WILLAMETTE BASIN

COMPREHENSIVE STUDY

Water and Related Land Resources

APPENDIX L

WATER POLLUTION CONTROL

WILLAMETTE BASIN TASK FORCE - PACIFIC NORTHWEST RIVER BASINS COMMISSION

1969

The WILLAMETTE BASIN

COMPREHENSIVE STUDY of

Water and Related Land Resources

APPENDIX L

WATER POLLUTION CONTROL

WILLAMETTE BASIN TASK FORCE - PACIFIC NORTHWEST RIVER BASINS COMMISSION

1969

CREDITS

This is one of a series of appendices to the Willamette Basin Comprehensive Study main report. Each appendix deals with a particular aspect of the study. The main report is a summary of information contained in the appendices plus the findings, conclusions, and recommendations of the investigation.

This appendix was prepared by the Water Pollution Control Committee under the general supervision of the Willamette Basin Task Force. The committee was chaired by the Federal Water Pollution Control Administration and included representation from the agencies listed below.

Department of Environmental Quality
(Formerly Oregon State Sanitary Authority)
Oregon State Water Resources Board
Oregon State Engineer's Office
Bureau of Commercial Fisheries
Bureau of Sport Fisheries and Wildlife
Bureau of Land Management
Bureau of Outdoor Recreation
Bureau of Reclamation
Geological Survey
Public Health Service
Soil Conservation Service

ORGANIZATION

PACIFIC NORTHWEST RIVER BASINS COMMISSION

Columbia Basin Inter-Agency Committee until 1967

WILLAMETTE BASIN TASK FORCE

State of Oregon - Chairman
Army
Agriculture
Interior
Commerce
Labor
Federal Power Commission
Health, Education and Welfare

REPORT WRITER

TECHNICAL STAFF

Army
Agriculture
Interior
State

PLAN FORMULATOR

APPENDIX COMMITTEES

A. Study Area
B. Hydrology
C. Economic Base
D. Fish and Wildlife
E. Flood Control
F. Irrigation
G. Land Measures and Watershed Protection
H. Municipal and Industrial Water Supply
I. Navigation
J. Power
K. Recreation
L. Water Pollution Control
M. Plan Formulation

WILLAMETTE BASIN TASK FORCE

State of Oregon	Donel J. Lane, Chairman Director, Oregon State Water Resources Board
Department of Army	Henry Stewart Chief, Planning Branch U. S. Army Engineers, Portland District
Department of Interior	John F. Mangan Area Engineer, Lower Columbia Development Office Bureau of Reclamation
Department of Agriculture	Oke Eckholm Assistant State Conservationist Soil Conservation Service
Department of Commerce	David J. Bauman Hydrologist, Weather Bureau Forecast Center
Federal Power Commission	Gordon N. Boyer Hydraulic Engineer Federal Power Commission
Department of Labor	Horace Harding Regional Economist Bureau of Employment Security
Department of Health, Education & Welfare	Francis L. Nelson Public Health Service Water Supply and Sea Resources Program

The Willamette Basin Comprehensive Study has been directed and coordinated by the Willamette Basin Task Force, whose membership as of April 1969 is listed above. The Task Force has been assisted by a technical staff, a plan formulator, and a report writer - Executive Secretary. Appendix committees listed on the following page carried out specific technical investigations.

APPENDIX COMMITTEES

Appendix-Subject		
A - Study Area	OSWRB - Chairman:	FWPCA, USBPA, USBLM, USBM, USBOR, USBR, USBSF&WL, USCE, USERS, USFS, USGS, USNPS, USSCS, OSDC, OSDF, OSDG&MI, OSS&WCC, OSU
B - Hydrology	USGS - Chairman:	FWPCA, USBPA, USBR, USCE, USSCS, USWB, OSE, OSWRB
C - Economic Base	USCE - Chairman:	FWPCA, USBPA, USBCF, USBM, USBOR, USBR, USBSF&WL, USDL, USERS, USFS, OSDC, OSU, UO, PSC-PR&C
D - Fish & Wildlife	USBSF&WL - Chairman:	FWPCA, USBCF, USBLM, USBOR, USCE, USDA, USFS, USGS, USSCS, OSFC, OSGC, OSWRB, USHEW
E - Flood Control	USCE - Chairman:	FWPCA, USBR, USDA, USGS, USSCS, USWB, OSDC, OSE, OSWRB, UO
F - Irrigation	USBR - Chairman:	USSCS, OSDC, OSWRB, OSU
G - Land Measures and Watershed Protection	USSCS - Chairman:	FWPCA, USBCF, USBLM, USBOR, USBR, USBSF&WL, USFS, OSU
H - M&I Water Supply	FWPCA - Chairman:	USBR, USBSF&WL, USGS, USSCS, OSBH, OSDC, OSWRB, USHEW
I - Navigation	USCE - Chairman:	OSDC, OSMB, POP, OSU
J - Power	USBPA - Chairman:	FPC, FWPCA, USBCF, USBR, USCE, USFS, USGS, OSE, OSWRB
K - Recreation	USBOR - Chairman:	FPC, FWPCA, USBLM, USBSF&WL, USCE, USFS, USNPS, USSCS, OSBH, OSDC, OSFC, OSGC, OSHD-PD, OSMB, OSWRB, LCPD, OCPA, USHEW
L - Water Pollution Control	FWPCA - Chairman:	USBCF, USBLM, USBOR, USBR, USBSF&WL, USGS, USSCS, OSBH, OSE, OSFC, OSGC, OSWRB, OSU, USHEW
M - Plan Formulation	Plan Formulator - Chairman:	USCE, USDA, USDI, OSWRB

FPC - Federal Power Commission
FWPCA - Federal Water Pollution Control Administration
USBPA - Bonneville Power Administration
USBCF - Bureau of Commercial Fisheries
USBLM - Bureau of Land Management
USBM - Bureau of Mines
USBOR - Bureau of Outdoor Recreation
USBR - Bureau of Reclamation
USBSF&WL - Bureau of Sport Fisheries and Wildlife
USCE - Corps of Engineers
USDA - Department of Agriculture
USHEW - Department of Health, Education and Welfare
USDI - Department of Interior
USDL - Department of Labor
USERS - Economic Research Service
USFS - Forest Service
USGS - Geological Survey
USNPS - National Park Service
USSCS - Soil Conservation Service
USWB - Weather Bureau

OSBH - Oregon State Board of Health
OSDC - Oregon State Department of Commerce
OSDF - Oregon State Department of Forestry
OSDG&MI - Oregon State Department of Geology and Mineral Industries
OSE - Oregon State Engineer
OSFC - Fish Commission of Oregon
OSGC - Oregon State Game Commission
OSHD-PD - Oregon State Highway Department - Parks Division
OSMB - Oregon State Marine Board
OSS&WCC - Oregon State Soil and Water Conservation Committee
OSWRB - Oregon State Water Resources Board
OSU - Oregon State University
PSC-PR&C - Portland State College - Center for Population Research and Census Service
UO - University of Oregon
LCPD - Lane County Parks Department
OCPA - Oregon County Parks Association
POP - Port of Portland

BASIN DESCRIPTION

Between the crests of the Cascade and Coast Ranges in northwestern Oregon lies an area of 12,045 square miles drained by Willamette and Sandy Rivers--the Willamette Basin. Both Willamette and Sandy Rivers are part of the Columbia River system, each lying south of lower Columbia River.

With a 1965 population of 1.34 million, the basin accounted for 68 percent of the population of the State of Oregon. The State's largest cities, Portland, Salem, and Eugene, are within the basin boundaries. Forty-one percent of Oregon's population is concentrated in the lower basin subarea, which includes the Portland metropolitan area.

The basin is roughly rectangular, with a north-south dimension of about 150 miles and an average width of 75 miles. It is bounded on the east by the Cascade Range, on the south by the Calapooya Mountains, and on the west by the Coast Range. Columbia River, from Bonneville Dam to St. Helens, forms a northern boundary. Elevations range from less than 10 feet (mean sea level) along the Columbia, to 450 feet on the valley floor at Eugene, and over 10,000 feet in the Cascade Range. The Coast Range attains elevations of slightly over 4,000 feet.

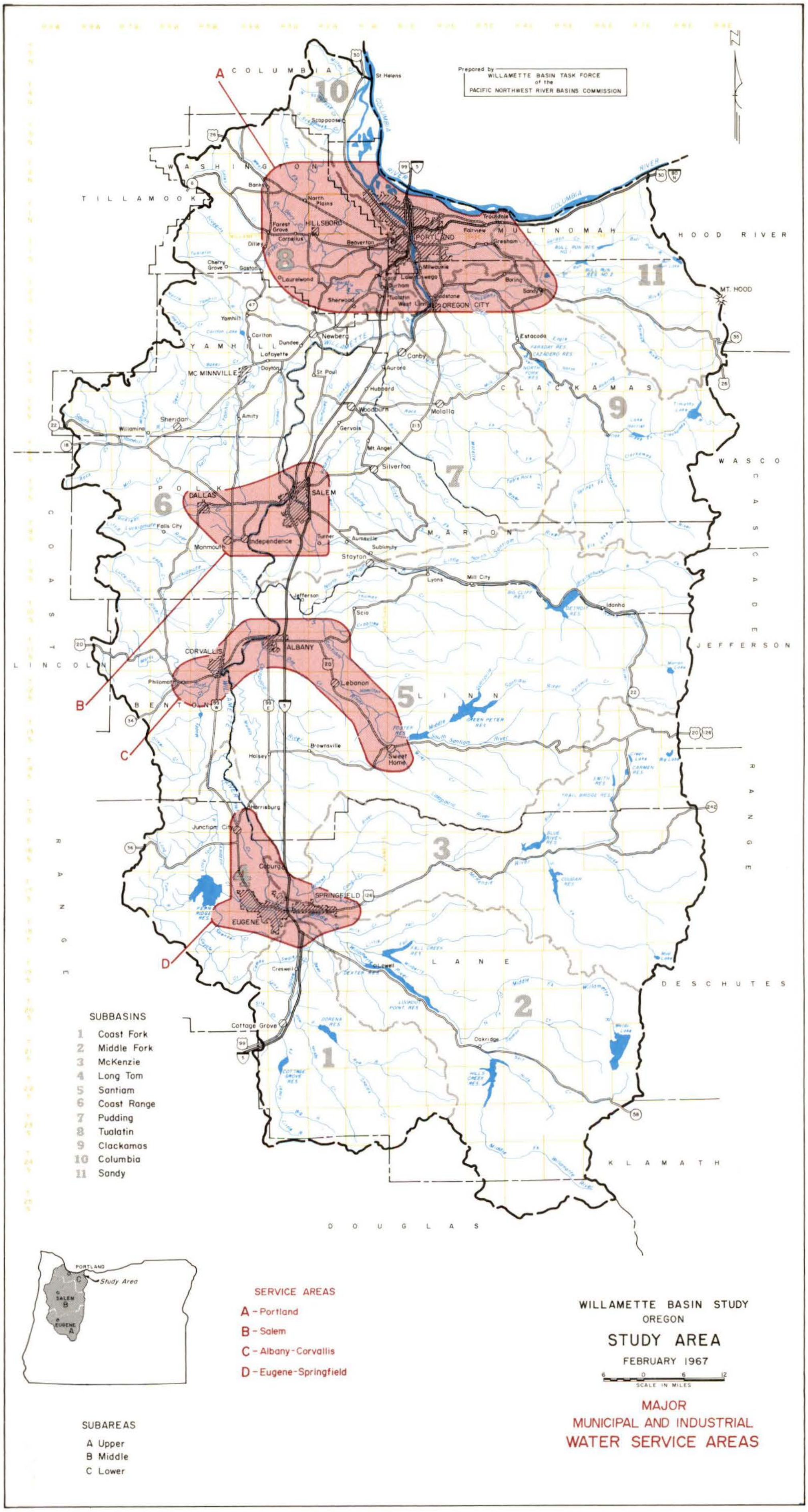
The Willamette Valley floor, about 30 miles wide, is approximately 3,500 square miles in extent and lies below an elevation of 500 feet. It is nearly level in many places, gently rolling in others, and broken by several groups of hills and scattered buttes.

Willamette River forms at the confluence of its Coast and Middle Forks near Springfield. It has a total length of approximately 187 miles, and in its upper 133 miles flows northward in a braided, meandering channel. Through most of the remaining 54 miles, it flows between higher and more well defined banks unhindered by falls or rapids, except for Willamette Falls at Oregon City. The stretch below the falls is subject to ocean tidal effects which are transmitted through Columbia River.

Most of the major tributaries of Willamette River rise in the Cascade Range at elevations of 6,000 feet or higher and enter the main stream from the east. Coast Fork Willamette River rises in the Calapooya Mountains, and numerous smaller tributaries rising in the Coast Range enter the main stream from the west.

In this study, the basin is divided into three major sections, referred to as the Upper, Middle, and Lower Subareas (see map opposite). The Upper Subarea is bounded on the south by the Calapooya Mountains and on the north by the divide between the McKenzie River drainage and the Calapooia and Santiam drainages east of the valley floor and by the Long Tom-Marys River divide west of it. The Middle Subarea includes all lands which drain into Willamette River between the mouth of Long Tom River and Fish Eddy, a point three miles below the mouth of Molalla River. The Lower Subarea includes all lands which drain either into Willamette River from Fish Eddy to its mouth or directly into Columbia River between Bonneville and St. Helens; Sandy River is the only major basin stream which does not drain directly into the Willamette.

For detailed study, the three subareas are further divided into 11 subbasins as shown on the map.



WBTF-O-1001abd-LL

TABLE OF CONTENTS

PART I - INTRODUCTION

PART II - PRESENT STATUS

TABLES

FIGURES

MAPS

PHOTOS
(Titles abridged)

PHOTOS (Cont.)

PART I

INTRODUCTION

INTRODUCTION

PURPOSE AND SCOPE

The purpose of this appendix is to appraise the existing level of water quality and to present recommendations for restoring and maintaining water quality at a level which will permit beneficial use of the water resource of the Willamette Basin. This study includes: (a) identification of those land-use and water-management practices which adversely affect water quality, and remedial measures to reduce or control such effects; (b) determination of requirements for treatment or control of pollutants emanating from the diverse sources; and (c) determination of needs for regulating streamflow, particularly for augmenting low flows to safeguard and enhance water quality. Factors considered in these determinations include organic waste, heat, bacteria, toxic materials, sediment, or dissolved solids carried to the rivers by storm drains, sanitary sewers, and surface runoff. Both direct and secondary effects of pollution are noted. An example of a secondary effect is dissolved solids or minerals leached from the soil and carried to a watercourse where they may act as nutrients for profuse biological growths in the stream.

