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DISPERSION OF 300 AREA LIQUID EFFLUENT IN THE COLUMBIA RIVER

By

G E Backman
Environmental Studies and Evaluation
Radiation Protection Operation

May 25, 1962

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DISPERSION OF 300 AREA LIQUID EFFLUENT IN THE COLUMBIA RIVER

INTRODUCTION

This study was conducted to determine the dispersion of 300 Area liquid effluents which are discharged into the Columbia River. More knowledge was needed because the potential for accidentally releasing radioactive materials in large quantities has increased substantially. The large inventory of fission products contained in the Plutonium Recycle Test Reactor (PRTR), the initiation of research programs involving kilocurie quantities of radioactive materials, and the proposed construction of the Fuels Recycle Pilot Plant (FRPP) which will process materials containing high inventories of fission products are major examples of existing and future programs located in the 300 Area which increase the potential.

Information on dispersion patterns was also needed because of plans for increased use of Columbia River water at sites not far below the 300 Area. The City of Richland will, in 1963, use the Columbia River for its sanitary water supply. Richland's intake will be only about four to five river miles downstream from the 300 Area, whereas the closest municipal intakes at the present time (Pasco and Kennewick) are approximately sixteen river miles from 300 Area. The possibility also exists that new industry which would use Columbia River water may locate close to the 300 Area.

Results from previously conducted dispersion studies (1)(2) of the liquid effluent discharged into the Columbia River by production reactors are not applicable to the 300 Area. The McNary Pool, which has an influence on river flow for approximately ten miles up river from the 300 Area, causes the principle difference.

DESCRIPTION OF TESTS

Three dye tests were made to trace the liquid effluent dispersion pattern from the outfall of the PRTR. The first test was made to determine whether or not near complete dispersion of liquid effluents from the 300 Area could be expected at the Pasco Pumping Station. Such an assumption had been used in calculating limits for some 300 Area facilities, and a firm basis for the limits was desired. The second test was conducted to simulate a situation unique to PRTR because of the containment feature. Approximately two minutes after a signal is received from the aqueous effluent monitoring station, valves close which completely contain the contents of the reactor. The brief delay is necessary to reduce the consequences which would result from extensive thermal shock. It is conceivable that high levels of radioactive materials could be discharged into the river during this short period of time. The third test was performed under the adverse condition of low river flow. In addition, some depth samples were collected to confirm the assumption that dye concentrations were about the same at all depths.

The tests consisted of the addition of fluorescein dye to the PRTR liquid effluent stream, followed by sampling of the river water from a boat, and visual inspection and aerial photography of the resulting dye patterns in the Columbia River. Five-hundred ml samples of water were collected at the surface at 50 to 100 yard intervals during traverses at predetermined locations below the PRTR aqueous effluent discharge point. The position of the boat at the sampling points was determined with a stadimeter. Proper sample collection times were determined by observation of the dye patterns and by estimating water travel times from data in Document HW-58312[3].

A series of water samples were also taken at the Pasco sanitary water intake.

Figure 1 shows the Columbia River from 300 Area to Pasco, Washington, with points of interest and locations where river traverses were made for the sampling program. Figures 2 through 7 are aerial photographs of dye patterns. Additional information is included under the figure captions.

RESULTS

The first dye test was run on August 22, 1961. The river flow for that date as measured at Priest Rapids Dam was 83,000 cfs maximum and 58,000 cfs minimum. PRTR was not operating. Nine pounds of fluorescein dye dissolved in water in a 50 gallon drum were discharged at a constant rate into the PRTR liquid effluent stream. The addition of the dye was begun at 0638 and completed at 0742.

Visual identification of the dyed water mass was possible for approximately four hours. The dye appeared to be held near the west (plant side) bank for the first four miles and the "cloud" passed very near the location of the proposed Richland Pumping Station (see Figure 1 for location). The dye passed on the east side of the fourth island, the southern tip of which is located just off Hunt Point in Richland. It was dispersed to where it was no longer visible just past this island.

