POLLUTION IN THE LOWER COLUMBIA BASIN IN 1948 - With particular reference to the Willamette River

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Foreword

The studies included in this report were conducted at the Corvallis Laboratory, Western Fish-Cultural Investigations, U. S. Fish and Wildlife Service. The laboratory facilities, equipment, and supplies contributed for these studies by the Section of Sanitary Engineering, School of Engineering and Industrial Arts, and by the Department of Fish and Game Management at Oregon State College are gratefully acknowledged. The invaluable data, advice, and interest contributed to the study by Profs. R. E. Dimick and Fred Merryfield were particulary helpful.

Messrs. Robert Vencill, John DeWitt, and R. A. Wagner assisted in these studies.

United States Department of the Interior
Oscar L. Chapman, Secretary
Fish and Wildlife Service
Albert M. Day, Director

Special Scientific Report - Fisheries
No. 30

POLLUTION IN THE LOWER COLUMBIA BASIN IN 1948

WITH PARTICULAR REFERENCE TO THE WILLAMETTE BASIN

By

Frederic F. Fish

Formerly Chief, Western Fish-Cultural Investigations*

and

Robert R. Rucker

Fishery Research Biologist

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* Now with Federal Security Agency, Pulbic Health Service.

ILLUSTRATIONS

WATER POLLUTION IN THE LOWER COLUMBIA BASIN, WITH PARTICULAR REFERENCE TO THE WILLAMETTE RIVER

I. A SURVEY OF POLLUTION PROBLEMS IN THE LOWER COLUMBIA BASIN.

Development of the salmon resources of the lower Columbia River Basin appears as sound insurance against the threat of a serious reduction in the runs to the upper river areas through the multiple-purpose programs of water development now under way by the Corps of Engineers, the Bureau of Reclamation, and private interests. Any comprehensive plan for the full development of the fisheries resources in the lower Columbia Basin must be predicated upon accurate knowledge of the waters therein polluted to a degree affecting fish life.

Pollution surveys have been made in the lower Columbia Basin at various times in the past -- the most intensive studies having been made in the Willamette Valley.

Although many major tributaries of the upper Columbia draining either areas of intense population or certain mining operations are reputed to be locally polluted, the main-stem Columbia River at Bonneville Dam was considered "unpolluted" by Lincoln and Foster (1943). Lincoln and Foster considered only three reaches of the Columbia River below Bonneville Dam as being polluted to a degree potentially affecting fish life, namely: (1) Camas Slough, polluted by pulp-mill wastes; (2) Multnomah and Columbia Sloughs, through which the heavily-polluted Willamette River enters the Columbia; and (3) the lower Cowlitz River, polluted by paper processing industries in the vicinity of Longview, Washington. Lincoln and Foster state categorically: "there appears no evidence, either direct or circumstantial, which would indicate that the salmon runs of the main Columbia River are being damaged by pollution in the main channel. Without doubt, however, some of the races which formerly did, and some which now do, ascend tributaries such as the Willamette, have and are suffering greatly from wastes discharged into these water courses."

Certain lower Columbia tributaries have been surveyed for pollution. Lincoln and Foster report the Umatilla, John Day, Deschutes, Klickitat, Wind, and Sandy Rivers "carry some domestic sewage, but the amounts are relatively small and ... any effects are probably localized." Merryfield and Wilmot (1945) state that "the Umatilla River below Pendleton is seriously contaminated."

The Willamette River has constituted a serious pollution problem of many years standing.

Routine samples were collected from the Willamette by the Portland City Health and City Engineering Departments at seven stations located between Sellwood Bridge (River Mile 16.5) and the confluence with the Columbia over a 27-month period between October, 1926, and December, 1928. During the month of August, 1927, and during both August and September, 1928, the oxygen content of the river was found to be less than three parts per million.

Rogers, Mockmore, and Adams (1930) made more critical studies when surveying the Willamette and major tributaries during July and August, 1929. They continued sampling at key stations on the main stem between the city of Cottage Grove and the Sellwood Bridge, Portland, at monthly intervals between October, 1929, and May 1930.

Gleeson (1936) made an intensive study of the pollution and tidal complex in the Portland Harbor area of the Willamette. Gleeson's studies were made between the Sellwood Bridge and the Columbia River, September 5 to 27, 1934.

Craig and Townsend (1946) report a series of seven spot samplings at Sellwood Bridge and at St. Johns Bridge, Portland, between February 4, and July 28, 1941, and four samplings between May 2, and August 21, 1942. Their data indicate that an oxygen block (i.e., less than 5 ppm.) formed in the Willamette River at St. Johns Bridge sometime between March 18 and May 1, 1941. Likewise, an oxygen block developed upriver at Sellwood Bridge between May 29 and July 17, 1941. An oxygen block developed at both sampling stations sometime between May 2, and early August in 1942.

The most recent pollution studies in the Willamette Basin were reported by Merryfield and Wilmot (1945) and by Dimick and Merryfield (1945). These studies included both the major tributaries and the main-stem Willamette (downstream to Sellwood Bridge) and were conducted between August and December, 1944 -- with bi-monthly sampling at critical main-stem stations extending until March 1945. Insofar as the main-stem Willamette is concerned, Merryfield and Wilmot demonstrated that an oxygen block extended upstream to approximately river mile 60 at the time their studies were undertaken in August. The block had been forced downstream to river mile 54 by October and disappeared entirely late in that month.

It is quite obvious from the studies that have been made to date that pollution constitutes a serious fisheries problem in the Willamette Basin and one which cannot be fully evaluated with existing data. Certain facts are known concerning the migratory-fish runs of the Willamette and also about the low-oxygen barrier in the lower reaches of the main stem. Neither are sufficiently well known, however, to evaluate the effect of pollution upon the fish runs.

II. 1948 STUDIES

A. Reconnaissance Survey, September-October, 1948.

Pollution research was added to the work program of Western Fish-Cultural Investigations on July 1, 1948. A cooperative project with the Section of Sanitary Engineering at Oregon State College was effected immediately thereafter. By the time that funds available for pollution studies were known, personnel concentrated, and laboratory facilities readied, the 1948 low-water stage of the Willamette had passed. Likewise, the summer of 1948 was accompanied by relatively high river flows and cool temperatures and it did not constitute a critical year for evaluating pollution at its maximum effect.

