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# ENVIRONMENTAL STATUS OF THE HANFORD RESERVATION FOR JULY-DECEMBER, 1968

By


The Environmental Evaluations Staff
Radiation Protection Department
TECHNICAL SERVICES DIVISION

C. B. Wooldridge, Editor


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# ENVIRONMENTAL STATUS OF THE HANFORD RESERVATION FOR JULY-DECEMBER, 1968

By

The Environmental Evaluations Staff
Radiation Protection Department
TECHNICAL SERVICES DIVISION

C. B. Wooldridge, Editor

April 17, 1969

# TABLE OF CONTENTS

## LIST OF FIGURES

## LIST OF MAPS

## LIST OF TABLES

# ENVIRONMENTAL STATUS OF THE HANFORD RESERVATION FOR JULY-DECEMBER, 1968

## I. INTRODUCTION

This report summarizes data collected during the last six months of 1968 from locations within the Hanford plant boundaries for the routine environmental surveillance program, under the direction of the Environmental Evaluations staff. These environmental data are reported here for the information of the Richland Operations Office of the Atomic Energy Commission and its contractors.

The previous report in this series is BNWL-CC-1850, "Environmental Status of the Hanford Reservation for January-June, 1968". However, to show long-term trends and facilitate comparisons, the graphs in this report show 14 months of data - for the current six months and the preceeding eight months. The reader may also wish to refer to BNWL-CC-1197-6, "Environmental Status of the Hanford Reservation for November-December, 1967 (Annual Summary)" which contains a complete summary of 1967 data. Ground water data are not included in this report but will be presented in a BNWL report, "Radiological Status of the Ground Water Beneath the Hanford Project, July-December, 1968" (BNWL-984). Data from off-site sampling locations is presented in the series of monthly reports, BNWL-778-__, "Environmental Surveillance in the Vicinity of Hanford for . . . , 1968".

The majority of radiochemical analyses presented in this report were performed by the U. S. Testing Company, Inc. on samples collected by Battelle-Northwest.

The term "analytical limit", as used herein, is the concentration at which the laboratory can measure a radionuclide with a precision of $\pm 100$ per cent at the 90 per cent confidence level. The detection limit for a specific radionuclide varies with sample type, sample size, counting time, and the amounts of interfering radionuclides present. The "analytical limits" were chosen to represent upper bounds to these fluctuating detection limits.

## II. SURVEILLANCE SUMMARY FOR JULY-DECEMBER, 1968

During the last six months of 1968, plant operations were reduced compared to previous years. However, Columbia River shoreline contamination continued at the high levels observed since 1967. Airborne radioactivity from chemical separations and waste processing activities continued to be observed around 200-East Area, as evidenced by air samples and particulate deposition on control plots.

A summary of surveillance highlights for the period is given below with references to the page numbers where more detail on the subject appears.

### Columbia River Water

One river water sample collected from North Richland on September 17, 1968 had a coliform count of >1000/100 ml. The limits for coliform count established by the Washington State Water Quality Standards for this reach of the Columbia River are 240/100 ml. No explanation was found for the unusual temporary increase. Other water quality measurements were well within state standards (p. 6).

### Swamps, Ditches, and Ponds

Total beta and total alpha concentrations in samples from open waters that receive low-level radioactive wastes were within the recommended limits of 50,000 pCi/ℓ (Ref. AEC Manual Chapter 0510) during the last six months of 1968.

### Airborne Radioactivity

Increased $^{131}I$ concentrations in air at the 300 Area during July were associated with above average $^{131}I$ releases from a laboratory building (p. 22). The highest $^{131}I$ concentrations in environmental air samples during the last half of 1968 were at 200-East Area (0.3 pCi/$m^3$) following slight increases in Purex releases (p. 22).

In September, increases in airborne particulate beta activity at 200-East Area were noted following temporarily increased releases from the chemical separations facilities, a contamination spread from "C" tank farm, and a filter vent failure at 200-East AR vault. The highest particulate beta activity measured during this period was at 200-East East Center (2 pCi/$m^3$) in early September (p. 23).

A general increase in the particulate total beta concentrations in the atmosphere in mid-December was attributed to an event at the Nevada Test Site. The highest total beta concentration measured since early 1967 was found on an air filter sample collected from Walla Walla (3.9 pCi/$m^3$) in December. Analysis of the air filter for gamma emitters indicated the presence of a 0.063 MeV gamma which was tentatively identified as radiotungsten (see p. 24).

Although there were several announced foreign nuclear weapons tests during the last half of 1968, no significant increases in airborne beta activity could be attributed to these sources. An overall decreasing trend from the first part of 1968 in beta activity, attributed to decreased fallout from nuclear weapons tests, continued until December.

No unusual total alpha activity was detected on particulate air filters, other than two occurrences of thoron daughter detection. (p. 24).

Radiation Surveys

Two instances of radioactive particulate deposition were detected during routine surveys of plant roads in the last six months of 1968. Both were on controlled dirt roads in the vicinity of the old contamination spread from the 200 B-C Crib area. One particle found in early October with activity exceeding 100,000 c/m (GM) was qualitatively analyzed for gamma emitters; $^{137}Cs$, $^{154}Eu$, and $^{155}Eu$ were present (see p.38).

In September and in October, 1968, routine surveys detected radioactive deposition on control plots at the perimeter of 200-East Area, attributed to the same sources as the positive air sample reported above (p.23, 40). The maximum radiation level encountered (>100,000 c/m[GM] with 85 mrad/hr [Juno-uncorrected for source size]) was on a particle collected east of the 200-East Area in October.

Inspection of retired waste burial grounds found contamination levels on exposed material up to 10,000 c/m (GM) at the 300 North Burial Ground and 3 mR/hr at 100-F. (See p. 42)

In August, a submerged boat was recovered from the Columbia River near 100-F. Contamination on the inside of the boat (30,000 c/m [GM] maximum) was associated with river silt and sand containing the gamma emitter $^{46}Sc$. (See p. 44).

The increased dose rates and surface contamination level at shoreline locations downstream from the reactors observed since October, 1967, were sustained in the last half of 1968. Distinct radioactive particles were detected on separate occasions along the Columbia River shoreline, at the Ringold, PRTR, and Richland Pump Plant sample locations (see p. 66). General contamination was occasionally associated with foam, but usually associated with mud and shoreline deposits. The maximum shoreline exposure rate during the last six months of 1968, 400 μR/hr, was measured on a special survey of the far shore near the Powerline Crossing above 300 Area in early December. (See p. 67).

## III. COLUMBIA RIVER WATER

The locations from which raw and drinking water samples were obtained are shown in Map 1.

### A. RAW WATER

During the last six months of 1968, a monthly composite of weekly cumulative samples of raw Columbia River water from the Priest Rapids Gauge Station was analyzed for $^{3}H$, $^{90}Sr$, $^{95}Zr$-$Nb$, $^{106}Ru$, and total alpha. Results appear in Table 1.

The higher $^{3}H$ concentration in July was attributed to flood run-off carrying increased fallout deposited earlier in the year.

TABLE 1

RADIONUCLIDE CONCENTRATIONS IN THE COLUMBIA RIVER AT THE PRIEST RAPIDS GAUGE STATION

| | $^{3}H$ (pCi/ℓ) | $^{90}Sr$ (pCi/ℓ) | Total α (pCi/ℓ) | Total β (c/m/ml) |
|---|---|---|---|---|
| Analytical Limit | 1000 | 0.50 | 1.0 | |
| July, 1968 | 3700 | <0.50 | <1.0 | <0.005 |
| August | 2500 | <0.50 | <1.0 | NA |
| September | 1100 | <0.50 | <1.0 | NA |
| October | 1700 | <0.50 | <1.0 | NA |
| November | 1800 | <0.50 | <1.0 | NA |
| December | NA | 0.68 | <1.0 | NA |

NA - No analysis made.

Table 2 shows comparable analytical results for similar samples collected at Richland.

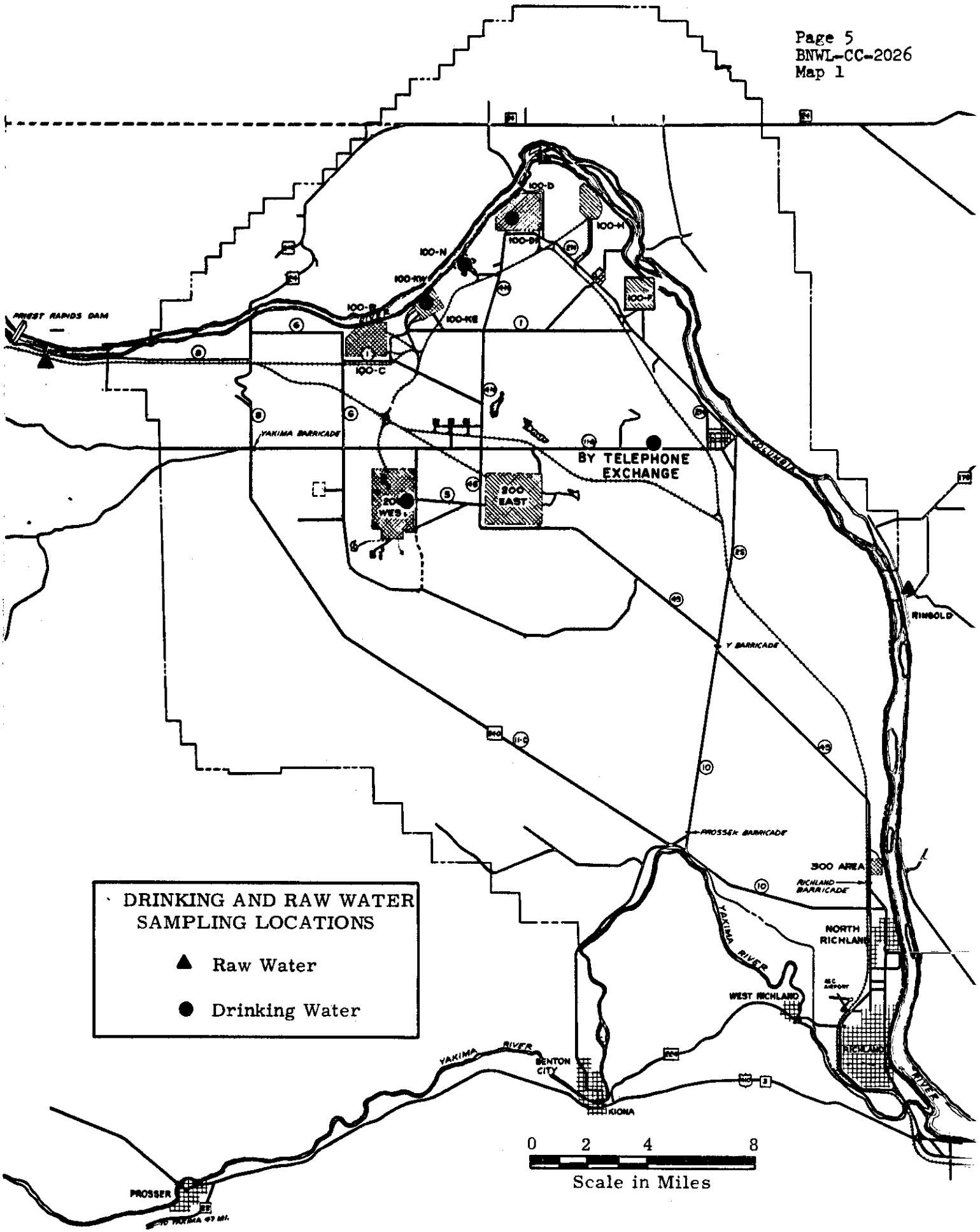

DRINKING AND RAW WATER SAMPLING LOCATIONS
Raw Water
Drinking Water
100-D
100-H
100-N
100-KW
100-KE
100-F
100-C
PRIEST RAPIDS DAM
YAKIMA BARRICADE
BY TELEPHONE EXCHANGE
200 WEST
200 EAST
RICHLAND
Y BARRICADE
RINGOLD
PROSSER BARRICADE
300 AREA
RICHLAND BARRICADE
NORTH RICHLAND
YAKIMA RIVER
WEST RICHLAND
BENTON CITY
KIONA
PROSSER
0 2 4 8
Scale in Miles

TABLE 2

RADIONUCLIDE CONCENTRATIONS IN THE COLUMBIA RIVER AT RICHLAND

| | $^{3}H$ (pCi/ℓ) | $^{90}Sr$ (pCi/ℓ) | Total α (pCi/ℓ) | Total β (c/m/ml) |
|---|---|---|---|---|
| Analytical Limit | 1000 | 0.50 | 1.0 | .02 |
| July, 1968 | NA | <0.50 | <1.0 | 1.2 |
| August | 3200 | <0.50 | <1.0 | 4.8 |
| September | 1300 | <0.50 | <1.0 | 3.3 |
| October | 1500 | 1.13 | <1.0 | 3.4 |
| November | 1500 | <0.50 | <1.0 | 8.2 |
| December | 2400 | 0.94 | <1.0 | 8.8 |

NA - No analysis made.

$^{90}Sr$ concentrations in October and December at Richland and in December at the Priest Rapids Gauge Station were above the analytical limit.

The total beta activity in river water at Ringold was obtained from analyses of weekly grab samples. Results of these analyses appear in Figure 1.

Semi-monthly samples from Vernita, 100-F, and North Richland were analyzed for coliform, enterococci and BOD (Table 3). Results were within the expected range of variation except for one sample collected at North Richland on September 17, 1968 that had coliform and enterococci counts that were >1000/100 ml. A follow-up sample from North Richland on September 24, 1968 gave a result of 65/100 ml. No explanation was found for the unusual temporary increase at that location.. This was the only result during 1968 above the limits for coliform (240/100 ml), as established by Washington State water quality standards for this reach of the Columbia River.

TABLE 3

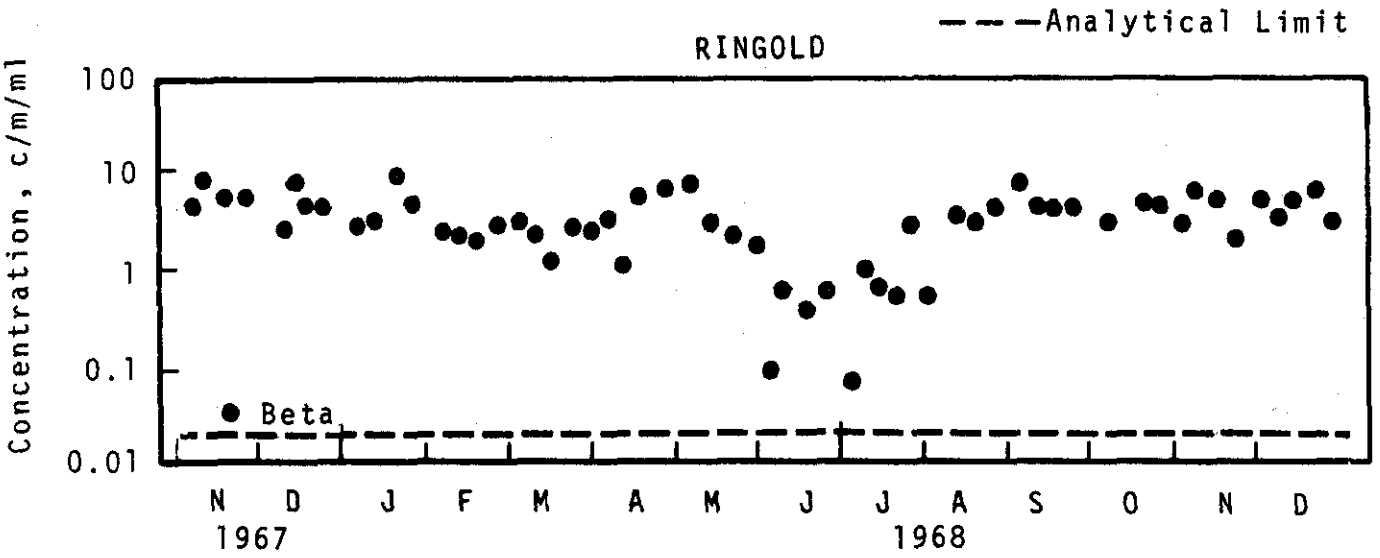
BIOLOGICAL MEASUREMENTS IN THE COLUMBIA RIVER

| Date | Vernita | | | 100 F | | | North Richland | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coliform count/100 ml | Enterococci count/100 ml | BOD mg/ℓ | Coliform count/100 ml | Enterococci count/100 ml | BOD mg/ℓ | Coliform count/100 ml | Enterococci count/100 ml | BOD mg/ℓ |
| 7-2-68 | 60 | 20 | 0.6 | 88 | NA | 4.1 | 140 | 44 | 2.3 |
| 7-16-68 | 28 | 25 | 0 | 28 | NA | 1.2 | 75 | 30 | 0.4 |
| 8-6-68 | 27 | 86 | 1.2 | 24 | 89 | 1.6 | 25 | 240 | 1.5 |
| 8-20-68 | 28 | 92 | 1.0 | 37 | 120 | 1.4 | 23 | 52 | 2.0 |
| 9-3-68 | 28 | 130 | 0.4 | 59 | 130 | 1.2 | 110 | 260 | 1.2 |
| 9-17-68 | 120 | 4 | 0.8 | 72 | 56 | 0.6 | >1,000 | >1,000 | 0.6 |
| 9-24-68 | NA | NA | NA | NA | NA | NA | 48 | 65 | NA |
| 10-8-68 | 12 | 44 | 0 | 50 | 77 | 0.8 | 110 | 100 | NA |
| 10-22-68 | 61 | 26 | 0 | 43 | 44 | 0 | 49 | 55 | 0 |
| 11-5-68 | 34 | 44 | 0.6 | 87 | 23 | 0.6 | 120 | 12 | 0.9 |
| 11-19-68 | 31 | 33 | 0.3 | 50 | 10 | 0.3 | 58 | 36 | 0.8 |
| 12-3-68 | 14 | 59 | 1.0 | 25 | 51 | 0.7 | 50 | 260 | 1.3 |
| 12-10-68 | NA | NA | NA | NA | NA | NA | 53 | 59 | 0.8 |
| 12-17-68 | 45 | 10 | 3.2 | 54 | 2 | 0.6 | 85 | 12 | 0.7 |

NA - No analysis made.

Figure 1

# RADIOACTIVITY OF COLUMBIA RIVER RAW WATER (GRAB) SAMPLES



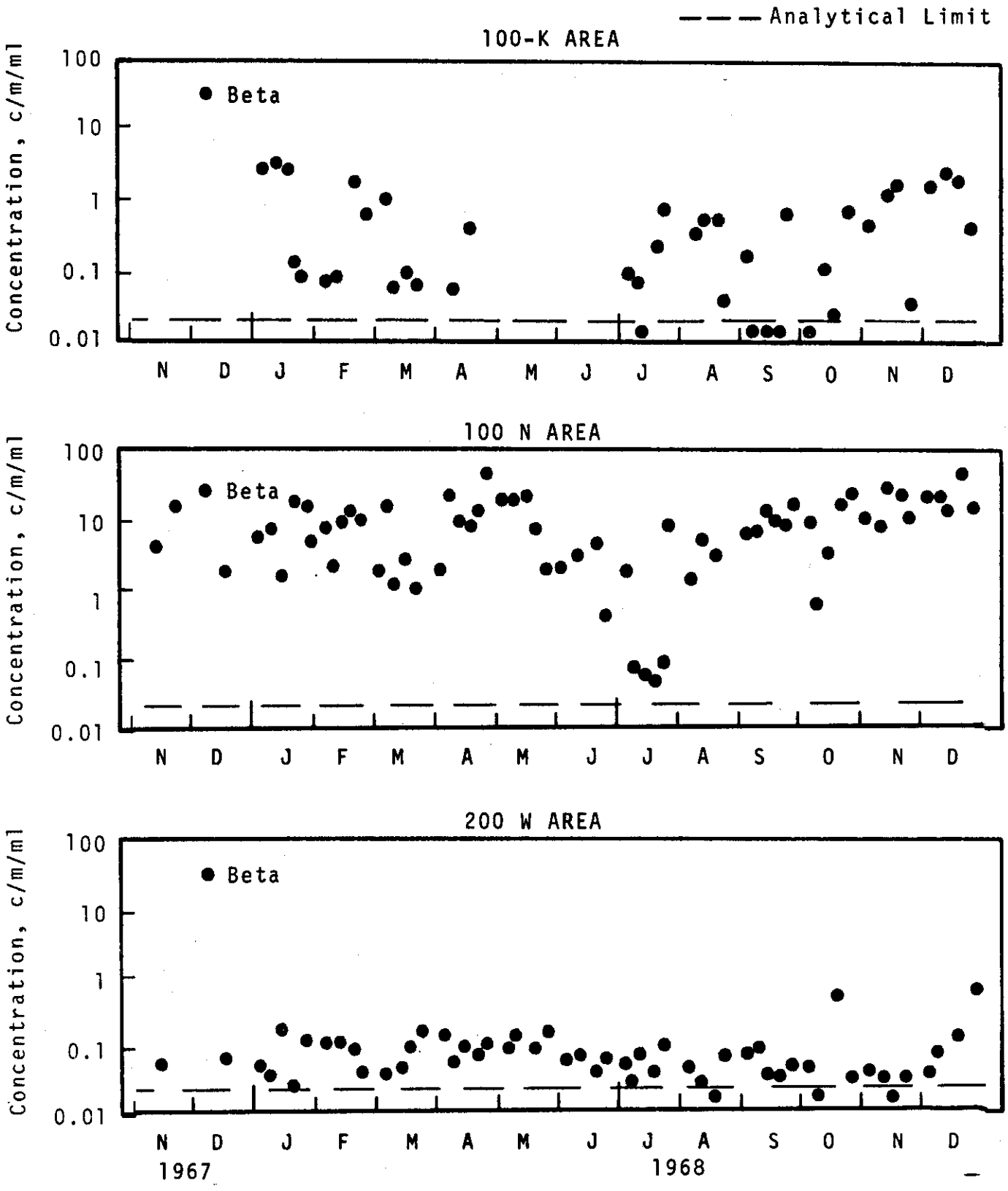
## B. DRINKING WATER

Total beta analyses of drinking water grab samples taken weekly from 100-K, 100-N, 200-W, and monthly from the B-Y Telephone exchange are shown in Figures 2 and 3. As expected, total beta concentrations at 100-K and 200-W continued to be significantly lower than those observed at 100-N, since the latter area includes a larger fraction of reactor effluent in the raw water. The monthly GI tract dose shown in Figure 3 is estimated from monthly isotopic and weekly total beta analyses of drinking water samples collected at 100-N with an assumed intake of drinking water of 0.93 ℓ/day, 5 days/week, 50 weeks/year. This estimate is based on recent dietary information (from surveys of 3,257 Richland adults) that indicates an average local daily water intake of 1.86 ℓ/day. One-half of that total daily intake is assumed to be at the place of work. Previous estimates assumed an intake of 1.2 liters per day, 5 days per week (BNWL-CC-1850), but Figure 3 has been revised to reflect the current intake value.

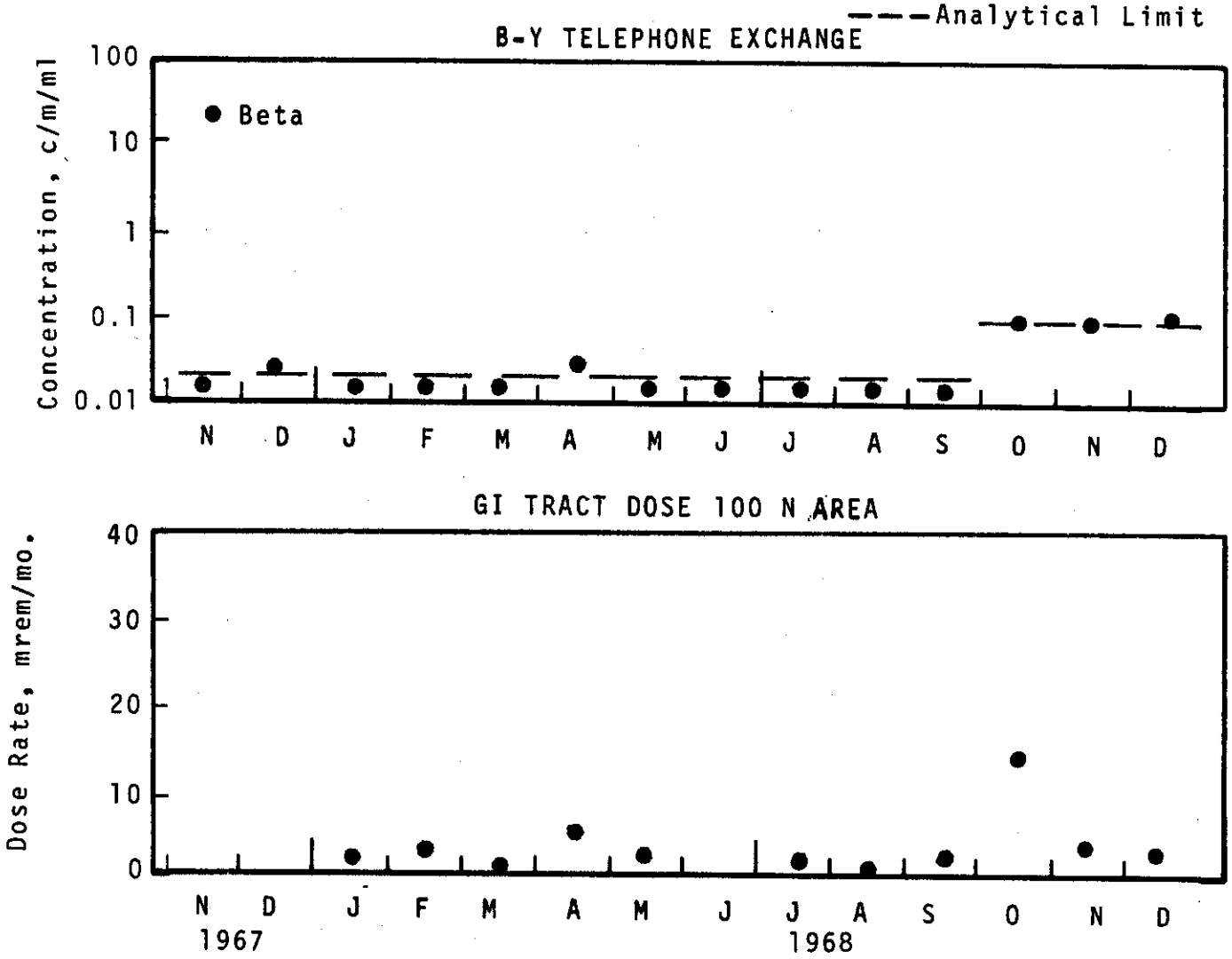
The temporary increase in the estimated GI tract dose at 100-N during October resulted from a high ratio of dose-rate to total beta count on a sample analyzed for individual radionuclides. However, individual isotopic concentrations measured were not significantly higher than in September.

Figure 2

# RADIOACTIVITY OF DRINKING WATER (GRAB) SAMPLES



# RADIOACTIVITY OF DRINKING WATER (GRAB) SAMPLES



## IV. SWAMPS, DITCHES, AND PONDS

### A. WATER

Open waters which may be used by migratory waterfowl are routinely sampled at the locations shown in Map 2. (Responsibility for sampling of the 234-5 Ditch Outlet, U Ditch Outlet, and Purex Chemical Sewer was assumed by ARHCO in July and analyses will no longer be reported here.) Grab samples were collected monthly with the exceptions of the 300 Area Process Pond Inlet which is a weekly cumulative sample and the 231 Ditch Outlet which is a weekly grab sample. All swamp samples collected between July and December were quantitatively analyzed for selected radionuclides. These results appear in Table 4.

Figures 4-6 show results of total beta and total alpha analyses on samples from swamps and ditches located within or near the 200 West Area, and Figure 7 shows data obtained from samples of swamps and ditches located within and near the 200 East Area. Figure 8 shows results of both radiochemical and chemical analyses on samples from the 300 Area Process pond.

1. 200 Area Waste Waters - Increases in total beta and $^{137}Cs$ concentrations beyond the expected range of variation were noted at the 200 West Area T Swamp in November. The appropriate ARHCO personnel were notified.

TABLE 4

RADIONUCLIDE CONCENTRATIONS IN WASTE WATER SAMPLES
(pCi/ℓ)

| | Date | $^{51}Cr$ | $^{65}Zn$ | $^{125}Sb$ | $^{131}I$ | $^{134}Cs$ | $^{137}Cs$ |
|---|---|---|---|---|---|---|---|
| T Swamp North | 8-3-68 | 1100 | ND | ND | ND | <310 | 1400 |
| | 9-20 | <480 | <96 | <310 | ND | ND | 290 |
| | 10-25 | 590 | ND | ND | <49 | ND | 230 |
| | 11-22 | ND | 520 | ND | 220 | 4000 | 21000 |
| | 12-20 | 720 | ND | ND | ND | ND | 230 |

| | Date | $^{51}Cr$ | $^{65}Zn$ | $^{131}I$ | $^{137}Cs$ |
|---|---|---|---|---|---|
| U Swamp North | 7-19-68 | 1100 | <96 | ND | 540 |
| | 8-23 | 650 | <96 | ND | 96 |
| | 9-20 | <480 | <96 | ND | <51 |
| | 10-25 | 480 | ND | <48 | <51 |
| | 11-22 | ND | <96 | <62 | 94 |
| | 12-20 | 570 | ND | ND | <51 |

ND - Not detected.

TABLE 4 (Continued)

RADIONUCLIDE CONCENTRATIONS IN WASTE WATER SAMPLES
(pCi/ℓ)

| | Date | $^{51}Cr$ | $^{65}Zn$ | $^{131}I$ | $^{137}Cs$ |
|---|---|---|---|---|---|
| 222-S Swamp | 7-19-68 | 770 | <96 | ND | <51 |
| | 8-23 | 1300 | <96 | ND | <51 |
| | 9-20 | <480 | <96 | ND | <51 |
| | 10-25 | 580 | ND | <48 | <51 |
| | 11-22 | ND | <96 | <62 | <51 |
| | 12-20 | 590 | ND | ND | 360 |
| | **Date** | **$^{51}Cr$** | **$^{65}Zn$** | **$^{131}I$** | **$^{137}Cs$** |
| Redox North East | 7-19-68 | 820 | <96 | ND | <51 |
| | 8-23 | 1400 | <96 | ND | <51 |
| | 9-20 | <480 | <96 | ND | <51 |
| | 10-25 | 840 | ND | <48 | <51 |
| | 11-22 | ND | <96 | 77 | <51 |
| | 12-20 | 840 | ND | ND | <51 |
| | **Date** | **$^{51}Cr$** | **$^{65}Zn$** | **$^{131}I$** | **$^{137}Cs$** |
| B Swamp North | 7-19-68 | 790 | <96 | 130 | <51 |
| | 8-23 | ND | ND | 2800 | <51 |
| | 9-20 | <480 | <96 | 450 | <51 |
| | 10-25 | 2400 | ND | 5300 | <51 |
| | 11-22 | ND | <96 | 850 | <51 |
| | 12-20 | ND | ND | 180 | <51 |
| | **Date** | **$^{51}Cr$** | **$^{65}Zn$** | **$^{131}I$** | **$^{137}Cs$** |
| Gable Swamp North | 7-19-68 | 670 | <96 | ND | 130 |
| | 8-23 | 690 | ND | ND | 63 |
| | 9-20 | 530 | <96 | 111 | 61 |
| | 10-25 | 660 | ND | 140 | <51 |
| | 11-22 | 670 | <96 | ND | <51 |
| | 12-20 | ND | ND | <81 | 70 |

ND - Not detected.

