SMITH-BYBEE LAKES
See pages 33, 34, 39, 46, 47, 49, 50, 57, 58, 69, 70, 71, 73, 80,
See also References, pages 87-88

# WATER QUALITY IN COLUMBIA SLOUGH, OREGON

1971 - 1973

State of Oregon
Department of Environmental Quality

April, 1974

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## FOREWORD

In 1972, the City of Portland, Multnomah County, Port of Portland, Corps of Engineers and the Department of Environmental Quality formed the Columbia Slough Environmental Improvement Task Force for the purpose of bringing together the land-use plans proposed for the Columbia Slough area. Numerous meetings were held with members of the public and organized citizen groups. The major topics considered by the Task Force and the public involved flood control, land-use patterns, fish and wildlife, recreation, and water quality improvement for the development of the Columbia Slough area.

The major objection to water quality in the Columbia Slough is the algal blooms that persist throughout the summer period. The citizens and planning agencies expressed a desire to improve the Columbia Slough system to accommodate various forms of recreation such as boating, sport fishing and swimming, especially in the upper sections of the Columbia Slough. The initial studies that form the basis of this report were performed during the summer of 1971 and assembled in a document entitled, "Status of Water Quality in Columbia Slough, Oregon" 1972. Additional water quality surveys were performed the entire length of Columbia Slough in 1972, and special surveys to relate the diurnal dissolved oxygen levels to fish populations. This report incorporates the 1971-1973 data collected by the Department of Environmental Quality and Oregon Wildlife Commission and it supercedes the earlier report published by this Department. The general concerns over water quality and the potential for improving the Columbia Slough water are addressed.

The information contained under the Chapter of Physical Description of Columbia Slough Area was provided by the U. S. Army Corps of Engineers, State Engineer's Office, and the Multnomah County Drainage District No. 1. The Oregon Wildlife Commission provided the information on the fish populations in the Columbia Slough system. The U. S. Army Corps of Engineers provided assistance of personnel and a work-barge which enabled the collection of bottom sediments. The help of these agencies and their personnel is gratefully acknowledged.

## SUMMARY

1. The Columbia Slough Drainage System lies within a regional groundwater discharge zone, receiving groundwater recharge from the Cascade Mountains to the east. Intermediate and local subsurface flow systems are superimposed on the regional discharge system, respectively. The isolated hills (Mt. Tabor, Mt. Scott, etc.) bordering and lying within the drainage system serve as intermediate recharge zones. The major surface drains receiving groundwater from the regional and intermediate flow systems are the Willamette, Clackamas, and Columbia Rivers. Most of the slough drainage area, however, is located within a local flow system. This system is primarily recharged by infiltrating precipitation and by an estimated daily discharge of 8 million gallons of domestic waste into cesspools within a 20 square mile area in central Multnomah County. The Columbia Slough South Arm serves as a cutoff drain for the local groundwater discharge system. Nitrate-nitrogen, one of the end products of decomposed domestic sewage, is relatively high (5.4 mg/l mean value) in the South Slough Arm at N. E. 122nd Avenue and in some of the community wells developing water from the local flow system within the unsewered area.

2. The Columbia Slough System, extending from the east edge of Fairview to the Willamette River, serves as an important area-wide drainage system for 53 square miles within North Portland and North Multnomah County. The Slough System drains 100,000± acre-feet of area surface and subsurface drainage based upon an average annual rainfall of 43.2 inches.

3. The minimum continuous flow that can be expected during any dry summer period from the upper to the lower slough is estimated to be 70 cfs.

4. The direction of flow and flushing characteristics in the lower 8.5 miles of Columbia Slough is directly influenced by the Willamette and Columbia River stages which are in turn influenced by the Pacific Ocean tides.

5. Water Quality

    a. The overall water quality in the upper Columbia Slough is variable:

        1). Water quality in Fairview Creek above Fairview Lake is generally good, and remains relatively free of extensive algal blooms. Dissolved oxygen saturation values ranged from 91 to 101 percent.

        2). The Main Drainage Canal between N. E. 185th and N. E. 122nd Avenue is slightly enriched with nutrients which causes algae to bloom. The mean nitrate-nitrogen and total phosphorus contents ranged from 1.2 to 1.7 mg/l and from 0.06 - 0.05 mg/l respectively.

        3). The South Slough Arm intercepts the bench area subsurface water. This water is laden with nutrients capable of producing extensive blooms of algae which elevate daytime dissolved oxygen concentrations to nearly 300% saturation. Normally, algal blooms extend from spring through summer.

4). The main drainage canal extending from N. E. 112th Avenue to the Multnomah County pumping plant is composed of a mixture of South Slough Arm and Main Canal water. This portion of the Columbia Slough produces large amounts of algae.

5). Fish production is favored by present water quality conditions which increases the potential for recreational fishing. Algal abundance and occasional bacterial contamination makes the waterway unsuitable for swimming.

b. The existing water quality in the lower Columbia Slough is influenced primarily by water routed from the upper slough. Many years of industrial organic discharges prior to July 1971, deposition of natural organic materials, poor flushing characteristics, and overflows from the City of Portland's combined sewers have also influenced water quality in the Lower Columbia Slough considerably.

1). Algae-laden waters routed from the upper slough to the lower portion will essentially not change in productivity potential during spring through summer despite the presence or absence of a dam near the mouth of the slough.

2). In the upper part of the slough immediately below the Multnomah County pumping plant, sediment deposits tend to aggrade the slough channel and reduce water depth.

3). Anaerobic decomposition of organic matter in the bottom sediments produced gases (for example, possibly methane, carbon dioxide, and hydrogen sulfide) which was evidenced during the summer of 1971 and 1972. In the summer of 1973, however, gasification was not apparent. The analysis of bottom sediments in 1972 confirmed that these sediments contained organic matter subject to further decomposition.

4). The sludge bank of calcium carbonate in the slough - caused by the Pacific Carbide settling pond dike failure in the winter of 1969 - was removed by Pacific Carbide in August, 1973.

5). Waste Discharge Permit violations - observed during the November 10, 1971 survey - were corrected prior to the survey on January 5, 1972. On subsequent surveys in 1972 and in 1973, some minor problems associated with industrial yard runoff were observed. These problems have either been corrected, or are now being evaluated.

6). Leachate samples collected from the Portland Sanitary Landfill site, fronting the Columbia and North Sloughs, yielded relatively low BOD's but relatively high suspended solids and COD concentrations. On outgoing tides, chloride concentrations were higher downstream from the landfill site than above. These conditions may not affect fish or other aquatic life.

7). The immediate removal of bottom sediments and the control of combined sewage overflows in the lower slough, the phase-out of three package sewage treatment plants found midway along the upper slough, and the complete sewerage of east Multnomah County which borders the South Slough Arm are not expected to significantly improve the apparent water quality in the Columbia Slough System for many years.

8). The Columbia Slough contains nine species of warmwater game fish and at least seven species of rough fishes. The rough fish species dominate the overall fish population in the Columbia Slough System because of the existing high enrichment. The collective water quality in the Columbia Slough System does not adversely affect these existing fish populations.

6. Water quality, bottom sediments, and associated biota in Smith and Bybee Lakes indicate that the lakes are moderately enriched, but not grossly polluted.

7. Recreational fishing for warmwater game fishes occurs primarily in the lower Columbia Slough. Limited public access probably discourages greater use of this waterway for fishing.

8. A land-use plan was submitted for the Rivergate and North Portland Peninsula in 1967 by the consulting firm of Daniel, Mann, Johnson and Mendenhall. This plan has apparently not been accepted by Multnomah County, City of Portland, or the Port of Portland for implementation.

9. A land-use proposal for the upper Columbia Slough area and the upper portion of the lower Columbia Slough area is currently being prepared by Multnomah County and the Port of Portland.

10. The land-use concepts adopted by the Columbia Slough Environmental Task Force are being reviewed and evaluated by the U. S. Army Corps of Engineers for possible assistance with implementation.

## CONCLUSIONS AND RECOMMENDATIONS

1. The three existing package sewage treatment plants, discharging a total of about 60,000 gallons per day of secondary treated effluent into the upper Columbia Slough System, should be phased out by December 31, 1974. The waste currently being treated by these facilities should be routed to the Inverness Sewage Treatment Plant operated by Multnomah County.

   On occasion, high coliform levels are present in the South Slough Arm and Main Drainage Canal below the location of the sewage treatment facilities. The coliforms are probably derived from the effluent discharge, from regrowth in the water, and possibly from malfunctioning subsurface disposal systems serving homes along the waterway.

2. Multnomah County should plan for and complete the expansion of the existing Inverness Sewage Treatment Plant to its maximum potential capacity (ca 12 MGD), and extend sewerage service to the unsewered areas in central Multnomah County by 1985.

   Within a 20 square mile area in central Multnomah County, 8 million gallons per day of sewage are disposed of in cesspools which contributes to the recharge of the local groundwater system. The end-products of decomposed waste enrich the groundwater which feeds the Columbia Slough South Arm. Nutrient enrichment stimulates blooms of aquatic plant production in the slough from spring through summer. It may take years for infiltrating precipitation to flush out the residual waste products from the substrata - even after the area is sewered.

3. The Oregon State Wildlife Commission, the U. S. Bureau of Sports Fisheries and Wildlife and possibly other interested groups should evaluate and demonstrate the potential for improving the warmwater fishery in Columbia Slough. This would include an evaluation of specific physical characteristics of the slough (depth, width, flow volume, etc.), operational procedures by the Multnomah County Drainage District No. 1 and the feasibility of improving a warmwater fishery. One must recognize that even with the achievement of recommendations numbered 1 and 2, the groundwater feeding the Columbia Slough System will continue to be nutrient enriched. This will stimulate blooms of algae and populations of zooplankton. Juvenile and some adult fishes, fresh-water clams and mussels will utilize the planktonic populations for food. Predatory fishes will benefit indirectly from plankton production by feeding on the juvenile fishes and other herbivores.

4. Because of high suspended sediment loads, Columbia River water should not be used to dilute the Columbia Slough during May, June early July or at other times when river flows measured at Vancouver, Washington are 250,000 cfs or greater. The use of this water for dilution purposes should not be considered until recommendation number (3) has been fully evaluated.

   The possible use of Columbia River water to dilute the dry-weather flow of enriched water in the Columbia Slough System has some drawbacks. The Columbia River freshet flows normally extend from March through mid-July, depending on the previous winter snowpack and on available storage capacity in the upper basin reservoirs. The sediment load in the Columbia River is high during the freshet flows, but relatively low after the high flow period. Columbia River freshet flows introduced into the Columbia Slough System would create additional water management problems in terms of dredging and spoils disposal with possibly little or no water quality improvement since Columbia River water is moderately enriched particularly during late summer. It would require at least 350 cfs of Columbia River water to dilute the enriched waters of the Columbia Slough to a level considered desirable for warmwater game fishes. But dilution may have little effect, if any, on algal growth and production.

5. The recreational development of the Columbia Slough should be limited to sport fishing and possibly small craft boating. Other recreational activities may be made less desirable by heavy growths of algae. Accordingly, throughout late spring and summer, favorable light, temperature, flow, and nutrient conditions in the Columbia Slough produce excessive quantities of algae which are objectionable to the general public. Even with the introduction of Columbia River water into the Slough System (for dilution purposes), algal growth may still reach bloom proportions. It would therefore be unwise to promote recreational development other than providing additional access for fishing if the public cannot accept the fact that high, uncontrollable plant growth and production will occur annually in the slough. Whether or not any effort is made to modify water quality, the Columbia Slough System will continue to produce sizable populations of fish and other aquatic life.

6. The local governmental planning agencies should incorporate the following considerations into their designs for Smith and Bybee Lakes if they are to provide various forms of recreation including habitats for fish and wildlife:

   a. Protect lake shorelines as much as possible in order to (1) minimize the effects of erosional processes and (2) maintain whatever fish and wildlife shoreline habitats which still exist.

   b. Provide, by dredging, a minimum water depth of 3 meters (10 feet) to reduce the opportunity for rooted aquatic vegetation to become established.

   c. Discourage public swimming areas in the lakes. Instead, provide swimming pool facilities nearby where the water supply and treatment can be better controlled.

   d. Consider a plant to circulate the Lower Willamette River waters through these lakes at the following rates in order to reduce the effects of algal blooms:

      1). Maximum complete exchange of water should be once each 15 days.

      2). Minimum complete exchange of water should be once each 30 days.

The introduced waters should not contain fishes, especially juvenile salmonids.

3. Cooperate with the Oregon Wildlife Commission and U. S. Bureau of Sport Fisheries and Wildlife to insure that various recreational uses will not degrade lake quality and disrupt fish and wildlife habitats.

7. The City of Portland should plan to provide for the complete separation of sewers discharging to Columbia Slough by 1985, or provide alternative means for controlling or treating these wastewaters so that untreated combined sewage is not discharged to Columbia Slough. The City of Portland should immediately evaluate and correct the conditions which cause the combined sewers to overflow during the dry weather period.

The City of Portland monitored the 12-combined sewer overflows in 1972. It was found that the sewers overflowed an average of 119 and 20 times during the wet and dry weather periods, respectively. The average duration of overflows ranged from 3.4 to 7.5 hours during wet weather, and from 0.0 to 6.2 hours during dry weather. The average total discharge rate for each wet and dry weather overflow incident was 50.6 mgd (ca. 76 cfs) and 3.1 mgd (4.7 cfs), respectively.

# INTRODUCTION

The Columbia Slough is a small dead-ended waterway located in North Portland and North Multnomah County, Oregon. The entire length of the slough lies in a flat valley that is bordered by agricultural areas, industries, swampy lands, and the northern sector of the Portland Metropolitan Area. It is fed by large spring flows, area surface water and subsurface drainage. The slough has a flat gradient which causes it to flow slowly, and its lower section is substantially influenced by tidal changes in the Willamette River.

In past years, the numerous industries located near the south bank of the lower section of Columbia Slough discharged inadequately treated organic wastes into the waterway. These industries were required by the Oregon Department of Environmental Quality to discontinue the discharge of organic waste to the slough by July 1971. Currently, the discharges into the slough include storm water runoff from the drainage basin, industrial cooling water, treated domestic waste, treated industrial inorganic wastes, leachates from the Portland Sanitary Landfill and combined sewage overflow from the City of Portland's sewers during periods of heavy rainfall.

Land-use studies are presently being conducted for the land area lying north of the slough by representatives of the Port of Portland, Multnomah County, City of Portland, U. S. Army Corps of Engineers, and many citizen committees. One aspect of this study is to develop some of the land adjacent to the slough for recreational purposes.

The purpose of this Columbia Slough report is to describe the water quality conditions therein, to list some of the main problems associated with existing water quality, to offer recommendations for water quality improvement, and to give guidance for the development and use of the aquatic resources.

## PHYSICAL DESCRIPTION OF COLUMBIA SLOUGH AREA

1. The Columbia Slough is located along North Multnomah County and City of Portland (Figure 1).

2. The slough flows parallel to the Columbia River and empties into the Willamette River.

3. The entire length of the slough and its branches is about 27 miles. The slough is physically divided into an upper and lower section by an earth-fill plug with the two sections connected by tide gates and a pumping station which transfers water from the upper to the lower section.

4. The upper section of slough is also known as the Multnomah County Drainage District No. 1. The boundaries of the area-wide drainage system and direction of drainage are as follows:

   a. Eastern portion of drainage system (contains 8,500 acres).

      1). East from N. E. 142nd Avenue levee.

      2). South from Columbia River levee.

      3). West of Campell Road.

      4). North of the hillside to the south.

   b. Western portion of drainage system (contains 13,500 acres).

      1). East from Peninsula Canal.

      2). South from Columbia River levee.

      3). West of N. E. 142nd Avenue levee.

      4). North of the hillside to the south.

   c. Total drainage area = 22,000 acres or 34.4 square miles.

   d. Of this total, the Multnomah Drainage District comprises 8,417 acres because the southern boundary is defined by the Union Pacific Railroad tracks.

5. Lower section of slough extending from the Peninsula Canal to the Willamette River.

   a. Peninsula Drainage District No. 2 drains 1,500 acres north of the slough extending from the Columbia River on the north, Denver Avenue on the west and Peninsula Canal on the east.

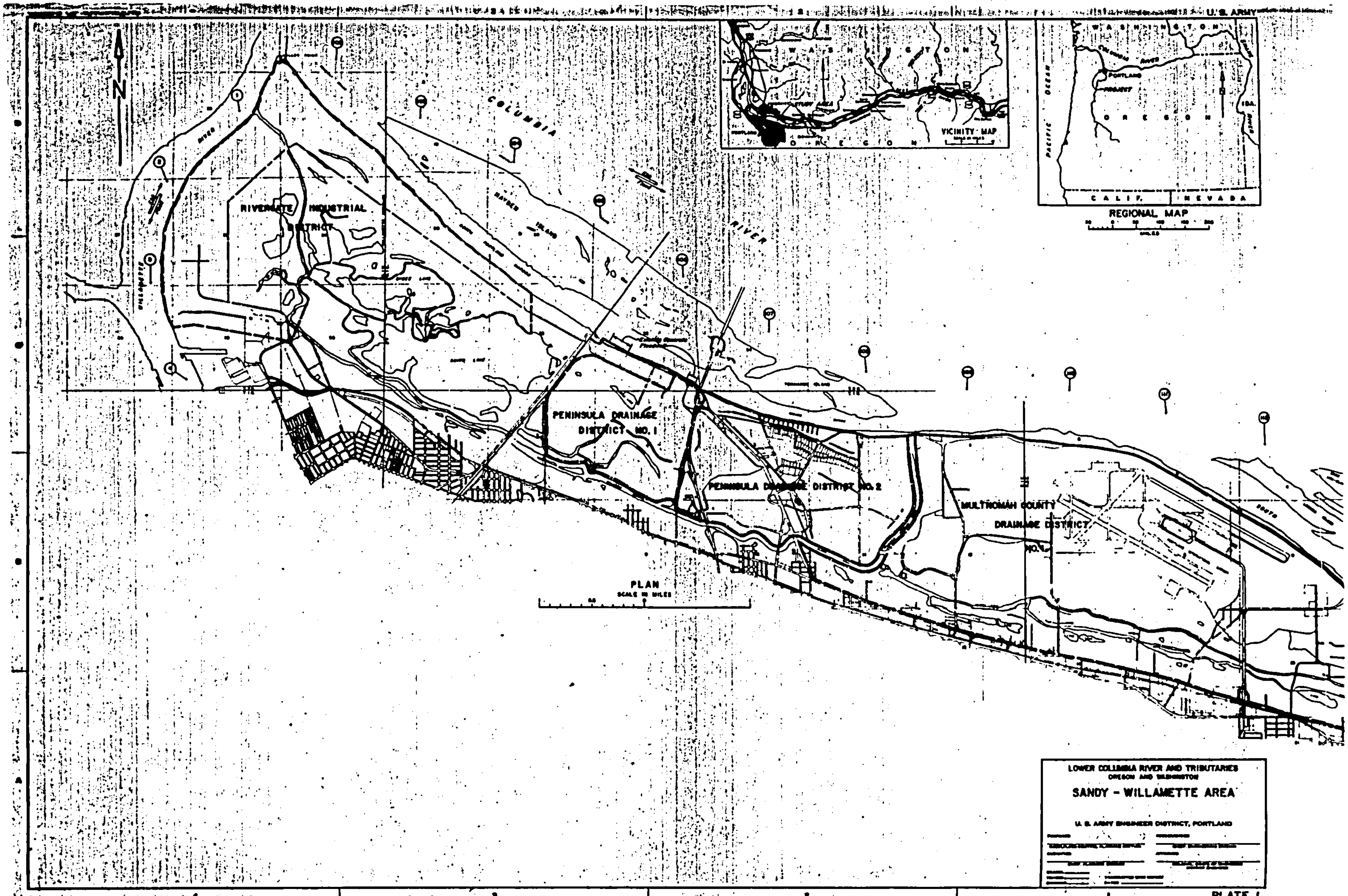
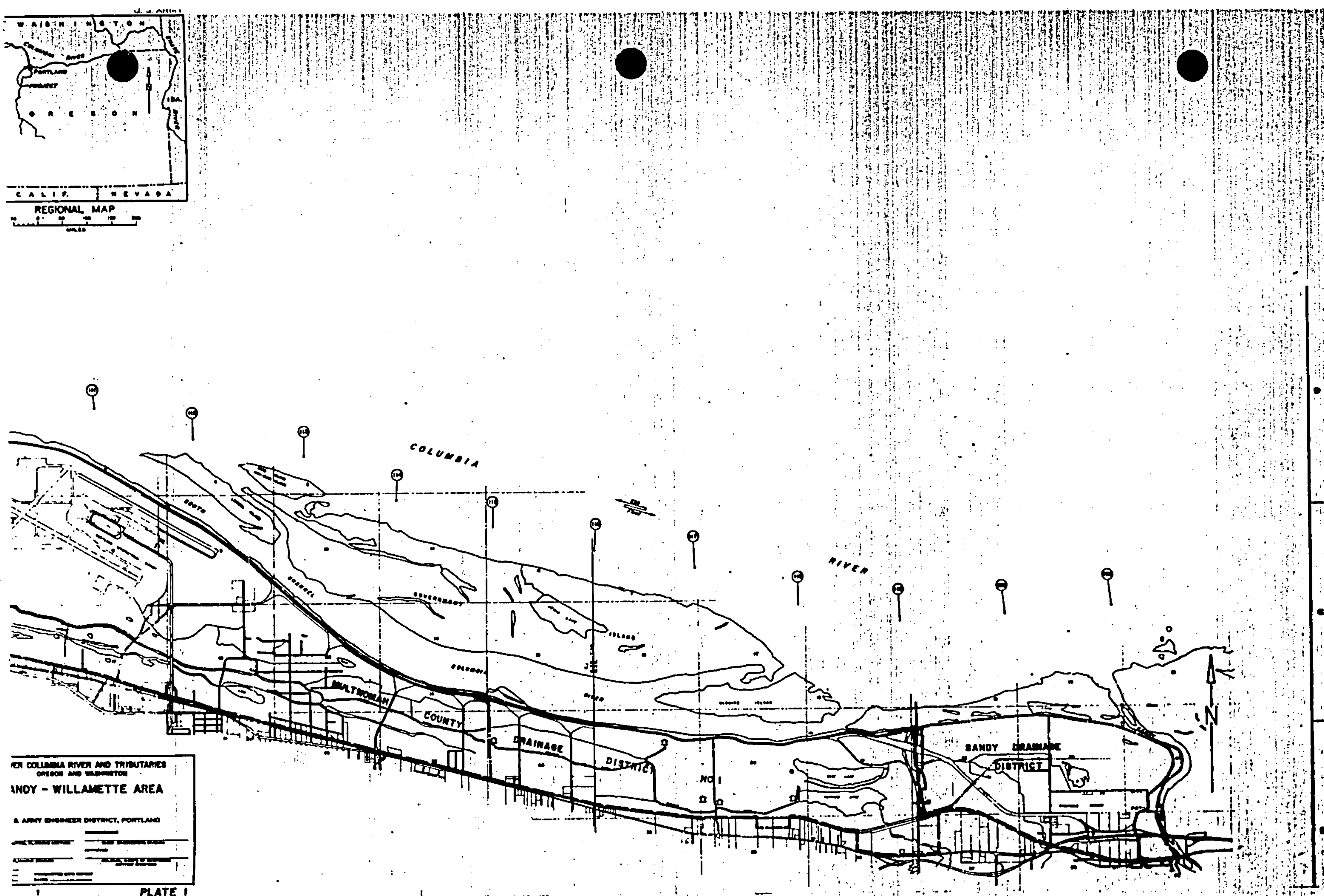

N
COLUMBIA
RIVER
RIVERGATE INDUSTRIAL DISTRICT
PENINSULA DRAINAGE DISTRICT NO. 1
PENINSULA DRAINAGE DISTRICT NO. 2
MULTNOMAH COUNTY DRAINAGE DISTRICT NO. 1
PLAN
SCALE IN MILES
W A S H I N G T O N
O R E G O N
VICINITY MAP
PACIFIC OCEAN
CALIF.
NEVADA
IDA.
PORTLAND
REGIONAL MAP
MILES
LOWER COLUMBIA RIVER AND TRIBUTARIES
OREGON AND WASHINGTON
SANDY - WILLAMETTE AREA
U. S. ARMY ENGINEER DISTRICT, PORTLAND

PLATE 1


WASHINGTON
COLUMBIA RIVER
PORTLAND
PROJECT
OREGON
IDA.
CALIF.
NEVADA
REGIONAL MAP
COLUMBIA
RIVER
MULTNOMAH
COUNTY
DRAINAGE
DISTRICT
NO 1
SANDY DRAINAGE
DISTRICT
N
ER COLUMBIA RIVER AND TRIBUTARIES
OREGON AND WASHINGTON
ANDY - WILLAMETTE AREA
S. ARMY ENGINEER DISTRICT, PORTLAND
PLATE I

b. Peninsula Drainage District No. 1 drains 1,000 acres north of the slough extending from the Columbia River on the north, SP & S Railroad on the west, and Denver Avenue on the east.

c. Rivergate Industrial District drains 5,200 acres extending from the Columbia River on the north, Willamette River on the west, the Western edge of the Portland landfill site and the northern edges of Bybee and Smith Lakes.

d. Portland City Area drains 4,500 acres into the south side of the slough.

e. Total drainage area within the lower Columbia Slough is 12,200 acres or about 19 square miles.