The measured concentrations of dye at the sampling locations in the river are summarized in Table I. At the cross section nearest the proposed Richland Pumping Station the maximum concentrations were from seven to ten times that which would be anticipated if complete dispersion had occurred. Analyses of the samples collected at the Pasco Pumping Station indicated that near complete dispersion had taken place by the time the dyed water mass had reached this location. It is interesting to note that at the first traverse (approximately 0.2 mile below the PRTR outfall) the dye had already been diluted by a factor of 300 over its calculated concentration in the effluent.

A limited amount of dye was available for the first test and the detection limit of the dye was 0.5 PPB as compared to 0.1 PPB for the latter two tests. Because of the difficulty in measuring the low concentrations of dye downriver from Richland, less confidence is placed in the results obtained during Test 1 than in those obtained in Tests 2 and 3.

Test 2 was conducted on October 24, 1961, in an effort to simulate the discharge of a large quantity of radioactive material into the river over a short period of time. Twenty pounds of fluorescein dissolved in water in a fifty gallon drum were discharged into the PRTR liquid effluent in less than two minutes at approximately 0700. The reactor was operating. For October 24, the maximum river flow was 83,000 cfs and minimum flow was 42,000 cfs as measured at Priest Rapids Dam.

The longitudinal spread of the dye during this test was somewhat surprising, for by the time the "cloud" had reached Richland, the visible pattern was approximately three miles long (note Figures 6 and 7). The path of the dye was similar to the one noted in Test 1, with the pattern staying near the west bank of the river, passing very near the proposed pumping station, and moving to the east side of the fourth island. Small pools of dye could be seen in many locations along the west bank after the main pattern had passed on down the river. Again the dye dispersed to a concentration where it was no longer visible as it passed the southern tip of the fourth island.

Sample analysis indicated that the dye had been diluted by a factor of 5,000 or more 0.2 mile below the PRTR outfall. (See Table II for complete results of all samples analyzed.) The longitudinal effect noted during visual inspection of the dye plume was confirmed by sample analysis also. The sample results indicated that the concentration at the proposed Richland Pumping Station was about what would be expected if complete vertical and transverse but no longitudinal dispersion had taken place. The samples taken at the Pasco Pumping Station indicated that an additional dilution factor of approximately 25 was achieved during river travel from Richland to Pasco.

The third test was conducted on January 8, 1962. Fifty pounds of dissolved fluorescein dye were added to the PRTR liquid effluent over an hour and 22 minute period beginning at approximately 0730. The river flow for that day was 73,000 cfs maximum and 36,000 cfs minimum as measured at Priest Rapids Dam. The reactor was not operating.

Visual observation showed the dye path to be similar to that observed in Tests 1 and 2. Because of the larger quantities of dye used in the test it was possible to see a pattern which extended well down the river from the fourth island. Considerably more dispersion appeared to take place off the southern tip of this island than at any other single location north to 300 Area, however. The main current seemed to sweep through the dye pattern at this point. Some dye could still be observed up until dusk.

Analyses of samples indicated a minimum dilution of 300 fold at the "A" traverse, 0.2 mile below PRTR outfall. Tables III-A and III-B show the complete results of all samples analyzed. The results from samples obtained during the "D" traverse, 3.2 miles below PRTR outfall, indicated that the maximum dye concentration was 2.5 to 5 times the expected concentration if complete dispersion had been accomplished. The "D" traverse was considered to be more indicative of the condition at the proposed Richland Pumping Station than the "DD" traverse because it is apparent that the sampling during the "DD" traverse was made ahead of the maximum concentration. From Table III-A it can be seen that results obtained from samples taken on the "E" traverse are higher than those collected on the "DD" traverse. The samples collected at the Pasco Pumping Station intake showed the dye concentrations to be less than would be anticipated if the dye was completely dispersed in the volume of water available from river flow alone. This is to be expected since there is considerably more water volume available at Pasco because of the McNary Pool. The fact that this was not noted during Test 1 may be due to inability to measure accurately the low concentrations of dye present and the high river flow.

