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-- EVALUATION OF ENVIRONMENTAL EXPOSURE --

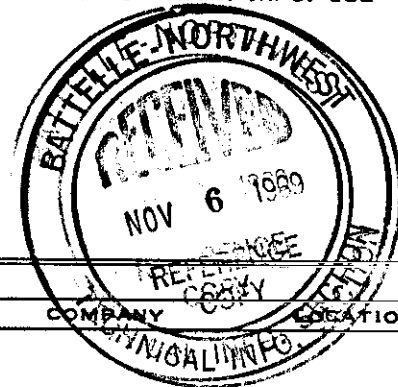
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RECREATIONAL USE OF THE COLUMBIA RIVER

-- EVALUATION OF ENVIRONMENTAL EXPOSURE --

October 7, 1969

PACIFIC NORTHWEST LABORATORY

RICHLAND, WASHINGTON

operated by

BATTELLE MEMORIAL INSTITUTE

for the

UNITED STATES ATOMIC ENERGY COMMISSION UNDER CONTRACT AT(45-1)-1830

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RECREATIONAL USE OF THE COLUMBIA RIVER
-- EVALUATION OF ENVIRONMENTAL EXPOSURE --

I. INTRODUCTION

The Hanford nuclear installation of the U. S. Atomic Energy Commission contributes small amounts of radioactivity to the area immediately adjacent to the plant and to the Columbia River which flows through the project. The plant's environment has been monitored and evaluated since the plant's beginning to make sure that the radioactivity is maintained at conservatively safe levels. In recent years, the evaluation process includes a determination of the annual dose contribution to population groups in the environment from radioactivity originating in the plant.⁽¹⁾

The environmental dose evaluation process consists of estimates of the dose contribution to critical organs of the affected population as a result of each of numerous pathways, and the summation of the pathways to provide a total annual critical organ dose.^(2,3) Some of the environmental dose comes from the internal deposition of radioactivity in the people affected as a result of radioactivity in various dietary components. There are continuing studies designed to contribute information assisting in the improved estimation of such depositions.^(4,5,6) In addition to the exposure from internally deposited radionuclides, a contribution is also potentially available as a result of external exposure from radionuclides in the environment. This external exposure is largely associated with radionuclides in the Columbia River and that concentrated in debris accumulated at the waterline. The opportunity for exposure to these radionuclides is

dependent upon the population's use of the Columbia River for fishing, hunting and other recreation.

In the evaluation of annual environmental dose, two forms of external exposure are generally included: exposure to the shoreline and water surface while fishing, hunting or picnicing; and immersion exposure received while swimming or water-skiing in the river. For 1967, the estimated average immersion exposure rate for the Columbia River at Richland was 2.5 mR/day.⁽⁷⁾ Assuming the average Richland resident swims in the Columbia River for 24 hours during the year, his whole body exposure from this pathway would be 2.5 mR. In the case of fishermen, the dose evaluation for the "maximum individual" assumes an enthusiastic fisherman who eats 200 meals of Columbia River fish per year and therefore must spend about 500 hours on the riverbank fishing. The average exposure rate at the shoreline at Sacajawea Park, near some of the most popular Tri-City fishing areas, includes a 0.53 mR/day from Hanford radionuclides. In 500 hours, the fisherman would therefore receive a gonad and torso exposure of about 11 mR. It is evident that these external dose estimates strongly depend upon the average exposure time assumed. The number of hours that have been used in calculating annual dose is quite arbitrary, having no firm statistical basis. The study reported here contributes some information on the amount of time Richland residents spend in recreational activities involving the Columbia River.

II. SUMMARY

A total of 430 teen-age students in Richland schools were questioned concerning their use of the Columbia River for recreation purposes. The survey investigated the frequency and length of swimming trips, water skiing trips, fishing and hunting trips and picnics associated with the Columbia River. The data are to be used in evaluating the external dose received by Richland residents from the radioactivity in the Columbia River and accumulated along the shoreline.

Of the students questioned, essentially all obtained recreational benefit from the Columbia River. On the average, they spent 115 hours per year in, on, or alongside the river. The most popular form of recreation was swimming, representing an average of 57 hours per year. A reasonable extrapolation of this teen-age data to the whole Richland population would suggest that 30 to 35 hours per year on the average is probably spent in Columbia River recreation. The estimated average exposure resulting from this use of the river is 1.6 mR, in close agreement with the value of 2 mR included in the 1967 environmental dose evaluation. Individual teen-agers were examined with regard to their possible external exposure and values of up to 68 mR were obtained in extreme cases.