It was decided that a reconnaissance survey of the Willamette and its major tributaries comprised the best use of the limited time available for field studies before the onset of the fall rains. It was fully recognized that a survey of this type would be subject to all the limitations inherent to spot sampling and that the results would be indicative but not conclusive. The survey should reveal all potential sources of pollution qualitatively if not quantitatively and thus indicate areas for future and more critical study.

Standard procedures were employed for the dissolved oxygen and biochemical oxygen demand tests. The field studies were undertaken on September 9, 1948, and each major tributary sampled at progressive intervals downstream--starting at a point above all apparent sources of major pollution.

The results obtained during the six-week period before river stages rose significantly with increasing rainfall are listed on Table 1.

B. Interpretation of Results

Five parts per million of dissolved oxygen customarily are accepted as the threshold between a satisfactory and an unsatisfactory environment for cold-water fishes. Dissolved oxygen concentrations ranging between three and five parts per million are considered to indicate moderate pollution by oxygen-consuming wastes, and concentrations below three parts per million indicative of severe pollution. A reduced dissolved oxygen concentration (DO), often expressed in terms of percentage saturation to compensate for variations in temperature, indicates only the degrading effects of oxygen-consuming wastes that have occurred up to the time and place of sampling, and it offers no index of any further degradation that may be expected from the oxygen-consuming wastes.

T A B L E 1

POLLUTION SURVEY DATA, SEPTEMBER - OCTOBER, 1948

A. Main-Stem, Willamette River

Sampling Station	River Mile	Date	Hour	Temp. °C	Dissolved Oxygen ppm.	Dissolved Oxygen % sat.	5-day B.O.D. ppm.	Conductivity mho x 10^{-6}
Springfield to Corvallis:								
1. Springfield Bridge	185.6	10/14	12:30	13.1	9.6	91	0.7	53.0
		10/28	10:10	7.8	10.7	89	0.6	52.6
City of Eugene	182.5							
2. Eugene-Coburg Road Bridge	182.2	10/14	13:15	12.8	9.7	91	0.7	53.6
3. Right bank, Wilbur Revetment	178.2	10/14	14:00	13.0	9.2	87	3.9	63.9
		10/28	9:30	8.4	10.3	88	0.8	52.0
4. Left bank, Wilbur Revetment	178.2	10/28	11:05	8.3	10.4	91	1.3	56.6
5. Above confluence of McKenzie	165.0	10/28	11:45	8.5	10.3	88	1.1	56.2
6. At 99-E Bridge, Harrisburg	164.3	10/14	15:00	12.0	9.2	85	0.0	51.7
		10/28	12:30	8.5	10.6	91	1.0	53.9
7. Irish Bend	148	10/28	13:00	8.9	10.4	92	0.7	53.4
8. Peoria Ferry site	144.5	10/14	15:30	13.0	8.8	83	1.3	49.8
		10/28	13:20	9.0	10.2	88	1.4	51.6
9. At Benton County Gravel Pit	137	10/ 8	13:45	13.0	9.9	94	1.8	45.7
		10/14	16:10	13.0	8.8	83	2.6	51.0
		10/15	8:30	12.2	9.7	90	2.4	48.8
		10/28	14:20	9.6	10.1	88	1.6	52.0
City of Corvallis	133.0							
Corvallis to Salem:								
10. Log Boom below Corvallis	130.8	10/8	14:35	13.0	9,8	93	2.0	47.9
		10/15	8:55	12.0	9.7	89	2.7	50.9
		10/28	14:45	9.7	10.0	88	2.3	53.4
11. Camp Adair Water Intake	122.5	10/15	9:15	12.2	9.7	90	2.6	50.9
City of Albany	119.4							

TABLE 1 - Continued

Main-Stem Willamette River

Sampling Station	River Mile	Date	Hour	Temp. °C	Dissolved Oxygen ppm.	Dissolved Oxygen % sat.	5-day B.O.D. ppm.	Conductivity mho x 10^{-6}
12. Ufford Revetment	116.5	10/15	9:35	12.3	9.9	92	3.1	51.8
13. Beuna Vista Ferry	106.5	10/15	10:30	12.3	9.6	89	2.3	47.2
14. Independence Ferry	96.2	10/15	11:05	1[illegible].3	9.6	89	2.2	49.1
15. Eola	87.5	10/15	12:00	12.3	9.6	89	2.1	49.7
		10/16	7:50	11.2	9.6	87	2.0	50.3
City of Salem	85.0							
Salem to Portland:								
16. At Wheatland Ferry	72.5	10/16	8:30	11.8	9.1	83	3.3	55.3
17. At Wilsonville Ferry	38.8	10/16	10:30	13.0	8.1	76	2.4	55.3
18. Bank Sample, New Era	31.8	10/16	11:10	13.1	7.7	73	2.5	55.3
19. Bank Sample above Clackamas and below Oregon City	25.7	10/16	11:45	13.0	7.7	73	4.9	57.1
20. Sellwood Bridge, Portland	16.5	10/16	12:30	13.2	7.9	75	3.6	56.4
21. Steel Bridge, Portland	12.1	10/16	14:00	13.0	7.4	70	4.5	56.7

T A B L E 1 - C o n t i n u e d

POLLUTION SURVEY DATA, SEPTEMBER - OCTOBER, 1948

B. Major Tributaries

Sampling Station	River Mile	Date	Hour	Temp. °C	Dissolved Oxygen ppm.	Dissolved Oxygen % sat.	5-day B.O.D. ppm.	Conductivity mho x 10^{-6}
I. Coast Fork Willamette Basin								
A. Coast Fork Willamette								
1. Above Cottage Grove Reservoir	34	9/10	11:15	20	8.7	94	0.7	88.5
2. Below Cottage Grove Reservoir	27	9/10	12:20	19.8	7.8	85	0.6	61.8
3. Highway 99, South of Cottage Grove	22	9/10	12:55	20.2	8.2	89	1.0	59.1
City of Cottage Grove	21							
4. Highway 99, North of Cottage Grove	19	9/10	15:40	20.9	8.0	87	1.3	62.5
Confluence of Row River	18							
5. At Saginaw Bridge	17	9/10	15:55	21	7.9	88	1.8	65.6
6. Below Goshen Revetment	1	9/10	16:30	23.8	8.9	104	1.0	60.3
B. Row River								
1. Above Dorena Dam Site		9/10	14:20	22.1	8.6	97	0.6	73.6
2. Below Dorena Dam Site *		9/10	15:00	22.4	7.7	88	1.7	71.7
C. Mosby Creek								
1. At SPRR Bridge		9/10	15:20	18.2	8.5	90	0.60	69.5