During the third test, water samples were also taken from bottom and mid-depth locations over the apparent center of the dye pattern at traverse locations "C", "D", "DD", and "E" (note Table III-B). No significant differences were found among the dye concentrations at the various depths. Earlier studies (one near the production reactors) have also shown concentrations of radioactive materials and water temperatures to be essentially the same between the surface and bottom of the river.

CONCLUSIONS

1. Near complete dispersion of the liquid effluents discharged into the river at 300 Area can be anticipated by the time the river flow reaches the Pasco Pumping Station.

2. Complete dispersion does not take place by the time the 300 Area effluent has reached the proposed Richland Pumping Station location. The

maximum concentration may be a factor of 10 above that which would be expected if complete dispersion were accomplished.

3. Because the longitudinal dispersion of materials discharged over a short time (approximately two minutes) is substantial, it is reasonable to assume that the equivalent of complete dispersion will take place by the time a "burst" of material has reached the location of the proposed Richland Pumping Station.

4. Significant dispersion takes place before the dye reaches the surface of the river.

5. Except within approximately 100 yards of the release point, the concentrations of radioactive materials discharged via the PRTR outfall can be expected to be reasonably uniform at any depth.

ACKNOWLEDGEMENTS

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BIBLIOGRAPHY

1. Watson, D. F., 100-K Outfall Study, Final Report, HW-58899 - Confidential January 31, 1959.

2. Soldat, J. K., A Compilation of Basic Data Relating to the Columbia River, Section 8, Dispersion of Reactor Effluent in the Columbia River, HW-69369, To be published. Secret

