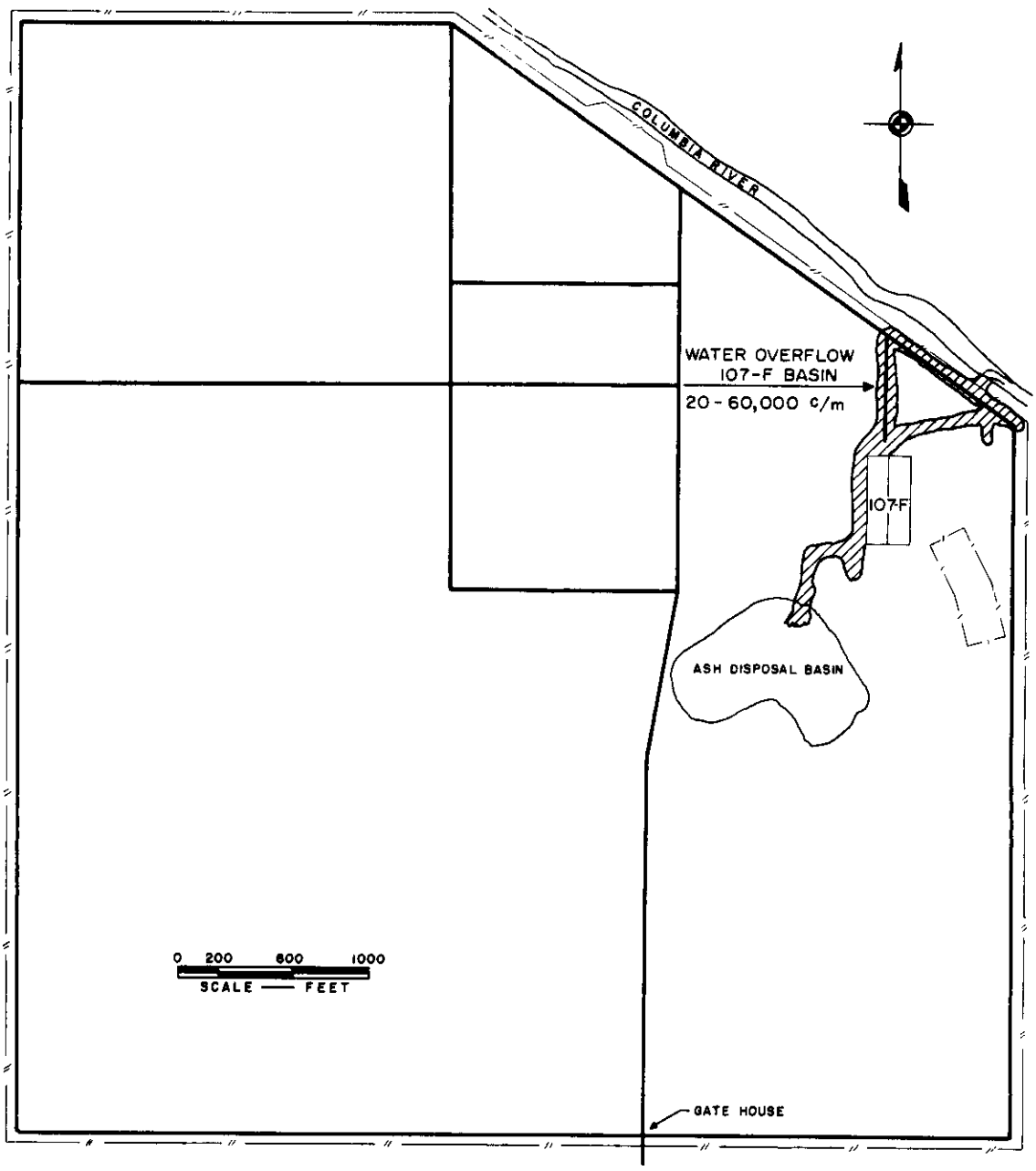

FIGURE - 2
GROUND CONTAMINATION PATTERN
100 - F
MAY 23, 1955

AEC-GE RICHLAND, WASH.

[redacted]

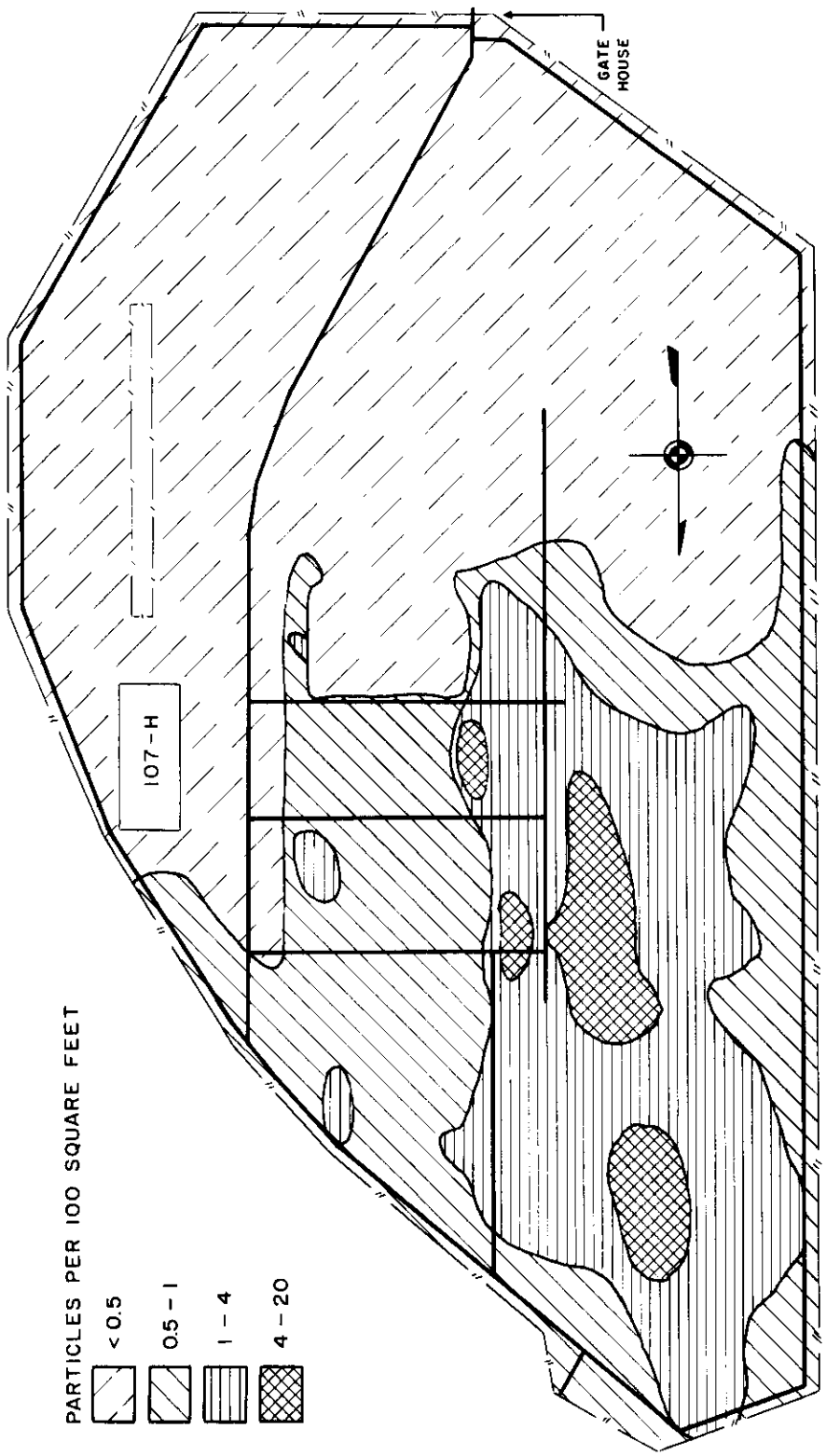

FIGURE - 3
GROUND CONTAMINATION PATTERN
100 - H
MAY 26, 1955

AEC-GE RICHLAND, WASH.

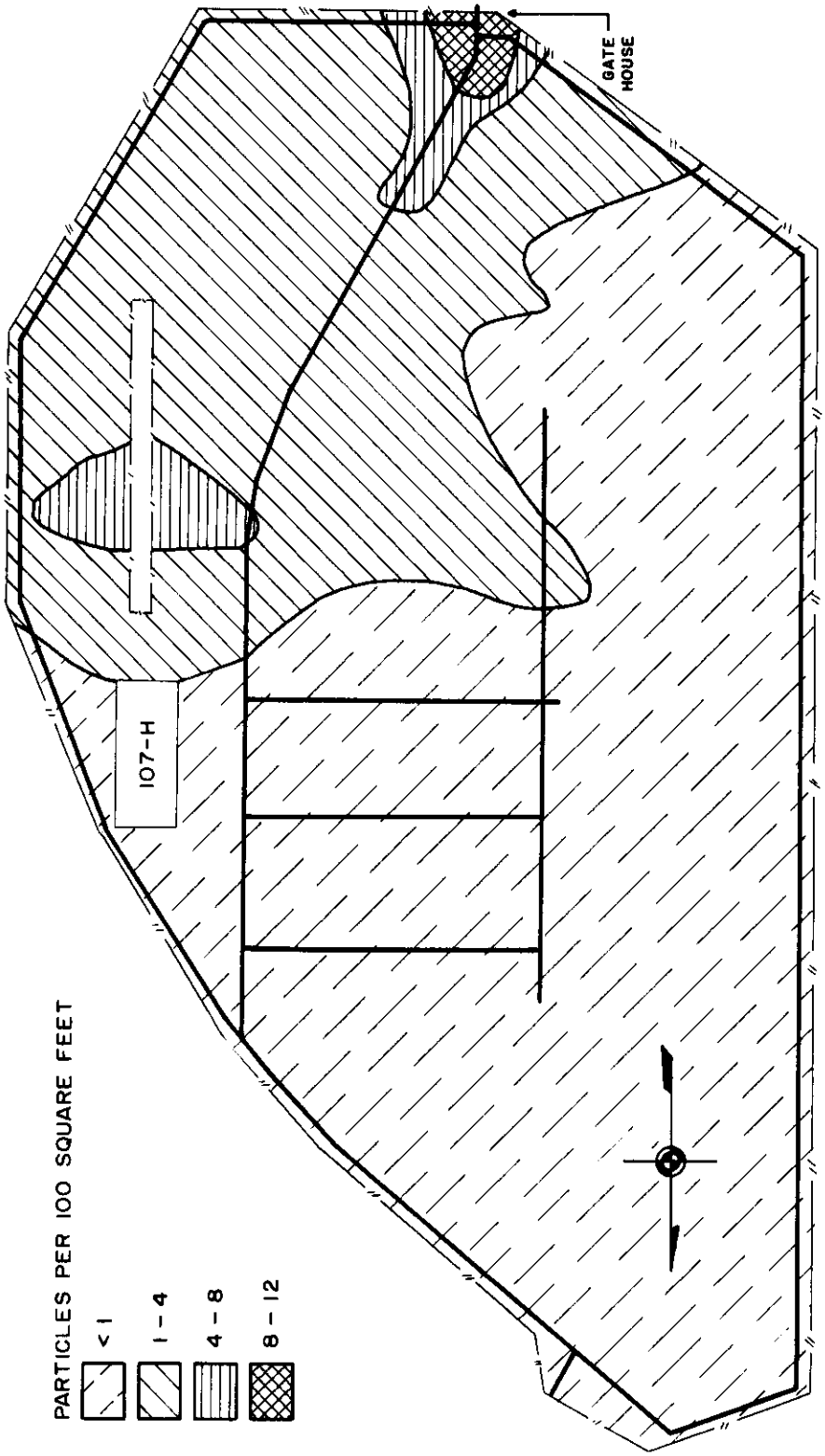

FIGURE - 4
GROUND CONTAMINATION PATTERN
100 - H
NOVEMBER 1-5, 1955

AEC-GE RICHLAND, WASH.

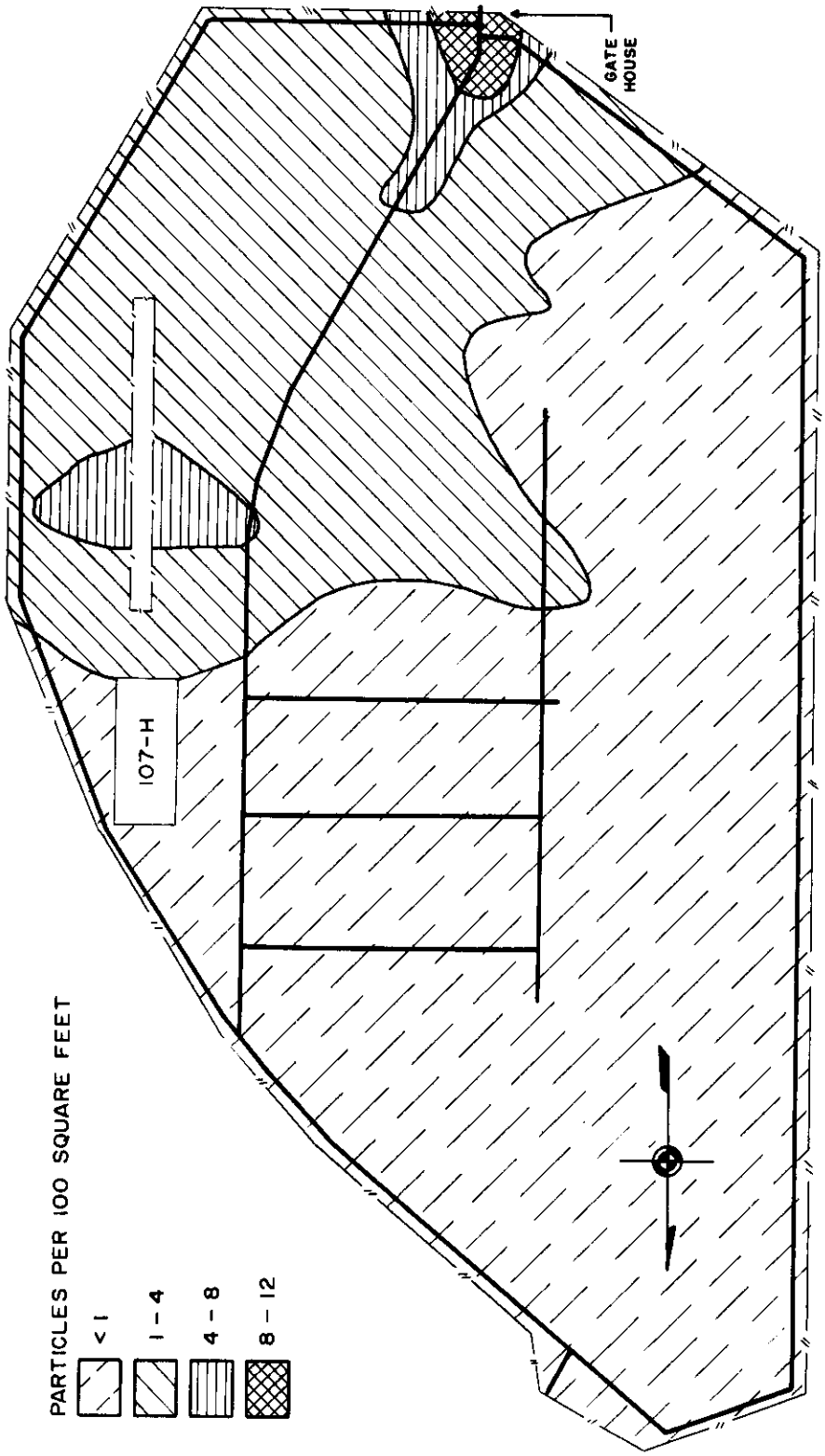

FIGURE - 4
GROUND CONTAMINATION PATTERN
100 - H
NOVEMBER 1-5, 1955

AEC-GE RICHLAND, WASH.

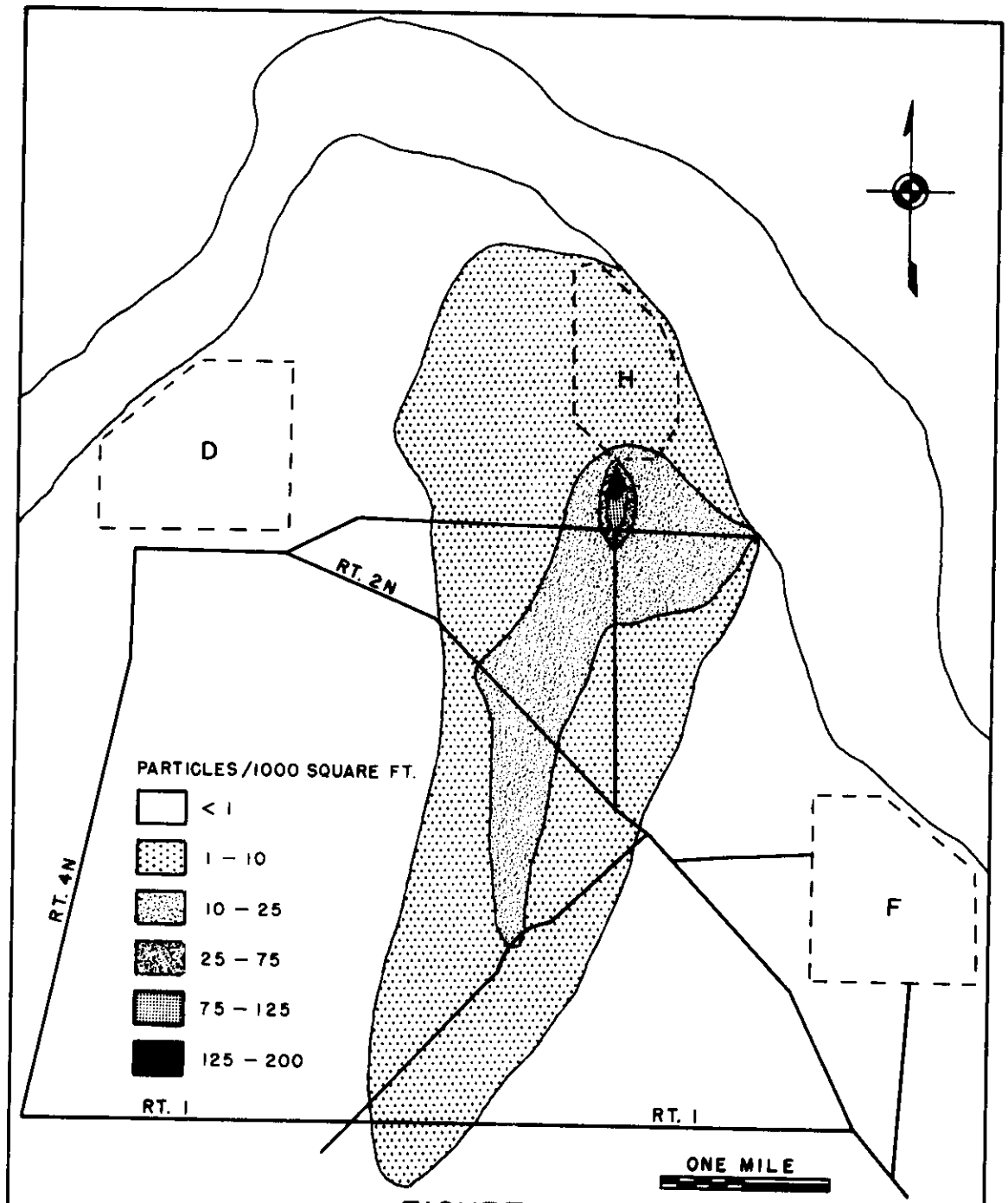

FIGURE - 5
GROUND CONTAMINATION PATTERN
100-H AND VICINITY
NOVEMBER 1-5, 1955

AEC-GE RICHLAND, WASH.