* Row River extremely turbid at this station from gravel washing at Dorena Dam

T A B L E 1 - C o n t i n u e d

B. Major Tributaries

Sampling Station	River Mile	Date	Hour	Temp. °C	Dissolved Oxygen ppm.	Dissolved Oxygen % sat.	5-day B.O.D. ppm.	Conductivity mho x 10^{-6}
II. Middle Fork Willamette Basin								
A. Middle Fork Willamette:								
1. Above Hills Creek	46.5	9/9	10:15	11.2	9.6	87	0.4	51.6
Town of Oakridge	44.0							
2. At Hells Gate Bridge	40.0	9/9	12:45	14	10.0	97	0.9	58.5
Confluence of North Fork	39.5							
3. At Eula	31.5	9/9	13:07	15.1	10.1	99	1.2	35:5
4. At Lowell Bridge	20.3	9/9	13:44	17.0	10.0	103	1.3	66.3
5. Town of Jasper	8	9/9	14:45	19.6	6.5	71	1.3	68.9
B. Hills Creek								
1. 100 feet above mouth		9/9	10:23	11.7	9.9	91	1.7	93.2
C. Salt Creek								
1. Military Road Bridge	1	9/9	10:38	10.3	10.2	90	1.0	63.3
D. Salmon Creek								
1. Highway 58 Bridge	0.5	9/9	11:16	12.8	9.3	88	0.6	58.6
E. North Fork of Middle Fork								
1. 300 feet above mouth		9/9	11:41	18.6	8.9	96	1.6	51.6
F. Fall Creek								
1. 1 mile above mouth		9/9	14:20	19.0	8.6	92	2.0	57.9
III. McKenzie River Basin:								
A. McKenzie:								
1. Eugene Water Board Bridge	50	9/14	9:45	10.6	10.5	94	1.3	54.0
2. At Walterville Bridge	26.4	9/14	10:50	13.0	8.7	82	0.0	55.8
3. At Mohawk Road Bridge	16.5	9/14	12:00	13.8	8.1	78	0.0	52.6
4. At Armitage Bridge	8.5	9/14	12:33	14.2	9.4	90	0.9	53.6
		10/14		10.9	10.3	93	0.3	49.4
		10/28		6.0	10.8	86	0.4	54.4

TABLE 1 - Continued

B. Major Tributaries

Sampling Station	River Mile	Date	Hour	Temp. °C	Dissolved Oxygen ppm.	Dissolved Oxygen % sat.	5-day B.O.D. ppm.	Conductivity mho x 10^{-6}
III. McKenzie River Basin- Continued								
B. Mohawk:								
1. 1 mile above mouth	1	9/14	11:40	17.1	7.4	76	0.1	61.5
IV. Long Tom River Basin:								
A. Long Tom River:								
1. Below Fern Ridge Dam	29	9/14	14:05	21.0	7.1	79	3.0	41.1
2. At Cheshire Bridge	23	9/14	14:35	21.0	7.8	86	1.8	52.8
3. At Monroe Bridge(Town of Monroe)	8.5	9/14	15:15	21.5	7.5	85	3.0	66.7
		10/28	15:30	9.0	9.0	77	3.8	43.1
4. At Alpine Bridge	6.2	9/14		21.5	8.8	99	1.3	64.5
5. At Burnett Bridge	2.6	9/14	16:25	21.0	7.9	88	1.1	69.8
6. At Bruce Bridge	1.0	9/14	16:00	20.8	6.3	71	0.8	74.8
V. Calapooya River Basin:								
A. Calapooya River:								
1. At Highway 228 Bridge	52	10/6	11:25	10.8	10.7	96	1.9	38.2
2. Below Crawfordsville	48.5	10/6	11:35	10.9	10.5	95	0.9	39.4
3. Thompson Mill race	24	10/6	12:40	13.0	9.3	87	1.3	46.2
4. At Highway 99-E Bridge	19.4	10/6	13:00	13.0	9.8	93	1.0	44.9
5. Old Corvallis Road Bridge	3.0	10/6	13:35	14.0	9.5	92	1.3	50.8
B. Albany Power Ditch at Albany		10/6	13:20	11.5	10.6	97	1.1	33.9
VI. Mary's River Basin:								
A. Mary's River:								
1. Near Harris School	25.0	9/15	9:45	14.8	8.4	83	0.3	82.7
		9/29	13:20	12.7	9.6	90	0.2	68.1
2. At US-20 Bridge above Wren	22.8	9/15	10.30	15.3	7.9	78	0.4	80.2
3. At H-II Bridge	21.7	9/15	10.05	15.5	7.9	80	0.9	88.7
		9/29	13:40	13.0	10.0	95	0.9	78.4