3. Soldat, J. K., Columbia River Flow Time Calculations, HW-58312, November 21, 1958.

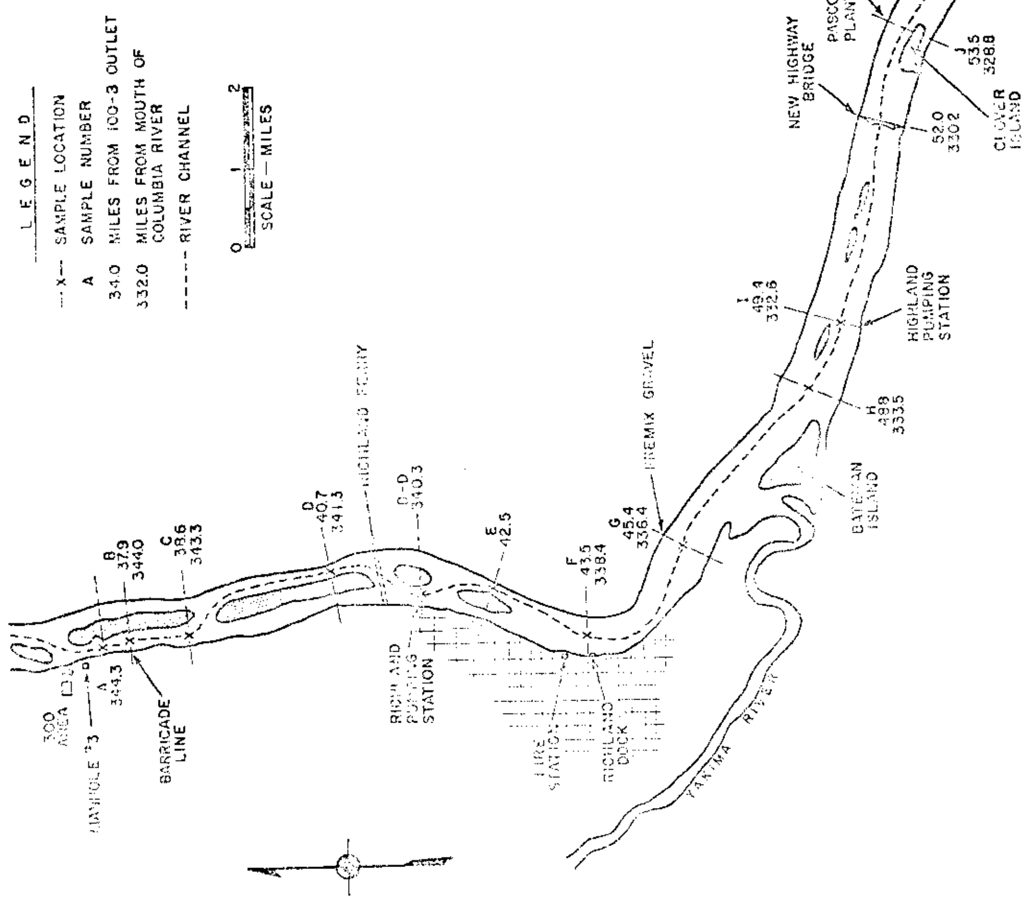

FIGURE 1

Columbia River - 300 Area to Pasco, Washington

FIGURE 2

The First Indication of Dye can be seen. The Dye Becomes Visible 50 to 100 Feet Below Where it Enters the River From the PRTR Outfall.

FIGURE 3

The Dye Pattern as it Appeared a Few Minutes After it Reached the River

FIGURE 4

The Picture Shows that the Dye Pattern did not Follow the Main Current Which Sweeps Between the Island Tips, But Remained near the Plant Side (West) of the River.