2. 300 Area Leach Trench - Samples were periodically collected from the 300 Area sanitary waste disposal site and analyzed for coliform, enterococci (a fecal organism) and BOD (biochemical oxygen demand).

TABLE 5

BIOLOGICAL MEASUREMENTS AT THE
300 AREA TRENCH AND SHORELINE SEEPAGE AREA

| | 300 Area Leach Trench | | |
|---|---|---|---|
| Date | Coliform/100 ml | Enterococci/100 ml | BOD mg/ℓ |
| 7-16-68 | 180,000 | NA | 4.1 |
| 8-20 | 20,000 | 16,000 | 5.0 |
| 9-17 | 50,000 | 3,300 | 17.4 |
| 10-22 | 22,000 | 1,400 | 6.1 |
| 11-19 | 40,000 | 6,800 | 22. |
| 12-17 | 120,000 | 17,000 | 77. |

| | River Shoreline Seepage Area | | |
|---|---|---|---|
| Date | Coliform/100 ml | Enterococci/100 ml | BOD mg/ℓ |
| 7-16-68 | 80 | 45 | 1 |
| 8-20 | 117 | 69 | 2 |
| 9-17 | 45 | 27 | 0.8 |
| 9-24 | 81 | 86 | NA |
| 10-22 | 32 | 98 | 0 |
| 11-19 | 53 | 220 | 1.1 |
| 12-10 | 35 | 19 | 0.7 |
| 12-17 | 38 | 25 | 1.7 |

NA - Not analyzed.

3. 300 Area Process Pond - Weekly cumulative samples were collected from the 300 Area process pond water throughout this reporting period. Results for total beta, uranium, nitrate, and hexavalent chromium analyses appear in Figure 8. Monthly average fluoride ion measurements appear below.

TABLE 6

FLUORIDE CONCENTRATIONS IN THE 300 AREA PROCESS POND

| Month | Average Concentrations (ppm) |
|---|---|
| July | 2.6 |
| August | 3.1 |
| September | 3.2 |
| October | 3.1 |
| November | 3.0 |
| December | 3.0 |

B. GAME BIRDS

The flesh of game birds that have utilized swamps and ponds receiving low-level radioactive wastes may contain $^{32}P$, $^{65}Zn$, $^{137}Cs$-$^{137m}Ba$, and other radionuclides. Table 7 shows the results of radioassays of three waterfowl collected at Gable Swamp during 1968.

TABLE 7

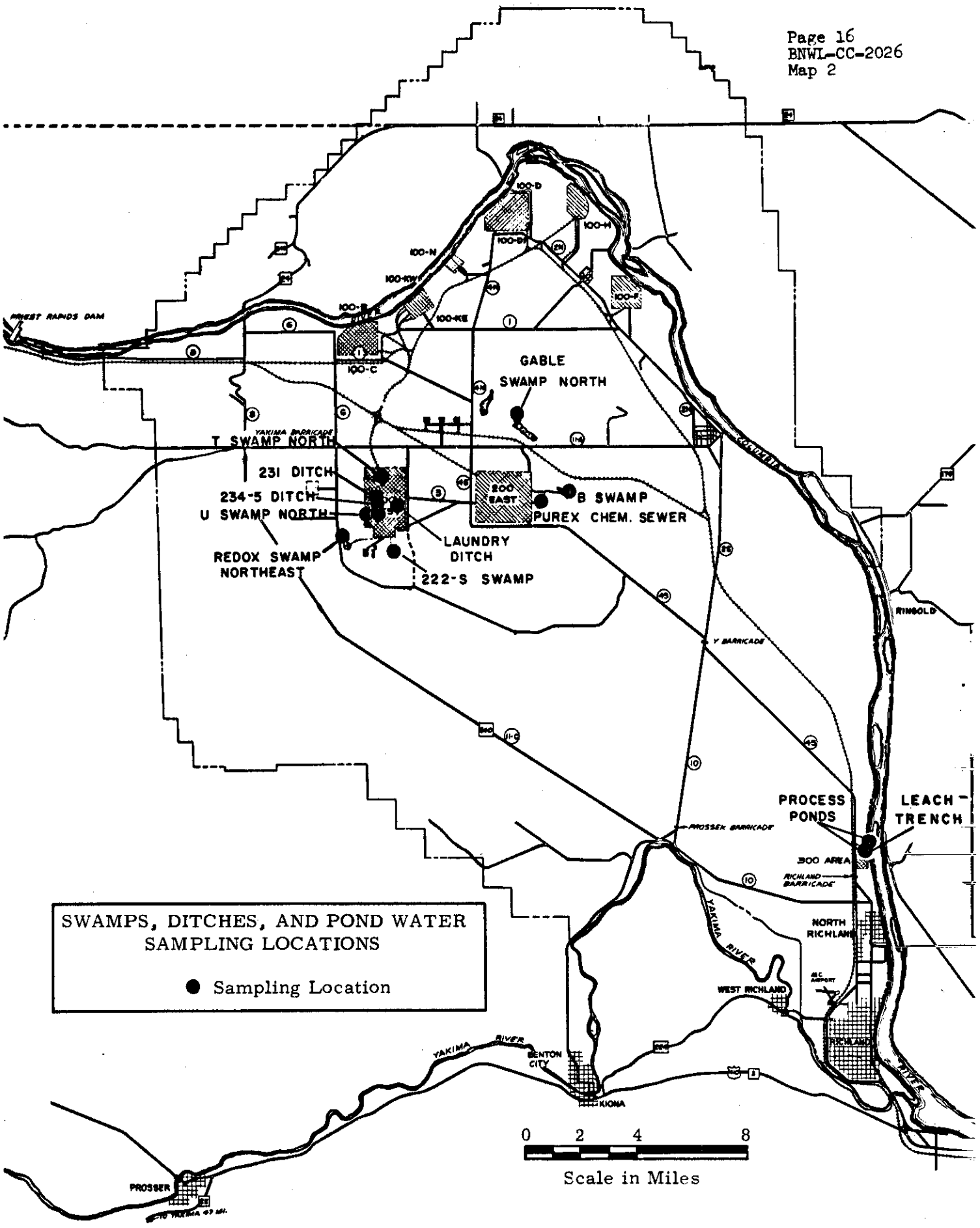
RADIONUCLIDE CONCENTRATIONS IN THE MUSCLE OF GAME BIRDS COLLECTED NEAR GABLE MOUNTAIN SWAMP

(pCi/g)

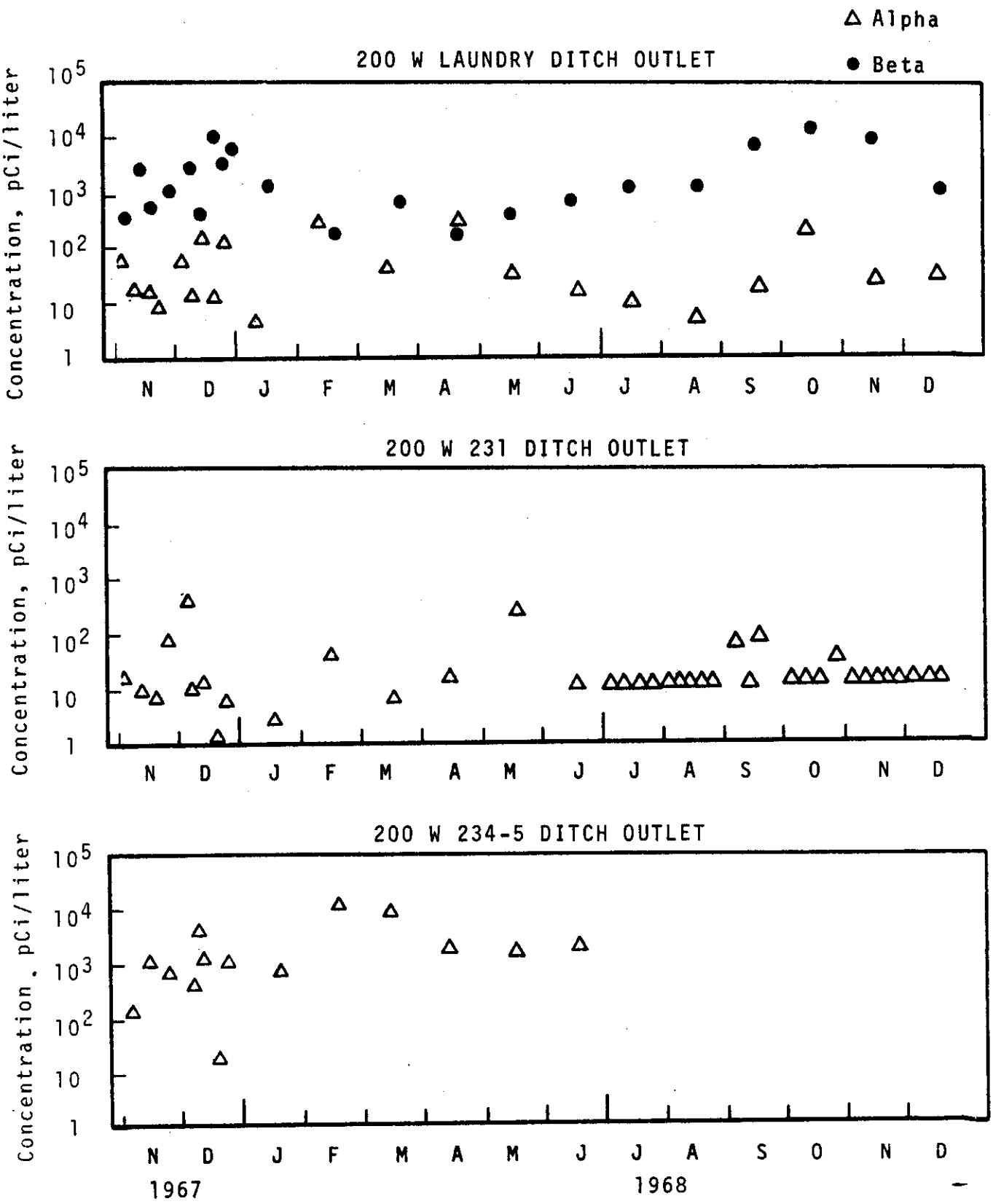
| Date | Species | $^{32}P$ | $^{65}Zn$ | $^{137}Cs$ | $^{137}Cs$-$^{137m}Ba$ |
|---|---|---|---|---|---|
| Analytical | Limit | 1 | 0.2 | - | 0.1 |
| 12-3-68 | Mallard | 38. | 2.9 | ND | 11. |
| 12-26 | Golden Eye | 2.9 | <0.3 | 8.6 | 500. |
| 12-27 | Gr. Winged Teal | 130. | <0.5 | 4.7 | 330. |

ND - Not detected.

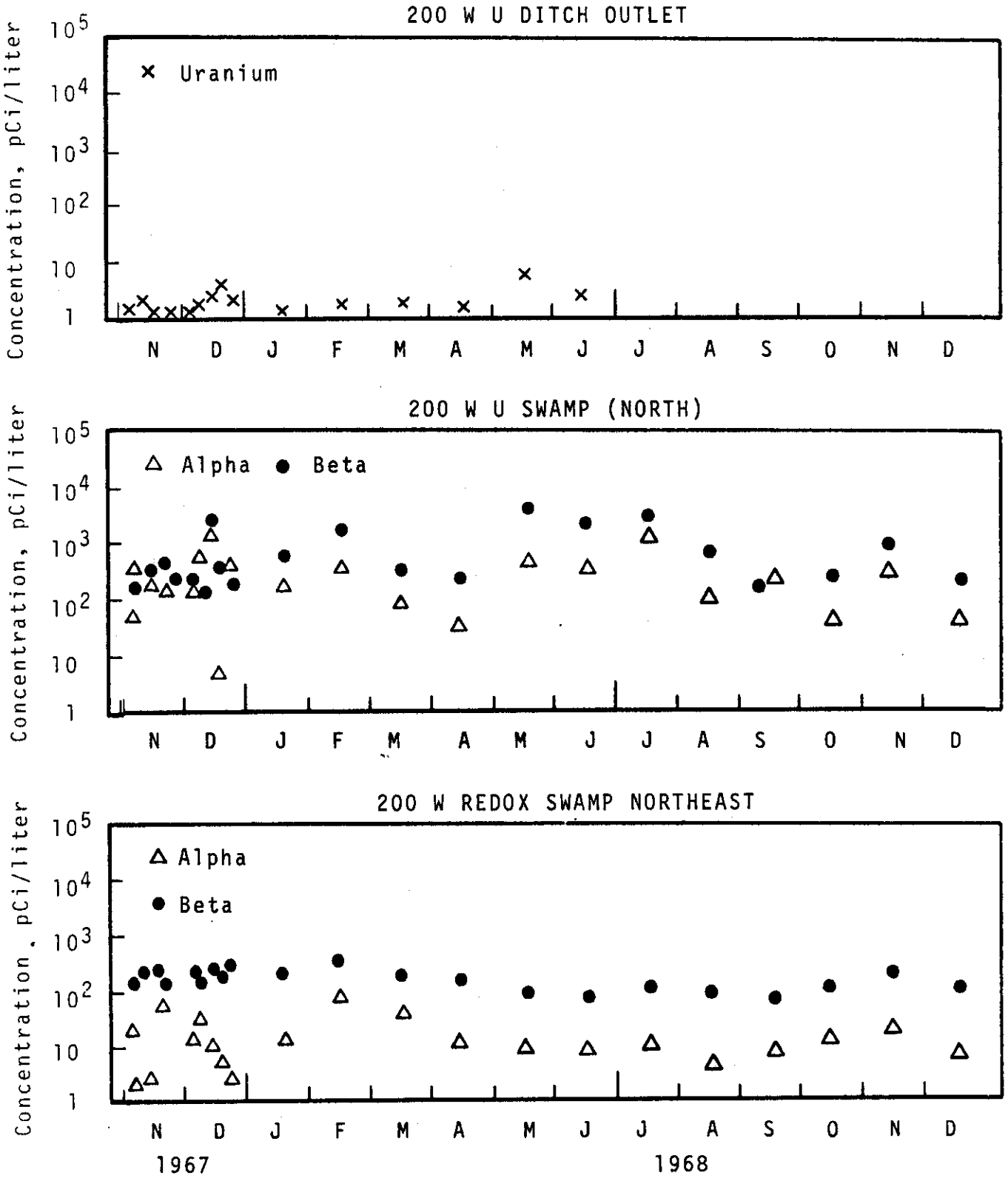
For comparison, the maximum concentrations of $^{32}P$ and $^{65}Zn$ in other game bird samples collected from locations adjacent to the Columbia River during December were 490 pCi/g and 12 pCi/g respectively. A mallard collected at Savage Island contained 8.5 pCi $^{137}Cs$/g, the highest $^{137}Cs$ concentration of 137 river birds sampled during 1968. No $^{134}Cs$ was detected in river birds during 1968. Data from past years indicate that river birds usually contain higher $^{32}P$ and $^{65}Zn$ concentrations and lower $^{137}Cs$ concentrations compared to birds collected from swamps. The combination of significant $^{32}P$ and $^{137}Cs$ concentrations in the Green Winged Teal collected at Gable Swamp is rather unusual.

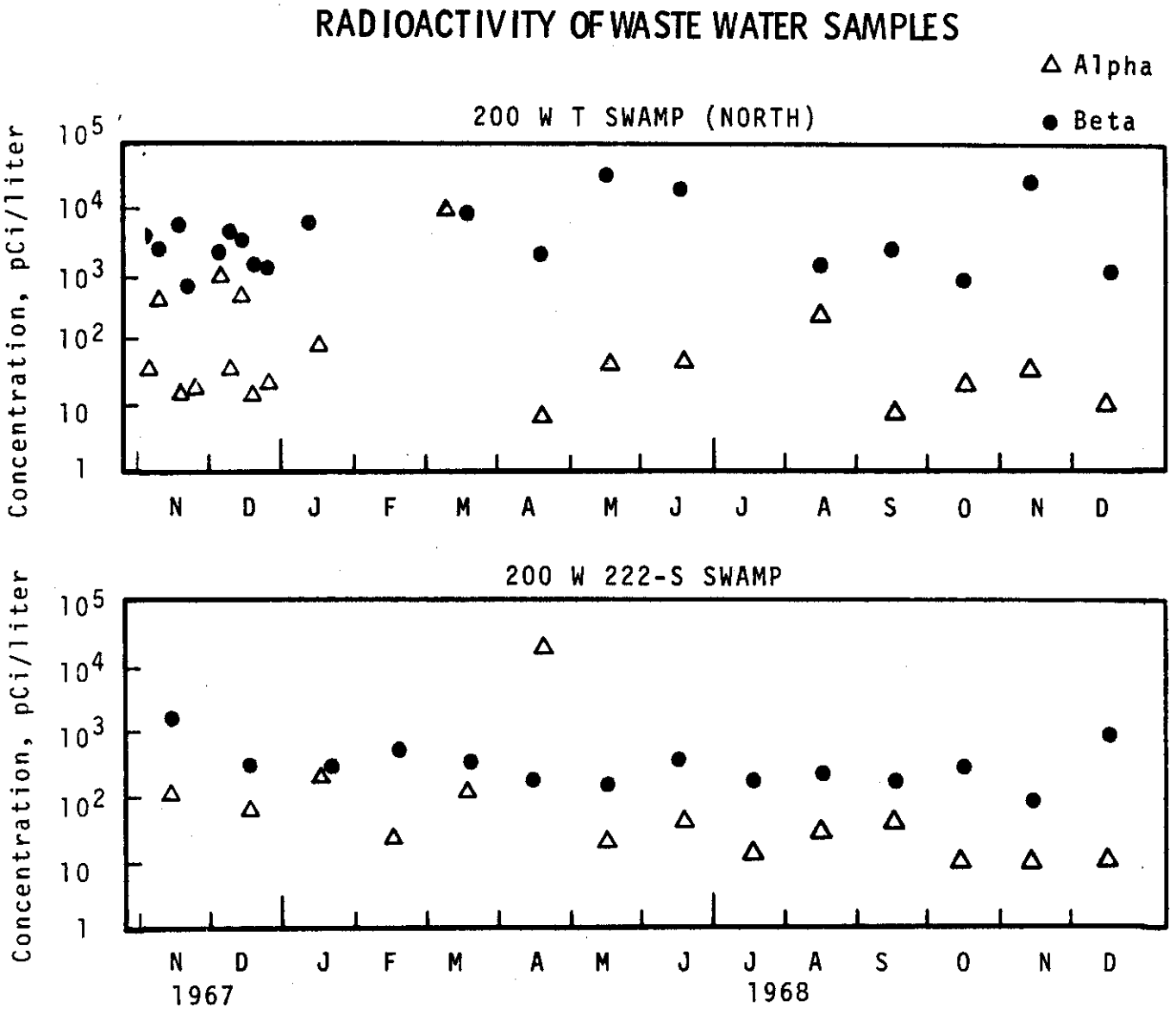

PRIEST RAPIDS DAM
100-D
100-H
100-N
100-KW
100-KE
100-F
100-C
GABLE
SWAMP NORTH
YAKIMA BARRICADE
T SWAMP NORTH
231 DITCH
234-5 DITCH
U SWAMP NORTH
200 EAST
B SWAMP
PUREX CHEM. SEWER
LAUNDRY
DITCH
REDOX SWAMP
NORTHEAST
222-S SWAMP
RINGOLD
Y BARRICADE
PROCESS
PONDS
LEACH
TRENCH
PROSSER BARRICADE
300 AREA
RICHLAND
BARRICADE
YAKIMA RIVER
NORTH
RICHLAND
WEST RICHLAND
RICHLAND
YAKIMA RIVER
BENTON
CITY
KIONA
PROSSER
SWAMPS, DITCHES, AND POND WATER
SAMPLING LOCATIONS
Sampling Location
0 2 4 8
Scale in Miles

# RADIOACTIVITY OF WASTE WATER SAMPLES

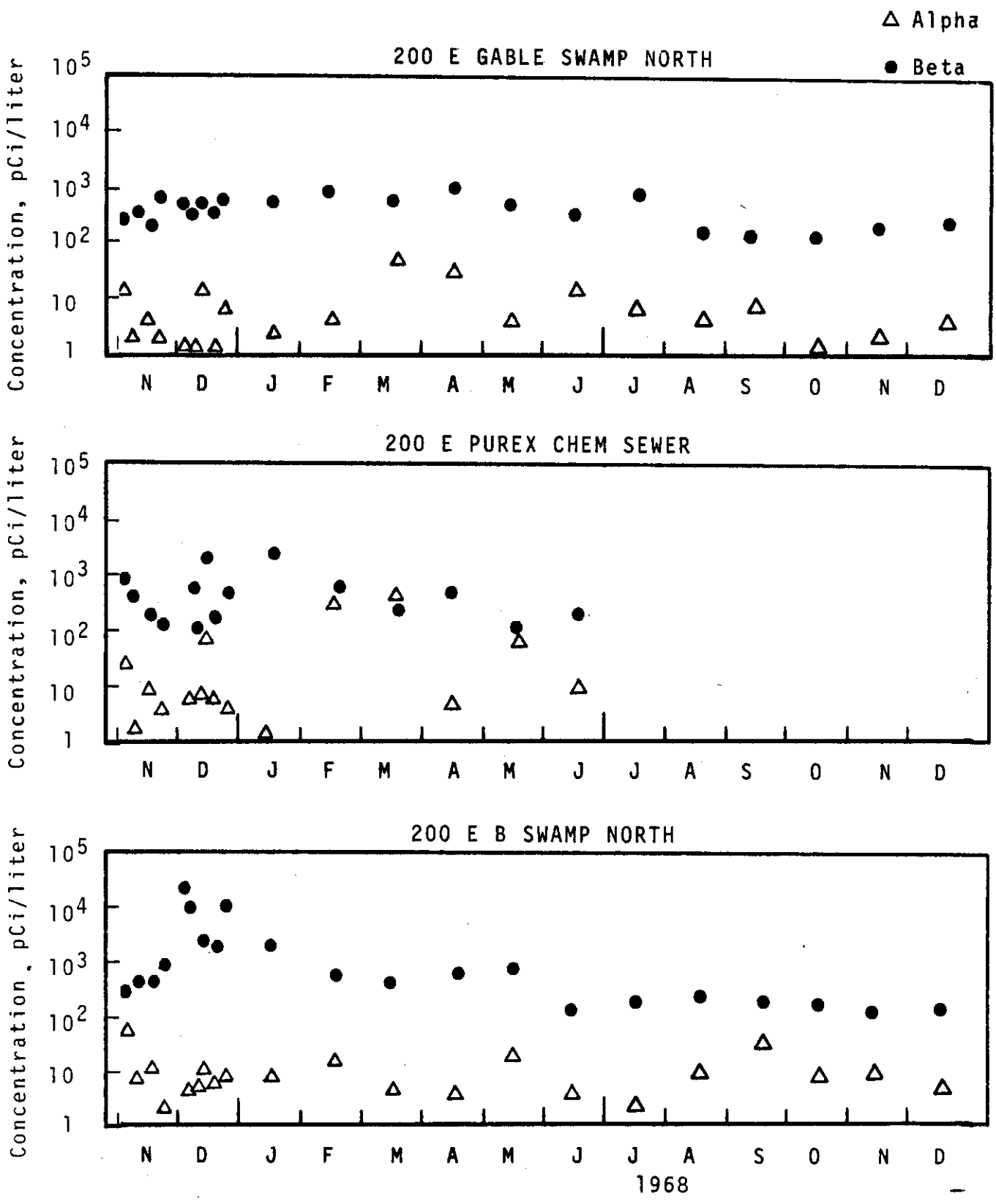


# RADIOACTIVITY OF WASTE WATER SAMPLES

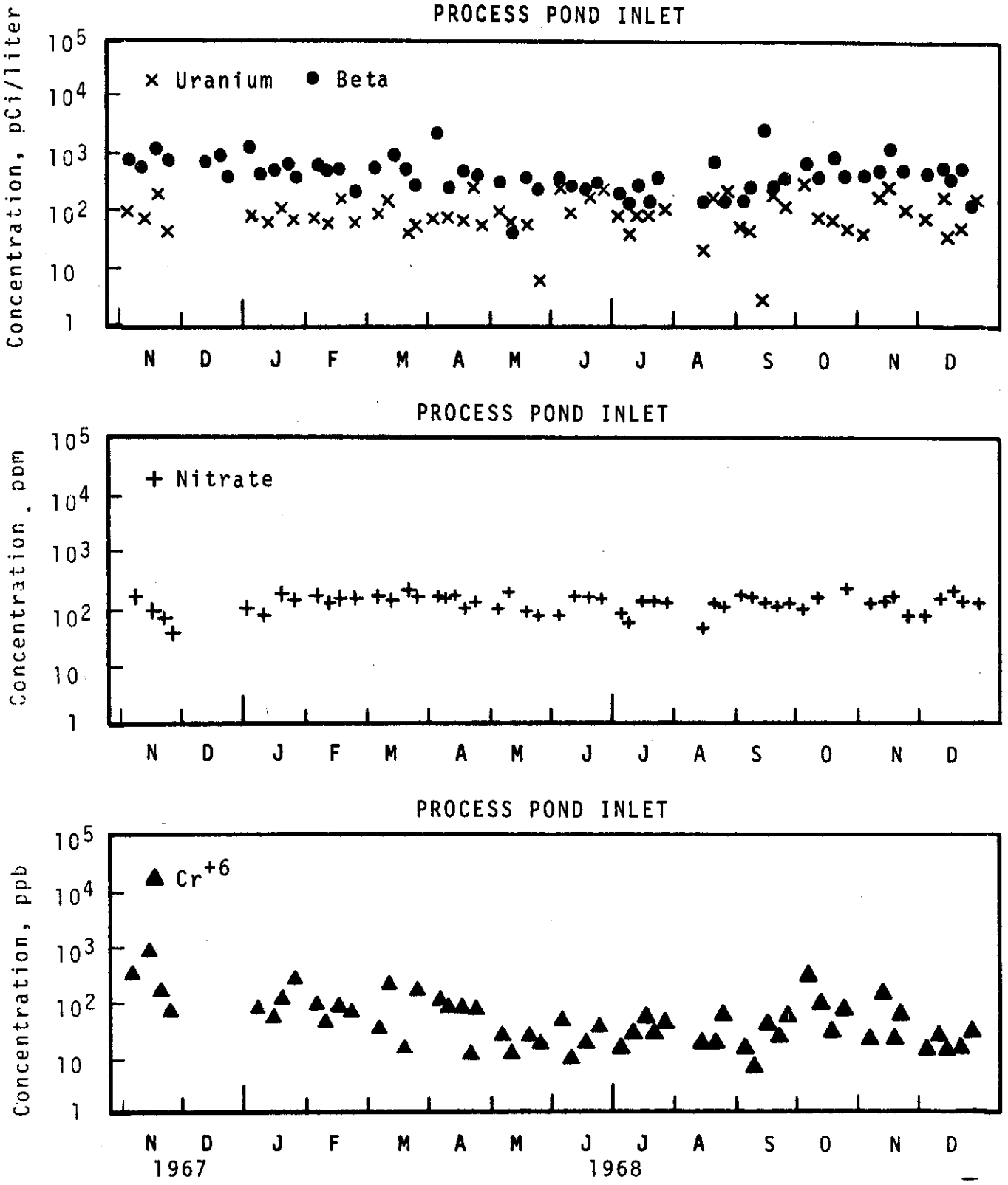



RADIOACTIVITY OF WASTE WATER SAMPLES
Δ Alpha
● Beta
200 W T SWAMP (NORTH)
Concentration, pCi/liter
10^5
10^4
10^3
10^2
10
1
N D J F M A M J J A S O N D
200 W 222-S SWAMP
Concentration, pCi/liter
10^5
10^4
10^3
10^2
10
1
N D J F M A M J J A S O N D
1967
1968

# RADIOACTIVITY OF WASTE WATER SAMPLES



# WASTE WATER SAMPLE ANALYSES - 300 AREA



## V. AIRBORNE RADIOACTIVITY

Results of routine sampling of the atmosphere for radioactivity at 20 locations within the Hanford Reservation (Map 3) are shown in Figures 9-15. (Sampling for chemical pollutants in the atmosphere is conducted and reported by Hanford Environmental Health Foundation.)

The sampling equipment sheltered in small buildings designated "614", draws air at a flow rate of 1.5 cfm through HV-70 filter paper and then through a solution of NaOH for $^{131}I$ collection. The normal sampling period is one week. "Total Beta" represents the gross activity of particulates collected on filter paper during the sampling period (calculated as $^{90}Sr$-Y). The 200-East North Center location was added to the routine schedule and sampling was resumed at the Wye Barricade in July.

### A. IODINE-131

During the period July-December, 1968, several transient increases in $^{131}I$ were observed. A month-by-month summary follows.

July - An increase in $^{131}I$ released from laboratory buildings in the 300 Area resulted in higher than usual $^{131}I$ concentrations at the 300 Area in early July (0.18 pCi/m$^3$ during 7-1/7-8).

August - The highest $^{131}I$ results in environmental air samples during this reporting period were 0.3 pCi/m$^3$ at both 200-East East Center and 200-East Southeast during the period 8-5/8-12. These and slight increases at other locations were attributed to temporarily increased $^{131}I$ releases from Purex during the period 7-15/8-12.

September - Increased release rates at a chemical separations facility resulted in somewhat higher $^{131}I$ and total beta concentrations at 200-East East Center (0.08 pCi $^{131}I$/m$^3$ for 9-2/9-9).

November - Concentrations of $^{131}I$ exceeded the detection limit (.02 pCi/m$^3$) at several locations in early November following an increased $^{131}I$ release rate at a chemical separations facility.

The annual average $^{131}I$ and particulate total beta concentrations for 1968 are shown below in Table 8 and, for comparison, the averages for the previous three years are also shown.

TABLE 8

AVERAGE $^{131}I$ AND PARTICULATE TOTAL BETA CONCENTRATIONS IN THE ATMOSPHERE
(Results in $pCi/m^3$)

| Location | Total Beta | | | | $^{131}I$ | | | |
|---|---|---|---|---|---|---|---|---|
| | 1968 | 1967 | 1966 | 1965 | 1968 | 1967 | 1966 | 1965 |
| 100 Areas[1] | .30 | .34 | .29 | .44 | .02 | .02 | .20 | .03 |
| 200 Areas[2] | .28 | .41 | .58 | .80 | .03 | .09 | .10 | .14 |
| Other On-Plant[3] Locations | .20 | .26 | .24 | .34 | .02 | .04 | .20 | .05 |

1 100-B, 100-K, 100-N, 100-D, 100-F, and 100-H. 100-H was discontinued after April 1968.