TABLE 1 - Continued

B. Major Tributaries

Sampling Station	River Mile	Date	Hour	Temp. °C	Dissolved Oxygen ppm.	Dissolved Oxygen % sat.	5-day B.O.D. ppm.	Conductivity mho x 10^{-6}
VI-A. Mary's River-continued								
4. At US-20 Bridge above Philomath	14.4	9/29	14:05	12.8	10.0	94	0.7	91.9
5. At Alsea Highway Bridge	13.3	9/15	10:50	17.0	7.3	75	1.1	104.3
6. At bridge south of Philomath	12.0	9/29	14:20	13.3	9.3	88	0.8	93.0
7. At bridge south of Union cemetery	9.5	9/15	11:30	17.4	7.1	73	0.2	110.1
		9/29	14:40	13.0	9.3	87	0.8	94
8. At bridge south of Plymouth	8.2	9/15	11:50	18.4	7.0	74	0.2	110.1
		9/29	14:55	13.3	9.2	88	0.7	95.1
9. At Wake Robin Lane bridge (above dam)	2.9	9/29	15:45	14.0	8.0	78	0.9	83.0
10. At KRUL Bridge (below dam)	0.6	9/15	12:30	21.8	1.5	17		119.4
		9/29	15:30	16.0	6.4	64	3.0	111.2
B. Chapman Ditch								
1. At 99-W Bridge		9/29	15:50	13.0	7.8	73	0.8	83.6
C. Greasy Creek								
1. Near Mouth		9/15	11:05	16.5	6.9	71	0.4	97.0
VII. Luckiamute River Basin:								
A. Luckiamute River								
1. At Maple Grove Bridge	16.3	9/16	11:05	16.7	7.8	80	0.5	66.1
2. At Helmick State Park	8.5	9/16	14:30	17.8	7.8	82	0.6	82.8
3. At Davidson Bridge	1.2	9/16	15:00	19.1	6.8	73	0.0	82.8
B. Little Luckiamute River								
1. Above Fall City	12.7	9/16	10:10	12.2	9.4	87	0.2	52.3
2. Below Fall City (Bridgeport)	9.0	9/16	10:35	13.8	8.8	85	0.3	51.8
3. At Elkins School Road Bridge	0.6	9/16	11:30	16.0	8.1	81	0.7	60.1
VIII. Rickreall Creek Basin:								
A. Rickreall Creek								
1. At Ellendale	16.3	9/16	12:25	14.5	8.8	86	0.3	103.5
		9/29	8:20	9.7	10.5	92	0.6	83.2

TABLE 1 - Continued

B. Major Tributaries

Sampling Station	River Mile	Date	Hour	Temp. °C	Dissolved Oxygen ppm.	Dissolved Oxygen % sat.	5-day B.O.D. ppm.	Conductivity mho x 10^{-6}
VIII. A. Continued								
2. At Highway 223 Bridge City of Dallas	13.0	9/29	8:30	10.6	9.9	89	7.0	281.8
3. At 1st bridge below Dallas	11.0	9/29	8:45	11.6	7.3	65	2.4	103.5
4. At 2nd bridge below Dallas	9.7	9/16	13:15	18.0	6.9	72	3.0	160.5
		9/29	9:00	12.2	8.1	75	3.5	109.3
5. At Highway 99-W Bridge	7.9	9/29	9:20	12.4	8.3	77	1.4	109.9
6. At Greenwood School Bridge	4.5	9/29	9:50	12.8	8.4	79	0.7	116.9
7. At Highway 51 Bridge	2.0	9/16	13:45	17.7	5.5	57	2.5	147.5
		9/29	10:05	13.0	8.1	77	0.9	111.4
IX. Santiam River Basin:								
A. South Santiam River								
1. 4.6 miles above Foster	53	9/30	8:35	8.5	10.8	92	0.7	42.1
2. At Waterloo Bridge	34.5	9/30	9:50	10.3	10.2	91	0.0	39.9
3. At Lebanon Bridge	30.0	9/30	10:50	11.3	10.2	93	0.2	41.1
4. At Crabtree Bridge	20.0	9/30	11:15	12.2	8.4	78	1.9	42.1
B. Middle Santiam River								
1. 1.5 miles above mouth	1.5	9/30	9:15	9.2	10.4	90	0.0	36.4
C. Thomas Creek								
1. Above Scio, near Arnold School		9/30	12:15	10.4	10.7	95	0.3	33.9
2. Below Scio, near Gilkey		9/30	11:50	11.0	10.2	92	0.3	34.6
D. Crabtree Creek:								
1. Near School #10		9/30	11:40	10.9	10.2	92	0.5	32.1
E. North Santiam River:								
1. At Gates Bridge	38.0	9/30	13:20	9.2	11.0	96	0.3	40.3

TABLE 1 - Continued

B. Major Tributaries

Sampling Station	River Mile	Date	Hour	Temp. °C	Dissolved Oxygen ppm.	Dissolved Oxygen % sat.	5-day B.O.D. ppm.	Conductivity mho x 10^{-6}
IX. E. Continued								
2. At SPRR Bridge, Mill City	34.5	9/30	13:40	10.3	10.5	93	0.0	40.0
3. At Mehama Bridge	26.0	9/30	14:05	12.3	10.5	98	0.3	37.3
4. At Green's Bridge	3.0	9/30	15:25	13.5	10.5	100	0.3	40.2
F. Little North Santiam:								
1. 1.0 miles above mouth	1.0	9/30	14:20	11.1	10.2	92	0.0	28.3
G. Santiam River:								
1. At old 99-E bridge	9.7	9/30	15:45	14.0	9.8	94	1.2	44.0
2. At new 99-E bridge	7.5	9/30	16:10	14.0	9.4	90	1.2	46.4
X. Yamhill River Basin:								
A. South Yamhill River								
1. At Wallace Bridge	43.7	9/22	8:25	13.8	8.9	85	1.3	88.3
2. At Sheridan Railroad bridge	37.3	9/22	9:10	14.5	8.7	85	0.9	98.5
3. At Ballston bridge	32.4	9/22	9:35	15.0	8.0	79	1.1	100.0
4. At Bellevue-Amity road bridge	26.3	9/22	10:15	15.8	7.7	77	1.3	113.3
5. At 99-W bridge above McMinnville	16.8	9/22	10:45	16.5	8.2	84	0.9	116.6
6. 3 miles below McMinnville	2.8	9/22	11:15	16.8	4.9	50	2.8	133.3
B. Willamina Creek								
1. At Highway 18 bridge at mouth		9/22	8:40	13.0	9.2	87	1.0	99.1
C. North Yamhill River								
1. West of Yamhill	13.8	9/22	12:25	13.6	8.6	83	1.0	105.2
2. Below Carlton Dam	8.6	9/22	12:55	15.3	7.3	72	1.8	111.7
3. Below Carlton	3.9	9/22	13:15	14.7	7.0	69	1.4	116.1
D. Yamhill River								
1. Forebay, Government Locks	7.5	9/22	13:50	16.7	2.6	26	1.5	137.6
2. At Dayton Bridge	5.1	9/22	14:10	17.6	5.6	58	1.0	136.5