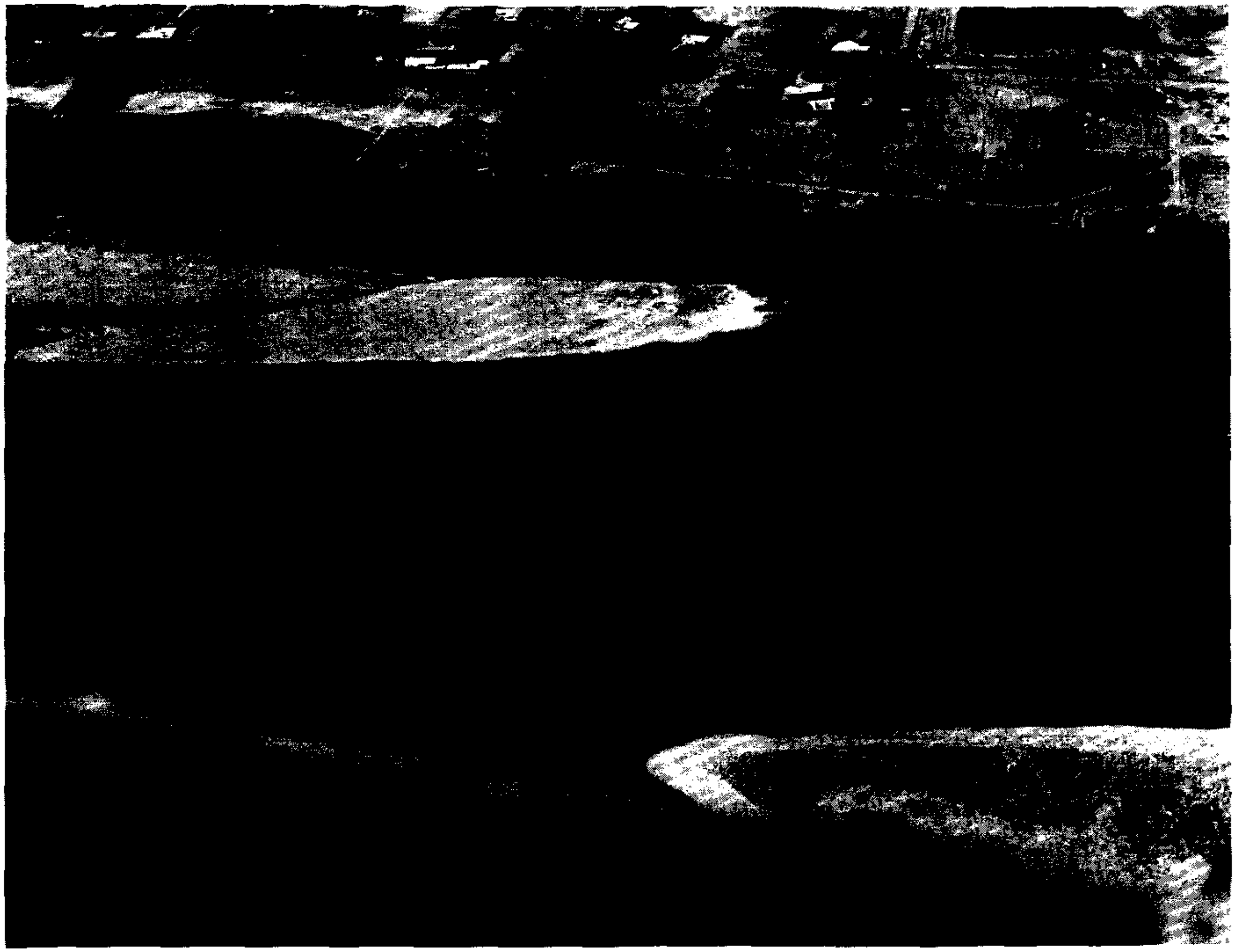

FIGURE 5

This Picture was Taken to Show that the Dye Pattern Broke Away From the West Bank and Passed on the far Side of the Fourth Island.