2 200-W Northeast, 200-W Redox, 200-W West Center, 200-East North Center (after June 1968), 200-E Hill and 200-E Main Gate. The latter 2 locations were discontinued after April 1968.

3 Midway, Rattlesnake Springs, ERC, Wye Barricade, Hanford, 300 Area, and Prosser Barricade.

B. TOTAL BETA

Several transient increases in total beta activity were observed during the reporting period. A month-by-month summary of unusual results is presented below.

September - Beta activity increased at 200-East East Center, 200-East North Center and at other nearby locations during early September following a contamination spread from "C" tank farm. Analyses of the air filter operated 9-2 to 9-9 at 200-East East Center indicated a total beta concentration of 1.9 $pCi/m^3$ air. A gamma scan of this air filter detected $^{95}Zr$-Nb, $^{106}Ru$-Rh, $^{137}Cs$-$^{137m}Ba$, and $^{144}Ce$-Pr. (See Table 9.) The following week, $^{95}Zr$-Nb and $^{137}Cs$-$^{137m}Ba$ were again detected on the 200-East North Center filter.

October - The 200-East East Center and 200-East North Center sampling locations continued to have higher beta concentrations in the atmosphere as a result of work in the 200-East Area tank farms. Analysis of the filter operated at 200-East East Center 10-14 to 10-21 indicated a concentration of 1.0 $pCi\beta/m^3$ air which was attributed to a pump change-out at "A" tank farm. (See Table 9.)

B. TOTAL BETA (Continued)

December - A general increase in beta activity in the atmosphere was attributed to regional fallout from an event at the Nevada Test Site. The highest activity measured (3.9 pCi/$m^3$) was at an off-site location (Walla Walla) during 12-6 to 12-20 and was attributed to radiotungsten and trace amounts of fission products. This concentration of particulate radioactivity was higher than any measured at any of the routine air sampling locations since January, 1967.

No significant contribution to atmospheric radiation levels was detected in December samples from the announced foreign nuclear weapons test of December 27, 1968.

TABLE 9

SPECIAL ANALYSES OF AIR FILTERS

| | | Radionuclide Concentrations (pCi/$m^3$) | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Gamma Emitters | | | |
| Date Off | Location | Total α | Total β | $^{95}$Zr-Nb | $^{106}$Ru-Rh | $^{137}$Cs-$^{137m}$Ba | $^{144}$Ce-Pr |
| 7-1 | 100-K Exclusion Area | 0.016 | 0.712 | NA | NA | NA | NA |
| 9-9 | 200-East East Center | 0.039 | 1.9 | NA | NA | NA | NA |
| 9-9 | 200-East East Center (Recount) | 0.002 | 1.6 | 0.3 | 1.7 | 0.5 | 0.3 |
| 9-16 | 200-East North Center | 0.0 | 0.9 | 0.1 | ND | 0.3 | ND |
| 9-30 | 200-East East Center | 0.009 | 1.0 | 0.3 | ND | 0.4 | ND |
| 10-21 | 200-East East Center | 0.025 | 1.04 | 0.4 | ND | 0.3 | ND |
| 10-28 | 200-East North Center (Recount) | 0.004 | NA | NA | NA | NA | NA |
| 12-9 | 200-East North Center | 0.003 | 1.1 | ND | ND | 0.7 | ND |
| 12-20 | Walla Walla | NA | 3.9 | ND | ND | ND | ND (see text) |

NA - Not analyzed.

ND - Not detected.

C. TOTAL ALPHA

Twelve of the 20 weekly filters which are analyzed for beta-gamma emitting radionuclides are also analyzed for alpha activity, with most such sampling sites located in the 200 Areas. These data are presented in Figures 16-19.

For most sampling locations, results were generally at or below the analytical limit of 0.01 pCiα/$m^3$ during the last half of 1968. On two occasions, the first week of September and the last week of October, increased alpha activity detected on 200 Areas air filter samples was attributed to naturally-occuring radon and thoron daughter products. In both instances the final counts on representative filters were below the analytical limit for alpha activity (see Table 9).

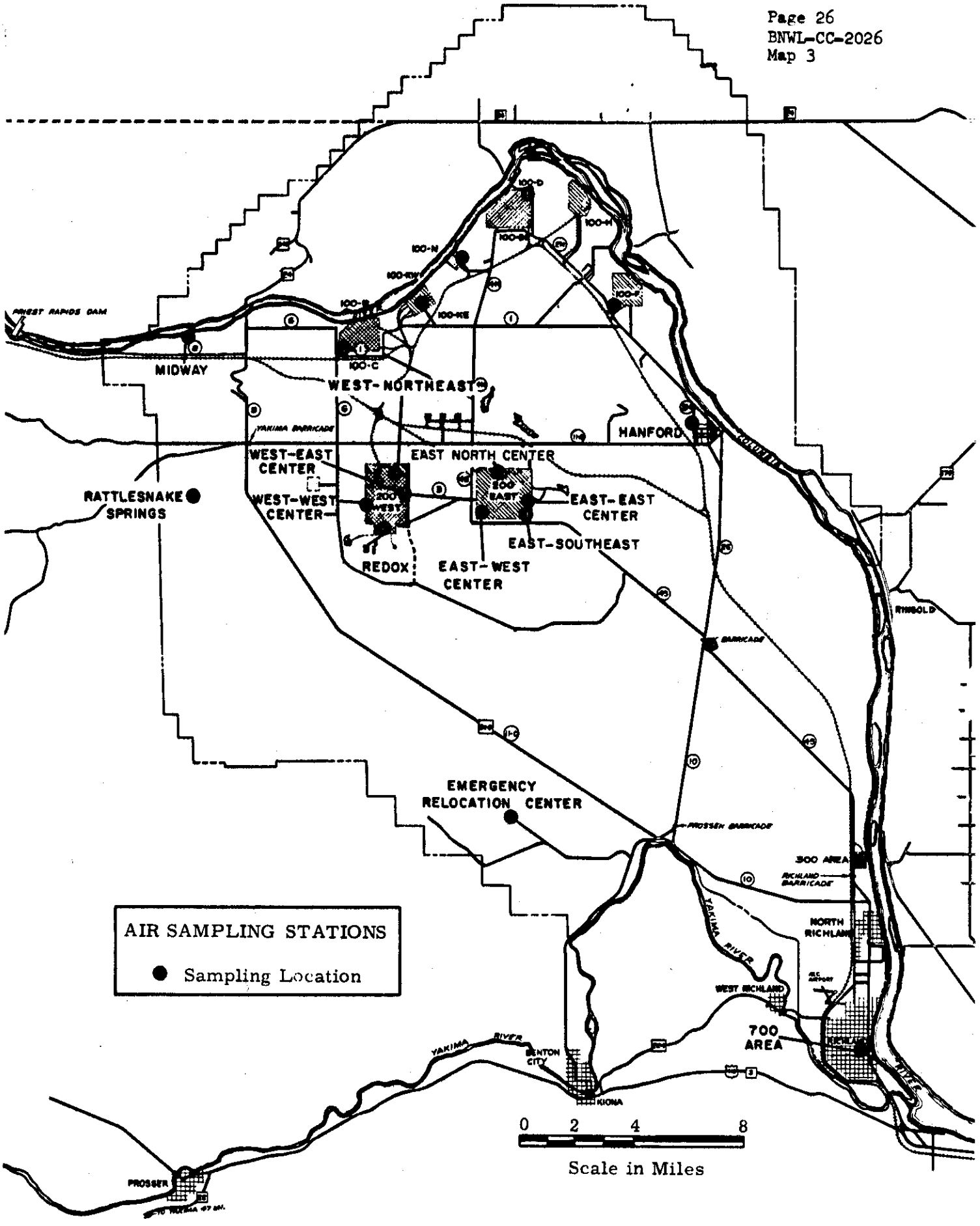
C. TOTAL ALPHA (Continued)

The annual average total alpha concentrations in the atmosphere for 1968 are presented in Table 10. For comparison, averages for the previous three years are also shown.

TABLE 10

AVERAGE TOTAL ALPHA CONCENTRATIONS IN THE ATMOSPHERE

| Location | 1968 | 1967 | 1966 | 1965 |
|---|---|---|---|---|
| 100 Areas | .006 | .01 | .01 | <0.02 |
| 200 Areas | .006 | .02 | .01 | <0.03 |
| 300 Area | .011 | .01 | .02 | 0.08 |
| 700 Area | .006 | .01 | .02 | <0.02 |


PRIEST RAPIDS DAM
MIDWAY
100-C
WEST-NORTHEAST
YAKIMA BARRICADE
HANFORD
WEST-EAST CENTER
EAST NORTH CENTER
RATTLESNAKE SPRINGS
WEST-WEST CENTER
200 WEST
200 EAST
EAST-EAST CENTER
EAST-SOUTHEAST
REDOX
EAST-WEST CENTER
RICHLAND
BARRICADE
EMERGENCY RELOCATION CENTER
PROSSER BARRICADE
300 AREA
RICHLAND BARRICADE
NORTH RICHLAND
YAKIMA RIVER
WEST RICHLAND
700 AREA
YAKIMA RIVER
BENTON CITY
KIONA
PROSSER
AIR SAMPLING STATIONS
Sampling Location
0 2 4 8
Scale in Miles

# IODINE-131 AND TOTAL BETA ACTIVITY IN THE ATMOSPHERE

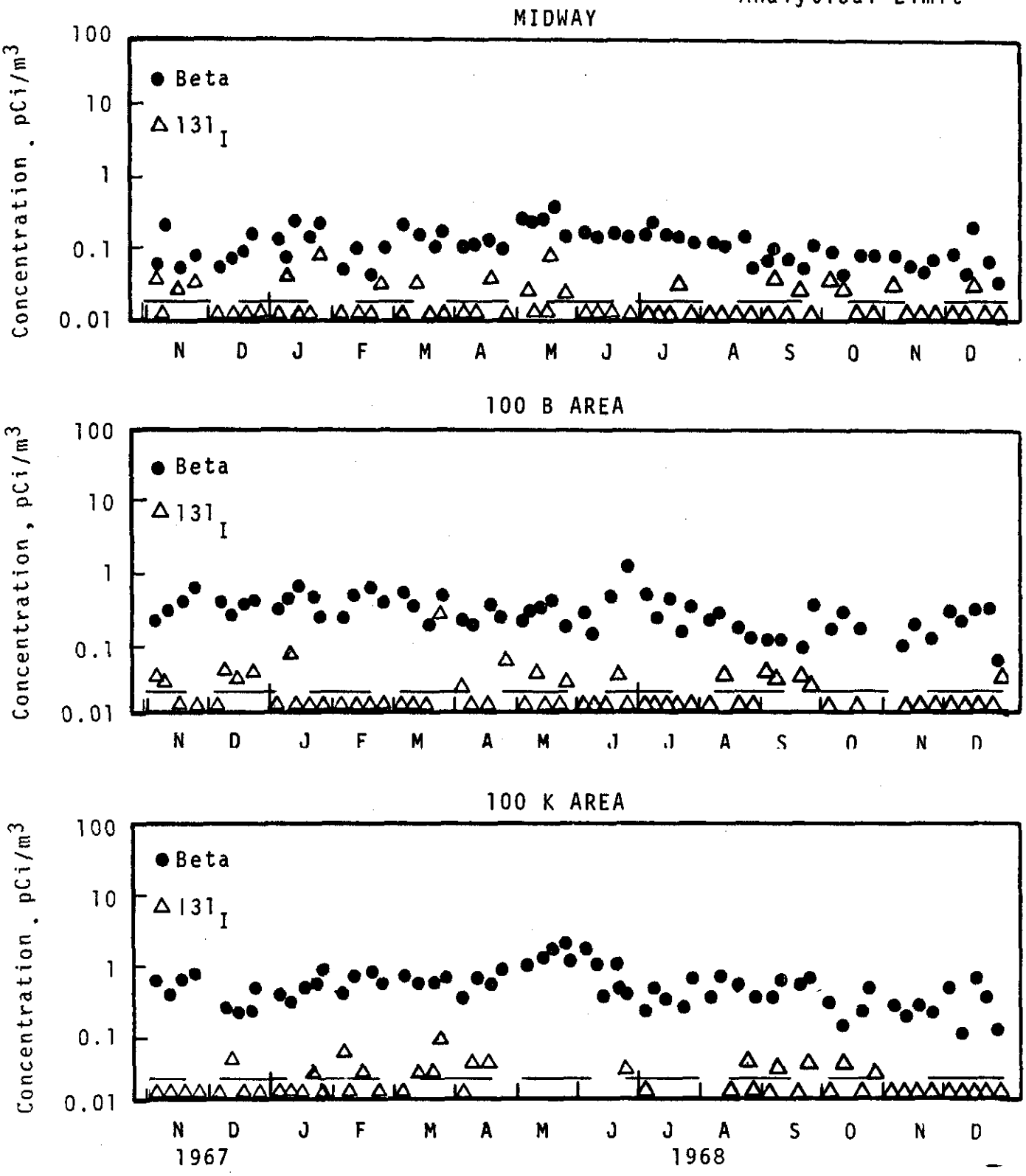
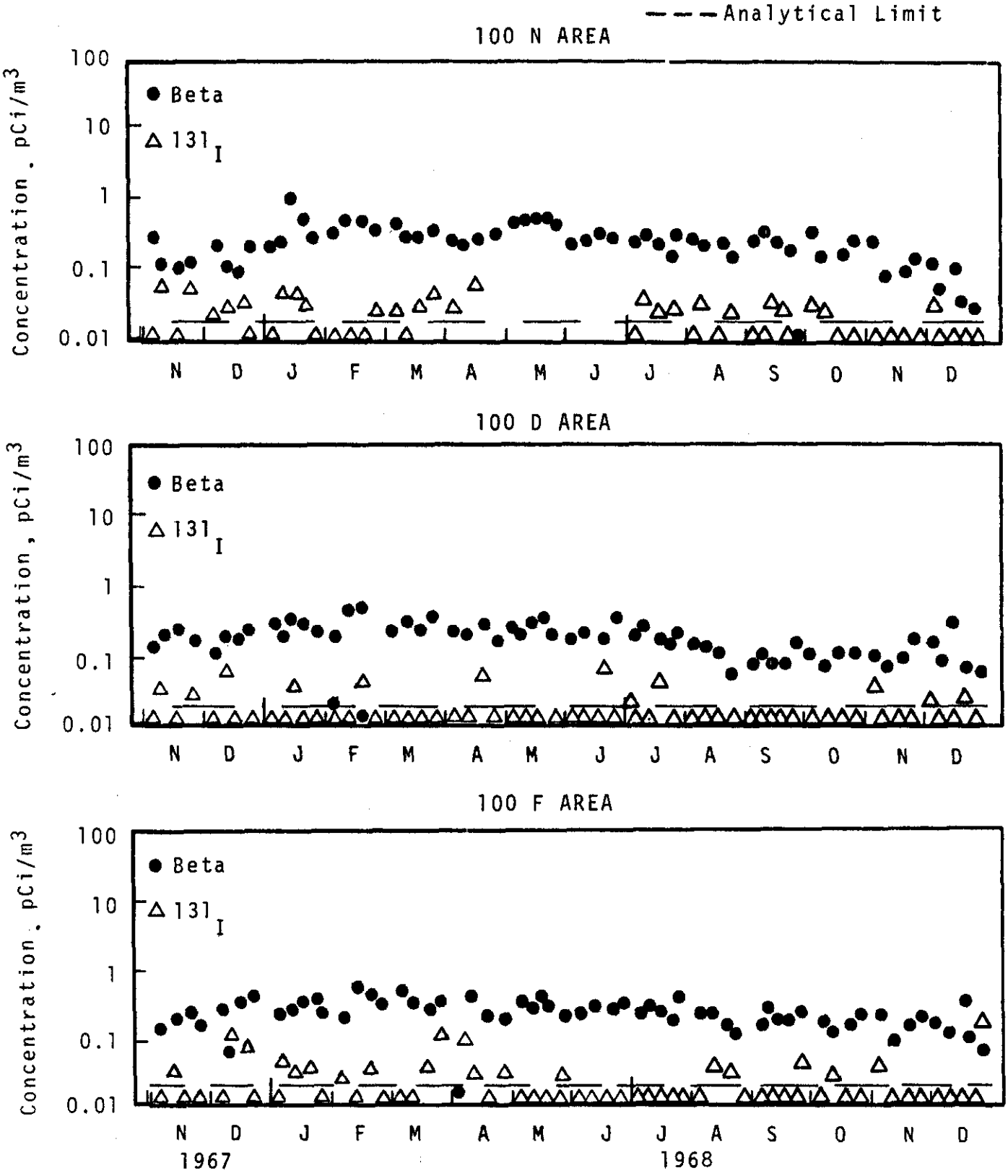
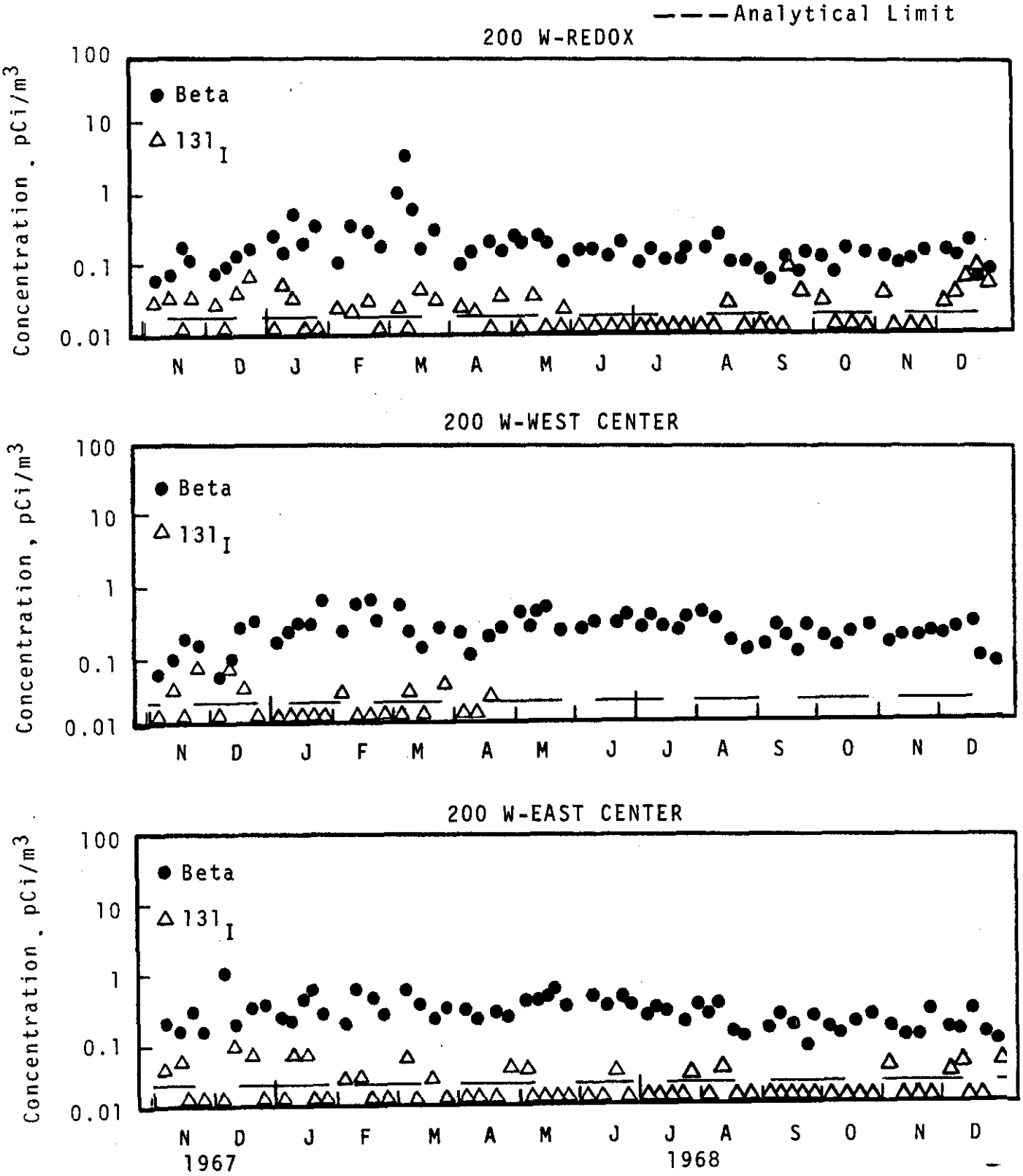


Figure 10

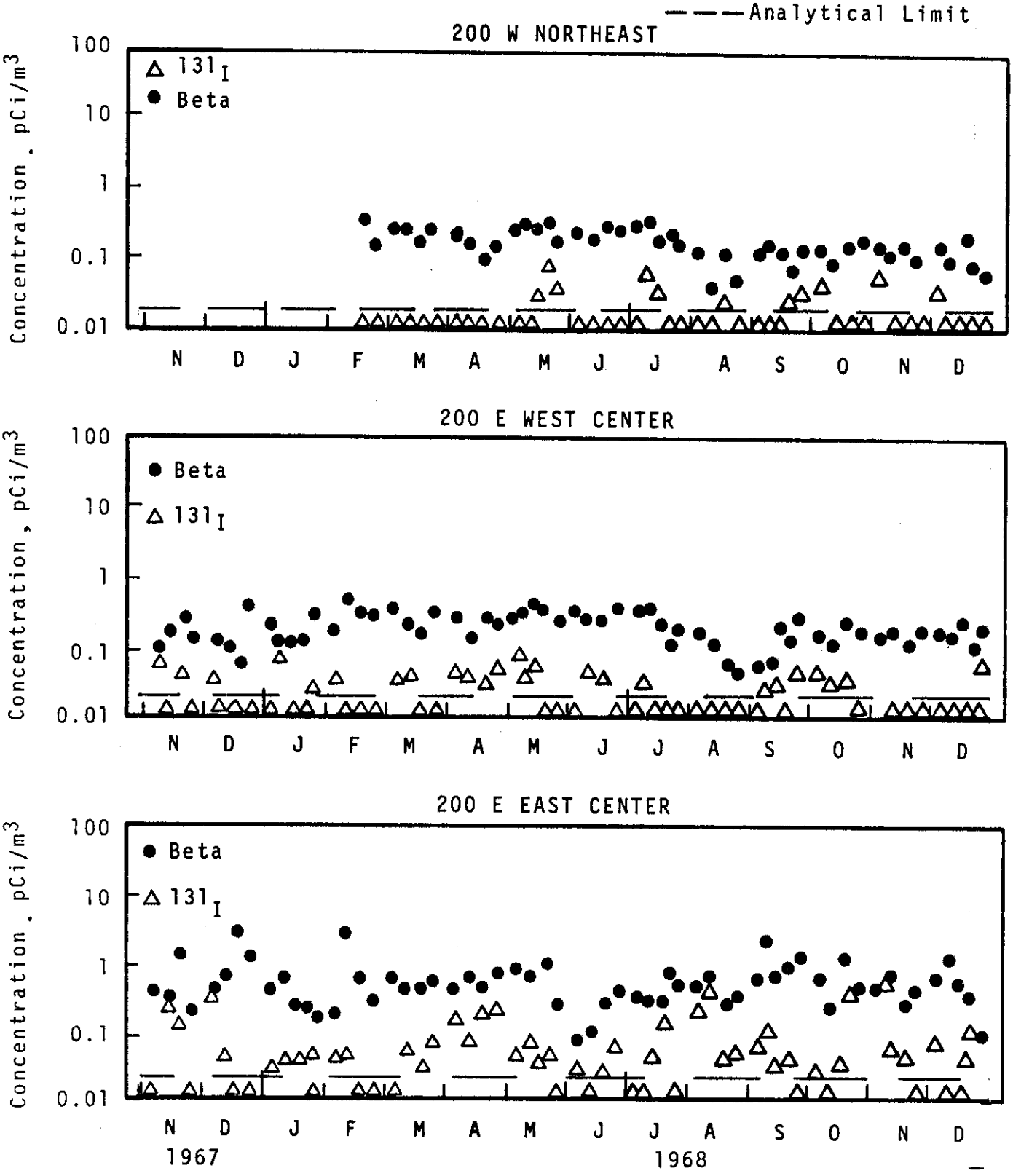
# IODINE-131 AND TOTAL BETA ACTIVITY IN THE ATMOSPHERE



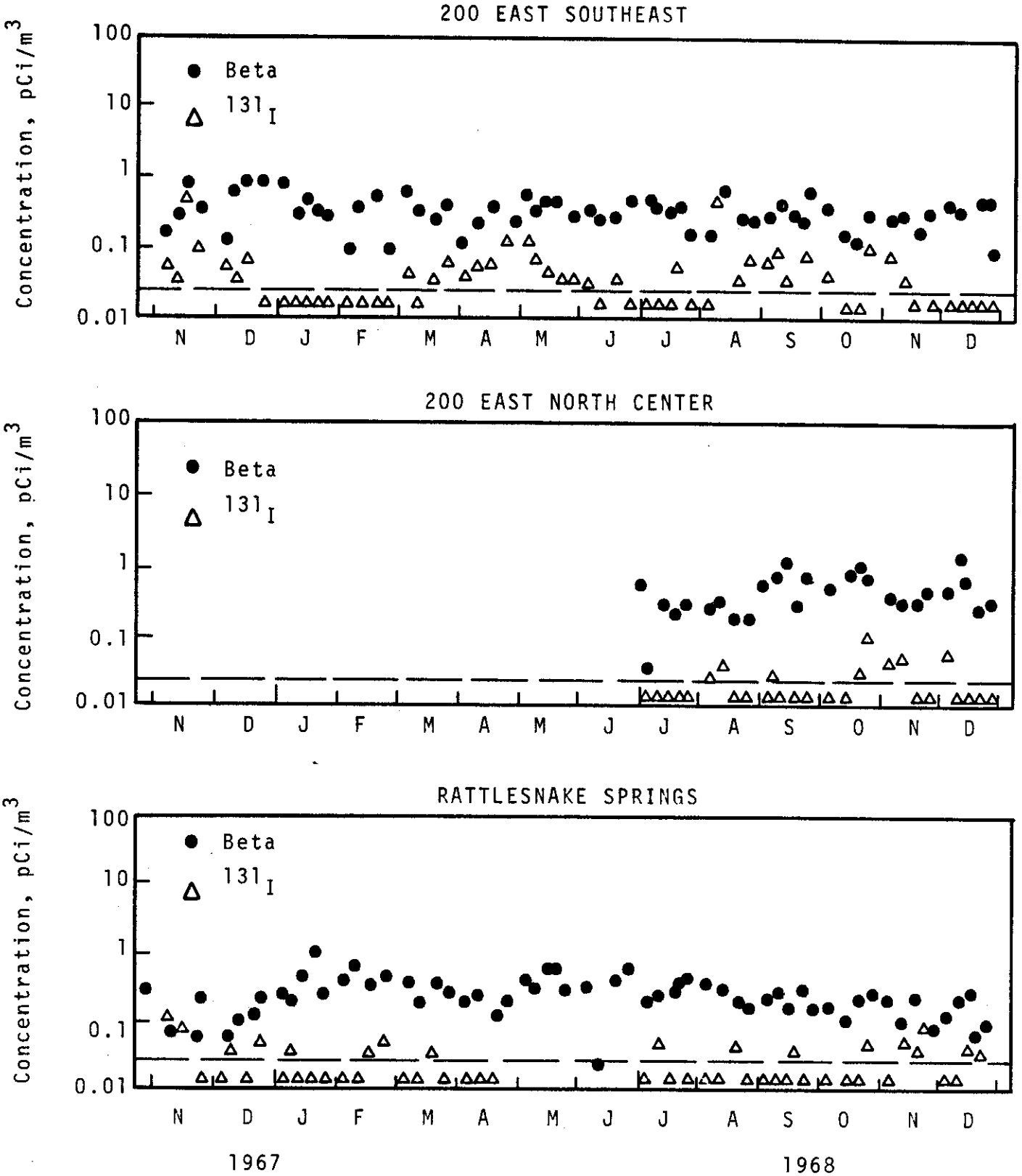
# IODINE-131 AND TOTAL BETA ACTIVITY IN THE ATMOSPHERE



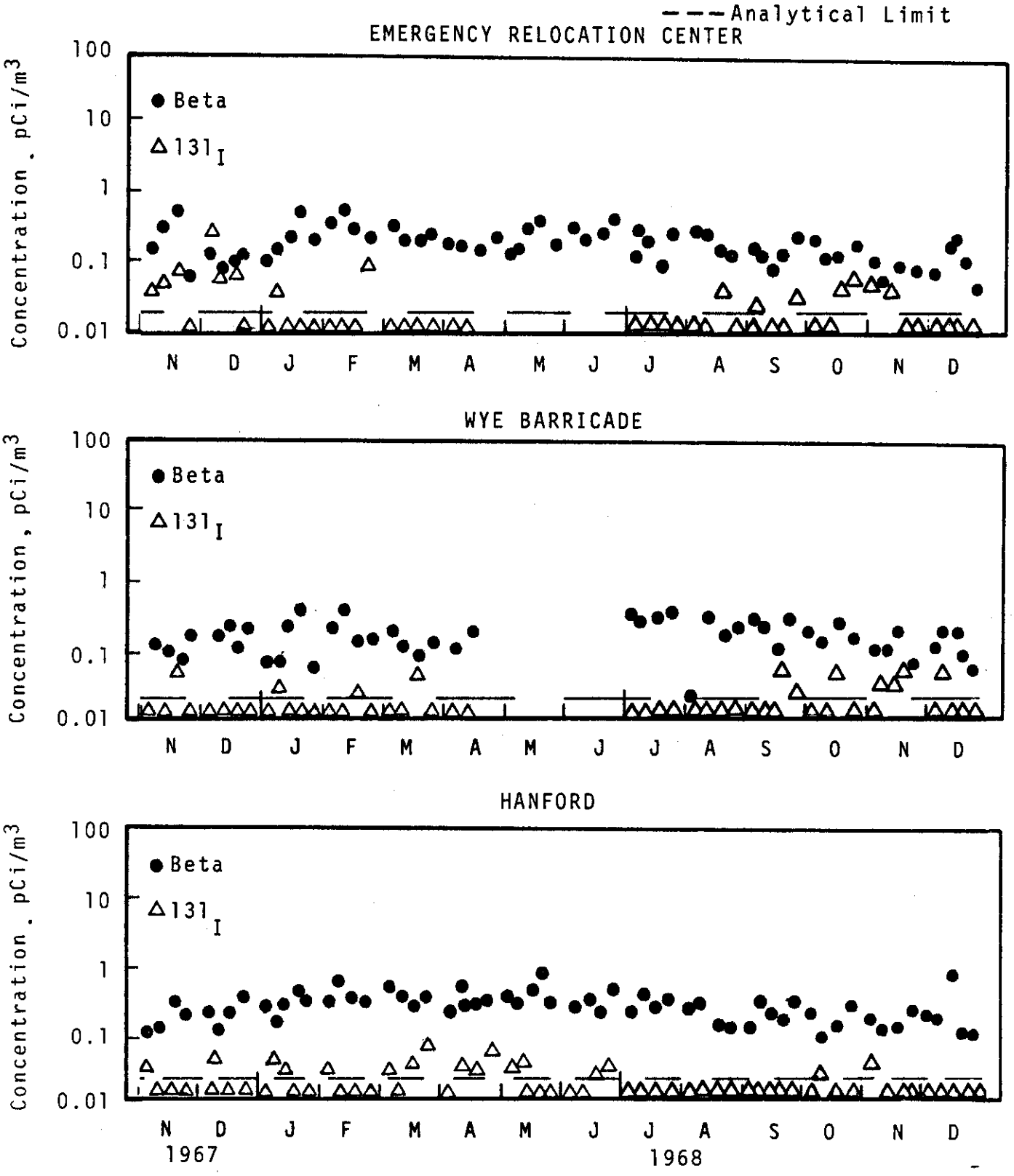
# IODINE-131 AND TOTAL BETA ACTIVITY IN THE ATMOSPHERE