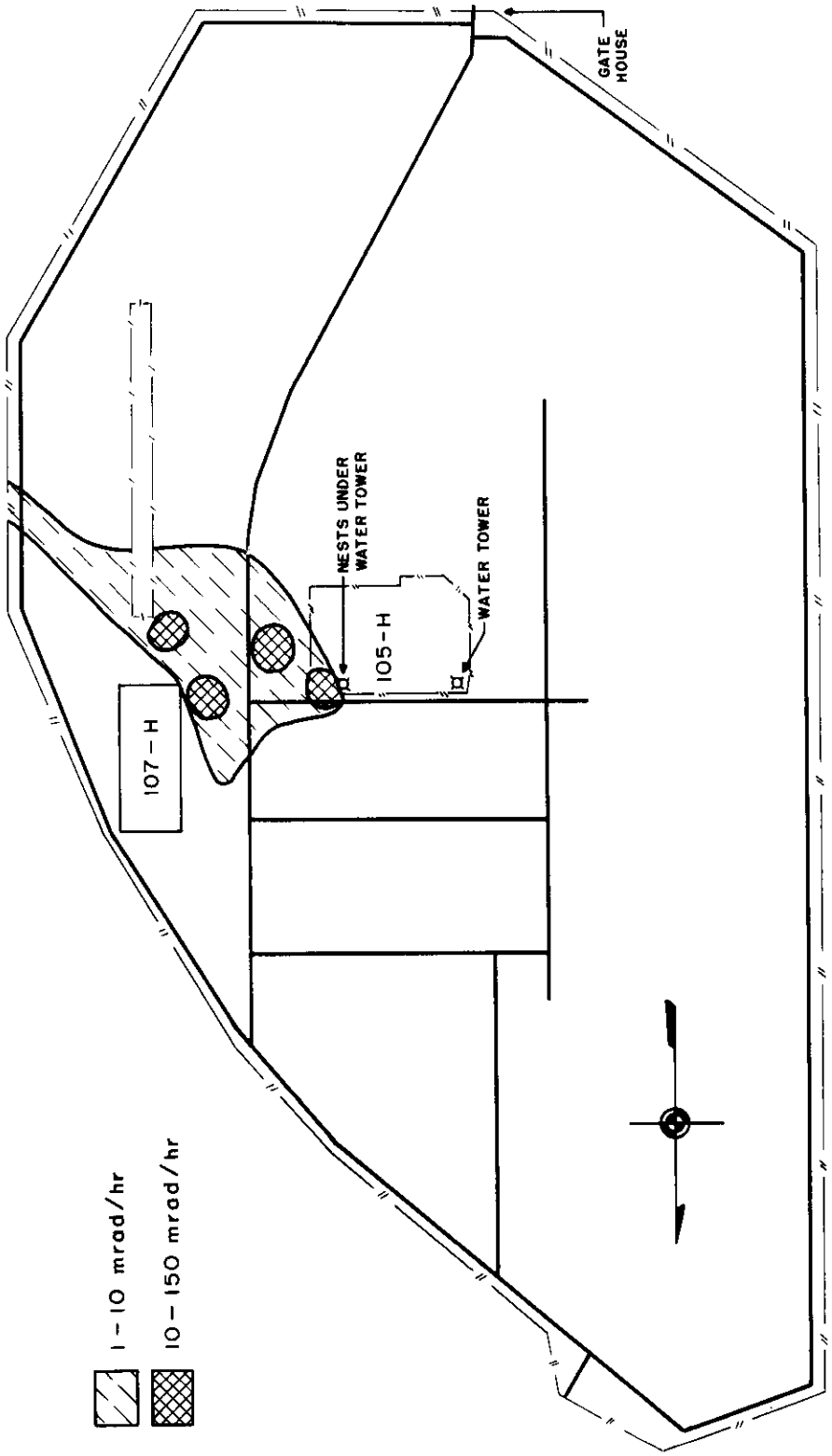

FIGURE - 6
GROUND CONTAMINATION PATTERN
100 - H
MAY 15, 1956

AEC-GE RICHLAND, WASH.

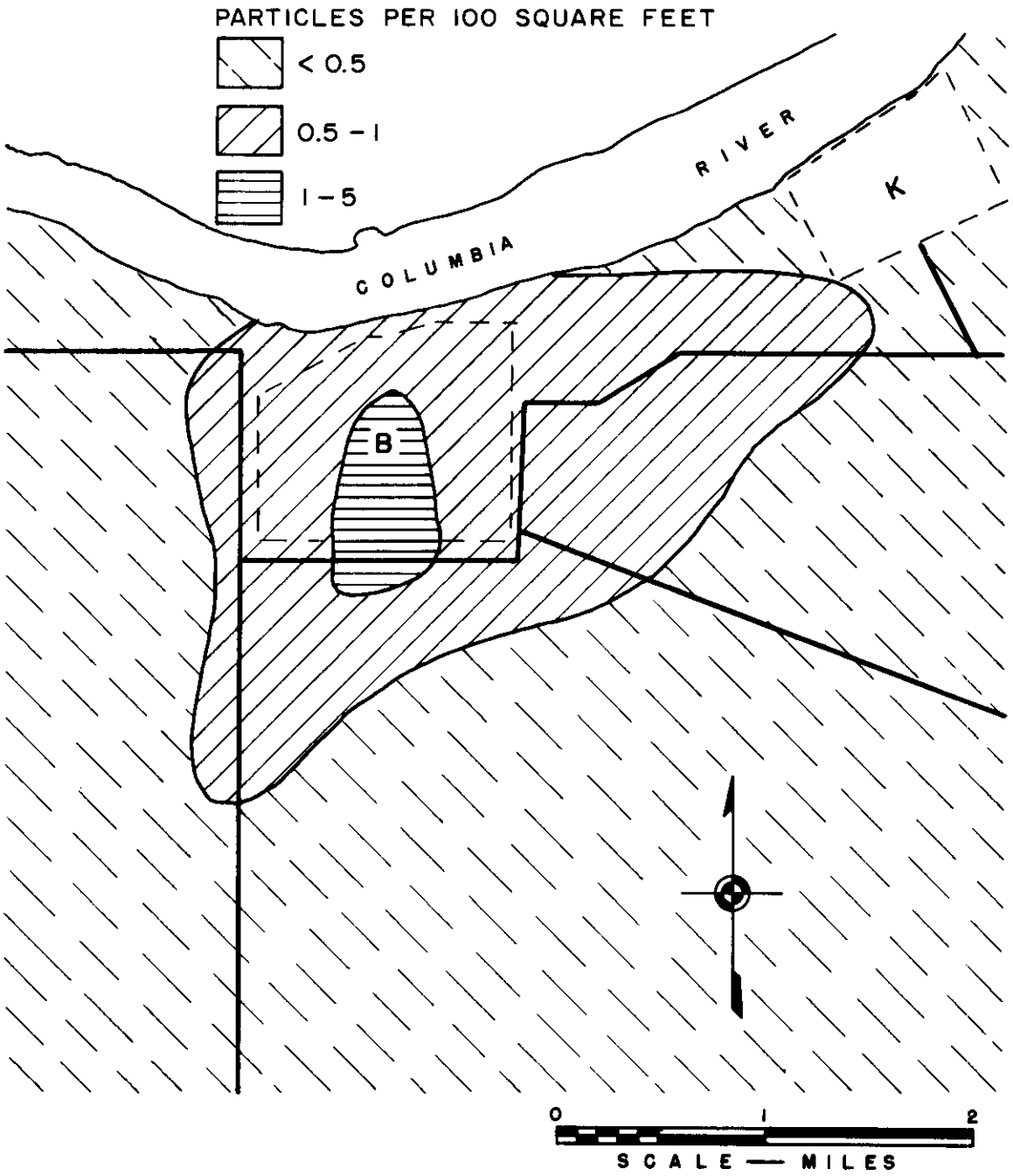

FIGURE - 7
GROUND CONTAMINATION PATTERN
100-B AND VICINITY
SEPTEMBER 18, 1956

AEC-GE RICHLAND, WASH.

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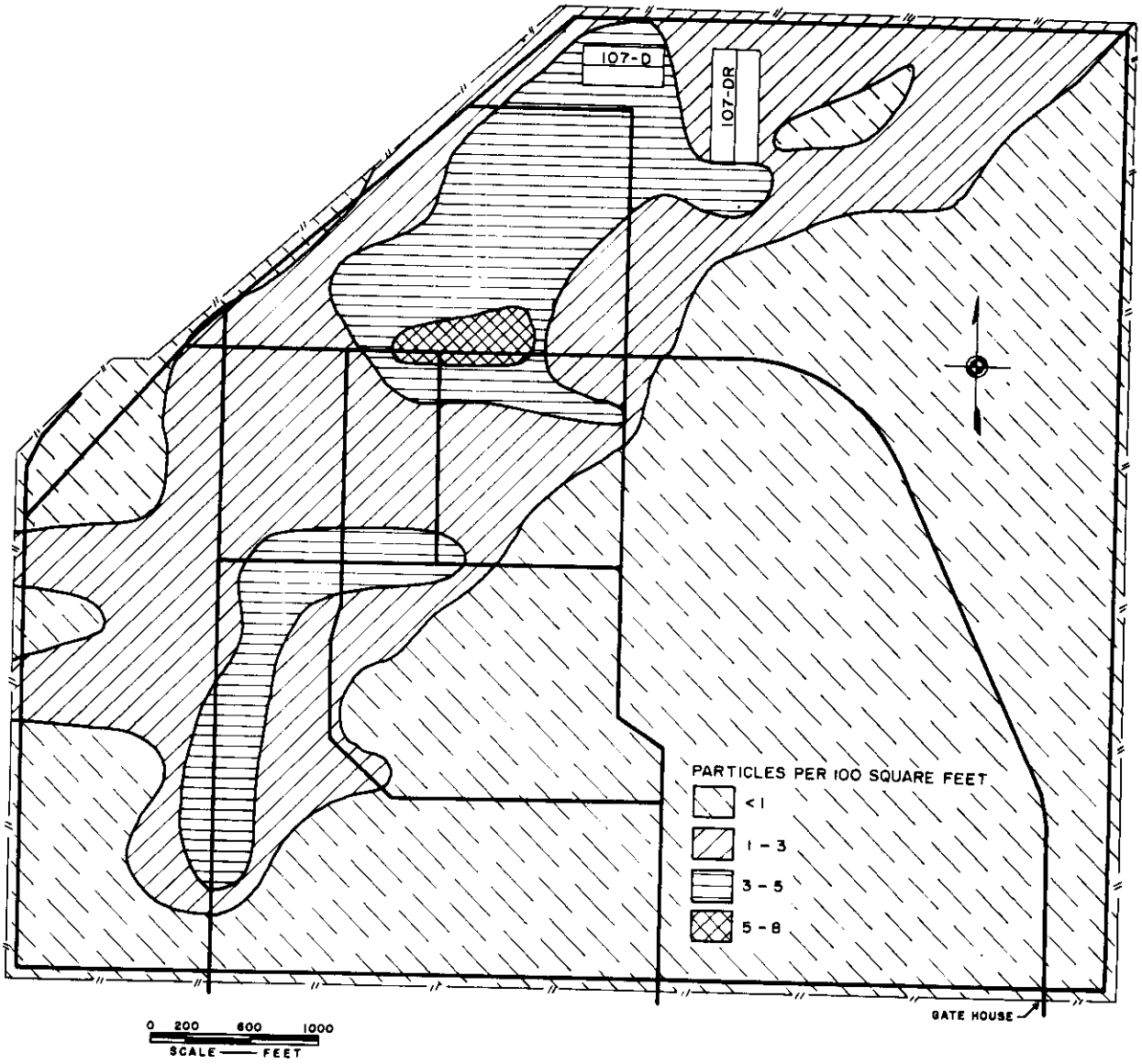


FIGURE - 8
GROUND CONTAMINATION PATTERN
100 - D
FEBRUARY 25, 1957

AEC-GE RICHLAND, WASH.

[redacted]

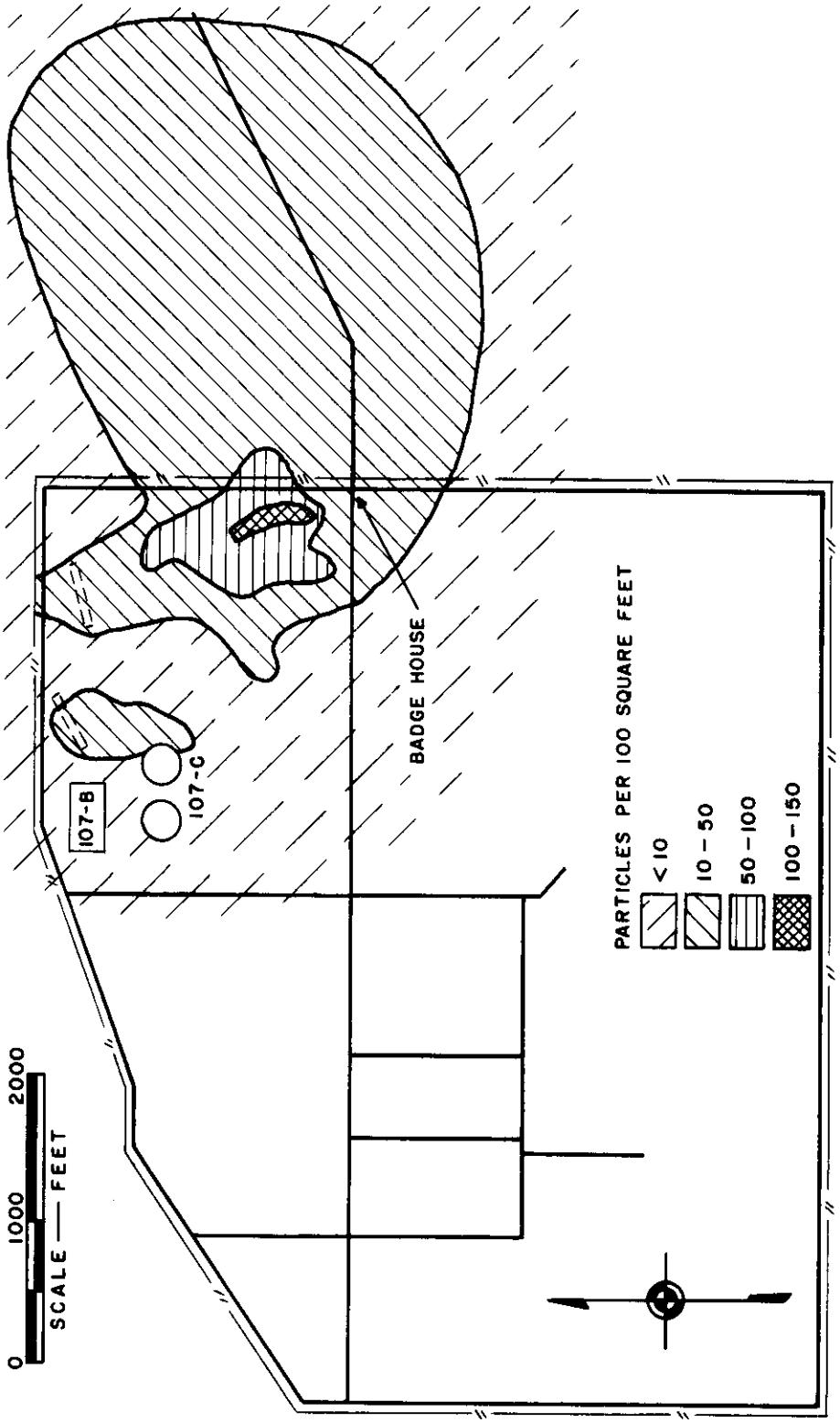


FIGURE - 9
GROUND CONTAMINATION PATTERN
100-B
MAY 3-10, 1957

AEC-GE RICHLAND, WASH.

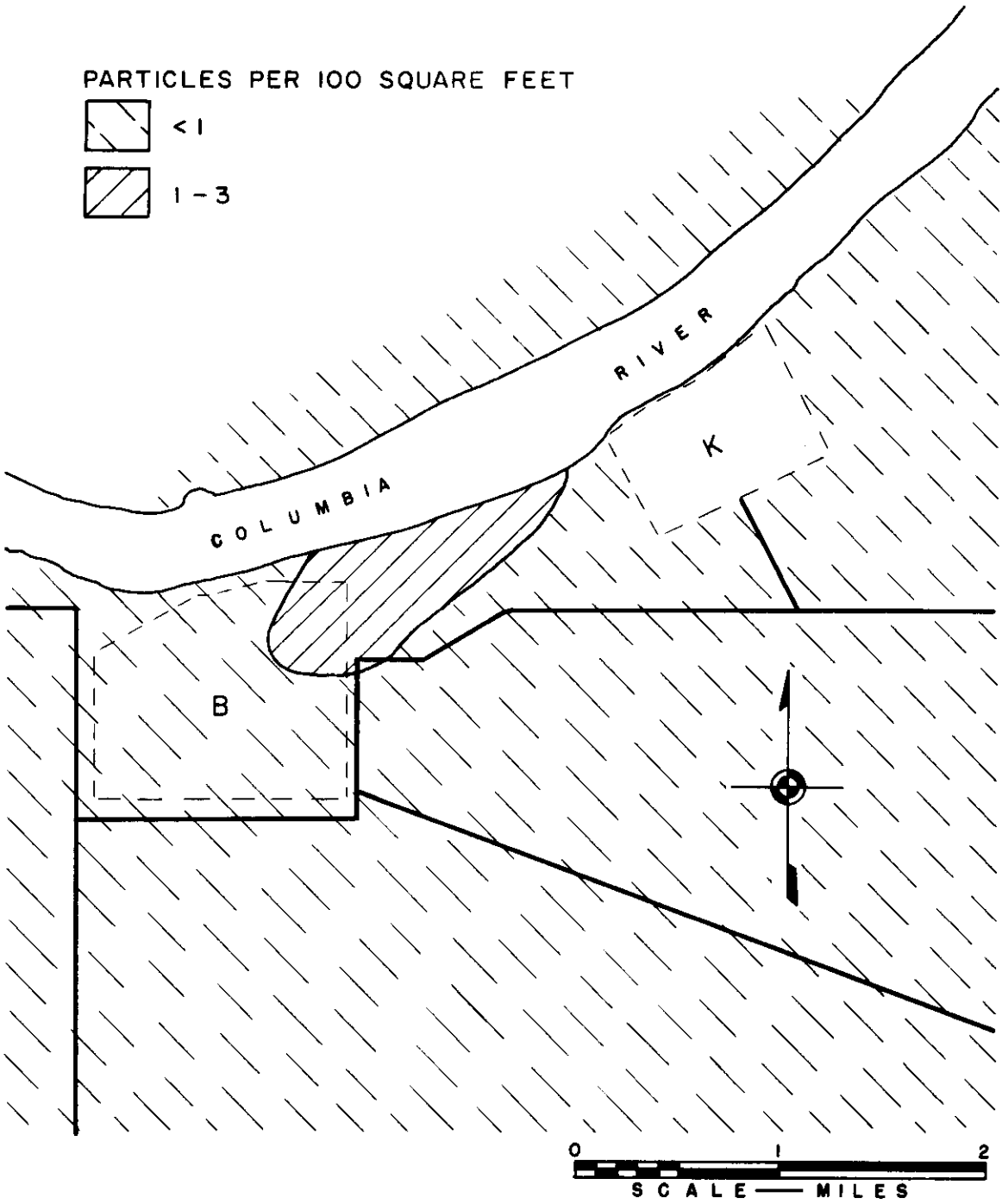


FIGURE - 10
GROUND CONTAMINATION PATTERN
100 - B AND VICINITY
DECEMBER 9-13, 1957

AEC-GE RICHLAND, WASH.

[redacted]

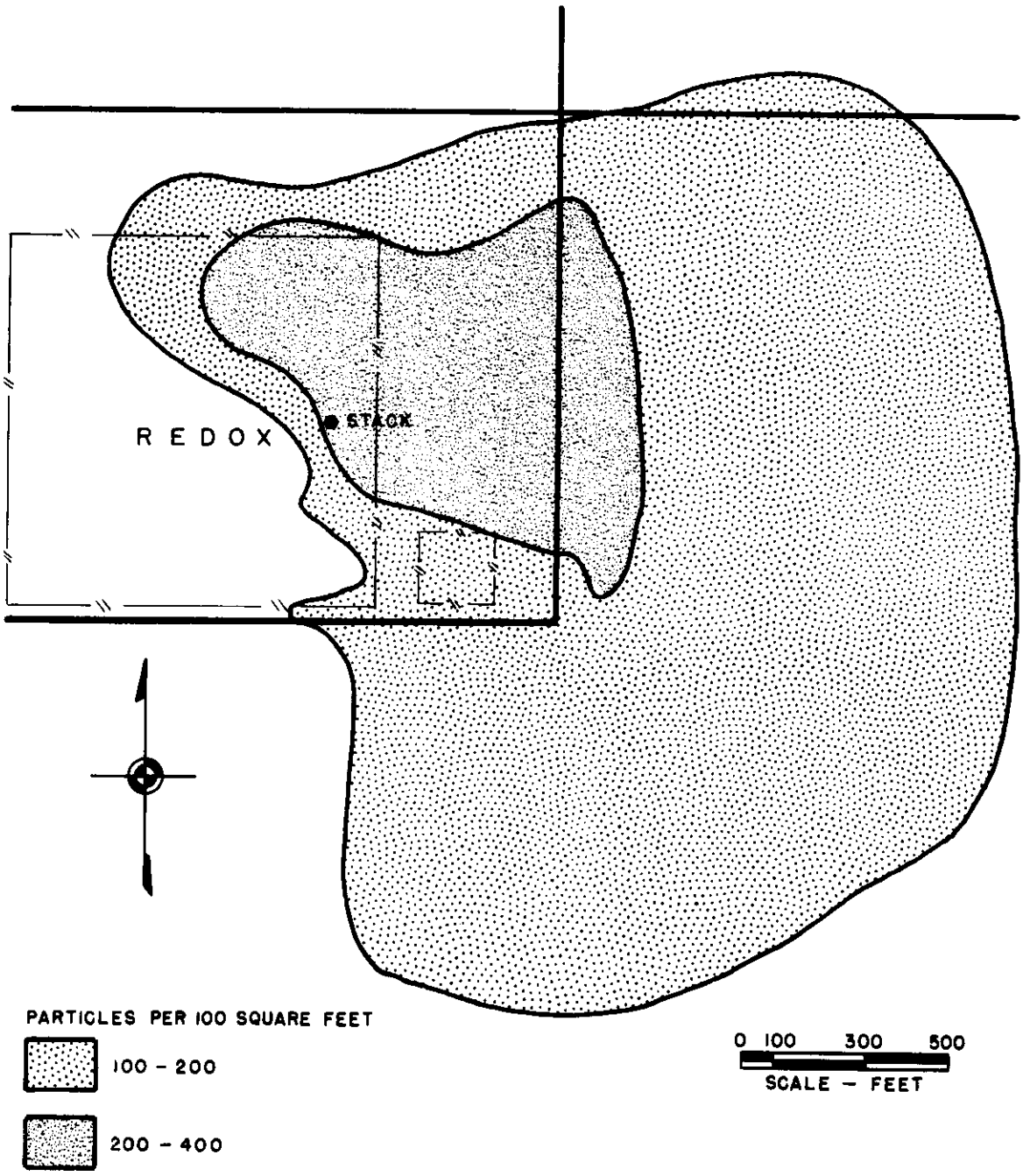


FIGURE - 11
GROUND CONTAMINATION PATTERN
200 WEST
MARCH 30 - MAY 3, 1952

AEC-GE RICHLAND, WASH.

