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RADIOLOGICAL CONSIDERATIONS OF OPENING THE COLUMBIA RIVER FOR RECREATIONAL PURPOSES--RINGOLD TO 100-F AREA

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RADIOLOGICAL CONSIDERATIONS OF OPENING THE COLUMBIA RIVER FOR RECREATIONAL PURPOSES--RINGOLD TO 100-F AREA

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TABLE OF CONTENTS

Page

I. INTRODUCTION 1

II. THE COLUMBIA RIVER--RINGOLD TO 100-F AREA. . . . 1

III. METHODS. 2

IV. RESULTS OF 1969 SPECIAL-SHORELINE SURVEYS. . . . 4

V. RESULTS OF ROUTINE ENVIRONMENTAL SURVEILLANCE--
1967 TO 1969. 27

VI. RESULTS OF SPECIAL FISH SAMPLING 29

VII. RESULTS OF AERIAL SURVEYS--1966 TO 1969. 29

VIII. COMPARISON OF CURRENT AND PAST DATA. 30

XI. CONCLUSIONS 31

X. ACKNOWLEDGMENT 33

XI. REFERENCES 34

APPENDIX A 35

RADIOLOGICAL CONSIDERATIONS OF OPENING THE COLUMBIA RIVER FOR RECREATIONAL PURPOSES--RINGOLD TO 100-F AREA

I. INTRODUCTION

At the request of the Richland Operations Office of the United States Atomic Energy Commission, a brief study of the radiological conditions on and along the Columbia River from Ringold to 100-F Area was performed in the fall of 1969. The study was to furnish radiation exposure information prerequisite to deciding whether that portion of the river should be opened for recreational use. This document constitutes the report on that study.

II. THE COLUMBIA RIVER--RINGOLD TO 100-F AREA

At present, hunting and fishing appear to be the main recreational offerings of this portion of the river. Migratory waterfowl are plentiful. Panfish should be abundant in or near the sloughs, and the river should provide good steelhead fishing. Rocky, silty shorelines, shallow water, swift current, and rather unappealing terrain make this portion of the river an unlikely location for much water skiing, swimming, or picnicking. However, this portion of the river might present a significant archaeological attraction.

Waterborne radionuclides originating at operating reactor areas are fairly well dispersed throughout the river by the time they reach 100-F Area. However, shoreline exposure rates on the plant shore are generally a little greater than on the far shore. The passage time of water from 100-F Area to Ringold ranges from about 3 hours at high flow rates to 5 hours at low flow rates. This passage time permits some radioactive decay, which slightly reduces exposure rates from the water as one travels downstream.

Much of the river between Ringold and 100-F Area is quite shallow, at least during periods of low flow rates. Portions of it, such as the stretch between the Hanford and F Area sloughs, have no discernible channel. Shorelines are generally very rocky, but contain occasional coves or short beaches of silt or fine, silty sand. Shoreline rocks are coated with silt or algae. Savage Island, above Ringold on the far shore, is an island only during high flow rates. Hanford Slough normally contains entirely backwater; however, during very high flow rates in the spring a new channel can create an island out of the peninsular body of land north of the slough. The F Area slough is formed by low, rocky hummocks submerged or surrounded by water to different extents, depending on the river flow rate, and headed at the upper end just below 100-F Area by a triangular peninsula that becomes an island during high water.

III. METHODS

This study is based largely on two rather extensive surveys made on October 11 and November 2, 1969. Information obtained during other special surveys and during routine surveys performed as part of the normal environmental surveillance program also is used to develop a picture as free as possible from uncertain influences of changes in reactor operations, time, and river flow rate. Routine and special surveys from which data are used in this study are briefly described as follows:

Weekly Shoreline Survey - Once each week, shoreline exposure rates and contamination levels are measured at Richland and at three upstream and two downstream locations.

Monthly Shoreline Survey - Once each month, shoreline exposure rates and contamination levels are measured at Richland and about fifteen upstream locations.

Columbia River Gamma Dose Rate Monitoring - Immersion dose is integrated over weekly intervals at Richland and at three upstream and one downstream locations.

Aerial Survey - Semiannual aerial survey flights are made over the Columbia from Priest Rapids Dam to McNary Dam.

Special Shoreline Survey--
October, 1961(1) - This survey, made at a daily average flow rate of 60,000 cfs, was one of three surveys made between July, 1961 and March, 1962 as part of a study concerning opening the Columbia River for recreational use from Richland to Ringold. This survey is included for comparative purposes.

Special Shoreline Survey--
August 21, 1969 - A special survey was made from above Ringold to Sacajawea Park during the evaluation of a sodium iodide scintillator. The flow rate varied from about 100,000 to 110,000 cfs during this survey.

Special Survey--
October 10, 1969 - A special survey on and along the public hunting area above Ringold was conducted at a daily average flow rate of about 80,000 cfs.

Special Shoreline Survey--
October 11, 1969 - A special shoreline exposure rate and contamination survey was performed from 100-F Area to Ringold at the request of the AEC. The Columbia River flow rate varied from about 70,000 to 90,000 cfs during this survey.

Special Shoreline Survey--
November 2, 1969 - A special shoreline exposure rate and contamination survey was performed from Locke Island to Powerline Crossing. This survey was performed at a flow rate of about 37,000 cfs.

Survey locations (Figures 1 through 9) were generally selected during the surveys on the basis of:

1. their anticipated recreational appeal, or

2. their anticipated tendency to contain higher than average exposure rates and contamination levels.

Therefore, the surveys probably tend to yield pessimistic estimates of radiation exposure to be received during recreational use of the river.

Shoreline exposure rate and contamination surveys were made as follows:

1. Unless noted otherwise, exposure rates were measured at a height of three feet using radium-calibrated 40-liter ionization chambers. (As described in Appendix A, the reliability of the 40-liter measurements was found to be adequate for purposes of this study.)

2. Surface contamination was surveyed using portable Geiger-Mueller (1885 detector) survey instruments with "walking stick" probe holders. Geiger-Mueller measurements were made at three feet as well as near the surface; however, only the latter values are reported here.

3. Mud, algae, and foam samples were returned to the laboratory for gamma analysis.

IV. RESULTS OF 1969 SPECIAL SHORELINE SURVEYS

The results of the shoreline exposure rate and contamination level surveys conducted during the fall of 1969 are shown in Table 1. Exposure rate data (μR/hr at 3 ft above the ground) are shown both for the shoreline at the time of the survey and the daily high wet line. Normally the surveys were conducted as follows: The point near where the boat landed was surveyed along the shoreline, covering an area of the order of 40 to 50 square feet and the "average" readings were recorded for both the 40-liter and GM. THis same technique was utilized at the daily high wet line. For the 10/11 survey, three locations along the shoreline and at the daily high wet line were measured and recorded, each separated from the previous by about 30 ft. In this manner a greater stretch of shoreline at each location