# IODINE-131 AND TOTAL BETA ACTIVITY IN THE ATMOSPHERE



# IODINE-131 AND TOTAL BETA ACTIVITY IN THE ATMOSPHERE



# IODINE-131 AND TOTAL BETA ACTIVITY IN THE ATMOSPHERE

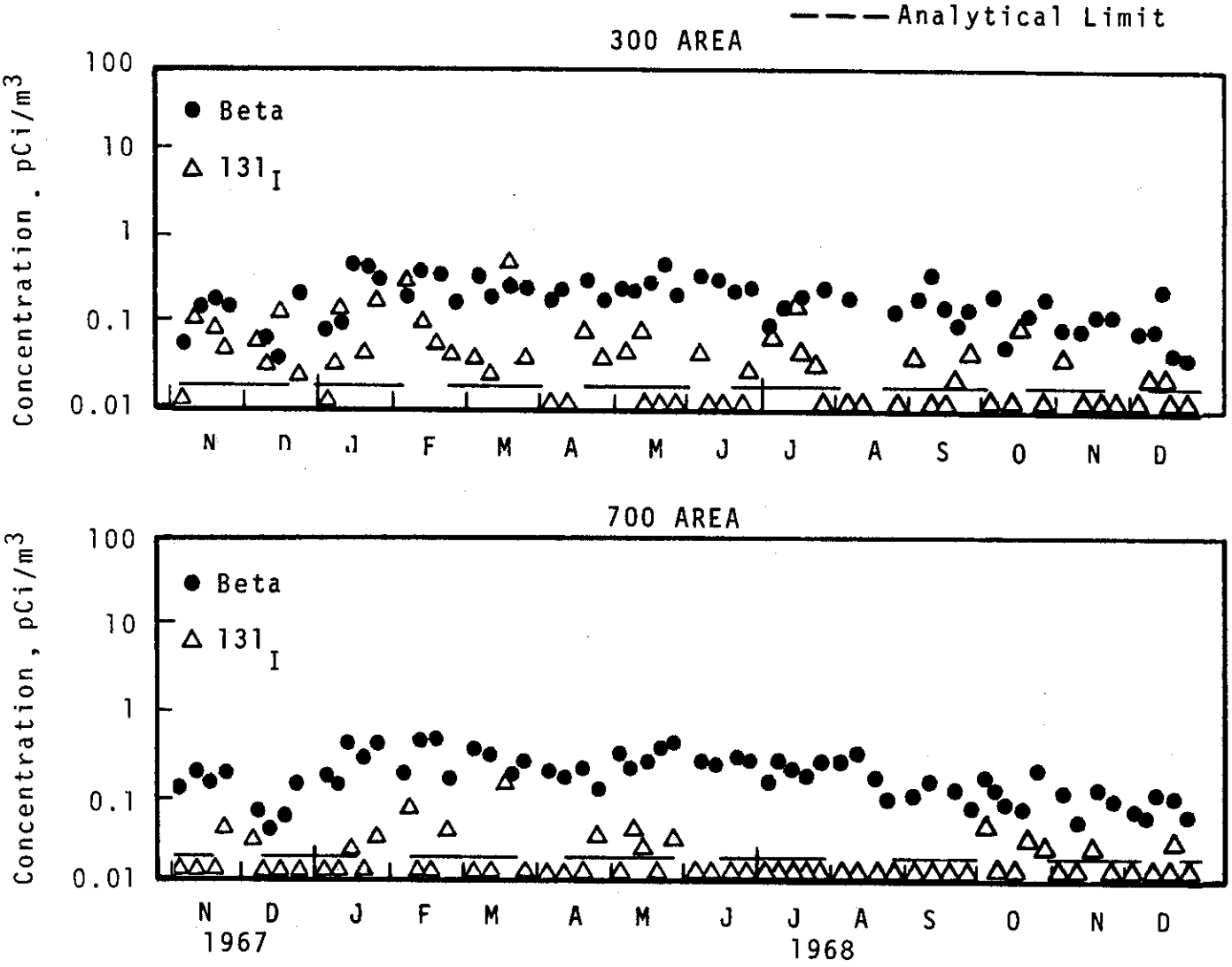
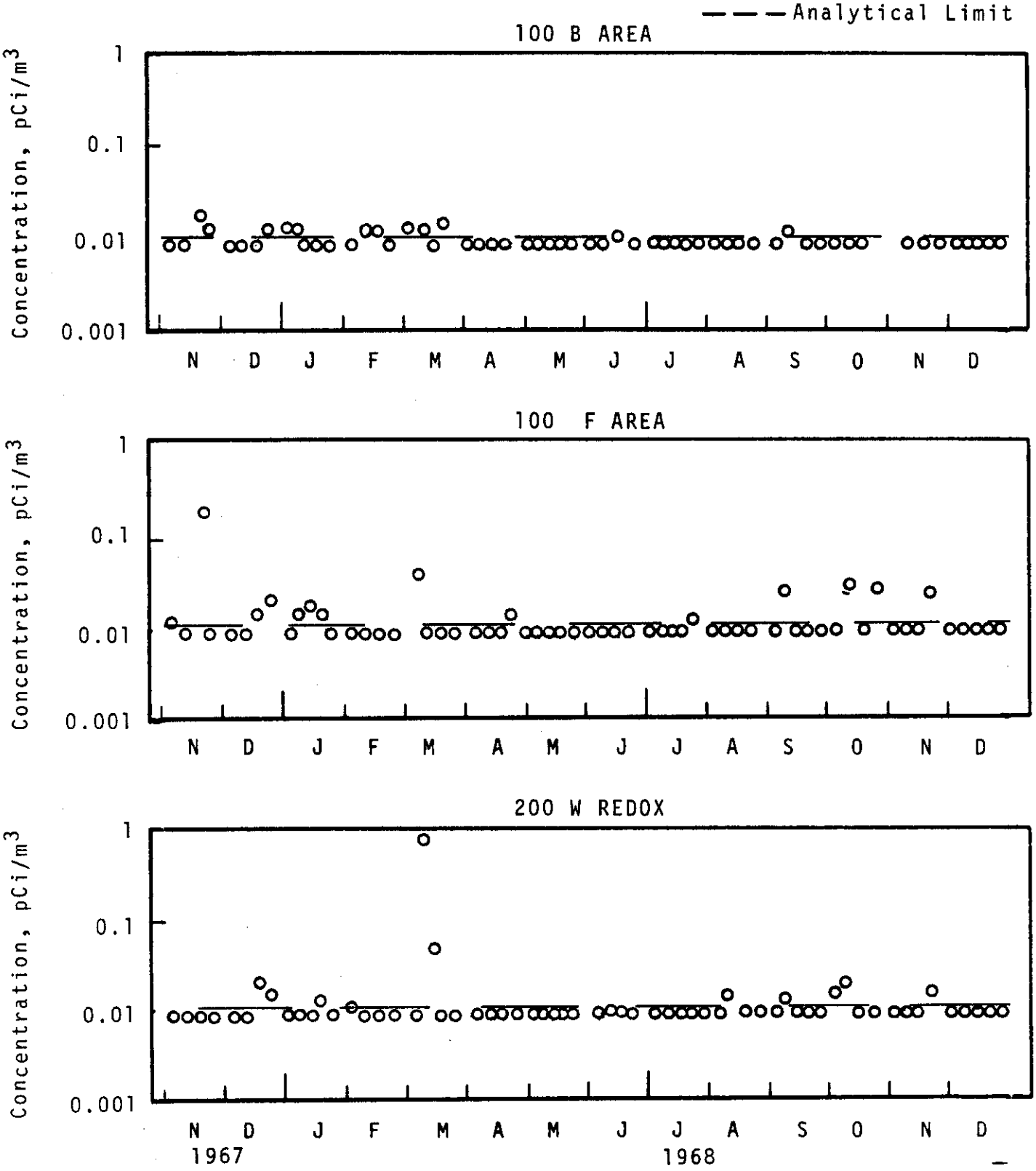


Figure 16

# TOTAL ALPHA ACTIVITY IN THE ATMOSPHERE



# TOTAL ALPHA ACTIVITY IN THE ATMOSPHERE

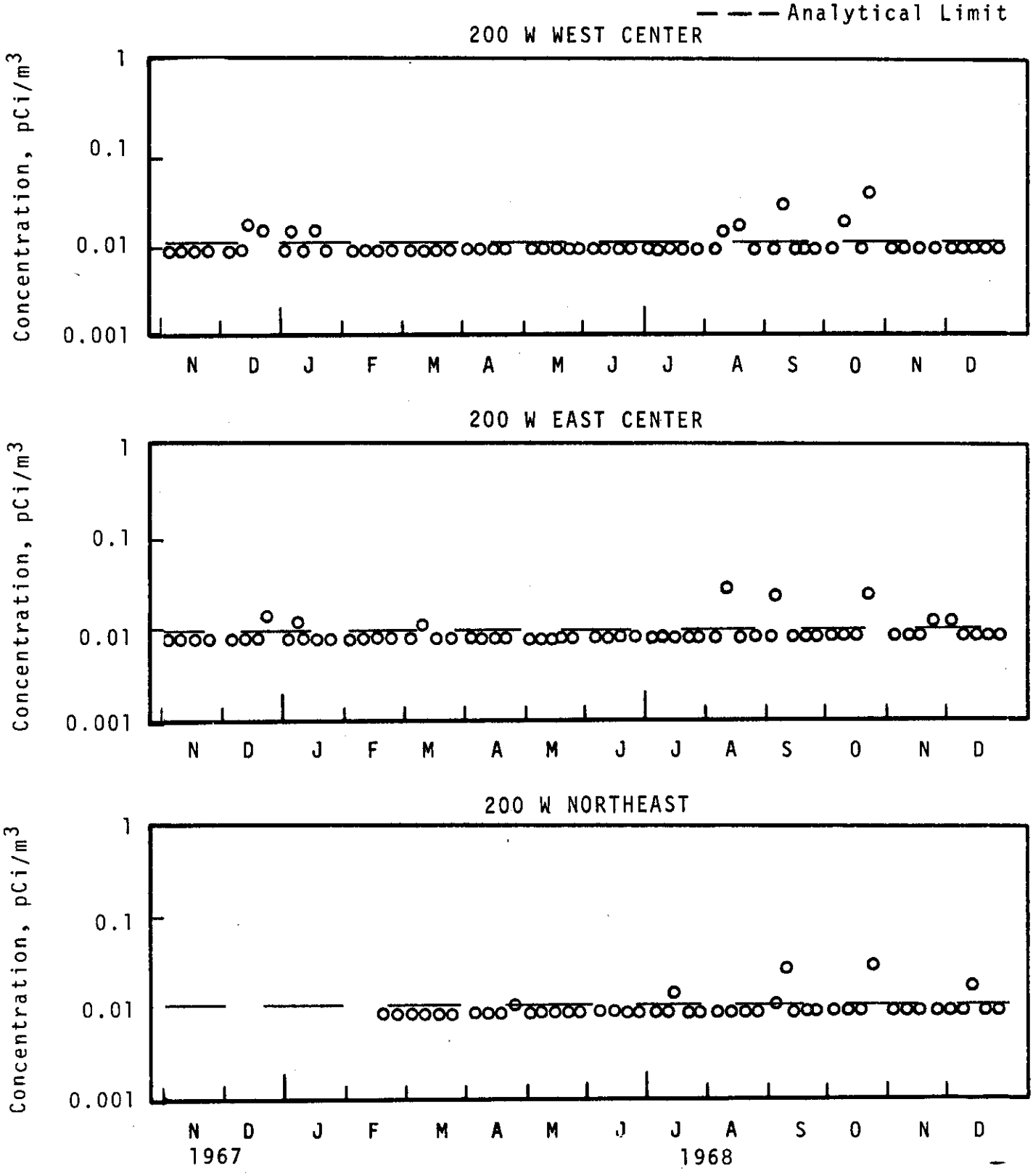
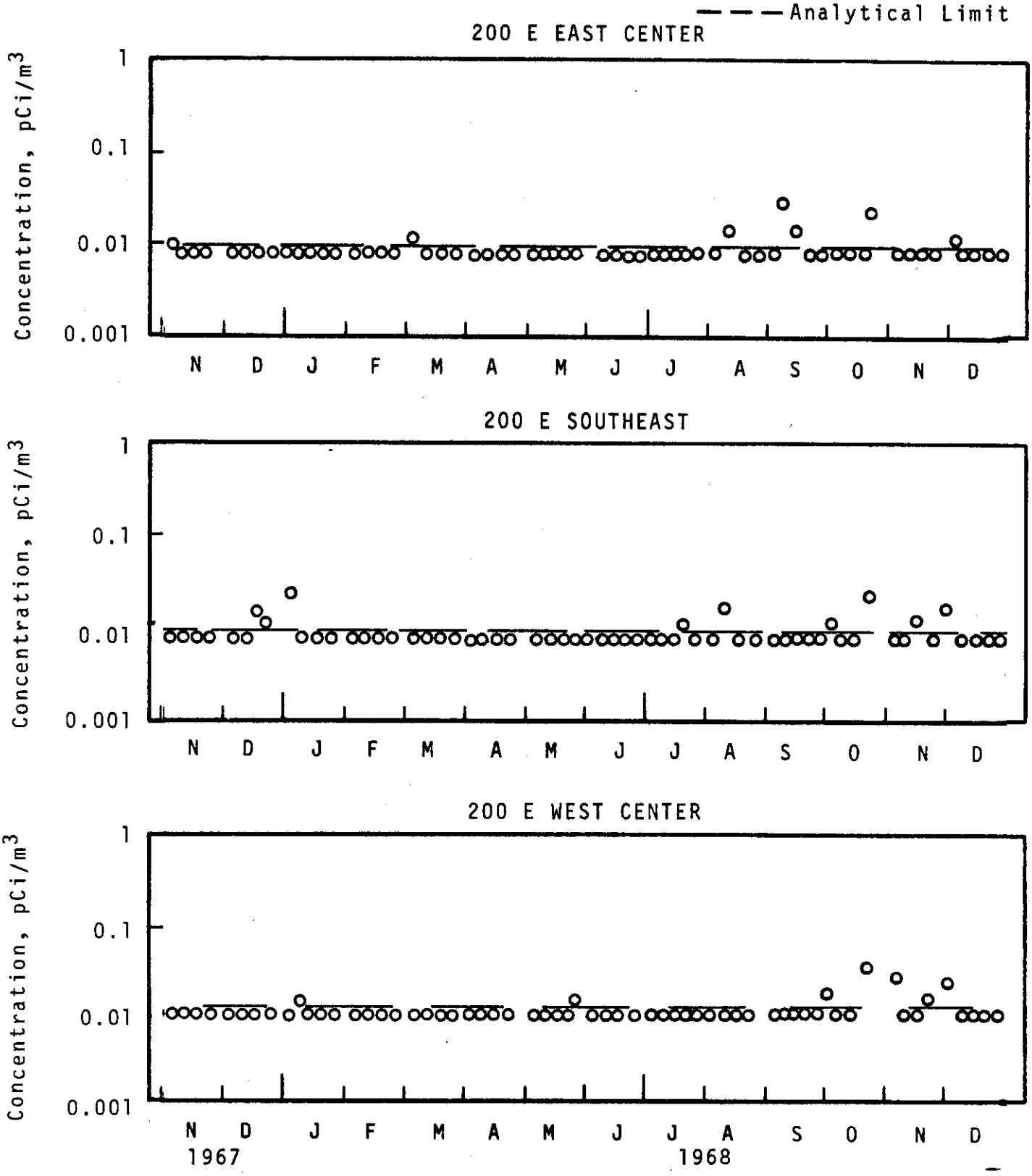


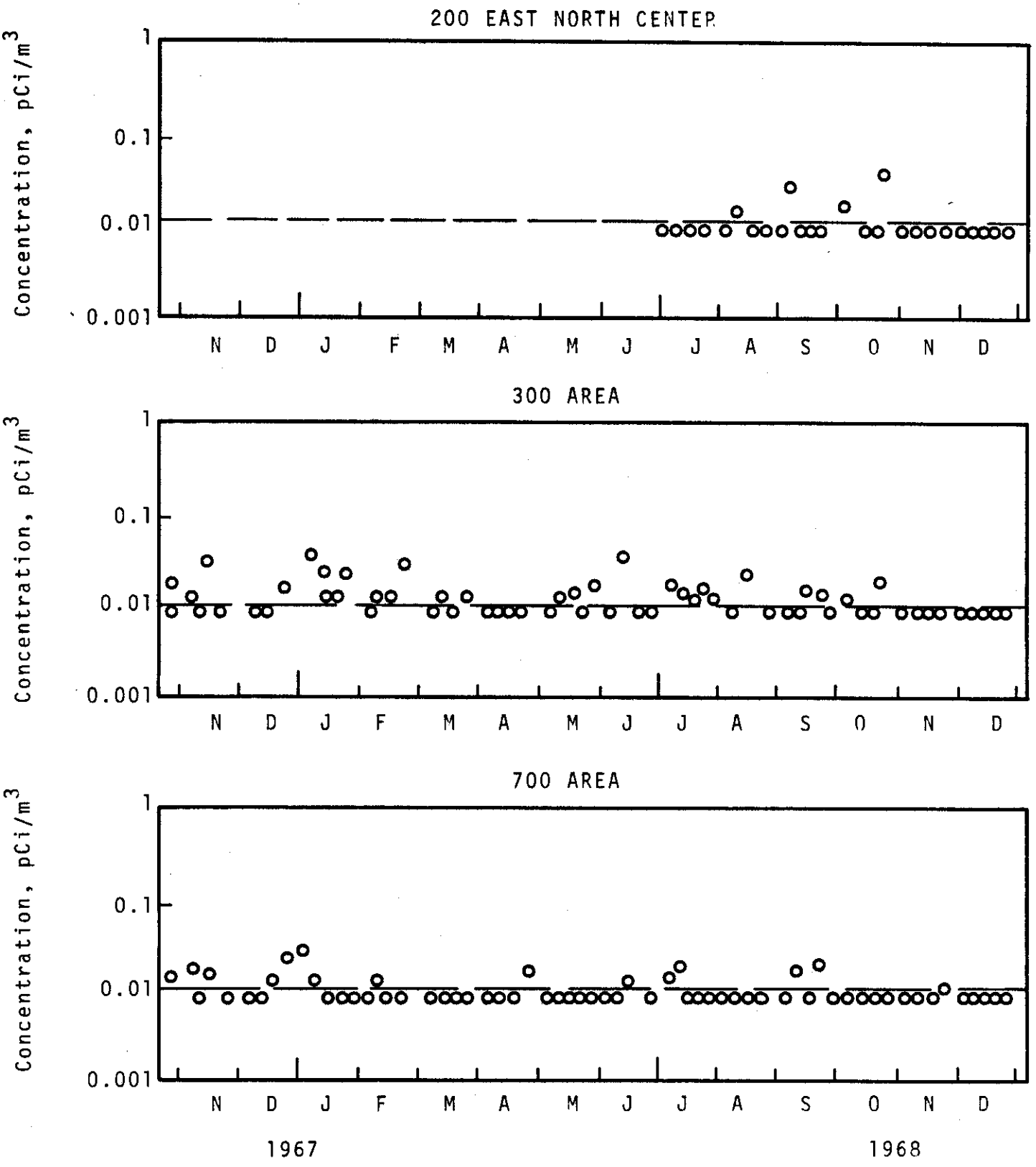
Figure 18



# TOTAL ALPHA ACTIVITY IN THE ATMOSPHERE



# TOTAL ALPHA ACTIVITY IN THE ATMOSPHERE

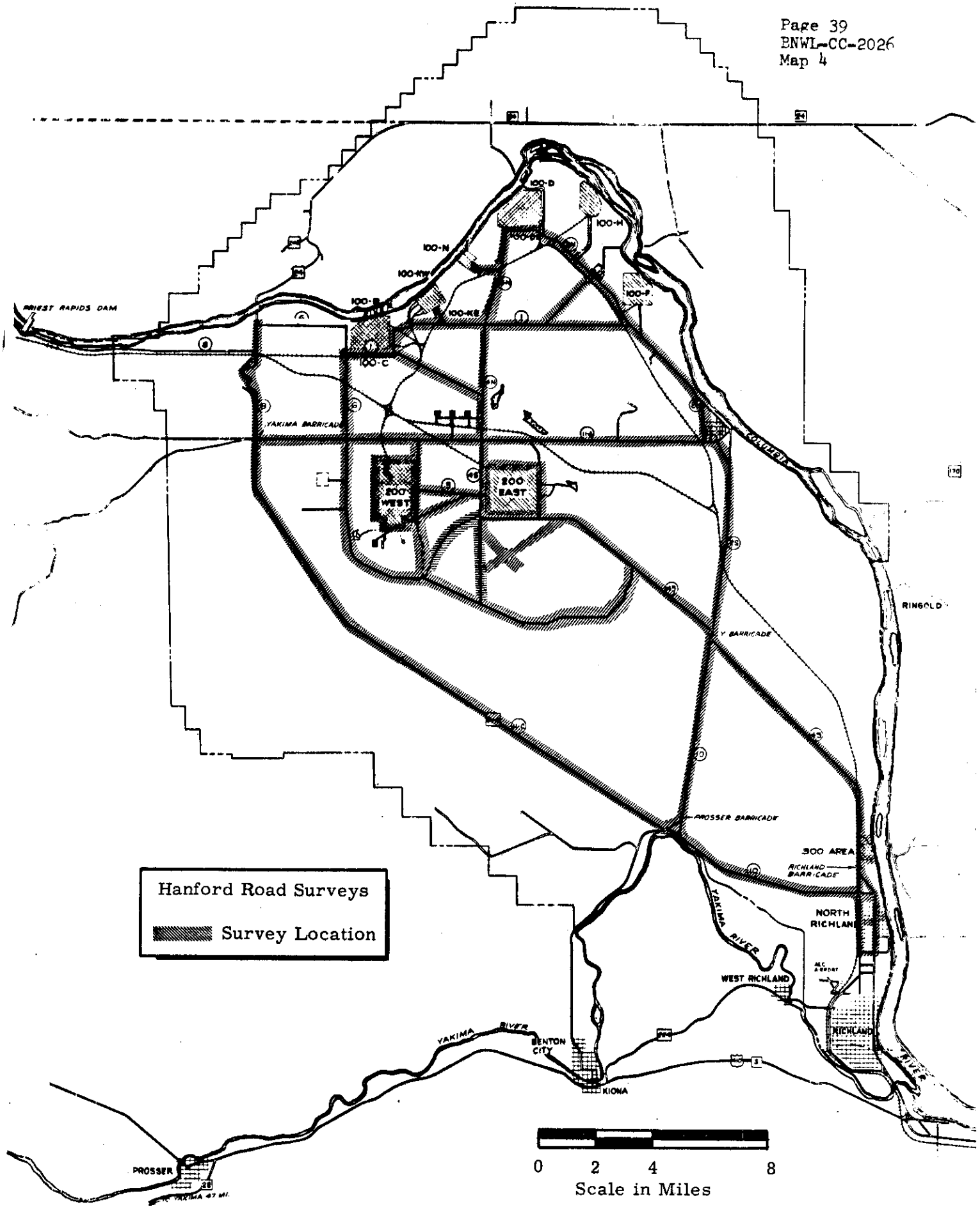


# VI. RADIATION SURVEYS

## A. SURFACE CONTAMINATION

### 1. Hanford Roads

Hanford roads are routinely surveyed (see Map 4) with a bioplastic scintillation detector attached to the front end of a truck and positioned about two feet above the road surface. The minimum level of contamination that can be detected by the road monitor corresponds to a portable GM survey meter surface reading of approximately 1000 c/m per probe area. The routes between the 300 Area and the 200 Areas were surveyed bi-weekly during the report period; the remainder of the Hanford roads were surveyed monthly. The only two instances of radioactive particulate contamination found on road surveys during the last half of 1968 were along controlled roads through the old contamination spread from the 200 B-C crib area. Two radioactive particles detected on October 29, 1968 were associated with dirt and had surface readings of 6,000 c/m and 40,000 c/m (GM) (10 mrad/hr-Juno). A nearby contaminated weed read 2,000 c/m (GM). Appropriate ARHCO personnel were notified of the findings. On December 20, 1968, routine surveys again detected several particles with the highest activity exceeding 100,000 c/m (surface-GM). Gamma energy analysis in the laboratory indicated the presence of $^{137}Cs$, $^{155}Eu$, and $^{154}Eu$.


100-D
100-H
100-N
100-KW
100-B
100-KE
100-F
100-C
PRIEST RAPIDS DAM
YAKIMA BARRICADE
200 WEST
200 EAST
RINGOLD
Y BARRICADE
PROSSER BARRICADE
300 AREA
RICHLAND BARRICADE
YAKIMA RIVER
NORTH RICHLAND
WEST RICHLAND
RICHLAND
BENTON CITY
KIONA
PROSSER
Hanford Road Surveys
Survey Location
0 2 4 8
Scale in Miles

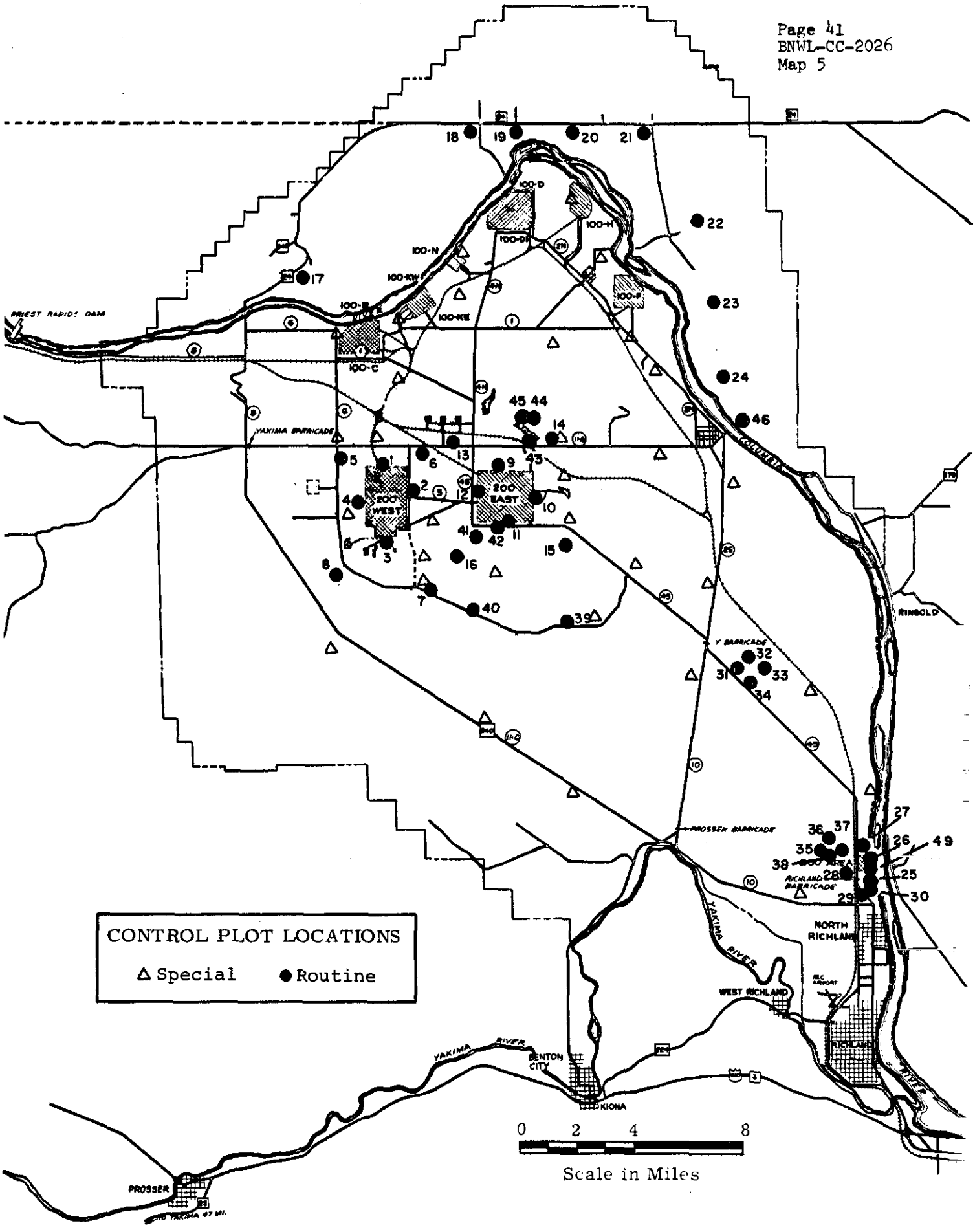
A. SURFACE CONTAMINATION (Continued)

2. Control Plots

Forty-six small areas, called control plots, are located within the Hanford boundaries (see Map 5). These plots, measuring 10' by 10', are periodically surveyed with a GM survey meter for deposited radioactive material. In addition, 32 special control plots located near test wells are surveyed on a semi-annual basis (see Map 5). No particles were found on surveys of the test well control plots during the last half of 1968.

On September 3, 1968, radioactive particles were detected on Control Plots 9 and 10 along the north and the east perimeter of 200 East Area. Several particles gave surface GM readings of 200-300 c/m with one particle on Control Plot 10 reading 7,000 c/m-GM.