[redacted]

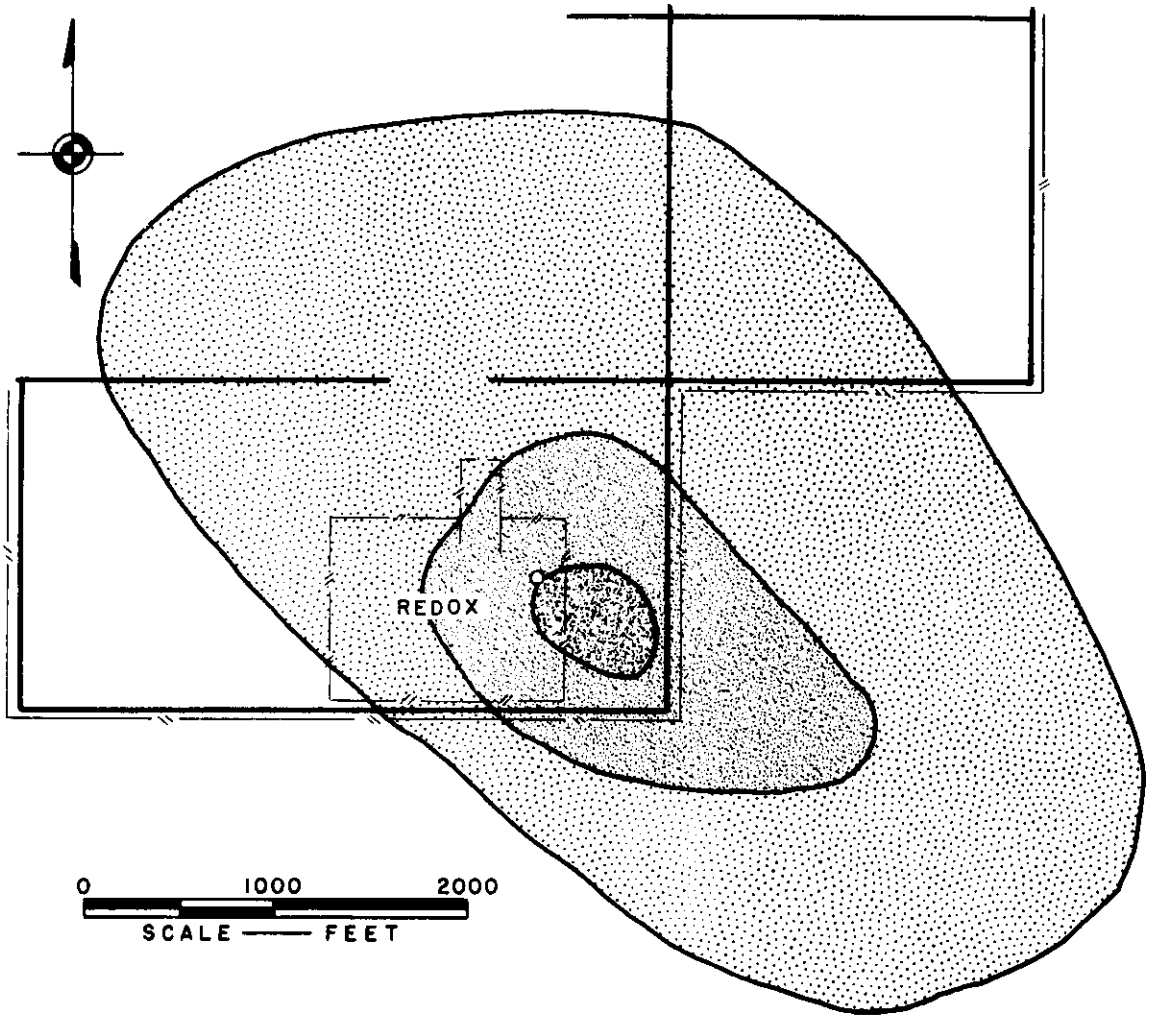


FIGURE - 12
GROUND CONTAMINATION PATTERN
200 WEST
JUNE, 1952

AEC-GE RICHLAND, WASH.

[redacted]

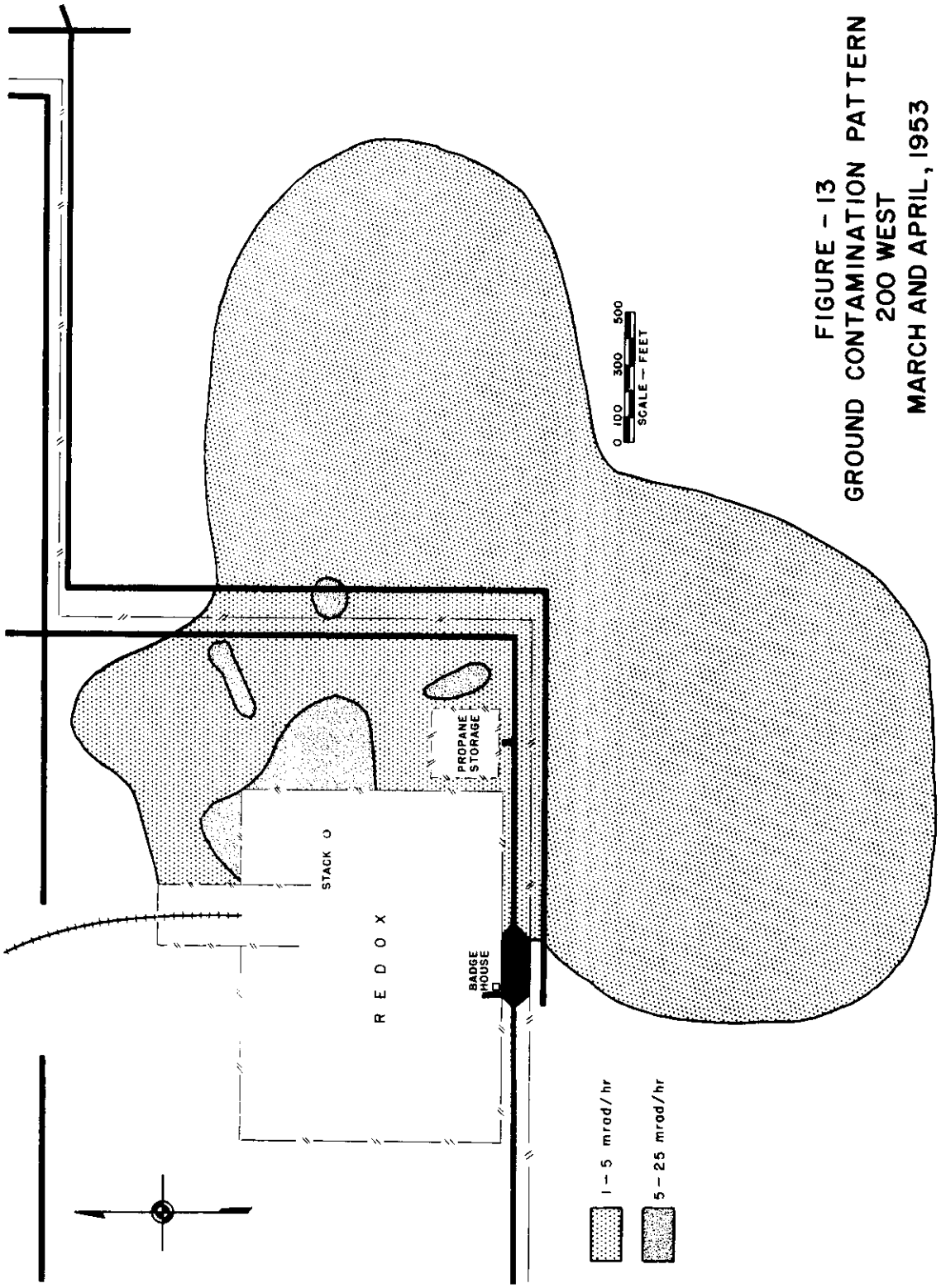


FIGURE – 13
GROUND CONTAMINATION PATTERN
200 WEST
MARCH AND APRIL, 1953

AEC-GE RICHLAND, WASH.

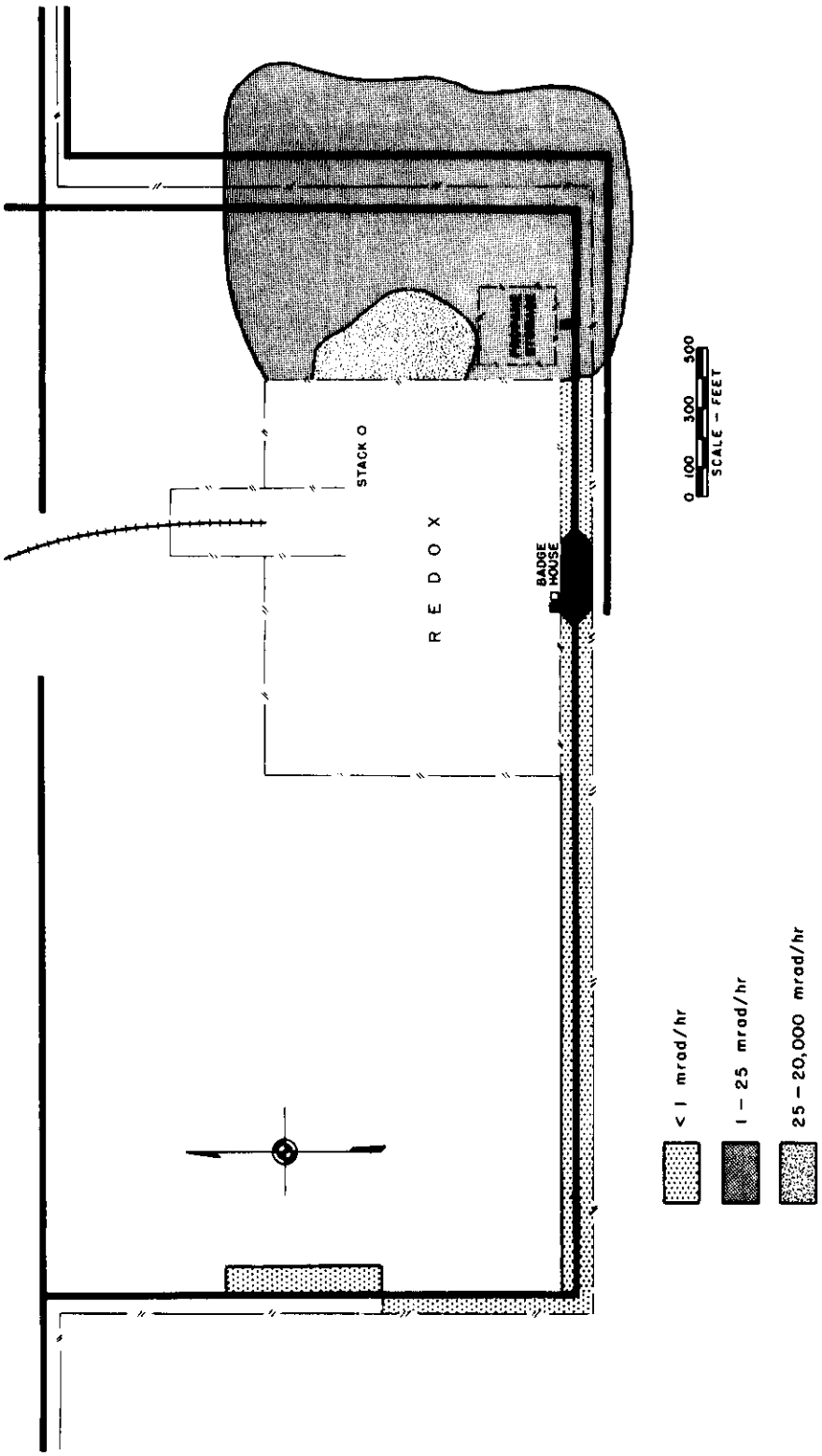
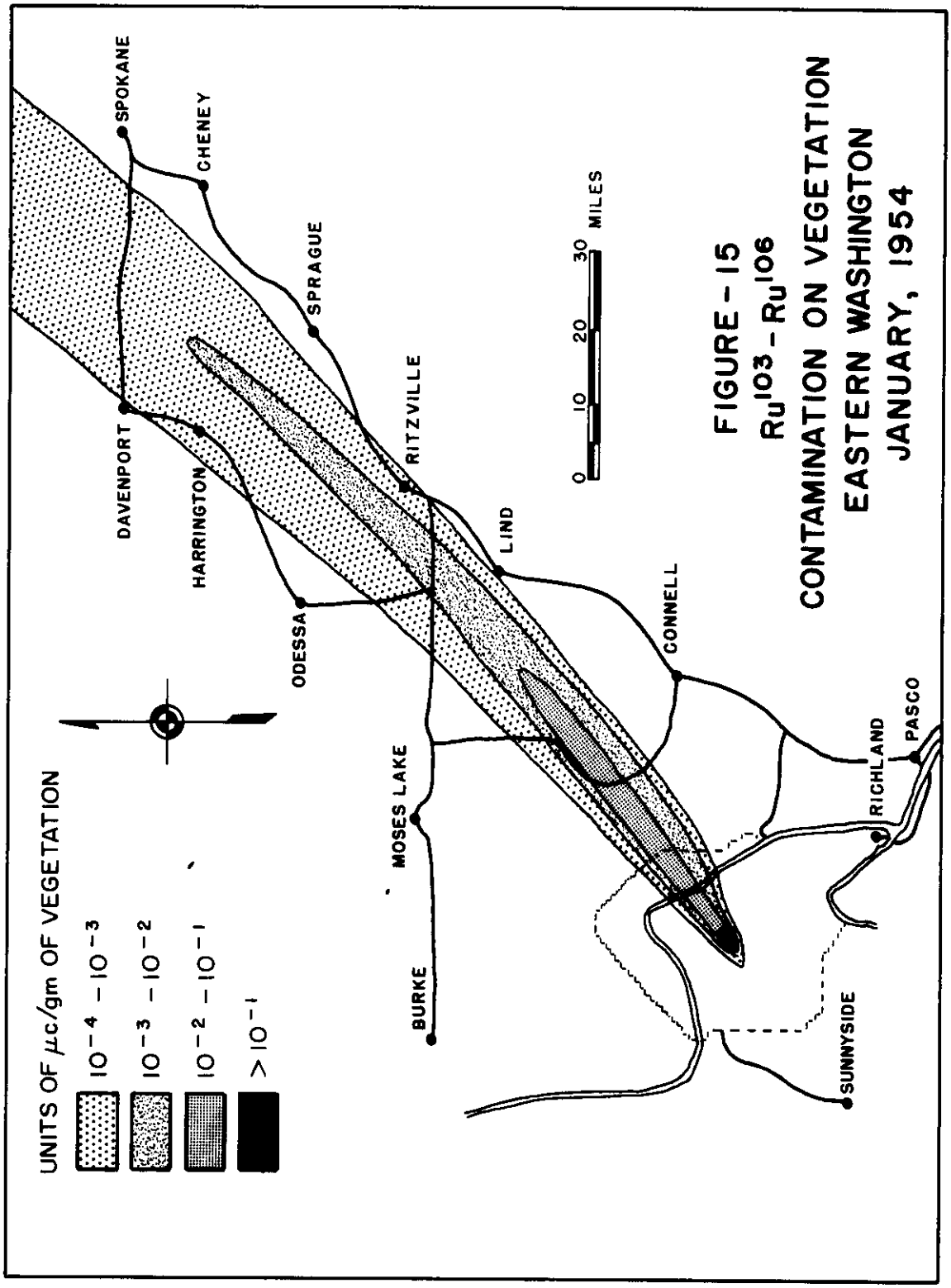


FIGURE - 14
GROUND CONTAMINATION PATTERN
200 WEST
AUGUST 19, 1953

AEC-GE RICHLAND, WASH.



[redacted]

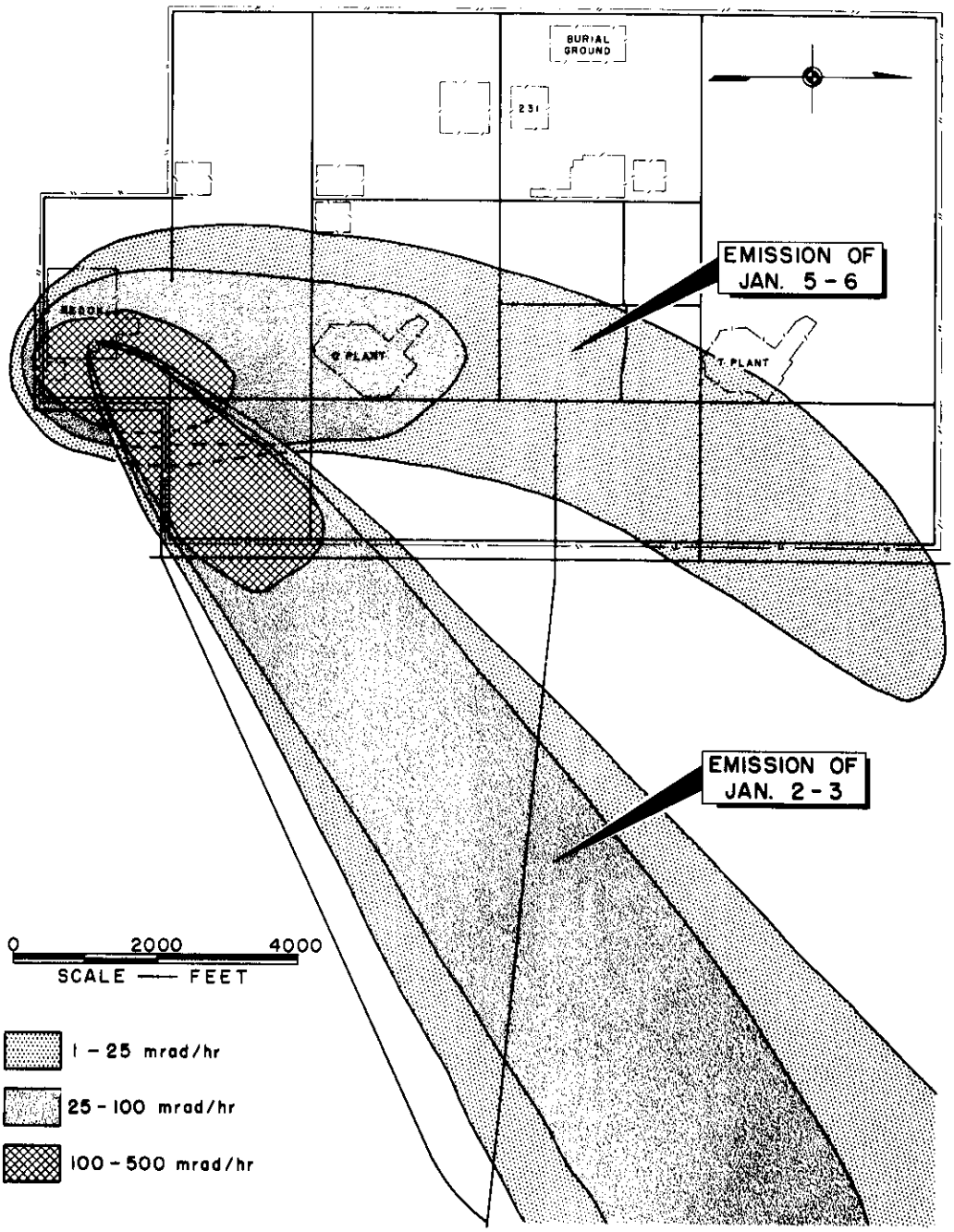


FIGURE - 16
GROUND CONTAMINATION PATTERN
200 WEST
JANUARY 2-9, 1954

AEC-GE RICHLAND, WASH.