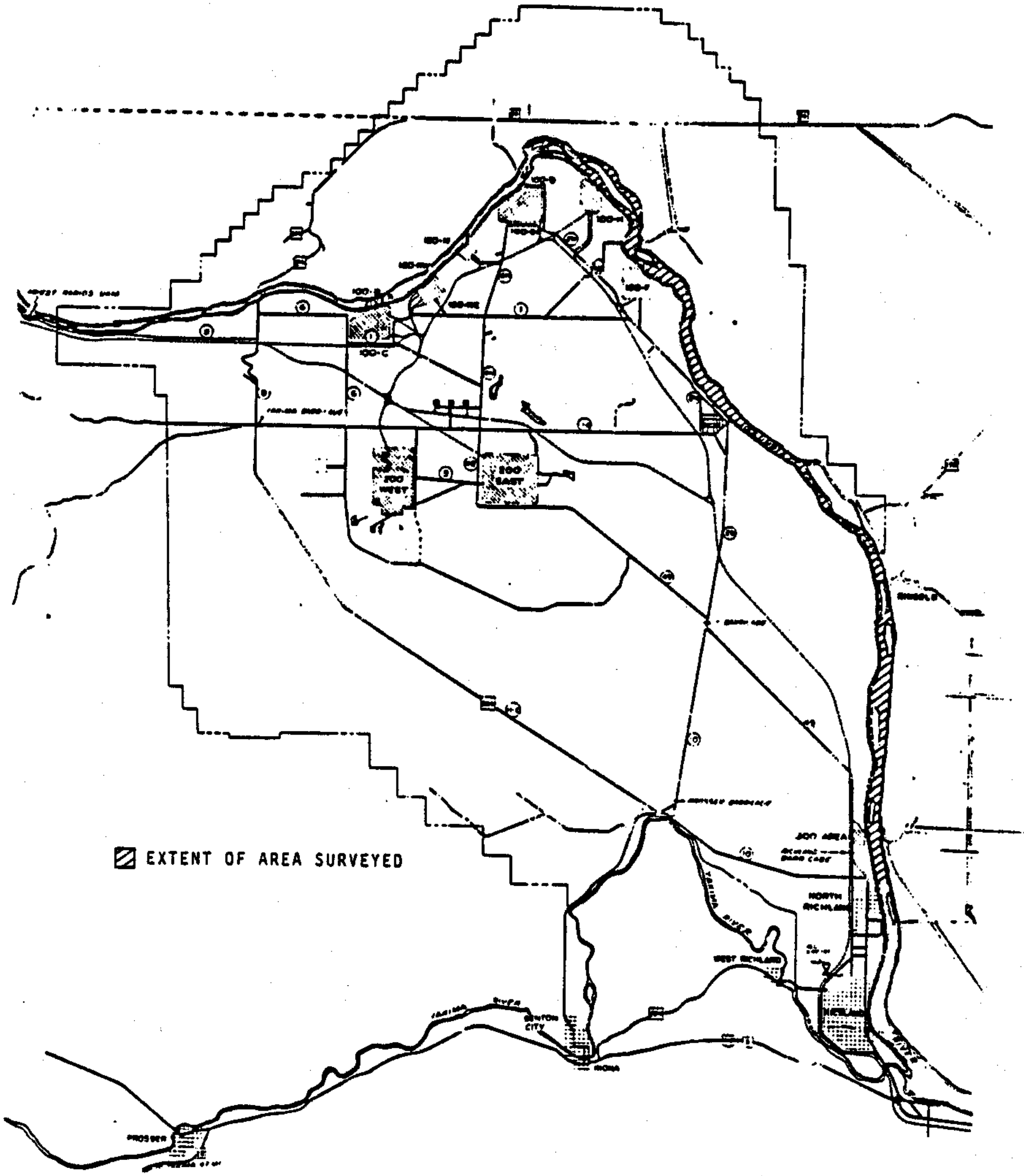

FIGURE 1. PORTION OF THE RIVER SURVEYED AND ITS RELATION TO THE HANFORD ENVIRONS

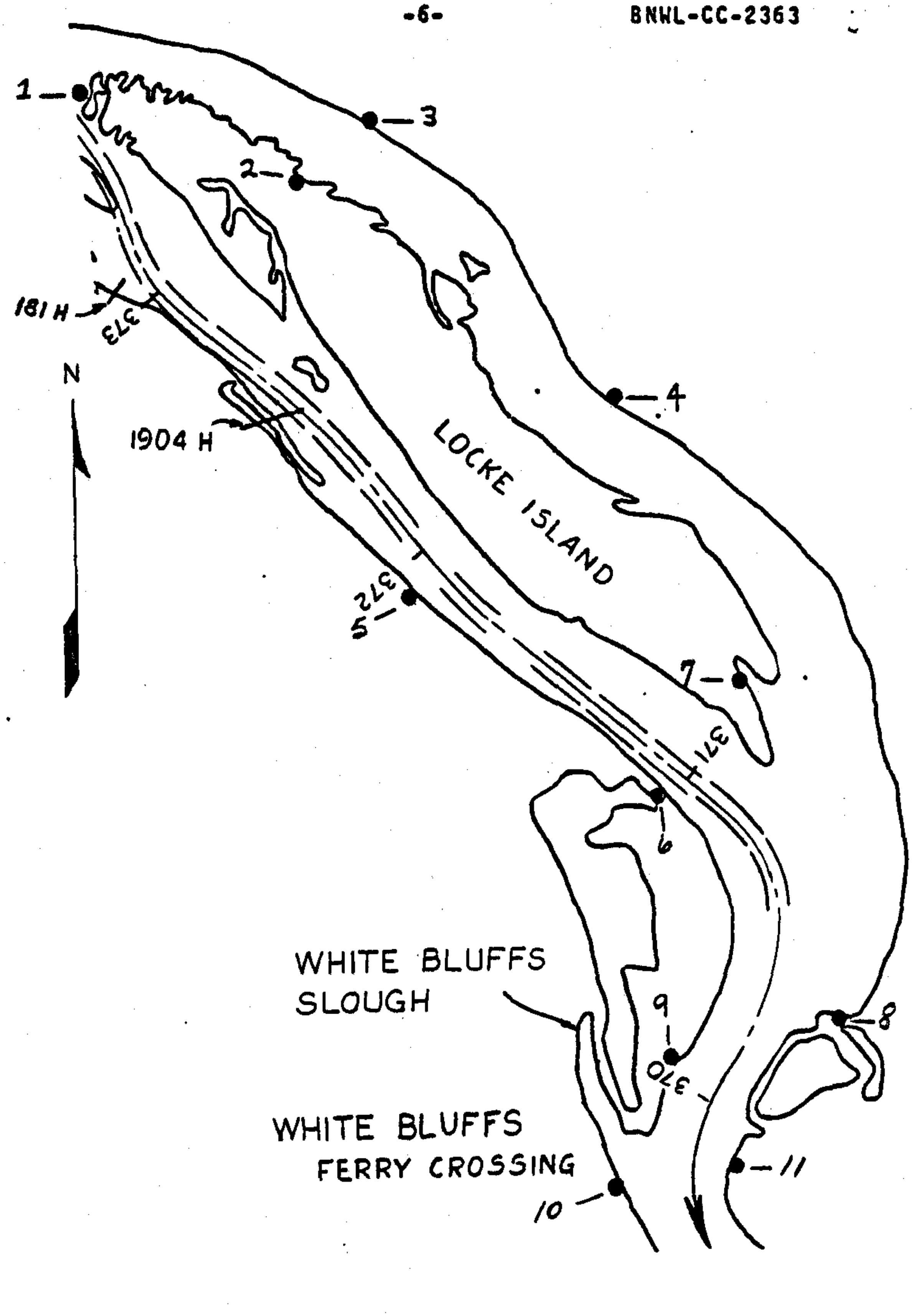

FIGURE 2. SHORELINE SURVEY LOCATIONS FROM RIVER MILE 373.6 TO RIVER MILE 369.6

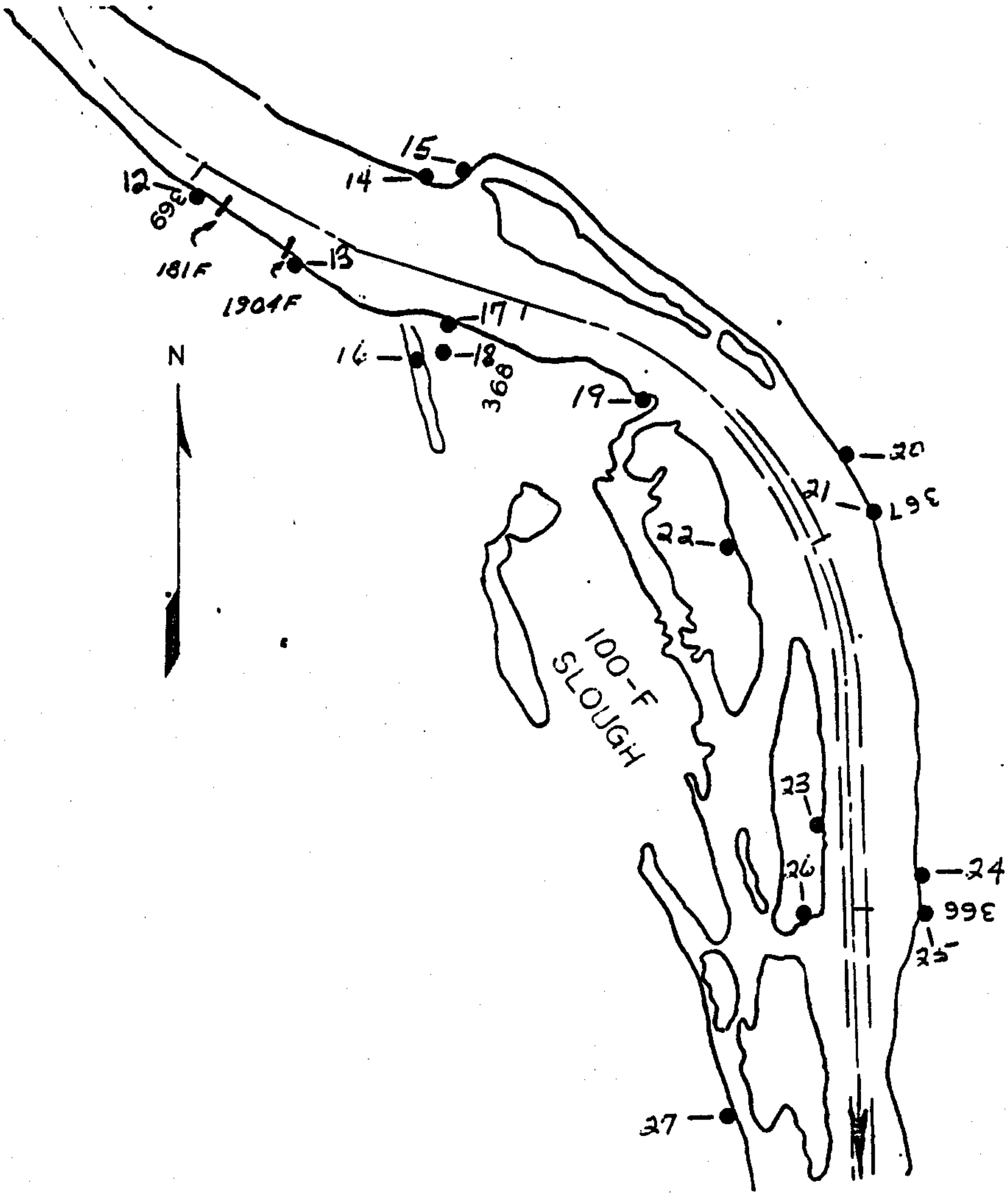

FIGURE 3. SHORELINE SURVEY LOCATIONS FROM RIVER MILE 369.6 TO RIVER MILE 365.2

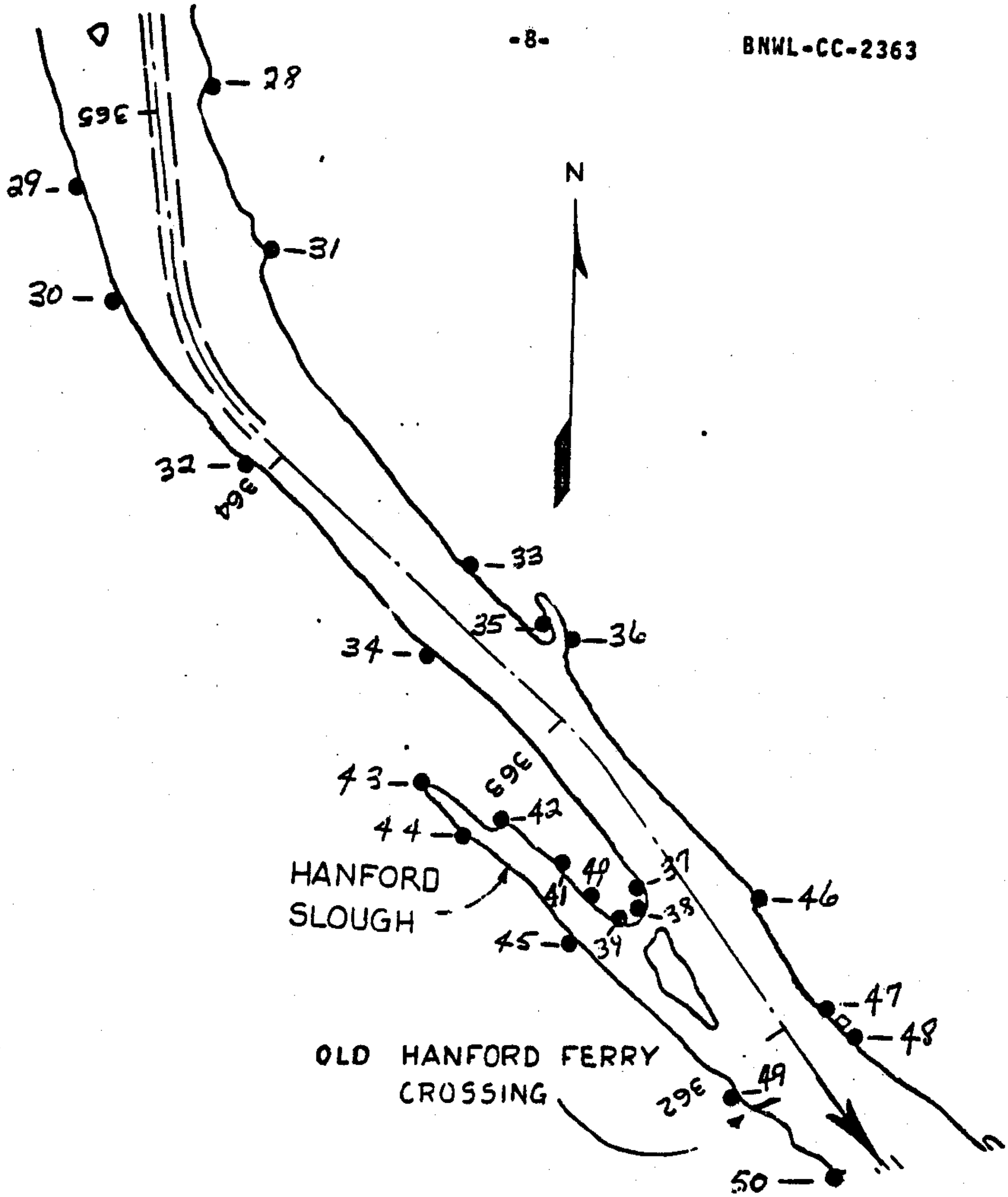

FIGURE 4. SHORELINE SURVEY LOCATIONS FROM RIVER MILE 365.2 TO RIVER MILE 361.6

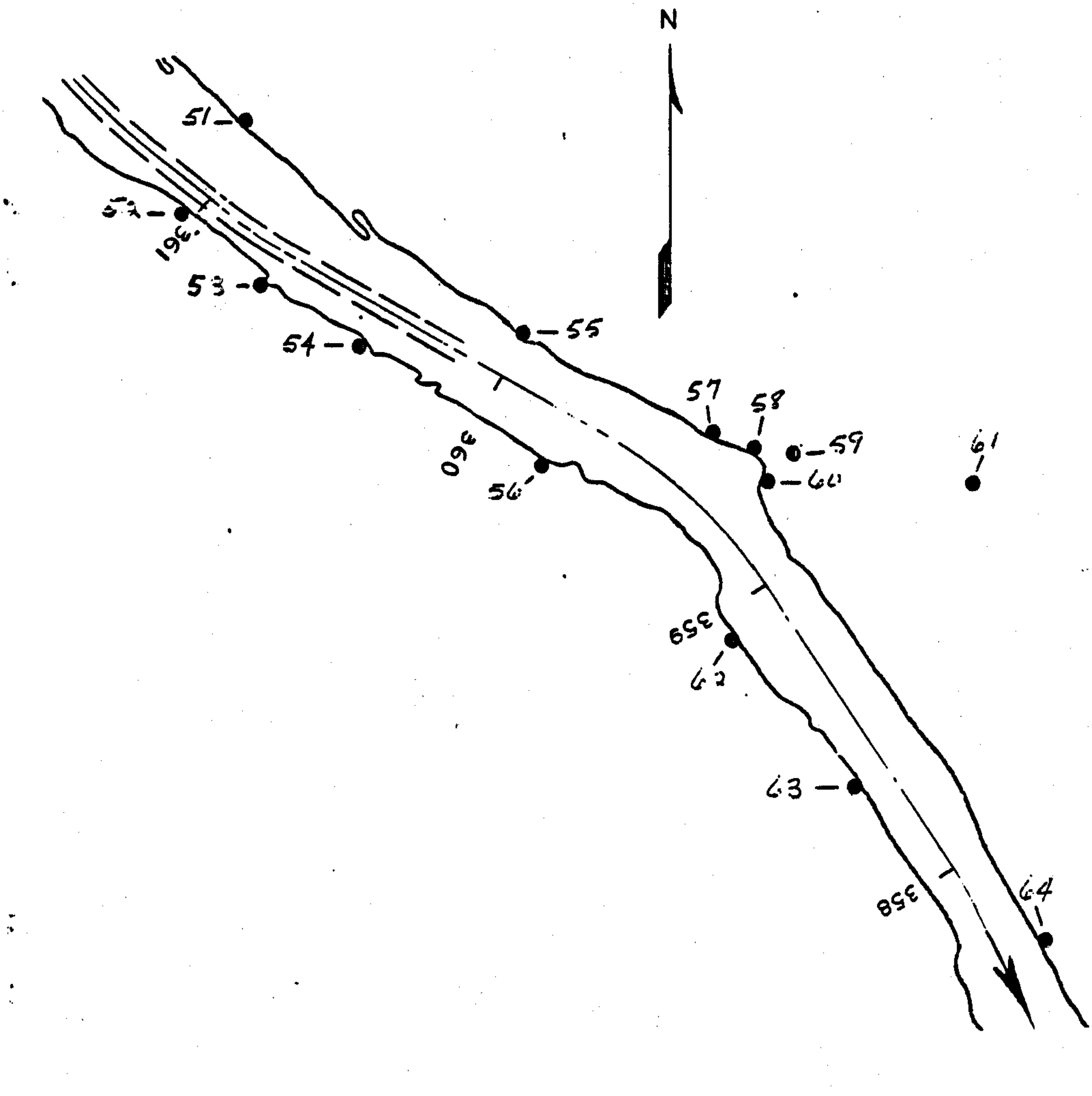

FIGURE 5. SHORELINE SURVEY LOCATIONS FROM RIVER MILE 361.6 TO RIVER MILE 357.5

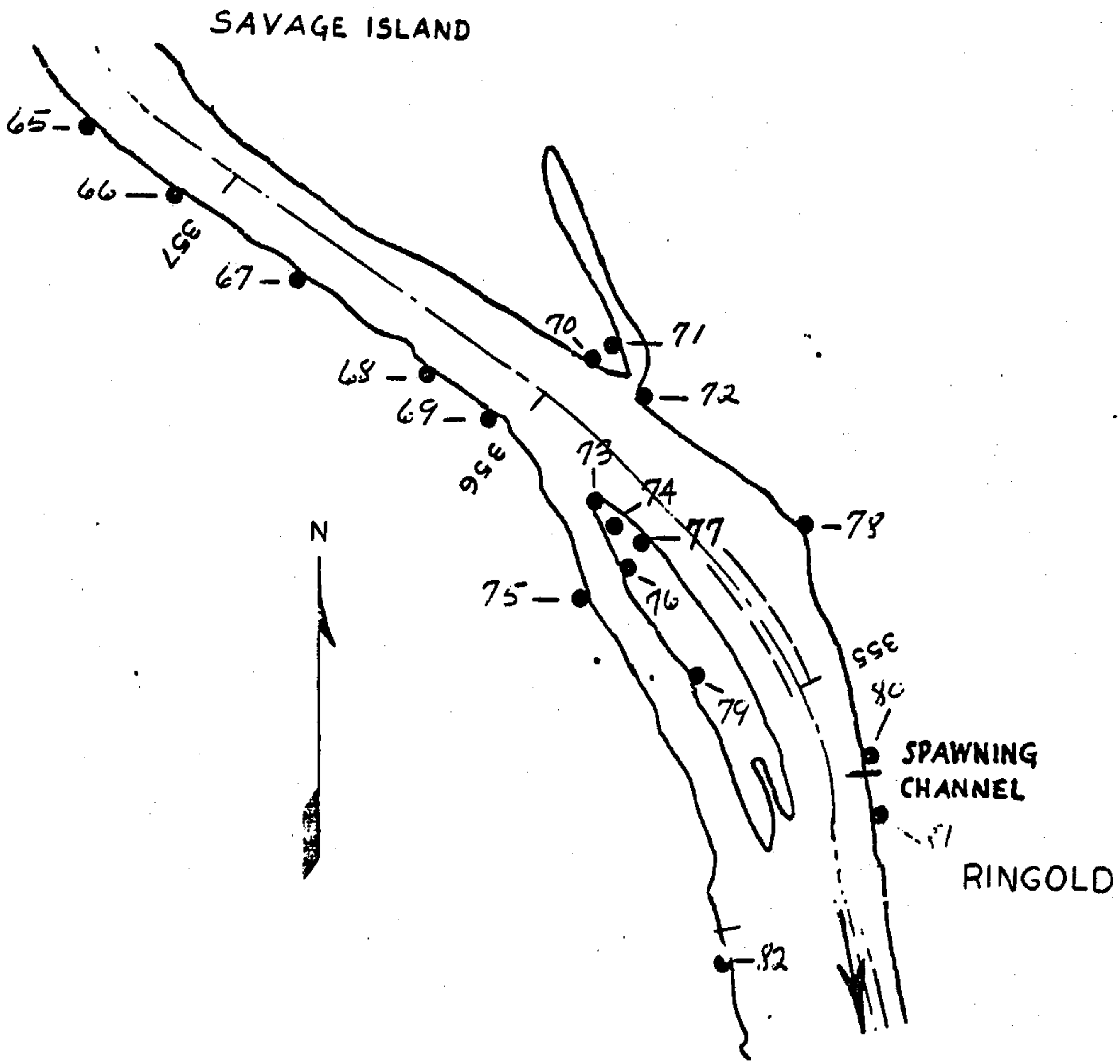

FIGURE 6. SHORELINE SURVEY LOCATIONS FROM RIVER MILE 357.5 TO RIVER MILE 354.1

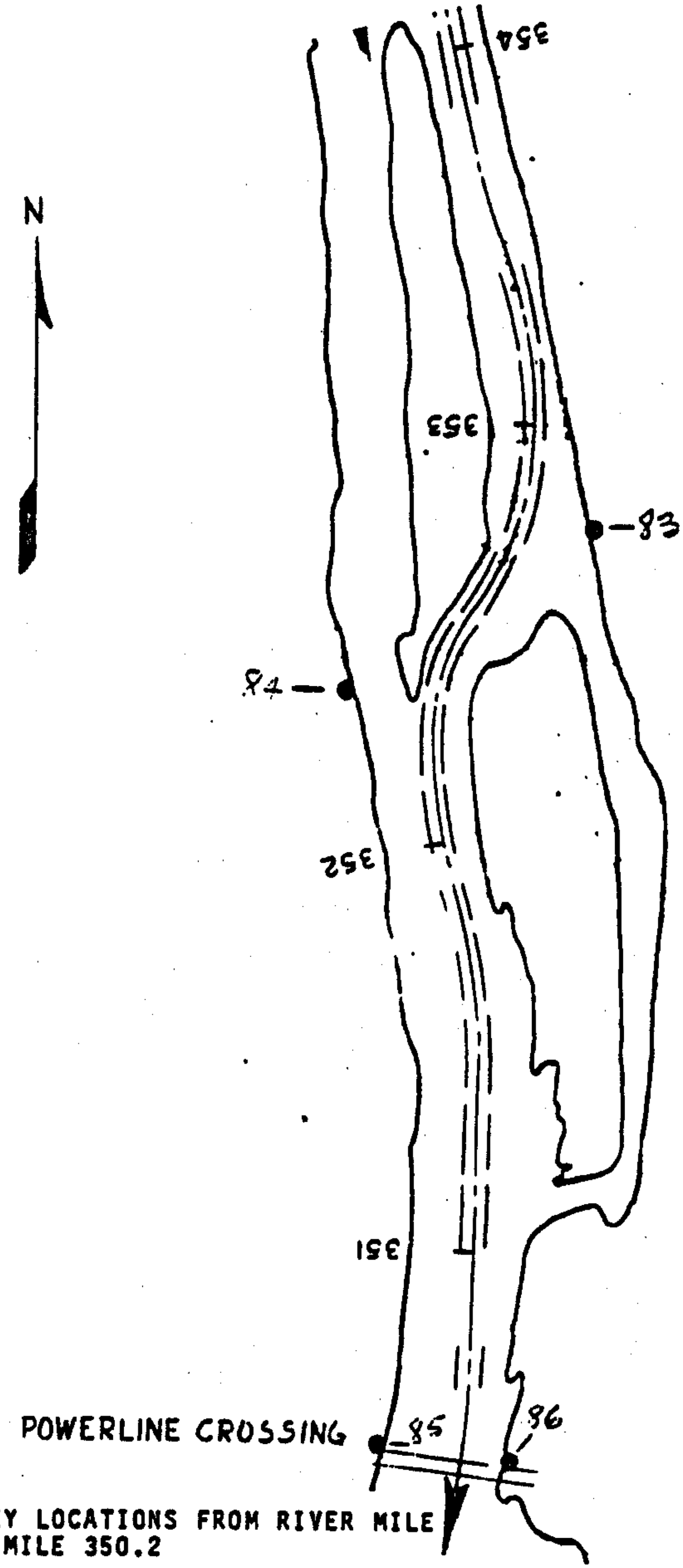