A radioactive particle with surface readings of >100,000 c/m-GM and 85 mrad/hr-Juno uncorrected for source size was found near Control Plot 10 east of 200 East Area on October 8, 1968. A gamma scan of the particle in the laboratory indicated the following gamma emitters: $^{144}$Ce-Pr, $^{154}$Eu, $^{156}$Eu, $^{103}$Ru, $^{106}$Ru, and $^{95}$Zr-Nb. A filter vent failure at AR vault was indicated as a possible source; however, extensive follow-up surveys by ARHCO personnel in the vicinity of the AR vault and "A" Tank Farm revealed no recent contamination. Additional surveys in the vicinity of Control Plot 10 also failed to detect any other radioactive deposition.

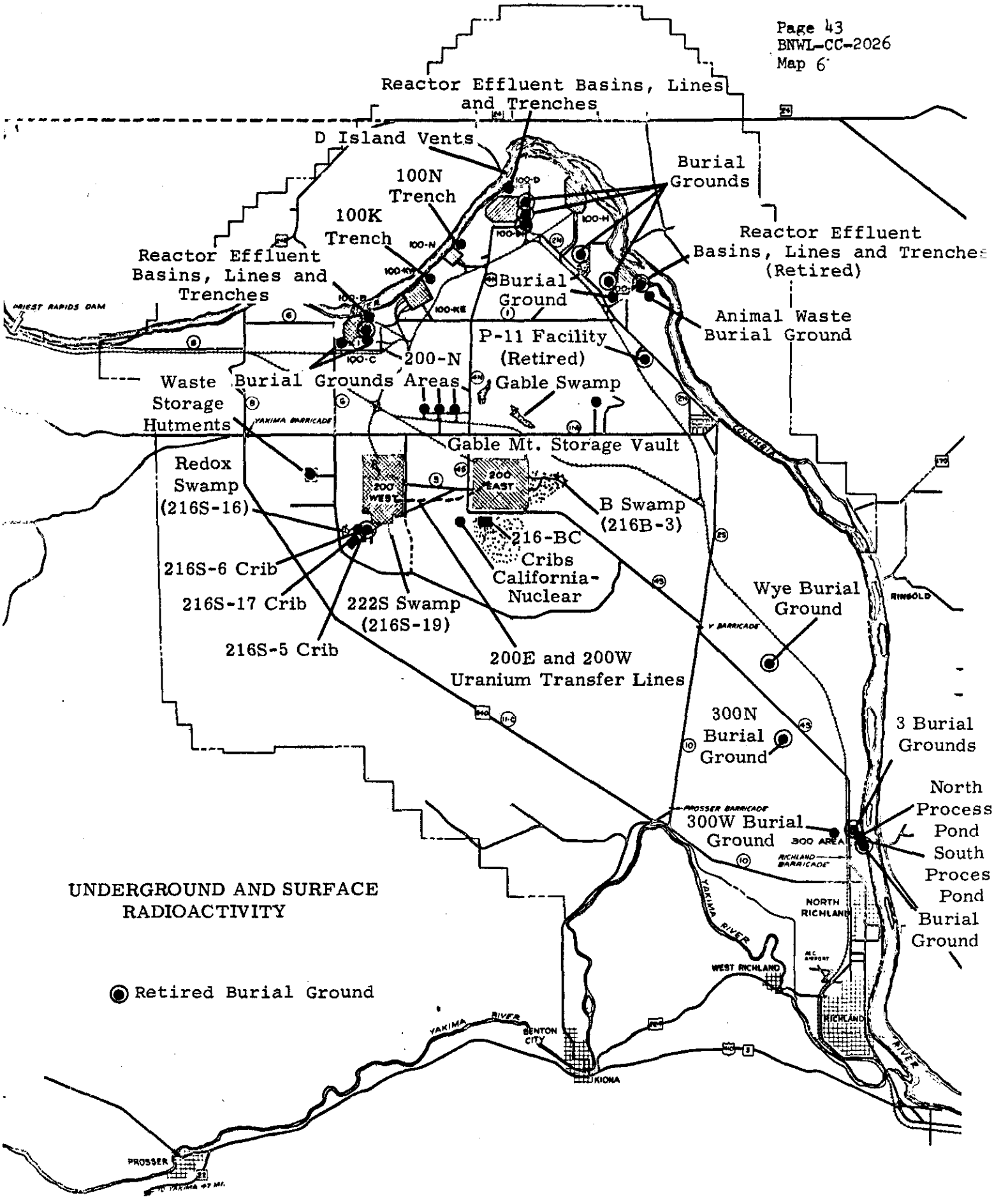

CONTROL PLOT LOCATIONS
△ Special ● Routine
0 2 4 8
Scale in Miles
PRIEST RAPIDS DAM
YAKIMA BARRICADE
100-D
100-H
100-N
100-KW
100-KE
100-F
100-C
200 WEST
200 EAST
Y BARRICADE
PROSSER BARRICADE
RICHLAND BARRICADE
RINGOLD
NORTH RICHLAND
WEST RICHLAND
RICHLAND
YAKIMA RIVER
BENTON CITY
KIONA
PROSSER

A. SURFACE CONTAMINATION (Continued)

3. Waste Disposal Sites

Retired waste burial grounds and areas where surface contamination is known to exist are inspected periodically for general physical condition and evidence of disturbance. The locations of such sites outside plant areas are shown in Map 6. During the last half of 1968, inspections were made of all the indicated areas. Unsatisfactory conditions were noted on August 8 at the 300 North Burial Ground (retired). Exposed material had maximum readings of 10,000 c/m on a GM survey meter. Conditions had been corrected prior to a re-survey on September 6, 1968.

At 100-F Area, an exposure rate of 3 mR/hr was found at an inactive burial ground on August 23, 1968 on exposed perforated dummies.


Reactor Effluent Basins, Lines and Trenches
D Island Vents
100N Trench
100K Trench
Burial Grounds
Reactor Effluent Basins, Lines and Trenches
Reactor Effluent Basins, Lines and Trenches (Retired)
Burial Ground
Animal Waste Burial Ground
P-11 Facility (Retired)
200-N
Waste Storage Hutments
Burial Grounds Areas
Gable Swamp
Gable Mt. Storage Vault
Redox Swamp (216S-16)
200 WEST
200 EAST
B Swamp (216B-3)
216-BC Cribs
California-Nuclear
216S-6 Crib
216S-17 Crib
222S Swamp (216S-19)
216S-5 Crib
200E and 200W Uranium Transfer Lines
Wye Burial Ground
300N Burial Ground
3 Burial Grounds
North Process Pond
South Proces Pond
300W Burial Ground
Burial Ground
UNDERGROUND AND SURFACE RADIOACTIVITY
Retired Burial Ground
PRIEST RAPIDS DAM
YAKIMA BARRICADE
PROSSER BARRICADE
RICHLAND BARRICADE
300 AREA
RINGOLD
NORTH RICHLAND
WEST RICHLAND
RICHLAND
BENTON CITY
KIONA
PROSSER
YAKIMA RIVER

A. SURFACE CONTAMINATION (Continued)

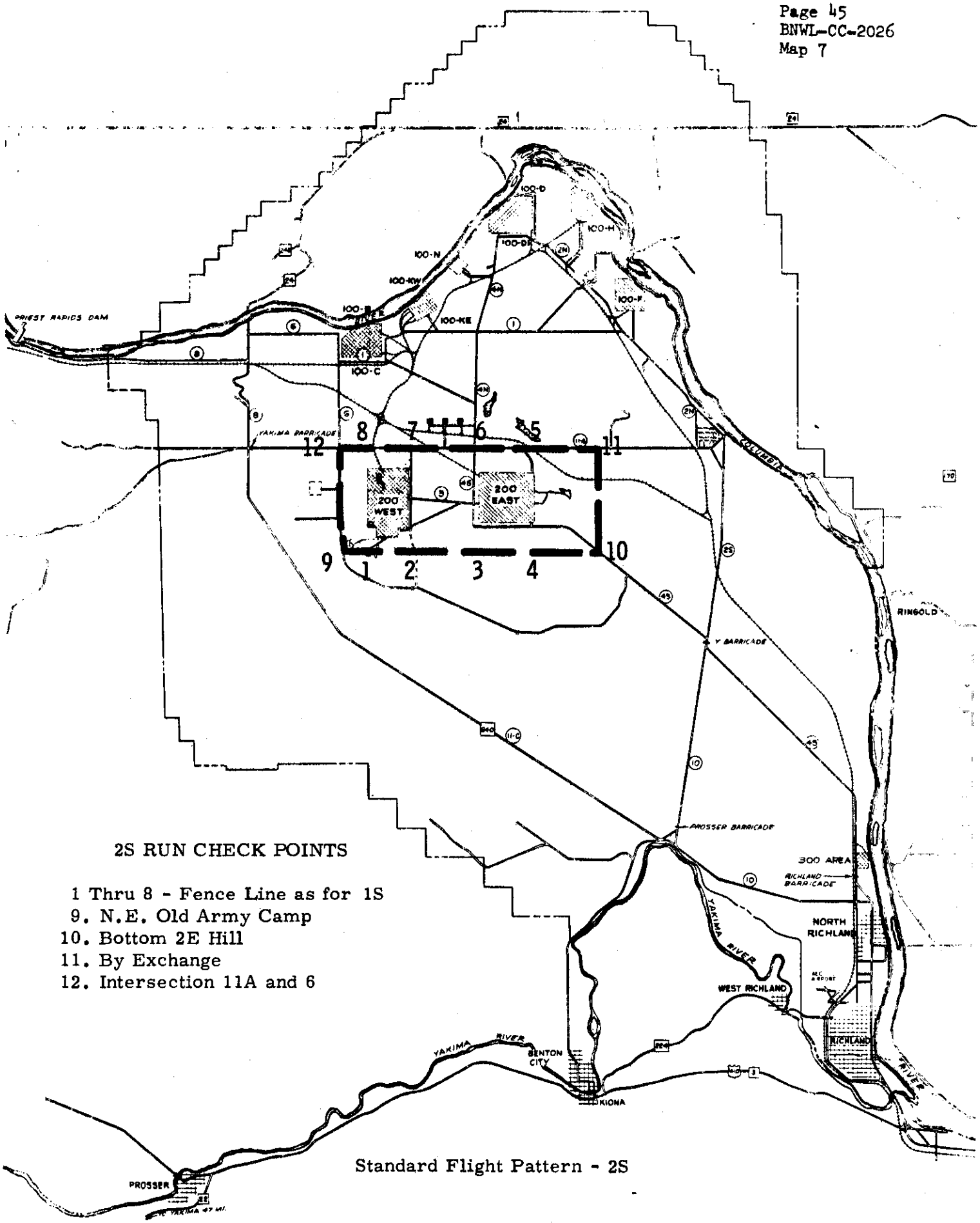
4. Aerial Surveys

Aerial surveys can be used to detect contamination which is spread over a large land area. Like road and control plot surveys, aerial surveys are only qualitative in nature, but through routine use of this technique, a capability for rapid assessment of an emergency situation is maintained. All surveys are conducted at an altitude of 150 meters (500 feet) using a three inch by five inch NaI (Tl) scintillation crystal detector. Nine flight patterns are located within and near the Hanford project perimeter. In addition, two flight patterns cover the Columbia River from Priest Rapids Dam to the Pacific Ocean, and two other flight patterns cover the Richland-Pendleton-Spokane "triangle" and the Richland-Ellensburg, Ritzville "triangle". Aerial survey flights made during the period July-December 1968 are shown on Maps 7-17.

On October 17, 1968, an unusual response was noted above the railroad crossing near the intersection of Road 11 A and Rt. 4S. However, follow-up road surveys were unable to detect any unusual activity in the area.

5. Other

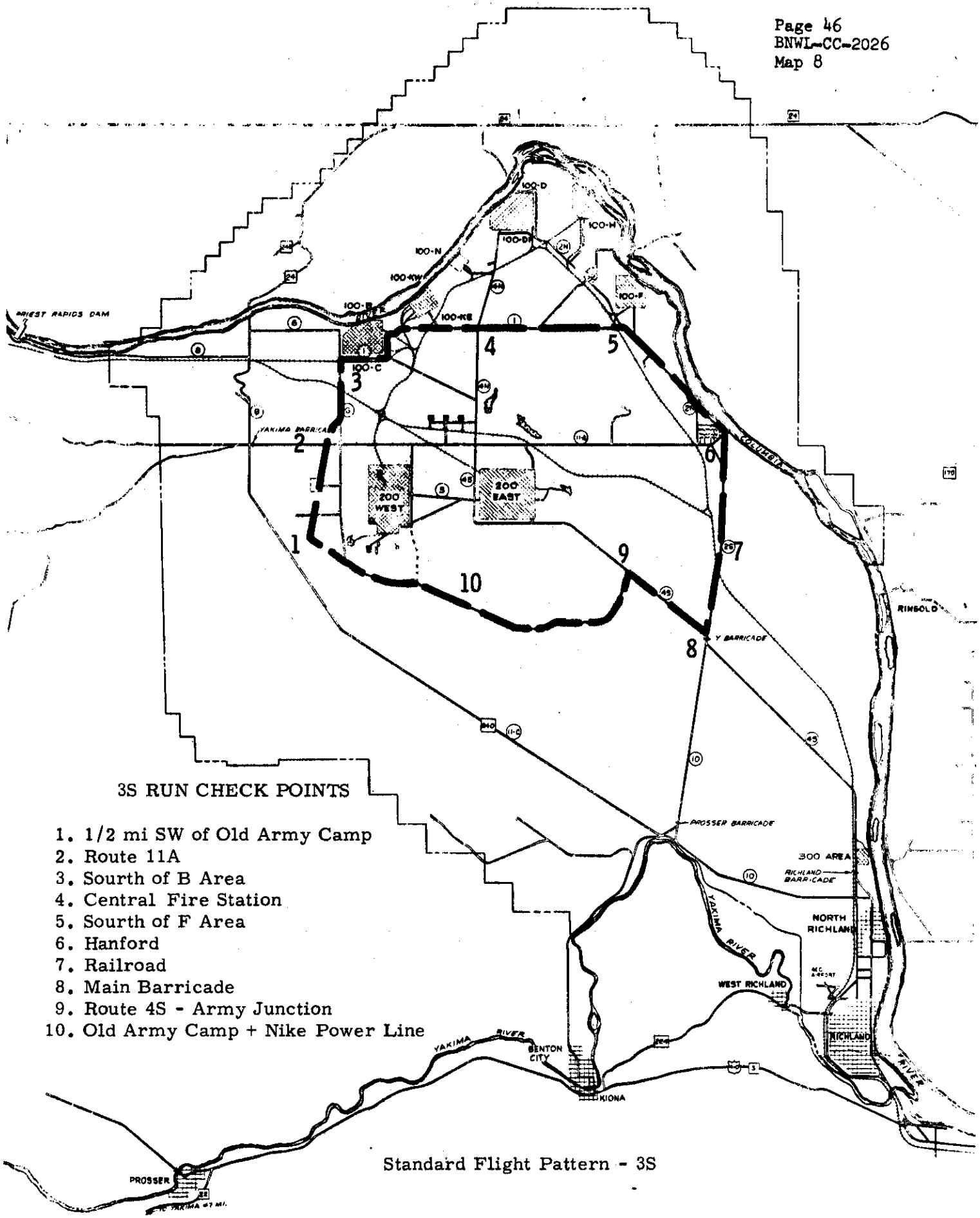
In August, a submerged boat, belonging to the Biology Department, was recovered from the Columbia River at 100-F Area. Survey of the boat indicated 30,000 c/m-GM (maximum) associated with river silt and sand on inacessible inside surfaces. Rough decontamination reduced the level to 6,000 c/m. Physical condition of the hull made further decontamination uneconomical. Laboratory analysis of the silt and sand indicated that $^{46}Sc$ was the principal gamma emitter present.




## 2S RUN CHECK POINTS

1 Thru 8 - Fence Line as for 1S
9. N.E. Old Army Camp
10. Bottom 2E Hill
11. By Exchange
12. Intersection 11A and 6

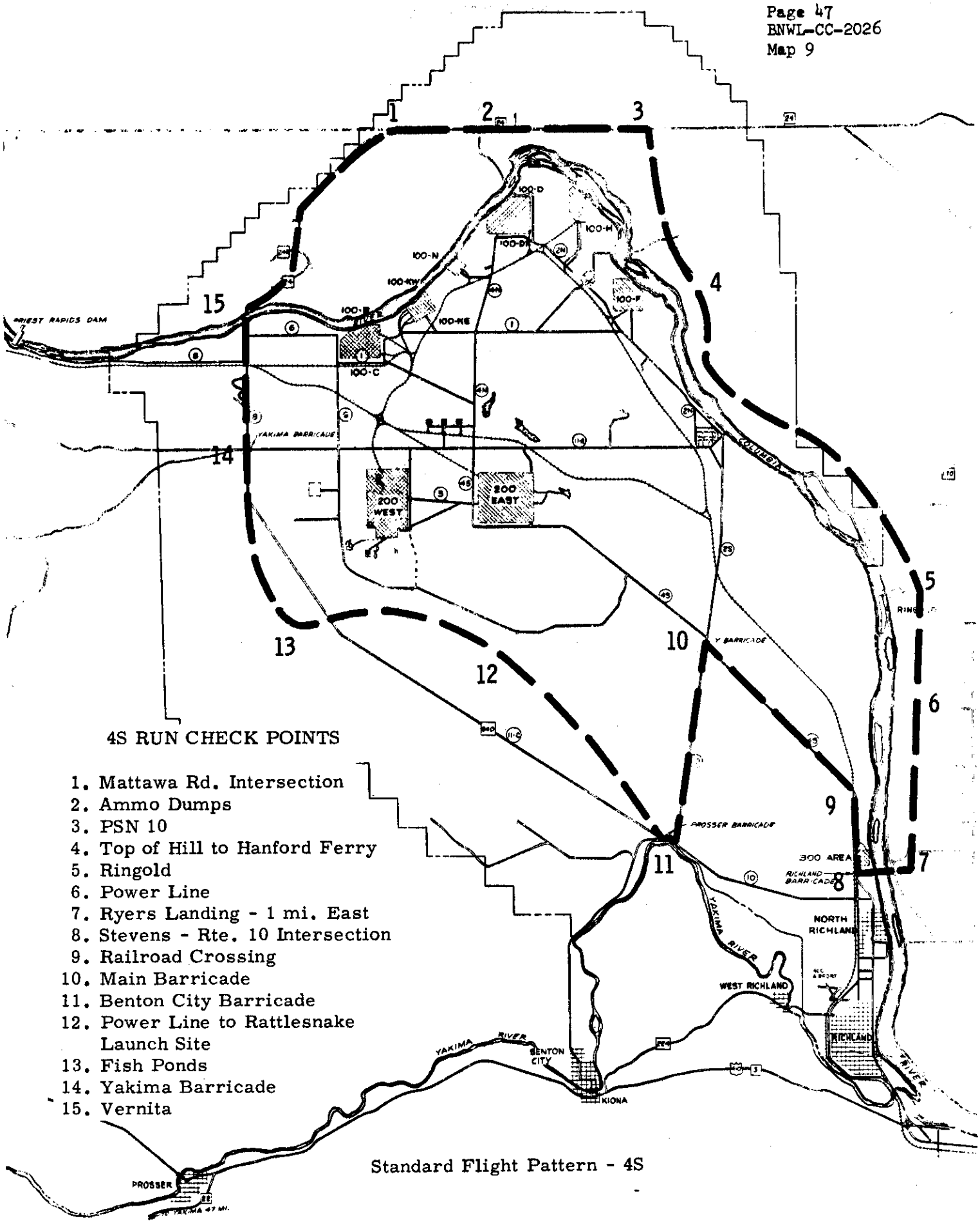
Standard Flight Pattern - 2S




3S RUN CHECK POINTS

1. 1/2 mi SW of Old Army Camp
2. Route 11A
3. Sourth of B Area
4. Central Fire Station
5. Sourth of F Area
6. Hanford
7. Railroad
8. Main Barricade
9. Route 4S - Army Junction
10. Old Army Camp + Nike Power Line

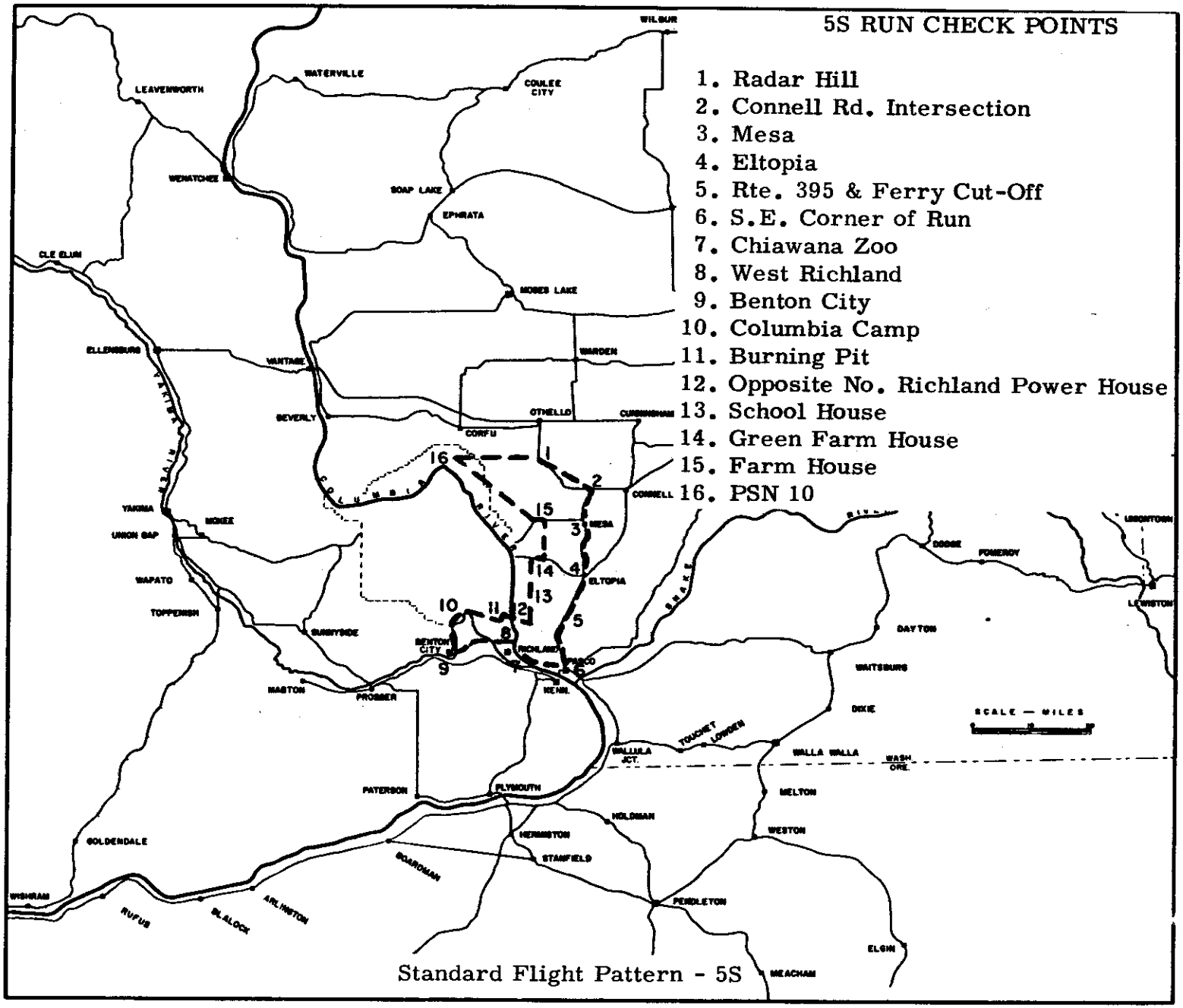
Standard Flight Pattern - 3S

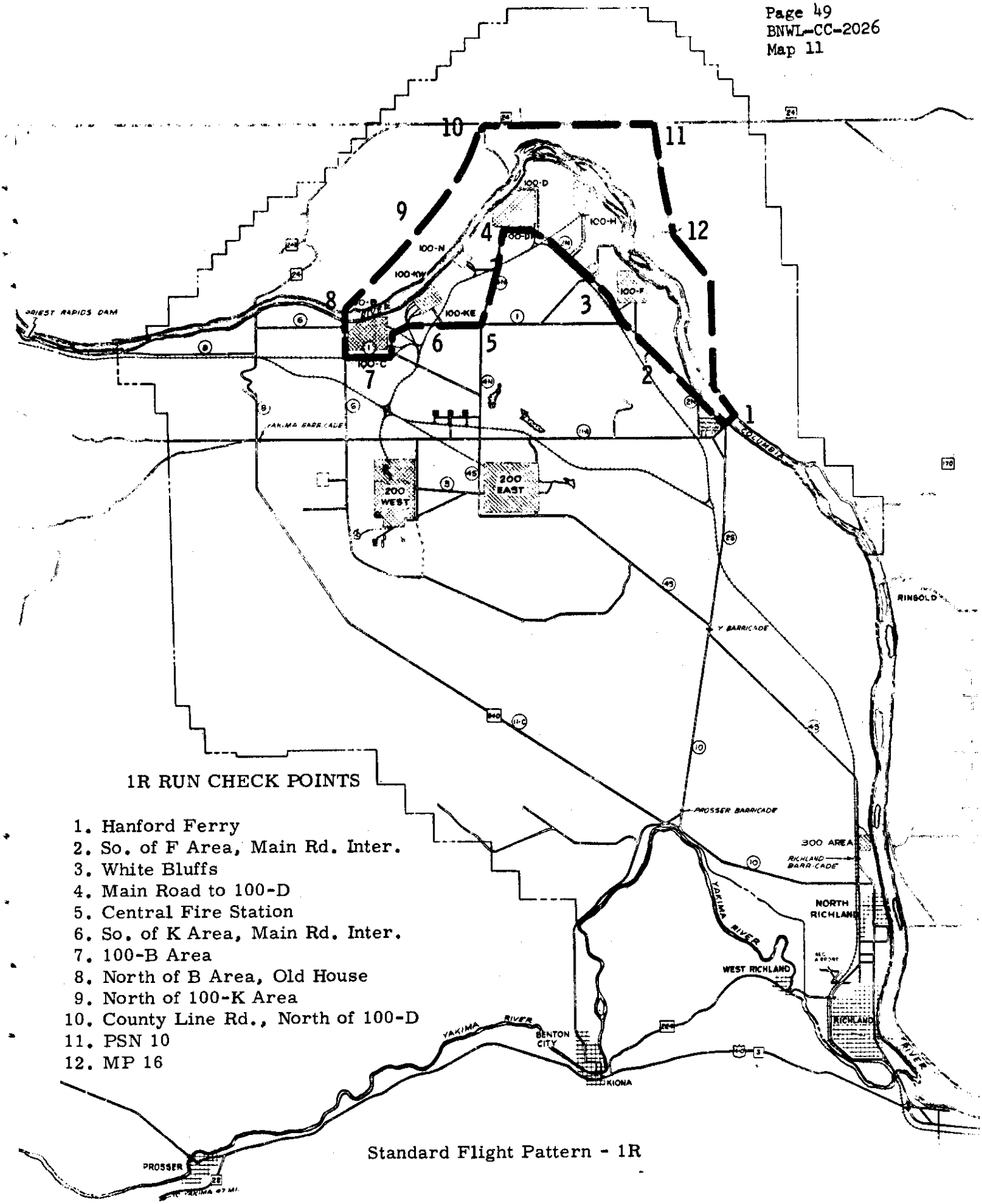



## 4S RUN CHECK POINTS

1. Mattawa Rd. Intersection
2. Ammo Dumps
3. PSN 10
4. Top of Hill to Hanford Ferry
5. Ringold
6. Power Line
7. Ryers Landing - 1 mi. East
8. Stevens - Rte. 10 Intersection
9. Railroad Crossing
10. Main Barricade
11. Benton City Barricade
12. Power Line to Rattlesnake Launch Site
13. Fish Ponds
14. Yakima Barricade
15. Vernita

Standard Flight Pattern - 4S

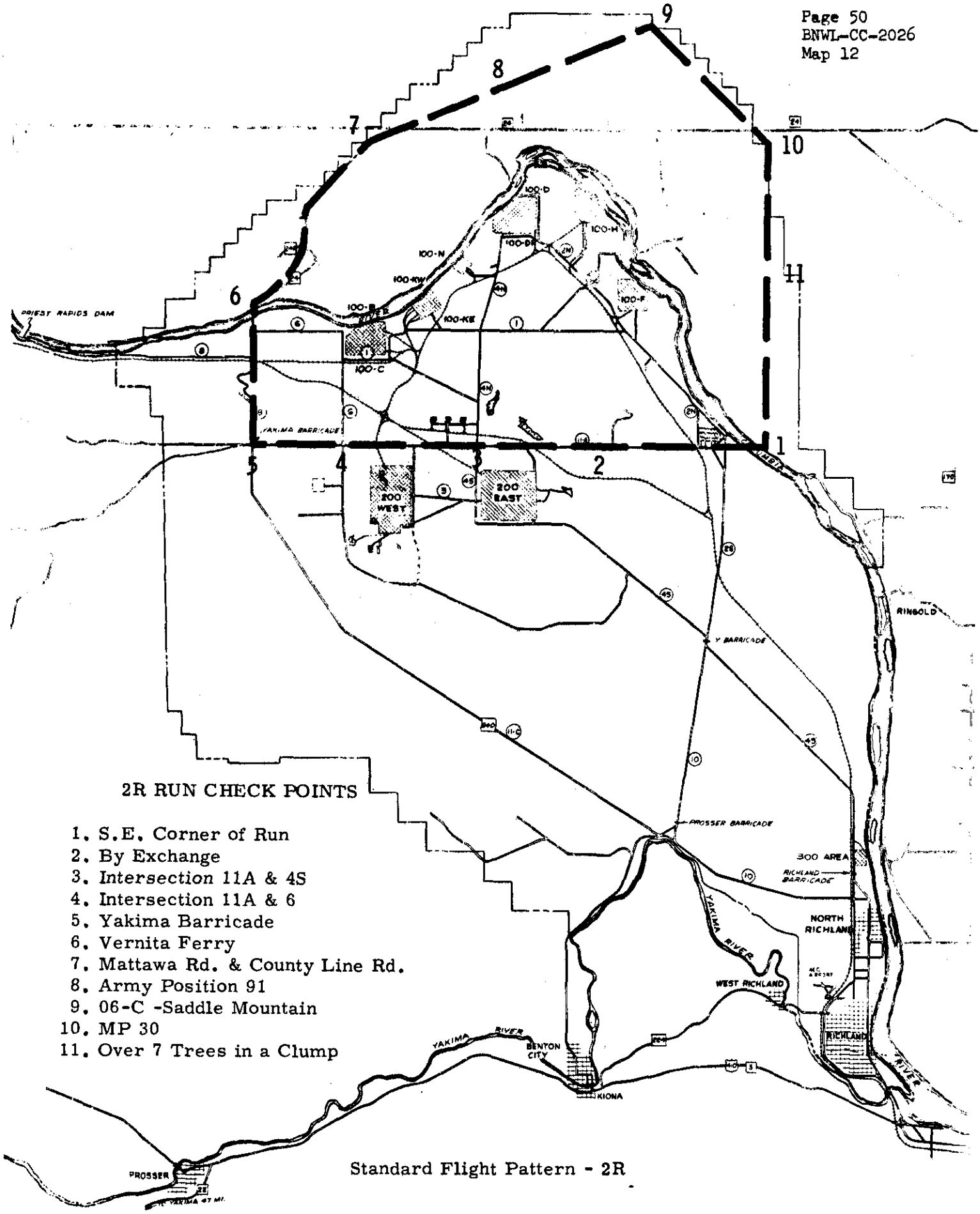

5S RUN CHECK POINTS
1. Radar Hill
2. Connell Rd. Intersection
3. Mesa
4. Eltopia
5. Rte. 395 & Ferry Cut-Off
6. S.E. Corner of Run
7. Chiawana Zoo
8. West Richland
9. Benton City
10. Columbia Camp
11. Burning Pit
12. Opposite No. Richland Power House
13. School House
14. Green Farm House
15. Farm House
16. PSN 10
WILBUR
WATERVILLE
COULEE CITY
LEAVENWORTH
WENATCHEE
SOAP LAKE
EPHRATA
CLE ELUM
MOSES LAKE
ELLENSBURG
VANTAGE
WARDEN
BEVERLY
OTHELLO
CUNNINGHAM
CORFU
CONNELL
YAKIMA
MOXEE
UNION GAP
MESA
WAPATO
ELTOPIA
TOPPENISH
SUNNYSIDE
BENTON CITY
RICHLAND
PASCO
KENN.
MABTON
PROSSER
DAYTON
WAITSBURG
DIXIE
SCALE — MILES
WALLULA JCT.
TOUCHET
LOWDEN
WALLA WALLA
WASH.
ORE.
PATERSON
PLYMOUTH
MELTON
HOLDMAN
WESTON
GOLDENDALE
HERMISTON
STANFIELD
BOARDMAN
PENDLETON
WISHRAM
RUFUS
BLALOCK
ARLINGTON
ELGIN
MEACHAM
Standard Flight Pattern - 5S