III. METHODS

During the course of a study of body burdens of teen-age students of Richland in the spring of 1969, a mobile whole body counter was positioned near the high school and one of the junior high schools and students were invited to stop in for measurement. In addition to measuring body burdens of radionuclides, the students were questioned concerning their diet habits and use of the Columbia River for recreation. The participation in the study was voluntary and the group of teen-age students who chose to participate may or may not have been a representative sample of the total Richland teen-age population. However, for purposes of evaluating residence time along the Columbia River to assist in dose estimates, this sample is assumed to be sufficient representative. A total of 430 teen-agers were questioned during the course of the program. Of these, 250 were from the high school, ranging in age from 15 years through 17 years, and 180 were from the junior high school, ranging from age 12 years through 14 years.

The answers to the questions were obtained from the students orally. This permitted some discussion and explanation of the questions. There was some evidence of reinforcement of answers from other students present in the whole body counter. The questions concerning Columbia River recreation that were posed to the students were:

During 1968, did you:

Swim in the Columbia River? How many times? How many hours each time? How many hours were you in the water?

Water-ski on the Columbia River? How many times? How many hours each time? How many hours were you in or on the water?

Fish or hunt from a boat on the Columbia River? How many times? How many hours each time?

Fish along the shoreline of the river? How many times? How many hours each time?

Picnic on islands in the Columbia River? How many times? How many hours each time?

The answers to these questions provided the statistical basis for the results presented in this report. Although some of the answers are of questionable merit, none were eliminated from the average.

IV. RESULTS

A summary of the responses to the questions used in this survey are shown in Table 1. The answers received seem reasonable on the average, although some individual responses were probably mistaken or exaggerated. Only 18 students (4 percent) indicated no recreational time on the Columbia River during 1968.

The most popular form of recreation was swimming, in which 81 percent of the students participated. Of those who swam in the river, the average time spent on swimming trips during 1968 was 72 hours. The next most popular recreational activity was picnicing on islands in the Columbia River, with 73 percent of the students indicating affirmative answers. The students who participated in picnics spent an average total of 24 hours on these trips during 1968. In the case of water-skiing, 49 percent of the teen-agers indicated some participation during 1968, which totaled an average of 36 hours. Both in the case of swimming and water-skiing, the students estimated that about half of their total time spent in these activities was involved actively in or on the water.

Fishing or hunting from a boat involved 35 percent of the teen-agers questioned and fishing along the shoreline involved 40 percent of those questioned. These boat trips averaged a total of 25 hours during the year, while the shoreline fishing trips averaged 33 hours during the year. The distribution of exposure times estimated by the teen-agers in this study for each of the various recreational

TABLE 1

TEEN-AGERS RESPONSE TO QUESTIONS

	<u>HIGH SCHOOL</u>	<u>JR. HIGH SCHOOL</u>	<u>COMBINED</u>
Number of students questioned	250	180	430
During 1968, did you swim in the Columbia River? Yes --	85%	75%	81%
How many times? How many hours each time? (Average affirmative answer in total hours of swimming trips)	75	67	72
How many hours were you usually in the water? (Average affirmative answer in total hours in the water)	43	30	38
During 1968, did you water-ski on the Columbia River? Yes --	58%	36%	49%
How many times? How many hours each time? (Average affirmative answer in total hours of water ski- ing trips)	32	43	36
How many hours were you in or on the water? (Average affirmative answer in total hours in or on the water)	18	17	18
During 1968, did you fish or hunt from a boat on the Columbia River? Yes --	33%	38%	35%
How many times? How many hours each time? (Average affirmative answer in total hours of boat trips)	25	26	25
During 1968, did you fish along the shoreline of the Columbia River? Yes --	38%	42%	40%
How many times? How many hours each time? (Average affirmative answer in total hours of fishing trips) Yes	30	38	33
During 1968, did you picnic on islands in the Columbia River? Yes --	70%	78%	73%
How many times? How many hours each time? (Average affirmative answer in total hours of trips)	22	26	24

opportunities is shown in Table 2. There is evidence of wide differences in the recreation habits of teen-agers from the rather broad distribution obtained. The sizeable number of students estimating more than 200 hours in recreation on the Columbia River during 1968 is evident in this table. For example, 34 students, representing 8 percent of the total questioned, estimated that they spent more than 200 hours on Columbia River fishing trips during 1968.