FIGURE 7. SHORELINE SURVEY LOCATIONS FROM RIVER MILE 354.1 TO RIVER MILE 350.2

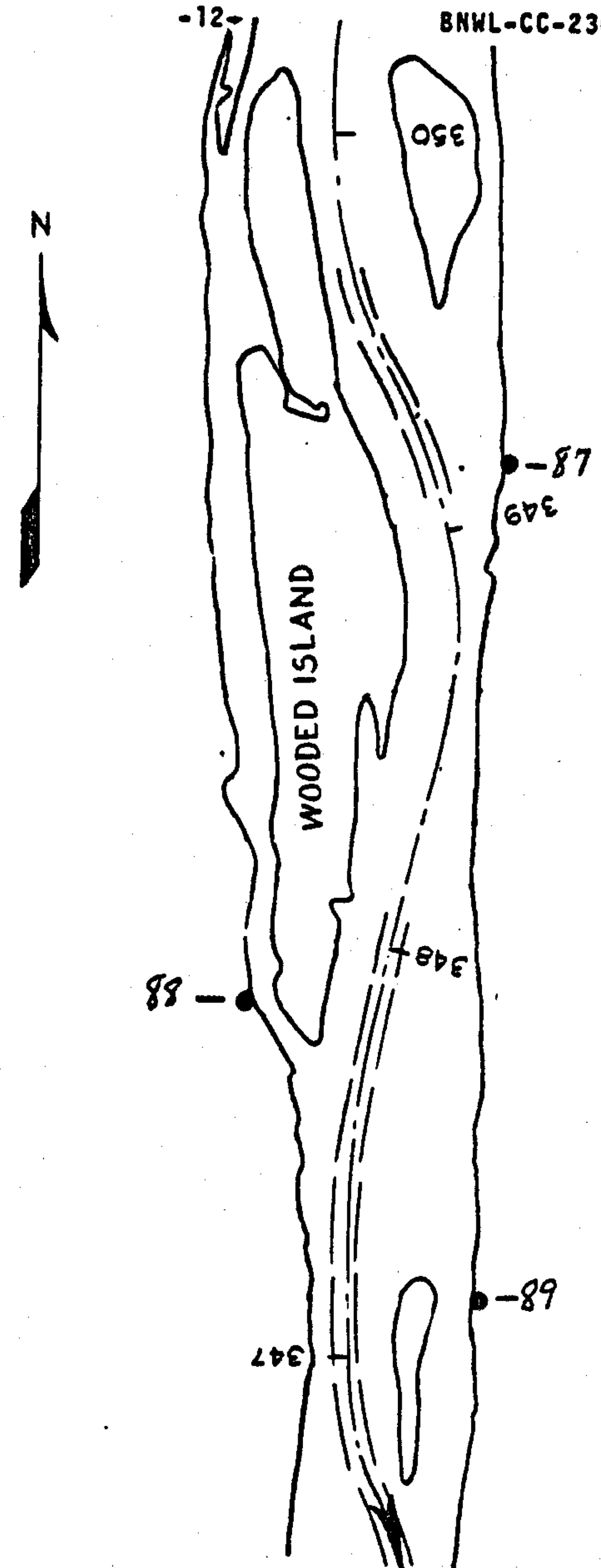

FIGURE 8. SHORELINE SURVEY LOCATIONS FROM RIVER MILE 350.2 TO RIVER MILE 346.5

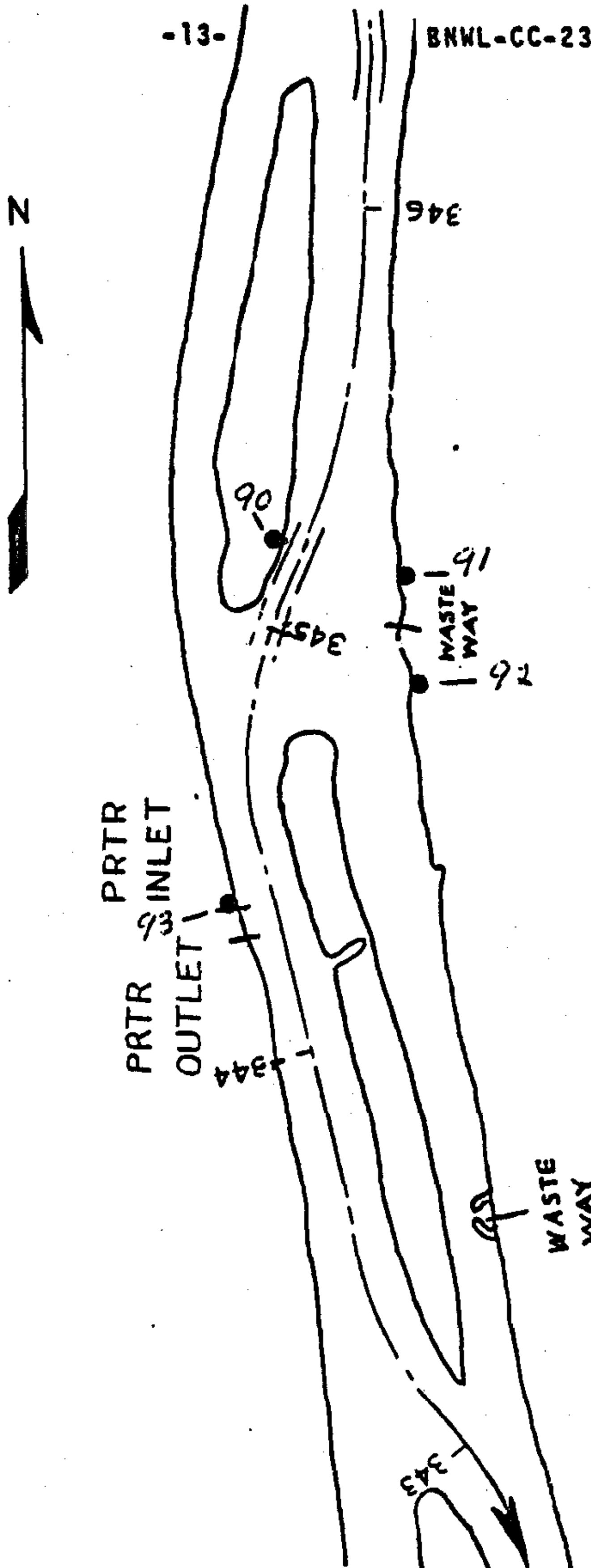

FIGURE 9. SHORELINE SURVEY LOCATIONS FROM RIVER MILE 346.5 TO RIVER MILE 342.7

TABLE 1

Summary Of Special Shoreline Survey Data

LOCATION*	DATE	40-Liter (3') μR/hr SHORE-LINE	WET LINE	GM (Surface) c/m HOT SPOT	RANGE	$^{46}Sc+^{65}Zn$ pCi/gm (WET WEIGHT) IN MUD SAMPLE	REMARKS
I 1	11/2	170	-	4000	1000-2000	-	Rocky
I 2	11/2	120	150	-	700- 800	-	Slime on rocks. Some puddles.
F.S. 3	11/2	66	-	-	600	-	Muddy cove.
F.S. 4	11/2	110	-	-	1500-2000	800	Steep, clay soil.
P.S. 5	11/2	-	-	-	1000-2000	3000	Small cobbles, shallow, several dead salmon.
P.S. 6	11/2	75	75	-	700-1000	-	Greenish growth on small cobbles.
I 7	11/2	120	35	-	200- 500	60	Sandy, easy boat access, good swimming, etc.
F.S. 8	11/2	130	180	-	700	-	Muddy, rocky.
P.S. 9	11/2	220	220	-	600- 900	-	Sandy, deep water, easily accessible
P.S. 10	9/26	160	150	-	1500-3000	600	----
	11/2			-	2000	-	Muddy rocks. White Bluffs Landing
F.S. 11	11/2	130	100	-	200- 600	1200	Clay mud.
P.S. 12	11/2	210	120	-	400-2000	1200 (mud) 4000 (algae)	Large cobbles, old wooden irrigation pipe. Two samples--one mud, one algae.
P.S. 13	11/2	120	120	-	500- 900	-	100-F outfall. Algal growth on spillway (upper).
F.S. 14	10/11	-	-	-	250	-	Steep, rocky (small rocks)
	11/2	80	70		200- 600	-	Steep, rocky (small rocks)
F.S. 15	11/2	-	-	-	200- 400	-	Muddy