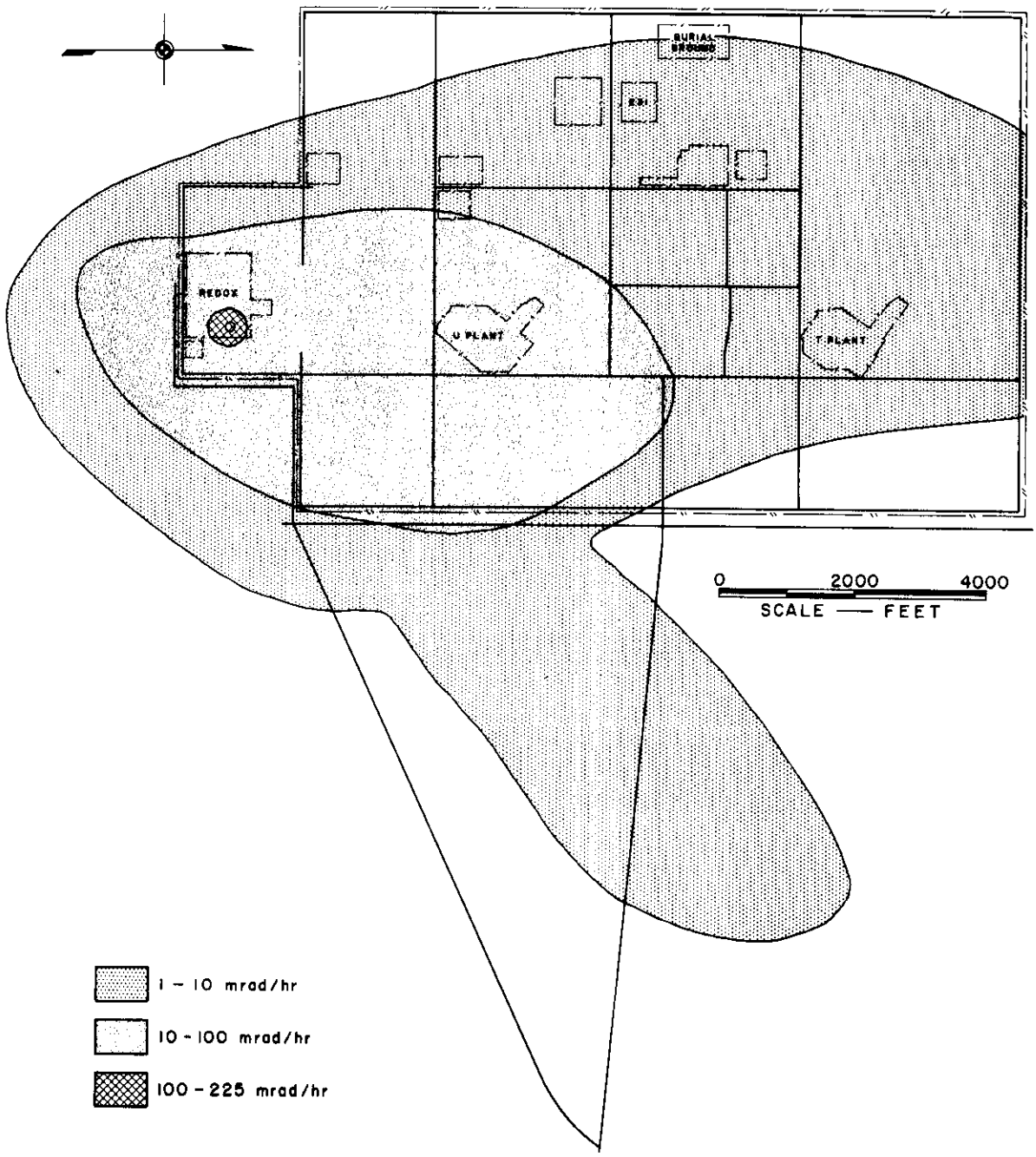


FIGURE - 17
GROUND CONTAMINATION PATTERN
200 WEST
FEBRUARY 15 - 19, 1954

AEC-GE RICHLAND, WASH.

[redacted]

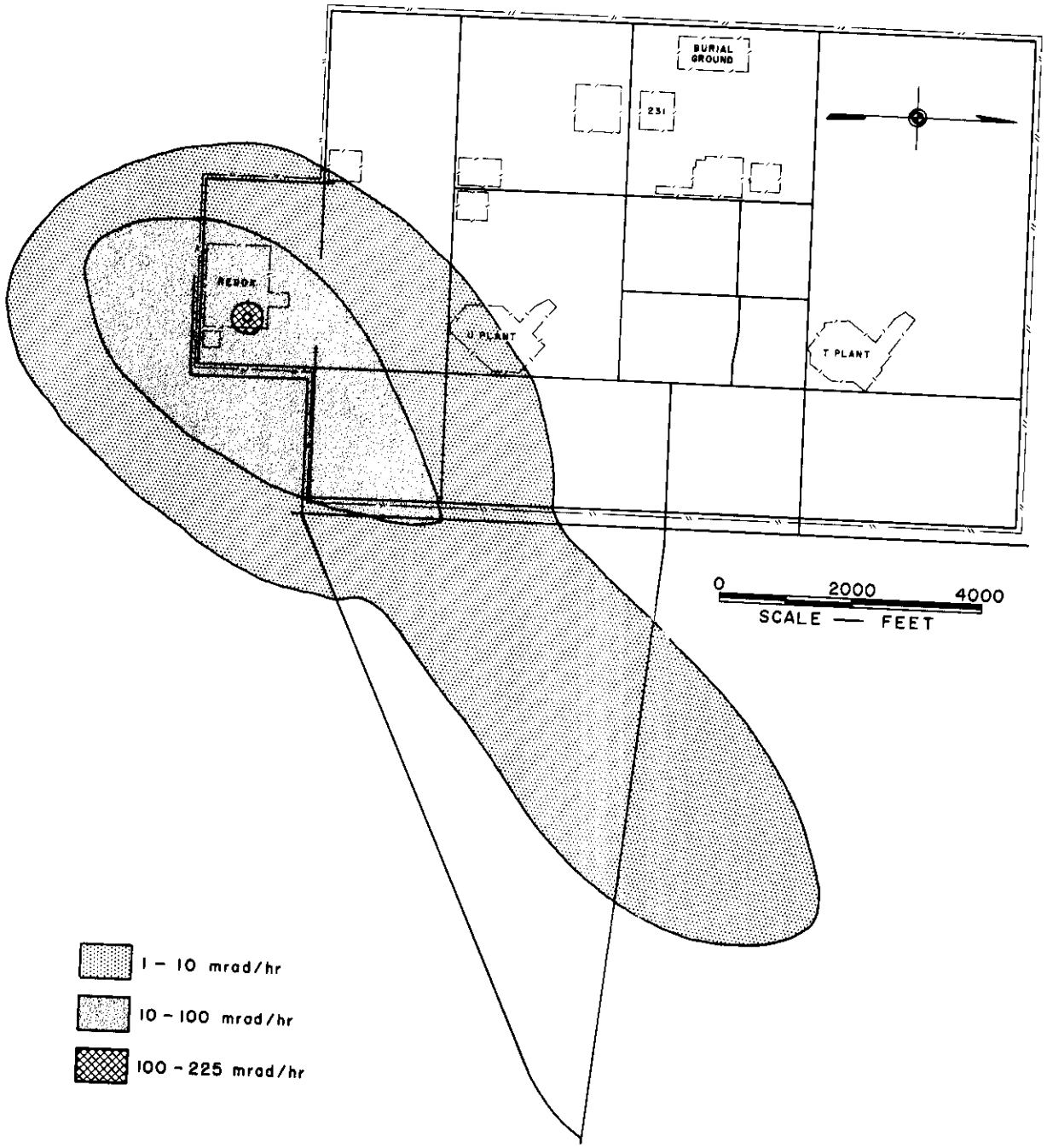


FIGURE - 18
GROUND CONTAMINATION PATTERN
200 WEST
MARCH 1-5, 1954

AEC-GE RICHLAND, WASH.

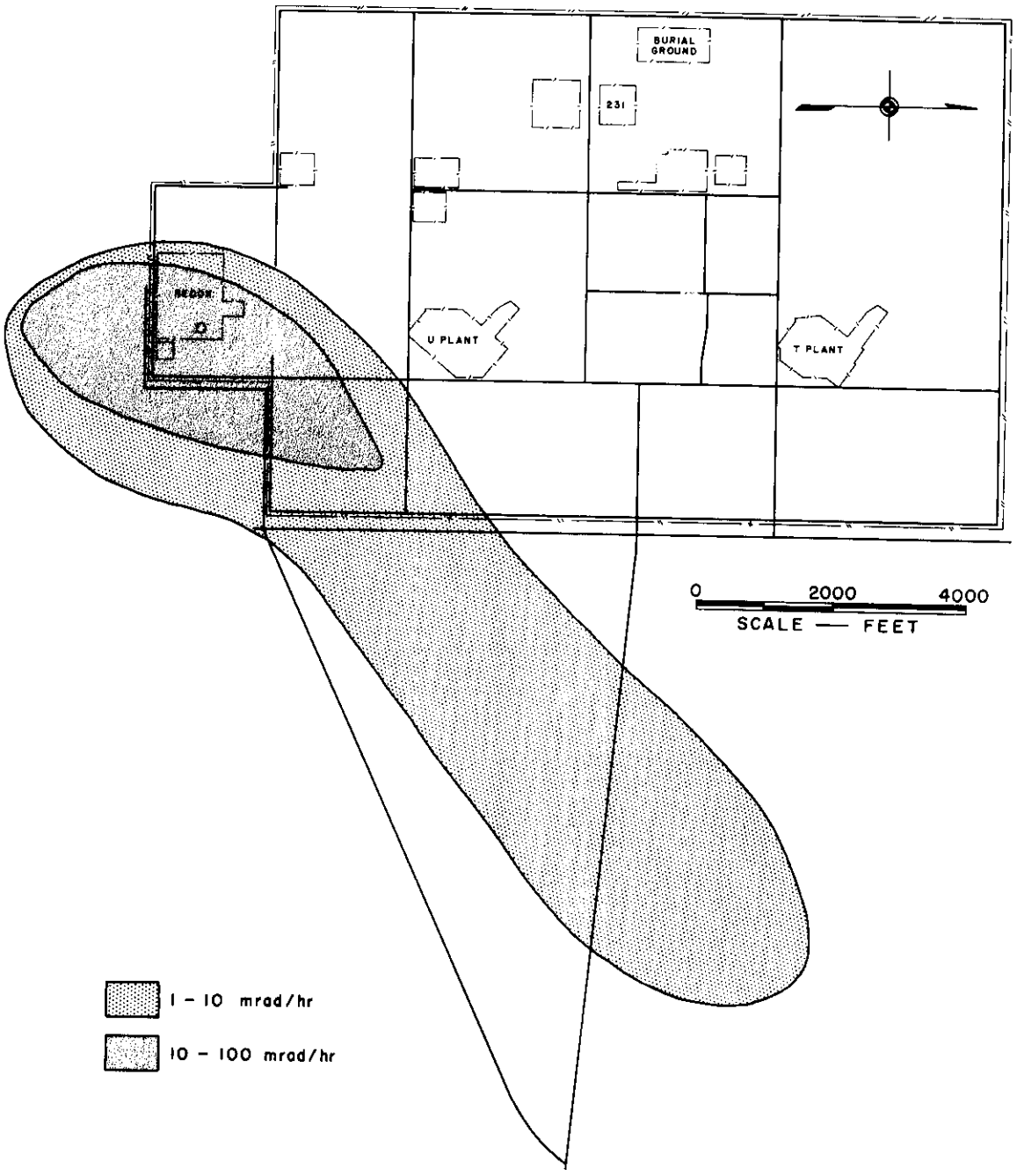


FIGURE - 19
GROUND CONTAMINATION PATTERN
200 WEST
MARCH 22-26, 1954

AEC-GE RICHLAND, WASH.

CONFIDENTIAL

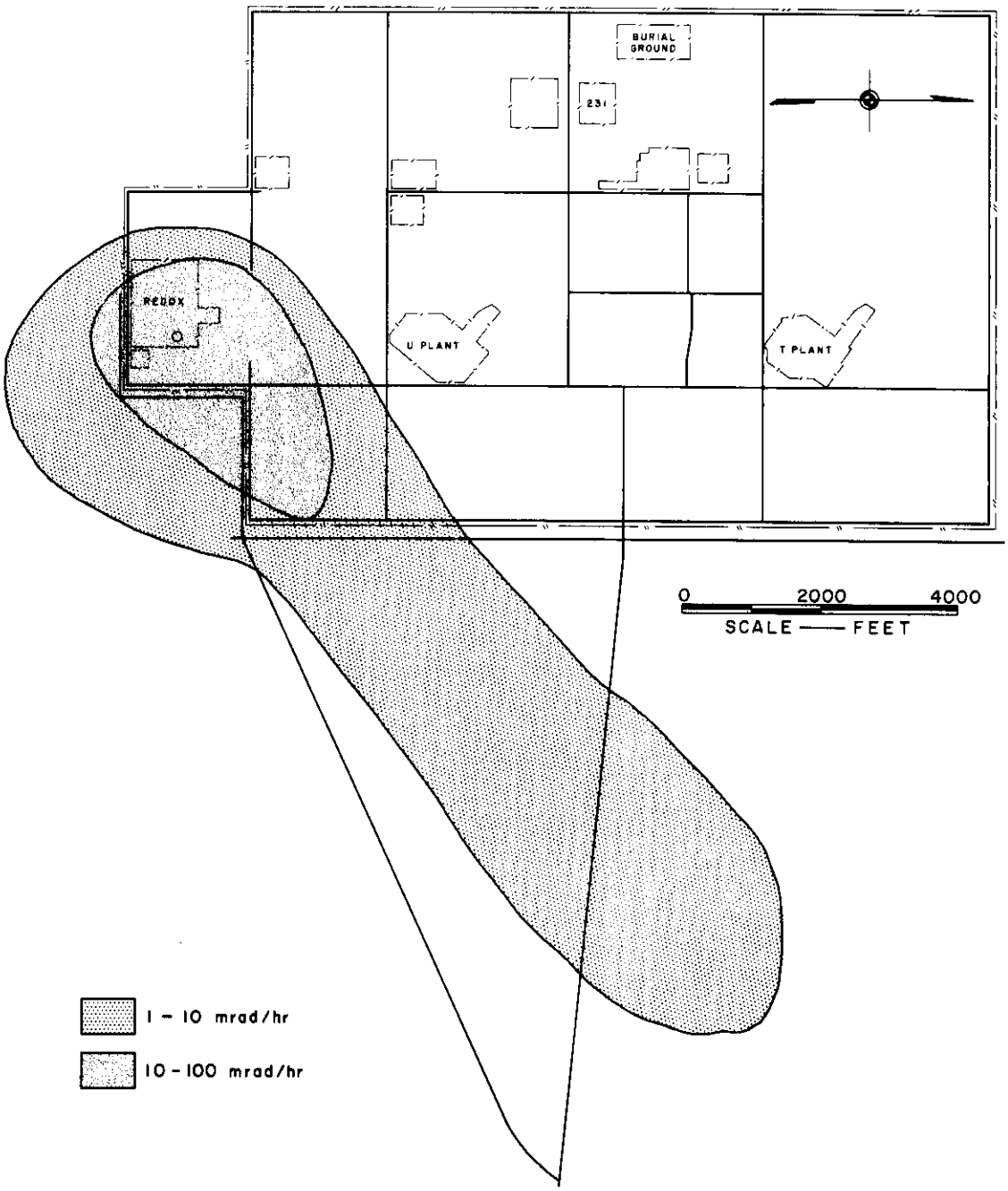


FIGURE - 20
GROUND CONTAMINATION PATTERN
200 WEST
MAY 17 - 21, 1954

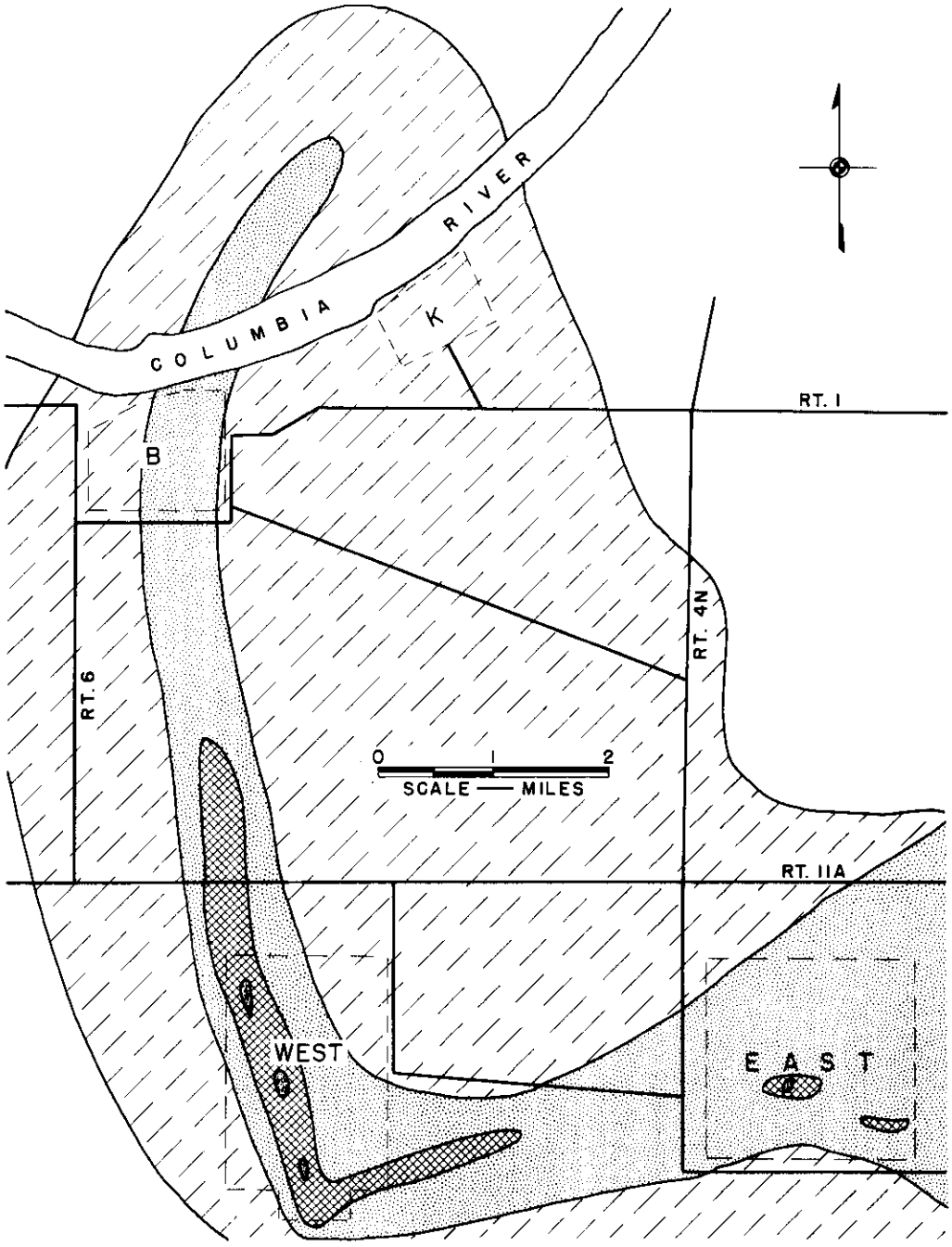


FIGURE - 21
GROUND CONTAMINATION PATTERN
200 WEST, 200 EAST, AND 100-B
MAY 25 TO JUNE 10, 1954

AEC-GE RICHLAND, WASH.