This appendix presents alternative solutions which would provide water quality suitable for specific uses. The combinations presented to meet a given quality goal for the year 1980 are relatively specific and require immediate implementation if this goal is to be achieved. The combinations of flow and waste loads presented for the years 2000 and 2020 are progressively less specific but are adequate for long-range planning.

RELATIONSHIP TO OTHER PARTS OF THE REPORT

Data from other appendices are necessary to describe adequately the quality of water, the extent of pollution, and the factors of pollution. Data from Appendix C--Economic Base--describe the present and projected levels of population and industry which, in turn, are related to waste production and water quality requirements. The hydrologic characteristics are derived from Appendix B--Hydrology. The water quality requirements for specific uses--principally municipal and industrial water, fish and wildlife, land measures, irrigation, and recreation--are predicated on data in the appropriate functional appendices.

HISTORY

Stream pollution and efforts to reduce it in order to protect public health were evident in localized areas in the Willamette Basin even before the turn of the century. The first basinwide evaluation of pollution and its control was made in 1926 by the Oregon State Board of Health. Other surveys in the late 1920's--by the Portland City Health Bureau, the U. S. Public Health Service, and the Engineering Experiment Station at Oregon State College--gave undisputed evidence that the Willamette River had become so polluted with municipal and industrial wastes that these waters were a menace to health, destructive of fish life, and unfit for certain other beneficial uses.

STATE AND LOCAL PARTICIPATION

Water pollution control by regulating waste discharges is of recent origin. The efforts of a Governor's committee in the 1930's eventually led to Oregon's first comprehensive pollution control law, approved by a three-to-one majority when presented to the voters in 1938. That initiative measure created the Oregon State Sanitary Authority (OSSA) and provided the basis of Oregon's present statewide pollution control program.

Photo I-1. Degraded water from upstream combines with local waste outfalls to create recurring problems of pollution in Portland Harbor. (Corps of Engineers, Portland, Oregon, Photo)

All of the basin communities and industries were required by the Sanitary Authority in 1939 to participate in a program of pollution abatement. This order called for construction and operation of primary treatment facilities. Manbrin Gardens (a Salem suburb) was the first to comply, in 1947. In the 10 succeeding years, 23 other industries and communities subject to the order also complied.

In 1958, the Sanitary Authority concluded that additional treatment was needed and called upon the cities of Eugene, Salem, and Newberg to install secondary treatment facilities. In addition, the City of Portland was instructed to accelerate its program of interception, and five pulp and paper mills were ordered to further reduce their pollutional loads. In September 1960, the order for secondary treatment was expanded to include all remaining communities below Salem.

The program resulted in improved water quality, but poor quality during periods of extreme low flow persisted at specific points, such as Portland Harbor. As a result, the Sanitary Authority staff conducted a survey of water quality in the Willamette Basin in the early 1960's, and issued a report of findings in May 1964. The principal conclusion of this report was that, although considerable progress had been made in the previous 25 years, Sanitary Authority standards still had not been met. The report detailed specific sources of pollution and showed what measures would be required to bring the Willamette River system up to standard. As a result of this report, the Sanitary Authority in 1964 adopted the following policies:

1. All industrial wastes from each pulp and paper mill in the basin must receive year-round primary sedimentation or equivalent treatment for removal of settleable solids.

2. Each sulfite pulp and paper mill, in addition to year-round settleable solids removal, must, during the period of critical streamflow (June to October, inclusive), effect an 85 percent reduction in the biochemical oxygen demand (BOD) of the effluents from the entire mill.

3. All other sewage and waste effluents must receive secondary treatment equal to 85 percent removal of BOD and suspended solids.

4. Higher degrees of treatment may be required in some cases, depending upon the size and nature of the waste load and of the receiving stream.

5. The deadline for meeting these requirements was established as December 1966.

The Federal Water Pollution Control Act, as amended by the Water Quality Act of 1965, provided for the establishment, by each state, of water quality standards for interstate waters. The State of Oregon was one of the first states to complete its standards and to have them approved by the Secretary of the Interior. These standards, approved June 18, 1967, covered the Willamette River from the mouth to Willamette Falls. At the same time the state issued intrastate standards which covered the remainder of the Willamette Basin. These standards are described in Part III.

FEDERAL PARTICIPATION

Congressional enactment of PL 80-845, the Federal Water Pollution Control Act of June 1948, made comprehensive planning for water pollution control a matter of Federal concern. This law required the Public Health Service to prepare programs to begin reducing or eliminating pollution of interstate waters and their tributaries, and to improve the sanitary conditions of surface and ground waters. The programs were prepared with due regard given to conservation of the Nation's waters for public water supplies, propagation of fish and aquatic life, recreational purposes, agriculture, and other legitimate uses.

A cooperative report by the U. S. Public Health Service and the Oregon State Sanitary Authority, in 1951, pointed out the importance of the water resource and the deplorable state of some waters of the Willamette Basin, listing 42 cities and 29 industries with deficiencies in their waste treatment facilities. The recommendations included establishment of water quality objectives, coordination of water resource development projects to maximize the effects of streamflow regulation, and adherence to erosion-control measures in public water supply watersheds.

The Federal Water Pollution Control Act of 1956 (PL 84-660) added the construction grants program to the role of the Federal Government in water pollution control. By the end of 1961, more than $2¼ million had been given in Federal grants for pollution control facilities in the Willamette Basin; total cost of these facilities was $10 million.

Public Law 84-660 and its 1961 amendments provided for comprehensive programs for water pollution control, including review of proposed Federal storage projects for water quality control features and benefits. Research, investigations, training, and information services were made available to qualified organizations involved in water pollution control. Provisions were also made to encourage cooperation among states and other agencies, to provide water pollution control grants, and to enter into enforcement measures against pollution of interstate or navigable waters.

Many other Federal actions during the past 70 years have been taken to control toxic materials, sediment, and ground-water contamination. The 1897 Organic Act created national forests and provided for protection of watersheds. Other legislation has added restrictive measures to offer protection from toxic chemicals, oil, dry refuse, and other pollutants.

An example of the use of water management for quality control occurred during August of 1965. The dissolved oxygen level in Portland Harbor dropped to a critically low level even with a high level of waste reduction. A meeting among the concerned agencies was set up by the Federal Water Pollution Control Administration officials, and emergency control measures for the immediate situation were defined. These measures included the early release of water stored for other purposes to augment the flow as a temporary measure. Industries--particularly the pulp and paper mills--and municipalities were notified that the amount of discharged waste must be held to a minimum and, in the case of industries, that continuation of poor quality might result in a shutdown order. As a result, water quality conditions were measurably improved through the critical period.

PART II

PRESENT STATUS

PRESENT STATUS

Average water quality in the Willamette Basin is, with the exception of bacterial pollution, at a generally acceptable level. However, water quality conditions in many streams become a serious problem during the summer months when low streamflows occur. The most severe conditions are apparent in the Portland Harbor reach of the Willamette River and in the Tualatin River.

Each year during periods of low river flow, the Portland Harbor reach undergoes periods of oxygen depression, slime growths, and bacterial contamination, caused by discharges of inadequately treated wastes by industries and municipalities. Water uses impaired include municipal supply, recreation, and fish migration. As an example, Lake Oswego voters recently chose the Clackamas River as a new source of supply, foregoing the less expensive, but poorer quality, Willamette River source. Present conditions in the harbor are improved over those found during the first major water quality survey in 1929, but subsequent construction of abatement facilities and regulation of flow for quality control have been offset, to a large extent, by increased population and industrial activity.

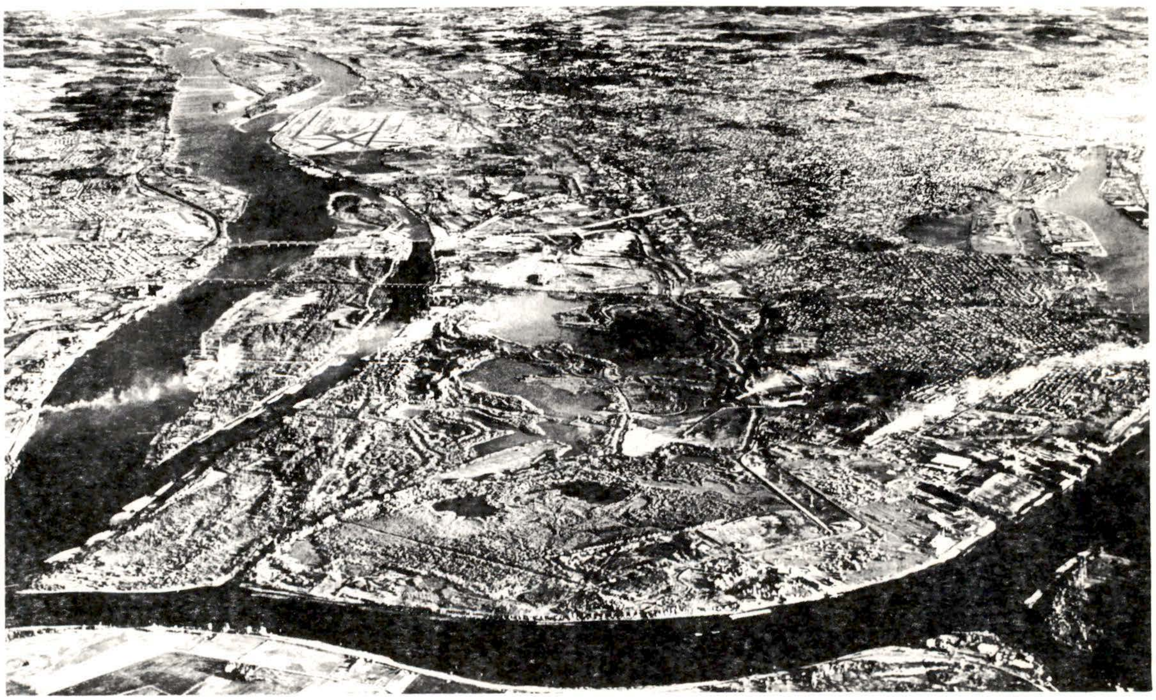


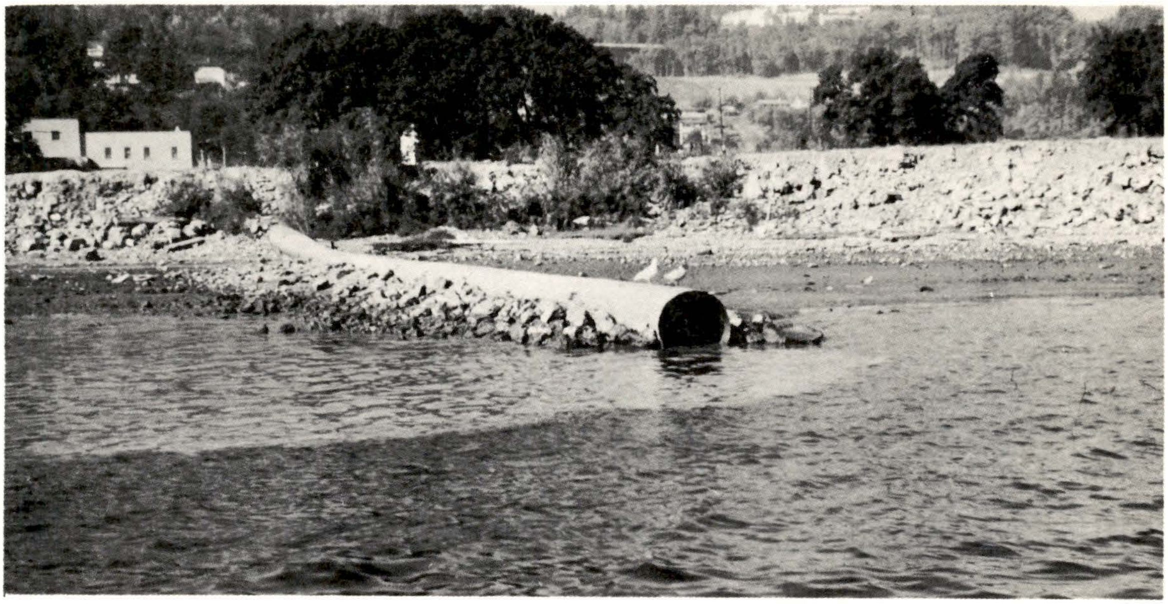
Photo II-1. The problem of pollution in Portland Harbor extends downstream through the Rivergate industrial area to the mouth of the Willamette River.

The Tualatin River receives more waste during periods of low flow than can be assimilated by its meager streamflow. Population growth and flow diversions in the Tualatin Subbasin have resulted in poor water quality conditions in spite of a high degree of treatment of waste discharges. Periods of low dissolved oxygen, bacterial contamination, slime and algal blooms, and contamination by toxicants occur nearly every year. Uses of the river are restricted to those requiring only low-quality water.

Construction of abatement facilities has resulted in generally improved water quality conditions in the Willamette River downstream as far as Newberg; flow regulation for navigation through augmentation of low natural streamflow has also contributed to quality improvement. On the other hand, increased habitation, recreation, and industry in the tributary stream watersheds have resulted in increased bacterial loads in previously "clean" streams. Ground cover has been disturbed and sediment production increased in certain areas by logging, road construction, farming, urban and suburban development, dam building, and other ground-disturbing developments.

A suitable projection base must be provided to establish a meaningful program for future water pollution control in the basin to fit anticipated needs. To make this possible, practices and activities that contribute to water quality degradation are identified and evaluated as sources of pollution. At present, some sources are of major significance, and others are quite minor; but all are essential to consideration of a major water pollution control program.

In some instances the present situation, as discussed in this section, represents development and conditions as they existed in 1965. Updated information has been included where possible to present a more current appraisal. Pollution control and abatement are accelerating within the basin, and a significant improvement in water quality has been made in recent years.



S O U R C E S   O F   P O L L U T I O N

Within the Willamette Basin, the major pollutional effects have been downgrading of aesthetic quality, bacterial contamination, dissolved oxygen depression, and sediment deposition.

Discharge of bacterially contaminated sanitary waste effluent has an immediate impact of public health significance and an adverse effect, both aesthetic and economic, on potential downstream uses. Color, heat, and solids in waste discharges are important to these uses. Oxidizable materials tend to deplete the dissolved oxygen content of the water, which, in turn, can be detrimental to the fishery. Toxicants are of public health significance and may convert a healthy aquatic environment to a biological desert.