6. The total area drainage system for the entire length of Columbia Slough including the lakes is 34,200 acres or 53.4 square miles.

7. Water Sources and Hydraulics of the Slough

a. Groundwater recharge and Discharge

1). The Columbia Slough drainage system lies within a regional groundwater discharge zone, receiving subsurface recharge from the Cascade Mountains to the east. Groundwater moves downward and away from recharge areas toward lowlands and groundwater discharge areas. Superimposed on this regional discharge system are intermediate and local groundwater flow systems. The isolated hills bordering and within the study boundary include Mt. Scott, Mt. Tabor, Kelly Butte, Powell Butte and Grant Butte, which are intermediate recharge zones. Underlying these intermediate recharge zones are unconsolidated and partly consolidated alluvial rocks of the Troutdale Formation and the massive basaltic Boring Lava (Hogenson et al, 1965; Trimble, 1963). The major surface drains receiving groundwater from the regional and intermediate flow systems are the Willamette, Clackamas and Columbia Rivers.

2). The major portion of the Columbia Slough System is located within a local discharge zone. This area receives recharge not only from the regional and intermediate flow systems but also from the local recharge zone. This local recharge area, south of the Columbia Slough South Arm, is underlain by unconsolidated fluviolacustrine (i.e., river and lake deposited) materials. The primary source of groundwater recharge in the local system is infiltrating precipitation. In addition, a significant amount of domestic waste -- estimated at 8 million gallons per day -- is introduced as supplemental local recharge via subsurface sewage disposal within central Multnomah County (Moffatt et al, 1965). The area dependent upon subsurface sewage disposal is bounded to the west by Portland city limits, to the north by the Union Pacific Railroad tracks, to the east by N. E. 162nd Avenue and to the south by the natural drainage divide (near S. E. Holgate).

3). Domestic sewage is characterized as having high concentrations of various nitrogen compounds which include ammonia, organic nitrogen, and minor amounts of nitrate and nitrite ions. However, during the disposal and percolation of waste effluent through the upper unsaturated aerobic soil column, nitrification takes place and the effluent leaching to the groundwater table contains nitrogen almost exclusively as nitrate-nitrogen. The nitrate-nitrogen content is a useful indicator of groundwater contamination, because it is not generally susceptible to absorption by clays, it mixes well, and it remains relatively unchanged in its travel with groundwater.

4). When the local recharge -- precipitation and nitrate-nitrogen enriched effluent -- reaches the groundwater table, it migrates a short distance downwards before encountering and merging with the lateral and upward moving intermediate and regional discharge systems. Some mixing and chemical dispersion of the local recharge waters with the intermediate discharge system takes place. However, the depth to which the local recharge can penetrate the intermediate flow system is limited by its hydraulic potential. Therefore, it is buoyed up and migrates laterally along the upper portion of the water table to its eventual surface drain, in this case the Columbia River System.

5). The Columbia Slough South Arm acts as a cutoff drain, intercepting the upper portion of the groundwater table which includes the previously described local flow system. Columbia Slough South Arm therefore collects much of the nitrate-nitrogen enriched groundwater. Flow in the Columbia Slough South Arm is much less than that in the Columbia River and there is little dilution of the groundwater discharge, including the nitrate-nitrogen enriched waters, by the South Slough Arm. This is shown below by a comparison of the nitrate-nitrogen concentrations between the South Slough Arm and the down-gradient Main Drainage Canal, before these two bodies of water mix:

| | Nitrate-Nitrogen, mg/l | | | | |
|---|---|---|---|---|---|
| | South Slough Arm | | | Main Canal | |
| | N.E. 122nd | N.E. Alder-wood Dr. | N.E. 33rd | N.E. 185th | N.E. 122nd |
| Average | 5.3 | 5.7 | 4.5 | 1.2 | 1.7 |
| Range | 3.5-7.2 | 4.4-6.8 | 3.6-5.9 | 0.2-2.3 | 0.8-2.9 |

6). Community well water supplies in Multnomah County

a). A number of communities within central Multnomah County currently obtain their water supply from wells. Several of the community wells are located within the unsewered area of the county. Fairview and Wood Village also obtain their water from wells, but these two communities have been sewered since 1958 and 1943, respectively. The well water quality in these two areas is discussed below.

b). Wells in unsewered area

[1] Russellville

[a] This community has been served by two wells located near N. E. 100th Avenue and N.E. Glisan Street since 1940 and 1941. Some of the pertinent information for these wells is as follows:

| Well No. | Year* Drilled | Approx. Elev., ft.(msl) | Well* Depth, ft. | Static* Water Level, Elev., ft.(msl) | Perforated* Zone(s), Elev., ft.(msl) |
|---|---|---|---|---|---|
| #1 | 1940 | 285 | 252 | - | 41 to 36 |
| #2 | 1941 | 288 | 304 | - | 49 to -19 |

*Taken from drilling logs.

The casing is perforated from 68-300 feet. Both wells are apparently developing water from the local flow system.

[b] Water samples collected from each of these wells in January, 1966, yielded the following results:

| | Wells #1 | Wells #2 |
|---|---|---|
| Total dissolved solids, mg/l | 204 | 184 |
| Nitrate-nitrogen, mg/l | 5.7 | 4.7 |
| Sulphate, mg/l | 6.5 | 5.5 |

[2] Parkrose Water District

[a] In 1952, this water district drilled a well (#1) on the terrace near N. E. 104th and Fremont Street. In 1970, this water district drilled two additional wells (#2 and #3) near N. E. 122nd and Sandy Blvd., a short distance south of the Columbia Slough South Arm. Some of the pertinent information for these wells is as follows:

| Well No. | Year* Drilled | Approx. Elev., ft.(msl) | Well* Depth, ft. | Static* Water Level, Elev., ft.(msl) | Perforated* Zone(s), Elev., ft.(msl) |
|---|---|---|---|---|---|
| #1 | 1952 | 210 | 265 | 12 | -7 to -37 |
| #2 | 1962 | 29 | 63 | 5 | -4 to -34 |
| #3 | 1970 | 29 | 65 | 7 | -12 to -32 |

*Taken from drilling logs.

[b] The water samples collected from the first and from one of the two new wells yielded the following results:

| | Parkrose Wells | |
|---|---|---|
| | #1 (June 1955) | #2 or #3 (March 1972) |
| Total dissolved solids, mg/l | 195 | 188 |
| Nitrate-nitrogen, mg/l | - | 5.4 |
| Sulphate, mg/l | 8.5 | 14 |

Each of the wells is developing from the same local discharge system that empties into the Columbia Slough South Arm in the vicinity of N. E. 122nd Avenue. Each of the above parameters compares very closely with the water quality present in the section of the South Slough Arm.

[3] Richland Water District

[a] This water district owns four wells located between N. E. 137th - 142nd and San Rafael near N. E. 140th and Halsey. Some of the pertinent information for these wells is as follows:

| Well No. | Year* Drilled | Approx. Elev., ft.(msl) | Well* Depth, ft. | Static* Water Level, Elev., ft.(msl) | Perforated* Zone(s), Elev., ft.(msl) |
|---|---|---|---|---|---|
| #1 | 1947 | 260 | 400 | 132 | 40 to -55 |
| #2 | 1956 | 260 | 490 | 115 | 115 to 60<br>20 to -20<br>-40 to -50<br>-52 to -70 |
| #3 | 1959 | 260 | 470 (backfilled to 445 ft. with gravel) | 61 | -55 to -60<br>-70 to -78<br>-95 to -180 |
| #4 | 1960 | 260 | 250 | 120 | 65 to 10 |

*Taken from drilling logs.

[b] Water samples collected from these wells in October, 1960 and in March, 1971, yielded the following results:

| | Richland Wells | | | | | | |
|---|---|---|---|---|---|---|---|
| | #1 | | #2 | | #3 | | #4 |
| | 1960 | 1971 | 1960 | 1971 | 1960 | 1971 | 1960 |
| Total dissolved solids, mg/l | 143 | 129 | 149 | 130 | 144 | 129 | 171 |
| Nitrate-nitrogen, mg/l | 0.11 | 1.5 | 0.10 | 0.24 | 0.15 | 0.17 | 0.6 |
| Sulphate, mg/l | 2.2 | 3.4 | 2.2 | 2.5 | 1.4 | 3.4 | 6.0 |

[c] Wells #1 and #3 are probably developing water from the intermediate and/or regional flow systems. Well #2 is open in a wide range of depths and probably develops water from the local, intermediate, and regional flow systems. Although well #4 is relatively shallow, it may be developing water from the intermediate and regional flow systems as well as the local flow system. Unfortunately, this shallow well has not been sampled since 1960. The water quality in this well, however, is quite similar to that observed in Russellville and Parkrose Water District, except that the nitrate-nitrogen content was considerably lower.

c). Wells in sewered area

[1] Fairview

[a] This community has been sewered since 1958.

[b] Fairview currently uses three wells which were constructed in 1956, 1963, and 1973 and numbered 3, 4, and 5, respectively.

[c] The pertinent information for these wells is as follows:

| Well No. | Year* Drilled | Approx. Elev., ft.(msl) | Well* Depth, ft. | Static* Water Level, Elev., ft.(msl) | Perforated* Zone(s), Elev., ft.(msl) |
|---|---|---|---|---|---|
| #3 | 1956 | 130 | 1,060 | 40 | -190 to -210 |
| #4 | 1963 | 130 | 420 | 62 | 25 to 15 |
| | | | | | -5 to -22 |
| | | | | | -64 to -85 |
| | | | | | -159 to -165 |
| | | | | | -205 to -220 |
| #5 | 1973 | 155 | 360 | 59 | -115 to -135 |
| | | | | | -175 to -185 |
| | | | | | -186 to -200 |

* Taken from drilling logs.

[d] Analysis of these well waters in 1973 yielded the following results:

| | Fairview Wells #3 Feb. | #4 Feb. | #5 June |
|---|---|---|---|
| Total dissolved solids, mg/l | 147 | 150 | 180 |
| Nitrate-nigrogen, mg/l | 0.01 | 0.03 | 0.82 |
| Suphate, mg/l | 2.6 | 3.5 | |

These deep wells are probably developing water from the intermediate and/or regional flow systems.

[2] Wood Village

[a] This community has been sewered since 1943.

[b] Wood Village has two wells which are located near N. E. 238th Drive and N. E. 242nd Street on Cherry Park Road. Some of the pertinent information for these wells is as follows:

| Well No. | Year* Drilled | Approx. Elev., ft.(msl) | Well* Depth, ft. | Static* Water Level, Elev., ft.(msl) | Perforated* Zone(s), Elev., ft.(msl) |
|---|---|---|---|---|---|
| #1 | 1942 | 170 | 360 | 105 | 0 to -185 |
| #2 | 1970 | 350 | 458 | 100 | -89 to -99 |

*Taken from drilling logs.

[c] Water analysis of these wells yielded the following results:

| | Wood Village Wells #1 (Jan.1966) | #2 (Jan.1970) |
|---|---|---|
| Total dissolved solids, mg/l | 166 | 120 |
| Nitrate-nitrogen, mg/l | 0.02 | 0.25 |
| Sulphate, mg/l | 1.0 | 3.4 |

These deep wells are probably developing water from intermediate and/or regional flow systems.

7). Comparison of well water quality in the sewered and unsewered areas.

a). The wells in Russellville and Parkrose appear to be developing water from the local flow system. Richland Water District's shallow well (#4) also appears to be primarily developing water from the same flow system. Total dissolved solids, nitrate-nitrogen, and sulphate ion concentrations in these wells are generally higher than that in deeper wells in both the sewered and unsewered areas.

b). The deeper wells in Richland Water District (unsewered area), Fairview and Wood Village appear to be developing water from the intermediate and/or regional flow system. The nitrate-nitrogen content in these well waters was less than 1.0 mg/l even though the total dissolved solids content is within the range of those observed in the well waters located in the unsewered area.

c). Since the areal geology in the terrace area within central Multnomah County is relatively uniform, there is no apparent reason to attribute the high nitrate-nitrogen content in the unsewered area to sources other than the practice of subsurface disposal of sewage. Therefore, in order to maintain acceptable water quality levels in the local flow system and to reduce the unnecessary chemical enrichment to Columbia Slough South Arm, Multnomah County should plan for and complete the expansion of the Inverness Sewage Treatment Plant to its maximum capacity (ca. 12 mgd), and extend sewerage service to the unsewered areas in central Multnomah County by 1985. It should be recognized that it will take an unknown number of years for infiltrating precipitation to flush the residual waste products from the substrata after this area is sewered.

b. Water Quantity Measurements

1). From July to October, 1957, the Corps of Engineers performed some hydraulic measurements in the lower portion of the slough in the Multnomah County Drainage District. The results of their study showed the following:

a). July 24 - August 13 study.

[1] Flow out of the tide boxes from the upper slough at the lower end of the Main Canal into the lower main slough occurred 54% of the time.

[2] An instantaneous maximum flow of 176 cfs occurred on July 31, 1957, when the rainfall in July was 0.19 inch as compared to a normal July rainfall of 0.42 inch.

[3] The average continuous flow during a 6-hour period was 79 cfs.

b). August 16 - September 23; October 2 - 16; October 25 - 27.

[1] Flow out of the tide box from Multnomah County Drainage District into the lower main slough occurred 54% of the time.

[2] The maximum flow recorded during a 6.5 hour period on October 23, 1957, was 171 cfs when the rainfall for October was 3.53 inches as compared to a normal of 3.17 inches for that month.

[3] The average continuous flow during this period was 79 cfs.

c). Based upon the results of this study, it was concluded that a minimum continuous average flow from the upper slough and out through the lower slough of 70 cfs could be expected during any summer period.

2). Cornell, Howland, Hayes & Merryfield ($CH_2M$) Consulting Engineers (1961), measured the quantities of water flowing in Deering Slough (South Slough Arm) and in Columbia Slough (Main Canal) in the vicinity of N. E. 122nd and 112th Avenues. The results of their flow measurements for September 24, 1959, are tabulated below.

| Description | Slough Flow Measurements | | |
|---|---|---|---|
| | gpm | Volume mgd | cfs |
| 20 inch vertical pipe (Upper end of Deering Slough) | 280 | 0.4 | 0.62 |
| Deering Slough at road crossing on Inverness Tract (N.E. 122nd Ave.) | 2,400 | 3.5 | 5.43 |
| Deering Slough at N. E. 112th Ave. | 6,600 | 9.5 | 14.73 |
| Columbia Slough at Road Crossing on Inverness Tract (N.E. 122nd Ave.) | 2.900 | 4.2 | 6.51 |

a). $CH_2M$ (1961) recorded a flow of 11.0 mgd at the Deering Slough crossing at N. E. 112th Avenue in June, 1959, using rather approximate methods.

b). They installed a water level recorder on July 24, 1961, at N. E. 112th Avenue to measure the fluctuations of level and the flow from Deering Slough. The average flow recorded during a two-week period was 11.7 mgd (ca. 18 cfs) with a maximum flow of 12.9 mgd (ca. 20 cfs).

3). Based upon the Corps of Engineers and $CH_2M$ flow studies, the upper 1-3/4 mile of South Slough Arm, extending from N. E. 148th to N. E. 112th Avenues, contributes about 26% of the total flow in the upper Columbia Slough during dry weather. Flow measurements near the outlets of the South Slough Arms at N. E. 42nd and N. E. 27th Avenues, which also empty into the Main Canal, are not known to have been performed.

c. Surface Water Runoff

1). Upper Columbia Slough

a). During the dry weather season, most of the flow in the Columbia Slough System results from the area subsurface drainage and to a minor extent from the spring seepage at the land surface.

b). During the rainy season, of course, the amount of flow in the upper slough would reflect some rainfall on road surfaces and rooftops from the 34.4 square miles of area plus the natural spring flows. There are currently 12 storm drains ranging from 12 to 60 inches discharging to Fairview Lake, Main Canal, and sections of South Slough Arm. Three additional storm sewers are proposed with discharge to Fairview Lake and upper portion of the Main Canal.

c). The Multnomah County Drainage District No. 1 maintains two pumping facilities, one at the upper and one at the lower end of the upper Columbia Slough to discharge surface runoff as follows:

[1] The upper pumping station near Blue Lake discharges into the Columbia River.

[a] Pumping operation in 1970 = 100 hours.

[b] Pumping capacity = 50,000 gpm.

[c] This pump station operates when 3 inches of rainfall occurs during a 24-hour period or when the water level in the upper slough reaches 10.5 feet during the daytime or 8.6 feet during the night except from mid-May through September when water is backed up from N. E. Alderwood Drive east for irrigation of farmlands. This pumping station does not operate during the irrigation season. Most of the pumping at this station, however, occurs at night.

[2] The lower pumping station near N. E. 17th Street discharges from the upper to lower Columbia Slough.

[a] Pumping operation in 1970 = 1,700 hours.

[b] Maximum pumping capacity = 165,000 gpm.

[c] This pump station operates when the water level at the station reaches 7.6 feet or when the Columbia River stage at Vancouver, Washington, reaches 8 feet or higher. When the Columbia stage at Vancouver is less than 8 feet, the discharge from the upper to the lower slough is by gravity flow through tide boxes.

d). As extensive urban development occurs in North Multnomah County, surface runoff will probably increase in the upper Columbia Slough enough to change the above hydrologic conditions.

2). Lower Columbia Slough

The City of Portland monitored the 12 combined sewers discharging to the lower Columbia Slough in 1972. The overflow frequencies, durations and approximate flow rates from each outfall are tabulated in Table O. These combined sewers overflowed an average of 119 and 20 times during the wet and dry weather periods, respectively. The average duration of these sewer overflows ranged from 3.4 to 7.5 hours during wet weather, and from 0.0 to 6.2 hours during dry weather. The average total discharge rate for each wet and dry weather overflow incident was 50.6 mgd (ca. 76 cfs) and 3.1 mgd (ca. 4.7 cfs), respectively. The outfalls having the highest overflow rates during wet weather are located at N. E. 13th Avenue (23.7 mgd) and N. Albina Avenue (9.0 mgd). These two combined sewers contributed an overflow rate of 33 mgd or 65% of the mean total discharge to the slough during the wet weather period.

d. Irrigation Practice

During the summer low flow season, the Multnomah County Drainage District restricts the flow in the North Slough Arm and Main Canal extending from N. E. Alderwood Drive to Fairview Lake. Wood planks are inserted in the upstream end of a 12-foot corrugated pipe at N. E. Alderwood Drive to raise the slough to the 9-foot stage which in turn raises the water table of the farmlands adjacent to the slough and provides sufficient water in the slough branches for farmland irrigation. The Multnomah County Drainage District has received complaints from this practice because the stagnant waters produce algal blooms.

e. Tidal Influence in Lower Columbia Slough

Normally from mid-July through mid-May daily stage fluctuations occur in the lower Columbia Slough as a result of influence by the Willamette and Columbia River stages and the Pacific Ocean tides. The maximum variation during a tidal cycle for this period is 3 feet. However, when the Columbia River stage at Vancouver, Washington, exceeds the 12-foot gage height level, as it normally does during the freshet flows extending from mid-May through mid-July, the daily tidal variations in the lower Willamette River and Columbia Slough are dampened out by the high flows. Following the freshet flows in the Columbia River when the river stage recedes, the Columbia Slough outflow velocities would not be sufficient to sweep out the debris accumulated on the slough bottom. Furthermore, during the remaining ten-month period when the lower Columbia Slough is subjected to daily tidal influence, it is doubtful that the outflowing velocities of the slough would remove accumulated debris from this waterway. Therefore, almost all of the organic debris that settles out can be expected to undergo decomposition in this water body.

With the recent additional reservoir storage capacity in the upper Columbia River System, the normal freshet flows would be shortened by a one-week period through the Corps of Engineers regulated flows in the Columbia River. This will probably reduce the period of non-tidal influence in the lower Columbia Slough up to early July, depending upon the Columbia River headwaters storage capacity, winter snow pack and subsequent runoff.

8. Current Land Uses Bordering the Slough.

a. Upper slough area.

1). Agriculture east of N. E. 82nd.

2). Industries.

3). Golf courses.

4). Urban-domestic.

b. Lower slough area.

1). Industries adjacent to the south bank.

2). Delta Park adjacent to north bank.

3). Portland Sanitary Landfill.

4). Minor agricultural practices.

## GENERAL WATER QUALITY

1. Upper Slough and Fairview Creek

a. Surveys to evaluate water quality in Fairview Creek and Upper Columbia Slough were performed by the Department of Environmental Quality staff on the dates listed below:

| Date | Fairview Creek | Upper Columbia Slough |
|---|---|---|
| August 18, 1971 | X | X |
| May 2, 1972 | X | X |
| June 19, 1972 | | X |
| July 5, 1972 | | X |
| August 2, 1972 | | X |
| September 12, 1972 | | X |
| November 17, 1972 | X | X |
| July 5-6, 1973 | X | X |
| September 4, 1973 | | X |

The area of concern extended from the Fairview community to about N. E. 17th Avenue, at the Multnomah County Drainage District No. 1 pumphouse intake.

b. Fairview Creek above Fairview Lake

1). A 36-inch storm sewer discharges into Fairview Creek (above the lake).

2). An existing 12-inch storm sewer discharges into Fairview Lake.

3). A 60-inch storm sewer is proposed for discharge into Fairview Lake.

4). The creek is formed by spring seeps originating just south of Fairview. During the dry weather period, the flow at N. E. 223rd Avenue may be about 1 cfs or less. Water is withdrawn from the creek for irrigation of nearby farmland.

5). The water quality data are tabulated in Table A.

6). These data indicate that the overall water quality is generally good during the dry weather period. The dissolved oxygen saturation levels ranged from 91% to 101% during the day on four surveys. A special survey was conducted on July 5 and 6, 1973, to determine the diurnal high and low dissolved oxygen concentrations in the creek. The mid-day maximum dissolved oxygen saturation level was 93% and the early morning hour minimum level was 88%, suggesting that the biological activity was rather low in Fairview Creek.

Nitrate-nitrogen concentrations were observed to be lower in late Spring (2.9 mg/l, on May 2, 1972) than during the late Summer and Fall period (6.1 mg/l, on August 18, 1971, and 5.9 mg/l on November 17, 1972). The concentrations of nitrate-nitrogen in Fairview Creek probably result from the leaching of applied fertilizers and the end products of soil microbial decay of waste vegetation in the top soil.

c. Upper Columbia Slough

1). The outflow from Fairview Lake forms the Upper Columbia Slough and the Main Drainage Canal, which extends West to about N. E. 17th Avenue.

2) The South Slough Arm lies parallel to and is located immediately south of the Main Drainage Canal. The South Slough Arm contains two separate sections, as follows:

a). The upper section extends from approximately N. E. 147th to N. E. 42nd Avenues.