To obtain total recreation time involving the Columbia River for each individual, the sum of the total hours of swimming trips, water-skiing trips, fishing or hunting boat trips, shoreline fishing trips and island picnicing trips was tabulated. The distribution of these total hours of Columbia River recreation are shown graphically in Figure I. The average total for the whole population group is 115 hours. If only the affirmative answers are averaged, the total becomes 120 hours per year. From Figure I, it is clear that a significant number of teen-agers estimate they spent in excess of 300 hours in Columbia River recreation per year. The details of the students whose total recreational time exceeded 300 hours are presented in Table 3. Although some of the answers do not appear logical, it is difficult to eliminate them on the basis of comparison with other responses.

TABLE 2

TEEN-AGE RECREATION ON THE COLUMBIA RIVER
DISTRIBUTION OF RESPONSES TO QUESTIONS - ANNUAL TOTALS

	NUMBER OF STUDENTS											
	1-19 Hrs.	20- 39 Hrs.	40- 59 Hrs.	60- 79 Hrs.	80- 99 Hrs.	100- 119 Hrs.	120- 139 Hrs.	140- 159 Hrs.	160- 179 Hrs.	180- 199 Hrs.	200- 299 Hrs.	>300 Hrs.
<u>High School</u>												
Total of swimming trips	88	28	22	13	10	5	4	6	2	7	16	11
Time in the water	104	40	16	10	9	7	6	9	1	5	4	1
Total of water-skiing trips	84	20	16	7	4	3	1	4	0	2	3	0
Time in or on the water	107	17	8	5	2	1	2	1	0	1	0	0
Total of fishing or hunting boat trips	50	12	5	7	4	1	2	0	1	0	0	0
Total of shoreline fishing trips	51	21	12	4	3	0	2	1	0	1	0	1
Total of picnic trips	118	35	12	5	2	1	1	0	0	0	0	2
<u>Junior High School</u>												
Total of swimming trips	44	22	18	12	11	8	5	3	4	1	3	4
Time in the water	74	25	15	7	7	2	2	0	0	1	0	2
Total of water-skiing trips	36	7	7	3	3	1	1	2	1	1	2	1
Time in or on the water	47	10	2	3	1	1	0	0	0	0	1	0
Total of fishing or hunting boat trips	42	14	4	2	2	0	1	1	2	0	0	0
Total of shoreline fishing trips	38	17	5	0	6	2	2	2	3	0	1	0
Total of picnic trips	75	35	19	5	4	0	0	0	0	0	2	0
<u>Combined</u>												
Total of swimming trips	132	50	40	25	21	13	9	9	6	8	19	15
Time in the water	178	65	31	17	16	9	8	9	1	6	4	3
Total of water-skiing trips	120	27	23	10	7	4	2	6	0	3	5	1
Time in or on the water	154	27	10	8	5	2	2	1	0	1	1	0
Total of fishing or hunting trips	92	26	9	9	6	1	3	1	3	0	0	0
Total of shoreline fishing trips	89	38	17	4	9	2	4	3	3	1	1	1
Total of picnic trips	193	70	31	10	6	1	1	0	0	0	2	2