[redacted]

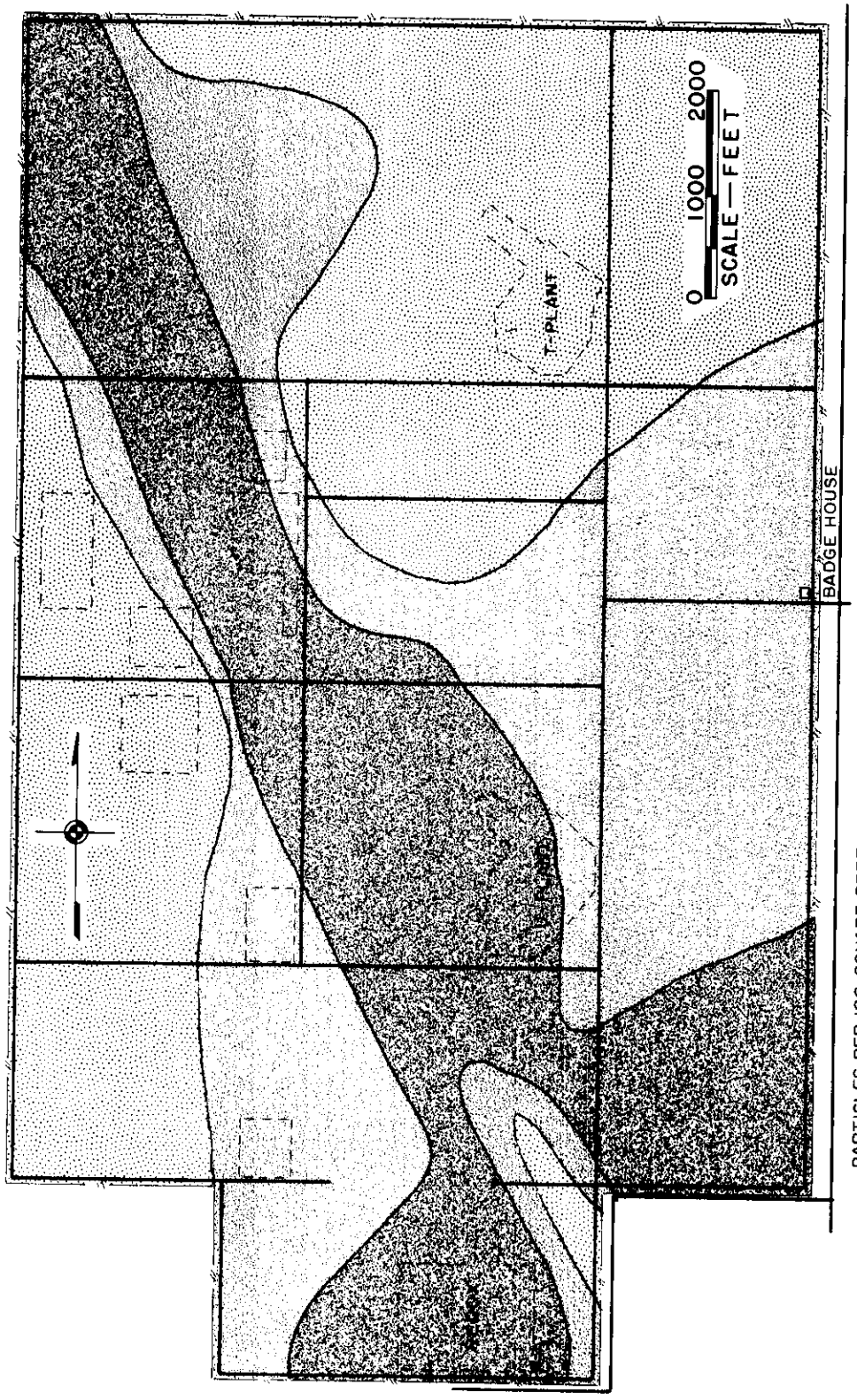


FIGURE - 22
GROUND CONTAMINATION PATTERN
200 WEST
NOVEMBER, 1954

AEC-GE RICHLAND, WASH.

[redacted]

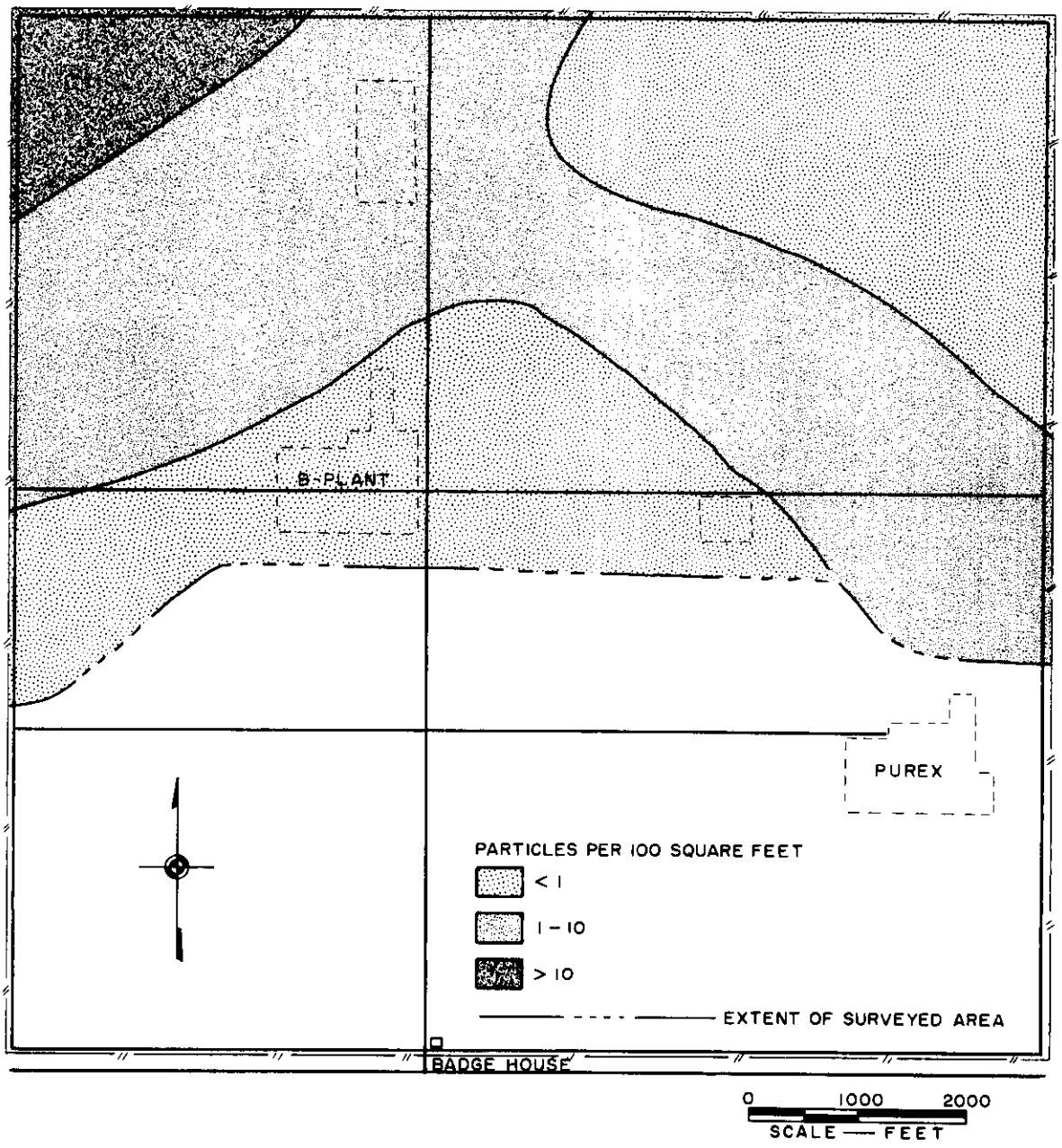


FIGURE - 23
GROUND CONTAMINATION PATTERN
200 EAST
JANUARY, 1955

AEC-GE RICHLAND, WASH.

[redacted]

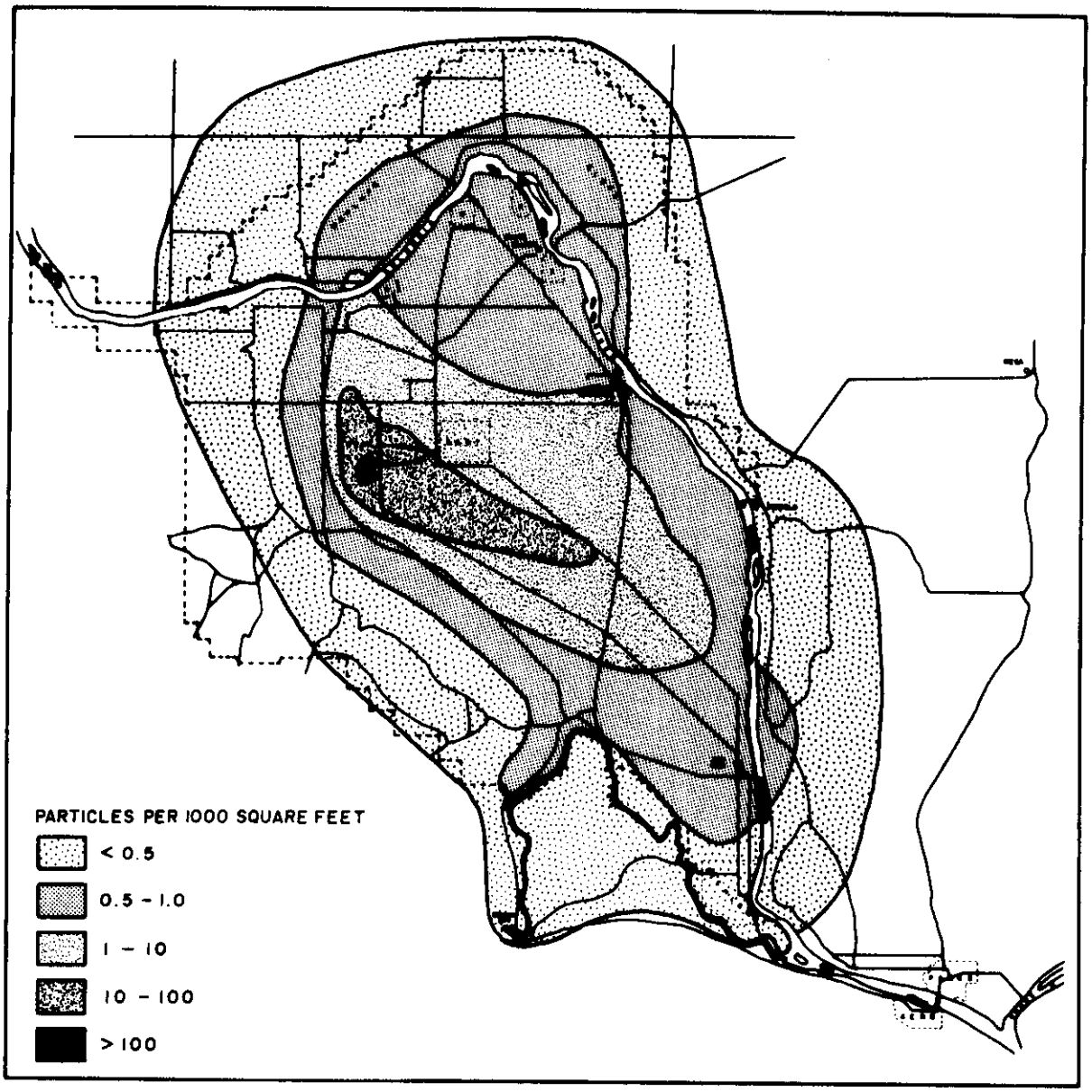


FIGURE 24

GROUND CONTAMINATION PATTERN
HANFORD AND VICINITY
JULY AND AUGUST, 1954

AEC-GE RICHLAND, WASH.

[redacted]

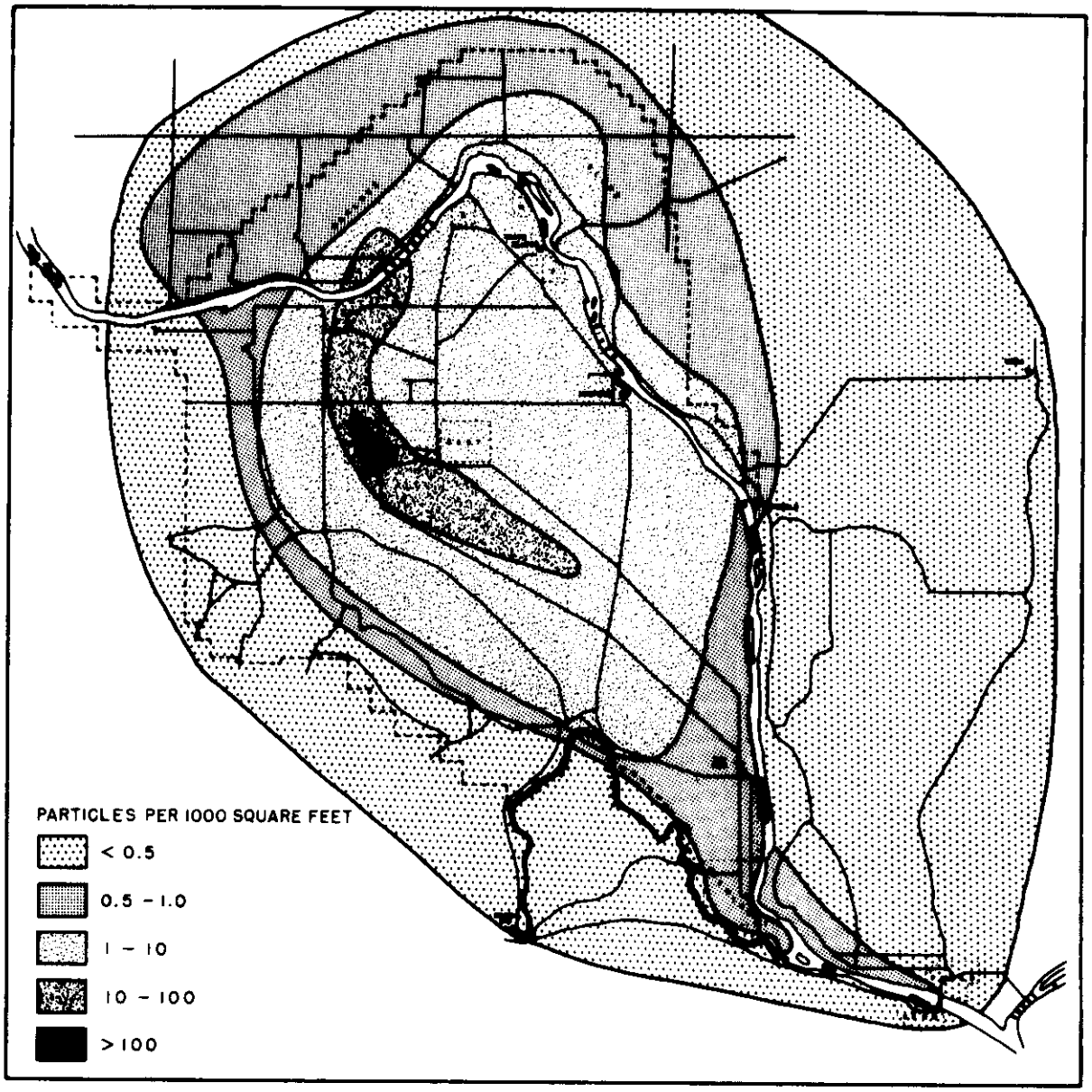


FIGURE 25

GROUND CONTAMINATION PATTERN
HANFORD AND VICINITY
SEPTEMBER AND OCTOBER, 1954

AEC-GE RICHLAND, WASH.

[redacted]

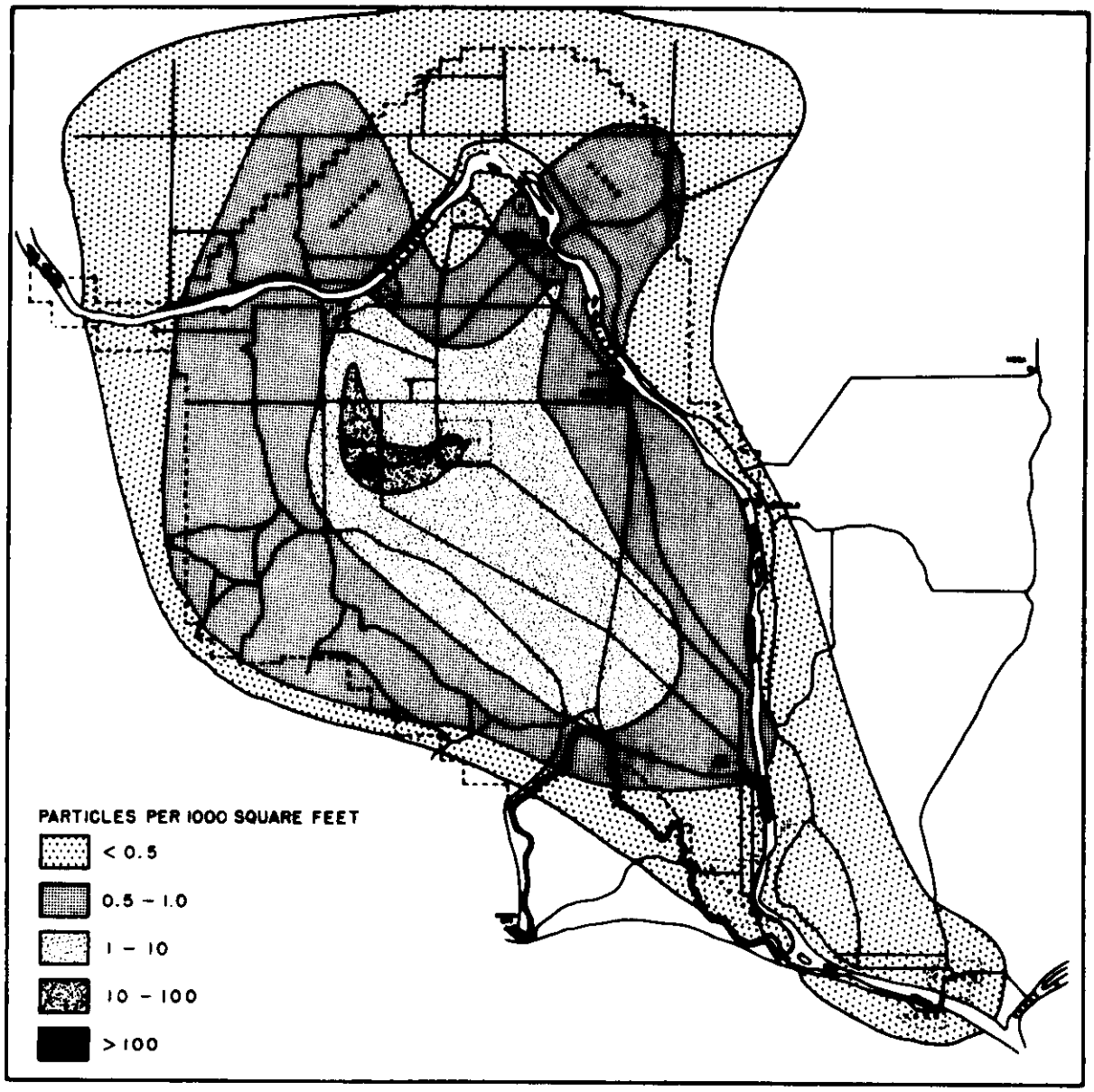


FIGURE 26

GROUND CONTAMINATION PATTERN
HANFORD AND VICINITY
DECEMBER, 1954

AEC-GE RICHLAND, WASH.