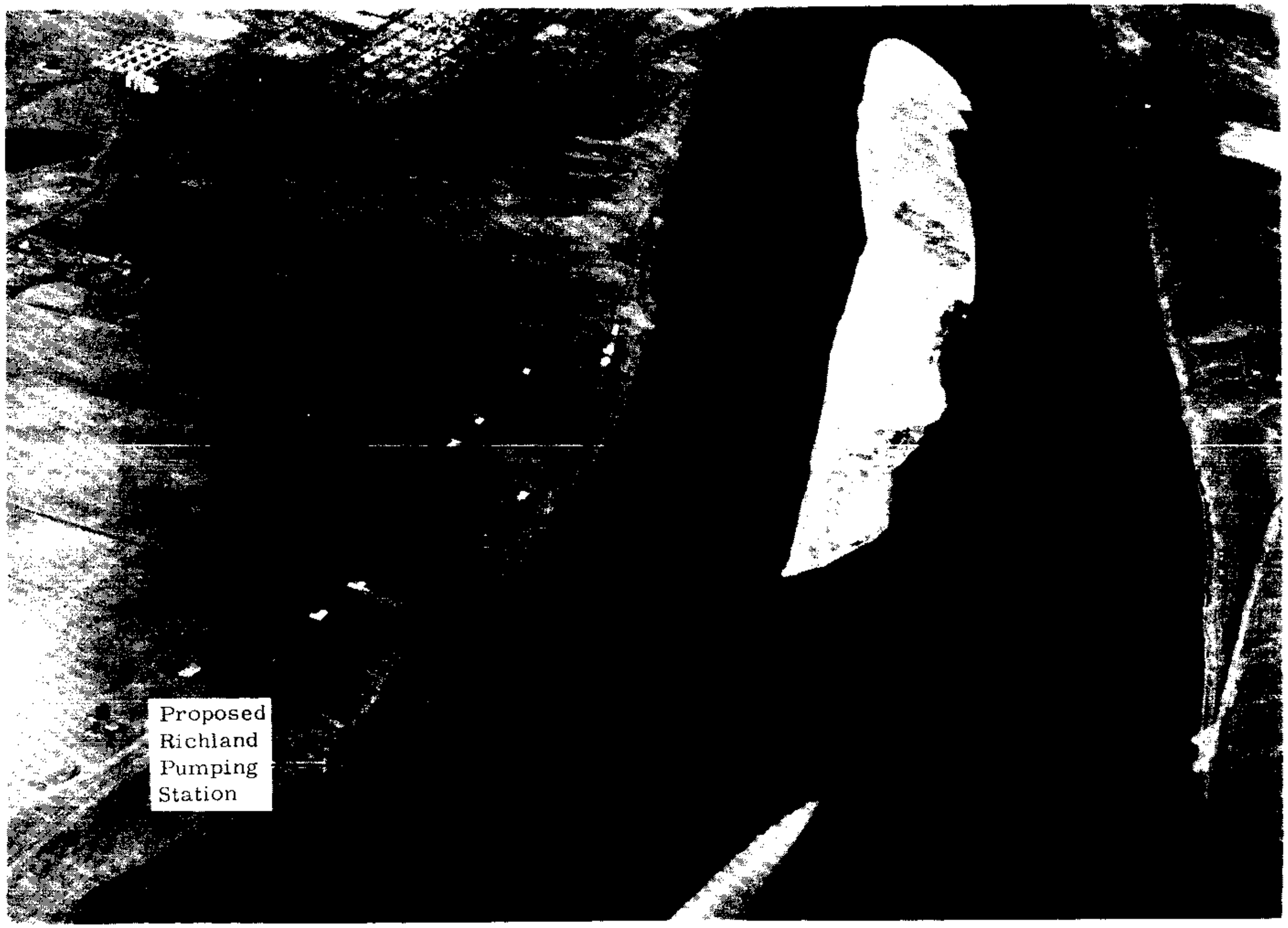

FIGURE 6

During the Second Test, the Dye was Added in Less than a Two Minute Period. The Pattern in the Picture is Over Two Miles Long and Indicates the Marked Effect of Longitudinal Dispersion. The Light Sections of the Photograph Near the Tips of Some of the Islands are the Result of Shallow Water.