1R RUN CHECK POINTS

1. Hanford Ferry
2. So. of F Area, Main Rd. Inter.
3. White Bluffs
4. Main Road to 100-D
5. Central Fire Station
6. So. of K Area, Main Rd. Inter.
7. 100-B Area
8. North of B Area, Old House
9. North of 100-K Area
10. County Line Rd., North of 100-D
11. PSN 10
12. MP 16

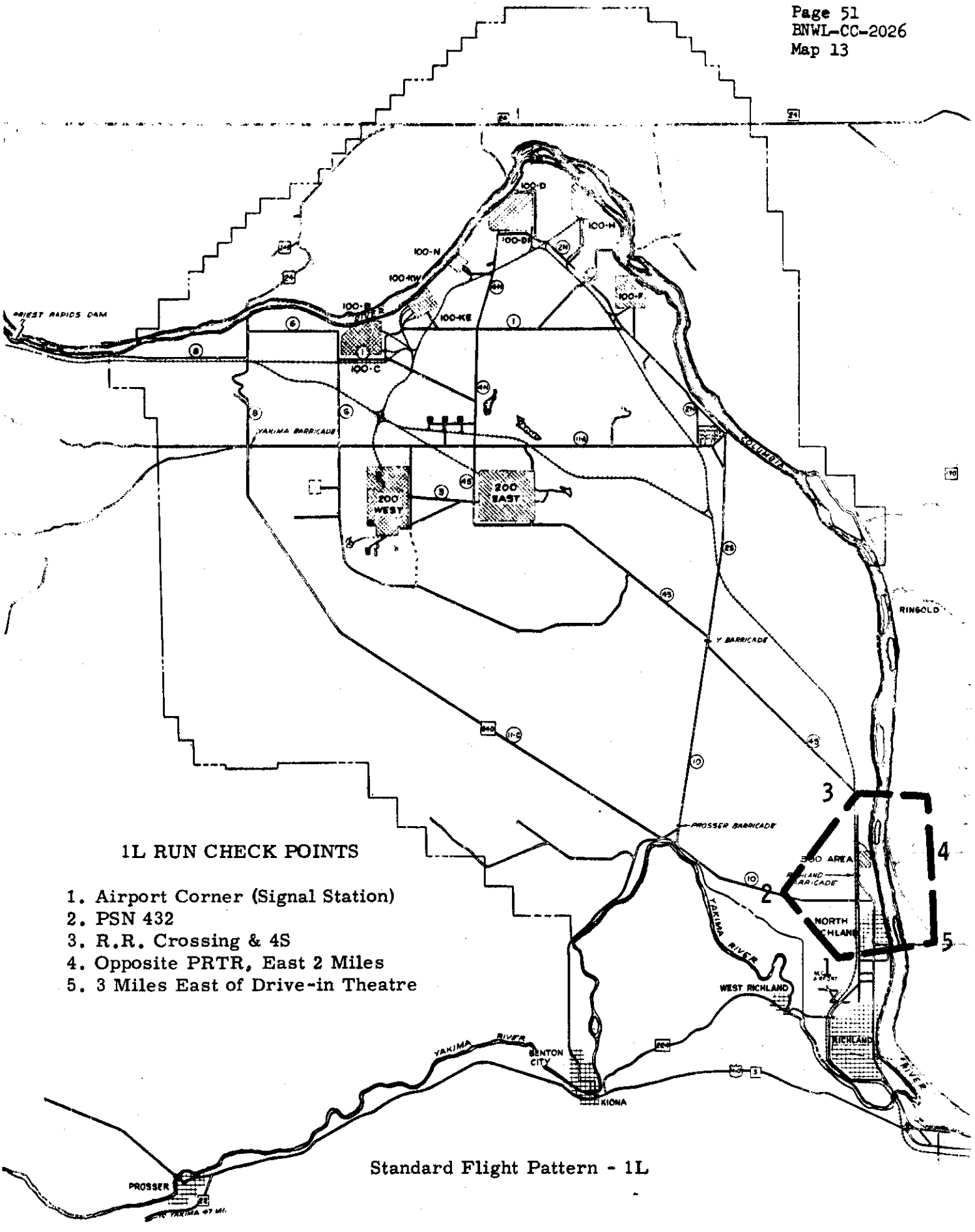
Standard Flight Pattern - 1R




## 2R RUN CHECK POINTS

1. S.E. Corner of Run
2. By Exchange
3. Intersection 11A & 4S
4. Intersection 11A & 6
5. Yakima Barricade
6. Vernita Ferry
7. Mattawa Rd. & County Line Rd.
8. Army Position 91
9. 06-C -Saddle Mountain
10. MP 30
11. Over 7 Trees in a Clump

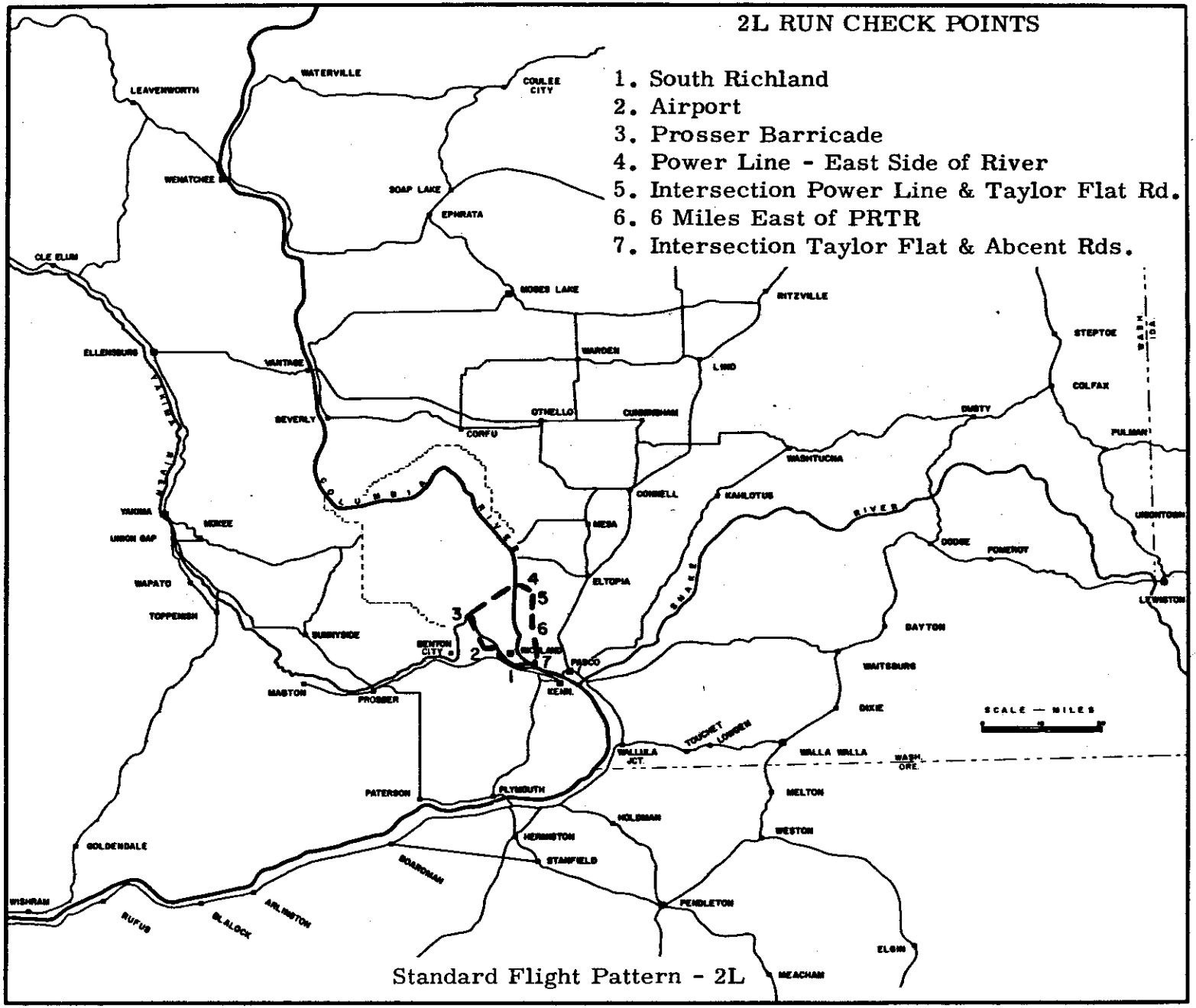
Standard Flight Pattern - 2R

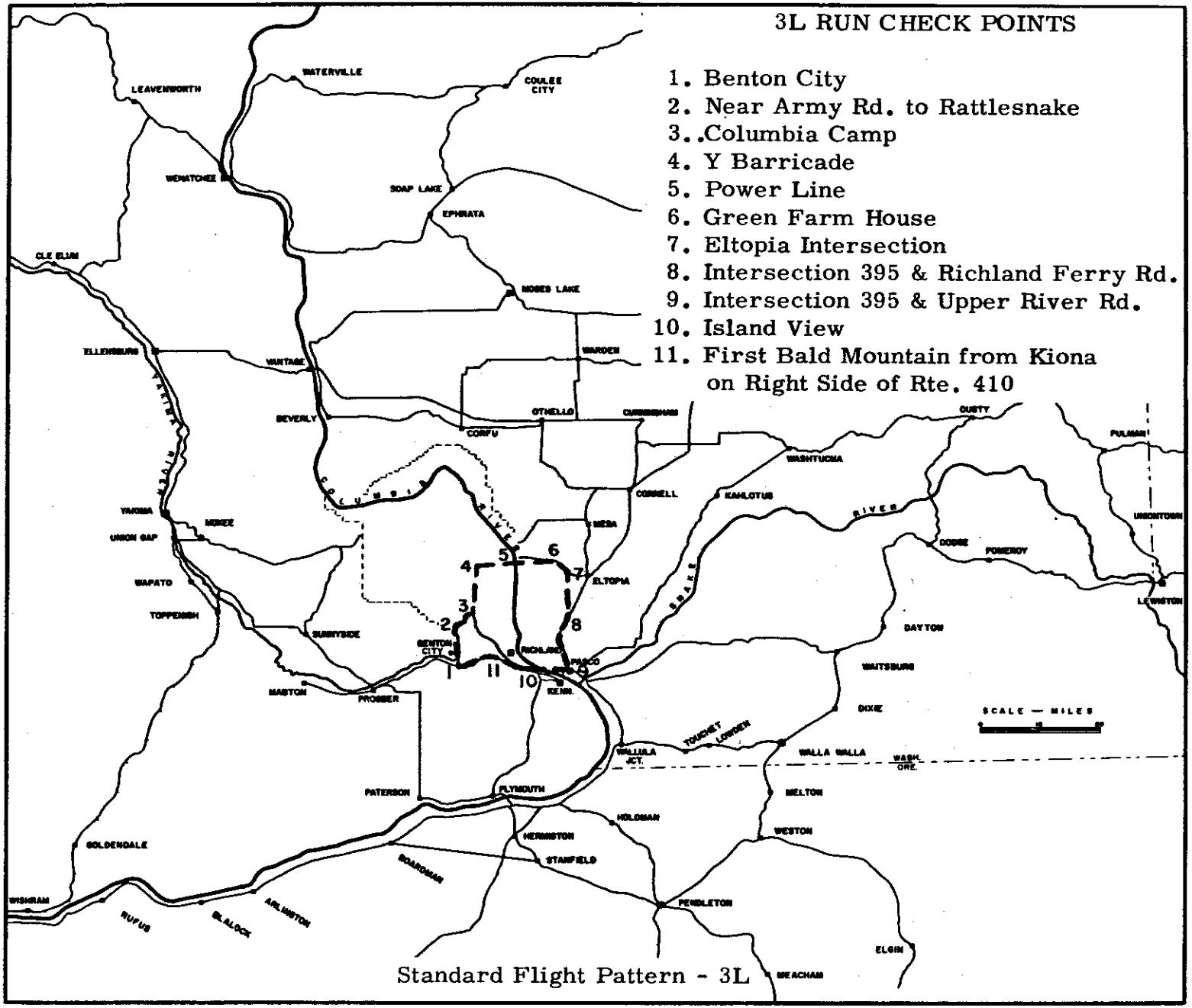



## 1L RUN CHECK POINTS

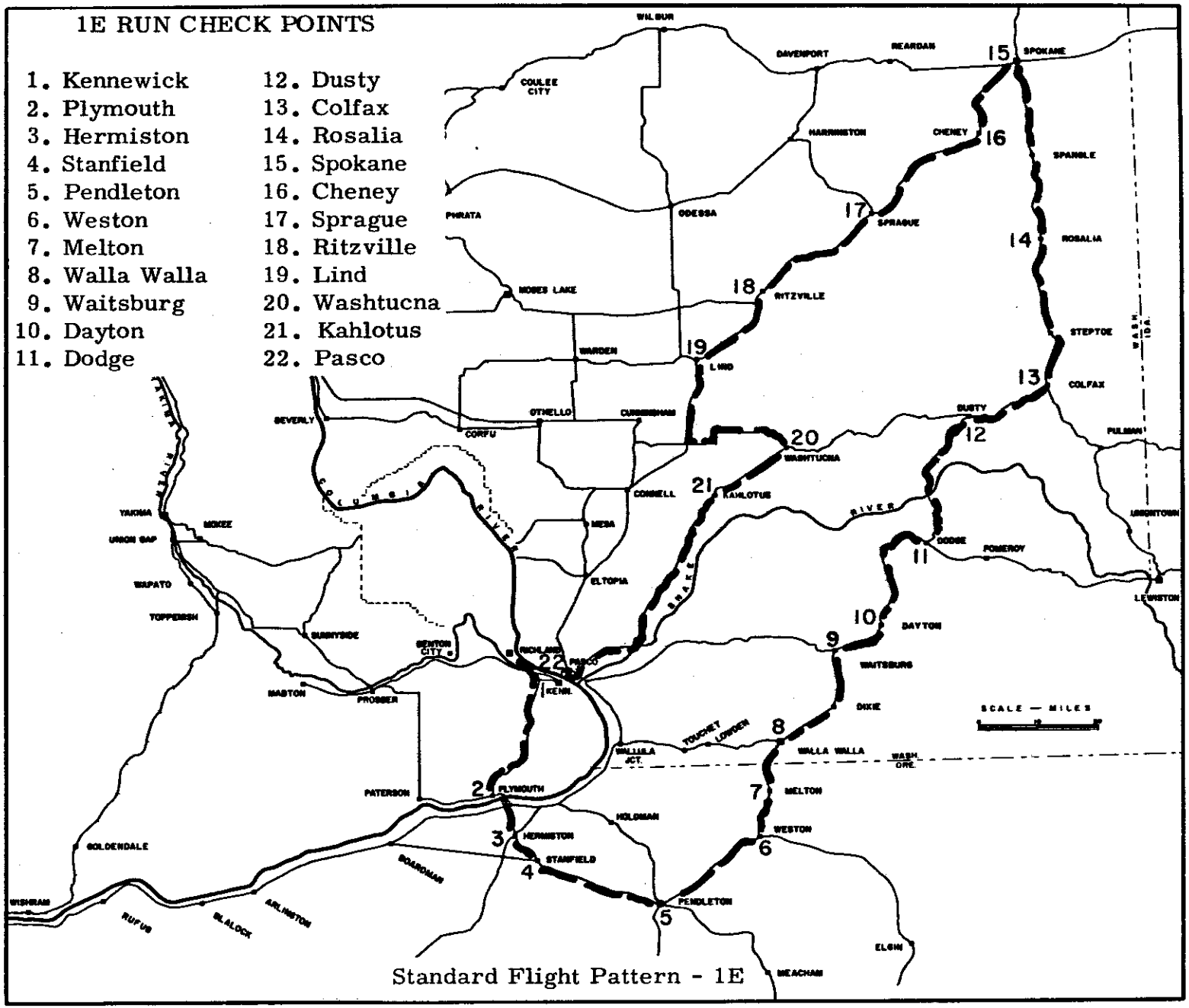
1. Airport Corner (Signal Station)
2. PSN 432
3. R.R. Crossing & 4S
4. Opposite PRTR, East 2 Miles
5. 3 Miles East of Drive-in Theatre

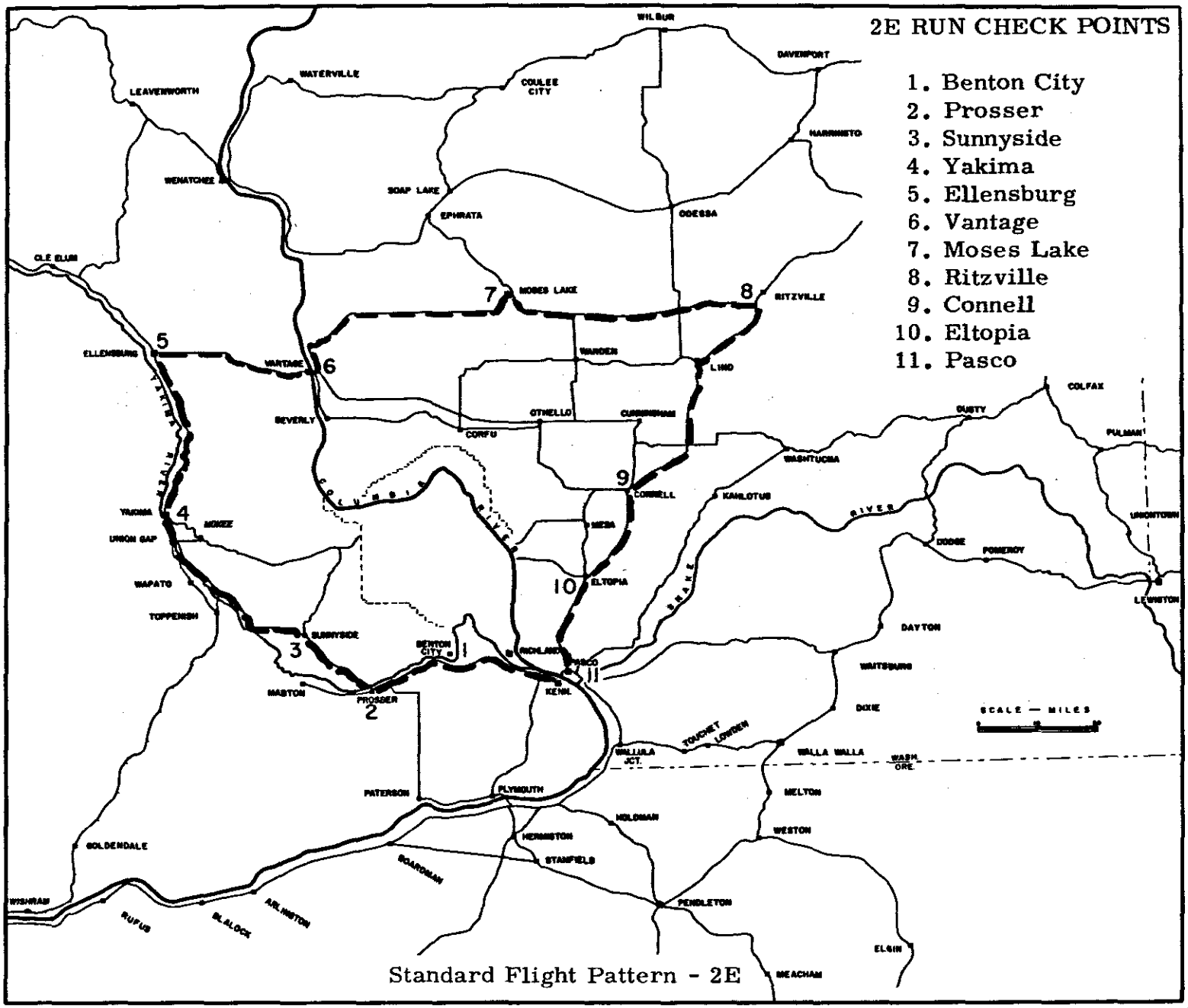
Standard Flight Pattern - 1L


2L RUN CHECK POINTS
1. South Richland
2. Airport
3. Prosser Barricade
4. Power Line - East Side of River
5. Intersection Power Line & Taylor Flat Rd.
6. 6 Miles East of PRTR
7. Intersection Taylor Flat & Abcent Rds.
WATERVILLE
LEAVENWORTH
COULEE CITY
WENATCHEE
SOAP LAKE
EPHRATA
CLE ELUM
MOSES LAKE
RITZVILLE
ELLENSBURG
YAKIMA
WARDEN
LIND
STEPTOE
COLFAX
PULLMAN
OTHELLO
CUNNINGHAM
CORFU
BEVERLY
WASHTUCNA
CONNELL
KAHLOTUS
MESA
ELTOPIA
MOXEE
UNION GAP
WAPATO
TOPPENISH
SUNNYSIDE
BENTON CITY
PASCO
KENNEWICK
RICHLAND
MABTON
PROSSER
DAYTON
WAITSBURG
DIXIE
WALLULA JCT.
WALLA WALLA
WASH. ORE.
TOUCHET
LOWDEN
PATERSON
PLYMOUTH
MELTON
HOLDMAN
WESTON
HERMISTON
STANFIELD
GOLDENDALE
BOARDMAN
PENDLETON
WISHRAM
RUFUS
BLALOCK
ARLINGTON
ELGIN
MEACHAM
SCALE — MILES
Standard Flight Pattern - 2L




Standard Flight Pattern - 3L


1E RUN CHECK POINTS
1. Kennewick
2. Plymouth
3. Hermiston
4. Stanfield
5. Pendleton
6. Weston
7. Melton
8. Walla Walla
9. Waitsburg
10. Dayton
11. Dodge
12. Dusty
13. Colfax
14. Rosalia
15. Spokane
16. Cheney
17. Sprague
18. Ritzville
19. Lind
20. Washtucna
21. Kahlotus
22. Pasco
WILBUR
DAVENPORT
REARDAN
SPOKANE
COULEE CITY
HARRINGTON
CHENEY
SPANGLE
PHRATA
ODESSA
SPRAGUE
ROSALIA
MOSES LAKE
RITZVILLE
STEPTOE
WARDEN
LIND
COLFAX
OTHELLO
CUNNINGHAM
SEVERLY
CORFU
DUSTY
PULLMAN
WASHTUCNA
CONNELL
KAHLOTUS
YAKIMA
MOXEE
UNION GAP
MESA
ELTOPIA
DODGE
POMEROY
LEWISTON
WAPATO
TOPPENISH
SUNNYSIDE
BENTON CITY
DAYTON
WAITSBURG
MABTON
PROSSER
KENN.
DIXIE
SCALE — MILES
WALLULA JCT.
WALLA WALLA
PATERSON
PLYMOUTH
MELTON
HOLDMAN
HERMISTON
WESTON
GOLDENDALE
STANFIELD
PENDLETON
BOARDMAN
WISHRAM
RUFUS
BLALOCK
ARLINGTON
ELSIN
MEACHAM
Standard Flight Pattern - 1E


2E RUN CHECK POINTS
1. Benton City
2. Prosser
3. Sunnyside
4. Yakima
5. Ellensburg
6. Vantage
7. Moses Lake
8. Ritzville
9. Connell
10. Eltopia
11. Pasco
WILBUR
DAVENPORT
WATERVILLE
COULEE CITY
LEAVENWORTH
HARRINGTO
WENATCHEE
SOAP LAKE
EPHRATA
ODESSA
OLE ELUM
MOSES LAKE
RITZVILLE
ELLENSBURG
VANTAGE
WARDEN
LIND
BEVERLY
OTHELLO
CUNNINGHAM
CORFU
COLFAX
GUSTY
PULLMAN
WASHTUCNA
CONNELL
KAHLOTUS
YAKIMA
MOXEE
MESA
UNIONTOWN
UNION GAP
DODGE
POMEROY
WAPATO
ELTOPIA
TOPPENISH
LEWISTON
SUNNYSIDE
DAYTON
BENTON CITY
RICHLAND
PASCO
WAITSBURG
MABTON
PROSSER
KENNEWICK
DIXIE
SCALE — MILES
WALLULA JCT.
WALLA WALLA
WASH.
ORE.
PATERSON
PLYMOUTH
MELTON
HOLDMAN
WESTON
GOLDENDALE
HERMISTON
STANFIELD
BOARDMAN
WISHRAM
PENDLETON
RUFUS
BLALOCK
ARLINGTON
ELGIN
MEACHAM
Standard Flight Pattern - 2E

## B. EXTERNAL RADIATION EXPOSURE RATES

### 1. Exposure Rates On-Plant

External radiation exposure rates were determined from pencil-type gamma dosimeters located (in clusters of three) within buildings designated "614" (Map 18). The average results for the last half of 1968 are presented in Table 11 below.

Measured exposure rates in the last half of 1968 were similar to or slightly lower than those of the first part of the year with the exception of July-August data. At most locations, the peak exposure rate which occurred during July was attributed to a combination of increased regional fallout, temporary increases in plant releases, and effects of unusually hot weather on the dosimeters.

Erratic results obtained during June, July, and August at the 700 Area location were attributed to dampness of the dosimeters caused by drainage from the roof of an adjoining building. Moving the dosimeters alleviated the problem.

An unusual increase in the exposure rate measured at 100-K was noted in September 1968 with a maximum value of 24 mR over the period 9-3-68 to 9-9-68. Personnel at DUN were notified. However, no explanation for the increase was found.

Early in November, temporary increases in exposure rates were noted at Rattlesnake Springs, the Emergency Relocation Center and the 300 Area. In late November and early December, exposure rates at the following locations increased slightly: Midway, 100-B, 100-N, 100-F, Hanford and 200-West Northeast. All such increases were within the normal range of variation of these measurements.

Due to repeated dosimeter reader malfunctions, no reliable data were obtained in the latter part of December. A replacement reader was subsequently installed.