TABLE 1 - Continued

B. Major Tributaries

Sampling Station	River Mile	Date	Hour	Temp. °C	Dissolved Oxygen ppm.	Dissolved Oxygen % sat.	5-day B.O.D. ppm	Conductivity mho x 10^{-6}
XI. Pudding River Basin:								
A. Pudding River:								
1. Near Brush Creek	32.0	10/1	8:35	10.8	8.2	74	1.3	60.3
2. At Cline Bridge	27.0	10/1	10:00	10.2	9.5	84	0.8	37.8
3. At Highway214 Bridge	17.5	10/1	10:35	12.6	9.1	85	1.0	70.4
4. East of Hubbard	10.0	10/1	11:10	13.0	7.1	67	1.8	69.9
5. At 99-E Bridge	8.2	10/1	15:10	13.8	8.4	80	1.3	79.5
6. At Pat's Acres Bridge	5.0	10/1	14:30	13.8	8.5	81	1.4	100.3
B. Silver Creek:								
1. Above Silverton	5.5	10/1	9:05	9.1	11.0	95	1.0	27.7
2. Below Silverton	1.1	10/1	9:35	10.0	9.7	86	1.5	31.4
C. Abiqua Creek:								
1. At Highway 214 Bridge		10/1	9:45	10.0	10.6	93	1.0	33.0
D. Mill Creek:								
1. At Aurora Bridge		10/1	14:50	13.0	8.7	82	1.0	373.4
XII. Molalla River Basin:								
A. Molalla River:								
1. Above Molalla	16.2	10/1	11:50	11.8	11.0	101	1.1	37.0
2. At Wright's Bridge	14.4	10/1	12:20	13.2	11.0	104	1.0	38.5
3. At Good's Bridge	6.4	10/1	13:05	14.0	11.0	106	1.0	43.7
4. At Knight's Bridge Site	2.5	10/1	14:20	14.0	10.4	101	0.8	45.6
B. Milk Creek								
1. Highway bridge near mouth		10/1	12:50	11.9	10.5	96	1.1	48.2
XIII. Tualatin River Basin:								
A. Tualatin River:								
1. South of Dilley	58.0	9/23	9:00	11.7	8.1	75	1.8	94.3
2. Bridge S&E of Forest Grove	52.0	9/23	10:10	12.4	7.7	71	0.3	105.8
3. Highway 219 bridge below Hillsboro	41.5	9/23	11:10	12.7	7.5	70	2.3	104.8

TABLE 1 - Continued

B. Major Tributaries

Sampling Station	River Mile	Date	Hour	Temp. °C	Dissolved Oxygen ppm.	Dissolved Oxygen % sat.	5-day B.O.D. ppm	Conductivity mho x 10^{-6}
XIII. A. - Continued								
4. At Farmington Bridge	32.4	9/23	11:30	13.4	5.8	55	1.3	140.5
5. At Scholls Bridge	26.4	9/23	11:50	14.2	5.2	50	1.3	128.0
6. At 99-W Bridge	11.7	9/23	12:25	15.6	5.4	55	1.7	133.4
7. Bridge east of Tualatin	8.4	9/23	12:50	15.0	5.7	56	1.6	135.3
8. At Field Bridge	1.7	9/23	14:00	15.4	7.9	78	2.2	129.5
B. Gales Creek:								
1. Above Forest Grove		9/23	9:20	11.8	8.8	81	0.0	106.1
2. Below Forest Grove		9/23	9:45	13.0	8.2	78	0.9	111.6
C. Dairy Creek:								
1. At Highway 6 Bridge		9/23	10:40	12.1	7.5	69	1.0	96.8
D. Oswego Canal:								
1. Middle Bridge		9/23	13:30	15.1	6.0	59	1.4	132.6
XIV. Clackamas River Basin:								
A. Clackamas River:								
1. At Highway 211 Bridge	24.2	9/20	11:55	12.8	9.5	89	1.4	63.6
2. At Barton Bridge	12.8	9/20	12:45	13.0	10.0	95	1.1	64.4
3. At Baker Bridge	7.7	9/20	13:20	13.5	10.3	100	1.3	60.5
4. At Highway 99-E Bridge	0.3	9/20	14:40	14.7	10.5	103	1.8	61.5
XV. Johnson Creek:								
1. At 99-E Bridge		9/20	10:25	14.0	8.4	81	0.5	171.5
XVI. Kellogg Creek:								
1. At Milwaukie Heights		9/20	10:45	13.2	9.6	91	0.6	166.2

The best (but by no means a completely satisfactory) quantitative measure of the organic pollution burden carried by a stream at the time of sampling is the Biochemical Oxygen Demand (BOD). The BOD determination represents the quantity of oxygen consumed in a sealed water sample during a five-day incubation period at 20° C. The five-day BOD grossly approximates two-thirds of the total quantity of oxygen that will be required for complete satisfaction of the oxygen-consuming wastes. The reverse of the DO concentrations ordinarily is used to assess BOD determinations, namely; a five-day BOD between zero and three parts per million is considered to indicate light pollution, a five-day BOD between three and five parts per million as indicating moderate to moderately heavy organic pollution, and determinations exceeding five parts per million as indicative of severe pollution.

Conductivity, *per se*, does not measure offensive pollution in that an increase in the electrical conductivity merely indicates an increase in the ionic concentration which may, or may not, be composed of ions toxic to fish life. It is used, primarily as an index of inorganic pollution.

Considering the results obtained from stream sampling during the September-October, 1948, reconnaissance survey, the following tentative conclusions appear warranted:

1. Main-Stem Willamette River.

The main-stem Willamette, between the Springfield Bridge above Eugene and the Steel Bridge in Portland, was surveyed on October 14, 15 and 16. Several partial surveys were made both before and after the main survey.