* I - Island, F.S. - Far Shore, P.S. - Plant Shore

TABLE 1

LOCATION	DATE	40-Liter (3') μR/hr SHORE-LINE	WET LINE	GM (Surface) c/m HOT SPOT	RANGE	$^{46}Sc+^{65}Zn$ pCi/gm (WET WEIGHT) IN MUD SAMPLE	REMARKS
P.S. 16	11/2	-	-	-	<200	-	Dry channel into 'F' Slough
P.S. 17	11/2	-	-	3000	1500	-	Muddy, rocky. Small hot spot
P.S. 18	11/2	-	-	-	300- 500	-	Grassy rocks, normally above water line.
P.S. 19	11/2	210	200	-	1000-3000	12,000	Point with red & white steel post. Muddy, rocky
	11/2	-	-	-	1000-2000	-	Muddy, rocks.
F.S. 20	10/11	-	-	-	200	-	Steep rocky shoreline
F.S. 21	11/2	66	66	-	400	100	Dried clay shoreline(appeared rocky)
I 22	10/11	200 200 210	200 100 70	9000	300- 400	600	Cove in sand dunes, some small (~2") cobbles
	11/2	-	-	-	2000-3000	-	Cove in sand dunes, some small (~2") cobbles
I 23	10/11	120	87	-	600- 800	-	Cobbles(small) & some algae
F.S. 24	10/11	33 37 30	25 27	-	200-300	-	----
F.S. 25	11/2	-	-	-	800-1000	-	Muddy cove
I 26	10/11	24	-	-	200	-	Steep rocky shoreline
P.S. 27	10/11	90 70 70	70 70 50	-	200-500	-	Extremely shallow getting into

TABLE 1

LOCATION	DATE	40-Liter (3') μR/hr SHORE-LINE	WET LINE	GM (Surface) c/m HOT SPOT	RANGE	$^{46}Sc+^{65}Zn$ pCi/gm (WET WEIGHT) IN MUD SAMPLE	REMARKS
F.S. 28	10/11	38	-	-	300-400	-	Steep shoreline
		58					
		39					
P.S. 29	10/11	50	40	-	200-300	-	Grass to water's edge, wet line about 10' from shoreline
		80	70				
		70	70				
	11/2	140	110	-	700-1000	-	Medium cobbles
P.S. 30	10/11	100	80	-	200-600	-	Deep, swift current near shore, grassy, some large cobbles
		50	90				
		125	70				
F.S. 31	10/11	47	51	-	300-350	-	----
		48	66				
		42	58				
P.S. 32	10/11	115	100	2000	500-800	10	8"-10" cobbles, daily wet line 30' from shore, hot spot on mud-soaked grass
		105	105				
		110	100				
	11/2	160	140	-	800-900	-	8"-10" cobbles
F.S. 33	10/11	99	68	-	250-700	-	Small rocks on sandy shoreline
		82	70				
		92	72				
P.S. 34	10/11	195,295	105,150	-	400-2500	8000	Shoreline undulates, large cobbles
		190,215	105,180				
		300,240	110,100				
		300,255					
	11/2	-	-	-	1000-2000	-	Shoreline undulates, large cobbles
	11/2	210,100	83,200	-	400-2000	2000	Still water backed up into small cove

TABLE 1

LOCATION	DATE	40-Liter (3') μR/hr SHORE-LINE	40-Liter (3') μR/hr WET LINE	GM (Surface) c/m HOT SPOT	GM (Surface) c/m RANGE	$^{46}Sc+^{65}Zn$ pCi/gm (WET WEIGHT) IN MUD SAMPLE	REMARKS
F.S. 35	10/11	55 50 50	52 49 49	4000	200-350	400	Large rocks on shoreline
	11/2	-	-	-	300-800	-	----
F.S. 36	10/11	70	-	-	500	-	Sandy shoreline
	11/2	-	-	-	300-800	-	----
P.S. 37	10/11	210	160	-	500-1500	-	River side of point
	11/2	-	-	5000	1500-2000	2000	Muddy, rocky - near powerlines
P.S. 38	10/11	160,210, 160,210	90,100, 160	-	300-1500	-	Sandy
	11/2	240,240, 190,130	110	-	400-1500	3000 (scraped from rock)	Isthmus connecting gravel bar to peninsula - cobbles some sandy area
P.S. 39	10/11	200,240, 160,110, 240	160,110, 100,95	-	200-1500	-	----
P.S. 40	10/11	180,160, 200	100,110, 105	-	300-700	-	Muddy
P.S. 41	10/11	70	100	-	300	-	Muddy
P.S. 42	10/11	90	90	-	400	-	Cobbles
P.S. 43	10/11	60	40	-	200	-	Upper end of Hanford Slough
P.S. 44	10/11	50	-	-	200	-	Oily springs north to end of slough
P.S. 45	10/11	80 50 75	80 90 50	-	200-400	-	Area covered with mud on cobbles; sandy cove

TABLE 1

LOCATION	DATE	40-Liter (3') µR/hr SHORE-LINE	WET LINE	GM (Surface) c/m HOT SPOT	RANGE	$^{46}Sc+^{65}Zn$ pCi/gm (WET WEIGHT) IN MUD SAMPLE	REMARKS
F.S. 46	10/11	120 140 150	57 35 45	-	350-1800	3000	Rocky shoreline coated with brown mud; sandy at daily wet line
	11/2	130	150	-	300	60	Rocky shoreline, slimy; sandy wet line
F.S. 47	10/10	-	-	-	500-800	-	Cobbles & silt; foam at water's edge; upstream side of point
	11/2	70	50	-	600-1500	-	Rocky
F.S. 48	10/10	-	-	*Juno @1"10mrad/hr 12w/open window	800-2000	20,000	Numerous small hot spots (1-3"size) typically 4000 c/m *Hottest sample at daily wet line
	11/2	310	180	5000	400-1000	800	Quicksand-like mud; dark band of contamination; muddy cove, south-side of Hanford Ferry landing
	11/2	-	-	5000	1000-2000	900	
	11/2	230	-	6000	1500	800	
P.S. 49	9/26	80	120	-	800-1000	100	
	10/11	190 200 260 150	220 210 150	3500 (foam)	600-700	800	Sandy, silt, cobbles
P.S. 50	10/11	100 a.m.	95 a.m.	-		-	Gentle slope, cobbles, cove. Where boat launched. Readings at p.m. were at higher river flow rate than a.m.
		115 a.m.	110 a.m.	-	400-700	-	
		125 a.m.	100 a.m.	-		-	
		115 p.m.	100 p.m.	-	800	-	
	11/2	140	140	-	500-700	-	
F.S. 51	10/11	66	-	-	600	-	All large rocks.
P.S. 52	10/11	175, 215, 105	105, 160, 100	- -	500-1000 500-1000	- -	Foam visible, a rocky point. Near Hanford traverse
	11/2	150	140	-	700-1500	2000	

TABLE 1

LOCATION	DATE	40-Liter (3') μR/hr SHORE-LINE	WET LINE	GM (Surface) c/m HOT SPOT	RANGE	$^{46}Sc+^{65}Zn$ pCi/gm (WET WEIGHT) IN MUD SAMPLE	REMARKS
P.S. 53	11/2	-	-	-	1000-2000	-	Generally fairly clean rocks, except coves muddy.
P.S. 54	10/11	160 170 160	100 110 110	4000	300-900		A foam sample was taken
F.S. 55	10/11	80 67 64	62	-	650-750	-	Large rocks.
P.S. 56	10/11	100 100 180	100 80 115	7000	400-800	-	Hot foam. Large cobbles. Tiny fish
	11/2	95	140	-	600	-	
F.S. 57	11/2	-	-	-	800	-	Upstream from dry channel at upper end of Savage Island
F.S. 58	11/2	-	-	3000	1500-2000	1200 (foam)	Mud at entrance to channel at upper end of Savage Island
F.S. 59	11/2	-	-	-	500	-	About 100 yds. up dry channel at upper end of Savage Island
F.S. 60	10/11	160,160, 70	120	-	700-1700	1600	Thick mud covered shoreline
	11/2	86	130	-	500-800	-	Rocky area
	11/2	180	-	-	600-800	500	Muddy area
F.S. 61	10/10	-	-	-	200-250	-	Steep bank with grass
P.S. 62	10/11	180,160, 210	80,50, 100	-	200-1000	-	All muck, no cobbles, shallow mucky bottom, many ducks, some foam
P.S. 63	10/11	120,170, 130	70,50, 70	-	200-1500	-	Boulders and cobbles

TABLE 1

LOCATION	DATE	40-Liter (3') μR/hr SHORE-LINE	WET LINE	GM (Surface) c/m HOT SPOT	RANGE	$^{46}Sc+^{65}Zn$ pCi/gm (WET WEIGHT) IN MUD SAMPLE	REMARKS
F.S. 64	10/11	50,60, 57	30,32, 37	-	350-650	-	----
P.S. 65	10/11	110,150, 110	68,62, 65	-	350-1700	-	----
P.S. 66	11/2	140	190,95	-	600-2000	5000	Medium cobbles
P.S. 67	11/2	-	-	-	1500-2000	-	Rocky shoreline
P.S. 68	10/11	73,70	38,24	5000	300-600	1000 3000	Shoreline was sandy with large rocks scattered about - hot spot 1/2 way between S.L. & DWL Two samples
P.S. 69	11/2	310	190	-	200-700	-	Sandy area
F.S. 70	11/2	-	-	-	1500-2000	-	Sandy shoreline
F.S. 71	11/2	-	-	-	200-1000	-	Sandy - west side of downstream inlet to Savage Island
F.S. 72	10/10	-	-	-	300-700	-	Muddy rocks, very level
I 73	10/11 11/2 11/2	120,86 130 -	98 130 -	- - -	600-700 900-2000 1000-2500	- - -	rocky rocky rocky
I 74	11/2	-	-	-	500	-	Rocky & grass
P.S. 75	11/2	-	-	3500	400-1200	.4500	Sandy beach with natural rock jetty upstream, fisherman on P.S.
I 76	11/2	-	-	-	1500-2000	-	muddy rocks
I 77	11/2	-	-	-	1500-2000	-	muddy rocks

TABLE 1

LOCATION	DATE	40-Liter*(3') μR/hr SHORE-LINE	WET LINE	GM (Surface) c/m HOT SPOT	RANGE	$^{46}Sc+^{65}Zn$ pCi/gm (WET WEIGHT) IN MUD SAMPLE	REMARKS
F.S. 78	8/21	90	-	-		200	Sandy
	10/11	79,100	28	-	300-500	-	Sandy
	11/2	92	60	-	600-1000	600	Sandy
I 79	11/2	-	-	-	1200-2000	-	Tiny, muddy cove
F.S. 80	8/21	67	-	-	-	-	Rocky, gentle slope, swimming & fishing
	9/26	-	-	-	200-300	10	
	10/11	76,96,	73	-	500-850	-	
		85	73	-	500-850		
	11/2	66	85	-	500-700	-	
F.S. 81	8/21	43	-	-	-	-	Flat, rocky, fishermen
P.S. 82	10/11	91,72, 50	43,42, 36	3000	350-400	250	Rocky and sandy
F.S. 83	8/21	72	-	-	-	-	Gravel, fairly steep, downstream side of Kinne ranch.
P.S. 84	8/21	100	-	-	-	-	Rocky, grass, stagnant
P.S. 85	8/21	120	-	-	-	700	Rocky, grassy. P.S. of Powerline Crossing
F.S. 86	8/21	120	-	-	-	-	Gravel. Powerline Crossing (F.S.)
	11/2	140	150	-	700-800	-	Rocky.
F.S. 87	8/21	110				400	Muddy, some rocks
F.S. 88	8/21	69				30	Sandy
F.S. 89	8/21	64					Rocky, steep bank; fishing
I 90	8/21	47,82					Rocky; swimming, water ski launch
F.S. 91	8/21	130				20	Sandy, dry sand; fishing
F.S. 92	8/21	96					Sandy(grass above)
P.S. 93	8/21	85					Roadbed

* 8/21 Survey was made with a portable, shock-mounted 3x3 inch NaI crystal and count rate meter calibrated with ^{226}Ra.