[redacted]

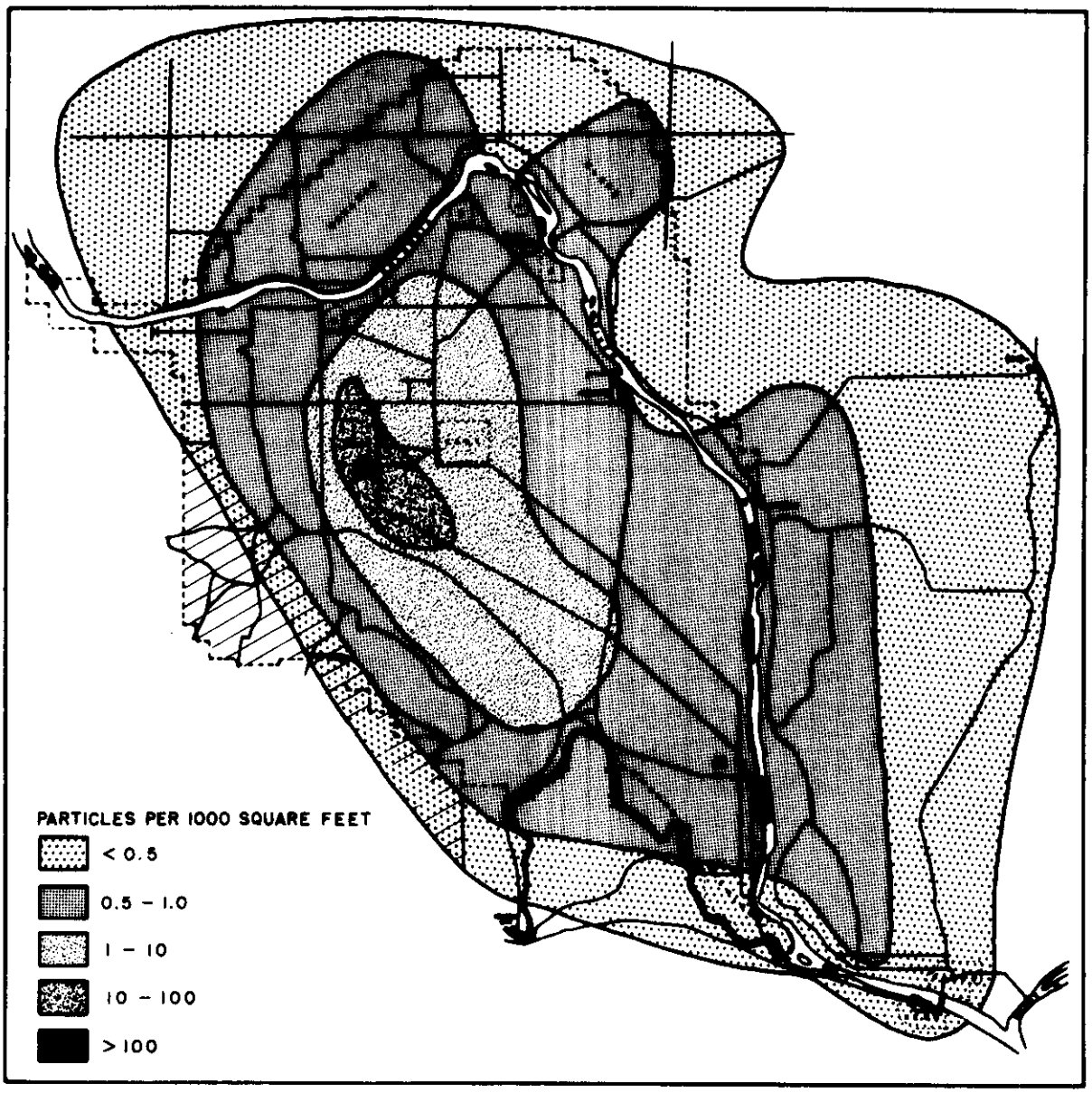


FIGURE 27

GROUND CONTAMINATION PATTERN
HANFORD AND VICINITY
FEBRUARY, 1955

[redacted]

AEC-GE RICHLAND, WASH.

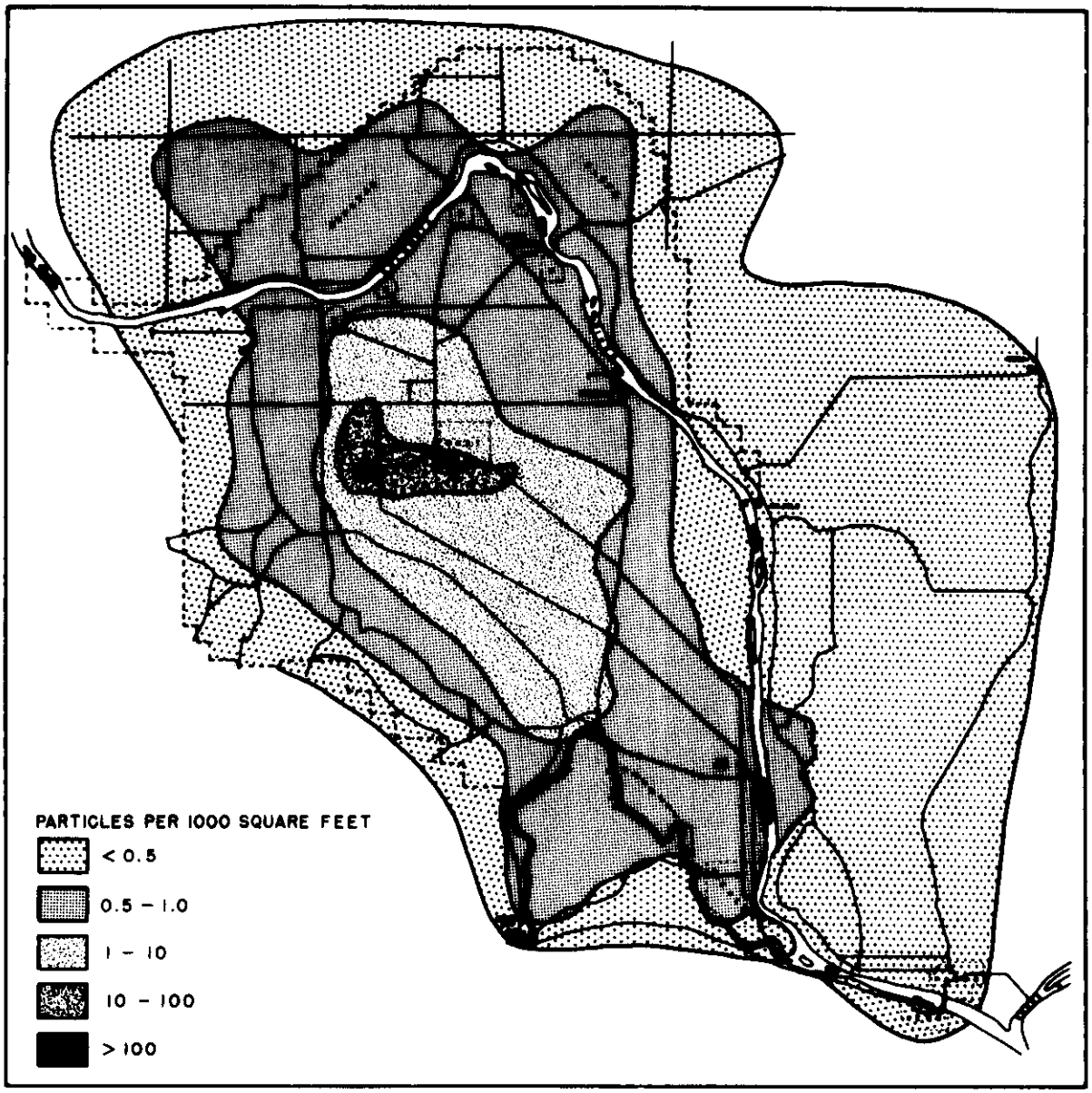


FIGURE 28

GROUND CONTAMINATION PATTERN
HANFORD AND VICINITY
MARCH, 1955

[redacted]

AEC-GE RICHLAND, WASH.

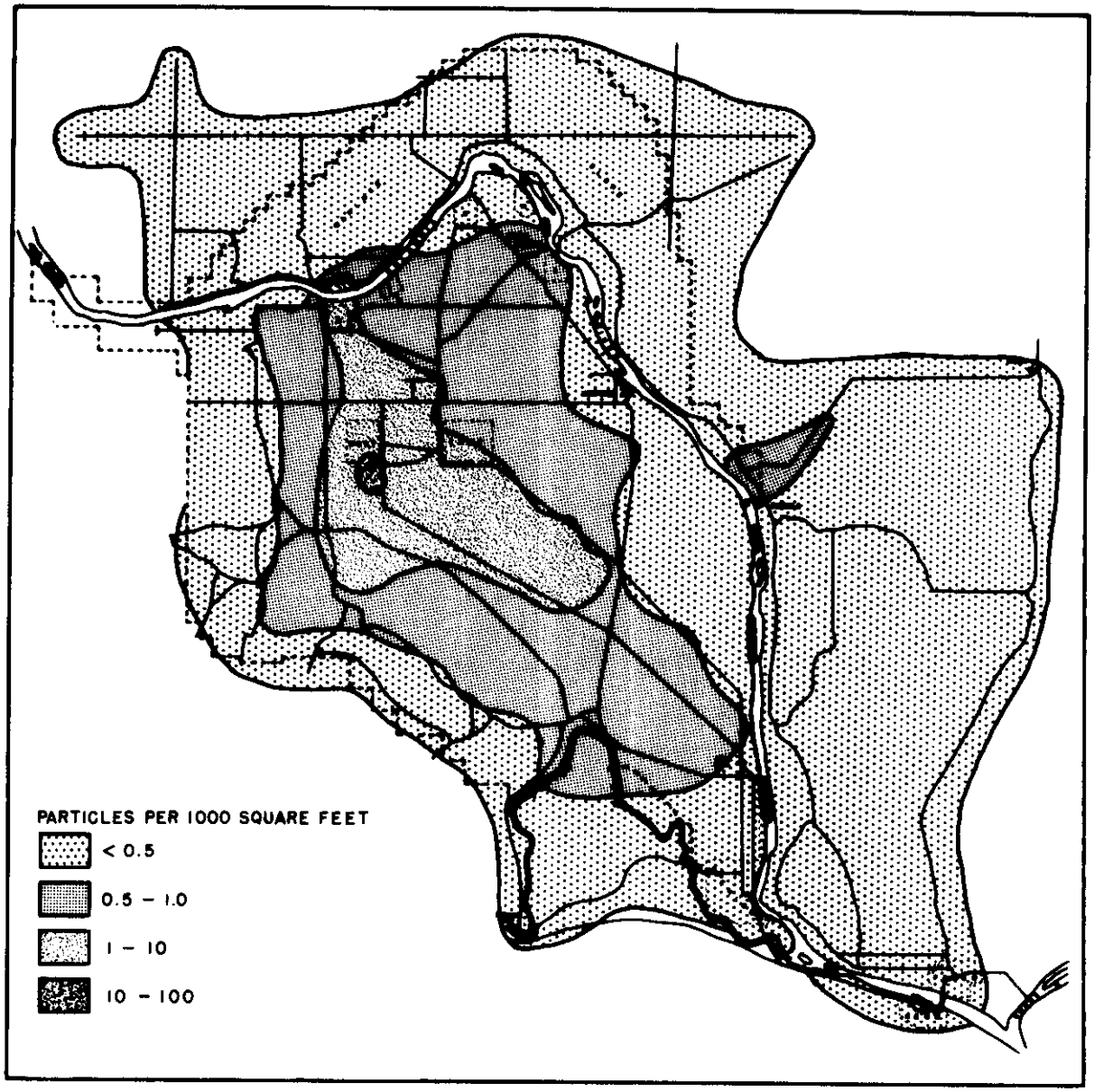


FIGURE 29

GROUND CONTAMINATION PATTERN
HANFORD AND VICINITY
JUNE, 1955

AEC-GE RICHLAND, WASH.

[redacted]

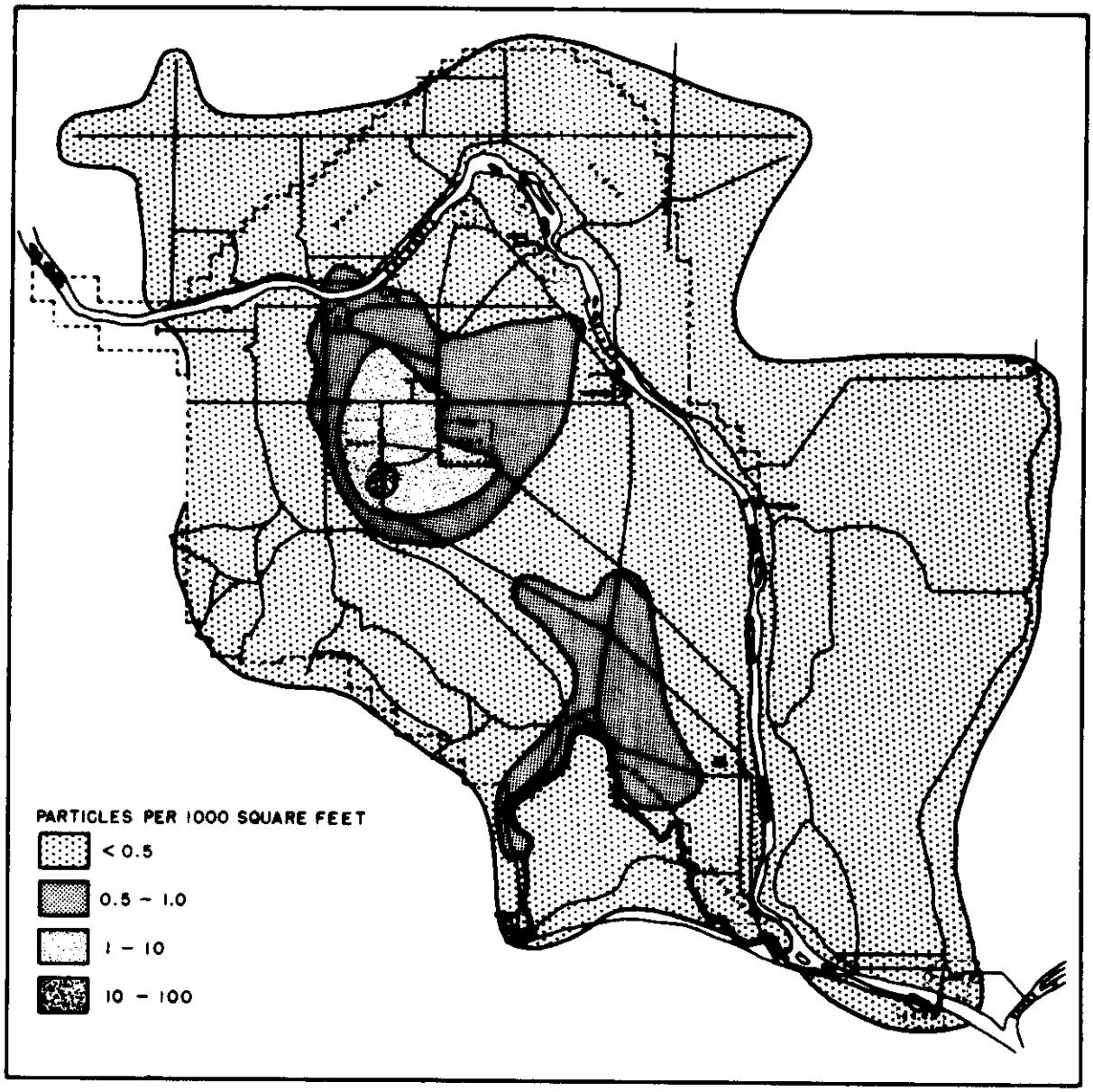


FIGURE 30

GROUND CONTAMINATION PATTERN
HANFORD AND VICINITY
SEPTEMBER, 1955

AEC-GE RICHLAND, WASH.

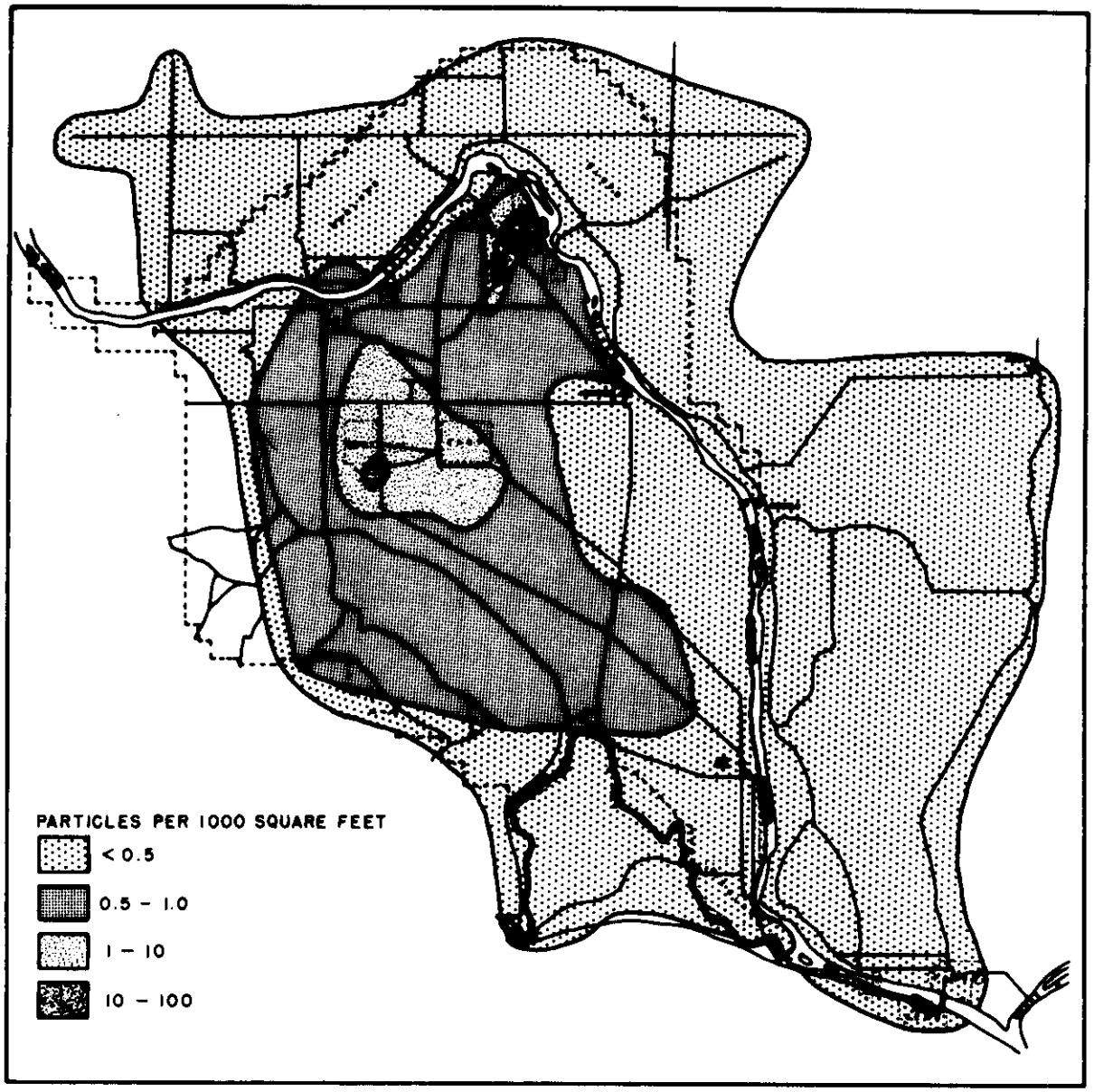


FIGURE 31

GROUND CONTAMINATION PATTERN
HANFORD AND VICINITY
NOVEMBER, 1955

AEC-GE RICHLAND, WASH.

[redacted]

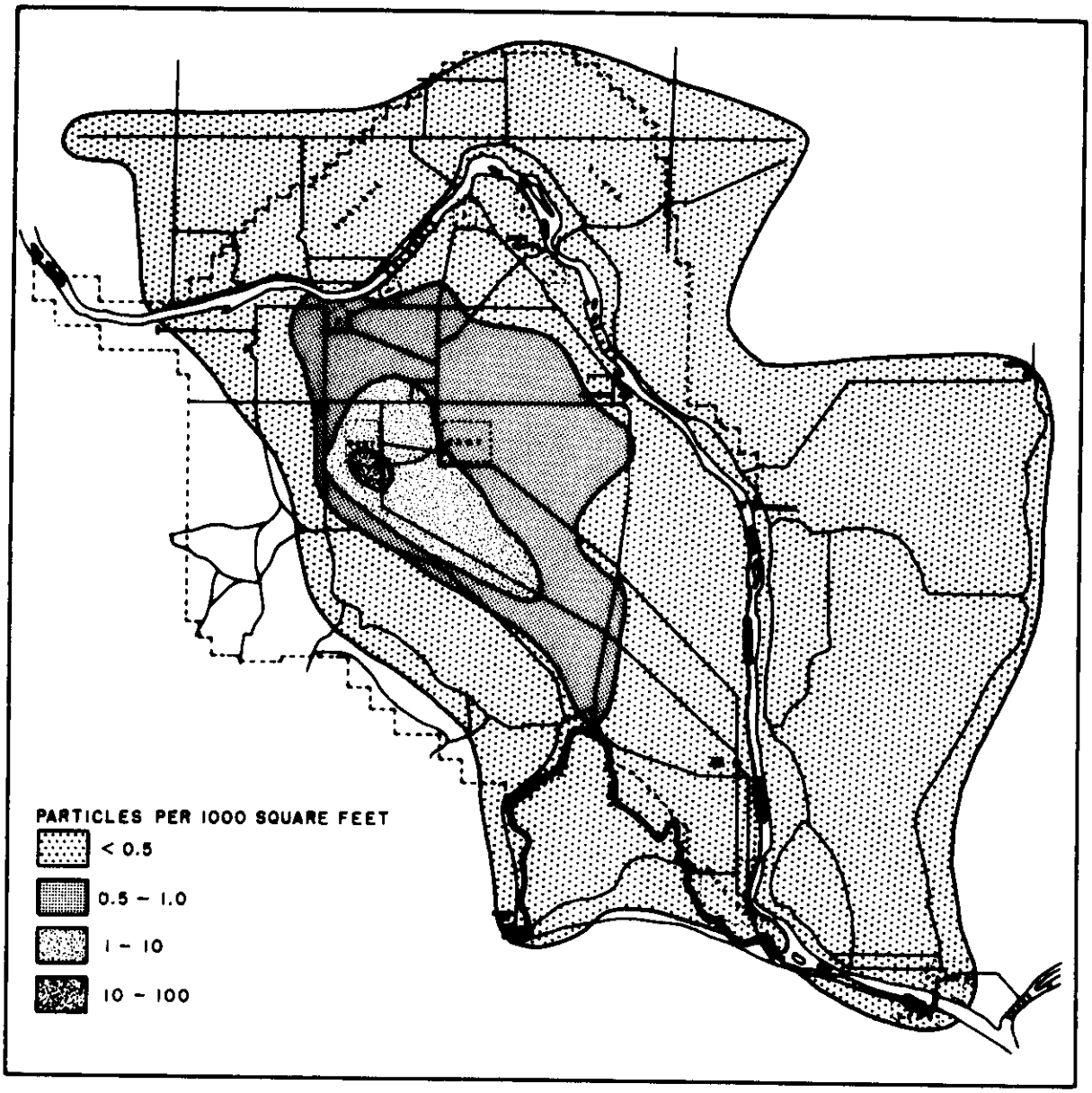


FIGURE 32

GROUND CONTAMINATION PATTERN
HANFORD AND VICINITY
MARCH, 1956

AEC-GE RICHLAND, WASH.