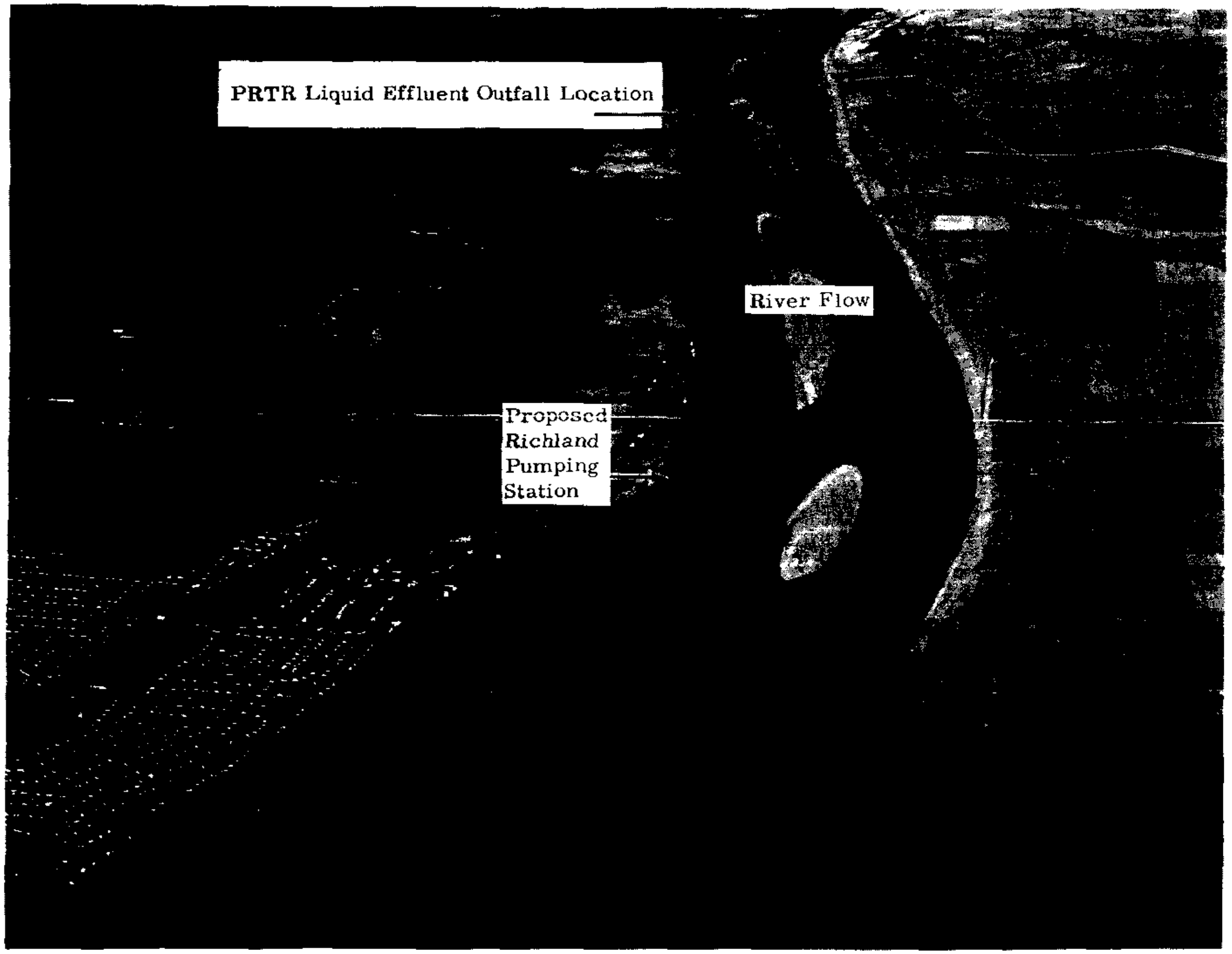

FIGURE 7

The Dye Pattern can be seen to Pass Very Near to the Future Richland Pumping Plant Intake.

TABLE I

FLUORESCEIN DYE TEST #1

Cross Section

Sample No.	A	B	C	D	E	F	G	H	I	J	Pasco Pumping Station
1	0.9	1.3	1.3	0.6	< 0.5	0.5	0.9	1.3	0.9	0.9	0.9
2	0.9	0.9	0.9	0.6	0.5	0.5	< 0.5	1.3	< 0.5	0.9	2.0
3	1.3	7.8	1.3	< 0.5	0.5	0.5	0.5	0.5	0.9	0.9	0.9
4	55.8	25.4	0.9	< 0.5	0.5	0.9	0.5	0.9	< 0.5	0.5	1.6
		25.2									
5	8.2	35.4	0.6	< 0.5	0.5	0.9	0.5	0.9	0.5	2.4	0.5
6	4.7	39.4	0.6	0.6	< 0.5	0.5	0.5	0.5	< 0.5	1.3	0.9
7	43.5	14.0	0.9	< 0.5	0.5	0.5	0.5	0.5	< 0.5	0.5	
8		8.6	6.9	< 0.5	0.9	0.9	< 0.5	0.5	< 0.5	1.3	
9		5.5	17.1	< 0.5	0.5	0.9	0.9	0.9	< 0.5	0.9	
10			9.2	< 0.5	0.5	0.5	0.6	0.9	< 0.5	0.9	
11			1.7	< 0.5	0.5	1.3	0.6	0.5	< 0.5	1.3	
12			0.9	< 0.5	2.8	0.9	0.6	0.5		0.9	
13			1.1	1.1	4.7	1.3	0.6	< 0.5		0.9	
14			3.9	2.8	2.0	0.9	< 0.5	0.5			
15				5.2	0.9			0.5			
16				5.2	0.5			0.9			
17				10.5	0.5			0.9			
				10.5							
18				9.0	0.5			0.9			
19				3.2	0.5			0.9			
20				0.9				0.9			
21				< 0.5	0.9						
					0.9						

All results are in parts per billion by weight.