[1] The large collection of spring flows extending from N. E. 147th to about N. E. 110th Avenue empty into the Main Drainage Canal near N. E. 110th Avenue.

[2] From N. E. 110th Avenue west to about N. E. 96th Avenue, the slough bed slopes eastward. During the dry weather period, the outflow from Johnson Lake (behind Owens-Illinois Glass Company) flows east, emptying into the Main Drainage Canal at N. E. 110th Avenue. During the wet weather period when the flows in this section of the slough are higher as a result of surface runoff, the Johnson Lake outflow may enter into the Canal draining east or it may drain west through the culvert under N. E. 96th Avenue and eventually empty into the Main Canal at N. E. 42nd Avenue.

b). The lower section of the South Slough Arm is deadended at about N. E. 26th Avenue. The general movement of water in this arm of South Slough is west, but a higher water level in the Main Drainage Canal can back up water, causing an eastward movement in this section of the South Arm.

3). The Main Drainage Canal extending from N. E. Alderwood Drive to N. E. 185th Avenue is backed up for irrigation of farm lands primarily located east of N. E. 82nd Avenue. The water is normally backed up from May through September.

4). Storm Sewers

a). Ten existing storm sewers ranging from 12 inches to 60 inches in diameter discharge between N. E. 43rd Avenue and N. E. 181st Avenue.

b). Two additional storm sewers are proposed.

c). The size of the storm sewers and their approximate locations are tabulated in Table B.

5). Domestic and Industrial Waste Outfalls

a). Three outfalls for treated domestic waste presently exist. The secondary treated waste from these treatment facilities total 60,000 gallons per day discharged.

b). Two industries presently discharge cooling water and treated metal wastes.

6). The water quality data are summarized in tables.

7). Main Drainage Canal

a). From N. E. 185th to N. E. 122nd Avenues.

[1] This area is primarily under agricultural production of truck crops. This reach of the Main Canal including Fairview Lake not only receives surface runoff but also acts as a surface drain receiving regional and intermediate groundwater discharges and limited local groundwater discharge, e.g. bank storage.

[2] The overall water quality is generally good. The water is moderately hard (65 mg/l to 87 mg/l), and moderately turbid at times (5 J.T.U.-27 J.T.U.). The nutrients of nitrate-nitrogen ($NO_3$-N) and compounds of phosphorus are considered to be essential in promoting plant production. The $NO_3$-N concentrations averaged 1.23 mg/l and 1.7 mg/l at N. E. 185th and N. E. 122nd Avenues, respectively. Total phosphorus, which includes the organic and inorganic species of phosphorus compounds, averaged 0.06 mg/l and 0.05 mg/l at N. E. 185th and N. E. 122nd Avenues, respectively. The algae production, as evidenced by the dissolved oxygen saturation levels, was generally greater at N. E. 122nd Avenue (range from 99% - 196% of saturation) than at N. E. 185th Avenue (range 72% - 114% of saturation).

[3] This stretch of the Upper Columbia Slough System yielded the lowest average concentration of nitrate-nitrogen.

b). From N. E. Alderwood Drive to Multnomah County pumping plant

[1] The lower 4 miles of the main drainage canal receive the drainage from the South Slough Arms and the discharges from three domestic waste treatment and two industrial treatment systems.

[2] The overall water quality is chemically fertile, having average nitrate-nitrogen concentrations ranging from 4.3 mg/l to 5.0 mg/l at N. E. Alderwood Drive and Multnomah County Pumping Plant respectively. The total phosphorus concentrations averaged 0.08 mg/l and 0.93 mg/l at the above two respective locations. The source of these nutrients in the main canal result primarily from the South Slough Arm with lesser amounts contributed by the sewage treatment plant discharges.

[3] Extensive algal growth occurs in this stretch of the Main Canal from May through September. Dissolved oxygen saturation levels have been observed to be generally above 100% during the Spring-Summer period. The highest observed dissolved oxygen saturation level of 260% occurred at N. E. 33rd Avenue.

[4] Total coliforms and on occasions fecal coliforms were high in this stretch of the Main Canal. The coliforms probably result from the package sewage treatment plant discharges located at N. E. 92nd and 82nd Avenues, regrowth of coliforms in the slough, or from failing subsurface disposal systems serving homes located along the Main Canal.

8). South Slough Arm

a). From N. E. 147th to N. E. 112th Avenue

[1] The large collection of springs in this 1-3/4 mile stretch of the South Slough Arm contributes about 26% of the total dry weather flow passing from the Upper Slough out through the tide gates at the Multnomah County pumping plant to the Lower Slough.

[2] The spring water is generally cold, ranging from 11°C - 15°C (51°F - 59°F), and it is relatively clear, generally having a turbidity level of less than 4 J.T.U. and a suspended solids concentration of 7 mg/l or less.

[3] The spring water is highly enriched with nutrients, having an average nitrate-nitrogen concentration of 5.3 mg/l and an average total phosphorus content of 0.12 mg/l. Dissolved oxygen saturation levels have

ranged from 62% to 196% but it is generally above 100% of saturation during the Spring-Summer period as a result of algae and rooted aquatic plant production in this stretch of slough. The sources of nitrate-nitrogen in the spring water result from the microbial activity and applied fertilizers in the topsoil that leach downward. The major source of nitrate-nitrogen presently existing in the springs results from the subsurface disposal of an estimated 8 million gallons per day of household waste into cesspools in the east Multnomah County area.

b). N. E. Alderwood Drive

[1] This stretch of the South Slough Arm is generally wide and shallow.

[2] The water quality in this section of the South Slough Arm is also chemically enriched with nutrients. The enriched waters and resulting algal blooms cause dissolved oxygen saturation levels to range from 135% to 240% of saturation.

[3] On July 5 and 6, 1973, a diurnal dissolved oxygen survey was conducted to determine if the high algae content in these waters would deplete the dissolved oxygen content at night during algal respiration. The mid-afternoon dissolved oxygen content was 230% of saturation and the early morning hour saturation was 147%, indicating that more than sufficient dissolved oxygen was present to sustain fish and other aquatic life throughout a 24-hour period.

c). N. E. 33rd Avenue

[1] This section of the South Slough Arm is deadended near N. E. 42nd Avenue. The Broadmoor Golf Course is located on either side of upper portion of the South Slough Arm and Main Canal.

[2] Like the upper sections of the South Slough Arm, this separated water body forming the South Arm is also highly enriched with nutrients. Algal blooms normally occur from Spring through Summer. Dissolved oxygen saturation levels have been observed to range from 95% to 282% of saturation. A diurnal survey on July 5-6, 1973, indicated a mid-afternoon saturation level of 242% and an early morning level of 175%, which is more than sufficient to sustain fish and other aquatic life.

2. Lower Slough, North Slough and Blind Slough

a. The Lower Slough extends from N. E. 17th Avenue to the Willamette River, a distance of about 8-1/2 miles.

b. Twelve (12) combined sewer outfalls ranging in size from 24 inches to 66 inches in diameter discharge to the lower slough from the south bank.

c. One (1) outfall for treated domestic sewage exists at present.

d. Sixteen (16) industrial discharges to the slough exist at present (Table P).

   1). Two are for treated inorganic wastes.

   2). Fourteen are for cooling water.

   3). Storm water is also discharged through six (6) of the industrial outfalls.

e. Some leachate from the Portland Sanitary Landfill reaches the slough.

f. Eight general water quality surveys were performed on the lower Columbia Slough between 1971 and 1973 on the dates listed below:

   1). 1971

      a). July 20

      b). August 18

      c). September 28

   2). 1972

      a). June 19

      b). July 5

      c). August 2

      d). September 12

   3). 1973

      a). July 9-10

      b). September 4

During the surveys of June 19 and July 5, 1972 the temporary sand plug was in place in the lower portion of the slough. This temporary sand plug was constructed as a flood control measure against the expected high freshet Columbia River flow. The sand plug was formed in early May and removed on July 7, 1972. The objectives of these surveys were to evaluate the general water quality in the slough following the elimination of organic industrial discharges by connection to the Portland Sewerage System and to determine whether or not leachates issuing from the Portland Sanitary Landfill site had any measurable impact on water quality in the slough. The summarized data contained in Table C showed the following conditions:

1). Main Columbia Slough

a). Water temperatures, extending from summer through early fall, ranged from 13°C to 25.5°C (Ca 55°F to 78°F).

b). The dissolved oxygen content was generally supersaturated because of the high algae production in the water. The algae laden waters were present in the upper Columbia Slough System even before it entered the lower Columbia Slough through the tide gates located at N. E. 17th Avenue.

c). The median MPN of total coliforms and fecal coliforms showed a general rise through the slough system. High bacterial counts occurred especially on September 28, 1971, when some of the combined sewers were overflowing. The coliforms related to fecal contamination are relatively lower during the periods of dry weather flow.

d). Anaerobic decomposition of the bottom sediment was extensive in July and August, 1971, and from June through August, 1972. Gasification, however, was not apparent in either July or early September 1973. Since the lower slough is subject to tidal influence, the direction of flow is reversed about each six hours, making it difficult to flush itself adequately. Tree leaves shed during late fall along the slough bank and organic and inorganic debris carried into the slough system from the combined and even storm sewers tend to be trapped in the slough. Bacterial decomposition of this organic matter during the winter and spring is normally a slow process because of the cold water. Therefore, much of the decomposition of organic matter occurs during the summer period of warmer water.

e). During the July and August, 1971 surveys, leachates were observed issuing from the Portland Sanitary Landfill site fronting Columbia Slough and North Slough. No attempt was made to observe for signs of leachates in Blind Slough because of the log jams in this waterway. One leachate sample was collected from the North Slough for heavy metals analyses in July. The results were as follows: Pb, 0.001 mg/l; Mn 3.4 mg/l; Cr, <0.002 mg/l; Fe, 25 mg/l; Cu, 0.006 mg/l, and Zn, 0.11 mg/l. Manganese and iron were relatively high, however, when the diluation power of the slough waters surrounding the landfill site are taken into account, the diluted metals concentrations would not be deleterious to fish or aquatic life. Neither dead nor distressed fish has been observed in this area of the slough.

During the August 1971 survey, four leachate samples were collected along various areas of the bank at the fill site. One sample was collected along the bank fronting Columbia Slough between the Portland Dump Road and Blind Slough. This sample yielded the following results: BOD, 345 mg/l; suspended solids, 1,000 mg/l; and COD 2,000 mg/l. The high results may be due to silt in the sample (especially suspended solids) because it required some digging into the bank to collect the sample.

The other three leachate samples were collected by allowing bottles to fill without disturbing the bank soil. Two of the samples were collected from the bank of Columbia Slough and one from the bank of North Slough. The sample collected from between the Sanitary Landfill Road Bridge and the BPA power line crossing along the Columbia Slough yielded these results: BOD, 18 and 60 mg/l; suspended solids, 156 mg/l; and COD, 520 mg/l. The other sample collected from between the BPA lines and mouth of North Slough yielded these results: BOD, 12 and 27 mg/l; suspended solids, 364 mg/l; and COD, 334 mg/l.

Leachate discharging immediately above the BPA power line crossing at the North Slough yielded these results: BOD, 27 and 12 mg/l; suspended solids, 364 mg/l; and COD, 512 mg/l. The fill along the North Slough area has been brought up to the level and grade recommended by the consulting engineers report.

The Portland Sanitary Landfill site fronting the Columbia Slough was not discharging leachate during the September, 1971 survey. Observations for possible leachate discharges into Blind and North Sloughs were not made. However, the high chloride content in North Slough suggested that leachings from land bordering the slough were entering into this small waterway.

Of the various water quality parameters measured in the Columbia Slough in the vicinity of the Portland Landfill site, only chloride levels showed a significant increase by an average of about 2 mg/l. This suggests that the landfill does not pose a threat to fish or other aquatic life.

f). Water quality did not apparently change either with or without the temporary sand plug in place in the lower portion of the slough. When the water in the Upper Columbia Slough at the Multnomah County pumping plant is laden with algae and microscopic animals, and supersaturated with dissolved oxygen, the outflow of this water to the Lower Columbia Slough will essentially reflect these same conditions.

2). Blind and North Sloughs

These two minor waterways border the Portland Sanitary Landfill site and are tributaries to the lower portion of the slough.

Blind Slough fronts the east edge of the landfill, while North Slough borders the northern edge of the fill site.

a). Blind Slough

[1] The lower portion of this slough was sampled in July and August 1971 only. During September 1971, this slough bed was dry.

[2] The impact of leachates on water quality in this small slough caused slight increases in alkalinity, sulfate, ammonia-nitrogen, and chlorides.

[3] The Blind Slough water quality impact on the main Columbia Slough after mixing, however, is insignificant.

b). North Slough

[1] Samples were collected from two points in this small slough in July and August. The very small flow in September prevented sampling above the mouth area.

[2] During dry weather flow in July and August 1971, the suspended solids content and turbidity levels were higher than in the main Columbia Slough. These higher readings were due to silt turbidity.

[3] During the wet September 1971 survey, the observed high turbidity and suspended solids content near the slough mouth was caused by silt.

3. Special Surveys

a. Diurnal Dissolved Oxygen Surveys

1). Diurnal dissolved oxygen surveys were conducted on the upper and lower Columbia Slough during July 1973.

2). These survey results are shown in Tables D and E.

3). Upper Columbia Slough

a). This survey was performed in mid-afternoon on July 5, 1973, when the dissolved oxygen was expected to be at its maximum level and the following early morning hours when the dissolved oxygen level was expected to be at its lowest level.

b). The difference in water temperature between mid-afternoon and the early morning hours ranged from 1°C to 3°C (Ca. 2°F to 5.5°F).

c). Fairview Creek and the Main Drainage Canal at N. E. 185th Avenue showed the least diurnal fluctuation in dissolved oxygen, varying only 5% and 7% respectively.

d). Mid-afternoon dissolved oxygen saturation levels, ranging from 195% to 242%, occurred in the entire reaches of South Slough Arm and in the Main Drainage Canal at N. E. 33rd Avenue and Multnomah County pumping plants. These two lower stations in the Main Canal receive the drainage from the South Slough Arm.

e). The lowest early morning dissolved oxygen saturations occurred at Fairview Creek and Main Canal at N. E. 185th Avenue, both being 88% and 85%, respectively.

f). None of the extremely high daytime nor early morning dissolved oxygen saturation levels would be expected to cause any adverse effects on fish or other aquatic life in these waters.

g). Wiebe et. al., (1932) performed experiments on juvenile crappie, largemouth bass, smallmouth bass, green sunfish, bluegill, goldfish, golden shiners, blunt-nosed minnows, orange-spotted sunfish, rainbow trout and brook trout, subjecting these fishes to abnormally high levels of dissolved oxygen concentrations (356% of saturation) for periods between 15 and 20 days. Based upon his experimental results, he concluded that the above-named species could survive such exposures of dissolved oxygen levels indefinitely.

4). Lower Columbia Slough

a). This survey was performed in mid-afternoon on July 9, 1973 and in the early morning hours on July 10, 1973, to observe the diurnal dissolved oxygen fluctuations.

b). This section of the Columbia Slough was under tidal influence during the survey period. During July 9, 1973, the tide was at high slack, and on July 10, 1973, it was observed to be flowing west.

c). The mid-afternoon and the early morning hour water temperature difference ranged between 1.5°C and 6°C (Ca. 3°F and 10°F).

d). The mid-afternoon dissolved oxygen levels ranged from 188% to 263%, extending from Union Avenue Bridge to the Portland Sanitary Landfill Bridge. The early morning dissolved oxygen concentrations ranged from 91% to 226%, with the lowest two readings occurring at the North Portland Road and Sanitary Landfill access bridges. The appearance, temperature, and pH of the water at the Portland Sanitary Landfill access bridge indicated that it was probably a mixture of Columbia Slough and Willamette River waters as this location was sampled about 3 hours following high slack tide.

e). Fish and other aquatic life would not be adversely affected by the day and night-time high dissolved oxygen concentrations.

5). The Oregon Wildlife Commission conducted fish population surveys on both July 6 and 10, 1973, which is discussed under the section of Fish and Other Aquatic Life.

b. Smith and Bybee Lakes

1). Smith and Bybee Lakes are broad, shallow water bodies located north of the main Columbia Slough in the vicinity of the Portland Sanitary Landfill.

2). Smith Lake dries up nearly every summer.

3). During the fall-winter seasons, migratory waterfowl use these lakes for resting areas.

4). A survey was conducted by the Department of Environmental Quality staff on December 29, 1971, to evaluate the quality of water, bottom sediments, and associated biota. These two lakes were also surveyed on July 5, 1972, when the temporary sand plug was in place in the lower reach of the Columbia Slough, backing up water in both lake systems.

5). The water quality data are tabulated in Tables F and G. The bottom sediment data are presented in Table H, and the suspended biological life are tabulated in Table L.

6). Water Quality

a). The data indicate that the waters in Smith and Bybee Lakes were generally of good quality in December, 1971. During the July 5, 1972 survey, the lakes were probably a mixture of Columbia Slough, Columbia River and Willamette River waters.

b). Nitrate-nitrogen and ortho-phosphate concentrations were inexplicably higher in December, 1971 than in July, 1972.

c). The effects of low concentrations of heavy (e.g. zinc, lead, copper, chromium, and mercury) measured during December, 1971 - on fish or other aquatic life are not known but may be minimal. The April, 1973 fish population survey indicated that a wide variety of game fish species were present in this lake.

7). Bottom Sediments

a). The high Chemical Oxygen Demand (COD) levels are probably due to the reduced iron (Fe) concentrations in Smith and Bybee Lakes.

b). Since there is a lack of data on bottom sediment for lakes in Oregon, there is little basis for drawing conclusions from the results found in Smith and Bybee Lakes. There are, however, no observed signs of gross pollution, and the organic content is lower than that in the Columbia Slough.

8). Biota Associated with December, 1971 Survey

a). The biota associated with the bottom sediments in Smith and Bybee Lakes indicated an abundance of Leptothrix discophous, a common iron bacterium.

b). Live diatom species present in Smith and Bybee Lakes included the following:

| Diatoms | Lakes: Smith | Lakes: Bybee |
|---|---|---|
| Melosira granulata | X | X |
| Melosira granulata var. angustissima | X | X |
| Melosira granulata var. angustissima forma spiralis | X | X |
| Melosira varians | | X |
| Pinnularia sp. | | X |
| Navicula sp. | | |

c). In general, both lakes differed from the Columbia and Willamette Rivers only in that a greater variety of plankton is usually found in these rivers.

9). Aphanizomenon flos-aqua, a blue-green alga was present in Smith Lake but not in Bybee Lake during the July 5, 1972 survey. This alga was also present in the North Slough which receives the outflow from Smith Lake. Aphanizomenon can exist in waters having a low nitrogen content, because it has the ability to fix nitrogen from the atmosphere. The reasons for its presence in Smith Lake are not known. One possible explanation is that the relatively low nitrogen level (ammonia-nitrogen, 0.10 - 0.13 mg/l) and (nitrate-nitrogen, 0.08 - 0.19 mg/l) gave this organism a competitive advantage because of its ability to fix atmospheric nitrogen. Another possible explanation is that blue-green algae are able to take up phosphorus from extremely dilute solutions, store it, and distribute it to daughter cells (McHugh, 1972).

c. Bottom Sediment Composition in Lower Slough

1). Bottom sediment cores were collected from the Columbia Slough and upper portion of North Slough with the assistance of the Corps of Engineers work-barge and personnel on June 19, 1972.

2). Unfortunately, the high water level in the Columbia Slough prevented the work-barge from proceeding upstream beyond the Union Pacific Railroad Bridge for sample collections.

3). The core samples were obtained by raising a weighted coring device about 10 feet above the water level and allowing it to plunge through the water column and into the sediment. The coring device sample tubes are 24 inches long and about one inch in diameter.

4). The analyses of each core sample are tabulated in Table I.

5). The core lengths obtained ranged from 4.25 inches to 14 inches. The bottom sediments were observed to be relatively fluid, causing some of the sample to flow out as the coring device was retrieved.

6). The top one-inch and bottom one-inch of each core sample were analyzed to provide comparative data relative to the organic content and the degree of stabilization of sediments in the main Columbia Slough.

7). Ballinger et al (1971) characterized bottom sediments based upon the product of the percentages of organic carbon and organic nitrogen in sediment samples. The product of these two constituents was termed the Organic Sediment Index (OSI). Based upon their experience in evaluating sediment samples, the following classification system was developed:

| OSI | Typical Bottom Deposits |
|---|---|
| 0.0 - 0.5 | Sand, clay, old stable sludge |
| 0.5 - 1.0 | Organic detritus, peat, partially stabilized sludge |
| 1 - 5 | Sewage sludge, decaying vegetation, pulp and paper wastes, sugar beet wastes |
| 5 and above | Actively decomposing sludge, fresh sewage, matted algae, packing house waste |

8). The OSI index for the core samples collected from the Columbia Slough and North Slough ranged from 0.95 to 26.7, with all but one observation being 3.1 and higher. Based upon the Ballinger et al (1971) classification system, the bottom sediments in the lower Columbia Slough system are essentially in an active decomposition state. Observations during the 1971 and 1972 surveys indicated signs of active anaerobic decomposition of the bottom sediments. The limited observations of the Columbia Slough in

July and September 1973, however, did not show these same signs of active anaerobic decomposition. The few observations in 1973 are not a conclusion that the organic content of the bottom sediments have reached stability.

9). Schmidt (1971) of the Environmental Protection Agency (EPA) performed surveys on the bacterial quality of the water and the bottom sediments in the Columbia Slough between April 7 and 20, 1971. He recommended dredging of the delta of calcium carbonate which formed in the slough when the Pacific Carbide settling pond dike breached in 1970. He also recommended that the sludge deposits in the vicinity of the meat packing and rendering plants be dredged following these industrial connections to the city sewer system. Pacific Carbide Company removed their sludge deposit from the Columbia Slough bed in August 1973.

10). The organic matter, as measured by the percentage of volatile solids, present in the bottom sediments range from about 7% to 19%. The organic matter present in the slough bed represents many years' accumulation of meat packing and rendering plant wastes and solids from the City of Portland's combined sewer overflow. Approximately 80% or more of the bottom sediment in the lower portion of the slough is composed of silt, sand particles and other inorganic materials. Silt, sand and inorganic matter enter the Columbia Slough System from road surface runoff into the upper slough and from the overflow of combined sewers into the lower slough. Evidence of an extensive build-up of sediment associated with surface runoff exists below the Multnomah County pumping plant outlet. Multnomah County Drainage District No. 1 has an annual program for maintenance dredging in the upper sections of the Columbia Slough System. A similar dredging program for the lower Columbia Slough does not exist.

11). The impact of the decomposing organic matter associated with the bottom sediments on the overlying water appears to contribute in part to the increase of the parameters listed below. The range of the mean values listed show the comparative increases in these parameters over that occurring at the Multnomah County pumping plant.

| Parameter | Range of Mean Value Increase, mg/l |
|---|---|
| Ammonia-Nitrogen | 0.05 - 0.41 |
| Sulfate | 0.7 - 1.0 |
| Sodium | 0.1 - 2.0 |
| Chloride | 1.3 - 4.3 |
| Potassium | 0.4 - 1.5 |
| Biochemical oxygen demand | 0.2 - 2.6 |
| Alkalinity | 1.4 - 23.3 |
| Hardness | 2 - 11 |

Of the above parameters, ammonia-nitrogen - which includes all of the nitrogen in the form of ammonia, ammonium hydroxide, and ammonium ions - has potential of adversely affecting fish life in the lower Columbia Slough when temperatures increase and when the pH of the water increases from 7.0 to 9.0 and above as a result of high algal production. But fish kills have not been observed which suggests that ammonium toxicity is not a problem.