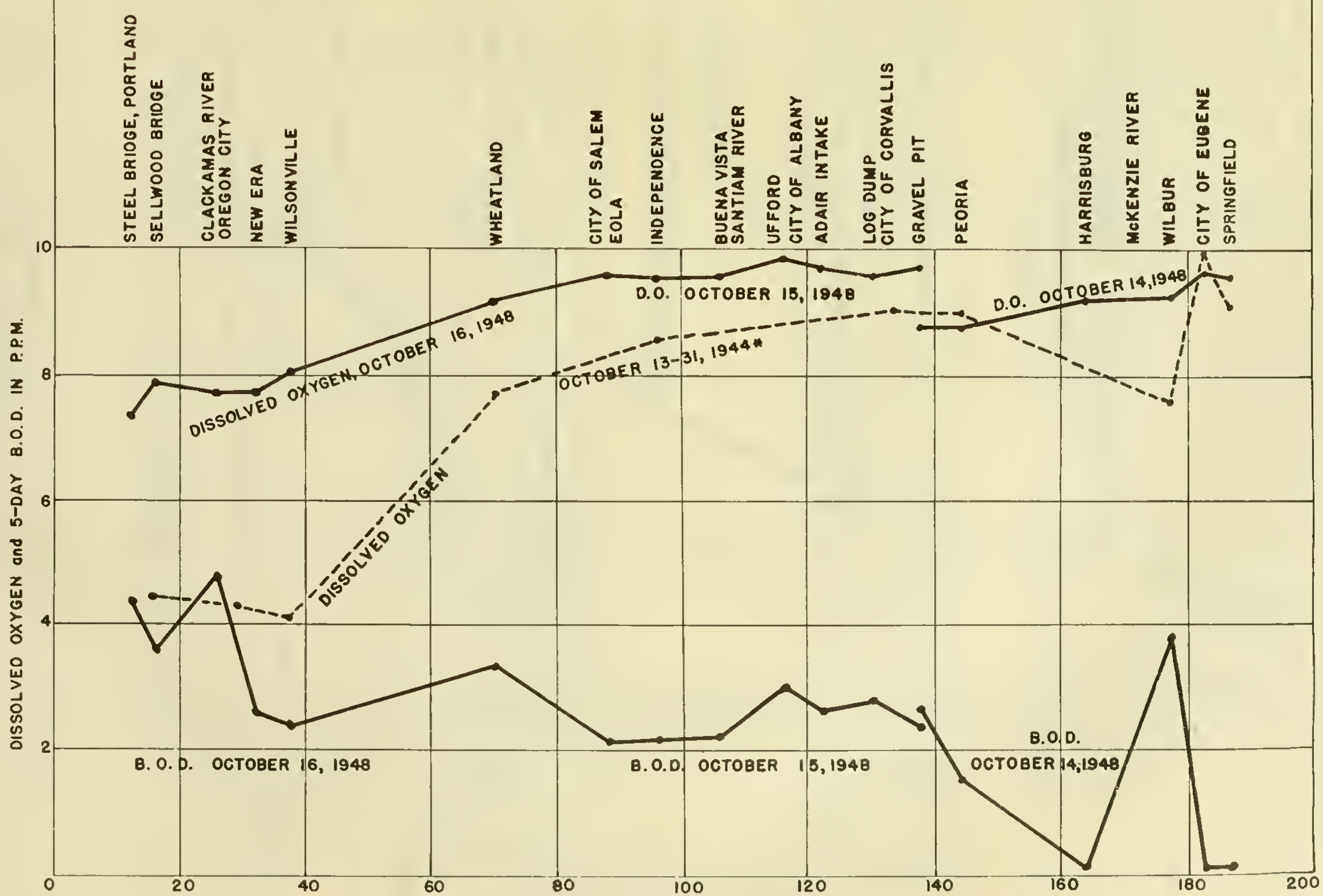
The results of the complete mid-October survey indicated that, in spite of an increasing BOD and conductivity and some decrease in DO at progressive downstream stations, no oxygen block existed at the time. Superficially, at least, the river was open to the passage of migratory fishes. The 1948 results differed in this major respect from those obtained by Merryfield and Wilmot during a comparable period in 1944. The 1948 DO and BOD data, superimposed upon the DO data from Merryfield and Wilmot (1945), are shown in Figure 1.

The difference in the DO picture obtained during October, 1944, and during October 1948, unquestionably stemmed from the much greater volume of river discharge prevailing during 1948. As shown in Figure 2, the river discharge during the 1948 survey was much greater than that prevailing at the time of the 1944 survey by Merryfield and Wilmot.