[redacted]

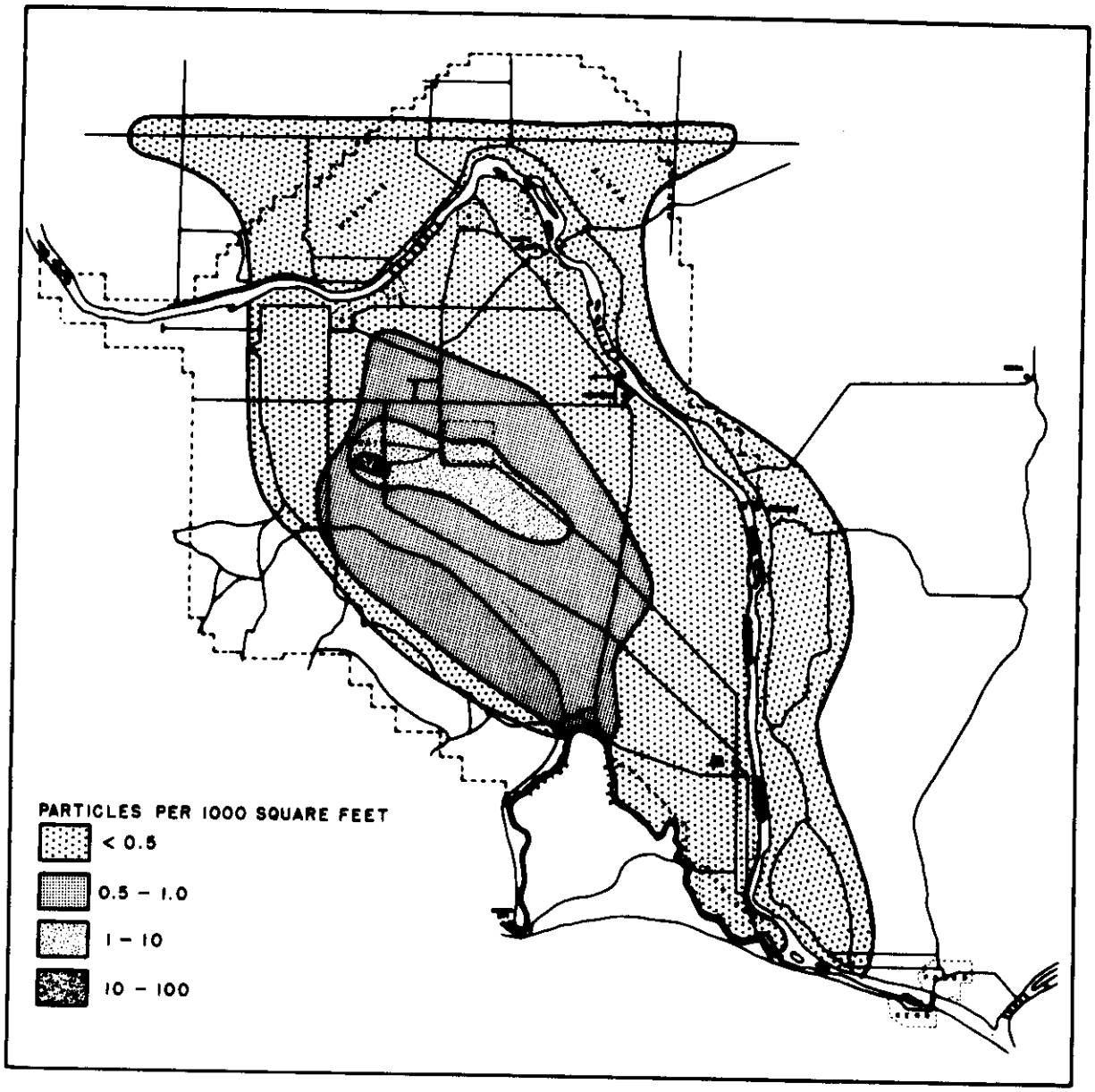


FIGURE 33
GROUND CONTAMINATION PATTERN
HANFORD AND VICINITY
JUNE, 1956

AEC-GE RICHLAND, WASH.

[redacted]

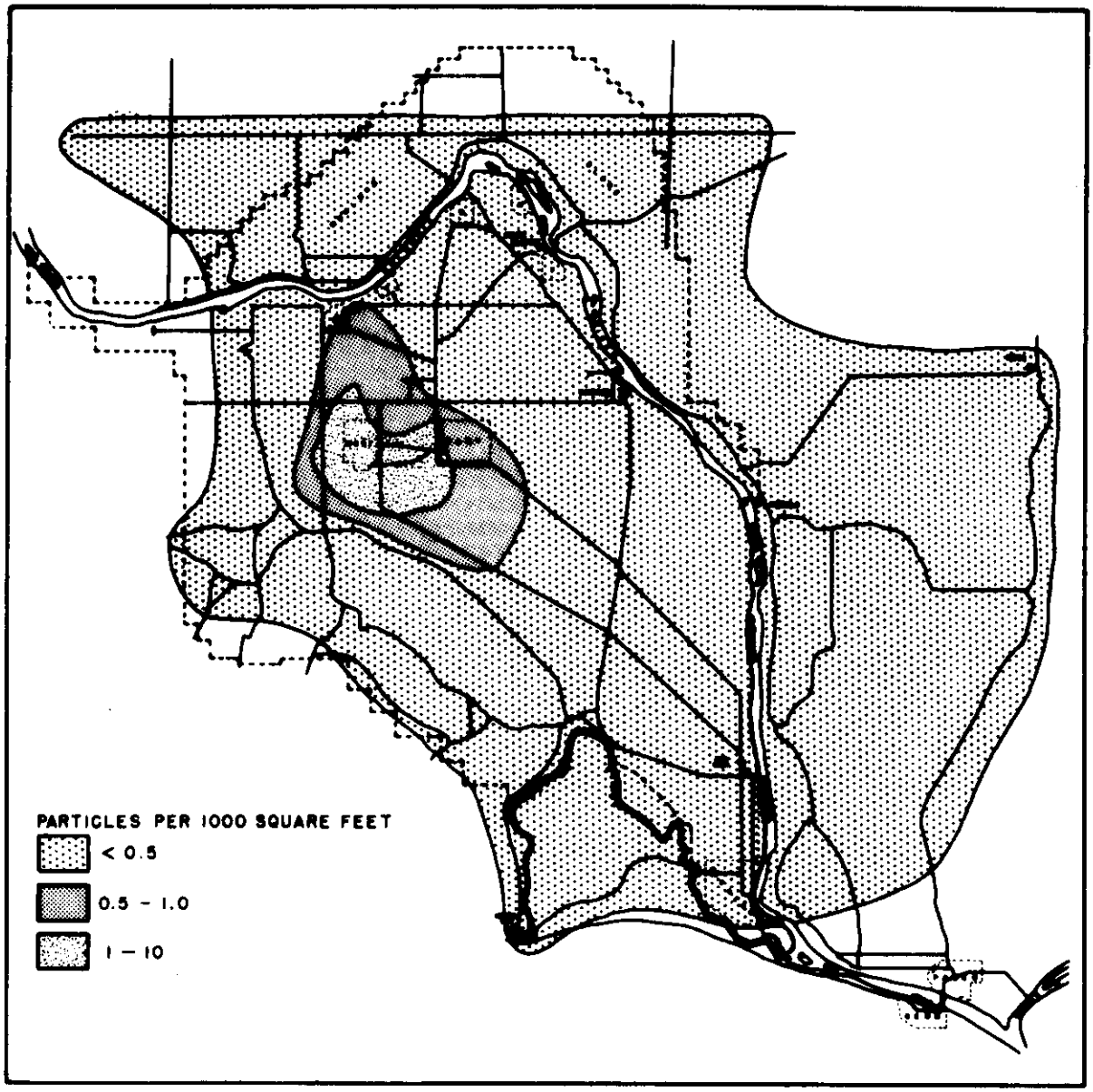


FIGURE 34

GROUND CONTAMINATION PATTERN
HANFORD AND VICINITY
OCTOBER AND NOVEMBER, 1956

AEC-GE RICHLAND, WASH.

[redacted]AL

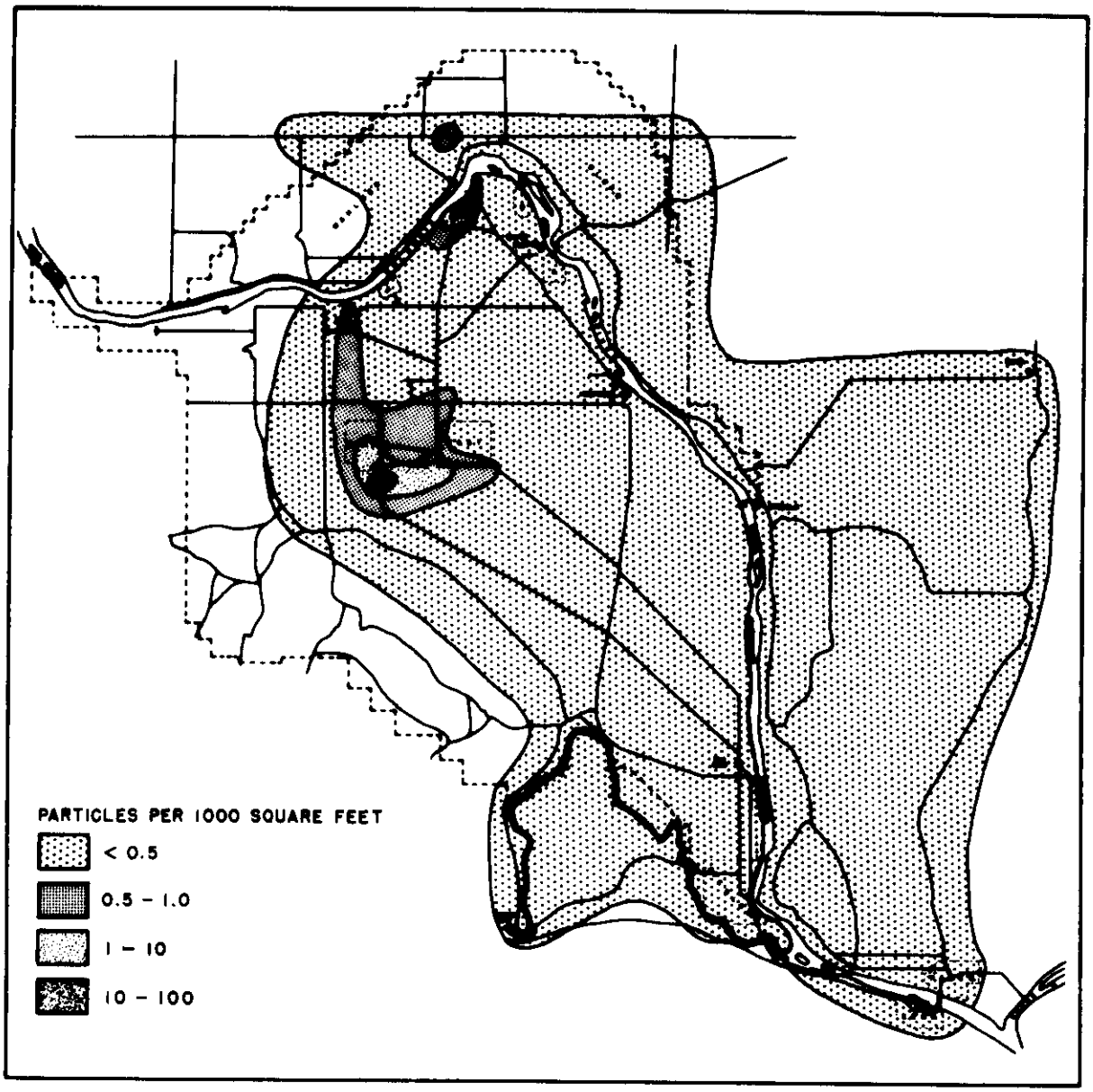


FIGURE 35

GROUND CONTAMINATION PATTERN
HANFORD AND VICINITY
FEBRUARY, 1957

[redacted]

AEC-GE RICHLAND, WASH.

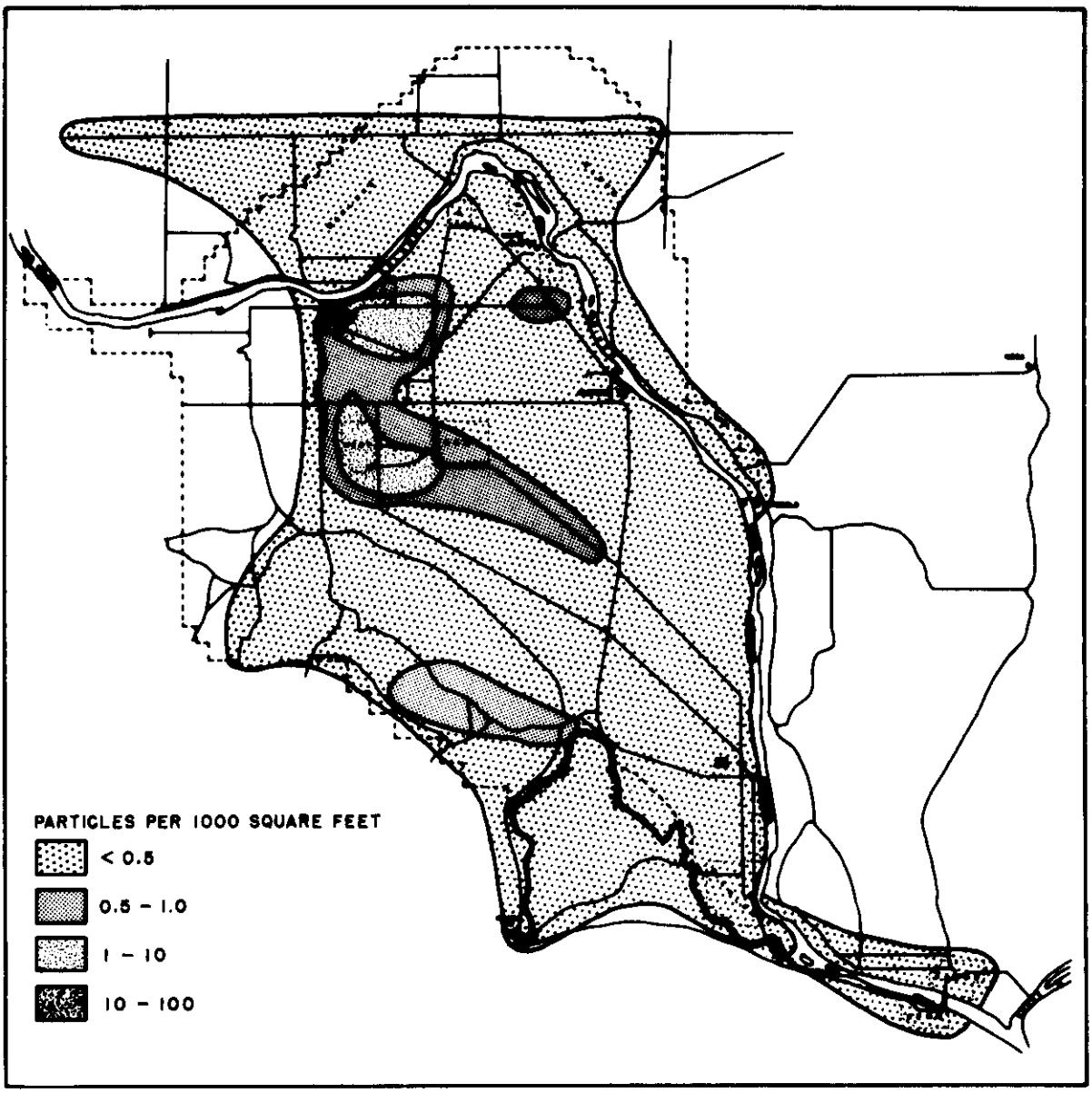


FIGURE 36

GROUND CONTAMINATION PATTERN
HANFORD AND VICINITY
APRIL, 1957

[redacted]

AEC-GE RICHLAND, WASH.

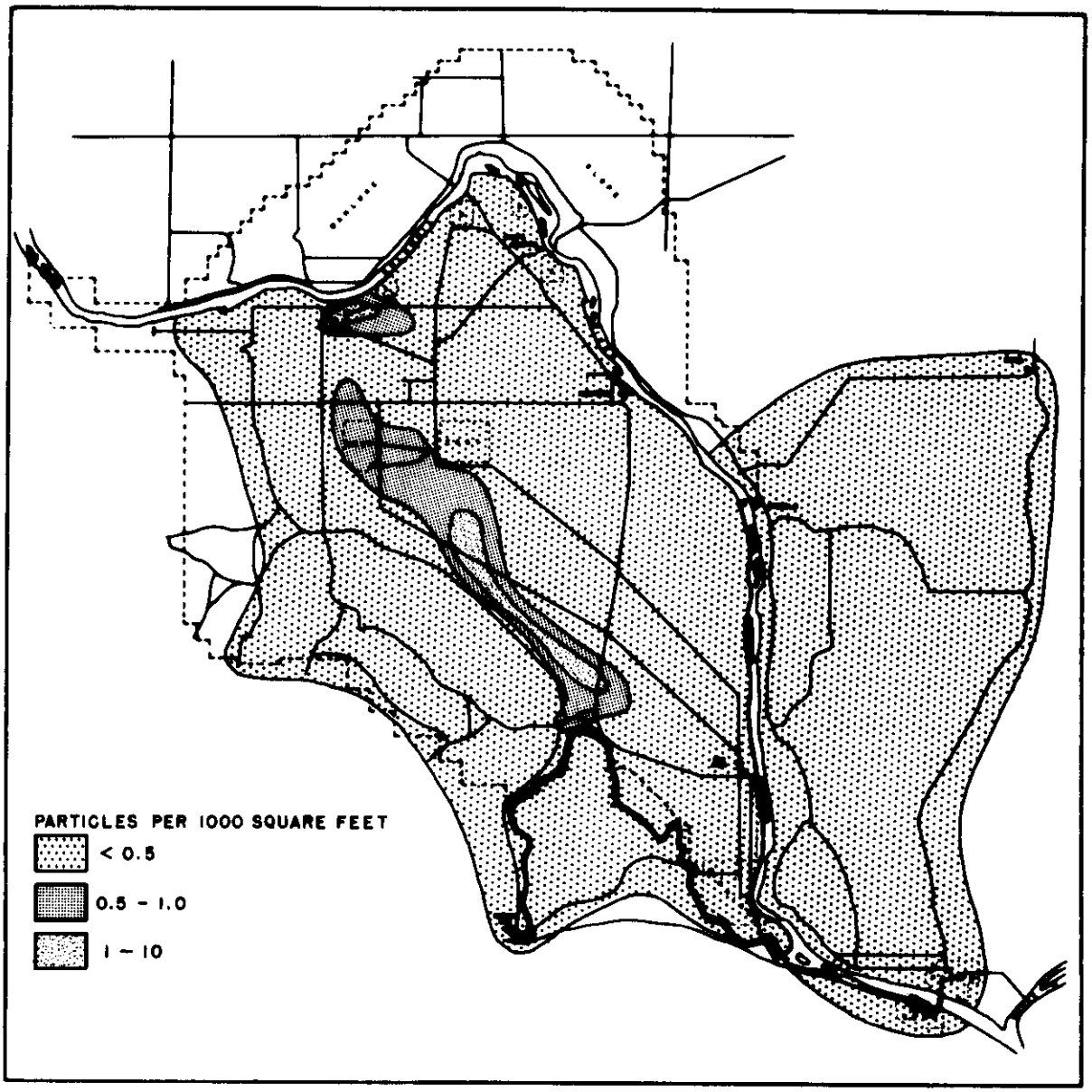


FIGURE 37
GROUND CONTAMINATION PATTERN
HANFORD AND VICINITY
AUGUST, 1957

AEC-GE RICHLAND, WASH.