12). The removal of the accumulated sediment bed in the lower Columbia Slough would undoubtedly help improve water quality to some extent. It would not, however, be expected to significantly decrease the production of algae in these waters because of the algae laden waters present in the outflow from the upper Columbia Slough to the lower Columbia Slough. If the organic sediments remain in the Columbia Slough System, the upper layer of the deposit would probably undergo aerobic decomposition. The layers below the superficial surface would undergo anaerobic decomposition which is a slower rate than that occurring at the sediment-water interface (Fair et al, 1941). Even though industrial organic waste is no longer discharged to the lower Columbia Slough, the combined sewer overflows and the autumn tree leaf fall can be expected to contribute an unknown amount of organic matter that will settle on the slough bottom annually. Before any program is initiated to remove the sediments from the Columbia Slough System, the following at least must be considered:

a). The depth and the extent of the sediment layer that should be removed must be determined. Such an evaluation would require more extensive sampling equipment than that on hand at this Department.

b). A spoils disposal site must be established where the runoff from the spoils would not enter into a fixed body of water.

# FISH AND OTHER AQUATIC LIFE

1. Fish Populations

   a. Fish Inventories

      1). The Oregon Wildlife Commission (formerly Oregon Game Commission) sampled fish populations in the upper and lower reaches of Columbia Slough, in Smith Lake, and in three ponds located in Delta Park between March 15 and April 6, 1973 (Bisbee et al, 1973). They also performed a similar, but less comprehensive survey during the period July 6 to July 10, 1973.

      2). March 1973 fish populations survey:

         a). Fish types observed in the Columbia Slough during March, 1973 and in Smith Lake during April, 1973 are as follows:

| Game Fish Species | Rough Fish Species |
|---|---|
| Black crappie | Carp |
| Bluegill | Cottid |
| Brown bullhead catfish | Goldfish |
| Largemouth bass | Peamouth chub |
| Warmouth bass | Stickleback |
| Pumpkinseed | Squawfish |
| White crappie | Coarse-scale sucker |
| White sturgeon | |
| Yellow perch | |
| Chinook (juvenile) | |

         b). Survey results are summarized as follows:

            [1] Entire length of Columbia Slough

| | | |
|---|---|---|
| Total fish caught | = | 724 |
| Total game fish | = | 110 |
| Percent game fish | = | 15.2% |

               [a] Upper Columbia Slough

| | | |
|---|---|---|
| Total fish caught | = | 546 |
| Total game fish | = | 14 |
| Percent game fish | = | 2.6% |

               [b] Lower Columbia Slough

| | | |
|---|---|---|
| Total fish caught | = | 178 |
| Total game fish | = | 96 |
| Percent game fish | = | 54% |

[2] Smith Lake

| | | |
|---|---|---|
| Total fish caught | = | 296 |
| Total game fish | = | 174 |
| Percent game fish | = | 58.8% |

3). July 1973 fish populations survey:

a). On July 6 and 10, 1973, the Oregon Wildlife Commission resampled fish populations in the Columbia Slough but at fewer stations (see Table J).

b). Survey results are summarized as follows:

[1] Entire length of Columbia Slough

| | | |
|---|---|---|
| Total fish caught | = | 271 |
| Total game fish | = | 29 |
| Percent game fish | = | 10.7% |

[a] Upper Columbia Slough

| | | |
|---|---|---|
| Total fish caught | = | 213 |
| Total game fish | = | 24 |
| Percent game fish | = | 11.2% |

[b] Lower Columbia Slough

| | | |
|---|---|---|
| Total fish caught | = | 58 |
| Total game fish | = | 5 |
| Percent game fish | = | 8.6% |

[2] Smith Lake Outlet

| | | |
|---|---|---|
| Total fish caught | = | 20 |
| Total game fish | = | 7 |
| Percent game fish | = | 35% |

4). The fish population surveys performed during spring and summer, 1973 indicated a greater diversity of warm-water game fish species than coarse species in the Columbia Slough System and in Smith Lake. Furthermore, game fish constituted less than 20% of the total fish in the entire Columbia Slough System. The highest percentage of game fish - occurring in March, 1973 - may be due to a seasonally high volume of water. The Willamette River stage at Portland during the March 15 - 21, 1973 survey ranged from 3.9 to 6.6 feet, while the July 6 and 10, 1973 stage height ranged from 2.3 to 3.3 feet. This suggested that water volume, relative depth, and perhaps unknown chemical and physical factors may influence fish distribution in the lower slough.

b. Water Fertility

1). The large populations of rough fish species in the Columbia Slough System is believed to be related to nutrient enriched water which stimulates high algal production. Moyle (1956) found this to be the case in Minnesota. From 1940 through 1951, he performed 1,546 water analyses on water samples collected from fish lakes, waterfowl lakes, and prospective fish-rearing ponds. The range of chemical constituents from these analyses were as follows:

| | Parts per Million |
|---|---|
| Total Alkalinity | 6.3 - 537.5 |
| Sulphate Ion | 0.0 1,210.0 |
| Chloride Ion | 0.0 - 113.0 |
| Total Phosphorus | 0.002 - 1.6 |
| Total Nitrogen | 0.06 - 5.9 |

2). Moyle (1956) also evaluated the standing crop of fishes in these lakes in an attempt to relate fish populations with water fertility during the summer periods. The average standing crop of fish populations and the average total phosphorus content are summarized as follows:

| Mean Total Phosphorus, mg/l | Average Pounds of Fish per Acre | Fish Populations |
|---|---|---|
| ≤ 0.02 | 40 | Lake trout, tullibee and white suckers. Centrachids were usually absent. |
| 0.034 | 90 | Yellow pike perch, yellow perch northern pike, brown and yellow bullheads, white suckers. The centrachids, especially large mouth bass, bluegills, and black crappies were present, and were sometimes abundant in smaller lakes, but often have slower growth rates than in more fertile waters. |
| 0.058 | 150 | Mostly bass-panfish waters, and despite 50 years of pike perch stocking, the panfishes still supplies the bulk of the fishing. |

| Mean Total Phosphorus, mg/l | Average Pounds of Fish per Acre | Fish Populations |
|---|---|---|
| 0.126 | 370 | Mostly populations of rough fish especially carp, buffalo-fish, and black bullheads. Centrachids were also present, and many of these lakes in Southern Minnesota were stocked with pike perch. These waters have been subjected to intensive rough-fish-removal operations for 25 years. Seining in 40 such fish lakes showed an average standing crop of 280 pounds of rough fish per acre plus about 90 pounds of other fishes, producing an average of 370 pounds per acre. |

3). Based upon the above conditions, Moyle (1956) concluded that (1) the optimal total phosphorus concentrations for lake trout, pike perch, centrachids, and carp were 0.02, 0.035, 0.05 and 0.10 mg/l, respectively, and (2) in the event of less than (or more than) optimal nutrient conditions, the structure of the fish populations is adjusted until it consists of species best able to tolerate the prevailing nutrient concentrations and associated environmental conditions.

4). The total phosphorus content in the upper Columbia Slough averaged 0.12 mg/l in the South Slough spring waters at N. E. 122nd, 0.055 mg/l at a point between N. E. 185th and 122nd Avenues in the Main Canal, and 0.93 mg/l at the Multnomah County Pumping Plant where Main Canal and South Slough Arm Waters mix. The mean total (P) content in the lower slough is about 0.1 mg/l.

c. Water Fertility and Flow Augmentation

1). Columbia River is regarded as a potential source of water to dilute the chemically and biologically enriched waters of the Columbia Slough during late spring and summer. The river water would be introduced at the head of the drainage canal adjacent to N. E. 185th Avenue and Marine Drive.

2). The water quality of the Columbia River should be evaluated as a potential water supply before it is used for dilution purposes. Foremost among required characteristics for dilution water are low quantities of total phosphorus and suspended solids to avoid additional enrichment and sedimentation in the Columbia Slough. These two water quality parameters are addressed as follows:

a). Total Phosphorus

[1] The mean total phosphorus contents on the Oregon side of the Columbia River near Vancouver, Washington are tabulated below for the months of June through September, 1964-65:

| Month | Columbia River Mean Total (P) mg/l 1964 | 1965 |
|---|---|---|
| June | 0.08 | 0.14 |
| July | 0.046 | 0.055 |
| August | 0.031 | 0.029 |
| September | 0.023 | 0.059 |

[2] In order to dilute the average summer flow (70 cfs) in the Columia Slough with Columbia River water, it would require the following volumes to reduce the total (P) content (i.e. 0.10 mg/l in lower slough, mean value) to 0.05 mg/l:

Columbia River

| Mean Total (P) mg/l | Volume Required, cfs |
|---|---|
| 0.03 | 170 |
| 0.04 | 350 |
| 0.045 | 700 |
| 0.049 | 3,500 |

[3] The previous tables suggest that during the months of June, July, and possibly in September, even Columbia River flows in excess of 1,000 cfs would not substantially improve water quality in the Columbia Slough - in order to reduce the effects of high algae production - because of the moderate levels of phosphorus in the Columbia River. However, if the total P content in the Columbia River is 0.04 mg/l or less, an introduced flow of 350 cfs would probably be sufficient to dilute the slough water to 0.05 mg/l total (P) or lower. The period of significant nutrient reduction would most likely occur in August. But even then, under reduced nutrient loading, algal production may persist - a condition which will continue to render the slough aesthetically unpleasant.

b). Suspended Sediments Associated with Flow Augmentation

[1] The Columbia River transports a high sediment load, especially during the freshet flow period which normally peaks between May and early July. The extent of the load depends on the previous winter snowpack, rate of runoff, and reservoir storage capacity in the upper basin.

The Columbia River suspended sediment loads at Vancouver, Washington, measured by the U. S. Geological Survey daily between 1963 and 1967 from April through September, are shown in Table K. The concentrations of suspended sediments in the Columbia River vary greatly with flow, ranging from 10 to 200 ppm.

If 350 cfs of Columbia River water were used to augment flows in the Columbia Slough - 350 cfs being roughly the maximum quantity of water that could be introduced - then one could expect varying amounts of suspended sediments to enter the slough. These amounts, depending on the flow of the Columbia River, are shown below:

Columbia River at Vancouver, Washington

Suspended Sediment*

| Approximate Flow Range, cfs | ppm | In 350 cfs flow Augmentation; Tons/day |
|---|---|---|
| | 200 | 189 |
| | 150 | 142 |
| (Highly variable) 300,000 to 650,000 | 100 | 95 |
| | 50 | 47 |
| | 35 | 33 |
| 250,000 | 25 | 24 |
| 200,000 | 20 | 19 |
| 155,000 | 10 | 10 |

Note: 10 tons of sand is equivalent to one 5-cubic yard truckload.

* Suspended sediment is the sediment that at any given time is maintained in suspension by the upward components of turbulent currents or that which exists in suspension as a colloid. The sediment is composed of solid material (disintegrated rocks), chemical and biochemical precipitates, and decomposed organic matter (U. S. Geological Survey, 1967).

[2] The data above indicate that Columbia River flows above 300,000 cfs (measured at Vancouver, Washington) contain considerable concentrations of suspended sediments that are generally associated with the spring freshet. Freshet flows, if introduced into the Columbia Slough, would not only fail to improve water quality in terms of nutrient level reduction, but would bring additional sediment which subsequently would require increased maintenance dredging and spoils disposal. At flows of 250,000 cfs or less - normally occurring after mid-July - 350 cfs of Columbia River augmentation flow would introduce an additional 10 to 24 tons of suspended sediment per day into the Columbia Slough. Therefore, in order to avoid excessive sedimentation, the best time to augment flow in the Columbia Slough would be during a period of 60 to 80 days, between July 15 and the middle of September when fall rain generally begins.

[3] Historically, the lower Columbia Slough was linked to the Columbia River via the Peninsula Drainage Canal which was constructed by the City of Portland in 1918. Columbia River flows entered the lower Columbia Slough immediately below the Multnomah County pumping plant for the purpose of flushing out domestic and industrial wastes. By 1929, the Columbia River freshet flows deposited enough sand to plug 5,000 feet of the northern portion of the Peninsula Canal. In an effort to maintain Columbia River flow through the system, a dam with culverts was installed at the north end of the canal. Shortly thereafter, sand also plugged these culverts. Both ends of the Peninsula Canal were permanently plugged with sand around 1950 to enhance flood protection for the drainage districts located on either side of the canal.

d. Water Fertility Without Flow Augmentation

1) The Oregon Wildlife Commission and the U. S. Bureau of Sports Fisheries and Wildlife do not believe that the introduction of water from the Columbia River is necessary to maintain a sport fishery in the Columbia Slough System. Since the Columbia Slough System currently supports both game and rough fishes and because the water quality does not appear to have any adverse effects on fish populations, it is these fisheries experts' belief that a desirable sport fishery can be established through poisoning and restocking efforts.

2). Game fish species can be reared in chemically enriched waters if dissolved oxygen concentrations are favorable.

Hallock et al,(1970) passed secondary treated domestic waste over filter basins composed of sand and gravel to rear channel catfish in ponds. The concentration of orthophosphate in the effluent ranged from 2 to 20 mg/l. Dissolved oxygen concentrations ranged from 0.24 mg/l to 37.4 mg/l. The resultant net production of channel catfish was 343 pounds per acre per year. In the Columbia Slough, such variations in orthophosphate and dissolved oxygen are much lower. Dissolved oxygen generally exceeds saturation levels, even at night when dissolved oxygen demands for algal respiration are greatest.

3). If Moyle's conclusions can be applied here, then the Columbia Slough should theoretically yield about 300 pounds of mostly rough fish per surface acre if augmentation flows were not introduced to the slough as a means of diluting enriched waters. Conversely, with flow augmentation, fish yield would be reduced by as much as 50%. But hopefully, the yield would consist mostly of game fish which are more successful in less enriched waters.

e. Effects of the Multnomah County Drainage District on fish pop- in the Columbia Slough.

1). Multnomah County Drainage District No. 1 evacuates excess water from upper Columbia Slough during the rainy season (October through April). Evacuation, made possible by a main pumping plant at N. E. 17th Avenue and a secondary plant near Blue Lake, provides storage capacity for surges of heavy surface runoff in order to minimize flooding of adjacent properties. Evacuation is followed by refilling, causing fluctuations in water level and flow velocity. This may be quite deterimental to warmwater game fish, particularly the post-evacuation period when water depth is extremely shallow and flow velocities are greater than normal. Shallow water and rapid flow, for example, prevented Oregon Wildlife Commission personnel from setting nets in the main drainage canal during March, 1973 (Brisbee et al, 1973).

2). The upper Columbia Slough may, in general, provide less than favorable habitat for warmwater game fish. Depth fluctuations as well as rapid flow velocities are generally not preferred by such fish as crappies, warmouth bass, bluegills and pumpkinseeds. The Oregon Wildlife Commission during March, 1973 (Bisbee et al, 1973) collected only 11 of these warmwater game fish from 11 sampling stations in the upper Columbia Slough while catches from only three stations in the lower reaches of the slough consisted of 83 crappies. Gill nets placed in Smith Lake on April 6, 1973 yielded 79 crappies and six bluegills.

3). Rough fish species such as carp, coarsescale sucker, peamouth and Columbia River chubs, squawfish and stickleback - possessing, among other features, more streamlined, torpedo-shaped bodies - may be best fit for fast moving waters and fluctuating depths which characterize the Upper Columbia Slough.

4). During the dry season (May through September), warmwater game fish (e.g., crappies, bluegills) may move into upper slough waters, particularly into quiet bays and cul-de-sacs, as favorable hydrologic conditions develop. Rough fish, nevertheless, predominate throughout the Columbia Slough all summer. This is due, in part, to increased water temperatures, nutrient loading and algal abundance.

f. Conclusions and Recommendation

1). Algal production and growth in the Columbia Slough are extensive during spring and summer months. Rough fish are generally favored by high algal production which may explain why rough species predominate. If the use of Columbia River water for dilution purposes - introduced to the slough at a rate of 350 cfs - achieves a reduction in algal growth and production, then perhaps rough fishes will also decline. The possible reduction in nutrients (e.g. phosphorus) and algae through the introduction of Columbia River water into Columbia Slough however may be temporary, lasting perhaps for 30 days or more. During the remainder of the spring-summer months, nutrient availability and biological production are expected to be excessive and thus favorable for rough fishes.

2). Pumping operations by the Multnomah County Drainage District to evacuate excess water from the Upper Columbia Slough during fall and winter months may be detrimental to warmwater game fish despite the diversion of some Columbia River water to the slough in an attempt to improve water quality and enhance the game fishery. In view of this, further consideration about the use of Columbia River water for dilution purposes should be made. This would include an evaluation of specific physical characteristics of the slough (depth, width, flow volume, etc.), operational procedures by the Multnomah County Drainage District No. 1 and the feasibility of improving a warmwater fishery.

2. Plankton

a. Biological surveys of the Columbia Slough and of Smith and Bybee Lakes during July, 1972 and July, 1973 indicated an abundance of planktonic organisms (Tables L and M). Diatoms and filamentous green algae were the predominant phytoplankters in the Columbia Slough while Smith and Bybee Lakes contained mostly diatoms and some bluegreen algae identified as *Aphanizomenon flos-aquae*. Zooplankton, including mostly copepods, cladocerans and rotifers, were also numerous.

b. Generally speaking, phytoplankton forms the basis of the aquatic food chain. Where the water is nutrient enriched, under favorable light and temperature conditions, the phytoplankton will increase noticeably until large concentrations or "blooms" have developed. Thereafter, concentrations of algae will diminish as the supply of nutrients are depleted and as herbivorous zooplankters, molluscs and small fish consume protions of the algae crop. During the bloom, the water will appear greenish or brownish depending on which algal form is predominant. Unpleasant odors and tastes will likely develop as large quantities of algal material undergoes decomposition in surface waters. This, of course, will probably render the waters unfit for various recreational uses.

c. Growth and production of algae are greatest during the late spring, summer and early fall months when light, temperature and nutrient conditions are most favorable. Nutrient availability is perhaps the most critical factor. Growth and production will be limited by a specific nutrient (e.g., phosphorus) even though other nutrients are abundantly available. Algal blooms will develop as long as minimum nutrient requirements are met. In the following table, theoretical minimum nutrient requirements are compared with concentrations found in local spring and deep well waters.

| | mg/l | | |
|---|---|---|---|
| Parameter | Minimum level Required for algal blooms | South Slough Spring, N. E. 122nd | Deep Well Water, (100-200 ft. below mean sea level) |
| Inorganic Phosphate (Sawyer, 1952) | 0.01 | 0.16 - 0.33 | 0.32 - 0.56 |
| Inorganic Nitrogen (Sawyer, 1952; Muller, 1953) | 0.3 | 3.5 - 7.2 | 0.02 - 1.5 |
| Total Alkalinity (Moyle, 1956; Kappe et al 1971) | ≤ 40 | 43 - 50 | 73 - 120 |
| Sulfate (Beauchamp, 1953) | 0.5 | 11.9 - 21.6 | 1.0 - 4.0 |

It appears that water entering Columbia Slough from the South spring at N. E. 122nd Avenue contains more than enough nutritive materials to stimulate bloom conditions. Even deep well water - the quality of which roughly resembles that being supplied to the Main Drainage canal - holds sufficient quantities of algal nutrients. Thus, as long as these nutrient sources exist, algal growth and production in the Columbia Slough during summer can be expected to remain excessively high. Even the use of Columbia River water for dilution purposes may be ineffective in reducing algal abundance - a possibility which deserves the attention of various resource agencies and the public. Possibly, the eradication of algae - or at least the reduction of algal growth and production - can never be accomplished in the Columbia Slough. Perhaps the public and the resource agencies should accept the slough for what it is - an enriched aquatic system able to support abundant quantities of fish, molluscs, zooplankton and algae.

## LAKE RESTORATION

1. Earlier Proposals for Restoring Smith and Bybee Lakes

   a. Daniel, Mann, Johnson, and Mendenhall, (1967), presented a proposal to deepen Bybee and Smith Lakes to accommodate small crafts, and a 100-year storm and to contain storm water during the rainy season.

   b. The Columbia Slough Environmental Task Force (1972) and the public expressed a desire to improve these two lakes for boating, fishing, and habitats for warm-water fishes and wildlife.

2. Recommendations

   The local governmental planning agencies should incorporate the following considerations into their designs for Smith and Bybee Lakes if they are to provide various forms of recreation including habitats for fish and wildlife:

   a. Protect the lake shorelines as much as possible in order to:

      1). minimize the effects of erosional processes, and

      2). maintain whatever fish and wilflife shoreline habitats which still exist.

   b. Provide, by dredging, a minimum water depth of 3 meters or 10 feet to reduce the opportunity for rooted aquatic vegetation to become established. Rooted aquatic vegetation provides food for waterfowl and shelter for fishes, but these plants are undesirable to sports anglers and boaters.

   c. Discourage public swimming in the lakes. Instead, provide swimming pool facilities nearby where the water supply and treatment can be better controlled.

   d. Cooperate with the Oregon Wildlife Commission and U. S. Bureau of Sports Fisheries and Wildlife to insure that various recreational uses will not degrade lake quality and disrupt fish and wildlife habitats.

   e. Consider a plan to circulate the lower Willamette River water through these lakes at the following rates in order to reduce the effects of algal blooms:

      1). Maximum complete exchange of water should be once each 15 days.

2). Minimum exchange of water should be once every 30 days.

The introduced waters should not contain fishes, especially juvenile salmonids.

Palmer (1959) indicated that when a reservoir receives its water from a stream, there is a period of time after which the stream plankton dies out in the reservoir and before the reservoir plankton has had time to develop. The ideal period of storage, as far as a low plankton count is concerned, therefore, may be between 10 and 14 days rather than a longer period of 28 to 30 days that has been recommended in the past.

## EVALUATION OF PRESENT DISCHARGES

1. Special Survey, November 10, 1971

   a. A special survey was conducted on November 10, 1971, in the lower slough to sample storm drains, industrial outfalls and the City of Portland's combined sewer outfalls that were not submerged. This survey was conducted during a rainy day when some of the combined sewers were overflowing. The tabulated results are shown in Table N.

   b. The results indicate overflowing storm and combined sewers are significant sources of coliform bacteria as would be expected.

   c. The meat packing plants (Pacific Meat and Kenton Packing) were discharging small volumes of waste (possibly yard runoff) that contained high numbers of coliforms and high BOD values in apparent violation of their waste discharge permits.

   d. Portland Rendering and Western States Rendering were both discharging small volumes of wastes containing high BOD values and coliform concentrations in apparent violation of their waste discharge permits.

   e. Pacific Carbide's discharge was in apparent violation of waste discharge permit limitations.

2. Followup on Apparent Violations

   a. Letters were sent to apparent violators on November 30, 1971, advising of the results of staff surveys and requesting immediate correction of violations.

   b. A followup on January 5, 1972 indicated that all discharges were in compliance with permit conditions.

3. Subsequent surveys in 1972 and 1973 revealed minor problems associated with industrial site runoff. These problems were either corrected or are being evaluated for correction.

4. In December of 1970 and January of 1971, the dike failure in Pacific Carbide's settling pond resulted in deposition of sludge consisting primarily of calcium carbonate in main Columbia Slough. This deposit of waste sludge was estimated to extend 250 feet along the toe of the dike, 150 feet out towards the channel, and 100 feet parallel to the bank, forming a trapezoid. The average depth was estimated to be 5 feet, giving a total volume of approximately 131,250 cubic feet of solids deposited into the slough. The company removed this deposit of sludge in August, 1973.

5. The City of Portland's combined sewer overflows contribute inorganic and organic matter to the slough. Separation of these sewers into sanitary and storm drains would eliminate raw domestic sewage from entering the slough. The storm sewer discharge would be composed of organic and inorganic debris associated with surface runoff. The cost of separating the 12 combined sewer outfalls currently discharging into the lower Columbia Slough has been estimated to be in excess of $50 million. The city should plan to provide for the combined sewer separation by 1985 or to provide alternative means for controlling or treating these wastewaters such that untreated combined sewage is not discharged to the slough. The City of Portland should immediately evaluate and correct the conditions causing eleven of the twelve combined sewers to overflow during the dry weather period.