FIGURE 1

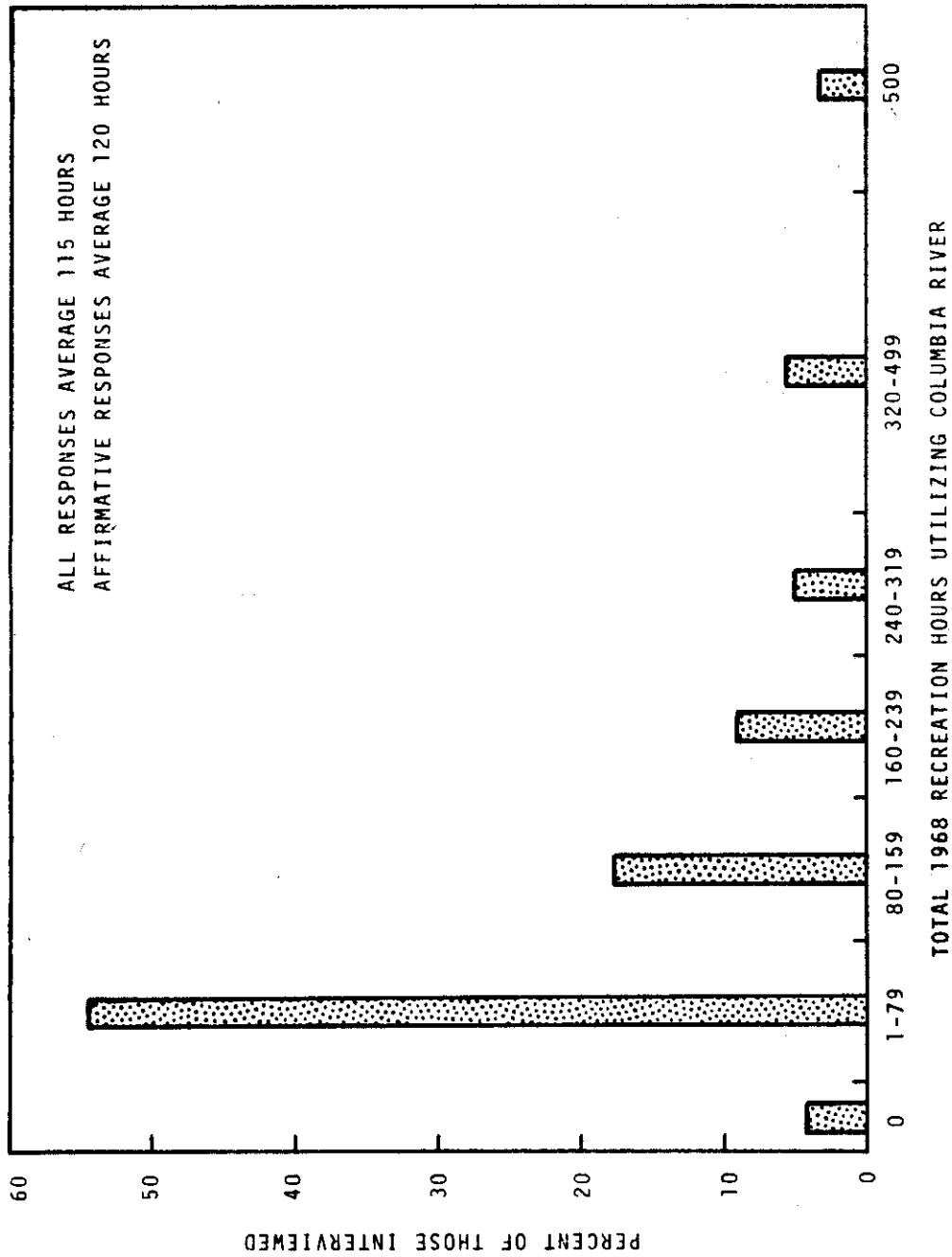


FIGURE 1. UTILIZATION OF THE COLUMBIA RIVER FOR RECREATION
(SWIMMING, WATER-SKIING, FISHING, PICNICING, ETC.)
SAMPLE GROUP QUESTIONED - 430 RICHLAND TEENAGERS

TABLE 3

DETAILS OF THE MAXIMUM RESPONSES TO
COLUMBIA RIVER RECREATION QUESTIONS

STANDING	TOTAL SWIM TRIP HOURS	TOTAL HOURS IN THE WATER	TOTAL WATER SKI TRIP HOURS	TOTAL HOURS IN OR ON THE WATER	TOTAL BOAT HUNT- ING & FISHING HRS.	TOTAL SHORELINE FISHING HOURS	TOTAL PICNIC HOURS ON ISLANDS	TOTAL COLUMBIA RIVER RECREATION HOURS	WHOLE BODY EXPO- SURE CALCULATED FROM THESE DATA, mR
1	1000	300	0	0	16	24	80	1120	49
2	750	450	180	120	8	2	24	964	68
3	600	300	80	20	60	150	30	920	47
4	600	150	200	50	90	0	0	890	36
5	360	180	0	0	60	360	8	788	32
6	90	90	180	180	0	0	450	720	38
7	100	75	200	100	30	100	240	670	29
8	450	270	10	10	120	21	39	640	37
9	300	150	150	75	18	20	75	563	31
10	60	15	240	60	0	12	240	552	18
11	240	120	150	75	64	80	12	546	28
12	240	80	180	30	16	20	90	546	21
13	90	90	270	90	60	80	18	518	26
14	420	180	45	45	6	6	35	512	30
15	100	50	300	200	50	6	40	496	31
16	360	120	36	36	0	30	48	474	23
17	140	105	140	70	160	20	12	472	25
18	450	180	0	0	0	0	8	458	25
19	270	180	40	40	60	20	60	450	28
20	270	135	48	6	8	20	96	442	21
21	80	40	40	20	0	0	320	440	15
22	210	70	200	13	7	0	16	433	16
23	280	140	60	20	80	0	8	428	23
24	240	90	120	120	12	20	30	422	27
25	400	100	8	2	0	0	12	420	18
26	280	140	30	20	16	80	0	406	22
27	250	250	100	100	0	0	50	400	38
28	320	160	18	2	0	0	60	398	22
29	225	135	25	25	70	45	24	389	22
30	300	100	6	6	0	0	45	351	16
31	150	100	30	15	40	120	10	350	17
32	80	20	160	60	40	28	40	348	14
33	150	150	150	150	48	0	0	348	32
34	50	50	50	50	100	60	80	340	16
35	100	25	0	0	150	0	80	330	9.3
36	200	100	90	60	4	0	32	326	20
37	300	90	0	0	0	0	25	325	15
38	140	70	48	12	48	32	40	308	14