The strength of organic wastes is expressed as biochemical oxygen demand (BOD) in milligrams of oxygen required for oxidation per liter of waste, per unit of time at a prescribed temperature. The total amount of oxidizable waste may be stated as pounds of BOD or as population equivalents (PE). The average value for one PE is 0.17 lb. of five-day BOD per day.

Municipal and industrial wastes discharged to streams and rivers are the primary cause of the present water quality degradation. These sources of pollution are potentially the most damaging, the most obvious, and aesthetically the most obnoxious. Since municipal and industrial waste discharges are the most readily observed and identified, they have received the greatest attention in most discussions of needed improvements to restore or preserve water quality. Other causes of degradation include: irrigation return flow, agricultural animal wastes (livestock and poultry), thermal-power cooling water, mining wastes, recreational activities, impoundments and streamflow depletion, and other land-use practices. However, these causes have had only minimal effects on water quality within the Willamette Basin, except locally.

Centralization of population and industry in four primary areas within the basin (Portland, Salem, Corvallis-Albany, and Eugene-Springfield) has concentrated the waste sources (Figure II-1). The importance of pulp and paper wastes is obvious by their relative magnitude, as shown in this figure. Temporary lagooning and barging of these wastes provide control during the summer low-flow period, but during the remainder of the year these wastes have been discharged to the watercourses undiminished in strength.

Treatment plants for municipal and industrial wastes are broadly grouped into three classes:

(1) Primary. Effects settleable solids removal and 35 to 45 percent reduction of BOD.

(2) Secondary. Effects about 85 percent reduction of BOD and solids, and about 95 percent bacterial reduction, with adequate chlorination.

(3) Tertiary. Effects 95 percent BOD reduction and removal of a high percentage of other pollutants by specialized processes.

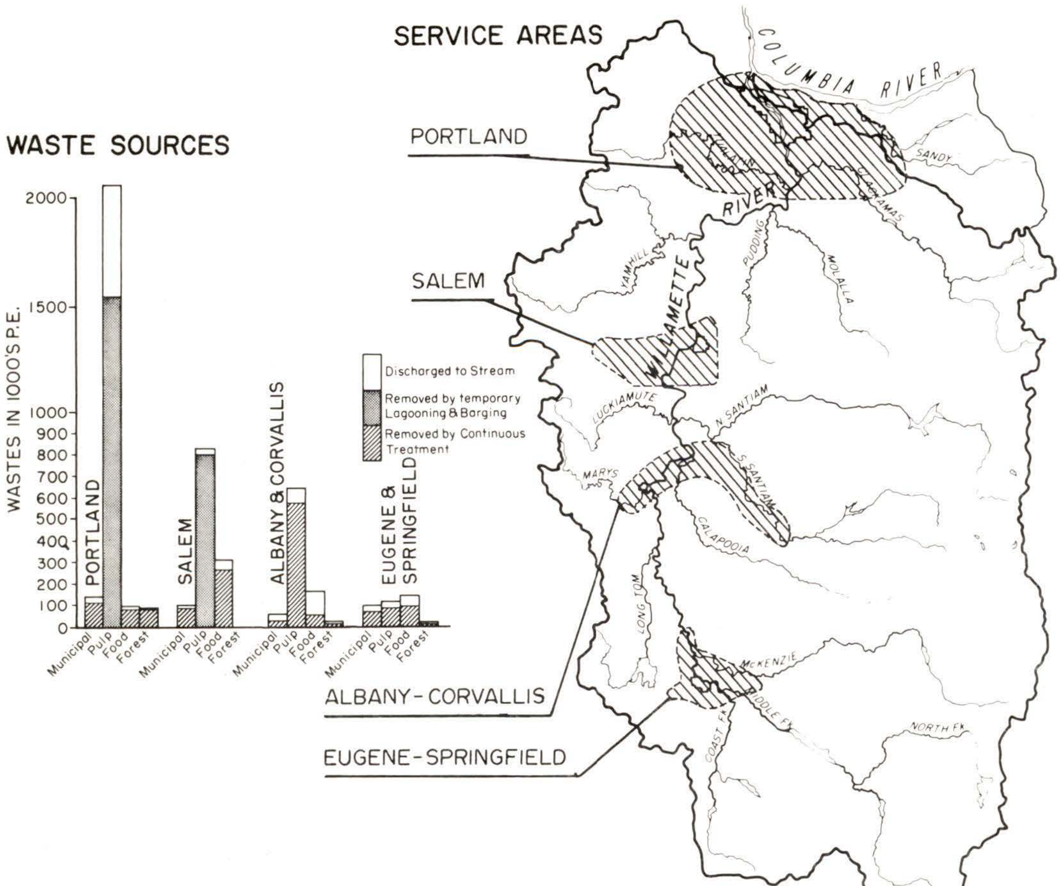


Figure II-1. Location and Extent of Major Waste Sources, 1965.

To effect adequate bacterial control, effluent from any waste treatment plant must be chlorinated. The Department of Environmental Quality (formerly the Oregon State Sanitary Authority) presently requires at least secondary treatment and effective effluent disinfection of all municipal wastes discharged to the Willamette River or its tributaries.

MUNICIPAL WASTES

Municipal waste collection and treatment facilities have been provided for 736,715 persons--about 55 percent of the basin's population. The remainder of the population is served by individual disposal systems. In 1965, only the community of Monroe (population 374) and portions of the City of Portland discharged untreated sewage to the rivers, but steps have been taken in both cases to eliminate this practice. Twenty years ago, direct discharge of raw sewage to the streams was common practice. The need for abatement facilities had been established earlier by the Oregon State Sanitary Authority, but virtually no progress had been made by communities prior to 1946. Since that time, more than $100 million has been spent by the taxpayers for sewerage facilities in the Willamette Basin.

The amount and strength of residential wastes are basically related to the number of people served by sewage collection facilities, but additional loads may be discharged to the system by commercial and industrial establishments. These wastes cause the total load to vary from a norm and may also cause significant fluctuation. Quantity and strength of wastes are influenced by infiltration of ground water into sanitary sewers and storm-water inflow to combined systems, both of which may cause bypassing of raw wastes directly to the river during periods of excessive sewer flow.

The major effects of municipal waste have been bacterial contamination and oxygen depression in the streams. Other adverse influences include buildup of excessive nutrients, color, toxicants, and solids.

Bacterial contamination has been of great public health significance in the basin during the past 60 years, and its presence has had a great influence on the waste control programs. Portions of nearly every major stream exceed generally accepted coliform bacteria standards for water-contact recreation and water supply sources.

Discharged wastes, even after treatment, contain oxidizable organic matter that exerts an oxygen demand on the receiving stream. The net effect depends upon the amount and strength of the effluent, and the size and characteristics of the receiving stream.

Municipal waste collection and treatment facilities provide several benefits. Sewer systems prevent public health dangers and water pollution at the waste sources by collecting liquid wastes and isolating them from surface and ground waters. Ideally, the treatment plant reclaims the water from the waste and returns it to the river for further use. Treatment plants are standard in purpose, although not in design, with the following objectives fulfilled in various ways: removal of grit and settleable solids; removal of oils, grease, and other floating material; removal of suspended solids; and reduction of bacteria. Final disposal or treatment of undesirable fractions includes digestion of solids, biological treatment of organics, burial of some solids in sanitary land fills, incineration of organics, and disinfection by chlorinating the bacteria.

Storm sewers occasionally contribute a significant amount of oxidizable material. Fortunately, storm-sewer flow in the basin usually occurs only during periods of relatively high river flow, and the effects are therefore usually minimal. Siltation is the most serious effect of storm-sewer flows, but creates a problem only in Portland Harbor.

The majority of the communities have complied with orders of the Oregon State Sanitary Authority by constructing and operating secondary treatment plants. As indicated in Table II-1, the plant efficiencies are below the desirable level of 85 percent. This is the result of overloaded older plants, particularly during the short-term peaks. Inadequate plants are being upgraded to provide at least 85 percent treatment in order to comply with OSSA policy directives.

Table II-1

Summary of Municipal Waste Treatment Facilities, 1965

Type of Treatment	Number of Plants	Population Served	Population Equivalents Untreated	Population Equivalents Discharged	Removal Efficiency %
Secondary	66	323,125	1,026,720	229,550	78
Primary1/	8	36,350	140,950	96,880	32
Lagoon	8	5,390	5,410	940	83
Other	9	1,850	1,850	1,050	43
Subtotal	91	366,715	1,174,930	328,420	72
City of Portland	1	370,000	385,000	2/	
BASIN TOTAL	92	736,715	1,559,930	328,420	79

1/ Under orders for improvement to secondary.
2/ Primary effluent to Columbia River.

INDUSTRIAL WASTES

Industrial wastes discharged to watercourses during the summer months amount to more than three times the municipal load in terms of biochemical oxygen demand (BOD). The major contributor is the pulp and paper industry with a discharged load of more than 1,000,000 population equivalents (PE). Discharged wastes include strong chemicals which exert an oxygen demand and are toxic to the extent that a favorable aquatic environment is damaged. In addition, wood fiber in these wastes settles and forms sludge beds that in many cases form gas during decomposition and rise to the surface as unsightly masses. The sludge beds decompose and exert a continuous oxygen demand on the flowing stream. A list of the basin's pulp and paper mills, with their production capacity, is presented in Table II-2.

Table II-2

Pulp and Paper Mills, 1966

Firm	Location	Tons/Day	Process
Boise Cascade Corporation	Salem	220	Sulfite
Crown Zellerbach Corporation	Lebanon	95	Sulfite
Crown Zellerbach Corporation	West Linn	710	Sulfite
		385	Groundwood
Evans Products Company	Corvallis	30	Sulfite
		40	Miscellaneous
Boise Cascade Corporation	St. Helens	385	Sulfate
Publishers' Paper Company	Oregon City	120	Sulfite
		350	Groundwood
Publishers' Paper Company	Newberg	150	Sulfite
Western Kraft Corporation	Albany	500	Sulfate
Weyerhaeuser Company	Springfield	450	Sulfate

Representative organic waste loads per ton of product for various pulping and papermaking processes are shown in Table II-3.

Table II-3

Organic Waste Loads

	Waste per Ton of Product	
Process	Expectable with Treatment Lbs. BOD	Willamette Basin Mills, 1965 Lbs. BOD
Sulfite pulping	50	550
Sulfate pulping	10	11
Groundwood pulping (bleached, refiner)	15	20
Papermaking	5	14

Food-processing plants discharge the second largest amount of organic industrial waste in the basin (Table II-4). Most of the processing plants rely upon municipal systems for waste disposal; a few provide individual facilities. Oxidation ponds or land disposal is the most common means of individual treatment. The peak of the vegetable- and fruit-processing season usually occurs when climatic conditions are favorable for lagoon or land disposal operations. Adverse effects on the receiving watercourse of effluent from food processors include stimulation of algal blooms, impartation of color, or discharge of settleable solids. A few plants are served only partially by municipal sewers, with the strong (high BOD) wastes going to the sewer, and weaker wastes (such as raw vegetable wash water) discharging to the land or rivers. Wash water is relatively low in BOD but does carry sediment and, at times, color.

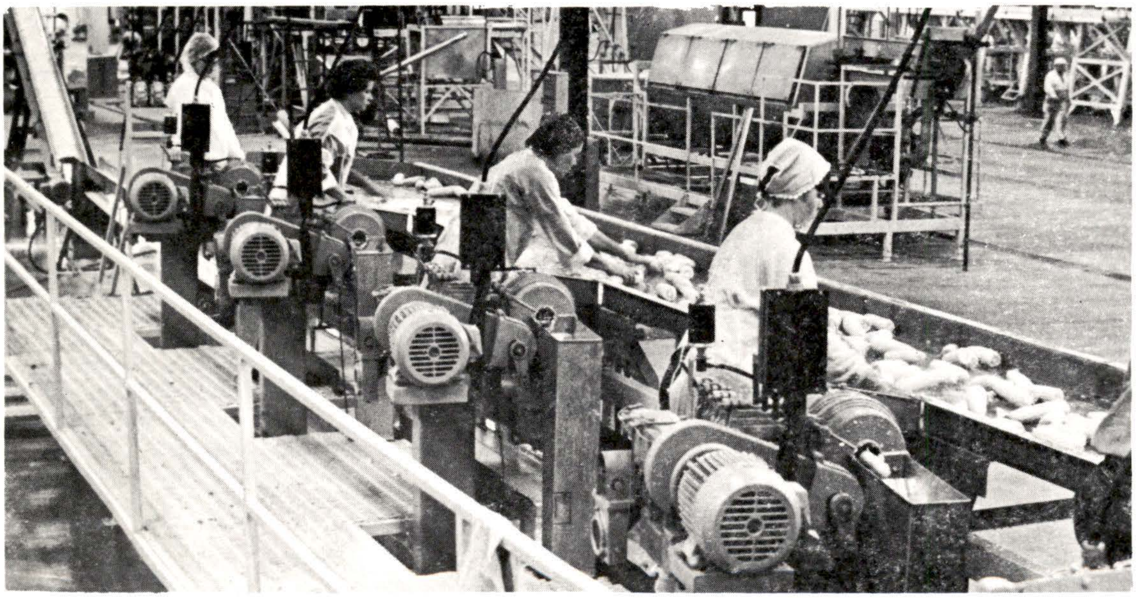


Photo II-2. Corn on the processing line--one of the many varieties of vegetables that are commercially prepared in similar plants throughout the Willamette Basin. (Oregon State Office of Economic Development, Portland, Oregon, Photo)

The lumber and wood products industry adversely affects water quality, although its wastes do not present problems which are as critical or widespread as those of the pulp and paper industry. Plants utilizing hydraulic barkers can contribute up to 25 pounds of suspended solids per cord of wood. These solids offer potential damage to aesthetic conditions by serving as a base for attachment of slimes. Log ponds are a source of suspended material and complex organic compounds which may generate undesirable color and odor.

A summary of industrial waste treatment facilities is presented in Table II-4.

Table II-4

Summary of Industrial Waste Treatment Facilities, 1965

Type of Industry	Number of Plants	Population Equivalents Untreated	Population Equivalents Discharged	Removal Efficiency %
Pulp and Paper[1/]	9	4,491,400	1,074,060	76[2/]
Food Products[3/]	13	134,550	4,100	97
Forest Products	20	22,950	9,690	58
Miscellaneous	5	38,850[4/]	29,090[4/]	25
BASIN TOTAL	47	4,687,750	1,116,940	76

1/ Includes two particle-board plants, but excludes one plant discharging to the Columbia and one building board and paper mill.