## BENEFICIAL USES OF COLUMBIA SLOUGH

1. Area-wide Drainage System

   a. One of the most useful purposes which the Columbia Slough System serves at the present time is that of receiving surface and subsurface drainage from within the 53.4 square miles drainage basin of North Portland and Multnomah County.

   b. With a normal annual precipitation of 43.2 inches in Portland, the resulting surface runoff must be adequately and rapidly drained into a waterway to avoid damages to industrial and private property and to reduce hazards to motor vehicular travels.

   c. Based upon the average rainfall in the Portland area, but neglecting the evaporative and other losses of water within the drainage basin, the computed average total annual volume of surface runoff entering the Columbia Slough System is as follows:

      1). Upper section = 79,200 ac. ft.

      2). Lower section

         a). Surface runoff from area north of Columbia Slough = 27,720 ac. ft.

         b). Surface runoff from area south of Columbia Slough assuming separation of combined sewers such that all storm water would be discharged to the slough = 16,200 ac. ft. Actual present discharges are less since some storm water is diverted through the city sewage treatment plant.

      3). Grand total

         a). 1 plus 2(a) = 106,920 ac. ft.

         b). 1 plus 2(a) plus 2(b) = 123,120 ac. ft.

2. Irrigation

   a. Water is pumped from the Main Drainage Canal east of N. E. Alderwood Drive to irrigate farm lands and from below this road to irrigate the golf courses.

   b. Water is pumped from the South Slough Arm to irrigate the golf courses bordering this waterway.

3. Fish and Wildlife

a. The trees, shrubs, briar patches, and grasses lining the Columbia Slough levees provide an important habitat to upland game birds and other wildlife species.

b. The upper Columbia Slough contains a wide variety of warm-water game fish such as largemouth bass, crappies, bluegills, catfish and yellow perch. The slough, however, is essentially dominated by populations of rough fish species.

c. Since the lower Columbia Slough empties into the Willamette River the fish populations would reflect the populations found in the Willamette and Columbia River Systems.

4. Recreation

a. Recreation hunting for wildlife is limited to the lower few miles of Columbia Slough and to Smith and Bybee Lakes and to the upper slough in the Fairview Lake vicinity.

b. Recreational fishing occurs primarily along road crossings where access to the waterways is readily available. Limited boat fishing occurs in the lower stretch of the slough because access must be from the Willamette River.

c. Swimming in the lower Columbia Slough has been discouraged by posted signs indicating contamination of the waterway. In addition, the excessive algae and minute animal production in this waterway does not make these waters attractive for swimming.

d. Recreational uses observed during surveys are summarized as follows:

1). Upper Slough - Three boys were fishing at the N. E. 122nd Avenue crossing of the Main Drainage Canal on the August 18, 1971 survey. The fishes in their catch included catfish, bluegills, crappies and largemouth bass.

2). Lower Slough

a). July 20, 1971

A family consisting of two adults and three children were observed fishing on the north end of North Portland Road Bridge.

b). August 17, 1971

[1] Three boys were observed fishing at the north end of Union Avenue Bridge.

[2] One man was fishing a short distance below Vancouver Avenue Bridge.

[3] One man was fishing on the bank opposite the Portland Landfill site below the BPA power lines.

[4] One boat consisting of one adult and three boys equipped with fishing rods was headed upstream beyond the landfill site.

[5] One boat containing two men was cruising up the Columbia Slough.

c). September 28, 1971

No boating or fishing activities were observed during the survey period.

d). Several boys were observed fishing on the south bank west of the Portland Sanitary Landfill access bridge on June 19, 1972. Their catch included carp and yellow perch.

e). Between 9 and 11 people were observed fishing between Union Avenue Bridge and the outlet of Bybee Lake on July 5, 1972. The catch was primarily brown bullhead catfish.

f). The Oregon Wildlife Commission reported observing 15 to 20 people fishing in this stretch of the slough on March 15 and 21, 1973 (Bisbee et al, 1973). The catch was primarily bullhead catfish and crappie.

5. Aesthetics

a. The apparent water quality of the slough system from May through September is generally greenish in color due to algal blooms, and from October through April, it is generally murky or muddy due to surface runoff.

b. Within the upper slough area, a number of golf courses have incorporated portions of the Main Canal and South Slough into the landscape design.

## PROBLEMS ASSOCIATED WITH THE USAGE OF COLUMBIA SLOUGH

1. The entire length of the Columbia Slough is primarily bordered by private lands, making it difficult for the public to reach the waterway.

2. A lack of boat ramps and off-street parking areas nearby the Slough crossings discourage many people from using the Slough for recreational fishing.

3. Low water flow during the summer period and numerous snags on the Slough bottom, especially in the lower Slough, make boating hazardous.

4. On occasions, the MPN total and fecal coliform levels are high in the upper Columbia Slough System, extending west of the three package sewage treatment plants, creating a potential health hazard. These coliforms may result from the effluent discharged from the sewage treatment facilities, regrowth of these bacteria in the waterway, or from failing subsurface disposal systems serving homes along the Main Drainage Canal and South Slough Arm west of N. E. 82nd Avenue.

5. The algae laden waters of the Columbia Slough System are apparently beneficial to the resident fish populations, and it limits the practical use of this water for fishing.

## PROPOSED RECLAMATION RECOMMENDATIONS

1. Upper Slough and Lakes

   a. Oregon Game Commission recommendations

      1). Acquisition of land along the slough and edge of Fairview Lake for public access and bank fishing.

      2). Construction of boat ramps along selected areas at Blue and Fairview Lakes and Columbia Slough.

      3). Eliminate the water pollution problems.

      4). Chemical treatment to rid the system of rough fish species and restocking with warmwater fishes.

      5). Investigate the possibility of installing screens in the tide boxes at the lower end of the slough to prevent re-infestation of rough fish from the lower slough.

      6). Consider augmentation of flow from the Columbia River during the summer period to improve water quality.

      7). Acquire and reclaim the pond at Owens-Illinois Glass Company property for a warm-water fishery.

   b. The Columbia South Shore Study, which has not yet been completed, is a land use plan for the upper slough area and the upper portion of the lower slough extending downstream to the Union Avenue Bridge.

2. Lower Columbia Slough and Lakes

   a. Report, "Rivergate and the North Portland Peninsula," (1967) by Daniel, Mann, Johnson and Mendenhall.

      1). Deepen Bybee and Smith Lakes to accommodate small crafts and a 100-year expectancy storm, and to contain storm water.

      2). Normal drainage from the Smith-Bybee Lakes storm water retention basin would be into the realigned Columbia Slough from the proposed barge canal.

      3). Rerouting Columbia Slough into Smith Lake and Bybee Lake.

      4). Raise the levee to protect the Rivergate and Smith Lake recreational area.

   b. Reports, "North Portland Peninsula Study," (1972) by the Columbia Slough Environmental Improvement Task Force.

1). Goals

a). Develop an integrated land-use plan for the North Peninsula Area, designating areas for industrial, commercial, recreational, and open-space development to best utilize the existing and potentially enhanced features of the environment.

b). Manage the natural and economic resources of the area to best serve the needs of the citizens of the Portland Metropolitan area.

2). Management of the water resources

a). Install a water level control device in the lower portion of Columbia Slough to provide protection for the weaker interior dikes, to provide flood protection, to increase the recreation potential, and to develop a warm-water fishery, and to provide a small boat facility.

b). To dredge Smith and Bybee Lakes to improve the habitat for wildlife and a warm-water fishery.

# APPENDIX

# TABLE A
## UPPER COLUMBIA SLOUGH
## MAIN DRAINAGE CANAL
## SUMMARIZED WATER QUALITY DATA
## 1971-1973

| PARAMETERS | Fairview Creek, NE 223 Ave. | | | MAIN DRAINAGE CANAL: NE 185th Ave | | | MAIN DRAINAGE CANAL: NE 122nd Ave. | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. of Samples | Mean | Range | No. of Samples | Mean | Range | No. of Samples | Mean | Range |
| Temperature, °C | 5 | 13.4 | 9-17 | 9 | 17.3 | 9-20 | 8 | 19 | 16-22 |
| pH | " | 7.3 | 7.0-7.5 | " | 7.3 | 7.1-7.6 | " | 7.4 | 6.9-8.3 |
| Dissolved Oxygen, mg/l | " | 9.8 | 9.0-11.2 | " | 8.6 | 6.8-10.8 | " | 11.9 | 8.7-18.2 |
| D.O. Saturation, % | " | 93 | 88-101 | " | 88.7 | 72-114 | " | 128.3 | 96-196 |
| Biochemical Oxygen Demand, mg/l | 2 | 2.3 | 2.2-2.4 | 6 | 4.6 | 1.3-6.9 | 6 | 5.7 | 2.4-9.0 |
| Total Solids, mg/l | " | 159 | 140-178 | " | 190 | 166-220 | " | 189 | 166-200 |
| Suspended Solids, mg/l | " | 8.5 | 8-9 | " | 46 | 35-76 | " | 41 | 22-60 |
| Alkalinity, mg/l | " | 35 | 31-39 | " | 71 | 54-85 | " | 70 | 61-78 |
| Hardness, mg/l | " | 60 | 58-62.2 | " | 76 | 64.8-84.8 | " | 76 | 69.2-87.3 |
| Sulfate, mg/l | " | 13.6 | 12.5-14.6 | " | 9.5 | 8.6-10.8 | " | 11 | 9.4-13.3 |
| Ammonia-Nitrogen, mg/l | 3 | ≤0.05 | <0.01-0.07 | 7 | ≤0.11 | <0.01-0.22 | " | 0.13 | 0.05-0.32 |
| Nitrate-Nitrogen, mg/l | " | 5.0 | 2.9-6.1 | " | 1.2 | 0.6-2.3 | " | 1.7 | 0.8-2.9 |
| Ortho-Phosphate, mg/l | 4 | 0.22 | 0.05-0.38 | 9 | ≤0.06 | <0.01-0.20 | 7 | ≤0.05 | <0.01-0.12 |
| Total-Phosphate, mg/l | 2 | 0.22 | 0.20-0.24 | 3 | 0.18 | 0.1-0.3 | 2 | 0.15 | 0.01-0.2 |
| Total-Phosphorus, mg/l | " | 0.08 | 0.07-0.08 | " | 0.06 | 0.05-0.10 | " | 0.05 | 0.03-0.07 |
| Sodium, mg/l | 1 | - | 6.4 | 5 | 8.3 | 6.4-10 | 5 | 7.4 | 6.0-9.5 |
| Chloride, mg/l | 3 | 4.9 | 4.2-6.0 | 7 | 5.9 | 4.7-7.3 | 6 | 6.2 | 5.2-7.8 |
| Potassium, mg/l | 1 | - | 2.5 | 5 | 2.6 | 2.4-2.8 | 5 | 2.4 | 2.0-2.6 |
| Turbidity, J.T.U. | 3 | 7 | 4-11 | 7 | 15.7 | 10-27 | 6 | 13.6 | 5-24 |
| Color, Units | 2 | 2 | 1-3 | " | 3.7 | 0-5 | " | 3.1 | 0-10 |
| Conductivity, umhos/cm | 3 | 183 | 178-191 | " | 208 | 181-242 | " | 208 | 183-236 |
| MPN-Total Coliform/100ml | 2 | 3,700* | 2,400-5,000 | 6 | 600* | 60-6,200 | " | 960* | 60-6,200 |
| MPN-Fecal Coliform/100ml | " | <290* | 130-<450 | " | <450* | <45-600 | " | <450* | 60-620 |

*Median Value

TABLE A (Cont'd.)
UPPER COLUMBIA SLOUGH
MAIN DRAINAGE CANAL
SUMMARIZED WATER QUALITY DATA
1971-1973

| PARAMETERS | NE Alderwood Dr. | | | NE 33rd Ave. | | | Mult. County Pump. Plant | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. of Samples | Mean | Range | No. of Samples | Mean | Range | No. of Samples | Mean | Range |
| Temperature, °C | 9 | 18.3 | 15-23 | 9 | 18.6 | 17-22 | 10 | 18 | 10-21 |
| pH | " | 6.8 | 6.7-7.1 | " | 7.4 | 6.8-8.5 | " | 7.2 | 6.9-8.0 |
| Dissolved Oxygen, mg/l | " | 12.0 | 10.0-15.7 | " | 16.4 | 11.6-22.9 | " | 14.5 | 9.9-18.8 |
| D.O. Saturation, % | " | 126.3 | 103-171 | " | 175 | 115-260 | " | 152.4 | 88-215 |
| Biochemical Oxygen Demand, mg/l | 7 | 4.2 | 3.1-5.4 | 7 | 5.8 | 2.9-8.5 | 7 | 5.2 | 3.5-7.2 |
| Total Solids, mg/l | " | 207 | 194-230 | " | 222 | 210-243 | " | 230 | 202-268 |
| Suspended Solids, mg/l | " | 22 | 5-35.5 | " | 25 | 9-54 | " | 34 | 20-70 |
| Alkalinity, mg/l | " | 58 | 56-61 | " | 69 | 62-74.5 | " | 73 | 67-85 |
| Hardness, mg/l | " | 79 | 74.5-84.3 | " | 92 | 88.2-101.9 | " | 97 | 90.1-110.9 |
| Sulfate, mg/l | " | 13.3 | 11.9-14.6 | " | 14 | 108.8-15.3 | " | 17.2 | 15.0-19.5 |
| Ammonia-Nitrogen, mg/l | " | 0.15 | 0.05-0.37 | " | 0.36 | 0.10-1.0 | 8 | ≤ 0.20 | <0.01-0.44 |
| Nitrate-Nitrogen, mg/l | " | 4.3 | 3.0-5.6 | " | 4.3 | 3.5-5.3 | " | 5.0 | 4.2-6.9 |
| Ortho-Phosphate, mg/l | 8 | 0.12 | 0.01-0.34 | 9 | 0.06 | 0.01-0.19 | 9 | 0.15 | <0.01-0.93 |
| Total-Phosphate, mg/l | 2 | 0.25 | 0.2-0.3 | 3 | 0.27 | 0.1-0.4 | 3 | 0.29 | 0.1-0.47 |
| Total-Phosphorus, mg/l | " | 0.08 | 0.07-0.10 | " | 0.09 | 0.03-0.13 | " | 0.93 | 0.03-0.15 |
| Sodium, mg/l | 6 | 7.4 | 6.0-8.5 | 6 | 8.0 | 7.1-8.8 | 6 | 8.5 | 6.5-10 |
| Chloride, mg/l | 7 | 7.4 | 7.1-9.1 | 7 | 8.0 | 7.3-8.6 | 8 | 7.5 | 6.8-8.6 |
| Potassium, mg/l | 6 | 3.2 | 2.5-4.2 | 6 | 3.1 | 2.5-3.5 | 6 | 2.6 | 2.5-3.5 |
| Turbidity, J.T.U. | 7 | 8.7 | 4-16 | 7 | 10.4 | 7-20 | 8 | 13 | 8-23 |
| Color, Units | " | 1 | 0-5 | " | 0.3 | 0-1 | " | 0.6 | 0-3 |
| Conductivity, umhos/cm | " | 231 | 207-248 | " | 260 | 218-290 | " | 266 | 227-291 |
| MPN-Total Coliform/100ml | 6 | 13,200* | 600-70,000 | " | 2,300* | 600-6,200 | 7 | 600* | 230-6,200 |
| MPH-Fecal Coliform/100ml | " | 610* | <450-70,000 | " | <450* | 230-6,200 | " | <450* | <45-6,200 |

*Median Value

TABLE A (Cont'd.)
SOUTH SLOUGH ARM
SUMMARIZED WATER QUALITY DATA
1971 - 1973

| PARAMETERS | N.E. 122nd Ave. No. of Samples | Mean | Range | N.E. Alderwood Dr. No. of Samples | Mean | Range | N.E. 33rd Ave. No. of Samples | Mean | Range |
|---|---|---|---|---|---|---|---|---|---|
| Temperature, °C | 9 | 13.6 | 11-15 | 9 | 18.3 | 15-22 | 9 | 18.2 | 10-21 |
| pH | " | 6.6 | 6.3-6.9 | " | 7.4 | 7.0-8.5 | 8 | 7.8 | 7.1-8.5 |
| Dissolved Oxygen, mg/l | " | 13.1 | 6.7-20 | " | 17.4 | 12.8-21.6 | 9 | 20.6 | 9.0-25.7 |
| D.O. Saturation, % | " | 125 | 62-196 | " | 184 | 135-240 | " | 190 | 95-282 |
| Biochemical Oxygen Demand, mg/l | 6 | 1.7 | 0.9-3.9 | 7 | 6.5 | 3.1-12.9 | 6 | 7.5 | 2.6-12.1 |
| Total Solids, mg/l | " | 185 | 171-198 | 5 | 221 | 212-238 | 5 | 234 | 233-236 |
| Suspended Solids, mg/l | " | 4.7 | 2-7 | " | 18.6 | 5-38 | " | 22.1 | 6-31.5 |
| Alkalinity, mg/l | " | 47.4 | 43-50 | " | 71.6 | 68-76 | " | 89.8 | 80-93 |
| Hardness, mg/l | " | 76.3 | 72-81 | " | 94 | 89-101 | " | 116.5 | 108-122 |
| Sulfate, mg/l | " | 14.3 | 11.9-21.6 | " | 15.8 | 15.0-17.3 | " | 21.7 | 18.6-24.6 |
| Ammonia-Nitrogen, mg/l | 7 | 0.08 | <0.01-0.18 | " | 0.29 | 0.13-0.49 | 7 | 0.15 | 0.02-0.40 |
| Nitrate-Nitrogen, mg/l | " | 5.3 | 3.5-7.2 | " | 5.7 | 4.4-6.8 | " | 4.5 | 3.6-5.9 |
| Ortho-Phosphate, mg/l | 8 | 0.25 | 0.16-0.33 | 8 | 0.14 | 0.01-0.29 | 8 | ~0.09 | <0.01-0.39 |
| Total-Phosphate, mg/l | 3 | 0.36 | 0.3-0.4 | 2 | 0.25 | 0.1-0.4 | 3 | 0.26 | 0.1-0.4 |
| Total-Phosphorus, mg/l | " | 0.12 | 0.10-0.13 | " | 0.08 | 0.03-0.13 | 3 | 0.08 | 0.03-0.13 |
| Sodium, mg/l | 5 | 7.1 | 6.0-10.0 | 5 | 9.7 | 7.5-11.1 | 5 | 7.1 | 6.8-9.3 |
| Chloride, mg/l | 7 | 7.7 | 6.5-12.4 | " | 9.5 | 9.0-10.3 | 6 | 6.8 | 5.0-8.2 |
| Potassium, mg/l | 5 | 2.9 | 2.5-3.2 | " | 3.6 | 3.2-3.8 | 5 | 3.5 | 3.0-4.6 |
| Turbidity, J.T.U. | 7 | ≤2.3 | <1-4 | 6 | 6.3 | 3-13 | 6 | 8.8 | 6-13 |
| Color, Units | 6 | 0.3 | 0-2 | 5 | 1.4 | 0-5 | 5 | 1 | 0-3 |
| Conductivity, µmhos/cm | 7 | 219 | 190-257 | " | 288 | 259-304 | 7 | 298 | 259-325 |
| MPN-Total Coliform/100ml | 6 | <450* | <450-2,300 | 7 | 2,300* | <450-70,000 | 6 | 900* | <450-2,300 |
| MPN-Fecal Coliform/100ml | " | <450* | <45-<450 | 7 | 600* | <450-24,000 | 6 | <450* | 45-<450 |

*Median Value

TABLE B

Storm and Combined Sewer
Outfalls in Columbia Slough Drainage Basin

| Sub-basin or Water Body | Street | Sewer: Storm | Sewer: Combined | Sewer Size Inches |
|---|---|---|---|---|
| 1. Fairview Creek | Fairview Avenue | x | | 36 |
| 2. Fairview Lake | NE 200th Avenue | x | | 12 |
| | | x | | 60* |
| 3. Upper Columbia Slough | | | | |
| a. Main Drainage Canal | | | | |
| | 1) NE 190th Avenue | x | | 54 |
| | 2) NE 181st Avenue | x | | 42 |
| | 3) NE 158th Avenue | x | | 42* |
| | 4) NE 148th Avenue | x | | 39* |
| b. South Slough Arm | | | | |
| | 1) NE 138th Avenue | x | | 42 |
| | 2) NE 127th Avenue | x | | 54 |
| | 3) NE 122nd Avenue | x | | 60 |
| | 4) NE 105th Avenue | x | | 54 |
| | 5) NE 92nd Avenue | x | | 30 |
| | 6) NE 85th Avenue | x | | 12 or 14 |
| | 7) NE 60th Avenue | x | | 24 |
| | 8) NE 43rd Avenue | x | | 30 |
| 4. Lower Columbia Slough | | | | |
| South Bank | | | | |
| | a) NE 13th Avenue | | x | 66 |
| | b) N. Willis Blvd. | | x | 36x36 |
| | c) N. Vancouver Ave. | | x | 30x30 |
| | d) N. Albina Avenue | | x | 42x42 |
| | e) N. Fenwick Avenue | | x | 24 |
| | f) N. Kenton Blvd. | | x | 42x42 |
| | g) N. Bayard Avenue | | x | 42x42 |
| | h) N. Chautauqua Ave. | | x | 36 |
| | i) N. Fiske Avenue | | x | 48x48 |
| | j) N. Oregonian Avenue | | x | 42x42 |
| | k) N. Oswego Avenue | | x | 36x36 |
| | l) N. James Street | | x | 30x30 |

*Proposed sewer

TABLE C
LOWER COLUMBIA SLOUGH, BLIND AND NORTH SLOUGHS
SUMMARIZED WATER QUALITY DATA
1971-1973

| | LOWER COLUMBIA SLOUGH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Below Mult. Co. pumping plant | | | Union Ave. Bridge | | | I-5 Br. to Denver Ave. Br. | | |
| PARAMETERS | No. of Samples | Mean | Range | No. of Samples | Mean | Range | No. of Samples | Mean | Range |
| Temperature, °C | 5 | 20 | 13-25 | 9 | 20 | 13-24 | 7 | 20 | 14-24.5 |
| pH | " | 7.5 | 6.9-8.7 | " | 7.5 | 6.9-8.5 | " | 7.8 | 6.9-8.9 |
| Dissolved Oxygen, mg/l | " | 13.9 | 9.8-18.9 | " | 14.1 | 9.7-18.3 | " | 13.9 | 9.6-15.7 |
| D.O. Saturation, % | " | 154 | 92-225 | " | 154 | 91-201 | " | 153 | 92-180 |
| Biochemical Oxygen Demand, mg/l | " | 5.9 | 2.6-11.2 | 7 | 5.6 | 2.9-8.7 | " | 6.0 | 4.7-7.0 |
| Total Solids, mg/l | " | 225 | 208-249 | " | 221 | 201-237 | 8 | 258 | 211-429 |
| Suspended Solids, mg/l | " | 30.4 | 16-41 | " | 33.3 | 16-48 | " | 57.4 | 14-217 |
| Alkalinity, mg/l | " | 74.4 | 70-80 | " | 72.7 | 63-79 | " | 79 | 72-95 |
| Hardness, mg/l | " | 97 | 88-105 | " | 96.3 | 87-106 | " | 102 | 90-119 |
| Sulfate, mg/l | " | 15.3 | 10.8-16.6 | " | 18.4 | 16.7-21.6 | " | 17.9 | 17.2-20.6 |
| Ammonia-Nitrogen, mg/l | " | 0.55 | 0.08-1.8 | " | 0.25 | 0.10-0.41 | " | 0.26 | 0.10-0.55 |
| Nitrate-Nitrogen, mg/l | " | 4.2 | 3.0-4.8 | " | 4.2 | 3.2-5.6 | " | 3.8 | 3.1-5.6 |
| Ortho-Phosphate, mg/l | " | ≤0.04 | <0.01-0.09 | " | 0.05 | <0.01-0.14 | 9 | 0.04 | <0.01-0.12 |
| Total-Phosphate, mg/l | 0 | | | 2 | 0.3 | 0.3 | 2 | 0.25 | 0.2-0.3 |
| Total-Phosphorus, mg/l | 0 | | | " | 0.1 | 0.1 | " | 0.85 | 0.07-0.1 |
| Sodium, mg/l | 2 | 8.6 | 8.5-8.7 | 4 | 8.2 | 7.5-9 | 5 | 9.0 | 7.5-9.3 |
| Chloride, mg/l | 5 | 8.8 | 8.2-10.7 | 7 | 9.0 | 7.5-10.1 | 8 | 9.4 | 8.0-11.5 |
| Potassium, mg/l | 2 | 3.0 | 3.0 | 4 | 3.2 | 3.0-3.5 | 5 | 3.2 | 3.0-3.4 |
| Turbidity, J.T.U. | 5 | 10 | 6-16 | 7 | 11.4 | 8.17 | 8 | 18.4 | 8-27 |
| Color, Units | " | 4.8 | 0-20 | " | 1.6 | 0-5 | " | 1.6 | 0-5 |
| Conductivity, $\frac{umhos}{cm}$ | " | 261 | 208-304 | " | 263 | 188-297 | " | 235 | 215-302 |
| MPN-Total Coliform/100ml | " | 600* | <450->700 | 7 | 2,400* | <450-24,000 | " | 6,600* | 2,300->70,000 |
| MPH-Fecal Coliform/100ml | " | <450* | 60->700 | " | 700* | 130-2,300 | " | 600* | 60-6,200 |