V. CONCLUSIONS, RECOMMENDATIONS

The limitations of the data obtained in this study for drawing firm conclusions are obvious. The responses to questions rely on the objective of the people questioned, resulting in probable systematic bias on the high side. Furthermore, the teen-age group sampled in this study could hardly be considered a suitable sample of the whole Richland population. Until additional information can be obtained, it is still necessary to make an intuitive correction of these results to obtain population averages.

According to a recent population analysis,⁽⁸⁾ the age distribution of the Tri-Cities during 1968 was:

0-5 years	10.2%
6-11 years	12.9%
12-17 years	13.7%
18-24 years	12.8%
25-34 years	11.2%
35-49 years	18.6%
50-64 years	14.6%
65 and over	6.0%

The 12-17 age group is almost precisely the group sampled in this study. They represent 13.7 percent of the Richland population, or about 3,924 individuals (based on a post office survey of May 1, 1968). The sample questioned is therefore nearly 11 percent of the total population. It seems reasonable to exclude part of the 0-5 and 65 and over age groups as being unlikely to contribute to the total population exposure as a result of Columbia River recreation. For this analysis, half of these two age groups are excluded.

If one assumes that the 12-17 age group receives some selected fraction of the total population external dose, it is possible to then calculate the average number of hours spent in recreation on the Columbia River. The 12-17 age group almost certainly spends more hours per year on the Columbia River than the population average; that is, one would expect the population average to be less than the 115 hours obtained from the teen-age sample. If one assumes that the 12-17 age group are the only members of the population utilizing the river, the population average becomes 16 hours per year. This is clearly too low. Intuitively, one would expect this age group to receive between 30 and 70 percent of the exposure, because of their relative freedom to participate in Columbia River recreational activities. The associated average population exposure ranges from 23 to 54 hours per year. In the absence of other information, an annual Columbia River recreation time of 32 hours seems reasonable for calculating average exposure of the Richland population.

The teen-agers estimated that of the 115 hours spent on the river, 50 percent was swimming trips, 16 percent was water-skiing trips, 8 percent was fishing or hunting from a boat, 11 percent was fishing from the shoreline and 18 percent was spent on picnics on islands. This distribution may not be representative of the average population, but is the best breakdown available. Assuming that half of the time spent on swimming and water-skiing trips is exposure time for immersion dose, 33 percent of the annual total or 11 hours per year would be a reasonable estimate for this purpose. The remainder, 21 hours per year, would

then be exposure to surface dose from the river or shoreline. If one applied the surface exposure rate (Sacajawea Park) and immersion exposure rate (Richland) of 0.53 mR/day and 2.5 mR/day, respectively, which was used in the 1967 dose evaluation to these estimated exposure traces, an average whole body exposure of 1.6 mR is obtained. This may be compared with the value of 2 mR calculated for inclusion in the 1967 dose estimate.

Of course, individual teen-agers who are enthusiastic water skiers or swimmers may differ considerably from the average. In the case of these students reporting greater than 300 hours per year total river recreation time, the individual whole-body exposures are shown in the right hand column in Table 3. These calculated exposures are derived from the 1968 recreation times estimated by each student and the immersion and surface exposure rates used in the 1967 environmental dose evaluation. The calculated whole body exposure for this group ranges from 9 to 68 mR. These students may be identified as a sample of the "critical population group" for this pathway, for which a whole body dose limit of 500 mrem per year is appropriate (individual members of the population). If the average external exposure calculated for this sample of the critical population, 26 mR, had been used in calculating the 1967 environmental dose for the "maximum individual," the whole body dose would have been 47 mrem instead of the value of 32 mrem included in that report.⁽⁷⁾ This still represents less than 10 percent of the appropriate limit and does not affect the conclusions drawn from that environmental evaluation.

The hypothetical "maximum individual" included in annual environmental dose evaluations has always been considered an avid fisherman because of the 200 meals of Columbia River fish ascribed to his diet. The data obtained from this study tend to suggest that recreation other than fishing may provide another critical pathway. The combined boat and shoreline fishing time estimated by the students gave no total as great as 500 hours and only three as great as 200 hours. Nearly 45 percent of the students did not fish at all. The importance of fishing as a form of recreation on the river probably increases among older members of the population.

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