2/ Refers only to summer period and reflects temporary withholding by lagoon storage, land application, and barging.

3/ Excludes wastes treated by municipal plants.

4/ Includes numerous small discharges to Portland Harbor.

IRRIGATION

Within the Willamette Basin, effects of irrigation on water quality are minimal. The most obvious potential for stream pollution from irrigation is by return flow, but about 95 percent of water application on the 244,000 acres of irrigated land is by sprinkler, with virtually no surface runoff. Application is regulated to minimize pumping costs and to obtain optimum productivity with but little excess water applied. Most chemicals applied are utilized by the crops or bound in the soil.

Runoff from fall and winter rains carries some natural and applied minerals and chemicals to the rivers. However, streamflow during these seasons is generally great enough to preclude development of problems.

Annual withdrawal of surface and ground water was estimated to be 569,000 acre-feet in 1965 (Appendix F--Irrigation). The flow of some streams is nearly depleted during periods of irrigation; thus, the quantity and quality of the remaining flow and return flow are insufficient to prevent degradation caused by the addition of any pollutants.

Present regulations and recommended practices give full cognizance to programs of water pollution control. Research efforts have resulted in guidelines for water and chemical application to produce optimum economic returns and at the same time to minimize water pollution.

LIVESTOCK AND POULTRY

Readily defined adverse effects of livestock and poultry on water quality have been limited to minor instances of localized pollution. Problems of bacterial contamination and organic pollution have usually been traced to improper discharge of liquid and solid wastes from large poultry houses or concentrations of cattle such as drainage from dairies and feed yards. Droppings and manure are frequently collected, stored, and applied to the ground in liquid form or treated in oxidation ponds.

Animal wastes flushed into streams not only contribute a high bacterial load but also exert a biochemical oxygen demand. The estimate of potential fecal streptococci from animal sources in the Willamette Basin for 1959 was over 78 times that from human sources. Assuming a 90 percent reduction by land disposal, the magnitude of the residual load from animal sources is almost eight times that from human sources before treatment.

Photo II-3. Wherever pasturelands are adjacent to watercourses (such as the Albany Ditch above), the streams receive animal wastes from watering sites like the one shown. (USDA, Soil Conservation Service, Portland, Oregon, Photo)

The oxygen demand of the wastes from the 223,000 head of livestock in the basin would be about equal to that of the total population of the basin. The amount of these wastes reaching the waterways is unknown. However, these relationships point out the necessity of proper handling and management of domestic animal wastes to prevent them from reaching the streams.

Present laws are adequate, but obtaining full and continuous compliance is a problem. Research activities include attempts to develop adequate waste treatment techniques that are also economical for use by the agricultural industry.

THERMAL POWER

Thermal power generation is essentially limited to production for peak loads at the present time. Existing steam-electric generating plants are located at load centers. Five such plants are in use intermittently in the basin with an aggregate nameplate capacity of 148,375 kilowatts; two are in Portland, and three are in the Eugene-Springfield area. The plants are relatively small, and no adverse effects of any magnitude have been identified with heat discharged from them.

MINERAL INDUSTRIES

Gravel removal and washing in, or immediately adjacent to, the streams are common practice and frequently cause serious stream pollution from turbidity and sedimentation. Mining (ore extraction) is very minor in the basin, and no problems have been associated with this segment of the mineral industry.

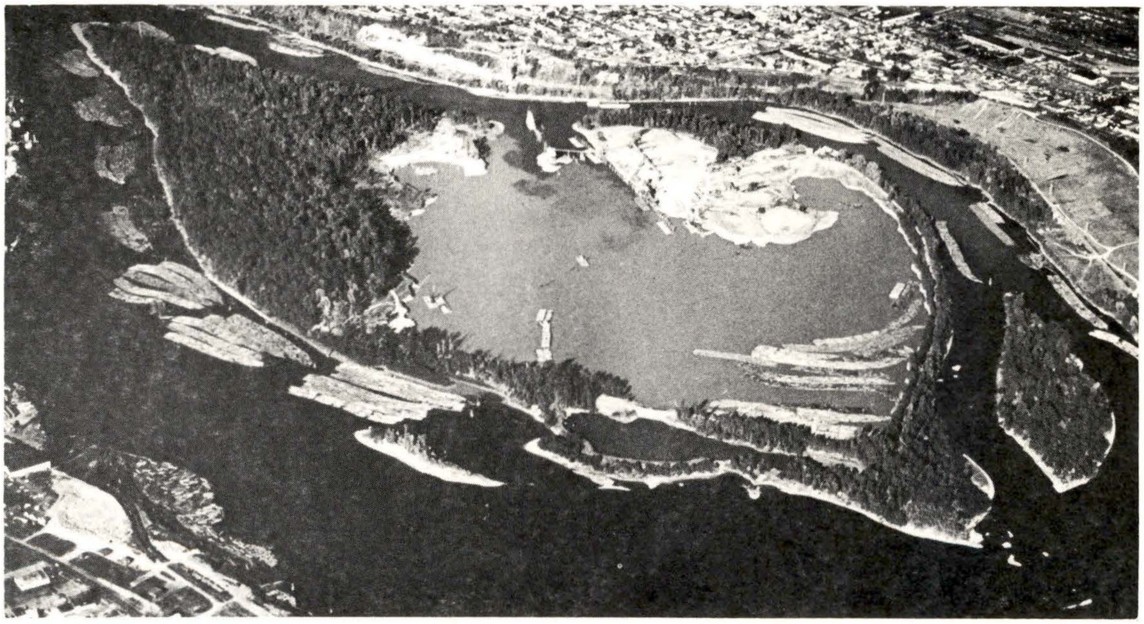


Photo II-4. Extensive dredging for sand and gravel has excavated the center of Ross Island, at the head of Portland Harbor.

The full effect of the sediment load discharged by the gravel industry cannot be identified, but municipal and industrial supplies, fish propagation, recreation, navigation, and general aesthetic values are adversely affected. Visual evidence of pollution from gravel-washing operations may be observed in the Willamette River between Eugene and the confluence of the Middle and Coast Forks. The Middle Fork is relatively clear as it joins the Coast Fork, but effluent from gravel pits and settling basins rapidly transforms the clear water to murky brown.

Present regulations need strengthening to control sediment pollution from this source and others as well. Dikes, berms, and settling basins are usually required at job sites, but these measures are not always fully effective. Breached dikes, improperly constructed dikes and ponds, and careless operation are common causes of excessive contributions of sediment.

RECREATION

The Willamette Basin has many water-based recreation areas. Developed and organized recreational installations have sanitary facilities designed to protect the public and the adjacent waters. Pit privies or central facilities, discharging to septic tanks and tile fields, are the most common means of waste disposal. Increased usage of a park area is frequently followed by construction of improved sanitary facilities.

Sanitary waste facilities are usually deficient at improvised recreation sites (such as many small boat landings and water-skiing areas) and in pleasure craft and houseboats. The load, organic and bacterial, from these sources has not been identified numerically, but its importance has been recognized.

Regulations governing installations of sanitary facilities are generally adequate, but are difficult to enforce because of the many improvised recreation sites. Research activities are oriented toward improvement of disposal facilities for small recreation areas, pleasure craft, and houseboats.

LAND USE EFFECTS

Land use practices can substantially alter the physical environment of a river basin and affect water quality. Changes in the following water quality parameters may result from land use practices in the Willamette Basin: sediment, minerals, nutrients, toxicants, temperature, bacteria, and organic matter. Discussion of these changes is limited to their causes and importance to water quality.

Sediment

In the Willamette Basin, the production and transport of sediment constitute the most significant impairment to water quality resulting from land use. High concentrations of sediment generally occur during periods of high precipitation or snowmelt and are carried in flood flows. Sediment is damaging both while suspended and after settling. It must be removed prior to use of the water for either municipal or industrial supplies. The transparent characteristic of water is destroyed by sediment loads, making diving and other water-contact recreation hazardous, as well as obscuring underwater objects from sight of boaters. Rewards of fishing in turbid waters are frequently very slight. Settled sediment suffocates aquatic flora and fauna while lying ready for further transport by the next freshet. Ultimate deposition frequently impairs navigation by filling channels; dredging is then required. Maximum sediment concentrations measured in several Willamette Basin streams, as of 1959, are listed in the following tabulation:

Location	Concentration (ppm)
Coast Fork Willamette River near London (above dam)	400
Coast Fork Willamette River below Cottage Grove Dam	260
Row River near Star (above dam)	330
Row River below Dorena Dam	130
Willamette River at Springfield	350
McKenzie River	240
Marys River	500
Calapooia River	340
Santiam River	503
Luckiamute River	410
Willamette River at Salem	400
South Yamhill River	800
Tualatin River	390

Annual average sediment production in the Willamette River, as measured in Portland Harbor, is 2.3 million tons. The sediment discharge of the Willamette River at Portland during the flood period from December 21 to 31, 1964, was 6,400,000 tons--almost three times the sediment transport for the average water year.

Photo II-5. Bank erosion damage from the flood of 1964 and subsequent rains, on the main stem of the Willamette River. (USDA, Soil Conservation Service, Portland, Oregon, Photo)

The lands most subject to erosion are forest lands on relatively steep slopes which are exposed to large amounts of rainfall and snowmelt. These lands comprise two-thirds of the basin. Some of the soils are highly susceptible to erosion, making it imperative that proper management practices be followed when making changes in the forest environment.

The major single source of sediment is bank-cutting caused by flood flows. Neither land management practices nor present flood control techniques and channel protection projects have controlled this type of erosion.

Stripping of vegetative cover and massive disturbance of soil in construction activities for urban-suburban structures and highways contribute large quantities of sediment during runoff periods. Construction activities produce 25,000 to 50,000 tons of sediment annually per square mile, as compared with 20 to 500 tons per year normally contributed from forest or crop lands, as reported in studies in Maryland and Virginia. 1/

Minerals

High rainfall and runoff in the Willamette Basin have historically dissolved and removed soluble minerals so that most streams have concentrations of less than 50 mg/l dissolved solids (the USPHS drinking water standard is 500 mg/l). Any accumulations of dissolved solids that might result from evapotranspiration in forests or irrigated and other agricultural lands are removed seasonally during the winter rains when runoff is greatest and the concentration of dissolved solids in the streams is the least. High mineral content of water restricts its use; present levels in the basin are virtually non-restrictive.

A number of the basin's waters have pH values below 7.0, a condition which brings more iron and silica into solution, especially in some ground waters. Consequently, the ground-water mineral content of some aquifers is less suitable than that of surface water for municipal and industrial use.

Nutrients

The chemical constituents termed "nutrients" stimulate aquatic growths. Slimes, algal forms, and other growths create unsightly nuisance conditions and obnoxious taste and odor problems. The exact nature of the nutrient balance which will produce algal blooms is not known; however, nitrogen and phosphorus appear to be significant factors in stimulating excessive growths.

1/ Interstate Commission of the Potomac River Basin. "A Program for Sediment Control in the Washington Metropolitan Region." Technical Bulletin 1963-1.

The total annual nitrogen yielded to the Willamette River, measured at Portland Harbor, is about 130,000 tons measured as nitrates. Of this total, it is estimated that 11 percent is contributed by people, 12 percent by agriculture, 5 percent by cattle, 5 percent by rain, and 67 percent by unknown sources.

Phosphate is of equal or greater significance, even though the quantity contributed is smaller, because much lower concentrations are required for algal growth. About 2,500 tons of phosphate annually reach watercourses of the basin. Two-thirds of that amount is contributed from fertilizers, and about one-third emanates from human wastes. The quantities of phosphorus and nitrogen reaching the basin's streams from forest and agricultural lands or other sources are quite small, except during periods of winter runoff. Problems have not arisen during these periods because water temperature is not amenable to optimum algal or aquatic growth.

Toxicants

Most of the substances that are toxic to the aquatic habitat are man-made or -caused. These include organic and inorganic pesticides, certain minerals, and petroleum products washed into streams from highways or industrial areas. None of these toxicants resulting from land use is considered to be a major problem in the Willamette Basin.

Pesticides are used extensively on agricultural and forest land in the Willamette Basin, with 1,600 tons of herbicides, 8,000 tons of fungicides, and 3,300 tons of insecticides applied annually. Careful use, combined with the ability of the soil to act as a filter, has generally prevented damaging concentrations from reaching the waterways. A hazard is present, however, when toxicants are handled by individuals without proper training. Therefore, regulation of the use of pesticides should be continued by control agencies.

Temperature

The present logging practice of clear-cutting small, scattered tracts causes temporary increases of one to eight degrees F in stream temperatures of local watersheds until sufficient vegetative cover is restored to provide ground shade. However, these increases have had little effect on temperatures of major streams in the basin, and no identifiable problems have resulted.

Bacteria

Animal feedlots located adjacent to streams or animal wastes flushed into Willamette streams not only contribute a high bacterial concentration to the streams but also exert a biochemical oxygen demand. This becomes particularly significant in times of low flow.

Organic Matter

Organic litter and debris are carried to the stream from areas in forest and farm land that have been recently disturbed. Some of this material floats and creates unsightly conditions while some settles and forms troublesome sludge beds. None of these have been identified as causing specific problems, but they contribute to water quality degradation and mechanically affect fish passage. The effects on water quality of log ponding and handling need further study and definition.

IMPOUNDMENTS AND STREAM REGULATION

When water as a free-flowing stream is impounded and a pool forms, its physical and chemical properties and biological populations are modified. Although these changes might result in improved water quality downstream, specific quality parameters within the reservoir are often adversely affected. These effects depend upon surface area, depth, and detention time. The changes in quality that occur during storage in a given environment are both beneficial and detrimental. Table II-5 shows the location and size of major reservoirs in the basin.