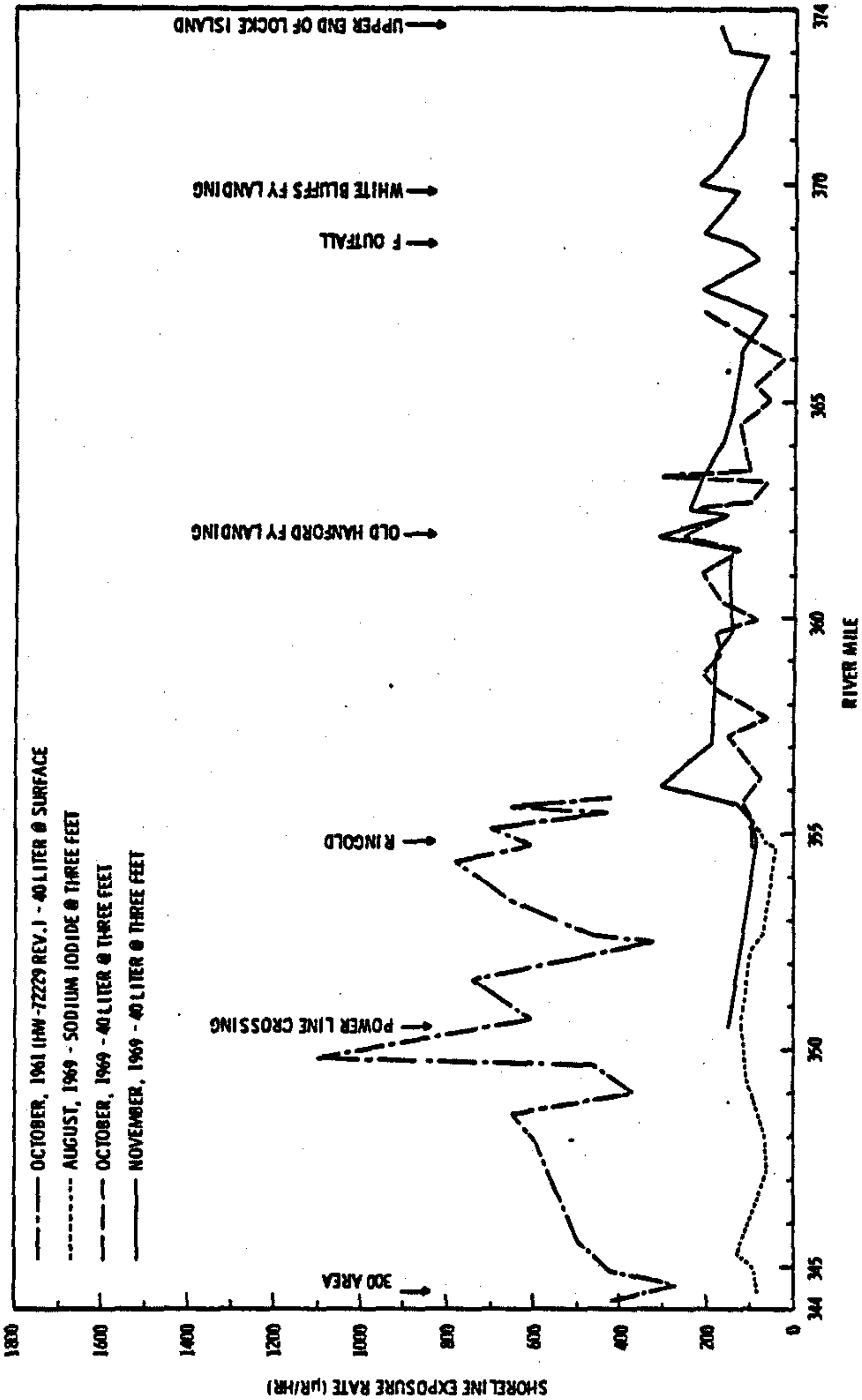

FIGURE 10. OBSERVED SHORELINE EXPOSURE RATES

was observed. However, this technique was abandoned for the 11/2 survey in the interest of time and also because the variation in exposure rate at each location was not observed on 10/11 to be greater than a factor of two.

For Figure 10, only the shoreline exposure rates were used. All of the recorded exposure rates on each survey date and at each location were tabulated and averaged (if more than one reading was obtained, such as on the 10/11 survey). This average exposure rate was plotted at the appropriate mileage in Figure 10, which includes data for island locations as well as both shorelines. Exposure rates measured in Hanford Slough were omitted from Figure 10 because the low exposure rates in this slough and backwater area were not considered representative of the river shoreline.

Surface GM results are shown as a range observed between the daily high wet line and the shoreline at each survey location. "Hot spots" were generally very localized, primarily in the form of particles associated with foam, scum, and the like. Only about a dozen such hot spots were detected during these rather extensive surveys. Thus, the radioactive contamination did not appear to be associated with scattered particles but rather seemed to be spread quite uniformly over the surfaces being surveyed.

Shoreline exposure rates were somewhat higher on the November 2 survey than had been observed on the previous surveys shown in Table 1, primarily as a result of the very low flow rates causing increased radionuclide concentrations in the river and larger contaminated shoreline areas. Typically, exposure rates on the far shore were lower than on the plant shore, particularly at upstream locations. Nearly equal exposure rates were observed on both shores at downstream locations. The highest exposure rate observed, 310 μR/hr on 11/2, was approximately the same as the lowest rate observed during the fall survey of 1961 reported by McConnon[1], as seen in Figure 10. The highest exposure rates were observed in the Hanford Townsite stretch of the river on both surveys (location 34 on the plant shore on 10/11 and location 48 near the old Hanford Ferry Landing on the far shore on 11/2), and on the plant shore across from the downstream end of Savage Island (location 69 on 11/2). Similar exposure rates have been observed during the past year, even for locations as far downstream as Powerline Crossing.

The average shoreline exposure rates and surface contamination levels for the 100-F to Hanford and Hanford to Ringold stretches of the river for the two major surveys are shown in Table 2. Data from the upper, backwater section of the Hanford Slough and that obtained at large distances from the shoreline were omitted from these averages. Only locations at which both 40-liter and surface GM measurements were obtained are included. The average shoreline exposure rate was about 25 percent higher on 11/2 than on 10/11 and the average surface contamination levels were 30 to 50 percent higher on 11/2 than on 10/11.

TABLE 2

Average 40-Liter and GM Measurements

	100-F to Hanford		Hanford to Ringold	
	10/11	11/2	10/11	11/2
μR/hr (3')	120	150	120	150
c/m(surface)	600	900	700	900

Samples of shoreline mud were collected at a number of locations (Table 1) and returned to the laboratory for analysis with a 3 in. x 3 in. sodium iodide crystal coupled to a multi-channel analyzer. Typical spectra from these samples are shown in Figures 11 and 12. The spectrum in Figure 11 was obtained from a sample of the muddy cove just downstream of the old Hanford Ferry Landing on the far shore, while that in Figure 12 was obtained from a clay-like, algae-covered rock sampled on the far shore below the White Bluffs. These two samples (Figures 11 and 12) were also analyzed with a lithium drifted germanium diode; the major gamma ray peaks observed with the diode are shown as vertical lines above the NaI spectra. All mud samples, except that shown in Figure 12, exhibited spectra nearly identical to that in Figure 11. The relatively large ^{95}Zr-Nb peak observed in the sample from White Bluffs (Figure 12) is typical of that observed in the past at White Bluffs.[2]

The area observed under the 1.12 MeV photopeak for each sample was assumed to be due to ^{46}Sc and ^{65}Zn for which no separation was made. Thus the area under this photopeak was calculated as ^{46}Sc+^{65}Zn (pCi/gm) for each sample. Analytical results are listed on a wet weight basis, although the difference in mud sample concentrations between wet and dry weights was determined for five samples and not found to vary by more than ±40%.