TABLE II

FLUORESCEIN DYE TEST #2

Cross Section

Sample No.	A	B	C	D	DD	E	F	G	H	Pasco Pumping Station
1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3
2	< 0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1
3	< 0.1	13.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	0.1
4	< 0.1	62	< 0.1	< 0.1	0.4	< 0.1	< 0.1	0.3	< 0.1	0.1
5	< 0.1	70	< 0.1	< 0.1	3.3	< 0.1	< 0.1	< 0.1	< 0.1	0.1
6	< 0.1	76	0.1	< 0.1	3.3	< 0.1	< 0.1	< 0.1	< 0.1	0.1
7	200	10.3	0.3	< 0.1	1.0	0.1	< 0.1	< 0.1	< 0.1	0.1
8	172	< 0.1	0.7	< 0.1	0.2	1.9	0.2	< 0.1	< 0.1	0.2
9	236	< 0.1	2.2	< 0.1	< 0.1	5.9	0.7	< 0.1	< 0.1	< 0.1
10	30	< 0.1	12.5	< 0.1	< 0.1	4.9	0.4	< 0.1	< 0.1	< 0.1
11	< 0.1	< 0.1	8.9	< 0.1	< 0.1	1.7	< 0.1	< 0.1	< 0.1	0.1
12		< 0.1	12.1	0.4	< 0.1	0.5	< 0.1		< 0.1	< 0.1
13		< 0.1	6.0	1.0	< 0.1	< 0.1	< 0.1			0.1
14			1.8	1.4	< 0.1	< 0.1				< 0.1
15			0.7	2.1	< 0.1	0.6				0.1
16			0.2	5.8	< 0.1	1.7				< 0.1
17			< 0.1	7.8	< 0.1	0.5				0.1
18				6.8	< 0.1	< 0.1				0.2
19				1.9	< 0.1					0.1
20				0.1	< 0.1					0.1
21				< 0.1	< 0.1					0.2
22					< 0.1					< 0.1
23					< 0.1					0.1
24					< 0.1					0.2
25										0.2

All results are in parts per billion by weight.

TABLE III-A

FLUORESCEIN DYE TEST #3

Cross Section

Sample No.	A	B	C	D	DD	E	F
1	0.2	0.2	0.9	0.1	0.9	< 0.1	0.6
2	0.3	0.2	0.3	1.4	< 0.1	0.3	0.1
3	0.1	< 0.1	< 0.1	5.4	< 0.1	< 0.1	0.1
4	< 0.1	< 0.1	0.1	10.5	0.2	< 0.1	< 0.1
5	62	20	0.5	7.4	0.2	0.2	< 0.1
6	36	48	19	1.6	< 0.1	< 0.1	0.1
7	5.1	27	25	< 0.1	0.1	< 0.1	0.1
8	3.8	5.4	13	< 0.1	0.1	0.1	0.2
9			1.1	0.5	0.1	0.1	0.5
10			11	0.6	< 0.1	1.5	0.1
11			4.4	0.6	< 0.1	5.6	0.1
12			0.5	0.1	< 0.1	4.9	< 0.1
13				< 0.1	0.1	0.7	< 0.1
14				< 0.1	0.2	0.4	< 0.1
15				< 0.1	0.3	0.3	< 0.1
16				< 0.1	0.4	0.2	
17				< 0.1	1.0	0.1	
18				< 0.1	1.4	0.1	
19				< 0.1	< 0.1	< 0.1	< 0.1
20				< 0.1	0.3	< 0.1	
21					0.2	< 0.1	
22					0.1	0.3	
23					< 0.1	< 0.1	
24						< 0.1	
25						0.1	

All results are in parts per billion by weight.

TABLE III-B

FLUORESCEIN DYE TEST #3

Sample No.	Pasco Pumping Station	Sample No.	Pasco Pumping Station
1	0.1	26	0.1
2	0.1	27	0.1
3	0.2	28	0.2
4	0.1	29	0.1
5	0.1	30	0.1
6	0.1	31	0.1
7	0.1	32	0.1
8	0.1	33	0.1
9	0.1	34	0.1
10	0.2	35	0.2
11	0.1	36	0.1
12	0.1	37	0.1
13	0.1	38	0.1
14	0.1	39	0.2
15	0.1	40	0.2
16	0.1	41	0.2
17	0.1	42	0.2
18	0.1	43	0.1
19	0.1	44	0.2
20	0.1	45	0.1
21	0.1	46	0.1
22	0.1	47	0.1
23	0.1	48	0.1
24	0.1	49	0.1
25	0.1		

Depth Samples

Sample No.	Cross Section C	D	DD	E
1*	12	11	3.1	3.8
2**	15	11	2.2	3.2

All results are in parts per billion by weight.

* Sample taken at bottom of river.

** Sample taken at mid-depth of river.