Table II-5

Major Storage Reservoirs, 1968

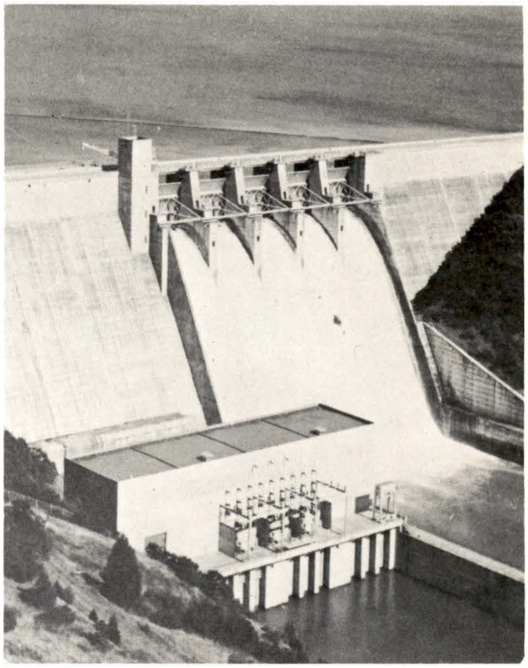
Reservoir	Stream	Drainage Area Sq. Mi.	Storage Acre-Feet Gross	Storage Acre-Feet Usable
Cottage Grove	Coast Fork Willamette R.	104	32,900	30,060
Dorena	Row River	265	77,500	70,500
Lookout Point	Middle Fork Willamette R.	991	456,000	349,400
Hills Creek	Middle Fork Willamette R.	389	356,000	249,000
Dexter	Middle Fork Willamette R.	996	28,000	4,800
Fall Creek	Fall Creek	184	125,000	115,000
Smith	Smith River	18	15,000	9,900
Cougar	South Fork McKenzie R.	208	219,300	165,100
Blue River	Blue River	88	89,000	85,000
Fern Ridge	Long Tom River	273	117,000	110,000
Detroit	North Santiam River	438	454,900	339,900
Green Peter	Middle Santiam River	277	430,000	333,000
Foster	South Santiam River	494	61,000	33,600
Big Cliff	North Santiam River	452	6,000	2,430
Timothy Meadows	Oak Grove Fork, Clackamas R.	54	65,700	61,650
North Fork	Clackamas River	665	19,200	6,000
Lake Ben Morrow	Bull Run River	74	30,700	30,100
Bull Run, Res. No. 2	Bull Run River	102	21,000	21,000

Beneficial Effects

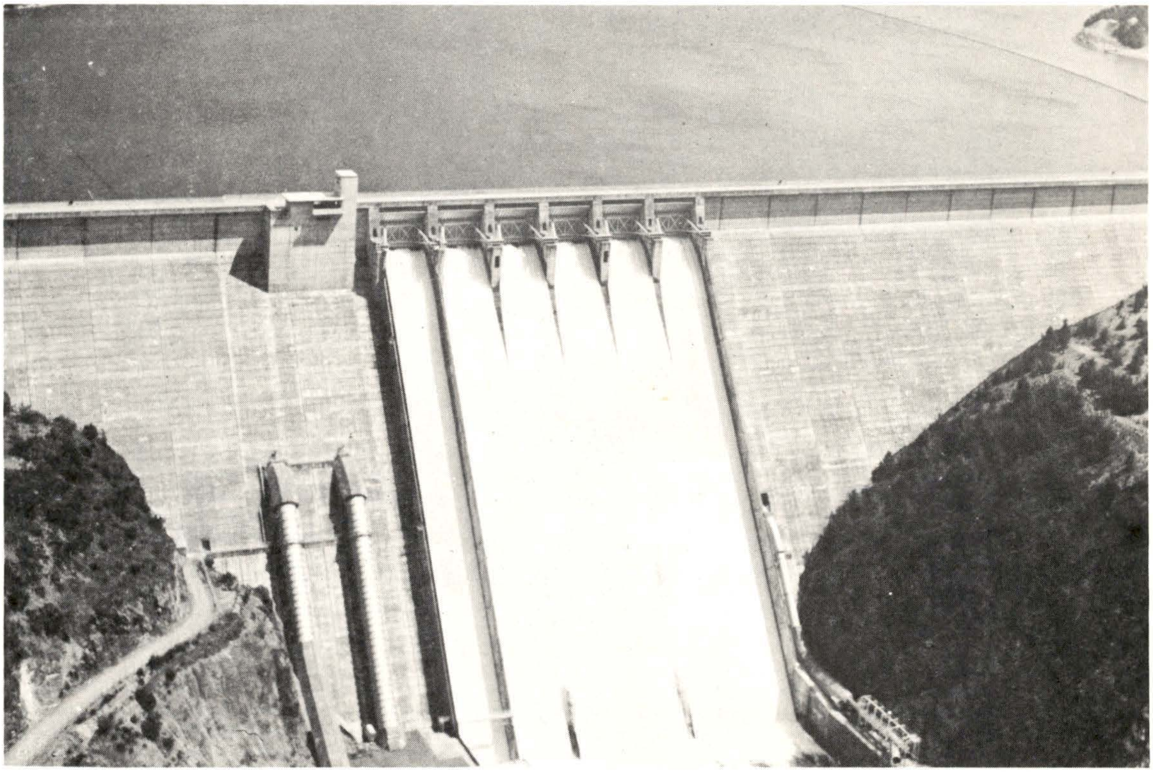
The greatly reduced velocity of flow through a reservoir section of a stream has a direct effect on water quality below the impoundment. Suspended solids and organic material transported from drainage areas above the dam usually settle out in the reservoir, effecting a reduction of oxygen-consuming material and turbidity in the water discharged from the structure. Bacterial quality is also improved because increased time-of-travel permits a natural "die-away" of bacteria within the reservoir. A reduction of 90 percent in coliform concentrations may be obtained even in small reservoirs, and up to 98 percent reduction has been observed in reservoirs providing long periods of retention.

Behind the high dams, such as Lookout Point, Hills Creek, Detroit, and others, cold, dense water layers are at the bottom of the pool, with the warmer, less dense water on top. Late summer releases of the water from the colder low levels decrease the downstream temperatures. This is normally beneficial to the fishery and usually desirable for municipal water supplies. Cool water also retards the growth of some aquatic slimes and other undesirable growths.

Hills Creek Dam



Lookout Point Dam



Detroit Dam

Photo II-6. Three major impoundments in the Willamette Basin are behind these dams, all of which have been involved in release of water for flow augmentation. (Corps of Engineers, Portland, Oregon, Photo)

Detrimental Effects

Conditions that benefit downstream water quality may also create adverse effects within the impoundment. Thermal stratification in deep reservoirs results in the isolation of surface and bottom layers and prevents reaeration of lower levels. Organic material and dead biological organisms are continually deposited on the bottom where they decompose and may completely deplete the oxygen resource. Significant deposits result in anaerobic decomposition, with generation of hydrogen sulfide, methane, and other toxic gases. Releases from low-level outlets during periods of thermal stratification, in the absence of reaeration, are therefore detrimental to downstream oxygen concentrations. However, because water can hold more oxygen at low temperatures, the reaeration potential is increased, especially in areas of turbulent flow below existing dams. Some research has been directed towards establishing satisfactory means of reaeration of penstock and turbine flow.

Stimulation of algal growth is another adverse effect of impoundments. Warm surface temperatures and increased depth of light penetration through the clear waters of reservoirs contribute to prolific algal growth, particularly in the presence of abundant quantities of nutrients such as nitrogen and phosphorus. These biological organisms create nuisance conditions, such as objectionable taste, odor, and color, and may affect the dissolved oxygen concentrations through their photosynthetic and respiratory activity and decomposition. An overabundant nutrient supply will eventually lead to a long-term stimulation of the algal population of the reservoir and result in premature "aging" of the lake. Algal productivity may also be accelerated during the early life of reservoirs by the nutrients and organics leached from the freshly exposed soil horizons within the new impoundments.

The design of outlet structures also limits reservoir effectiveness in controlling water quality. Single-level outlets limit withdrawals to one depth and to the quality characteristics existing at that depth, whereas multiple-level outlets could provide the necessary flexibility to control the quality of releases.

Present Effects

Adverse effects of impoundments on water quality in the Willamette Basin are not considered to be a major problem today, nor are the potential benefits to water quality fully realized. Willamette dams are relatively new, and changes in reservoir water quality that may be occurring are still slight enough that they are difficult to detect. However, fisheries agencies have complained that some reservoirs in the Coast Fork Subbasin have seasonally released warm water downstream, lowering the quality for fish use. Extremely low-temperature water releases have been reported in the McKenzie Subbasin. Turbidity problems, including those produced by algae, have been reported in Middle Fork Subbasin reservoirs. Because there are presently no major waste sources entering the streams above Willamette reservoirs, there have been few complaints of poor water quality in the reservoirs; in a few cases, high algal populations have caused taste and odor problems in downstream water supplies and in game fish.

The Federal Water Pollution Control Administration, in cooperation with the Army Corps of Engineers, has carried out a series of monthly water quality investigations in Detroit Reservoir since 1964. Temperature, dissolved oxygen, inorganic phosphate, nitrate, chlorophyll, and pH were measured. Preliminary results indicate that oxygen depressions, although slight (80 to 90 percent saturation), occur at deeper levels due to the demand exerted by decaying algae and other organic matter which have settled through the water column. Periodic surveys of other reservoirs in the basin have substantiated the premise that these conditions are typical.

E V A L U A T I O N   F A C T O R S

Characteristics of the basin's streams are of prime importance in considering the effects of man's activities on water quality. Stream discharge quantity, velocity, turbulence, and temperature are all significant in evaluating these effects. Climatic characteristics of the basin, although not controllable to any significant degree, also influence water quality. Existing physical and statutory regulations likewise have a major effect on conditions.

STREAM CHARACTERISTICS

The quantity of receiving water is of primary importance in considering the effects of discharged wastes. Flow in all streams of the basin fluctuates greatly on a seasonal basis. The flow pattern closely resembles the rainfall pattern and is nearly inverse to seasonal waste production. Design criteria for determining the need for, and value of, flow regulation for water quality control include a probable drought-recurrence interval of one year in ten. The variance of flow is shown in Figure II-2. As an example, the flow of the Willamette River at Portland ranges from 37,000 cubic feet per second (the annual average flow) to 7,200 cfs (the average August flow) to only 5,200 cfs for August, the critical month, during a critical (one-in-ten-year) drought.

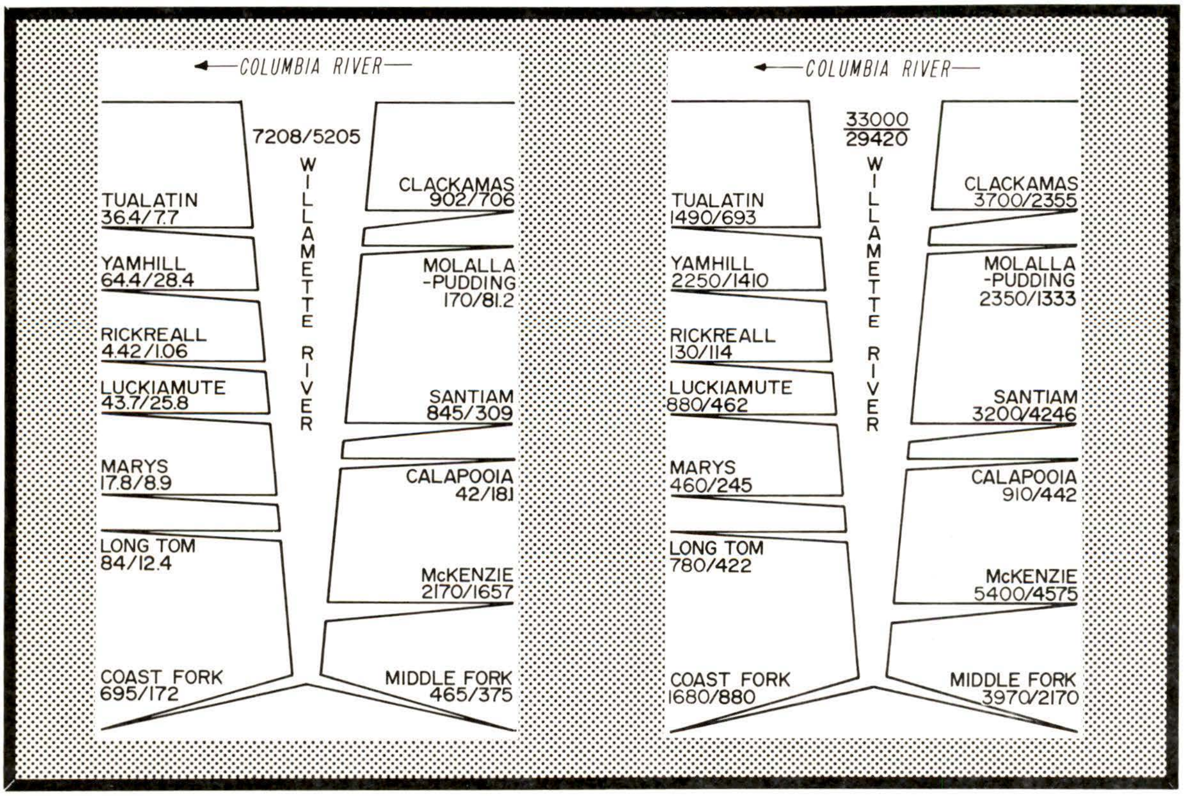


Figure II-2

Observed Average and Minimum August Flows in cfs *Annual Average and Critical Year Flows in cfs*

Regulation of flow by impoundments has a major effect on the Coast and Middle Forks of the Willamette River and on the North Santiam, Clackamas, and Willamette Rivers. Present regulation is principally for the purposes of flood control, power generation, and navigation. Low summer streamflows are depleted by diversions for consumptive uses.

During the period from 1961 to 1966, the Oregon State Water Resources Board established minimum perennial streamflows at 96 points in the Willamette Basin. These are flows below which water may not be appropriated except for domestic or livestock use or by holders of water rights established prior to the date of the Board's order. These flows established as legal minimums are not always satisfied by natural conditions. At some locations minimum flows involve only natural streamflows, while at others they involve both natural streamflows and water released from storage. Seasonal minimum perennial flows established in the lower basin have as many as four flow values at some points at different times of the year. Table II-6 lists some of these points and the minimum flows set at each. A complete listing is contained in Appendix B--Hydrology. Further reference could be made to the Oregon State Water Resources Board programs for the Upper, Middle, and Lower Willamette Basins (equivalent to the Upper, Middle, and Lower Subareas) for exact locations of the flow points and the values set at these points.

Photo II-7. Summertime low flow at Willamette Falls. Most of the river is being diverted through two power turbines.