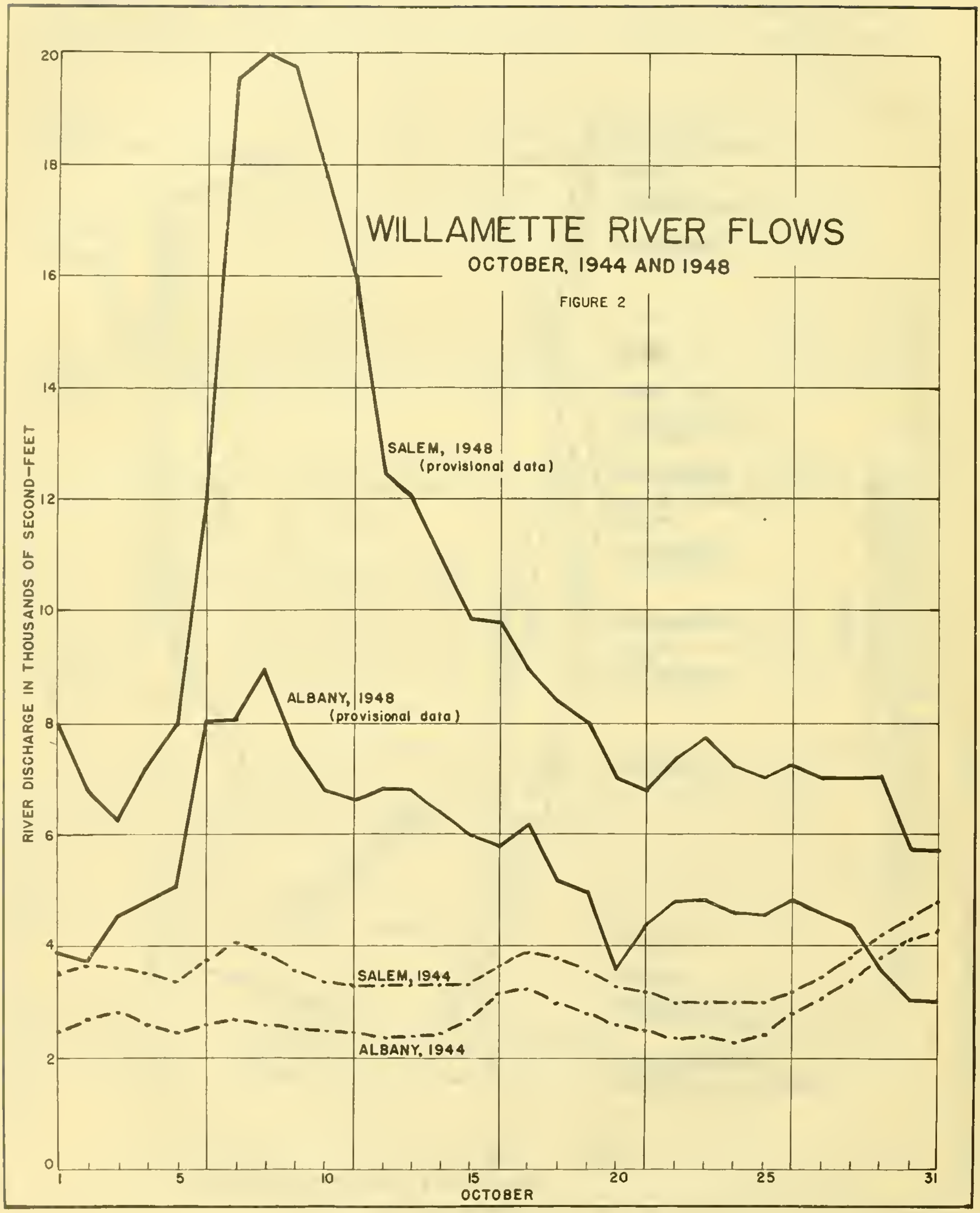
OXYGEN PROFILES, WILLAMETTE RIVER

OCTOBER, 1944 AND 1948

FIGURE 1



* Data from Merryfield and Wilmot (1945)


WILLAMETTE RIVER FLOWS
OCTOBER, 1944 AND 1948
FIGURE 2
RIVER DISCHARGE IN THOUSANDS OF SECOND-FEET
SALEM, 1948
(provisional data)
ALBANY, 1948
(provisional data)
SALEM, 1944
ALBANY, 1944
OCTOBER
0
2
4
6
8
10
12
14
16
18
20
1
5
10
15
20
25
31

The diluting effect of the higher 1948 flows can more clearly be demonstrated by comparing the data in terms of pounds per day rather than in parts per million. Merryfield and Wilmot did not report BOD determinations during their October 1944 survey. The 6.4 ppm. 20-day BOD reported by these authors at Wheatland during late August 1944, however, represents a demand of approximately 100,000 pounds of oxygen per day based upon river discharges at the time recorded on the Salem gage twelve miles upstream. The 4.88 ppm. 20-day BOD obtained at Wheatland on October 16, 1948 represents a demand of approximately 250,000 pounds of oxygen per day. A similar comparison of data obtained at a common sampling point below Corvallis indicates an oxygen demand of approximately 35,000 pounds per day in late August 1944, in comparison with a demand of approximately 75,000 pounds per day in October 1948.

The assumption appears tenable, therefore, that the pollution burden of the main-stem Willamette during October 1948, was considerably heavier than that during late August 1944. Whether the increased oxygen demand stemmed from a heavier pollution burden added to the Willamette during the intervening four years or from normal seasonal variations in the pollution burden cannot be determined with available data.

2. Major Tributaries

a. Coast Fork Willamette Basin

The changes found in both DO and BOD concentrations of water passing through the Cottage Grove Reservoir presumably are not significant. The sharp drop in conductivity at the downstream sampling station indicates that the water being discharged from the reservoir at the time of the survey was not of the same composition as that entering the reservoir. The gradual increase in BOD and the accompanying decrease in DO at progressive stations downstream from the city of Cottage Grove indicate the addition of oxygen-consuming wastes--presumably domestic sewage--over this area. The Cottage Grove Reservoir was being evacuated at the time of the survey and the downstream reach of the Coast Fork Willamette was flowing bankfull. Flows recorded at Saginaw Bridge on September 10 (date of survey) were 1,070 cfs. in comparison with a normal seasonal minimum of about 65 cfs. It is probable, therefore, that the pollution added to the Coast Fork Willamette in the vicinity of Cottage Grove would be serious during the period of minimum flow--as found by Merryfield and Wilmot. Pollution of the Coast Fork Willamette affects only resident game fishes as this tributary supports no migratory-fish runs.

Neither the Row River nor Mosby Creek, major tributaries of the Coast Fork Willamette, yielded any evidence of serious pollution. The relatively high BOD of the Row obtained below the Dorena Dam site presumably resulted from temporary gravel washing operatings attending construction work on the dam.

b. Middle Fork Willamette Basin

No evidence of serious pollution was found in the Middle Fork Willamette Basin. As might be expected, a gradual rise in both BOD and conductivity developed progressively downstream, but neither approached the borderline of significant pollution.

c. McKenzie River Basin

No evidence of serious pollution was found in the McKenzie River drainage.

d. Long Tom River Basin

Water discharged from the Fern Ridge Reservoir exhibited a relatively high BOD indicating that oxygen-consuming decomposition within the reservoir had not yet reached the state of complete oxygen satisfaction. Aeration and dilution (indicated by the increasing conductivity) in the next six miles downstream reduced the BOD and increased the DO. The sharp rise in BOD and conductivity at the town of Monroe indicated an increase in pollution, presumably by domestic sewage, at that point. There is no evidence that the pollution burden added at the town of Monroe would prove of serious consequence even during low water. The Long Tom River on September 14 (date of first survey) was flowing 37 cfs. at Monroe in comparison with a normal season minimum of about 25 cfs. at this point.

e. Calapooya River

No evidence of a serious pollution was found in the Calapooya River--at least above the city limits of Albany. The Calapooya was, at the time of the survey, well above minimum stage--a flow of 219 cfs. being reported at Albany on October 15 (one week after the survey) in comparison with a normal seasonal minimum flow of approximately 20 cfs. Merryfield and Wilmot (1945) stated ". . .the Calapooya shows evidence of severe contamination."

f. Marys River

No evidence of pollution of sufficient intensity to affect fish life was found in Marys River except in the reach between the Chapman Mill Dam and the City of Corvallis. The intervening "dry stretch" of the Marys apparently is seriously polluted during the summer months probably by a combination of organic material accumulating in the pools when high river flows provide a spill over the Chapman Dam and domestic sewage entering from Squaw and Oak Creeks. Unfortunately, the slack-water polluted reach of Marys River borders Avery Park, an area of extremely high recreational value in which the city of Corvallis has a considerable investment in swimming and boating facilities.

g. Luckiamute River

No evidence of pollution was found in either the Luckiamute or Little Luckiamute River drainages.

h. Rickreall Creek

The City of Dallas apparently seriously pollutes Rickreall Creek as evidenced by an extremely high BOD, a marked increase in conductivity, and a decreased DO, obtained below Dallas on each of the two surveys. Rickreall Creek is not gaged but it is believed that the flows observed during both surveys were considerably above the minimum seasonal flow.