TABLE 11

AVERAGE EXTERNAL GAMMA EXPOSURE RATES
(mR/day)

| | Location | July-December 1968 | January-June 1968 |
|---|---|---|---|
| 100 Areas | Midway | 0.60 | 0.57 |
| | 100-B | 0.69 | 0.82 |
| | 100-K | 1.65 | 2.13 |
| | 100-N | 0.91 | 1.38 |
| | 100-D | 0.41 | 0.73 |
| | 100-F | 0.43 | 0.68 |
| | Hanford | 0.56 | 0.92 |

TABLE 11 (Continued)

AVERAGE EXTERNAL GAMMA EXPOSURE RATES
(mR/day)

| | Location | July-December 1968 | January-June 1968 |
|---|---|---|---|
| 200-West Area | Redox | 0.61 | 0.56 |
| | West-Center | 0.43 | 0.41 |
| | East-Center | 0.41 | 0.41 |
| | West-Northeast | 0.48 | - |
| 200-East Area | North-Center | 0.58 | - |
| | West-Center | 0.42 | 0.52 |
| | Southeast | 0.46 | 0.50 |
| | East-Center | 0.53 | 0.46 |
| Other | Rattlesnake Springs | 0.42 | 0.40 |
| | Emergency Relocation Center | 0.41 | 0.40 |
| | Wye Barricade | 0.62 | 0.62 |
| | Rt. 10 Mile 1.6 | 0.34 | 0.38 |
| | 300 Area | 0.63 | 0.55 |
| | 700 Area | 0.62 | 0.31 |

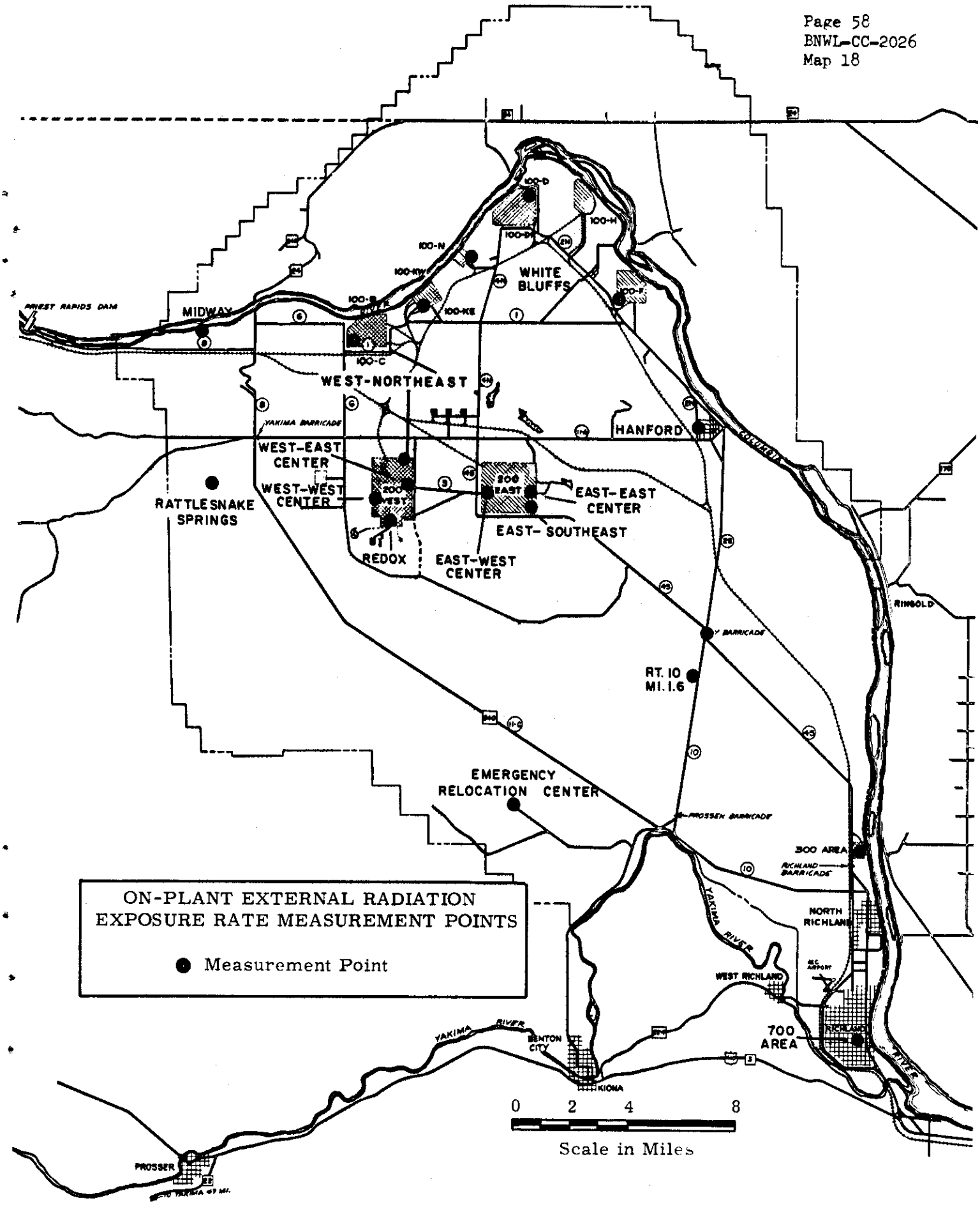

PRIEST RAPIDS DAM
MIDWAY
100-D
100-H
100-N
100-DR
100-HR
WHITE BLUFFS
100-F
100-KE
100-B
100-C
WEST-NORTHEAST
YAKIMA BARRICADE
HANFORD
WEST-EAST CENTER
WEST-WEST CENTER
200 WEST
200 EAST
EAST-EAST CENTER
EAST-SOUTHEAST
RATTLESNAKE SPRINGS
REDOX
EAST-WEST CENTER
RINGOLD
Y BARRICADE
RT. 10 MI. 1.6
EMERGENCY RELOCATION CENTER
PROSSER BARRICADE
300 AREA
RICHLAND BARRICADE
NORTH RICHLAND
YAKIMA RIVER
WEST RICHLAND
700 AREA
BENTON CITY
KIONA
PROSSER
ON-PLANT EXTERNAL RADIATION
EXPOSURE RATE MEASUREMENT POINTS
Measurement Point
0 2 4 8
Scale in Miles

Figure 20

# EXTERNAL RADIATION ON PLANT

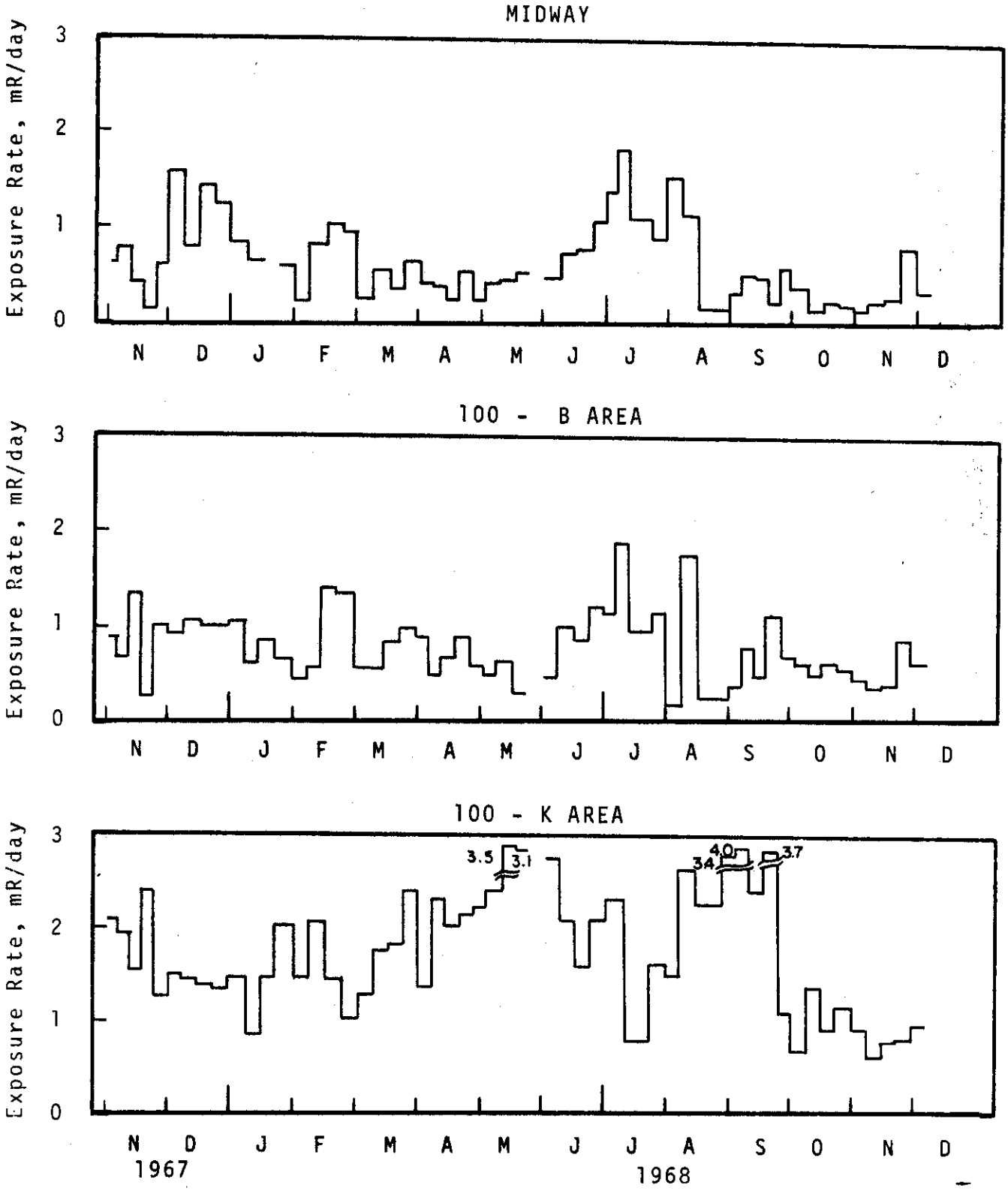
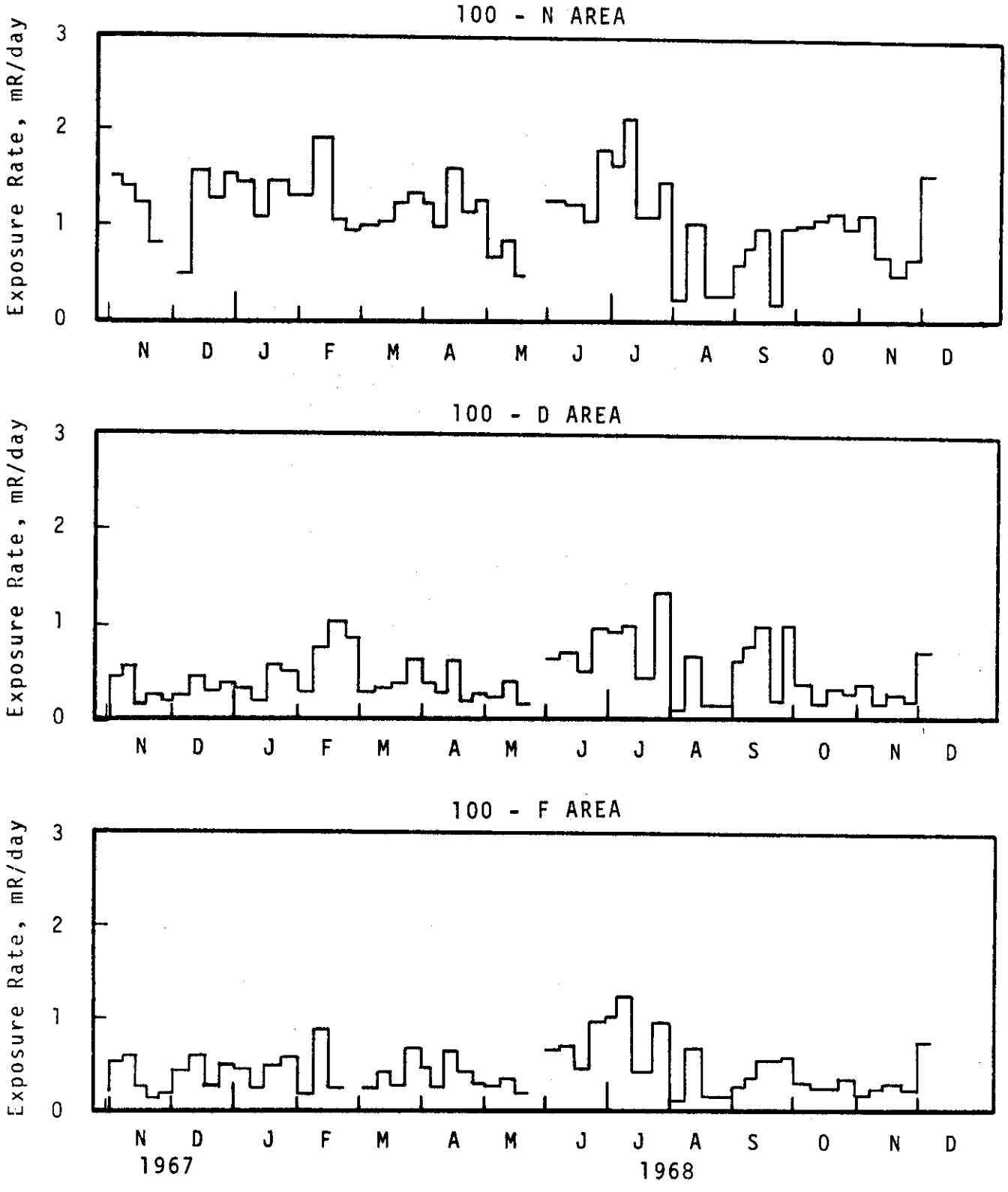


Figure 21

# EXTERNAL RADIATION ON PLANT



# EXTERNAL RADIATION ON PLANT

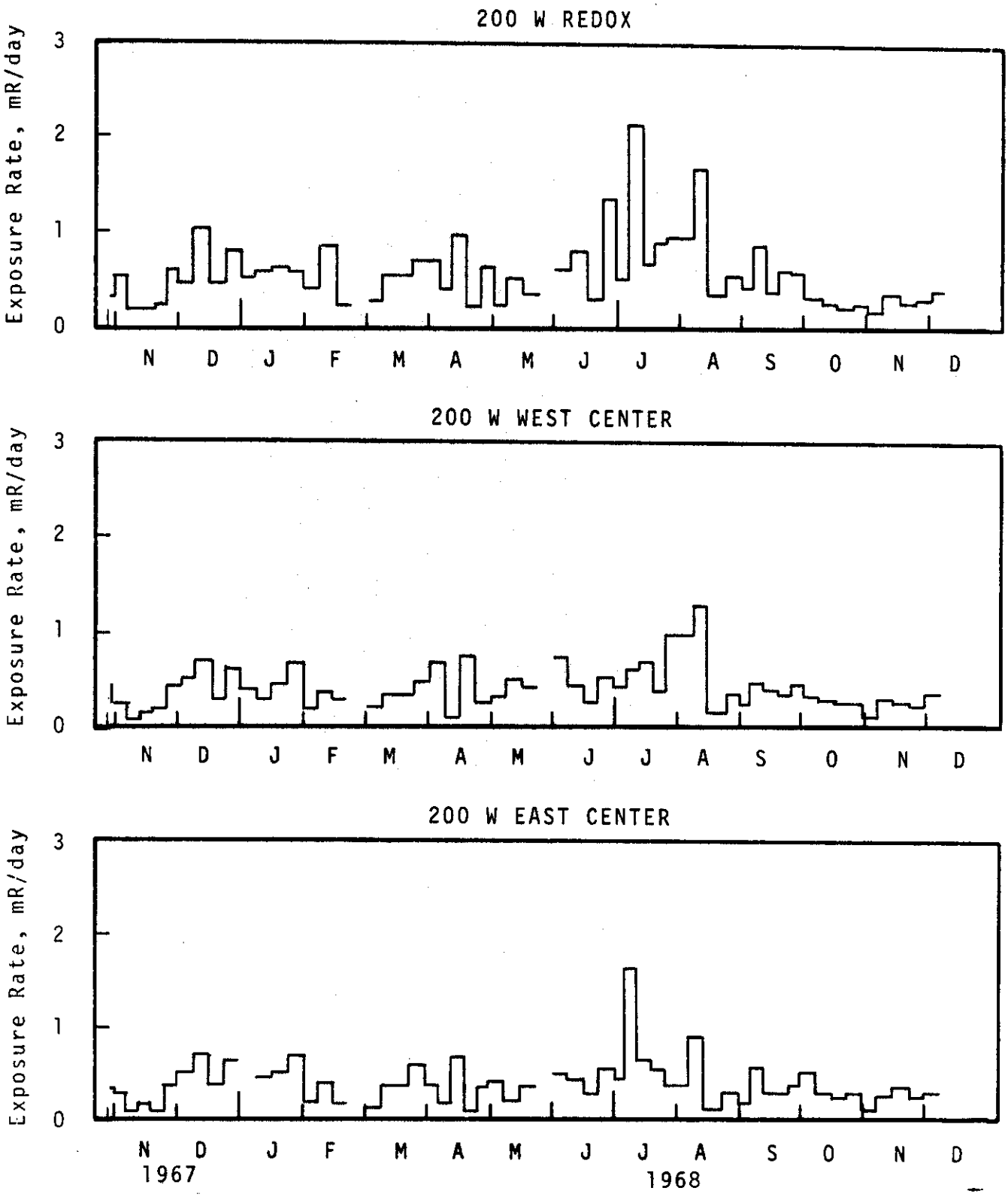


Figure 23

# EXTERNAL RADIATION ON PLANT

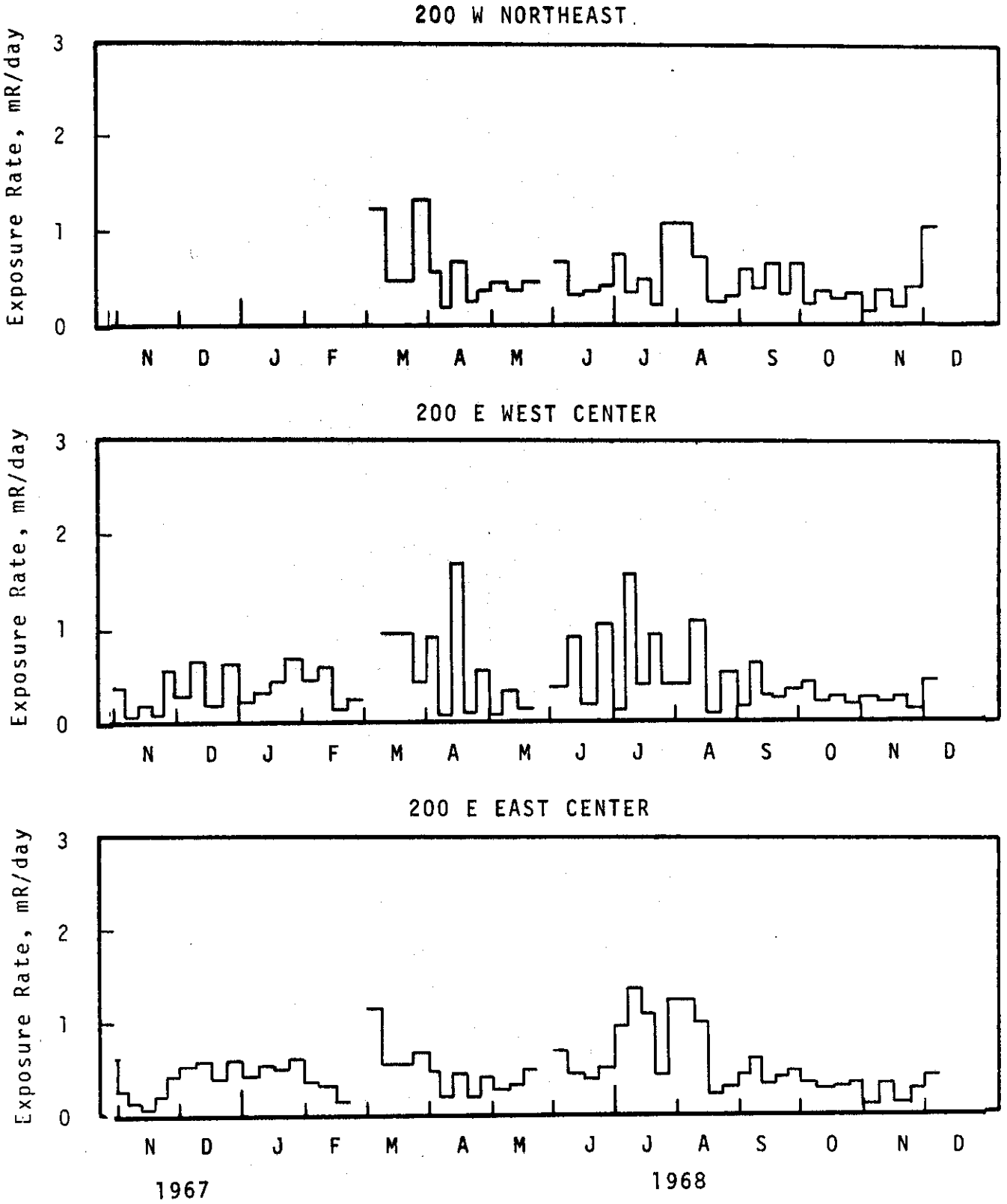
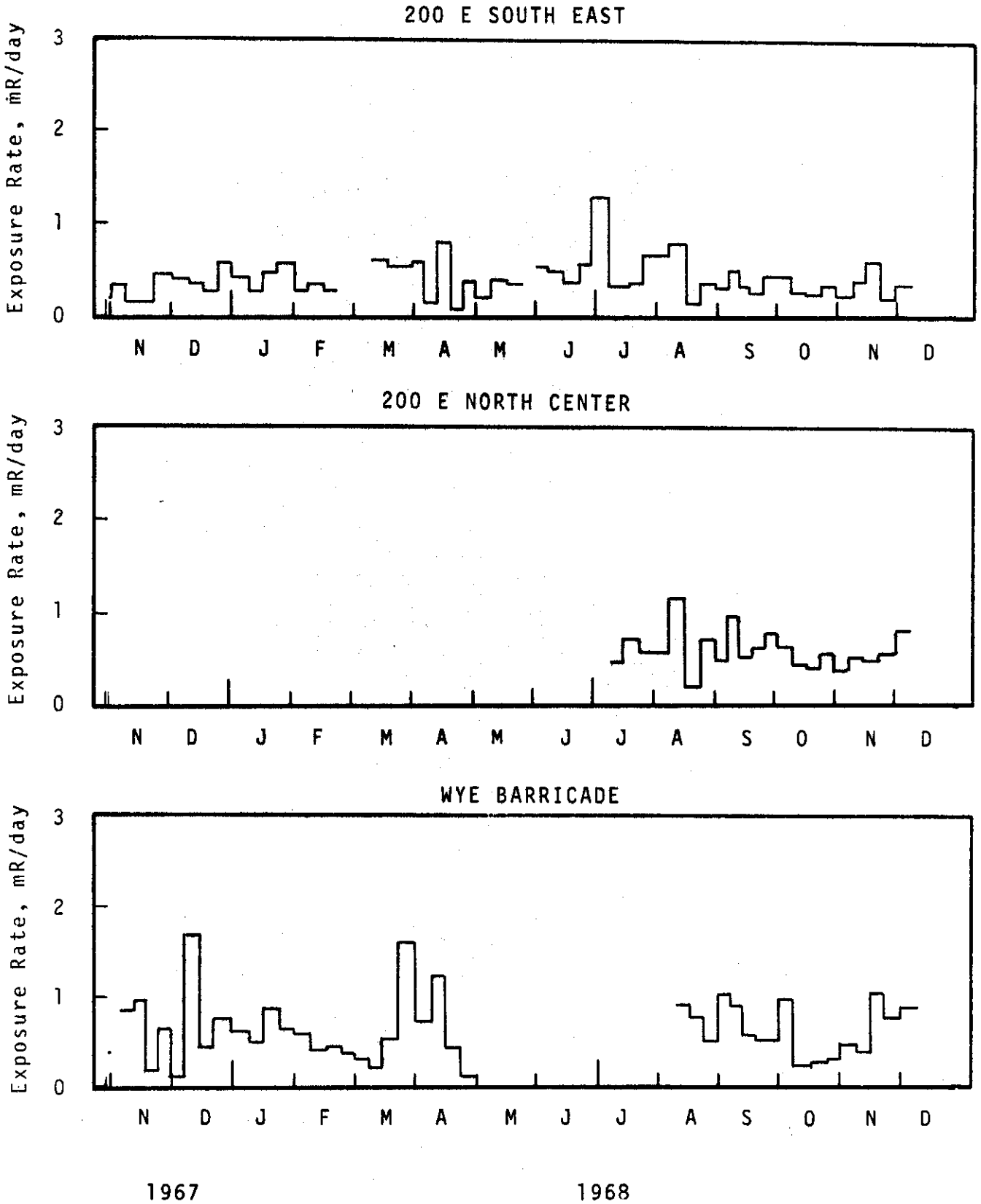


Figure 24

# EXTERNAL RADIATION ON PLANT



# EXTERNAL RADIATION ON PLANT

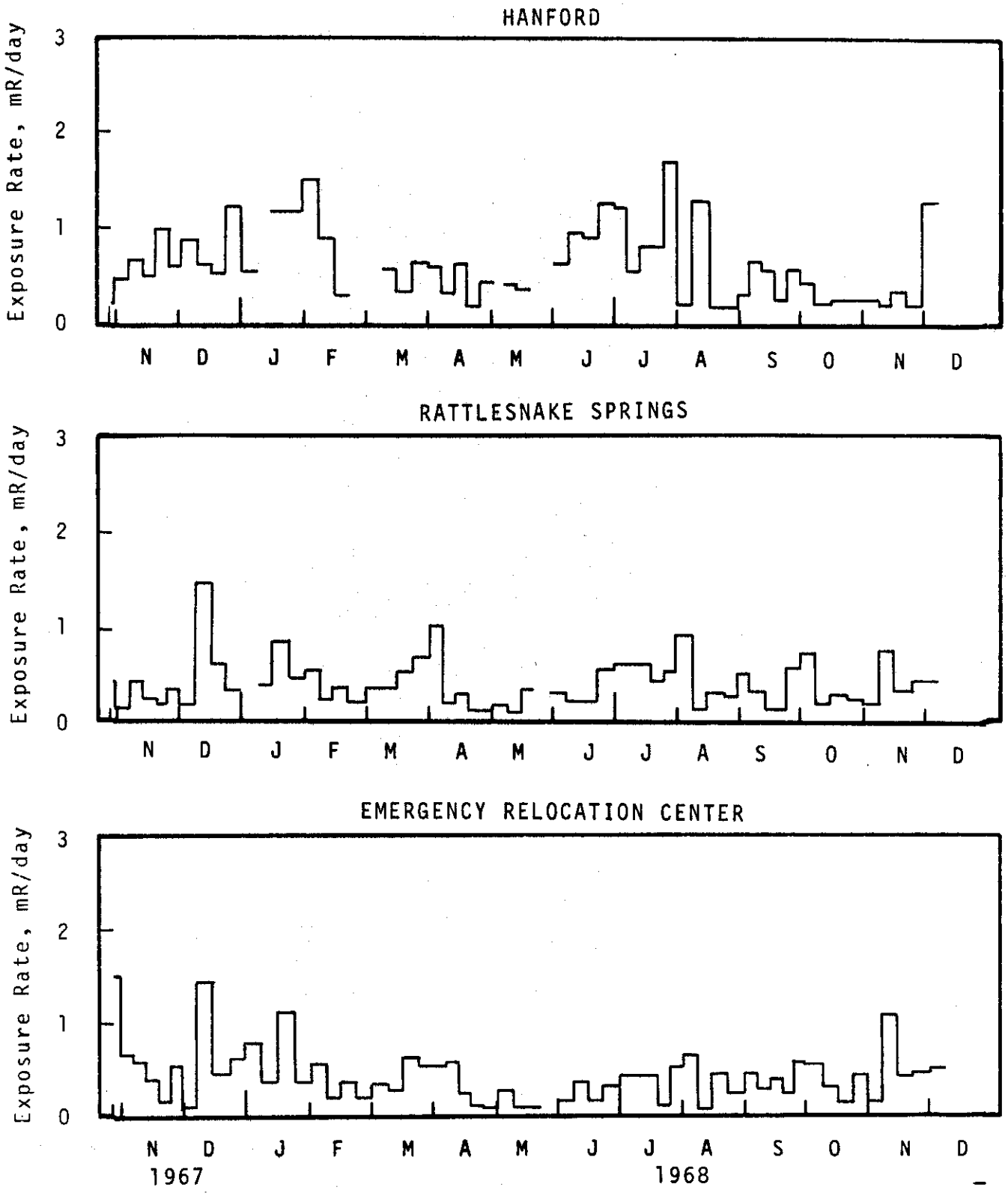
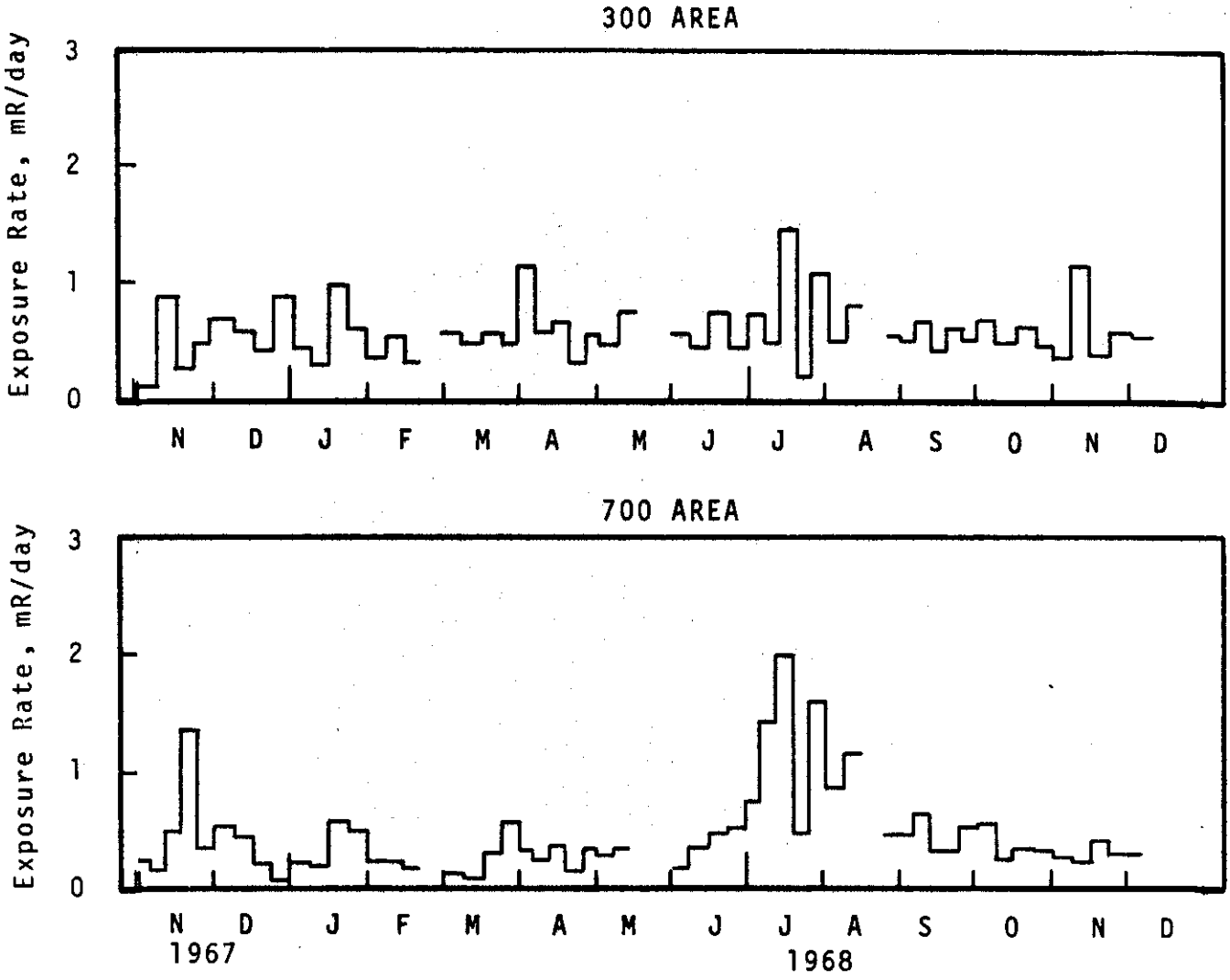


Figure 26

# EXTERNAL RADIATION ON PLANT



## 2. Exposure Rates at the Columbia River Shoreline

Shoreline exposure rates (Map 19 and Figures 27 and 28) are measured weekly at 3 feet above the ground with a 40-liter ionization chamber whose response is calibrated in μR/hr (radium gamma). This approximates the exposure rate to the gonads of a person standing on the riverbank. Additional monthly shoreline surveys, covering the reach from the reactor outfalls to Richland, include both the exposure rate at 3 feet and the levels of surface contamination as measured with a portable GM survey meter. These data are presented in Table 12. The upstream measurement site was moved from Vernita to the Priest Rapids Gauge Station in July.

On four occasions during the last half of 1968, distinct radioactive particles were detected at the Columbia River shoreline. On several other occasions, general particulate contamination associated with foam and shoreline deposits was observed. Shoreline exposure rates indicated that some of the increases over previous years noted in 1967 were sustained in 1968.

Normally, exposure rates correlate inversely with river flow rates. This results in a seasonal pattern of low exposure rates during the summer period of high river flow followed by increasing exposure rates through the fall and winter until spring run-off appears. A month-by-month summary of unusual shoreline measurements is presented below.