Table II-6

Minimum Flows, Willamette Basin

Stream Point	Natural Flow cfs	Storage Release cfs
Coast Fork Willamette River, above Row River	15	100
Row River, at mouth	40	150
Coast Fork Willamette River, at mouth	40	250
North Fork of Middle Fork Willamette R., at mouth	115	
Fall Creek, at mouth	40	470
Middle Fork Willamette River, at mouth	640	1,475
McKenzie River, at gage #14-1625 near Vida	1,400	580
Mohawk River, at mouth	20	
McKenzie River, at Int. #5 Hwy. bridge	1,025	700
Long Tom River, at gage #14-1700 at Monroe		370
Calapooia River, at gage #14-1720 at Holley	30	340
Calapooia River, at gage #14-1735 at Albany	20	340
South Santiam River, at gage #14-1850 below Cascadia	50	
Middle Santiam River, at gage #14-1865 near Foster	110	260
Wiley Creek, at mouth	10	
South Santiam River, at gage #14-1875 at Waterloo	170	930
North Santiam River, at gage #14-1780 near Detroit	345	
North Santiam River, at gage #14-1815 at Niagara	500	640
North Santiam River, at gage #14-1841 near Jefferson	430	640
Santiam River, at gage #14-1890 at Jefferson	330	1,570
Santiam River, at mouth	320	1,570
Marys River, at gage #14-1710 near Philomath	10	
Marys River, at mouth	5	
Luckiamute River, at gage #14-1905 near Suver	25	
Luckiamute River, at mouth	20	
Rickreall Creek, at gage #14-1907 near Dallas	5	
South Yamhill River, at gage #14-1925 near Willamina	20	
Willamina Creek, at gage #14-1930 near Willamina	20	
South Yamhill River, at gage #14-1940 near Whiteson	15	
North Yamhill River, at gage #14-1970 at Pike	10	
Yamhill River, at gage (site) #14-1975 at Lafayette	15	
Pudding River, at gage #14-2010 near Mt. Angel	10	
Pudding River, at gage #14-2020 at Aurora	35	
Molalla River, at gage #14-1985 near Wilhoit	35	
Molalla River, at gage #14-2000 near Canby	60	
Willamette River, at gage #14-1740 at Albany	1,750	3,140
Willamette River, at gage #14-1910 at Salem	1,300	4,700
Willamette River, at gage #14-1980 at Wilsonville	1,500	4,700
Tualatin River, at mile 70	10-65-20	
Seine Creek, at mouth	2-25-8	
Tualatin River, at gage #14-2035 near Dilley	15	
Gales Creek, at mouth	12-100-35	
Gales Creek, at mile 12	8-70	
Beaver Creek, at mouth	1-17-3	
East Fork Dairy Creek, at mile 13	12-50-25	
Tualatin River, at gage #14-2075 at West Linn	15-30-20	
Clackamas River, at gage #14-2080 at Big Bottom	150-240	
Collawash River, at mouth	75-250-200	
Oak Grove Fork Clackamas River, at mouth	10	
Clackamas River, at gage #14-2095 above Three Lynx	400	
North Scappoose Creek, at mouth	5-40-20	

Stream gradients influence water quality because they affect reaeration rates, time-of-travel, and bottom deposits. In the upland areas, the streams cascade through gorges and over rocks, providing a high reaeration rate and a short time of passage. In these reaches, all but the heaviest solids are carried in suspension by the stream. In the lower reaches, flatter gradients result in low reaeration rates and an extended travel time. Low velocities allow almost all settleable solids to fall out to form bottom deposits. Gradients of the Willamette River range from an average of four feet per mile between Eugene and Corvallis to 1.7 feet per mile between Corvallis and Newberg, to a barely perceptible drop through Portland Harbor. The east-side streams generally have steeper gradients than the west-side streams; the average gradient of the Santiam River is 22 feet per mile, and gradients of the west-side streams on the valley floor are one to three feet per mile.

Time-of-travel is a function of stream gradients and quantity of flow. Long travel times, indicative of flat gradients, result in adverse quality conditions because of prolonged retention of wastes in sluggish pools which provide little reaeration. Bacterial densities usually decrease through these reaches because of natural die-off, a time function. The dissolved oxygen level is depressed as waste stays in the same area through its periods of greatest oxygen demand, and benthic deposits deplete the oxygen from bottom layers of water. Algal activity is accelerated by increased solar exposure, and growth may be profuse in slow-moving pools. Typical times-of-travel are shown in Figure II-3.

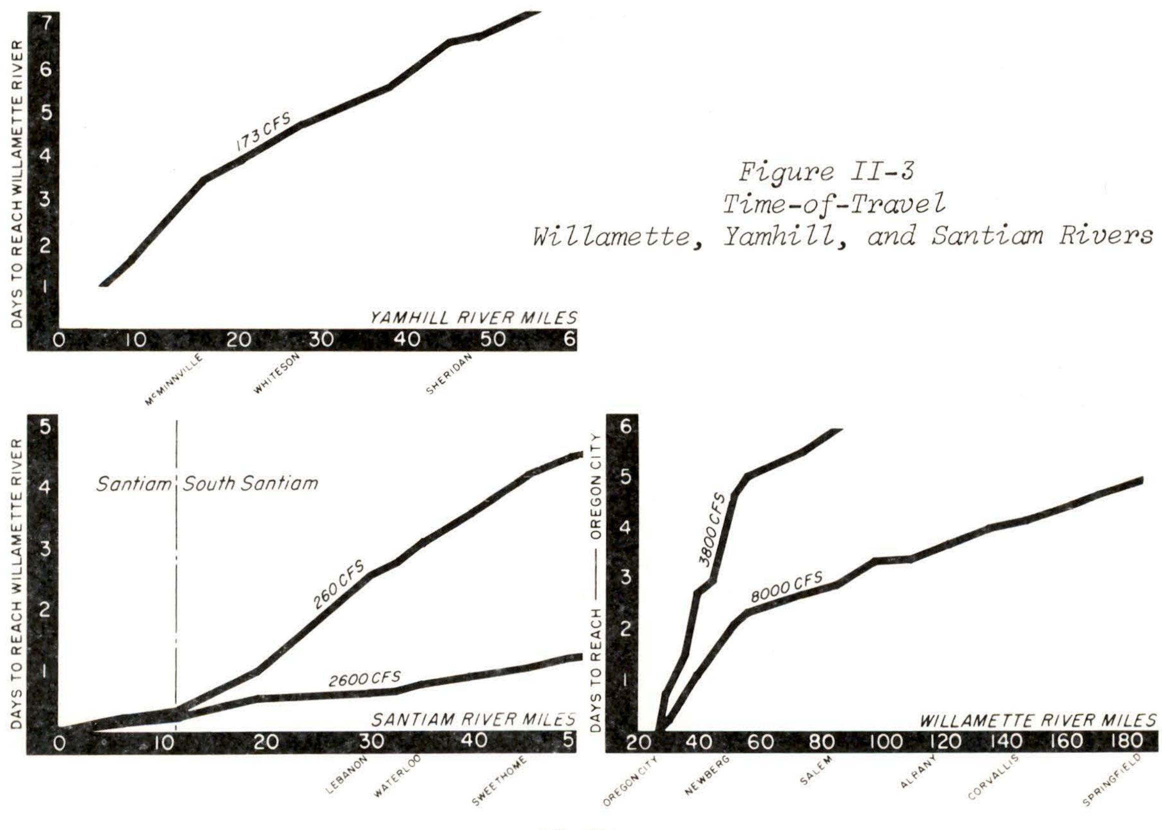


Figure II-3
Time-of-Travel
Willamette, Yamhill, and Santiam Rivers

CLIMATIC CONSIDERATIONS

The monthly distribution of rainfall influences water quality through its effect on runoff, streamflow, and water use. Figure II-4 illustrates the average monthly precipitation recorded at Salem and is representative of the pattern of monthly distribution of precipitation throughout the basin; the similarity of streamflow distribution is also shown. A detailed discussion of the basin's climate and runoff is presented in Appendix B--Hydrology.

Average annual precipitation is not uniform throughout the basin because of the varied topography and direction of the moisture-bearing winds. Relatively high annual precipitation occurs on the Coast Range (with values reaching more than 200 inches)--mostly as rain, except at the higher elevations. Similar precipitation intensities occur on the higher slopes of the Cascades--primarily as snow. Bottom lands lie in the rain shadow of the Coast Range and Calapooya Mountains and receive average annual precipitation ranging between 40 and 50 inches, occurring almost entirely as rain in the winter months.

Due to the control they exercise over water temperature in streams and reservoirs, thermal influences in the environment have a significant effect upon water quality. Temperature influences biological-biochemical processes, and the ability of the water body to absorb oxygen.

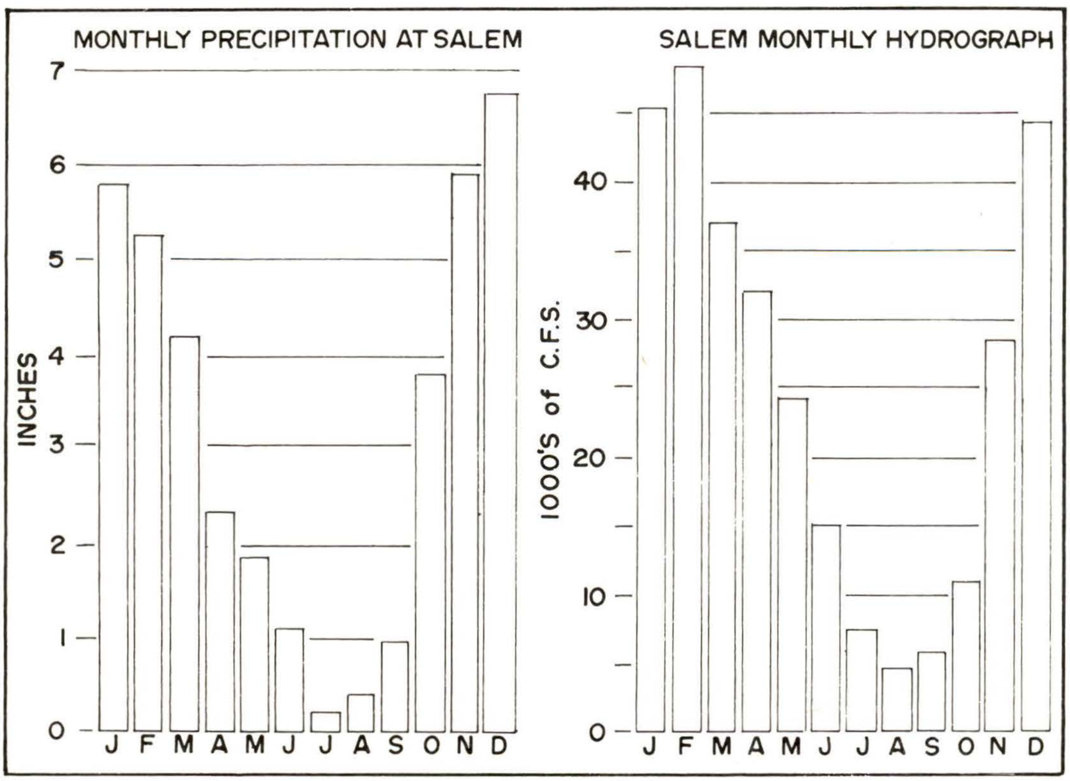


Figure II-4. Precipitation and Runoff at Salem, Oregon.

The principal meteorologic factors contributing heat to natural bodies of water are short-wave solar radiation and long-wave atmospheric radiation. In the Willamette Basin, clear-sky solar radiation varies from about 500 BTU/sq.ft./day in January to about 2,800 BTU/sq.ft./day in July. Solar radiation reaching the earth's surface is reduced by sky cover. Long-wave atmospheric radiation is a function primarily of air temperature and humidity, and varies from 2,400 to 3,200 BTU/sq.ft./day. A body of water loses heat to the environment largely through long-wave radiation and evaporation. Radiation emitted by the water is dependent upon the temperature of the water and generally ranges from 2,400 to 3,600 BTU/sq.ft./day.

Evaporation is a function of water temperature, as well as wind speed and humidity. As water is vaporized, heat is consumed at the rate of about 1,000 BTU per pound of water evaporated. Evaporation from lakes and reservoirs in the basin can reach values of 0.5 inch/day during summer with a corresponding heat loss of 2,500 BTU/sq.ft./day.

W A T E R Q U A L I T Y A N D P O L L U T I O N

The present quality of surface water in the Willamette Basin is generally good. However, in most cases, the governing quality factor is the worst condition, not the average. Water quality data from the Oregon State Sanitary Authority (OSSA), the U. S. Geological Survey, and the Federal Water Pollution Control Administration show acceptable average quality levels at all sampling stations, with the exception of bacterial concentrations below areas of dense population. These data also show that the quality is degraded at times during the year.

Photo II-8. It begins here: The upland country around seven-eighths of the Willamette Basin's periphery is the source of the region's surface waters.

Table II-7 shows the general water quality situation in the basin for the critical month of August, both for the period of record and for the August 1965 survey by the OSSA. In most cases, the figures represent analytical results from "grab" samples taken on a schedule ranging from daily to monthly. More frequent sampling is desirable, but beyond the financial reach of the agencies concerned. Some of the extreme values shown, particularly the minimum oxygen concentrations, resulted from past conditions and are not representative of present conditions. Other parameters--conductivity, color, turbidity, residue, total alkalinity, total hardness, sulfate, ammonia, nitrate, phosphate, chloride, and iron--are determined at some stations periodically, but are not included in the table.