*Median Value

TABLE C (Cont'd.)
LOWER COLUMBIA SLOUGH, BLIND AND NORTH SLOUGHS
SUMMARIZED WATER QUALITY DATA
1971-1973

| | LOWER COLUMBIA SLOUGH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Near North Portland Rd. Br. | | | Portland San. Landfill Br. | | | BPA Transmission Lines | | |
| PARAMETERS | No. of Samples | Mean | Range | No. of Samples | Mean | Range | No. of Samples | Mean | Range |
| Temperature, °C | 10 | 21 | 15-25 | 9 | 21 | 15-25 | 3 | 22 | 15-25.5 |
| pH | " | ≥7.6 | 6.9->8.4 | " | 7.4 | 6.9-8.5 | " | ≥7.3 | 7.0->7.6 |
| Dissolved Oxygen, mg/l | " | 12.7 | 8.7-22.1 | " | 11.8 | 8.8-12.9 | " | 10.3 | 9.1-11.3 |
| D.O. Saturation, % | " | 140 | 100-263 | " | 13.1 | 88-225 | " | 116 | 89-133 |
| Biochemical Oxygen Demand, mg/l | 8 | 7.0 | 4.4-11.2 | 7 | 5.7 | 4.1-8.6 | " | 7.8 | 4.6-11.0 |
| Total Solids, mg/l | 7 | 248 | 216-271 | 8 | 250 | 217-289 | " | 259 | 233-294 |
| Suspended Solids, mg/l | " | 50.3 | 20-74 | " | 51.6 | 14-81 | " | 50.3 | 37-76 |
| Alkalinity, mg/l | " | 82.3 | 72-89 | " | 88.6 | 71-101 | " | 96.3 | 78-114 |
| Hardness, mg/l | " | 104 | 98-113 | " | 105 | 89-116 | " | 108 | 94-119 |
| Sulfate, mg/l | 8 | 18.2 | 16.8-21.6 | " | 17.2 | 16.9-19.7 | " | 18.0 | 17.3-18.4 |
| Ammonia-Nitrogen, mg/l | " | 0.26 | 0.13-0.40 | " | 0.38 | 0.16-0.51 | " | 0.51 | 0.31-0.81 |
| Nitrate-Nitrogen, mg/l | " | 3.7 | 2.6-5.6 | " | 3.3 | 2.4-5.1 | " | 3.0 | 2.3-4.0 |
| Ortho-Phosphate, mg/l | " | 0.05 | <0.01-0.12 | 9 | 0.06 | 0.01-0.22 | " | 0.05 | 0.01-0.08 |
| Total-Phosphate, mg/l | 2 | 0.3 | 0.3 | 2 | 0.35 | 0.3-0.4 | 0 | | |
| Total-Phosphorus, mg/l | " | 0.1 | 0.1 | " | 0.12 | 0.10-0.13 | 0 | | |
| Sodium, mg/l | 5 | 9.5 | 7.5-10.6 | 5 | 10.4 | 8.3-12.1 | 0 | | |
| Chloride, mg/l | 8 | 9.7 | 7.9-10.6 | 8 | 10.2 | 7.7-12.9 | 2 | 11.8 | 11.6-12.0 |
| Potassium, mg/l | 5 | 3.3 | 3.0-3.5 | 5 | 3.5 | 3.0-4.0 | 0 | | |
| Turbidity, J.T.U. | 8 | 18.5 | 8-23 | 8 | 17.1 | 9-23 | 3 | 20 | 14-29 |
| Color, Units | " | 2.3 | 0-5 | " | 1.9 | 0-5 | " | 1 | 0-2 |
| Conductivity, $\frac{umhos}{cm}$ | " | 277 | 220-307 | " | 283 | 213-316 | " | 280 | 225-327 |
| MPN-Total Coliform/100ml | " | 6,600* | <450->70,000 | " | 15,100* | 600->70,000 | " | 2,400* | 2,300->70,000 |
| MPN-Fecal Coliform/100ml | " | 1,370* | 130-24,000 | " | 600* | 60-24,000 | " | <450* | 130-9,500 |

*Median Value

TABLE C (Cont'd.)
LOWER COLUMBIA SLOUGH, BLIND AND NORTH SLOUGHS
SUMMARIZED WATER QUALITY DATA
1971-1973

| PARAMETERS | LOWER COLUMBIA SLOUGH 1/4 mi. below North Slough | | | Blind Slough | | | North Slough | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. of Samples | Mean | Range | No. of Samples | Mean | Range | No. of Samples | Mean | Range |
| Temperature, °C | 6 | 21 | 15-25 | 3 | 21.2 | 15-25.5 | 8 | 22 | 14-25.5 |
| pH | " | 7.5 | 7.1-8.1 | " | 7.2 | 6.9-7.5 | " | 7.9 | 7.3-8.5 |
| Dissolved Oxygen, mg/l | " | 9.1 | 4.5-11.4 | " | 10.6 | 8.7-11.7 | " | 9.5 | 7.2-10.7 |
| D.O. Saturation, % | " | 102 | 48-134 | " | 119 | 85-141 | " | 108 | 69-149 |
| Biochemical Oxygen Demand, mg/l | " | 6.1 | 3.3-10.2 | " | ≳ 9.6 | >8.6-≥11.2 | " | 7.7 | 6.6-8.9 |
| Total Solids, mg/l | " | 243 | 192-275 | " | 283 | 233-368 | " | 254 | 176-310 |
| Suspended Solids, mg/l | " | 48.8 | 18-69 | " | 32.7 | 9.2-51 | " | 98.4 | 30-157 |
| Alkalinity, mg/l | " | 91 | 78-109 | " | 98 | 71-112 | " | 75.3 | 58-94 |
| Hardness, mg/l | " | 99 | 85-126 | " | 112 | 87.8-131.4 | " | 78.5 | 52.8-103.6 |
| Sulfate, mg/l | " | 16.1 | 12.3-17.5 | " | 18. | 17-19 | " | 13.0 | 10.5-16.2 |
| Ammonia-Nitrogen, mg/l | " | 0.61 | 0.22-0.90 | " | 0.86 | 0.21-1.6 | " | 0.56 | 0.17-2.2 |
| Nitrate-Nitrogen, mg/l | " | 2.4 | 1.8-3.3 | " | 3.0 | 2.4-3.8 | " | 0.55 | 0.16-1.25 |
| Ortho-Phosphate, mg/l | " | 0.08 | 0.02-0.24 | " | 0.04 | 0.01-0.07 | " | ≤ 0.06 | 0.01-0.22 |
| Total-Phosphate, mg/l | 0 | | | 0 | | | 0 | | |
| Total-Phosphorus, mg/l | 0 | | | 0 | | | 0 | | |
| Sodium, mg/l | 3 | 10.4 | 9.5-12.1 | | | | 3 | 10.2 | 9-11.7 |
| Chloride, mg/l | 6 | 10.8 | 8.9-12.2 | 3 | 13.9 | 12.4-15.8 | 8 | 8.8 | 3.2-11.3 |
| Potassium, mg/l | 3 | 4.1 | 3.2-5.8 | 0 | - | - | 3 | 3.0 | 3-5.3 |
| Turbidity, J.T.U. | 6 | 20.5 | 9-32 | 3 | 21.3 | 12-32 | 8 | 39 | 1-61 |
| Color, Units | " | 4.3 | 2-10 | " | 2.7 | 0-4 | " | 4.3 | 2-10 |
| Conductivity, $\frac{\mu mhos}{cm}$ | " | 272 | 230-326 | " | 279 | 225-310 | " | 216 | 200-304 |
| MPN-Total Coliform/100ml | " | 4,300* | <450-24,000 | " | 2,300* | 620->70,000 | 9 | 2,300* | 620-7,000 |
| MPN-Fecal Coliform/100ml | " | <450* | 60-6,200 | " | 600* | 130-24,000 | " | <450* | 130-620 |

*Median Value

TABLE D

UPPER COLUMBIA SLOUGH

DIURNAL DISSOLVED OXYGEN SURVEY

July 5-6, 1973

| LOCATION | July 5, 1973 (1:40 PM-4:05 PM) Temp. °C | Dissolved Oxygen mg/l | Dissolved Oxygen % Saturation | July 6, 1973 (4:20 AM-6:15 AM) Temp. °C | Dissolved Oxygen mg/l | Dissolved Oxygen % Saturation |
|---|---|---|---|---|---|---|
| A. Fairview Creek | | | | | | |
| N.E. 233rd Ave. | 17 | 9.0 | 93 | 14 | 9.2 | 88 |
| B. Main Drainage Canal | | | | | | |
| 1. N.E. 185th Ave. | 19 | 9.6 | 102 | 18 | 8.1 | 85 |
| 2. N.E. 122nd Ave. | 20 | 14.3 | 156 | 19 | 11.4 | 121 |
| 3. N.E. Alderwood Dr. | 19 | 13.3 | 141 | 16 | 10.9 | 109 |
| 4. N.E. 33rd Ave. | 20 | 19.2 | 209 | 17 | 13.6 | 140 |
| 5. Multnomah County pumping plant | 20.5 | 19.6 | 215 | 18 | 15.6 | 165 |
| C. South Slough Arm | | | | | | |
| 1. N.E. 22nd Ave. | 15 | 20.0 | 196 | 14 | 14.3 | 137 |
| 2. N.E. Alderwood Dr. | 19 | 21.6 | 230 | 16 | 14.7 | 147 |
| 3. N.E. 33rd Ave. | 20 | 22.2 | 242 | 18 | 16.6 | 175 |

TABLE E

LOWER COLUMBIA SLOUGH

DIURNAL DISSOLVED OXYGEN SURVEY

July 9-10, 1973

| LOCATION | July 9, 1973 (2:40 PM-4:15 PM) Temp. °C | Dissolved Oxygen mg/l | Dissolved Oxygen % Saturation | July 10, 1973 (4:05 AM-5:20 AM) Temp. °C | Dissolved Oxygen mg/l | Dissolved Oxygen % Saturation |
|---|---|---|---|---|---|---|
| 1. Union Ave. Br. | 22 | 16.5 | 188 | 20.5 | 18.3 | 201 |
| 2. Vancouver Ave. Br. | 23 | 19.7 | 204 | 21 | 20.3 | 226 |
| 3. Denver Ave. Br. | 22 | 18.5 | 210 | 21 | 18.0 | 200 |
| 4. North Portland Rd. Br. | 25 | 22.1 | 263 | 20 | 11.1 | 121 |
| 5. Portland Sanitary Landfill Br. | 25 | 18.9 | 225 | 19 | 8.6 | 91 |

# TABLE F

## Smith and Bybee Lakes

## Summarized Water Quality Data

## December 29, 1971

mg/l

| Lakes | BOD | COD | Solids Total | Solids Total Volatile | $NO_3$-N | $PO_4^{\equiv}$ | Fe | Mn | Zn | Pb | Cr | Cu | Hg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Smith | 2 | 12 | 143-155 | 31-59 | 0.73-0.82 | 0.16-0.45 | 2.1-2.2 | 0.07-0.11 | 0.05-0.12 | <0.3 | <0.03 | <0.05 | 0.0004-0.0008 |
| Bybee | 2 | 12 | 112-121 | 73-94 | 0.73-0.94 | 0.32 | 1.5 | 0.07-0.11 | 0.20-0.44 | <0.3 | <0.03 | <0.05 | 0.0004 0.0006 |

TABLE G

Smith and Bybee Lakes
Summarized Water Quality Data
July 5, 1972

| Parameters | Lakes | |
|---|---|---|
| | Bybee | Smith |
| Temperature, $^{o}C$ | 23 | 24-25 |
| ph | 8.2 | 8.9 |
| Dissolved Oxygen, mg/l | 10.3 | 11.5-13.0 |
| D. O. Saturation, % | 118 | 135-155 |
| Biochemical Oxygen Demand, mg/l | 3.9 | 3.7-4.3 |
| Total Solids, mg/l | 178 | 140 |
| Suspended Solids, mg/l | 29 | 19-31 |
| Alkalinity, mg/l | 91 | 72-77 |
| Hardness, mg/l | 98.2 | 79.6-81.3 |
| Sulfate, mg/l | 11.9 | 9.0-9.4 |
| Ammonia-Nitrogen, mg/l | 0.11 | 0.10-0.13 |
| Nitrate-Nitrogen, mg/l | 0.57 | 0.08-0.19 |
| Ortho-phosphate, mg/l | 0.02 | 0.02 |
| Sodium, mg/l | 8.3 | 7.6-9.4 |
| Chloride, mg/l | 9.9 | 7.7-8.0 |
| Potassium, mg/l | 4.2 | 3.0-3.5 |
| Turbidity, J. T. U. | 12 | 11 |
| Color, Units | 10 | 5 |
| Conductivity, $\frac{\mu mhos}{cm}$ | 283 | 229-235 |
| MPN-Total Coliform/100ml | $<$ 450 | $<$ 450 |
| MPN-Fecal Coliform/100ml | $<$ 450 | $<$ 450 |

TABLE H

Smith and Bybee Lakes

Summarized Bottom Sediment Data

December 29, 1971

| Lakes | % Total Volatile Solids | BOD | COD | $NO_3$-N | $PO_4^{\equiv}$ | Fe | Mn | Zn | Pb | Cr | Cu | Hg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ← mg/kg (dry weight) → | | | | | | | | | | |
| Smith | 6.3- | <3,000 | 53,000- | 47-73 | 1,760- | 37,100- | 653- | 144- | <20 | 20-28 | 40- | 0.56- |
| | 6.7 | | 56,200 | | 1,880 | 41,800 | 907 | 193 | | | 47 | 0.65 |
| Bybee | 6.3- | <4,000 | 51,300- | 29-137 | 1,760- | 33,200- | 532- | 153- | <14 | 23-24 | 33- | 0.47- |
| | 6.5 | | 55,600 | | 1,820 | 40,600 | 635 | 182 | | | 46 | 0.53 |

TABLE I

LOWER COLUMBIA SLOUGH

Sediment Composition, Core Samples

June 19, 1972

| Sampling Description | Core Length, Inches | % VS | COD mg/kg | % Organic Carbon | Total Kjeldahl Nitrogen mg/kg | % K-N | % Organic Nitrogen | OSI | mg/kg $PO_4$ as P | mg/kg Fe | mg/kg Mn | mg/kg Zn | mg/kg Pb | mg/kg Cr | mg/kg Cu | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Union Pacific Railroad Bridge | 10 | | | | | | | | | | | | | | | |
| a. Top 1" | | 17.7 | 244,300 | 9.2 | 41,000 | 4.1 | 2.9 | 26.7 | 328 | 31,200 | 312 | 328 | 164 | 54 | 53 | 7.7 |
| b. Bottom 1" | | 15.7 | 203,400 | 7.6 | 32,000 | 3.2 | 2.2 | 16.7 | 377 | 36,100 | 320 | 448 | 91.5 | 60 | 62 | 7.6 |
| 2. North Portland Rd. Bridge | 14 | | | | | | | | | | | | | | | |
| a. Top 1" | | 12.2 | 112,000 | 4.2 | 30,000 | 3.0 | 1.6 | 6.7 | 404 | 31,600 | 378 | 353 | 182 | 63 | 51 | 7.3 |
| b. Bottom 1" | | 16.1 | 176,000 | 6.6 | 43,000 | 4.3 | 2.3 | 15.2 | 414 | 38,900 | 420 | 423 | 147 | 66 | 65 | 7.7 |
| 3. Old Radio Tower | 4.25 | | | | | | | | | | | | | | | |
| a. Top 1" | | 12.6 | 151,300 | 5.7 | 42,000 | 4.2 | 2.2 | 12.5 | 600 | 45,200 | 597 | 440 | 295 | 84 | 80 | 7.2 |
| b. Bottom 1" | | 8.2 | 70,000 | 2.6 | 20,000 | 2.0 | 1.1 | 2.9 | 215 | 18,500 | 351 | 363 | 14 | 77 | 41 | 7.4 |
| 4. Landfill Access Road | 11 | | | | | | | | | | | | | | | |
| a. Top 1" | | 11.9 | 134,000 | 5.0 | 30,000 | 3.0 | 1.1 | 5.5 | 386 | 43,200 | 694 | 468 | 159 | 73 | 86 | 7.2 |
| b. Bottom 1" | | 9.8 | 55,900 | 2.1 | 8,620 | 0.8 | 0.45 | 0.95 | 328 | 28,400 | 476 | 153 | 39 | 33 | 33 | 7.2 |
| 5. North Slough near Head | 10.5 | | | | | | | | | | | | | | | |
| a. Top 1" | | 8.9 | 92,900 | 3.5 | 14,000 | 1.4 | 1.0 | 3.5 | 253 | 23,400 | 972 | 299 | 86 | 72 | 54 | 7.2 |
| b. Bottom 1" | | 18.4 | 244,200 | 9.1 | 16,000 | 1.6 | 1.2 | 10.9 | 55 | 31,600 | 322 | 72 | 24 | 67 | 38 | 7.1 |
| 6. 1/8 Mile above Sand Plug | 10.5 | | | | | | | | | | | | | | | |
| a. Top 1" | | 7.6 | 72,600 | 2.7 | 12,000 | 1.2 | 1.3 | 3.51 | 355 | 48,300 | 1,090 | 300 | 51 | 65 | 56 | 7.2 |
| b. Bottom 1" | | 7.4 | 81,900 | 3.1 | 22,000 | 2.2 | 1.0 | 3.1 | 181 | 30,300 | 494 | 295 | 72 | 80 | 45 | 7.2 |

Notes: mg/kg is expressed on a dry weight basis
OSI = organic sediment index

TABLE J
Upper and Lower Columbia Slough
and Smith Lake[1/]
Fish Populations
July 6 and 10, 1973

| | Upper Slough | | | | Lower Slough | | Smith Lake |
|---|---|---|---|---|---|---|---|
| | South Arm | | | Main Canal | | | |
| FISH SPECIES | N.E. 112th | N.E. 66th | Near N.E. 42nd St.* | Mult. Co. Pumping Plant | Below Mult. Co. Pumping Plant | Near Denver Ave. Bridge* | Outlet to North Slough |
| 1. Game Fish | | | | | | | |
| a. Bluegill | | | 3 | | | 1 | |
| b. Brown bullhead catfish | | | 5 | 1 | | 2 | |
| c. Black crappie | | | 1 | | | | |
| d. White crappie | | | 3 | 10 | | 2 | 5 |
| e. Largemouth bass | | | | 1 | | | 1 |
| f. Sturgeon | | | | | | | 1 |
| g. Yellow perch | | | | | | | 1 |
| 2. Rough Fish | | | | | | | |
| a. Carp | 3 | 3 | 3 | | 5 | 35 | 7 |
| b. Chiselmouth | | | | 1 | | | |
| c. Columbia River chub | 4 | 7 | 17 | 11 | | | 1 |
| d. Coarse-scale sucker | 8 | 25 | 95 | 5 | 1 | 2 | |
| e. Cottid | | | 5 | | | | |
| f. Goldfish | | | | | | 10 | 4 |
| g. Squawfish | | 2 | | | | | |
| TOTAL | 15 | 37 | 132 | 29 | 6 | 52 | 20 |

* Cul-de-sac

1/ Oregon State Wildlife Commission Data

# TABLE K

COLUMBIA RIVER MAIN STEM--Continued

14-1447. COLUMBIA RIVER AT VANCOUVER, WASH.--Continued

Suspended sediment, water year October 1963 to September 1964--Continued

| Day | APRIL Mean discharge (K cfs) | APRIL Suspended sediment: Mean concentration (ppm) | APRIL Suspended sediment: Tons per day | MAY Mean discharge (K cfs) | MAY Suspended sediment: Mean concentration (ppm) | MAY Suspended sediment: Tons per day | JUNE Mean discharge (K cfs) | JUNE Suspended sediment: Mean concentration (ppm) | JUNE Suspended sediment: Tons per day |
|---|---|---|---|---|---|---|---|---|---|
| 1.. | 125 | 11 | 3710 | 173 | C 16 | 7470 | 440 | 158 | 188000 |
| 2.. | 138 | 11 | 4100 | 179 | C 16 | 7730 | 448 | C 110 | 133000 |
| 3.. | 155 | 12 | 5020 | 180 | C 16 | 7780 | 461 | C 110 | 137000 |
| 4.. | 150 | 14 | 5670 | 190 | C 16 | 8210 | 474 | C 110 | 141000 |
| 5.. | 145 | 16 | 6260 | 191 | C 25 | 12900 | 520 | C 110 | 154000 |
| 6.. | 109 | 15 | 4410 | 212 | C 25 | 14300 | 522 | C 110 | 155000 |
| 7.. | 113 | 14 | 4270 | 195 | C 25 | 13200 | 529 | C 110 | 157000 |
| 8.. | 124 | 14 | 4690 | 176 | C 25 | 11900 | 523 | 116 | 164000 |
| 9.. | 110 | 13 | 3860 | 180 | C 25 | 12100 | 564 | 122 | 186000 |
| 10.. | 123 | 13 | 4320 | 182 | C 25 | 12300 | 581 | 132 | 207000 |
| 11.. | 120 | 12 | 3890 | 199 | C 25 | 13400 | 593 | 181 | 290000 |
| 12.. | 121 | 12 | 3920 | 211 | 28 | 16000 | 580 | 153 | 240000 |
| 13.. | 129 | 12 | 4180 | 240 | 32 | 20700 | 599 | 196 | 317000 |
| 14.. | 138 | 15 | 5590 | 291 | 50 | 39300 | 614 | 150 | 249000 |
| 15.. | 152 | 20 | 8210 | 274 | 50 | 37000 | 617 | 128 | 211000 |
| 16.. | 158 | 25 | 10700 | 288 | 47 | 36500 | 616 | 132 | 220000 |
| 17.. | 159 | 20 | 8590 | 301 | 50 | 40600 | 617 | 138 | 230000 |
| 18.. | 156 | 18 | 7580 | 289 | 52 | 40600 | 649 | 132 | 231000 |
| 19.. | 143 | 17 | 6560 | 313 | 64 | 54100 | 675 | 155 | 282000 |
| 20.. | 130 | 17 | 5970 | 360 | 93 | 90400 | 658 | 145 | 258000 |
| 21.. | 140 | C 18 | 6800 | 385 | 106 | 110000 | 654 | 130 | 230000 |
| 22.. | 154 | C 18 | 7480 | 411 | 108 | 120000 | 648 | 123 | 215000 |
| 23.. | 172 | C 18 | 8360 | 445 | 178 | 214000 | 642 | C 119 | 206000 |
| 24.. | 178 | C 18 | 8650 | 447 | 150 | 181000 | 638 | C 119 | 205000 |
| 25.. | 167 | C 18 | 8120 | 422 | 122 | 139000 | 629 | C 119 | 202000 |
| 26.. | 158 | C 18 | 7680 | 386 | 72 | 75000 | 620 | C 119 | 199000 |
| 27.. | 155 | C 18 | 7530 | 370 | 77 | 76900 | 625 | C 119 | 201000 |
| 28.. | 155 | C 16 | 6700 | 370 | 76 | 75900 | 623 | C 119 | 200000 |
| 29.. | 158 | C 16 | 6830 | 368 | 73 | 72500 | 613 | C 119 | 197000 |
| 30.. | 163 | C 16 | 7040 | 363 | 84 | 66900 | 596 | 92 | 149000 |
| 31.. | -- | -- | -- | 413 | 100 | 112000 | -- | -- | -- |
| Total | 4298 | -- | 186690 | 9024 | -- | 1759690 | 17564 | -- | 6154000 |