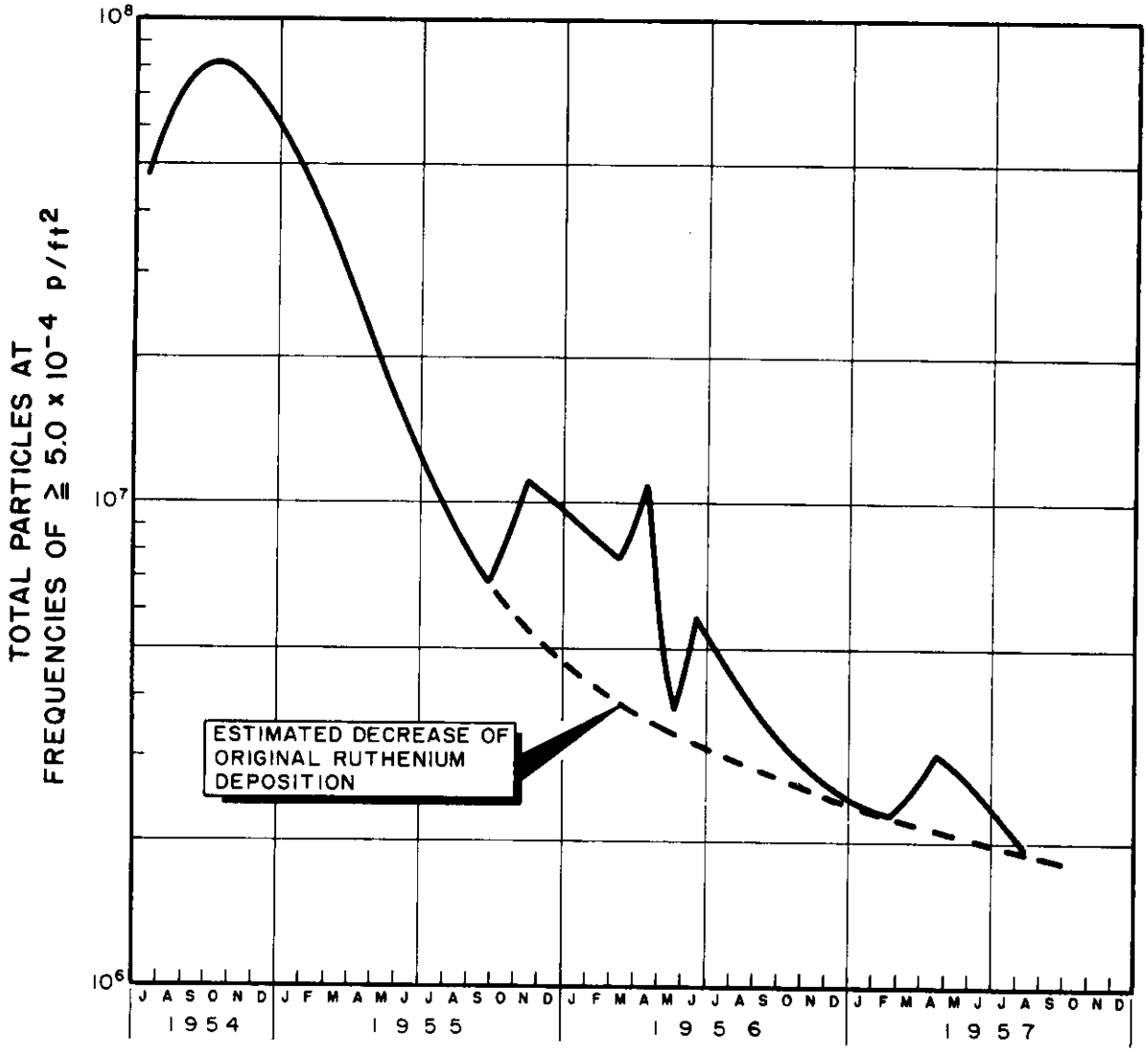


FIGURE – 38
TOTAL RADIOACTIVE PARTICLES
HANFORD PROJECT AND VICINITY
JULY, 1954 – SEPTEMBER, 1957

AEC-GE RICHLAND, WASH.

[redacted]

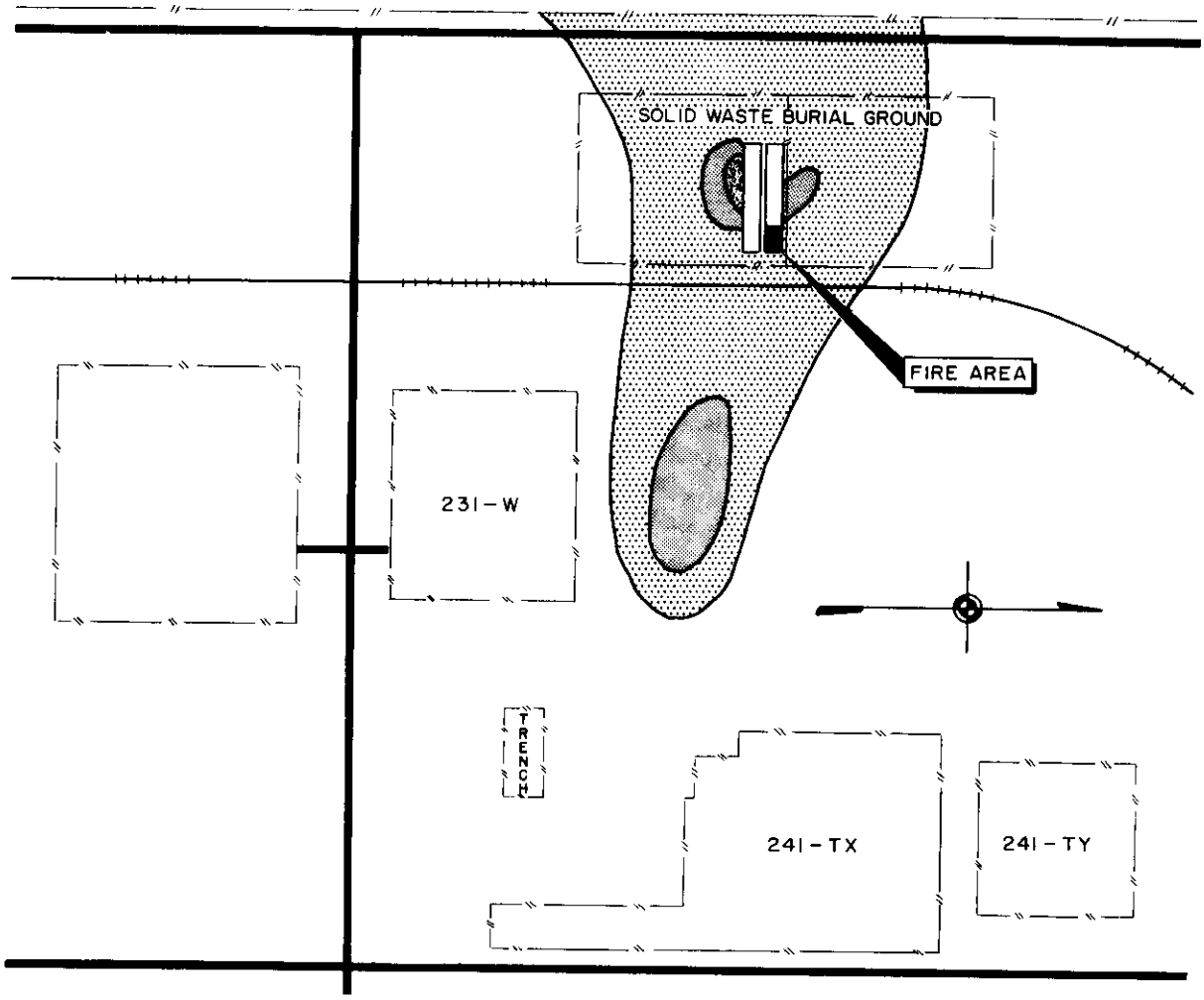


FIGURE - 39
GROUND CONTAMINATION PATTERN
200 WEST
JULY 9, 1952

AEC-GE RICHLAND, WASH.

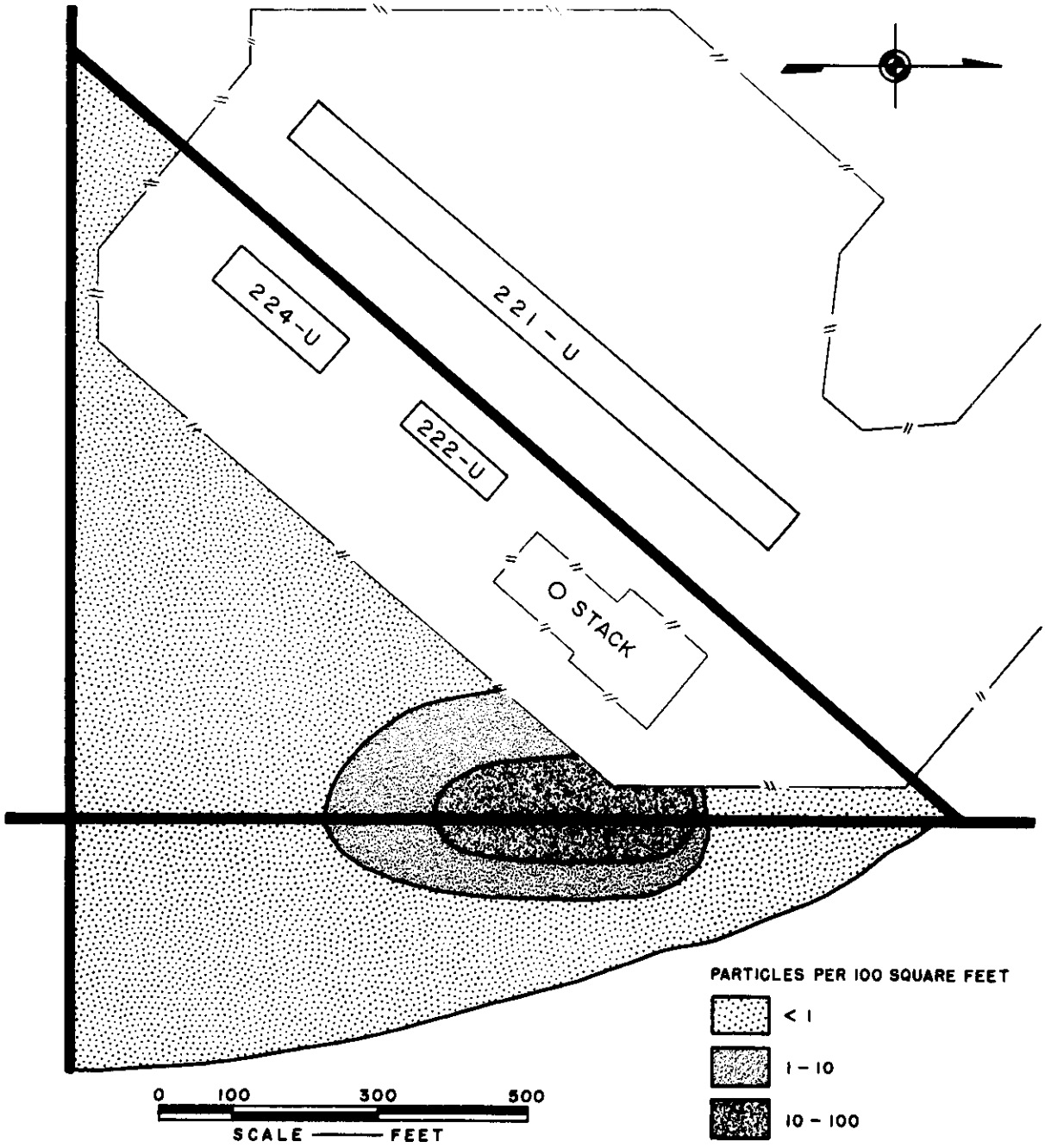
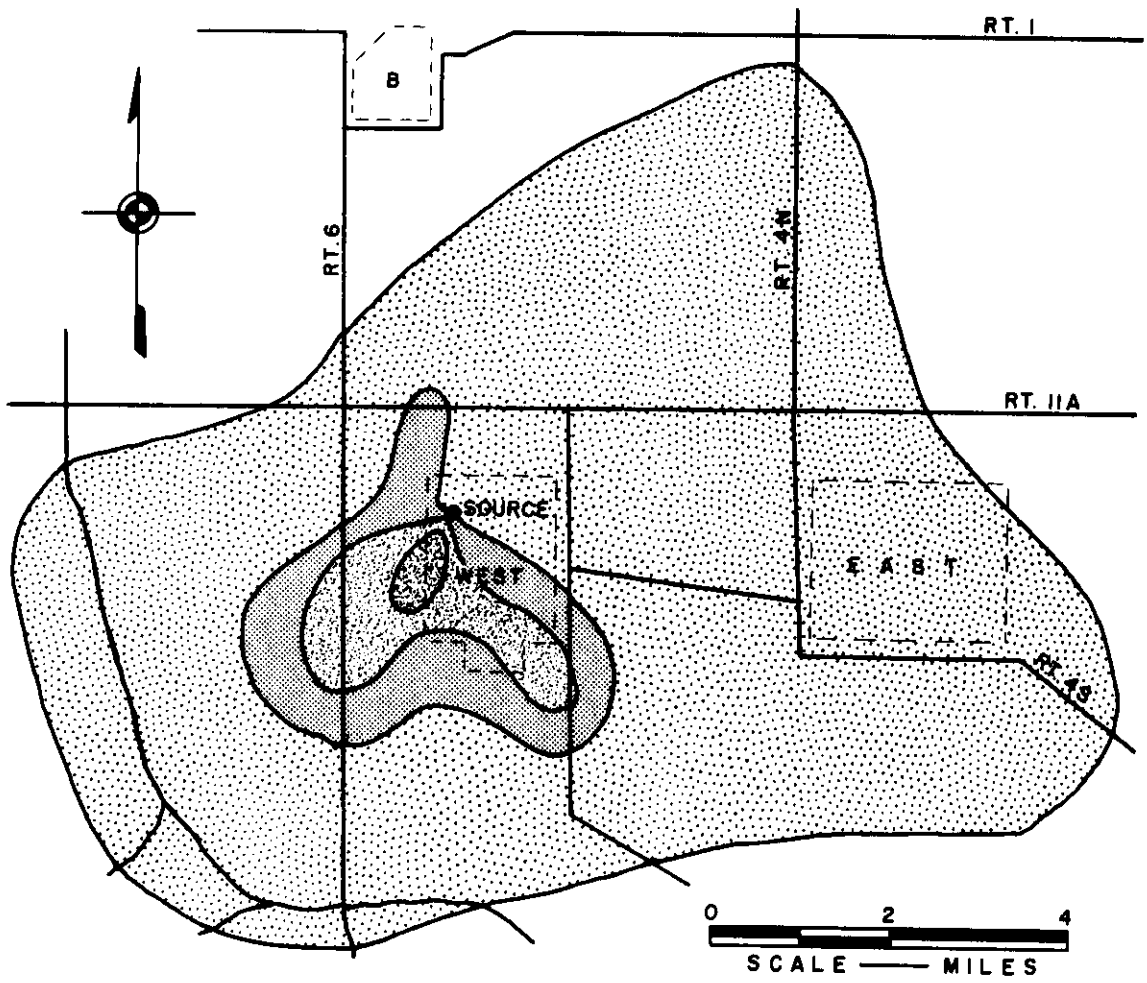


FIGURE - 40
GROUND CONTAMINATION PATTERN
200 WEST
JUNE 4, 1956

AEC-GE RICHLAND, WASH.

[redacted]



PARTICLES PER 1000 SQUARE FEET

- < 5
- 5 - 25
- 25 - 50
- 50 - 100

FIGURE - 41
GROUND CONTAMINATION PATTERN
200 WEST AREA & VICINITY
NOVEMBER 7-12, 1957

AEC-GE RICHLAND, WASH.

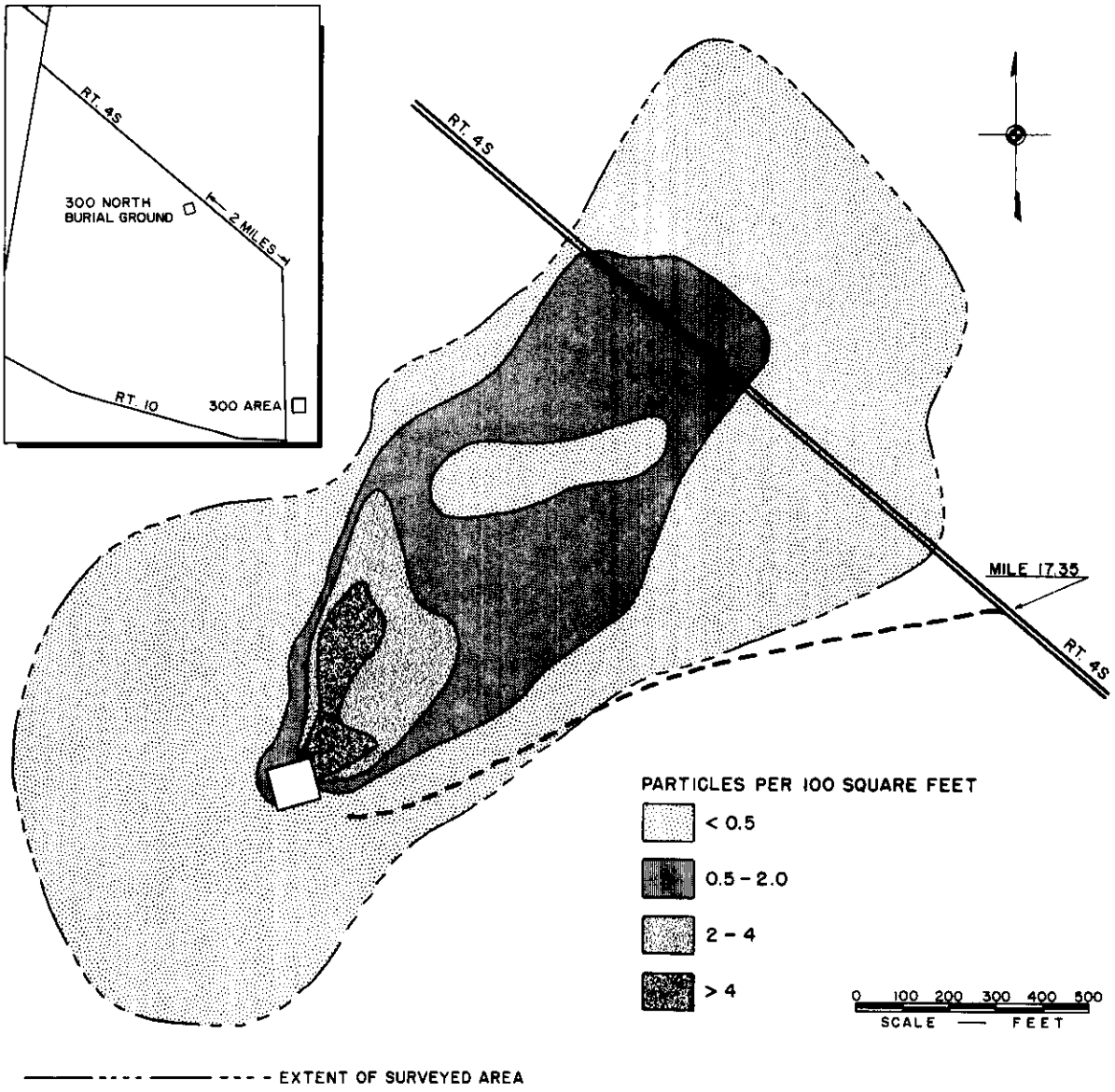


FIGURE - 42
GROUND CONTAMINATION PATTERN
300 AREA NORTH BURIAL GROUND
AUGUST 16, 1955

AEC-GE RICHLAND, WASH.

[redacted]