Table II-7

Sampling Stations and Data
Willamette Basin

	pH Std. Units	Temp. Degrees (C)	Dissolved Oxygen mg/1	Dissolved Oxygen Percent Sat.	BOD_5 20° (C) mg/1	SWL PBI mg/1	Coliform Count MPN/100 ml
COAST FORK WILLAMETTE ABOVE COTTAGE GROVE (RM 25.81), CODE 402051							
Minimum	6.6	13.0	7.9	84	0.1	1.0	10
Maximum	7.3	22.0	9.9	96	2.1	1.0	240
8-5-65	7.1	14.0	9.7	93	2.1	-	240
COAST FORK WILLAMETTE BELOW COTTAGE GROVE (RM 6.41), CODE 402047							
Minimum	6.8	15.0	8.1	86	0.5	1.0	43
Maximum	7.4	21.0	10.4	110	3.8	6.0	6,200
8-5-65	7.3	20.0	9.7	105	3.8	-	2,400
MIDDLE FORK WILLAMETTE AT JASPER BRIDGE (RM 8.01), CODE 402054							
Minimum	7.0	15.0	9.1	91	0.1	1.0	6
Maximum	7.4	20.0	10.5	108	1.6	1.0	6,200
8-5-65	7.3	17.0	10.5	108	0.9	-	23
McKENZIE RIVER AT HAYDEN BRIDGE (RM 14.81), CODE 402046							
Minimum	7.1	12.0	6.2	62	0.1	1.0	13
Maximum	7.5	18.0	10.7	110	2.4	5.0	700
8-17-65	7.2	15.0	9.5	93	-	5.0	700
McKENZIE RIVER AT COBURG ROAD BRIDGE (RM 7.31), CODE 402044							
Minimum	6.7	13.0	8.3	88	0.2	1.0	23
Maximum	7.5	19.0	11.0	112	2.7	9.0	2,300
8-17-65	7.1	16.0	8.8	88	0.3	5.0	620
LONG TOM RIVER NEAR MOUTH (RM 7.01), CODE 402042							
Minimum	6.9	16.0	5.7	67	0.6	1.0	22
Maximum	7.9	27.0	9.7	115	4.9	12.0	24,000
8-11-65	7.9	24.0	5.7	67	-	-	230
CALAPOOIA RIVER BRIDGE IN ALBANY (RM 3.01), CODE 402040							
Minimum	7.2	19.0	7.6	84	0.3	1.0	230
Maximum	7.4	25.0	8.9	95	1.0	117.0	2,400
8-17-65	7.3	25.0	7.6	90	0.4	9.0	600
SOUTH SANTIAM RIVER AT GRANT STREET BRIDGE, LEBANON (RM 18.31), CODE 402037							
Minimum	6.8	16.0	6.7	76	0.4	1.0	13
Maximum	7.4	26.0	9.4	111	1.5	7.0	2,400
8-17-65	7.3	24.0	7.3	87	-	7.0	46
SOUTH SANTIAM RIVER AT FITZWATER FARM (RM 13.81), CODE 402036							
Minimum	6.0	17.0	0.3	1	0.0	85.0	47
Maximum	7.0	26.0	7.7	79	33.0	772.0	70,000
8-17-65	6.7	25.0	3.0	36	2.3	253.0	70,000
SANTIAM RIVER AT I-5, TWIN BRIDGES (RM 6.41), CODE 402033							
Minimum	6.9	15.0	7.9	86	0.1	1.0	49
Maximum	7.4	22.5	10.3	112	2.7	49.0	70,000
8-17-65	7.2	21.0	10.1	112	0.8	20.0	7,000
MARYS RIVER AT CORVALLIS (RM 0.21), CODE 402041							
8-17-65	7.3	23.0	8.1	93	2.1	-	2,300
RICKREALL CREEK AT HIGHWAY 51 (RM 2.21), CODE 402032							
8-17-65	7.1	19.0	6.1	65	2.3	-	7,000
YAMHILL RIVER AT DAYTON (RM 4.91), CODE 402031							
8-17-65	7.1	22.0	6.5	74	4.0	-	7,000
PUDDING RIVER NEAR CANBY (RM 4.31), CODE 402030							
8-17-65	7.7	24.0	13.6	160	5.2	-	60
MOLALLA RIVER NEAR CANBY (RM 3.61), CODE 402029							
8-17-65	7.5	24.0	9.4	111	0.6	0	2,400
WILLAMETTE RIVER AT SPRINGFIELD, HIGHWAY 28 BRIDGE (RM 185.31), CODE 402027							
Minimum	6.6	14.0	5.9	62	0.1	1.0	7
Maximum	7.4	20.0	11.6	122	3.9	5.0	6,000
8-17-65	7.1	16.0	9.7	97	0.2	5.0	230
WILLAMETTE RIVER AT BELTLINE BRIDGE (RM 178.21), CODE 402025							
Minimum	6.9	15.0	6.4	68	0.5	1.0	34
Maximum	7.1	23.0	10.3	113	21.9	16.0	70,000
8-17-65	7.0	18.0	8.4	88	1.2	5.0	4,500
WILLAMETTE RIVER AT HARRISBURG 99-E BRIDGE (RM 161.21), CODE 402023							
Minimum	7.1	?	5.1	54	0.2	1.0	25
Maximum	7.3	22.0	10.1	112	1.4	4.0	70,000
8-17-65	7.1	19.0	8.7	93	1.0	4.0	70,000
WILLAMETTE RIVER AT CITY WATER INTAKE (RM 134.11), CODE 402021							
Minimum	7.2	16.0	7.6	81	0.4	1.0	11
Maximum	7.5	23.0	9.9	112	1.7	3.0	13,000
8-17-65	7.2	20.0	8.3	90	0.4	3.0	2,300
WILLAMETTE RIVER AT BUENA VISTA FERRY (BELOW ALBANY) (RM 106.41), CODE 402016							
Minimum	7.1	17.0	3.7	41	0.8	1.0	36
Maximum	7.9	24.0	10.0	115	2.9	7.0	13,000
8-17-65	7.2	20.5	8.2	90	1.2	5.0	6,200
WILLAMETTE RIVER AT WHEATLAND FERRY (BELOW SALEM) (RM 71.91), CODE 402012							
Minimum	6.7	17.0	6.5	73	0.4	1.0	9
Maximum	7.3	25.0	9.0	105	5.0	68.0	70,000
8-17-65	7.1	20.5	7.7	85	1.2	18.0	2,300
WILLAMETTE RIVER AT CANBY FERRY (NEAR CANBY) (RM 34.41), CODE 402007							
Minimum	6.5	18.0	3.8	42	0.6	1.0	30
Maximum	7.1	24.5	7.9	91	2.3	125.0	70,000
8-17-65	6.8	20.0	6.4	70	0.6	28.0	1,200
WILLAMETTE RIVER AT MARINA MART (ABOVE FALLS)(RM 27.81), CODE 402006							
Minimum	6.5	18.0	3.1	36	0.7	1.0	38
Maximum	7.1	25.0	7.6	85	2.4	98.0	7,000
8-17-65	6.9	20.5	6.4	70	0.8	30.0	600
WILLAMETTE RIVER AT SPORTSCRAFT LANDING (BELOW FALLS) (RM 25.61), CODE 402005							
Minimum	6.4	18.0	3.0	34	1.3	1.0	29
Maximum	7.0	25.0	7.1	76	8.7	218.0	70,000
8-17-65	6.8	20.5	6.1	67	3.0	63.0	70,000
WILLAMETTE RIVER AT STEEL BRIDGE (PORTLAND) (RM 12.11), CODE 402001							
Minimum	6.2	18.0	0.4	1	0.6	2.0	37
Maximum	6.9	26.0	5.4	57	4.8	246.0	70,000
8-17-65	6.5	21.0	3.1	34	1.1	102.0	6,200
WILLAMETTE RIVER AT SP&S RR BRIDGE (PORTLAND) (RM 7.01), CODE 402000							
Minimum	6.3	18.0	0.7	1	0.4	30.0	46
Maximum	6.9	25.0	4.8	53	8.0	167.0	24,000
8-17-65	6.6	20.0	3.2	35	0.9	68.0	2,300

1/ pH: Hydrogen ion concentration. The weight of hydrogen ions in grams per liter of solution. Commonly expressed as the pH value that represents the logarithm of the reciprocal of the hydrogen ion concentration.

DO: Dissolved oxygen. The oxygen dissolved in water, usually expressed in milligrams per liter or percent of saturation.

mg/1: Milligrams per liter.

BOD_5: Five-day biochemical oxygen demand. The quantity of oxygen utilized in the biochemical oxidation of organic matter in five days at 20° (C). It is not related to the oxygen requirements in chemical combustion, but is determined entirely by the availability of the material as a biological food and by the amount of oxygen utilized by the microorganisms during oxidation.

SWL: An abbreviation for sulfite waste liquor, a by-product of sulfite-type paper mills. It is characterized by: (1) high BOD, (2) toxicity, and (3) color. Much of SWL is composed of highly oxidizable organic constituents which produce a high BOD_5. However, toxic substances in SWL called lignins produce a blue color when dissolved in water. Thus, a water sample known to contain lignins can be tested spectrophotometrically to obtain the lignin concentration by comparing the results with that of a standard prepared sample of which the lignin concentration is known.

PBI: Pearl Benson Index. Used to measure SWL concentrations. Briefly, the Pearl-Benson test measures, spectrophotometrically, the relative concentrations of the lignin sulfonates of SWL, referenced against a standard, calcium-base, 10% solids SWL solution. SWL values are concentrations in parts per million (ppm) by volume of a solution containing 10% dry liquor solids by weight.

Coliform bacteria: A species of genus escherichia bacteria, normal inhabitant of the intestine of man and all vertebrates.

MPN: Most probable number. In the testing of bacterial density by the dilution method, that number of organisms per unit volume which, in accordance with statistical theory, would be more likely than any other possible number to yield the observed test result or which would yield the observed test result with the greatest frequency. Expressed as density of organisms per 100 ml.

Photo II-9. Heavy waste loadings in the Willamette main stem, especially during low flows, create a biochemical oxygen demand that causes long reaches of the river to become oxygen depleted.

Dissolved oxygen (DO) is the most frequently used quality parameter and is indicative of general conditions within a body of water. Low dissolved-oxygen content indicates that the organic and chemical matter is present in sufficient quantity to exert a greater demand for oxygen than can be replaced by the natural reoxygenation capability of the water body. Concentrations of dissolved oxygen greater than 100 percent of saturation indicate either recent violent physical reoxygenation or photosynthetic oxygen production by algae. The latter may cause great diurnal fluctuation of dissolved oxygen concentration with an upper extreme of more than 130 percent of saturation. A dissolved oxygen concentration near saturation with very little diurnal fluctuation is most desirable.

Figure II-5 shows generalized dissolved oxygen profiles of the Willamette River during summer periods of 1929, 1944, and 1963. Figure II-6 shows the dissolved oxygen and temperature in Portland Harbor for the periods May through September, 1967 and 1968. Also shown are the flows at Salem for the same periods. Low dissolved oxygen, low flow, and high temperature all occur at the same time. These values represent daily averages measured by a continuous monitor operated by the Federal Water Pollution Control Administration at Swan Island. During winter months, the pulp mills discharge all wastes, and additional organic matter is discharged from storm sewers and bypasses from overloaded sanitary sewage treatment plants; however, dilution is adequate to prevent oxygen depletion.

Biochemical oxygen demand (BOD) is a measure of the oxygen-demanding properties of the organic waste in the water. The BOD does not necessarily deplete the dissolved oxygen in a river if the rate of natural reaeration is high but, if the stream pools, the reaeration rate decreases, the BOD is exerted, and the dissolved oxygen level diminishes. Water quality objectives in terms of BOD have not been established because of the variable effects under different stream conditions.