| Day | JULY Mean discharge (K cfs) | JULY Mean concentration (ppm) | JULY Tons per day | AUGUST Mean discharge (K cfs) | AUGUST Mean concentration (ppm) | AUGUST Tons per day | SEPTEMBER Mean discharge (K cfs) | SEPTEMBER Mean concentration (ppm) | SEPTEMBER Tons per day |
|---|---|---|---|---|---|---|---|---|---|
| 1.. | 563 | 98 | 149000 | 190 | C 22 | 11300 | 132 | 8 | 2850 |
| 2.. | 522 | 72 | 101000 | 224 | C 22 | 13300 | 121 | 8 | 2610 |
| 3.. | 492 | 70 | 93000 | 254 | C 22 | 15100 | 125 | 10 | 3370 |
| 4.. | 456 | 66 | 81300 | 241 | 21 | 13700 | 134 | 8 | 2890 |
| 5.. | 448 | 64 | 77400 | 219 | 21 | 12400 | 132 | 8 | 2850 |
| 6.. | 435 | 60 | 70500 | 212 | 20 | 11400 | 114 | 8 | 2460 |
| 7.. | 421 | 42 | 47700 | 209 | 20 | 11300 | 99.5 | 7 | 1880 |
| 8.. | 416 | 40 | 44900 | 185 | 18 | 8990 | 108 | C 7 | 2040 |
| 9.. | 424 | 46 | 52700 | 160 | 15 | 6480 | 114 | C 7 | 2150 |
| 10.. | 434 | 49 | 57400 | 170 | C 13 | 5970 | 134 | C 7 | 2530 |
| 11.. | 432 | 47 | 54800 | 180 | C 13 | 6320 | 126 | C 7 | 2380 |
| 12.. | 421 | 44 | 50000 | 180 | C 13 | 6320 | 117 | 7 | 2210 |
| 13.. | 408 | 40 | 44100 | 155 | C 13 | 5440 | 118 | 7 | 2230 |
| 14.. | 406 | 36 | 39500 | 160 | C 13 | 5620 | 117 | C 7 | 2210 |
| 15.. | 400 | 50 | 54000 | 170 | 13 | 5970 | 119 | C 7 | 2250 |
| 16.. | 396 | 39 | 41700 | 175 | 12 | 5670 | 118 | C 7 | 2230 |
| 17.. | 390 | 42 | 44200 | 175 | 12 | 5670 | 125 | C 7 | 2360 |
| 18.. | 381 | 42 | 43200 | 175 | C 12 | 5670 | 124 | C 7 | 2340 |
| 19.. | 368 | 42 | 41700 | 170 | C 12 | 5510 | 98.6 | 8 | 2130 |
| 20.. | 361 | 42 | 40900 | 165 | C 12 | 5350 | 101 | 9 | 2450 |
| 21.. | 348 | C 34 | 31900 | 161 | C 12 | 5220 | 101 | 10 | 2730 |
| 22.. | 344 | C 34 | 31600 | 153 | 10 | 4130 | 97.6 | 11 | 2900 |
| 23.. | 345 | C 34 | 31700 | 154 | 10 | 4160 | 107 | 12 | 3470 |
| 24.. | 320 | C 34 | 29400 | 152 | C 9 | 3690 | 96.7 | 10 | 2610 |
| 25.. | 296 | C 34 | 27200 | 152 | C 9 | 3690 | 106 | 10 | 2860 |
| 26.. | 272 | C 34 | 25000 | 160 | C 9 | 3890 | 105 | 11 | 3120 |
| 27.. | 289 | C 34 | 26500 | 157 | C 9 | 3820 | 100 | 11 | 2970 |
| 28.. | 274 | C 22 | 16300 | 145 | C 9 | 3520 | 107 | 12 | 3470 |
| 29.. | 265 | C 22 | 15700 | 130 | 9 | 3160 | 114 | 12 | 3690 |
| 30.. | 240 | C 22 | 14300 | 131 | 8 | 2830 | 118 | 11 | 3500 |
| 31.. | 191 | C 22 | 11300 | 133 | 8 | 2870 | -- | -- | -- |
| Total | 11758 | -- | 1489900 | 5397 | -- | 208460 | 3429.4 | -- | 79740 |

Total discharge for year (K cfs-days)........ 71606.0
Total load for year (tons)........ 10423290

C Composite period.



U. S. Geological Survey.
Part 2. Surface Water Records

# TABLE K (Cont'd.)

COLUMBIA RIVER MAIN STEM--Continued

14-1447. COLUMBIA RIVER AT VANCOUVER, WASH.--Continued

Suspended sediment, water year October 1964 to September 1965--Continued

| Day | APRIL Mean discharge (K cfs) | APRIL Suspended sediment: Mean concentration (ppm) | APRIL Suspended sediment: Tons per day | MAY Mean discharge (K cfs) | MAY Suspended sediment: Mean concentration (ppm) | MAY Suspended sediment: Tons per day | JUNE Mean discharge (K cfs) | JUNE Suspended sediment: Mean concentration (ppm) | JUNE Suspended sediment: Tons per day |
|---|---|---|---|---|---|---|---|---|---|
| 1.. | 156 | C 14 | 5900 | 374 | 190 | 192000 | 482 | 121 | 157000 |
| 2.. | 162 | C 14 | 6120 | 390 | 210 | 221000 | 496 | 138 | 185000 |
| 3.. | 163 | 14 | 6160 | 437 | 254 | 300000 | 498 | 198 | 266000 |
| 4.. | 138 | 14 | 5220 | 444 | 221 | 265000 | 505 | 144 | 196000 |
| 5.. | 142 | C 14 | 5370 | 428 | 182 | 210000 | 508 | 148 | 203000 |
| 6.. | 142 | C 14 | 5370 | 416 | 158 | 177000 | 510 | 152 | 209000 |
| 7.. | 144 | C 14 | 5440 | 416 | 150 | 168000 | 524 | 155 | 219000 |
| 8.. | 179 | C 14 | 6770 | 399 | 130 | 140000 | 522 | 182 | 257000 |
| 9.. | 179 | C 14 | 6770 | 374 | 120 | 121000 | 525 | 152 | 215000 |
| 10.. | 177 | 18 | 8600 | 373 | 97 | 97700 | 534 | 158 | 228000 |
| 11.. | 187 | 22 | 11100 | 377 | 138 | 140000 | 532 | 160 | 230000 |
| 12.. | 180 | 26 | 12600 | 369 | 90 | 89700 | 525 | 166 | 235000 |
| 13.. | 166 | C 31 | 13900 | 355 | 65 | 62300 | 526 | 172 | 244000 |
| 14.. | 183 | C 31 | 15300 | 391 | 96 | 101000 | 530 | 177 | 253000 |
| 15.. | 191 | C 31 | 16000 | 412 | 120 | 133000 | 533 | 188 | 271000 |
| 16.. | 192 | C 31 | 16100 | 431 | 140 | 163000 | 506 | 140 | 191000 |
| 17.. | 208 | 35 | 19700 | 440 | 173 | 206000 | 483 | 100 | 130000 |
| 18.. | 227 | 39 | 23900 | 438 | 174 | 206000 | 487 | 111 | 146000 |
| 19.. | 248 | 44 | 29500 | 436 | 130 | 153000 | 495 | 108 | 144000 |
| 20.. | 273 | 48 | 35400 | 436 | 120 | 141000 | 499 | 105 | 141000 |
| 21.. | 295 | 64 | 51000 | 412 | 132 | 147000 | 501 | 102 | 138000 |
| 22.. | 364 | 100 | 98300 | 406 | 125 | 137000 | 502 | 109 | 148000 |
| 23.. | 432 | 141 | 164000 | 421 | 118 | 134000 | 498 | 116 | 156000 |
| 24.. | 424 | 160 | 183000 | 411 | 106 | 118000 | 502 | 102 | 138000 |
| 25.. | 386 | 180 | 188000 | 409 | 150 | 166000 | 500 | 89 | 120000 |
| 26.. | 391 | 206 | 217000 | 412 | 92 | 102000 | 501 | 90 | 122000 |
| 27.. | 376 | 196 | 199000 | 406 | 110 | 121000 | 499 | 91 | 123000 |
| 28.. | 377 | 160 | 163000 | 403 | 112 | 122000 | 468 | 92 | 121000 |
| 29.. | 371 | 195 | 195000 | 392 | 114 | 121000 | 473 | 94 | 120000 |
| 30.. | 370 | 176 | 176000 | 417 | 116 | 132000 | 449 | 95 | 115000 |
| 31.. | -- | -- | -- | 460 | 118 | 147000 | -- | -- | -- |
| Total | 7423 | -- | 1889520 | 12685 | -- | 4732700 | 15133 | -- | 5421000 |

| Day | JULY Mean discharge (K cfs) | JULY Mean concentration (ppm) | JULY Tons per day | AUGUST Mean discharge (K cfs) | AUGUST Mean concentration (ppm) | AUGUST Tons per day | SEPTEMBER Mean discharge (K cfs) | SEPTEMBER Mean concentration (ppm) | SEPTEMBER Tons per day |
|---|---|---|---|---|---|---|---|---|---|
| 1.. | 432 | 81 | 94500 | 182 | 21 | 10300 | 165 | C 22 | 9800 |
| 2.. | 415 | 67 | 75100 | 164 | 20 | 8860 | 160 | C 22 | 9500 |
| 3.. | 390 | 65 | 68400 | 159 | 20 | 8590 | 148 | C 22 | 8790 |
| 4.. | 369 | 63 | 62800 | 184 | 20 | 9940 | 150 | 20 | 8100 |
| 5.. | 368 | 61 | 60600 | 184 | 20 | 9940 | 157 | 18 | 7630 |
| 6.. | 373 | 59 | 59400 | 192 | 20 | 10400 | 128 | 16 | 5530 |
| 7.. | 353 | 58 | 55300 | 193 | 20 | 10400 | 123 | C 14 | 4650 |
| 8.. | 349 | 57 | 53700 | 187 | 20 | 10100 | 133 | C 14 | 5030 |
| 9.. | 355 | 56 | 53700 | 201 | C 20 | 10900 | 134 | C 14 | 5070 |
| 10.. | 350 | 56 | 52900 | 190 | C 20 | 10300 | 134 | C 14 | 5070 |
| 11.. | 349 | 56 | 52800 | 207 | C 20 | 11200 | 132 | 15 | 5350 |
| 12.. | 344 | 55 | 51100 | 205 | C 20 | 11100 | 111 | 15 | 4500 |
| 13.. | 350 | 50 | 47200 | 194 | C 20 | 10500 | 110 | C 16 | 4750 |
| 14.. | 342 | 45 | 41600 | 196 | 20 | 10600 | 116 | C 16 | 5010 |
| 15.. | 331 | 48 | 42900 | 190 | 20 | 10300 | 119 | C 16 | 5140 |
| 16.. | 331 | 50 | 44700 | 178 | C 20 | 9610 | 118 | C 16 | 5100 |
| 17.. | 314 | 46 | 39000 | 190 | C 20 | 10300 | 115 | C 16 | 4970 |
| 18.. | 296 | 43 | 34400 | 185 | C 20 | 9990 | 122 | 16 | 5270 |
| 19.. | 282 | 40 | 30500 | 196 | C 20 | 10600 | 125 | 16 | 5400 |
| 20.. | 279 | 43 | 32400 | 192 | C 20 | 10400 | 134 | C 16 | 5790 |
| 21.. | 259 | 46 | 32200 | 193 | 19 | 9900 | 113 | C 16 | 4880 |
| 22.. | 252 | 40 | 27200 | 179 | 18 | 8700 | 114 | C 16 | 4920 |
| 23.. | 273 | 34 | 25100 | 178 | C 17 | 8170 | 117 | C 16 | 5050 |
| 24.. | 278 | 31 | 23300 | 166 | C 17 | 7620 | 115 | C 16 | 4970 |
| 25.. | 273 | 28 | 20600 | 173 | C 17 | 7940 | 113 | 15 | 4580 |
| 26.. | 277 | C 24 | 17900 | 179 | C 17 | 8220 | 108 | 14 | 4080 |
| 27.. | 250 | C 24 | 16200 | 192 | C 17 | 8810 | 108 | C 13 | 3790 |
| 28.. | 238 | C 24 | 15400 | 164 | 19 | 8410 | 112 | C 13 | 3930 |
| 29.. | 239 | C 24 | 15500 | 153 | 21 | 8680 | 110 | C 13 | 3860 |
| 30.. | 219 | C 24 | 14200 | 157 | C 22 | 9330 | 106 | C 13 | 3790 |
| 31.. | 197 | 22 | 11700 | 157 | C 22 | 9330 | -- | -- | -- |
| Total | 9727 | -- | 1772300 | 5660 | -- | 299440 | 3752 | -- | 164300 |

Total discharge for year (K cfs-days)........................................ 86795.2
Total load for year (tons)........................................ 29610710

C Composite period.

COLUMBIA RIVER MAIN STEM--Continued

14-1447. COLUMBIA RIVER AT VANCOUVER, WASH.--Continued

Suspended sediment, water year October 1965 to September 1966--Continued

| Day | APRIL | | | MAY | | | JUNE | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean discharge (K cfs) | Suspended sediment: Mean concentration (ppm) | Suspended sediment: Tons per day | Mean discharge (K cfs) | Suspended sediment: Mean concentration (ppm) | Suspended sediment: Tons per day | Mean discharge (K cfs) | Suspended sediment: Mean concentration (ppm) | Suspended sediment: Tons per day |
| 1.. | 184 | C 18 | 8940 | 158 | C 18 | 7680 | 344 | 79 | 73400 |
| 2.. | 200 | C 18 | 9720 | 152 | C 18 | 7390 | 347 | 78 | 73100 |
| 3.. | 190 | C 17 | 8720 | 166 | C 18 | 8070 | 338 | 78 | 71200 |
| 4.. | 155 | C 17 | 7110 | 158 | C 18 | 7680 | 349 | 75 | 70700 |
| 5.. | 162 | C 17 | 7440 | 169 | C 18 | 8210 | 359 | 72 | 69800 |
| 6.. | 170 | C 17 | 7800 | 186 | C 18 | 9040 | 365 | 68 | 66600 |
| 7.. | 163 | C 17 | 7480 | 227 | 30 | 18400 | 369 | 71 | 70700 |
| 8.. | 164 | C 17 | 7530 | 263 | 50 | 35500 | 373 | 74 | 74500 |
| 9.. | 161 | C 17 | 7390 | 300 | 75 | 60700 | 377 | 76 | 77400 |
| 10.. | 167 | C 24 | 10800 | 330 | 100 | 89100 | 383 | 78 | 80700 |
| 11.. | 155 | C 24 | 10000 | 377 | 145 | 148000 | 387 | 79 | 82500 |
| 12.. | 181 | C 24 | 11700 | 325 | 100 | 87700 | 407 | 80 | 87900 |
| 13.. | 208 | C 24 | 13500 | 297 | 62 | 49700 | 415 | 75 | 84000 |
| 14.. | 201 | C 24 | 13000 | 350 | 61 | 57600 | 407 | 70 | 76900 |
| 15.. | 172 | C 24 | 11100 | 342 | 60 | 55400 | 394 | 66 | 70200 |
| 16.. | 170 | C 24 | 11000 | 297 | 59 | 47300 | 378 | 59 | 60200 |
| 17.. | 144 | C 15 | 5830 | 287 | 51 | 39500 | 351 | 54 | 51200 |
| 18.. | 134 | C 15 | 5430 | 279 | 43 | 32400 | 336 | 50 | 45400 |
| 19.. | 147 | C 15 | 5950 | 260 | 36 | 25300 | 330 | 46 | 41000 |
| 20.. | 163 | C 15 | 6600 | 252 | 29 | 19700 | 328 | 43 | 38100 |
| 21.. | 166 | C 15 | 6720 | 247 | 30 | 20000 | 314 | 40 | 33900 |
| 22.. | 162 | C 15 | 6560 | 266 | 31 | 22300 | 328 | 37 | 32800 |
| 23.. | 177 | C 15 | 7170 | 281 | 32 | 24300 | 330 | 40 | 35600 |
| 24.. | 162 | C 17 | 7440 | 284 | 36 | 27600 | 326 | 44 | 38700 |
| 25.. | 139 | C 17 | 6380 | 294 | 40 | 31800 | 303 | 43 | 35200 |
| 26.. | 162 | C 17 | 7440 | 278 | 38 | 28500 | 310 | 42 | 35200 |
| 27.. | 156 | C 17 | 7160 | 269 | 35 | 25400 | 323 | 41 | 35800 |
| 28.. | 165 | C 17 | 7570 | 265 | 40 | 28600 | 311 | 40 | 33600 |
| 29.. | 173 | C 17 | 7940 | 287 | 48 | 37200 | 306 | 40 | 35000 |
| 30.. | 172 | C 17 | 7890 | 297 | 56 | 44900 | 288 | 37 | 28800 |
| 31.. | -- | -- | -- | 327 | 64 | 56500 | -- | -- | -- |
| Total | 5025 | -- | 249310 | 8270 | -- | 1161470 | 10474 | -- | 1708100 |

| Day | JULY | | | AUGUST | | | SEPTEMBER | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.. | 288 | 34 | 26400 | 226 | C 24 | 14600 | 120 | C 18 | 5830 |
| 2.. | 289 | 31 | 24200 | 222 | C 24 | 14400 | 124 | C 18 | 6030 |
| 3.. | 284 | 28 | 21500 | 199 | C 24 | 12900 | 108 | C 18 | 5250 |
| 4.. | 292 | 25 | 19700 | 212 | C 24 | 13700 | 101 | C 9 | 2450 |
| 5.. | 298 | 23 | 18500 | 188 | C 24 | 12200 | 105 | C 9 | 2500 |
| 6.. | 305 | 27 | 22200 | 164 | C 24 | 10600 | 107 | C 9 | 2600 |
| 7.. | 294 | 31 | 24600 | 163 | C 16 | 7040 | 106 | C 9 | 2580 |
| 8.. | 294 | 36 | 28600 | 157 | C 16 | 6780 | 101 | C 9 | 2450 |
| 9.. | 294 | 33 | 26200 | 185 | C 16 | 7990 | 110 | C 9 | 2670 |
| 10.. | 292 | 30 | 23700 | 170 | C 16 | 7340 | 109 | C 9 | 2650 |
| 11.. | 299 | 26 | 21000 | 185 | C 16 | 7990 | 120 | C 19 | 6160 |
| 12.. | 298 | 28 | 22500 | 183 | C 16 | 7910 | 110 | C 19 | 5640 |
| 13.. | 306 | 30 | 24800 | 160 | C 16 | 6910 | 102 | C 19 | 5230 |
| 14.. | 297 | 30 | 24100 | 150 | C 12 | 4860 | 110 | C 19 | 5640 |
| 15.. | 302 | 30 | 24500 | 158 | C 12 | 5120 | 116 | C 19 | 5950 |
| 16.. | 295 | 30 | 23900 | 165 | C 12 | 5350 | 113 | C 19 | 5800 |
| 17.. | 283 | C 31 | 23700 | 157 | C 12 | 5090 | 105 | C 19 | 5390 |
| 18.. | 276 | C 31 | 23100 | 149 | C 12 | 4830 | 105 | C 22 | 6240 |
| 19.. | 275 | C 31 | 23000 | 144 | C 12 | 4670 | 114 | C 22 | 6770 |
| 20.. | 279 | C 31 | 23400 | 145 | C 12 | 4700 | 110 | C 22 | 6530 |
| 21.. | 279 | C 31 | 23400 | 114 | C 15 | 4620 | 108 | C 22 | 6420 |
| 22.. | 272 | C 31 | 22800 | 106 | C 15 | 4290 | 105 | C 22 | 6240 |
| 23.. | 262 | C 31 | 21900 | 130 | C 15 | 5260 | 100 | C 22 | 5940 |
| 24.. | 254 | C 46 | 31500 | 128 | C 15 | 5180 | 97.7 | C 22 | 5800 |
| 25.. | 261 | C 46 | 32400 | 129 | C 15 | 5220 | 98.3 | C 18 | 4780 |
| 26.. | 245 | C 46 | 30400 | 116 | C 15 | 4700 | 99.6 | C 18 | 4840 |
| 27.. | 240 | C 46 | 29800 | 114 | C 15 | 4620 | 94.8 | C 18 | 4610 |
| 28.. | 255 | C 46 | 31700 | 101 | C 18 | 4910 | 107 | C 18 | 5200 |
| 29.. | 259 | C 46 | 32200 | 99.8 | C 18 | 4850 | 107 | C 18 | 5200 |
| 30.. | 228 | C 46 | 28300 | 97.7 | 18 | 4750 | 109 | C 18 | 5300 |
| 31.. | 221 | C 24 | 14300 | 106 | C 18 | 5150 | -- | -- | -- |
| Total | 8616 | -- | 768300 | 4723.5 | -- | 218530 | 3220.4 | -- | 148690 |

Total discharge for year (K cfs-days).................................................. 63257.0
Total load for year (tons)................................................................ 5346770

C Composite period.