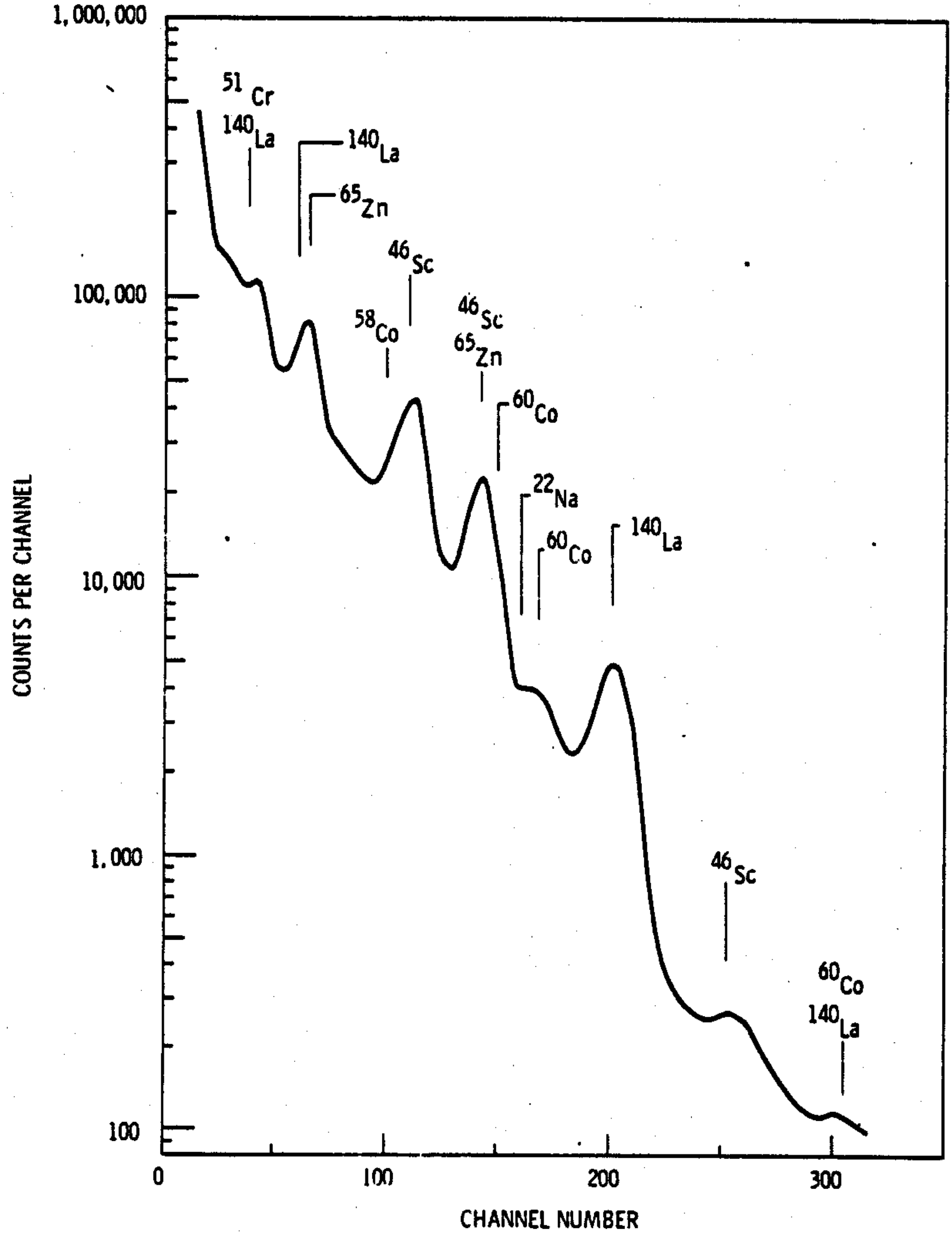

FIGURE 11. GAMMA RAY SPECTRUM OF A TYPICAL SHORELINE MUD SAMPLE

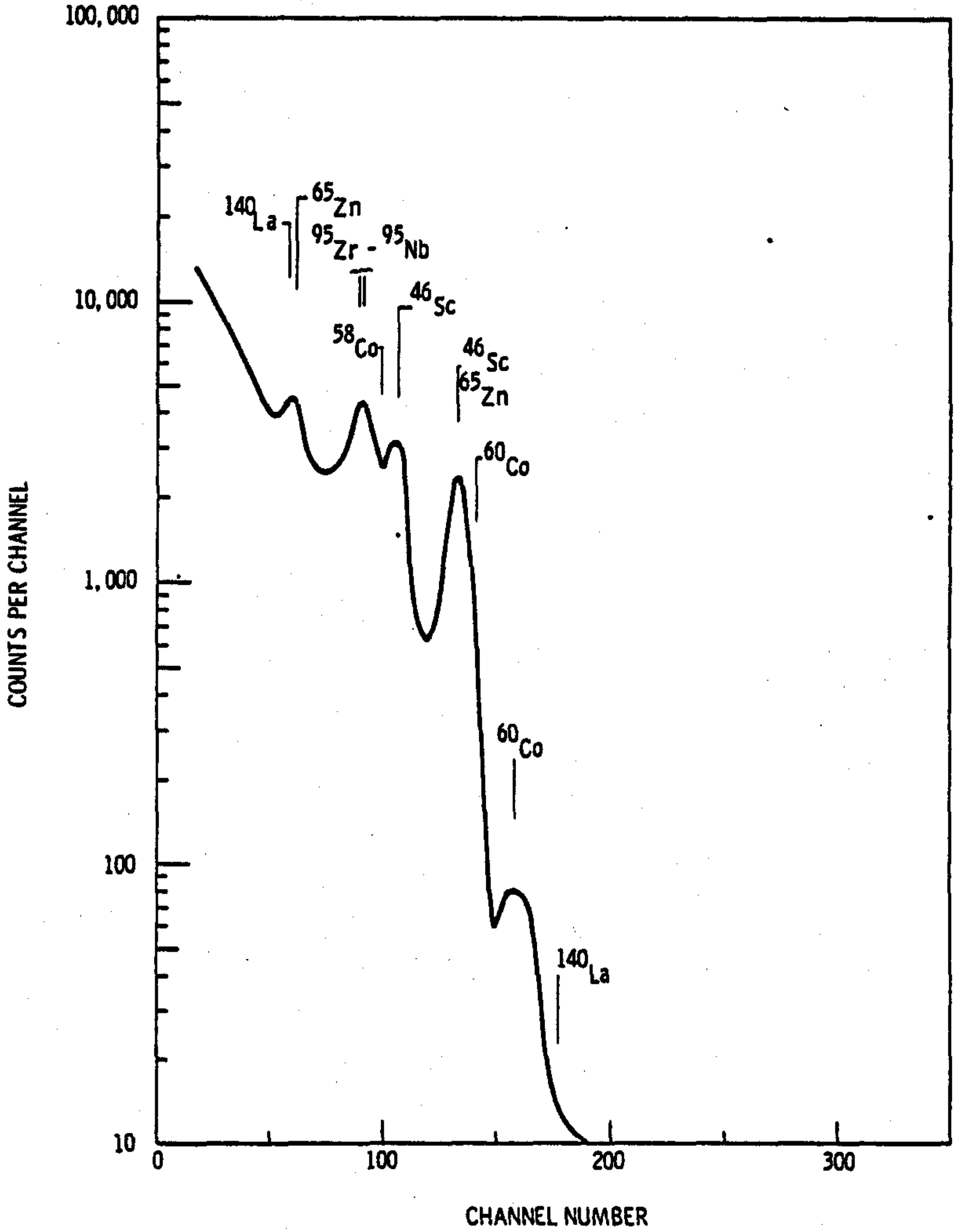

FIGURE 12. GAMMA RAY SPECTRUM OF ALGAL GROWTH ON A SAMPLE OF CLAY-LIKE ROCK

The mud samples returned to the lab were characterized into several basic types by simple visual analysis. Those samples which were silty and charcoal or rusty in color (e.g., from locations 19, 34, 48) generally had a strong odor typical of algal growth and showed the greatest concentration of contaminants (Table 1). Sandy samples (e.g., from locations 4, 22, 35) indicated smaller $^{46}Sc+^{65}Zn$ concentrations, but still appeared to contain some silt-like materials. Finally, those samples which contained a coarse sand or small gravel showed the lowest concentrations. In general, the concentration of contaminants in the mud appeared to be related to its organic content.

In the remarks column of Table 1 we have attempted to summarize, somewhat subjectively, the type of shoreline on which the measurements were made. If a particular shoreline or island location appeared to be attractive for recreational purposes such as picnicking, swimming, water skiing, or boat launching, these items also were noted.

V. RESULTS OF ROUTINE ENVIRONMENTAL SURVEILLANCE - 1967 TO 1969

Table 3 summarizes the data obtained during the past three years from the routine environmental surveillance program conducted by the Environmental Evaluations Section. These data are presented primarily for comparison with the data collected during the special surveys of October and November, 1969. Two types of data are shown--averages of the weekly and monthly 40-liter ionization chamber measurements at 3 ft above the river shoreline, and averages of weekly data obtained from "pencil" ion chambers immersed (in a sealed container) in the Columbia River. The spring floods, which normally occur during the months of May thru July, inundate several locations along the shoreline and make them inaccessible for shoreline monitoring or retrieving the immersed pencils. In addition, the very high flow rates, often exceeding 300,000 cfs, dilute the concentration of contaminants in the river. Data from these periods have been omitted from the table. The data from upstream (Vernita or Priest Rapids) of the operating reactors are shown for comparison, since no "background" has been subtracted from any of the data.

TABLE 3

Summary of Data Obtained from Routine Environmental Surveillance of the Columbia River and its Shoreline - 1967 through October, 1969

Averages of Shoreline Exposure Rates*
at 3 ft Above the Ground

μR/hr

Location	1967**	1968**	1969**
Vernita***	(18)	(15)	(13)
White Bluffs Ferry (Plant Shore)	200	160	75
White Bluffs Ferry (Far Shore)	84	64	56
Hanford (Plant Shore)	110	130	88
Hanford (Far Shore)	88	130	100
Ringold (Far Shore)	63	78	45
Powerline Crossing (Plant Shore)	120	150	110
Powerline Crossing (Far Shore)	130	120	72
300 Area (Plant Shore)	88	82	60
Richland	(31)+	(54)	(26)

Averages of Weekly Immersion Dose Rates
in the Columbia River

mR/day

Location	1967	1968	1969
Vernita***	0.6	0.5	0.7
100-F	-	6.2++	6.5
Hanford Ferry	3.4	2.8°	-
Ringold (Far Shore)	2.3	1.8	2.1
300 Area	3.8	3.2	-
Richland	2.5	1.9	2.6

* From weekly surveys when in parentheses. Otherwise, from monthly surveys.
** Data from May through July excluded.
*** Surveys made near location of Vernita Bridge (plant shore) until July 1968; thereafter, surveys made at the Priest Rapids Dam gauge station.
\+ Average of weekly data at Sacajawea Park (~13 miles downstream of Richland).
++ Data only from August through December.
° Data only for January through April.

VI. RESULTS OF SPECIAL FISH SAMPLING

Because the Hanford Slough area has been reported as a good location for bass sport fishing, four bass, four perch, and a sturgeon were collected by Environmental Monitoring on October 9 and 10, 1969. Concentrations of several radionuclides in these fish samples are shown in Table 4. These nuclide concentrations are not discernibly different from those observed at downstream locations such as Island View, Burbank, or Hover during the same time of the year.

TABLE 4

Radionuclide Concentrations in Fish Caught in the Hanford Slough - October 9-10, 1969

Nuclide	Observed Concentrations (pCi/gm)								
	Bass				Sturgeon	Perch			
	a	b	c	d		a	b	c	d
^{32}P	132	17	8.3	65	15	41	52	70	2.9
^{24}Na	6.6	3.0	0.6	4.3	4.0				
^{40}K	3.1	2.6	4.4	3.6	4.0				
^{60}Co	<0.15	<0.15	<0.15	0.17	<0.15				
^{65}Zn	8.9	3.1	2.4	5.3	3.0				
^{137}Cs-Ba	0.4	0.1	0.3	0.6	0.2				

VII. RESULTS OF AERIAL SURVEYS - 1966 TO 1969

For several years, aerial surveys have shown that, with one or more reactors operating, exposure rates above the river at Hanford are generally 20 to 50 percent less than at 100-F. Similarly, those at the 300 Area are generally 35 to 65 percent less than at Hanford. Such exposure rates (and the above-mentioned reductions) are attributable mainly to short-lived radionuclides in the river water. On the other hand, an aerial survey taken in August, 1966, when all the reactors were shut down due to the strike, showed essentially no variation in exposure rate from 100-F to the 300 Area. This survey, which was observing longer lived radionuclides on the river shoreline, also showed the exposure rates at 100-F and below to be only about 30 percent higher than at Priest Rapids and Vernita.