Pollution of Rickreall Creek would constitute a resident fish problem primarily as migratory fishes apparently only occasionally enter this stream.

Dimick and Merryfield (1945) reported a DO of 2.2 parts per million obtained on September 6, 1944, in the lower reach of Rickreall Creek.

i. Santiam River Basin

Pollution of sufficient intensity to affect fish life was not present in the Santiam River Basin at the time of this survey. A marked rise in both BOD and conductivity, with an accompanying drop in DO, was found immediately below the City of Lebanon on the South Santiam. These observations tend to confirm those by Dimick and Merryfield (1945) that extremely serious pollution does exist in the lower reach of the South Santiam during low water stages as a result of industrial and domestic wastes added at Lebanon. A DO of 8.3 ppm was recorded at Crabtree Bridge, 10 miles below Lebanon, on September 30, 1948. Dimick and Merryfield reported a 0.0 DO obtained at the same station on September 8, 1944.

j. Yamhill River Basin

No evidence of serious pollution was found in the Yamhill Basin except for the reach of the South Yamhill between McMinnville and the forebay of Government Locks on the main Yamhill.

The 4.9 ppm DO concentration found in the South Yamhill below McMinnville on September 22, 1948, when the river flow was approximately 45 cfs, is indicative of a DO depression to about 1 ppm at the low-water stages of about 25 cfs. This indication of severe pollution agrees with the findings of Dimick and Merryfield who reported a 4.0 ppm DO concentration obtained near the mouth of the Yamhill on August 23, 1944.

The pollution problem on the Yamhill would be of consequence primarily to resident game fishes. Attendants occasionally report seeing "large fish" at Government Locks, but it is believed that very few migratory fishes enter the Yamhill at the present time.

k. Pudding River Basin

The quality of the Pudding River, as revealed by a survey on October 1, 1948, fell well within the tolerance limits established for cold-water fishes. The BOD was consistently high over the entire course of this stream, but at no station was it found to be seriously high. A DO of 7.1 ppm and a 5-day BOD of 1.77 ppm were recorded at River Mile 10 below Woodburn--the same station from which Dimick and Merryfield reported a DO of 0.2 ppm and a 20-day BOD of 23.2 ppm on September 22, 1944. The discrepancy in results may be explained, in part, by the difference in water flows on the dates in question. The flow on September 22, 1944 was 76 cfs. compared with a flow of 107 cfs. on October 1, 1948. Pollution of the Pudding reputedly results from wastes discharged from the extensive food-processing industries near Woodburn. The results obtained, therefore, would depend upon the nature and volume of the food processing operations, as well as the river flows, prevailing shortly before the time of sampling.

Pollution of the Pudding River warrants further seasonal study in that this tributary is of some immediate--and considerable potential--value to the fisheries resources of the Willamette Valley.

l. Molalla River Basin

The Molalla River Basin was found free from any evidence of serious pollution when surveyed on October 1, 1948.

The effect upon the Molalla from seasonal pollution of the Pudding should be determined as these streams converge for approximately one-half mile before emptying into the main-stem Willamette.

The Molalla is of considerable present--and of great potential--value to the Willamette Valley fisheries resources.

m. Tualatin River Basin

Evidence of pollution in sufficient quantity to affect fish life was found in the Tualatin River principally below the Cities of Forest Grove and Hillsboro. Although the DO of the Tualatin remained above the arbitrary threshold of 5 ppm throughout the entire length on September 23, a DO of 5.2 ppm was found in the quiet-water reach at Scholl's Bridge. The flow at Farmington Bridge (6 miles above Scholl's Bridge) was 81 cfs. at the same time in comparison with a seasonal minimum of approximately 55 cfs. Conditions as found at Scholl's Bridge on September 23, indicate a DO approximating 2.8 ppm in the reach of the Tualatin during low flows.

The depressed DO in the mid-section of the Tualatin presumably stemmed from the decomposition of domestic and industrial wastes entering the river principally from the populated areas of Forest Grove and Hillsboro.

A seasonal study of pollution in the Tualatin is indicated for this stream supports resident game fish as well as a few migratory food-fishes.

n. Clackamas River Basin

The increase in both BOD and conductivity normally anticipated in any stream draining a well populated area was found in the lower reaches of the Clackamas. The DO remainded consistently high, however, with no evidence of depression. It is concluded, that under the conditions prevailing on September 20, 1948, the Clackamas was fully capable of absorbing the pollution burden being placed upon it.

III. SUMMARY AND RECOMMENDATIONS

1. Existing data indicate that the most critical pollution problem in the Lower Columbia Basin--insofar as fish life is concerned--exists in the Willamette River and certain of its tributaries.

2. A reconnaissance survey, conducted during September and October of 1948, indicated pollution in sufficient severity to affect fish life may develop in reaches of the Coast Fork Willamette, Marys, Rickreall, South Santiam, South and Main Yamhill, Pudding, and Tualatin Rivers--as well as in the main-stem Willamette between Eugene and the confluence of the McKenzie, and between Salem and the Columbia River. The 1948 data confirm many observations made by earlier investigators.

3. Main-stem pollution, which is sufficient to cause a low-oxygen block during low-water stages, constitutes a problem of particular consequence to the migratory food-fish resources of the Columbia Basin.

4. At the present time, too little is known of the circumstances under which the main-stem Willamette oxygen barrier forms and lifts to permit any accurate evaluation of its affect upon existing migratory fish runs. Likewise, too little is known to permit an accurate evaluation of benefits from the abatement program being vigorously prosecuted by the Oregon State Sanitary Authority or of the probable benefits of pollution abatement stemming from the Corps of Engineers' Willamette Valley Project.

5. The main-stem Willamette pollution block should receive top priority in any study of pollution affecting fishlife in the Pacific Northwest.

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