# TABLE K (Cont'd.)

COLUMBIA RIVER MAIN STEM--Continued

14-1447. COLUMBIA RIVER AT VANCOUVER, WASH.--Continued

Suspended sediment, water year October 1966 to September 1967--Continued

| Day | APRIL Mean discharge (K cfs) | APRIL Suspended sediment: Mean concentration (ppm) | APRIL Suspended sediment: Tons per day | MAY Mean discharge (K cfs) | MAY Suspended sediment: Mean concentration (ppm) | MAY Suspended sediment: Tons per day | JUNE Mean discharge (K cfs) | JUNE Suspended sediment: Mean concentration (ppm) | JUNE Suspended sediment: Tons per day |
|---|---|---|---|---|---|---|---|---|---|
| 1.. | 173 | 12 | 5610 | 145 | C 15 | 5870 | 463 | 85 | 106000 |
| 2.. | 171 | 12 | 5540 | 145 | C 15 | 5870 | 487 | 94 | 119000 |
| 3.. | 154 | C 14 | 5820 | 148 | C 15 | 5990 | 483 | 95 | 124000 |
| 4.. | 150 | C 14 | 5670 | 142 | 16 | 6130 | 517 | 96 | 134000 |
| 5.. | 148 | C 14 | 5590 | 146 | 17 | 6700 | 539 | 96 | 140000 |
| 6.. | 145 | C 14 | 5480 | 137 | 17 | 6290 | 551 | 97 | 144000 |
| 7.. | 149 | C 14 | 5630 | 147 | 18 | 7140 | 572 | 109 | 168000 |
| 8.. | 153 | 15 | 6200 | 142 | C 19 | 7280 | 608 | 120 | 197000 |
| 9.. | 162 | 15 | 6560 | 152 | C 19 | 7800 | 620 | 132 | 221000 |
| 10.. | 151 | C 15 | 6120 | 175 | C 19 | 8980 | 640 | 138 | 238000 |
| 11.. | 155 | C 15 | 6280 | 182 | C 19 | 9340 | 640 | 144 | 249000 |
| 12.. | 146 | C 15 | 5910 | 230 | C 19 | 11800 | 630 | 150 | 255000 |
| 13.. | 164 | C 15 | 6640 | 222 | 22 | 13200 | 630 | 118 | 201000 |
| 14.. | 171 | C 15 | 6930 | 217 | 25 | 14600 | 630 | 85 | 145000 |
| 15.. | 154 | 16 | 6650 | 199 | 28 | 15000 | 637 | 102 | 175000 |
| 16.. | 135 | 17 | 6200 | 189 | 27 | 13800 | 638 | 118 | 203000 |
| 17.. | 144 | C 18 | 7000 | 212 | 26 | 14900 | 630 | 105 | 179000 |
| 18.. | 146 | C 18 | 7100 | 227 | 30 | 18400 | 630 | 92 | 156000 |
| 19.. | 190 | C 18 | 9230 | 239 | 34 | 21900 | 630 | 80 | 136000 |
| 20.. | 186 | C 18 | 9040 | 252 | 44 | 29900 | 640 | 84 | 145000 |
| 21.. | 181 | C 18 | 8800 | 288 | 56 | 43500 | 640 | 86 | 149000 |
| 22.. | 166 | 18 | 8070 | 311 | 66 | 55400 | 630 | 90 | 153000 |
| 23.. | 136 | 19 | 6980 | 340 | 74 | 67900 | 630 | 90 | 153000 |
| 24.. | 143 | C 19 | 7340 | 400 | 82 | 88600 | 620 | 90 | 151000 |
| 25.. | 163 | C 19 | 8360 | 456 | 93 | 115000 | 620 | 90 | 151000 |
| 26.. | 189 | C 19 | 9700 | 467 | 104 | 131000 | 630 | 91 | 155000 |
| 27.. | 164 | C 19 | 8410 | 464 | 91 | 114000 | 630 | 91 | 155000 |
| 28.. | 169 | C 19 | 8670 | 422 | 78 | 88900 | 630 | 91 | 155000 |
| 29.. | 166 | 17 | 7620 | 445 | 65 | 78100 | 620 | 91 | 152000 |
| 30.. | 159 | 17 | 7300 | 453 | 70 | 85600 | 610 | 93 | 153000 |
| 31.. | -- | -- | -- | 462 | 76 | 94800 | -- | -- | -- |
| Total | 4783 | -- | 210450 | 8156 | -- | 1193690 | 18055 | -- | 4962000 |

| Day | JULY Mean discharge (K cfs) | JULY Mean concentration (ppm) | JULY Tons per day | AUGUST Mean discharge (K cfs) | AUGUST Mean concentration (ppm) | AUGUST Tons per day | SEPTEMBER Mean discharge (K cfs) | SEPTEMBER Mean concentration (ppm) | SEPTEMBER Tons per day |
|---|---|---|---|---|---|---|---|---|---|
| 1.. | 590 | 83 | 132000 | 198 | C 17 | 9090 | 151 | 8 | 3260 |
| 2.. | 577 | 73 | 114000 | 224 | C 17 | 10300 | 128 | 8 | 2760 |
| 3.. | 563 | 62 | 94200 | 242 | C 17 | 11100 | 117 | 8 | 2530 |
| 4.. | 537 | 51 | 73900 | 237 | C 17 | 10900 | 110 | C 8 | 2380 |
| 5.. | 529 | 40 | 57100 | 248 | 15 | 10000 | 116 | C 8 | 2510 |
| 6.. | 495 | 44 | 58800 | 235 | 14 | 8880 | 120 | C 8 | 2590 |
| 7.. | 488 | 48 | 63200 | 210 | 13 | 7370 | 108 | C 8 | 2330 |
| 8.. | 494 | 40 | 53400 | 201 | C 12 | 6510 | 108 | C 8 | 2330 |
| 9.. | 461 | 32 | 39800 | 201 | C 12 | 6510 | 129 | 9 | 3130 |
| 10.. | 448 | 24 | 29000 | 194 | C 12 | 6290 | 126 | 9 | 3060 |
| 11.. | 431 | 24 | 27900 | 177 | C 12 | 5730 | 130 | C 10 | 3510 |
| 12.. | 408 | 25 | 27500 | 153 | 12 | 4960 | 118 | C 10 | 3190 |
| 13.. | 385 | 25 | 26000 | 152 | 12 | 4920 | 130 | C 10 | 3510 |
| 14.. | 370 | 25 | 25000 | 160 | 12 | 5180 | 129 | C 10 | 3480 |
| 15.. | 360 | 25 | 24300 | 171 | 11 | 5080 | 128 | C 10 | 3460 |
| 16.. | 362 | 24 | 23500 | 158 | C 10 | 4270 | 131 | 10 | 3540 |
| 17.. | 344 | C 23 | 21400 | 180 | C 10 | 4860 | 130 | 10 | 3510 |
| 18.. | 324 | C 23 | 20100 | 176 | C 10 | 4750 | 114 | C 10 | 3080 |
| 19.. | 314 | C 23 | 19500 | 192 | 10 | 5180 | 111 | C 10 | 3000 |
| 20.. | 319 | C 23 | 19800 | 158 | 10 | 4270 | 139 | C 10 | 3750 |
| 21.. | 306 | C 23 | 19000 | 172 | C 10 | 4640 | 134 | C 10 | 3620 |
| 22.. | 293 | 21 | 16600 | 184 | C 10 | 4970 | 139 | C 10 | 3750 |
| 23.. | 286 | 19 | 14700 | 177 | C 10 | 4780 | 140 | 10 | 3780 |
| 24.. | 272 | C 18 | 13200 | 161 | C 10 | 4350 | 120 | 10 | 3240 |
| 25.. | 269 | C 18 | 13100 | 119 | C 10 | 3210 | 123 | C 10 | 3320 |
| 26.. | 265 | C 18 | 12900 | 140 | 10 | 3780 | 126 | C 10 | 3400 |
| 27.. | 277 | C 18 | 13500 | 140 | 10 | 3780 | 134 | C 10 | 3620 |
| 28.. | 267 | C 18 | 13000 | 150 | C 10 | 4050 | 99.0 | C 10 | 2670 |
| 29.. | 270 | 18 | 13100 | 150 | C 10 | 4050 | 120 | C 10 | 3240 |
| 30.. | 265 | 17 | 12700 | 174 | C 10 | 4700 | 120 | 10 | 3240 |
| 31.. | 231 | C 17 | 10600 | 177 | C 10 | 4780 | -- | -- | -- |
| Total | 11800 | -- | 1102300 | 5611 | -- | 183240 | 3726 | -- | 94790 |

Total discharge for year (K cfs-days)........................................ 76101.3
Total load for year (tons).................................................. 8474870

C Composite period.

## TABLE L

### Relative Abundance of Plankton in Upper and Lower Columbia Slough, Smith and Bybee Lakes

### July 5, 1972

A. Upper Columbia Slough

1. South Arm

a. Spring seep at N. E. 138th Avenue.

90% filamentous green algae, composed of Spirogyra sp., Stigeoelonium tenue.

5% diatoms, including: Melosira varians, Hannaea arcus, Stauroneis phoenicenteron, and Synedra ulna.

3% Amorphous organic debris

2% Sand grains

b. N. E. Alderwoood Drive

90% Spirogyra sp., a filamentous green alga

8% Other filamentous algae, including Cladophora glomerata, and Lyngbya sp.

2% diatoms, including Nitzschia sigmoidea, Cymatopleura solea, Stauroneis phoenicenteron, and Melosira varians.

2. Main Drainage Canal at the Multnomah County Drainage District pumping plant.

99% animal plankton, including: Copepodids and naupluis larvae, Bosmina longirostris, Diaphanosoma leuchtenbergianum, and rotifers, Platyias polyacanthus and Platyias quadricornis.

1% plant plankton, including: Scenedesmus acuminatus, Scenedesmus quadricauda, Pediastrum duplex, and Melosira granulata.

B. Lower Columbia Slough

1. Main Canal

a. Below Multnomah County pumping plant

100% animal plankton, mostly the rotifer Platyias polyacenthus with a few Copepodids and nauplius larvae. No algae present.

b. Union Avenue Bridge

99% animal plankton, about one-half being composed of Copepodid and Copepod nauplius larvae, and about one-half of rotifers, mostly Platyias polyacanthus.

1% plant plankton, including: Scenedsmus quadricauda, Selenastrum sp., Pediastrum Boryanum, which, while still b-mesosaprobic, would indicate considerable organic matter present.

c. Minnesota Freeway Bridge (I-5)

100% animal plankton, including: Copepodids, nauplius larvae, Bosmina longirostris, and a few rotifers.

A few diatoms, Asterionella formosa colonies.

d. Piling below Denver Avenue Bridge.

90% attached green algae, including Scenedesmus quadricaudus, S. acuminatus, and S. obliquus, and Pediastrum duplex and P. Boryanum.

e. Head of Island above Pacific Carbide Company

100% animal plankton, including: Copepodids, naupluis larvae, Diaphanosoma leuchtenbergianum, and Bosmina longirostus.

Few plant plankton, including: Pediastrum duplex, Asterionella formosa, Scendesmus quadricauda, and Scendesmus abundans.

f. North Portland, Road Bridge

99% animal plankton, including: Copepodids, and naupluis larvae, Bosmina longirostris, Diaphanosoma leuchtenbergianum, and rotifers, platyias polyaconthus, and Platyias quadricornis.

1% plant plankton, including: Scenedesmus acuminatus, Scenedesmus quadricauda, Pediastrum duplex, and Melosira granulata.

g. Portland Landfill access bridge

1). Surface Sample

100% animal plankton, including: Copepodids, naupluis larvae, Diaphananosoma leuchtenbergianum, Bosmina longirostus, and few rotifers.

A few diatoms, including: Asterionella formosa and Melosira granulata.

2). Log Boom Sample

99% *Cladophora glomerata*, one of the commonest river filamentous green algae in the State of Oregon.

1% Diatoms, mostly attached to Cladophora, including: *Melosira varians*, *Asterionella formosa*, *Melosira granulata* var. *angustissima*, and several species of *Cymbella*.

h. One-eighth mile above temporary sand plug -

99% animal plankton, mostly Copepodid and naupluis larvae, plus a few rotifers and a Cladoceran, *Diaphanosoma leuchtenbergianum*.

1% plant plankton, including *Asterionella formosa*, *Scenedesmus quadricauda*, and *Pediastrum Boryanum*.

C. North Slough

99% animal plankton composed of Copepodids and nauplius larvae, *Bosmina longirostris*.

1% a few *Aphanizomenon flos-aquae* bundles, a few diatoms, including *Melosira varians* and *Melosira granulata*.

D. Mid-Bybee Lake

95% animal plankton, mostly Copepodids, and nauplius larvae, with a few Cladocera, *Bosmina longirostris*.

5% plant plankton, mostly composed of *Melosira granulata*, *M. granulata* var. *angustissima*, and *M. granulata* var. *angustissima* forma *spiralis*.

These diatoms were conspicuous in the Willamette River throughout the Summer of 1972.

E. Smith Lake

1. Northern one-third of lake

65% animal plankton composed of Copepodids and nauplius.

30% *Aphanizomenon flos-aquae*, a blue-green alga.

2% plant plankton, mostly diatoms, composed of *Melosira granulata*, *Melosira varians*, *Pediastrum Boryanum*.

3% Miscellaneous organic debris.

2. Southern one-third of lake.

99% animal plankton, including: Copepodids and nauplius larvae, *Daphnia* sp., *Bosmina longirostris*.

1% *Aphanizomenon flos-aquae*.

TABLE M

Relative Abundance of Plankton

Upper and Lower Columbia Slough
July 5 & 9, 1973

A. Fairview Creek at N. E. 223rd Avenue (July 5, 1973)

The only living organisms were large numbers of Aphanizomenon flos-aquae, a planktonic blue-green alga. Many dead skeletons of diatoms which indicate moderate enrichment (Synedra ulna, Melosira varians, and Surirella ovata), and few recently dead and disintegrating cells of Pediastrum and Synura uvella. The Aphanizomenon may have washed down from ponds upstream. Most of the sample was composed of organic detritus and sand grains.

B. Upper Columbia Slough (July 5, 1973)

1. Main Drainage Canal

a. N. E. 185th Avenue

40% Melosira granulata
40% Melosira granulata var. angustissima forma spiralis.
10% Pediastrum duplex

The sample also contained some Euglena sp., Cymbella aspera, Asterionella formosa, and Pediastrum simplex.

b. N. E. 122nd Avenue

98% Melosira granulata
2% Melosira granulata var. angustissima forma spiralis, Asterionella formosa, Pediastrum simplex, and various rotifers.

c. N. E. Alderwood Drive

90% Melosira granulata
5% Melosira granulata var. angustissima forma spiralis.
5% M. granulata var. angustissima, Pediastrum simplex, Scenedesmus quadricauda, Scenedesmus armatus, Phacus sp., Dinabryon sertularia, Asterionella formosa, numerous Difflugia and rotifers.

d. N. E. 33rd Avenue

1. Nearly a pure population of Fragillaria crotonensis var. oregona.

2. Also, few Melosira granulata var. angustissima forma spiralis, Synura uvella, and Scenedesmus bijuga.

e. Multnomah County Pumping Plant

98% Fragillaria crotonensis, var. oregona.

2% Ankistrodesmus falcatus, Scenedesmus quadricauda, Synura uvella, Melosira granulata, M. granulata var. angustissima forma spiralis, and various rotifers.

2. South Slough Arm

a. N. E. 122nd Avenue

1. Large numbers of Spirogyra sp. filaments, a filamentous green alga.

2. Some Synura uvella colonies.

3. Sheets of gelatinuous pellicle, probably covering bottom mud or some solid material such as stone or wood, composed of thousands of diatoms, mostly Cocconeis sp.

b. N. E. 112th Avenue

99% Synura uvella.

Few Melosira varians.

c. N. E. Alderwood Drive

99% Fragillaria crotonensis var. oregona.

1% Scenedesmus bijuga, Scenedesmus quadricauda, and various rotifers.

d. N. E. 33rd Avenue

90% Asterionella formosa

10% Difflugia sp.

Also, few Melosira granulata

C. Lower Columbia Slough (July 9, 1973)

1. Union Avenue Bridge

98% Fragillaria crotonensis var. oregona.

2% Scenedesmus quadricauda, Melosira varians, Melosira granulata var. angustissima, and various rotifers.

TABLE M (Cont'd.)

2. Vancouver Avenue Bridge

99% _Fragillaria crotonensis_ var. _oregona_.
1% _Melosira granulata_, _M granulata_ var. _angustissima_ forma _spiralis_, _Asterionella formosa_, _Synura uvella_, _Pediastrum simplex_, and _Scenedesmus quadricauda_.

3. Denver Avenue Bridge

98% _Fragillaria crotonensis_ var. _oregona_.

2% _Melosira granulata_, _M. granulata_ var. _angustissima_ forma _spiralis_, _Scenedesmus quadricauda_, and species of _Difflugia_ and rotifers.

4. North Portland Road Bridge

98% _Fragillaria crotonensis_ var. _oregona_.

2% _Melosira granulata_, _M. granulata_ var. _angustissima_ forma _spiralis_, and species of _Difflugia_ and rotifers.

# TABLE N

TABLE

Outfalls Survey Data
Lower Columbia Slough - November 10, 1971

| Outfall Location | Est. Discharge, gpm | Mg/l DO | Mg/l BOD | Mg/l S.S. | MPN/100 ml Coliform | MPN/100 ml Fecal Coliform |
|---|---|---|---|---|---|---|
| 1. 13th Avenue | Tide gate closed | | | | | |
| 2. N. Willis Boulevard | Submerged | | | | | |
| 3. N. Vancouver Avenue | No estimate | 4.9 | ≥75 | | 700,000 | 240,000 |
| 4. N. Albina Avenue | No estimate | 9.5 | 5.4 | | 62,000 | 23,000 |
| 5. N. Fenwick Avenue | Submerged | | | | | |
| 6. N. Kenton Avenue | No flow | | | | | |
| 7. Armour Meat Company | 100 | Turbid - no sample collected | | | | |
| 8. Pacific Meat Company | 15 | | ≤60 | | 700,000 | 700,000 |
| 9. First pipe below Pacific Meat | 25 | | ≥90 | | >700,000 | 240,000 |
| 10. Kenton Packing Company | 40 | | ≤90 | | 240,000 | 240,000 |
| 11. N. Chautauqua Street | Trickle | | | | | |
| 12. Portland Rendering | 25 | | 1200-1320 | | >700,000 | 240,000 |
| 13. Western States Rendering | 30 | | 1400-1530 | | >700,000 | >700,000 |
| 14. Pacific Carbide | | | | 82 | | |
| 15. N. Fisk | | 6.4 | 69 | | >700,000 | >700,000 |
| 16. Street drain below N. Portland Road Br. | 10 | 9.3 | 8.9 | | 240,000 | 240,000 |
| 17. Columbia Steel Casting Co. | 30 | No sample collected - appeared to be clean cooling water. | | | | |
| 18. N. Oregonian Avenue | No flow | | | | | |
| 19. N. Oswego Avenue | No estimate | 7.9 | >7.8 | | 240,000 | 62,000 |
| 20. N. James Street | No estimate | 9.0 | ≥8.9 | | 240,000 | 62,000 |
| 21. Union Carbide Corp. | No estimate | | | 49 | | |
| 22. Storm drain | No estimate | 8.0 | 1.8 | | 23,000 | <4,500 |

TABLE O

LOWER COLUMBIA SLOUGH 1/
COMBINED SEWER OVERFLOWS
1972

| Combined sewer Location | No. of overflow incidents per year | | Overflow duration, mean hours/Incident | | Approx. flow rate per Incident, mgd | |
|---|---|---|---|---|---|---|
| | Wet Weather | Dry Weather | Wet Weather | Dry Weather | Wet Weather | Dry Weather |
| N. E. 13th Ave. | 126 | 7 | 5.7 | 6.2 | 23.7 | 0.23 |
| N. Willis Blvd. | 104 | 0 | 5.0 | 0.0 | 0.8 | 0.0 |
| N. Vancouver Ave. | 126 | 11 | 4.7 | 1.4 | 2.0 | 1.04 |
| N. Albina Ave. | 111 | 6 | 3.7 | 0.4 | 9.0 | 0.09 |
| N. Fenwick Ave. | 125 | 18 | 3.6 | 0.6 | 1.0 | 0.40 |
| N. Kenton Ave. | 123 | 19 | 5.7 | 1.0 | 2.0 | 0.07 |
| N. Bayard Ave. | 116 | 36 | 3.9 | 1.0 | 3.6 | 0.52 |
| N. Chautauqua Blvd. | 98 | 2 | 4.3 | 0.6 | 1.0 | 0.54 |
| N. Fiske Ave. | 123 | 20 | 7.5 | 0.9 | 0.6 | 0.04 |
| N. Oregonian Ave. | 128 | 3 | 3.4 | 0.5 | 3.9 | 0.15 |
| N. Oswego Ave. | 127 | 42 | 5.0 | 1.5 | 1.7 | 0.02 |
| N. James Ave. | 119 | 73 | 7.0 | 7.5 | 1.3 | 0.02 |
| TOTAL | | | | | 50.6 mgd | 3.1 mgd |

1/ City of Portland Data. 1974

TABLE P

CURRENT DOMESTIC AND INDUSTRIAL WASTE DISCHARGES TO COLUMBIA SLOUGH

| Sub-basin | Plant Name | Type of Waste |
| --- | --- | --- |
| A. Upper Columbia Slough | | |
| | 1. A. P. Industrial Park sewage treatment plant | Treated domestic waste |
| | 2. Propco sewage treatment plant | Treated domestic waste |
| | 3. Mountain States Investment Builders sewage treatment plant | Treated domestic waste |
| | 4. Metier Corporation Modern Fire Screen | Cooling water and treated metal waste |
| | 5. Anodizing, Incorporated | Treated metal wastes |
| B. Lower Columbia Slough | | |
| | 1. Portland Trailer Court | Treated domestic waste |
| | 2. Associated Meat Company | Cooling water |
| | 3. Vann Barrel Company | Cooling water |
| | 4. Brander Meat Company | Cooling water |
| | 5. Voit Rubber Company | Cooling water (through N. Kenton Blvd. sewer outfall) |
| | 6. Simpson Timber & Chemical Company | Cooling water (through North Kenton Blvd. sewer outfall) |
| | 7. Armour Meat Company | Cooling water, storm water |
| | 8. Pacific Meat Company | Cooling water, storm water |
| | 9. Kenton Packing Company | Cooling water, storm water |
| | 10. Malarkey Paper | Cooling water, storm water |
| | 11. Portland Rendering Company | Cooling water, storm water |
| | 12. Western States Rendering Company | Cooling water |
| | 13. Silver Falls Packing Company | Cooling water |
| | 14. H. B. Fuller Company | Cooling water (to be closed February 1972) |
| | 15. Pacific Carbide & Alloy | Treated inorganic waste, cooling water, storm water |
| | 16. Columbia Steel Casting Company | Cooling water |
| | 17. Union Carbide Company | Treated inorganic waste |

## REFERENCES


1. Ballinger, D. G. and G. D. McKee. "Chemical Characterization of Bottom Sediments." Journal Water Pollution Control Fed. 43(2): 216-227. 1971.

2. Beauchamp, R. S. A. "Sulphates in African Island Waters." Nature 171: 769-771. 1953.

3. Bisbee, L. and J. Massey. "Fish Population Investigations in Columbia Slough and Adjacent Waters." Oregon State Game Commission. 6 pgs. mimeo. 1973.

4. City of Portland. "NPDES Application. Columbia Boulevard Waste Water Treatment Plant 070." 1974.

5. Cornell, Howland, Hayes & Merryfield, Consult. Engrs. "An Engineering Report on a Supply Investigation for the City of Parkrose Water District, Portland, Oregon." 76 + App. A-D.

6. Daniel, Mann, Johnson and Mendenhall. Rivergate and the North Portland Peninsula. 1967.

7. Fair, G. M., E. W. Moore and H. A. Thomas, Jr. "The Natural Purification of River Muds and Pollution Sediments." Sewage Works Journal 13(4): 756-779. 1941.

8. Hallock, R. J. and C. D. Ziebell. "Feasibility of a Sport Fishery in Tertiary Treated Wastewater." Journal Water Pollution Control Fed. 42(9): 1656-1665. 1970.

9. Hogenson, G. M. and B. L. Foxworthy. "Ground Water in the East Portland Area, Oregon." Geological Survey Water Supply Paper 1793: 78. 1965.

10. Kappe, D. S. and S. E. Kappe. "Algal Growth Exciters." Water and Sewage Works. 118(8): 245-248. 1971.

11. McHugh, R. A. "An Interim Study of Some Physical, Chemical and Biological Properties of Selected Oregon Lakes." Oregon Department of Environmental Quality, 1972.

12. Moffatt, Nichol & Taylor, Consult. Engrs. "Master Plan of Severage Suburban East Multnomah County." 110 + Apps. A-F. 1965.

13. Moyle, J. B. "Relationships Between the Chemistry of Minnesota Surface Waters and Wildlife Management." Journal Wildlife Management. 20(3): 302-320. 1956.

14. Muller, W. "Nitrogen Content and Pollution of Streams." Water Pollution Abstracts. 28(2) Abs. No. 454. 1953.

15. Oregon Game Commission. Present and Potential Fish and Wildlife Values of the Columbia South Shore Study Area with Recommendations for Improvement. 1971.

16. Palmer, C. M. "Algae in Water Supplies." Public Health Service Publication No. 657. 88. 1959.

17. Sawyer, C. N. "Some New Aspects of Phosphates in Relation to Lake Fertilization." Sewage and Industrial Wastes. 24(6): 768-776. 1952.

18. Schmidt, W. B. Enforcement Survey Report Columbia Slough." Fed. Water Pollution Control Admin., N. W. Region. 15 pgs. mimeo. 1971.

19. The Columbia Slough Environmental Improvement Task Force. "A Plan for the North Portland Peninsula." 36. 1972.

20. Trimble, D. E. "Geology of Portland, Oregon and Adjacent Areas." Geological Survey Bulletin 1119: 119. 1963.

21. U. S. Geological Survey. "Water Resources Data for Oregon."
    a. Water Quality Records in Oregon. 135 p. 1964.
    b. Part 2. Surface Water Records. 149 p. 1965.
    c. Part 2. Surface Water Records. 163 p. 1967.

22. Wiebe, A. H. and A. M. McGavock. "The Ability of Several Species of Fish to Survive on Prolonged Exposure to Abnormally High Concentrations of Dissolved Oxygen." Trans. American Fisheries Society. 62: 267-274. 1932.