VIII. COMPARISON OF CURRENT AND PAST DATA

It can be seen from Figure 10 that the shoreline exposure rate is suprisingly constant over the thirty miles from Locke Island to the 300 Area. The reduction in shoreline exposure rates between the 1961 survey and the 1969 surveys is assumed to have resulted largely from the shutdown of production reactors. While only the October, 1961 survey is plotted, McConnon[1] reported on similar surveys made in July, 1961 and March, 1962. Exposure rates during the July survey were slightly lower than during the October and March surveys, due to higher flow rate in July. However, for all three surveys it was concluded that shoreline exposure rates result mainly from general contamination rather than hot spots and that shoreline exposure rates vary little from Ringold to Richland.

In April, 1965, Bovingdon[3] observed that the shoreline from Hanford to Richland could be considered uniformly contaminated and that shoreline exposure rates were generally a factor of 4 or 5 lower than those reported by McConnon (above). He also pointed out that only one hot spot was detected--60,000 c/m at the lower end of Hanford Slough.

In another 1965 survey, the results of which were reported in Reference 4, Bovingdon found that radiological conditions along the east shore of the river downstream from 100-F Area to Ringold were not significantly different from those further downstream.

Later in 1965, in a survey that extended from Vernita Ferry Landing to Sacajawea, Grande[5] found that the radiation level at the water's edge remained fairly constant from Hanford to the 300 Area. He also observed that the highest counting rates obtained with a GM meter were at the river side of the Hanford Slough and the far shore at the old Hanford Ferry Landing.

On October 10, 1969, a special survey was performed in the public hunting area on the far shore between approximately river miles 355 and 362. This rather spotty survey yielded two noteworthy findings (Table 1). One was that there was no detectable (i.e., long-lived) contamination along the channel (not flowing at the time of this survey) on the far side of Savage Island. The most significant finding was that a small cove on the downstream side of the Hanford Ferry Landing jetty contained numerous small hot spots (typically about 4,000 c/m with GM survey instrument) and one spot about a foot in diameter measuring 10 mrad/hr at about one inch.

Hot spots do not seem to be common along the shoreline, as indicated by the recurring observation of uniformity of contamination. However, there do appear to be areas having a tendency toward spotty contamination or toward above average shoreline exposure rates. As indicated in the above references to earlier surveys, the Hanford Ferry Landing (far shore) and the river side of the Hanford Slough are such areas.

IX. CONCLUSIONS

Radiation exposure rates on and along the Columbia above Ringold are affected somewhat by river flow rate, which normally averages below 100,000 cfs except during the spring when it typically exceeds 300,000 cfs. In general, the effect of increased flow is to dilute the river's radionuclides and to inundate contaminated shoreline, thus causing a reduction in exposure rates. Conversely, reduced flow creates higher radionuclide concentrations and uncovers more contaminated shoreline. Under the greatest extremes in flow rate, exposure rates at any location between Ringold and 100-F Area are not likely to vary by a factor of ten for a given set of reactor operating conditions.

Using exposure time estimates reported by Honstead[6] and Soldat[7] and exposure rates shown in Tables 2 and 3, conservative estimates of the annual external dose to various population groups have been calculated. If the "Maximum Individual-Fisherman"[7, 8, 9] were to fish exclusively in the Ringold to 100-F stretch of the river, his annual external exposure could reach 75 mrem, 15 percent of the limit for individuals in uncontrolled areas. If the "Maximum Individual-Teenager"[6, 8, 9] were to swim and water ski exclusively between Ringold and 100-F, his annual external exposure might reach 95 mrem, 19 percent of the same limit. If the "Average Richland Resident"[6, 8, 9] were to swim, picnic, and fish exclusively between Ringold and 100-F, his annual external exposure might reach 17 mrem, 10 percent of the limit for population groups in uncontrolled areas.

The above estimates are conservative, due to the assumption of exclusive use of the river above Ringold. A more realistic assumption appears to be that the river below Ringold will continue to be utilized to a major degree and that future external exposures will differ little from those presently being received. On the other hand, there is some risk that on rare occasions people may be exposed for brief intervals to hot spots such as the one located on October 10, 1969 near the Hanford

Ferry Landing. Such hot spots could deliver a few percent of the annual dose limit during a single recreational outing.

In order to obtain some perspective of the risk of ingestion of contaminated debris from the shoreline, it was assumed that a small child (1-2 years) consumed up to 100 grams of mud from a hot spot such as the one found on October 10 near the old Hanford Ferry Landing. If such were to occur, the internal organ doses to the child would be: thyroid - 600 mrem, GI tract - 400 mrem, whole body - 30 mrem, and bone - 400 mrem. The thyroid dose would be 40 percent of the appropriate "Maximum Individual" limit.

Fish and game birds caught in or near the Columbia River may constitute an additional source of exposure for area residents who consume these foodstuffs. As shown in Table 4, analysis of the fish sampled on October 9 and 10 did not turn up surprising results. Therefore the internal exposure potential from this source is not expected to be substantially different from that which has been previously estimated.(8) Migratory water fowl utilizing the river downstream from the reactors and upland game birds living near the river may be a significant source of the bone-seeking radionuclides ^{32}P and ^{65}Zn for persons who consume such birds. No special game bird collections were made as a part of this study; however, data from our routine environmental surveillance program suggest that consumption of game birds should not constitute a source of exposure significantly different from that observed in the past.(8)

The effect of a Hanford emergency on members of the public using the river upstream from Ringold has not been considered in this study.

X. ACKNOWLEDGMENT

The authors wish to thank T. H. Essig, W. C. Horton, and C. B. Wooldridge for their advice and for participating in two of the special surveys, which had to be performed on weekends.

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APPENDIX A

The Validity of 40-Liter Chamber Measurements

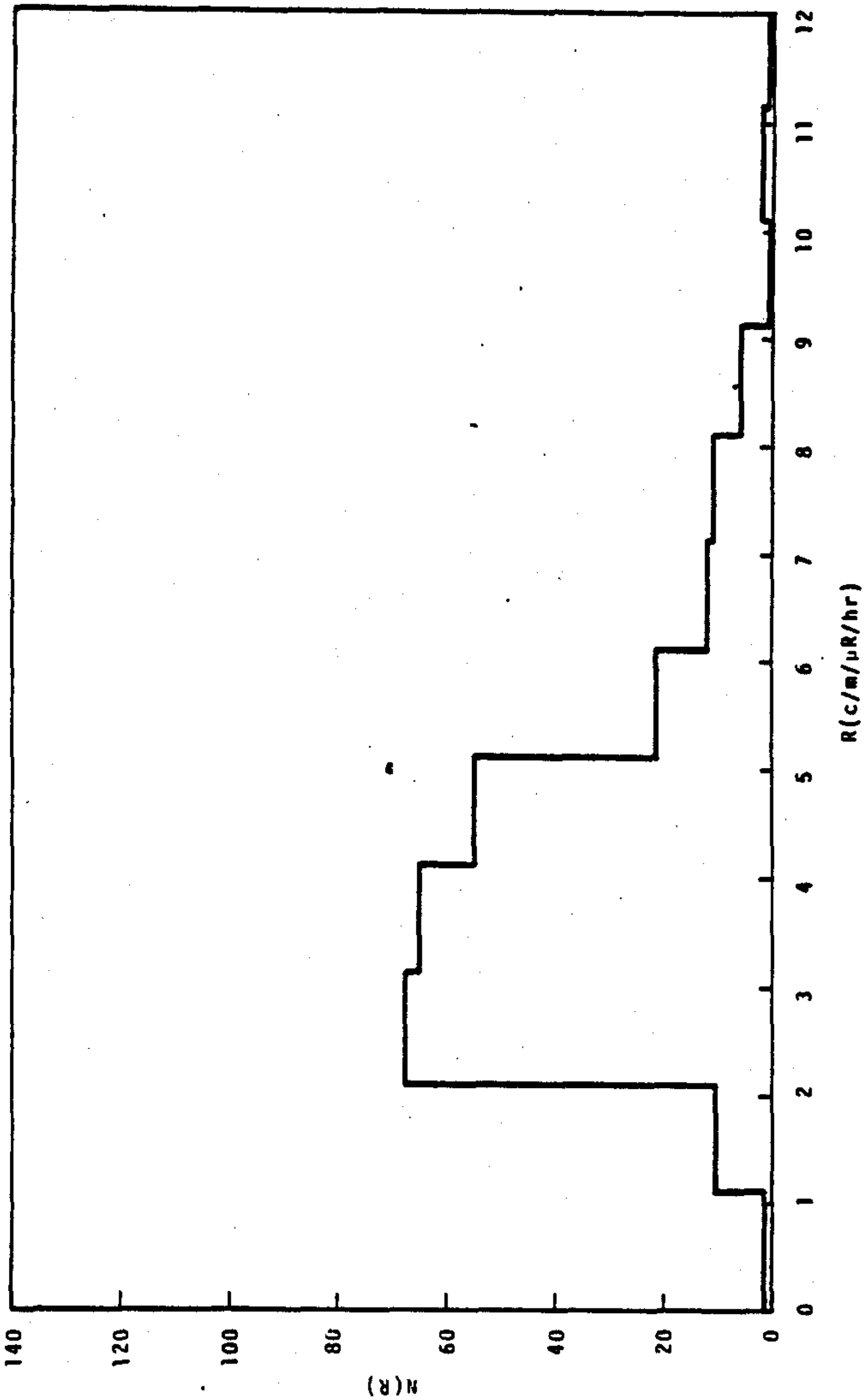
During the course of the October 11 and November 2 surveys, both 40-liter and GM measurements were made at the same location (at a height of three feet) on 257 occasions. This large number of observations provided an opportunity to examine the validity of the 40-liter measurements by comparing them to measurements obtained with the GM survey meters, which are quite stable. Such a comparison requires the seemingly valid assumption that gamma energy, temperature, pressure, and other variables encountered during these surveys could not have caused significant changes in the response of either type of instrument.

Having made that assumption, the comparison can be made by dividing each GM measurement by its corresponding 40-liter measurement. That is, we can observe the variability of the ratio:

$$R = \frac{c/m}{\mu R/hr}$$

These ratios, the distribution of which is shown in the attached Figure, have mean and median values of 4.2 and 3.8 $\frac{c/m}{\mu R/hr}$, respectively.

Some bias was introduced into these ratios through excessive rounding off of the GM data by the persons taking the measurements. This bias seems to be minor, except for measurements made at low exposure rates, the source of most ratios having a value greater than about 5. Despite this minor bias, the ratios have a standard deviation of about fifty percent. The ratio being affected statistically by both its components (i.e., 40-liter and GM data), we should then be able to expect a lesser standard deviation in the 40-liter measurements alone. On this basis it is concluded that the 40-liter chambers performed satisfactorily during the surveys.



DISTRIBUTION OF GM-TO-40-LITER CHAMBER RATIOS