July - Several radioactive particles were detected on July 3, 1968 near the PRTR pump intake during a temporary decrease in flood water elevation. Particles had also been found at this location in June (see BNWL-CC-1850). After re-flooding and re-exposure, another survey of the same location on July 12, 1968 still detected several radioactive particles with a maximum GM reading of 6,000 c/m. A gamma energy analysis showed $^{144}$Ce-Pr, $^{141}$Ce, $^{51}$Cr, $^{46}$Sc, and $^{60}$Co as the dominant gamma emitters. Subsequent surveys detected no recurrence.

At the Hanford Far Shore location and at the Powerline Crossing on July 25, maximum GM readings of 4,000 c/m were obtained on mud.

August - At the Richland Pump Plant, two particles (800 c/m-GM) were detected on August 28, 1968.

September - On September 5, the shoreline exposure rate measured at the Richland Pump Plant was generally 75 μR/hr with a maximum of 100 μR/hr. No distinct particles were detected although the maximum GM reading was 800 c/m. In the previous week, two particles had been found.

October - A shoreline exposure rate of 45 μR/hr (significantly higher than any other comparable measurement upstream from the reactors since March, 1967) was measured at the Priest Rapids Gauge Station on October 8, 1968. No explanation was found for this temporary increase.

2. Exposure Rates at the Columbia River Shoreline (Continued)

Downstream exposure rates during October exceeded 200 μR/hr at three locations. The maximum, 380 μR/hr, was measured at the Hanford Far Shore which represents the furthest northward point open to the general public, but only during hunting season (mid-October/mid-January).

General shoreline surface GM readings of 2,000-4,000 c/m were obtained at the plant shore downstream to the Powerline Crossing. One particle reading 25,000 c/m was detected at Ringold on October 23, firmly affixed to a large rock. No analysis was made.

November - Although the shoreline exposure rate at the Hanford Far Shore location decreased to 155 μR/hr, shoreline exposure rates at five locations exceeded 200 μR/hr. The maximum measured during the month was 330 μR/hr on the plant shore below 181-KE on November 13, 1968. On the same day at "D Island", an unusual reading of 40,000 c/m-GM was found associated with foam. Laboratory analysis of this foam by gamma spectrometry indicated the major emitters were $^{141}Ce$, $^{140}Ba$-La, $^{51}Cr$, $^{65}Zn$, $^{76}As$, $^{46}Sc$, $^{59}Fe$, and $^{60}Co$.

December - During December, shoreline exposure rates exceeded 200 μR/hr at five locations.

At Powerline Crossing Far Shore, 200 μR/hr was measured on the routine weekly survey conducted December 4. Follow-up surveys on the next day found maximum exposure rates of 400 μR/hr (the maximum for the month) at the Powerline Crossing Far Shore and 110-150 μR/hr at Ringold in shoreline areas near the usual sampling stations. A part of the radioactivity at both locations was apparently associated with a mud-organic mixture deposited on the shoreline with fluctuations in the river flow. Analysis of this material for gamma emitters indicated $^{51}Cr$ and $^{46}Sc$ (major contributors) and $^{60}Co$ and $^{106}Ru$ (minor). In the Ringold sample, a trace of $^{95}Zr$-Nb was also detected. At both locations, routine surveys on the following week indicated reduced exposure rates.

# TABLE 12

## MAXIMUM READINGS FROM MONTHLY SHORELINE SURVEYS[1]

A. COLUMBIA RIVER - PLANT SHORE

| | Above 181 KW | Below 181 KE | Above 181 NE | Below 181 NE | Below 181 D | Below 181 H | White Bluffs Ferry | Hanford | Powerline | PRTR | Richland Ferry[4] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| July 25, 1968 | 64(300)[2] | 48(900) | 24 (150) | 34 (350) | 35 (250) | 52 (700) | 65 (700) | 86 (900) | 94 (4000) | 37 (800) | 34 (700) |
| Aug. 29 | 52(250) | 85(350) | 50 (300) | 70 (400) | 82 (600) | 70 (<100) | 130 (2000) | 55 (300) | 130 (500) | 34 (300) | 25 (200) |
| Oct. 2 | 30(200) | 120(2000) | 110(2500) | 130(3000) | 180(3500) | 170 (4000) | 220 (3300) | 180 (3000) | 150 (3000) | 130 (700) | 60 (500) |
| Nov. 13 | 33(300) | 330(5500) | 220(5000) | 180(3000) | 205(3000) | 145 (2500) | 225 (3300) | 130 (3000) | 150 (2000) | 80 (800) | 40 (400) |
| Dec. 12 | 40(150) | 185(10,000) | 205(2500) | 175(2000) | 180(2500) | 340 (3500) | 150 (900) | 230 (3500) | 185 (2000) | 53 (450) | 29 (150) |

B. COLUMBIA RIVER - FAR SHORE

| | Below 181 KE | Above 181 D | D Island | Below 181 D | White Bluffs Ferry | Hanford[3] | Ringold[3] | Powerline[4] | Byer's Landing[4] |
|---|---|---|---|---|---|---|---|---|---|
| July 25, 1968 | 16 (150)[2] | 12 (100) | 105 (400) | 18 (350) | 25 (400) | 78 (4000) | 52 (300) | 23 (200) | 40 (600) |
| Aug. 29 | 16 (<100) | 20 (<100) | 130 (1000) | 28 (<100) | 26 (200) | 64 (400) | 130 (500) | 40 (200) | 105 (500) |
| Oct. 2 | 16 (150) | 14 (150) | 220 (3000) | 40 (200) | 60 (600) | 380 (4000) | 150 (3000) | 130 (2000) | 90 (700) |
| Nov. 13 | 20 (250) | 22 (200) | 235(40,000) | 70 (650) | 90 (600) | 155 (3000) | 150 (2000) | 175 (1500) | 117 (600) |
| Dec. 12 | 18 (100) | 40 (250) | 272 (3000) | 29 (150) | 54 (500) | 73 (400) | 105 (2000) | 105 (900) | 77 (300) |

1. No survey was made in September.

2. Measurements reported in μR/hr are taken with a 40-liter ionization chamber, the center of the chamber 3 ft above ground and 3 ft back from the water's edge. Measurements reported in ( ) are the maximum c/m found with a GM in the immediate area of the water's edge.

3. Point only open to the general public on Wednesdays, Saturdays, and Sundays, during the hunting season.

4. Point open to the general public during the entire year.

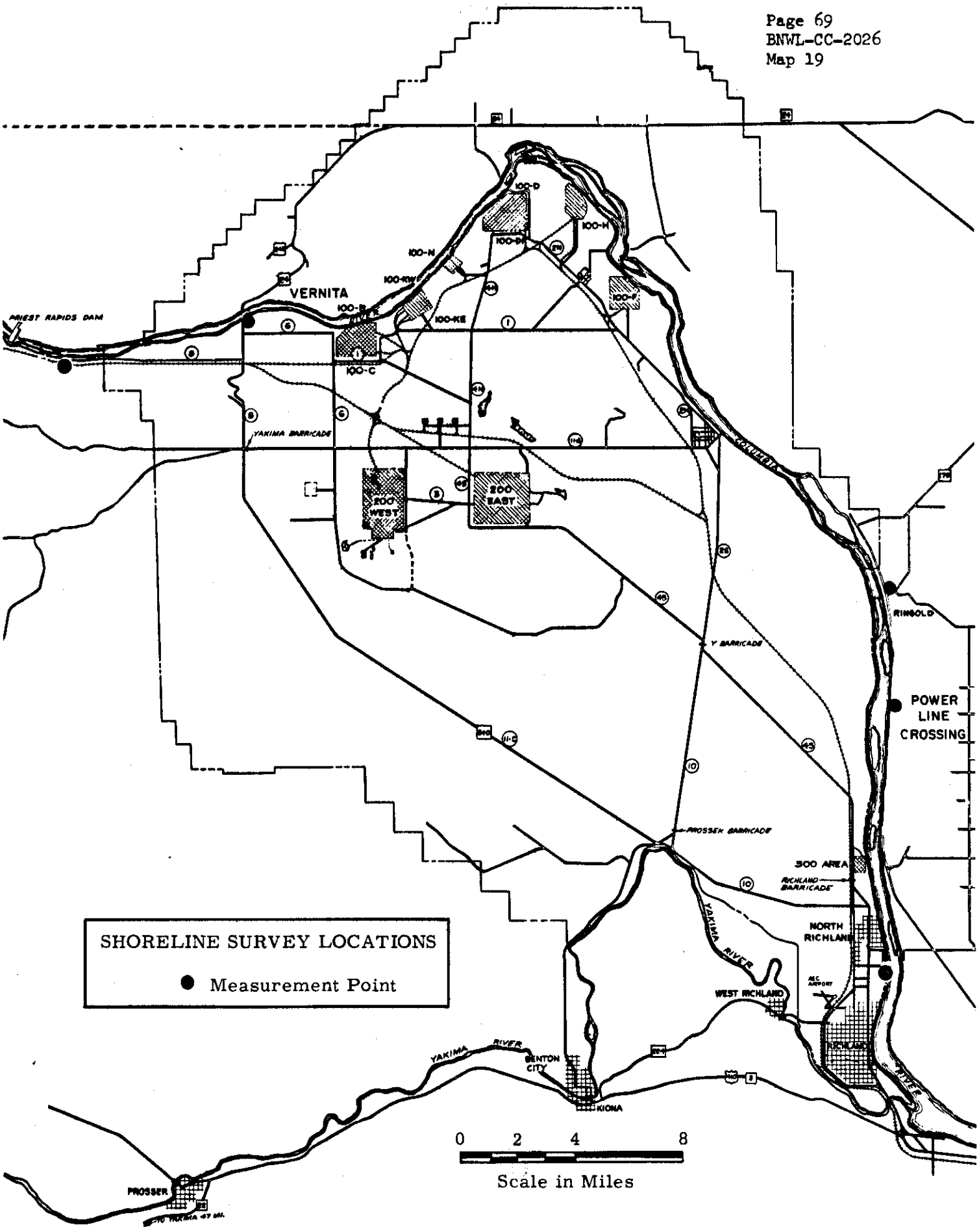

VERNITA
PRIEST RAPIDS DAM
100-D
100-H
100-N
100-KW
100-B
100-KE
100-F
100-C
YAKIMA BARRICADE
200 WEST
200 EAST
COLUMBIA
RINGOLD
Y BARRICADE
POWER LINE CROSSING
PROSSER BARRICADE
300 AREA
RICHLAND BARRICADE
NORTH RICHLAND
YAKIMA RIVER
WEST RICHLAND
BENTON CITY
KIONA
PROSSER
SHORELINE SURVEY LOCATIONS
Measurement Point
0 2 4 8
Scale in Miles

Figure 27

# EXTERNAL RADIATION AT THE COLUMBIA RIVER SHORELINE

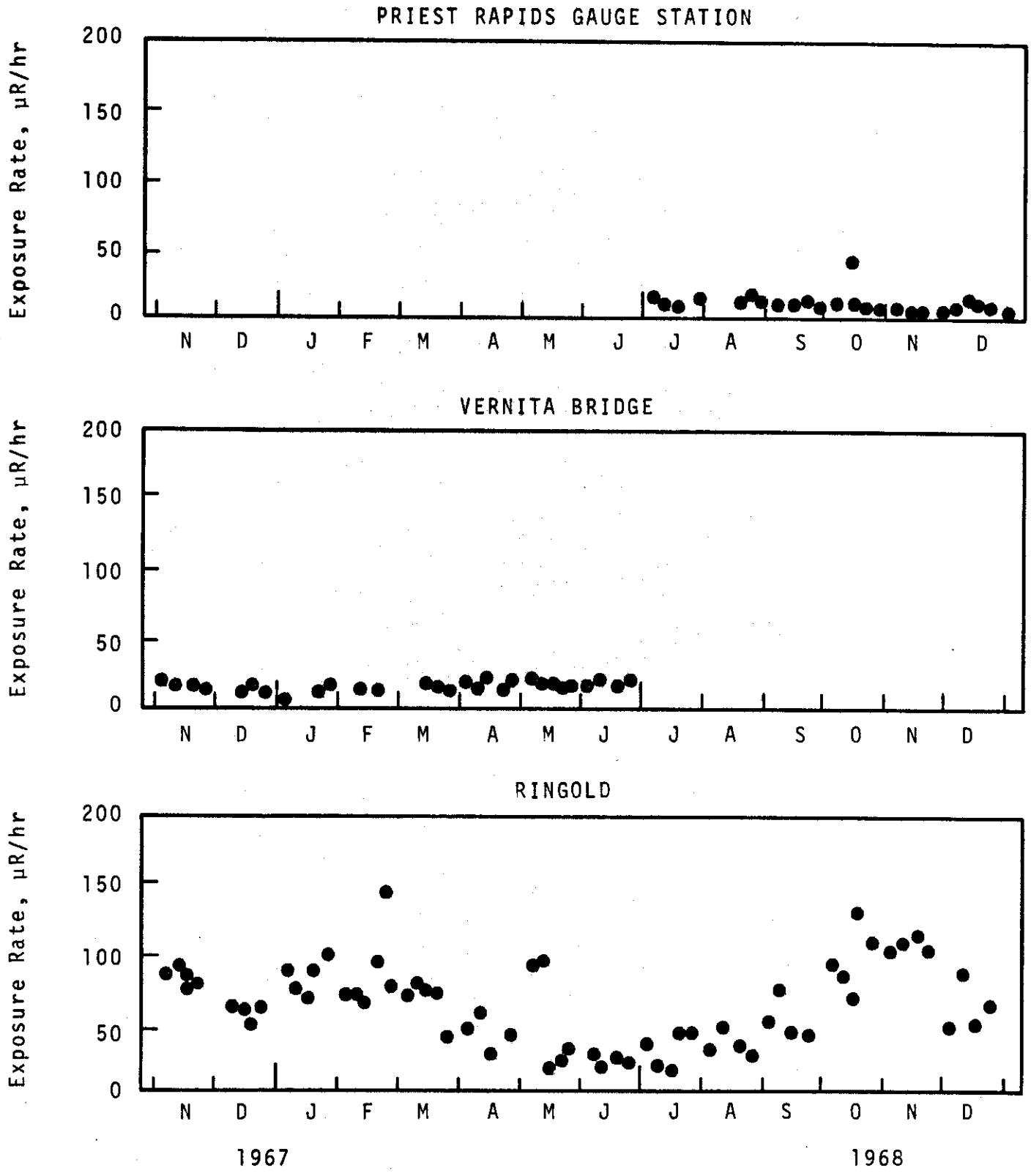
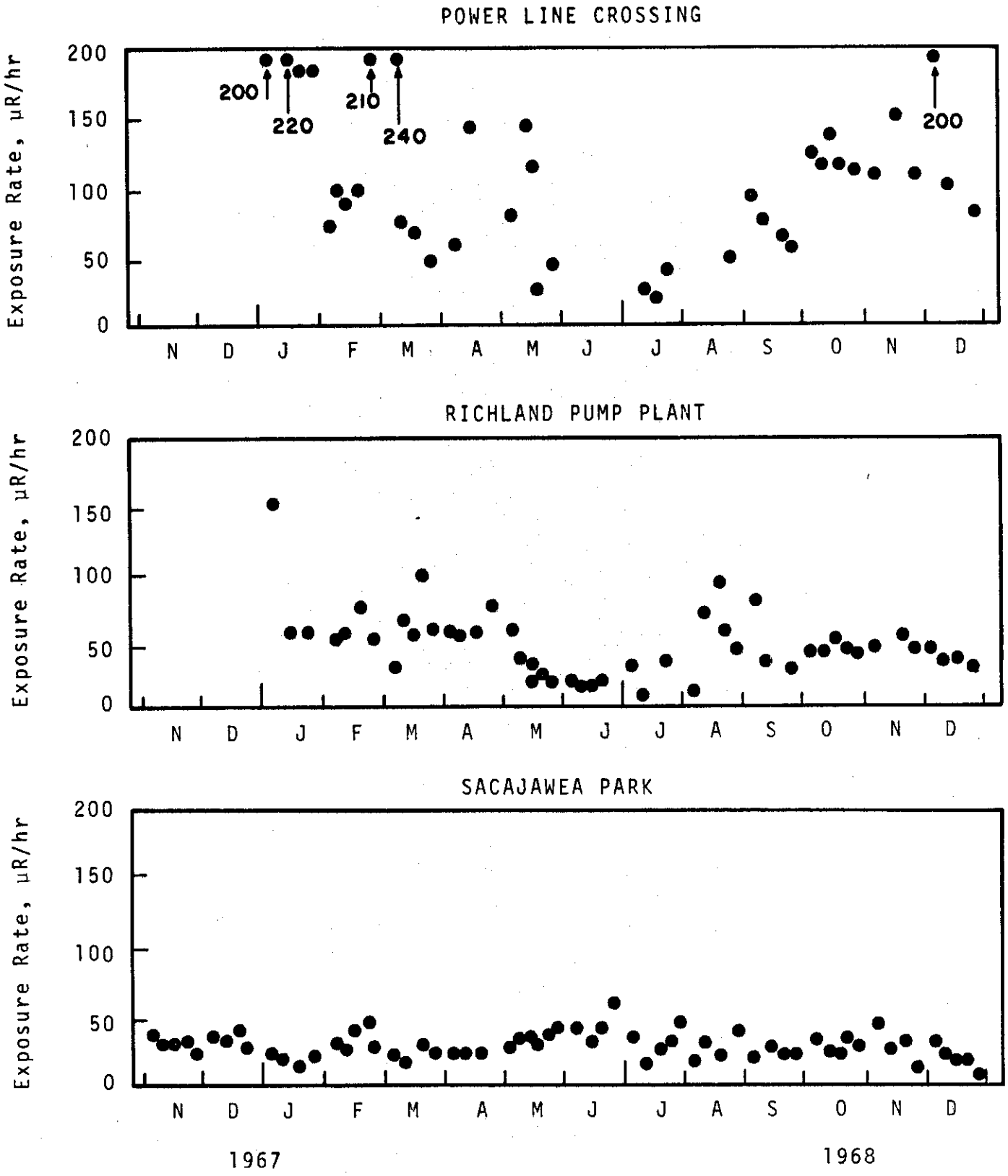


Figure 28

# EXTERNAL RADIATION AT THE COLUMBIA RIVER SHORELINE



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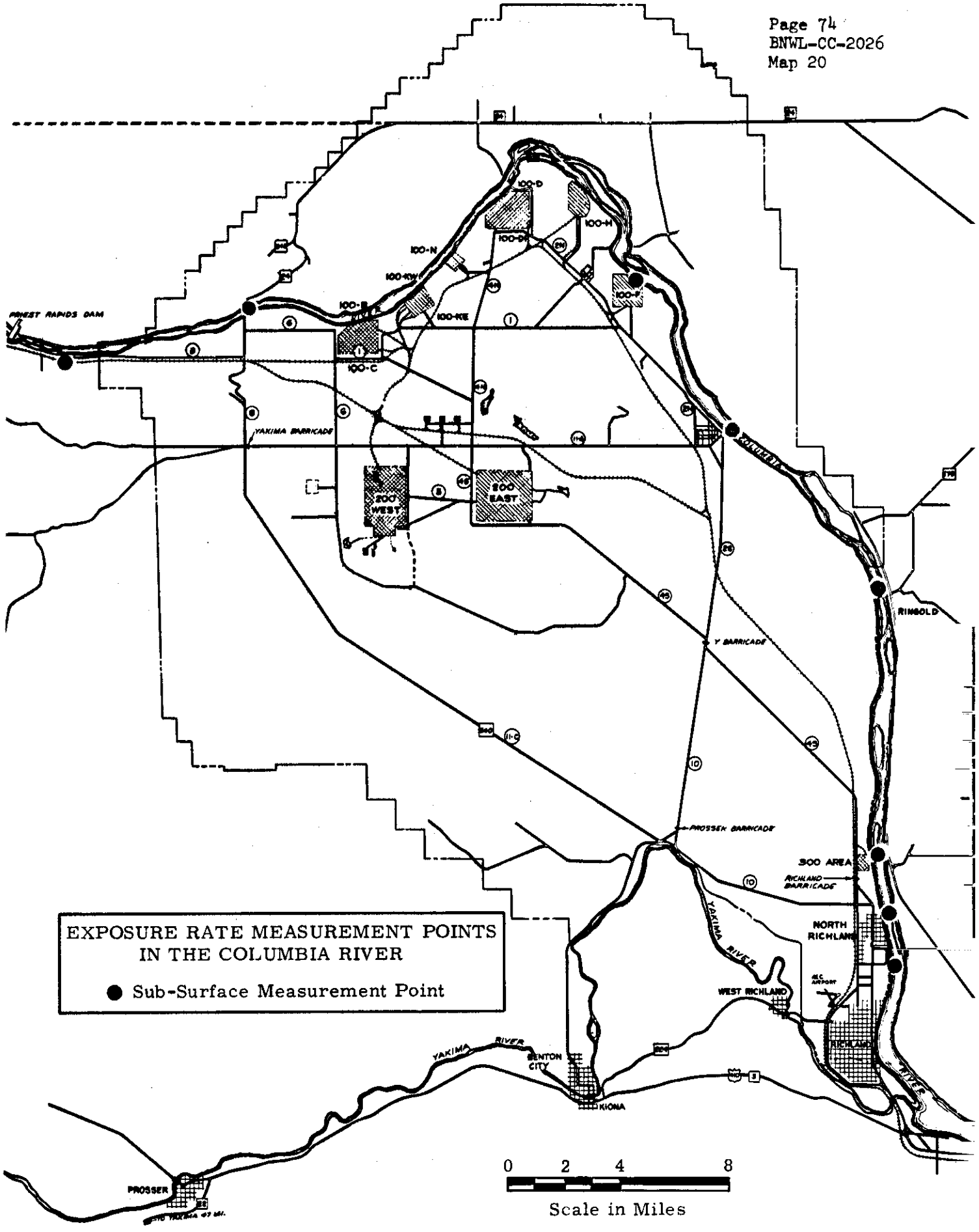
### 3. Exposure Rates Below the Surface of the Columbia River

Exposure rates in the river (Figures 29-31) were determined from a cluster of five pocket dosimeters contained within submerged bottles at the locations shown in Map 20. (Missing data were the result of lost containers or equipment malfunctions.) The upstream sampling location was moved from Vernita Bridge to Priest Rapids Gauge Station in July, 1968. The nearest measurement location downstream from the reactors was moved in May, 1968 from Hanford to 100-F because present use of the old Hanford townsite interfers with normal sample collection.

Immersion exposure rates at Richland during the last half of 1968 were measured at the Richland Pumphouse rather than at the Richland Marina.

Expected seasonal increases were observed at downstream locations as the river flow rate decreased.


PRIEST RAPIDS DAM
100-D
100-H
100-N
100-KW
100-KE
100-F
100-B
100-C
YAKIMA BARRICADE
200 WEST
200 EAST
COLUMBIA R.
RICHLAND
Y BARRICADE
PROSSER BARRICADE
300 AREA
RICHLAND BARRICADE
NORTH RICHLAND
YAKIMA RIVER
WEST RICHLAND
AEC AIRPORT
BENTON CITY
KIONA
PROSSER
EXPOSURE RATE MEASUREMENT POINTS
IN THE COLUMBIA RIVER
Sub-Surface Measurement Point
0 2 4 8
Scale in Miles

# EXTERNAL RADIATION BELOW THE SURFACE OF THE COLUMBIA RIVER

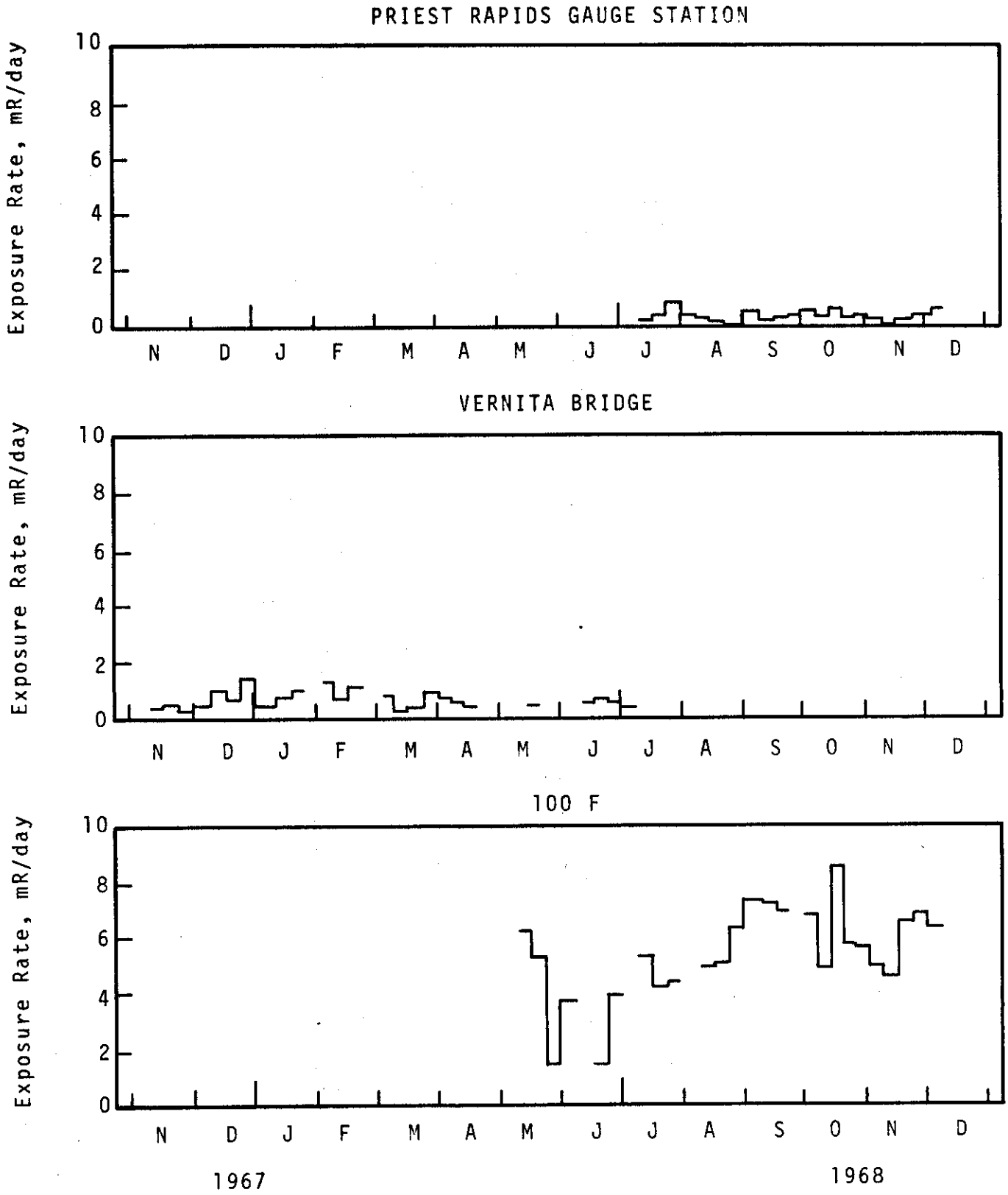


Figure 30

# EXTERNAL RADIATION BELOW THE SURFACE OF THE COLUMBIA RIVER

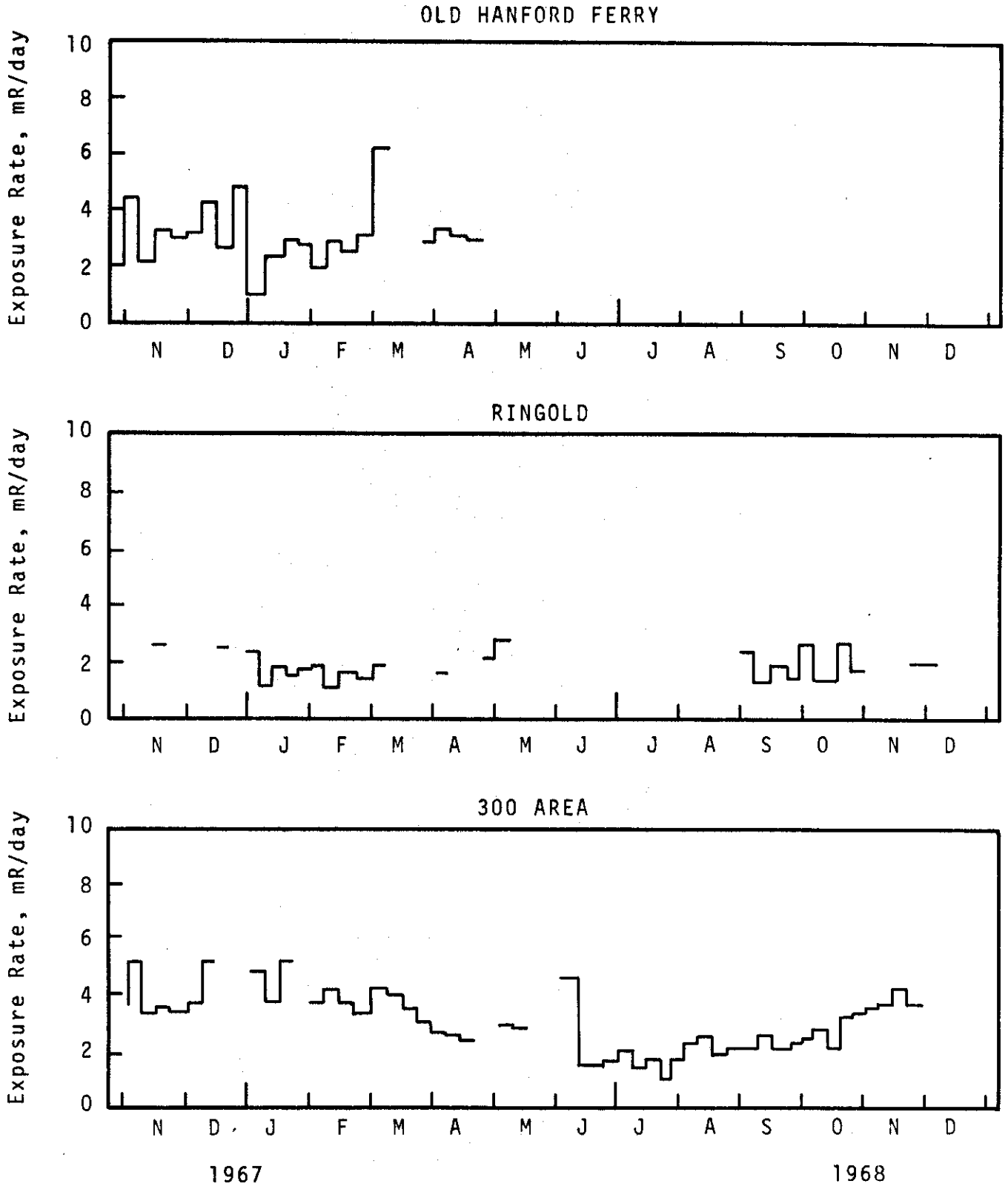


Figure 31

# EXTERNAL RADIATION BELOW THE SURFACE OF THE COLUMBIA RIVER