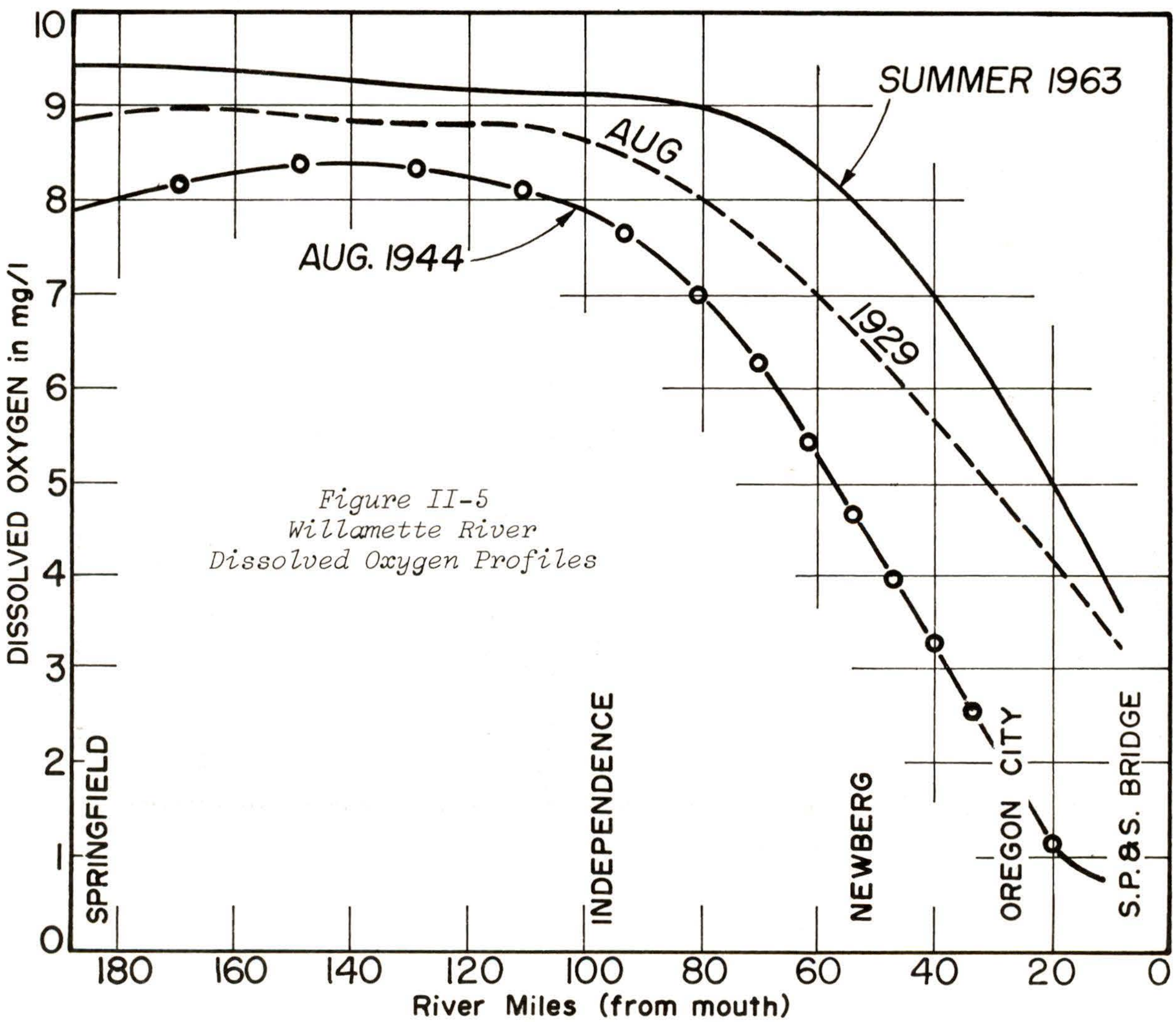


Figure II-5
Willamette River
Dissolved Oxygen Profiles

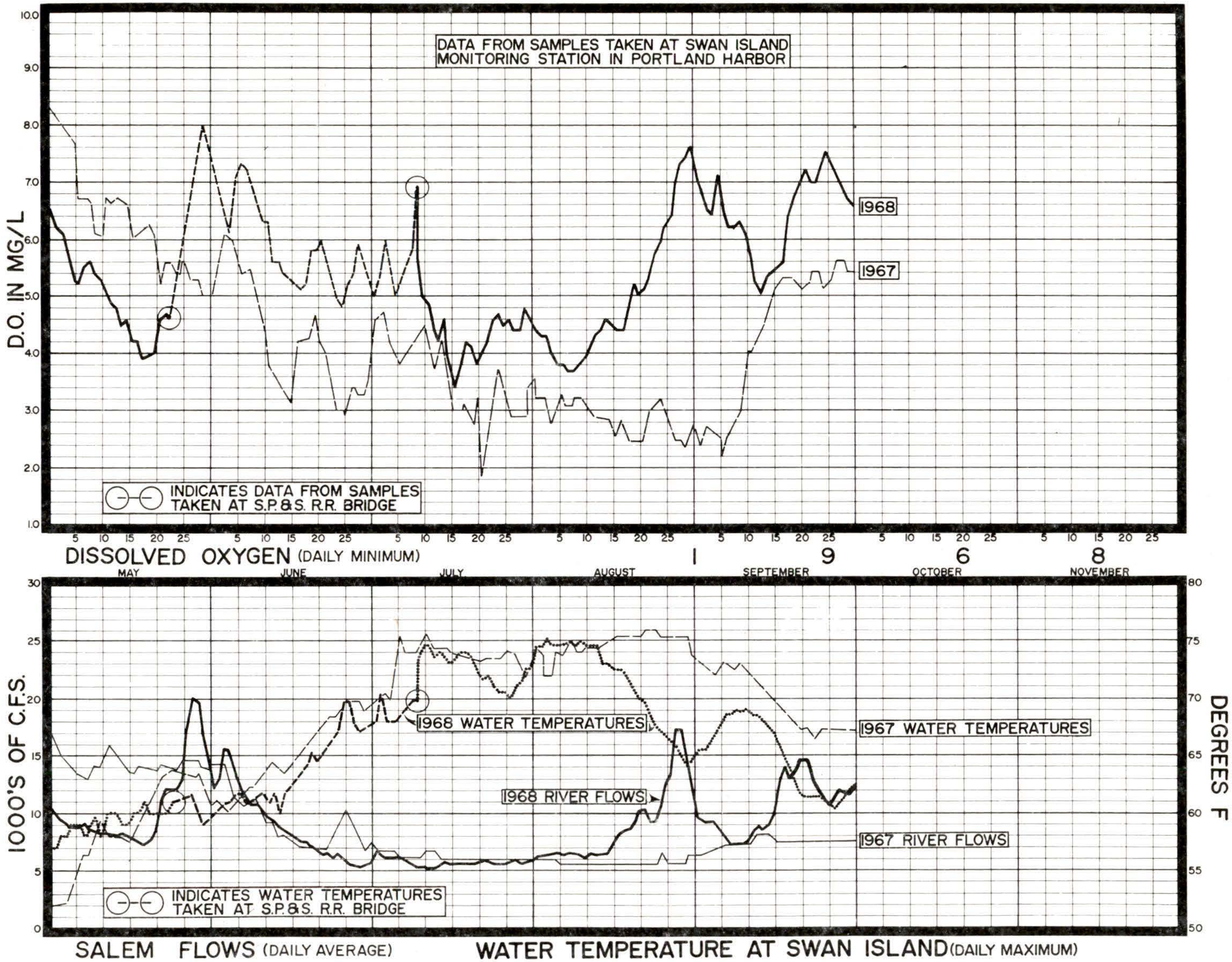


Figure II-6. Dissolved Oxygen and River Flows, 1967-1968.

Bacterial contamination of the basin's rivers, as measured by coliform density, has been general and widespread, with many areas having counts of over 5,000 organisms per 100 ml (Figure II-7). During recent years, bacterial quality has been improved as a result of the higher degree of waste treatment and improved effluent disinfection. Reductions have also resulted from restricting septic tank use to suitable areas and expanding sewerage collection systems in many communities. Maximum densities presented in Table II-7 show, however, that many areas still are subject to gross bacterial pollution.

Total dissolved solids are quite low throughout the basin. Discharge of wastes and pollutants has not materially degraded the mineral-free quality of the water.

Sediment loads are normally low, but are very high during periods of high streamflow. Sediment is a pollutant in that it adds an economic burden to users and results in damage to the aquatic environment.

Toxic elements and compounds are not normally found in the basin's rivers. Accidental spills and improper application of sprays and chemicals do, however, result in infrequent and localized pollution and fish kills. Runoff of oil from streets, parking lots, and garages has not given rise to critical problems. Oil spills in Portland Harbor have been detected and violators prosecuted under the provisions of the Oil Pollution Act.

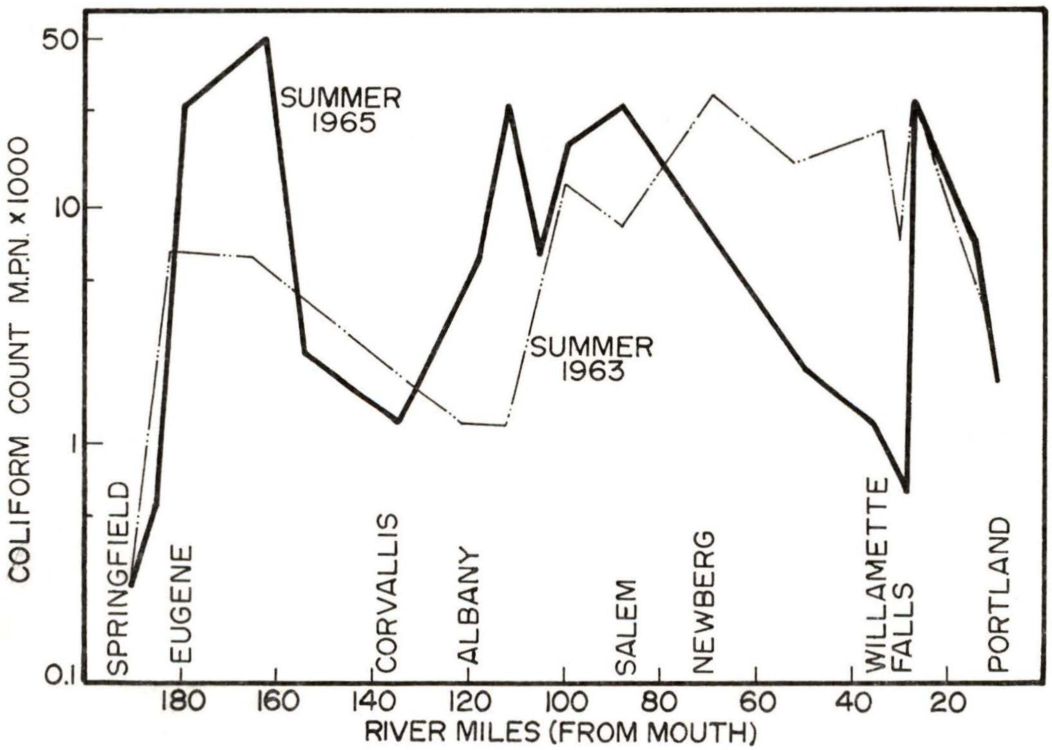


Figure II-7. Coliform Density Profiles, Willamette River.

W A T E R U S E S A N D Q U A L I T Y R E Q U I R E M E N T S A N D O B J E C T I V E S

The many uses served by waters of the Willamette Basin are possible only because high-quality water is available at many locations. Suitable water for all uses is obtainable in ample supply at most places; however, all uses cannot be served at all places at all times. The most important use--municipal or domestic water supply--has high quality requirements. The total daily use of municipal water is nearly 180 million gallons, with about 90 percent being used in the four major centers of population. Approximately 90 percent of the total is supplied from surface sources.

A general recommendation of long standing for municipal water supply sources is to use the best available source. Water Quality Objectives, published by the Pollution Control Council, Pacific Northwest Area, include the following criteria:

Coliform bacteria. If the supply is to be treated by chlorination only, raw water must average less than 50 organisms per 100 ml in any month. If the supply is to be given complete treatment, raw water must average less than 2,000 organisms per 100 ml over any consecutive 30 days, and not more than 20 percent of samples examined during this period should exceed 2,000 per 100 ml.

Dissolved oxygen. Greater than 75 percent saturation--simple chlorination. Greater than 60 percent saturation, but less than 75 percent--complete treatment.

pH. Between 6.5 and 8.5.

Turbidity. Less than five Jackson Turbidity Units (unless natural conditions exceed this level).

Temperature. Below 60 degrees F (15 degrees C).

Dissolved inorganic substances. Total dissolved solids under 500 mg/l.

Residues (oils, floating solids, sludge deposits). Below normally detectable amounts.

Sediment. Below normally measurable amounts in water diverted and used with chlorination only. In supplies with complete treatment, the load should not interfere with established levels of treatment.

Toxicants. Conform with U.S.P.H.S. Drinking Water Standards.

Color. True color less than 15 color units unless natural conditions exceed this value.

Radioactivity. Conform with U.S.P.H.S. Drinking Water Standards.

Industrial water supply is a major use with about 180 million gallons per day used for purposes ranging from cooling to food processing. The quality necessary for these uses varies. Water used in food processing and other special processes has higher quality requirements, in some respects, than the average municipal supply, while other uses require only that the water be wet. The most common request by industry is that raw water quality remain constant. Almost any adverse quality condition can be corrected, but water which is relatively free of minerals and solids and which has a pH of 7.0 to 8.0, with a temperature of less than 70 degrees F, is most desirable.

Water-based recreation such as bathing and swimming has high quality requirements. There are presently about 230 public water-based recreation sites in the basin. The most significant requirements are that the bacterial content be low so as to safeguard against disease transmission, and that the water be aesthetically pleasing. The Pollution Control Council, Pacific Northwest Area, in November 1966 specified that coliform bacteria should: "Average less than 1,000 per 100 ml with 20 percent of the samples not to exceed 2,400 per 100 ml. Clear water lakes and upper areas of streams should average less than 240 per 100 ml and not exceed this in more than 20 percent of samples."

Photo II-10. Sport fishermen enjoying an outing along the Willamette River.

The basin's rivers support an important fishery. The sports fishery accounts for approximately one million angler-days annually. Salmon and steelhead contribute to the commercial and sport fishery in the Columbia River and the Pacific Ocean. Quality requirements vary with types of fish and seasonal activity. Water quality objectives established by the Pollution Control Council for fisheries are as follows:

Bacteria. Same as that for recreational use to protect associated recreational values.

Dissolved oxygen. Range from 75 percent saturation at diurnal and seasonal lows to 100 percent saturation during spawning, hatching, and egg sac and swim-up fry stages, and when water temperatures exceed 68 degrees F for cold-water fish and 85 degrees F for warm-water fish.

Temperature. More critical than for other uses, with objectives of 65 and 85 degrees for cold-water and warm-water fishes, respectively, and 55 degrees during fall spawning.

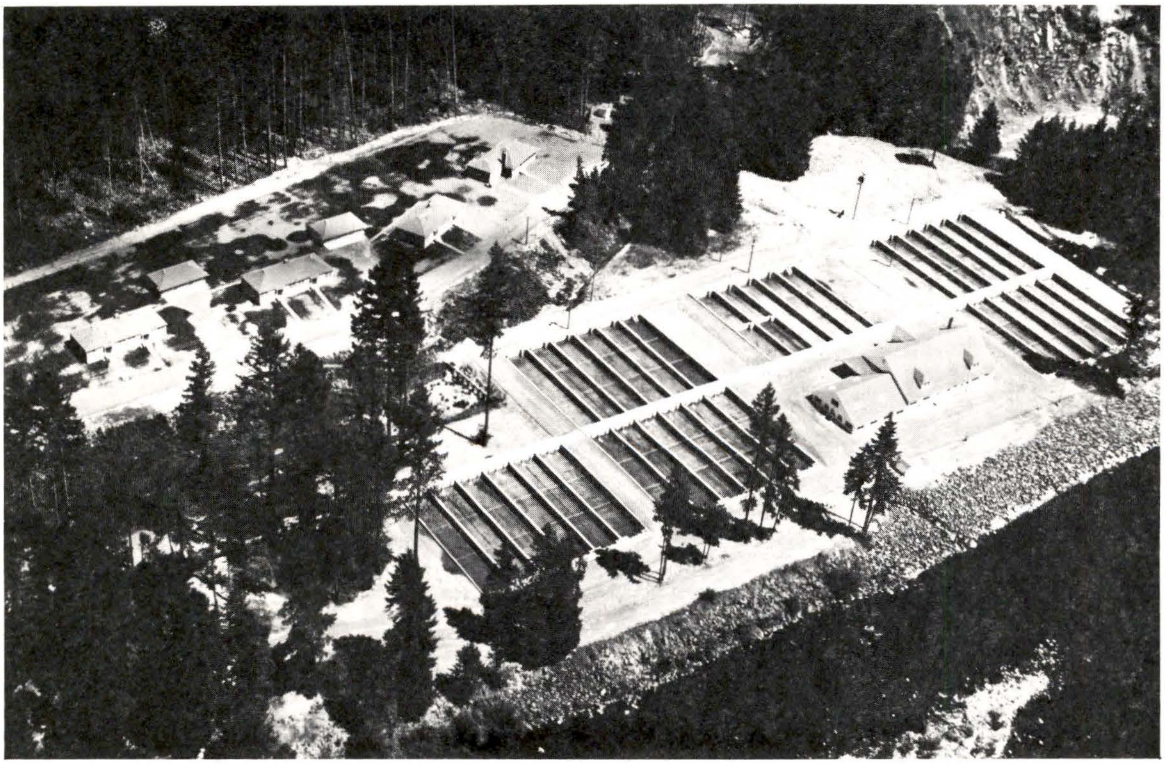


Photo II-11. The Leaburg Trout Hatchery on the McKenzie River requires water of high quality. (Corps of Engineers, Portland, Oregon, Photo)

Other uses of importance with certain quality requirements include those related to agriculture. Water for stock, irrigation of crops for human consumption, and general farm use should meet the bacterial objective set for bathing waters. Other objectives are easily met by nearly every basin stream.

S U B B A S I N   A N A L Y S E S

The effects of water quality levels on water uses and problems resulting from the conflict between the water quality available and that required are presented by subbasins and by the main stem of the Willamette River. This presentation is limited to 1965 conditions and uses.

COAST FORK SUBBASIN

The Coast Fork Willamette and its tributaries are a production area for salmon and trout, and a source of municipal water supply for the City of Cottage Grove. The municipal intake is located in the headwaters where the natural quality is excellent. Recreational use of the watershed is large, with recreational use of Cottage Grove and Dorena Reservoirs being particularly heavy.

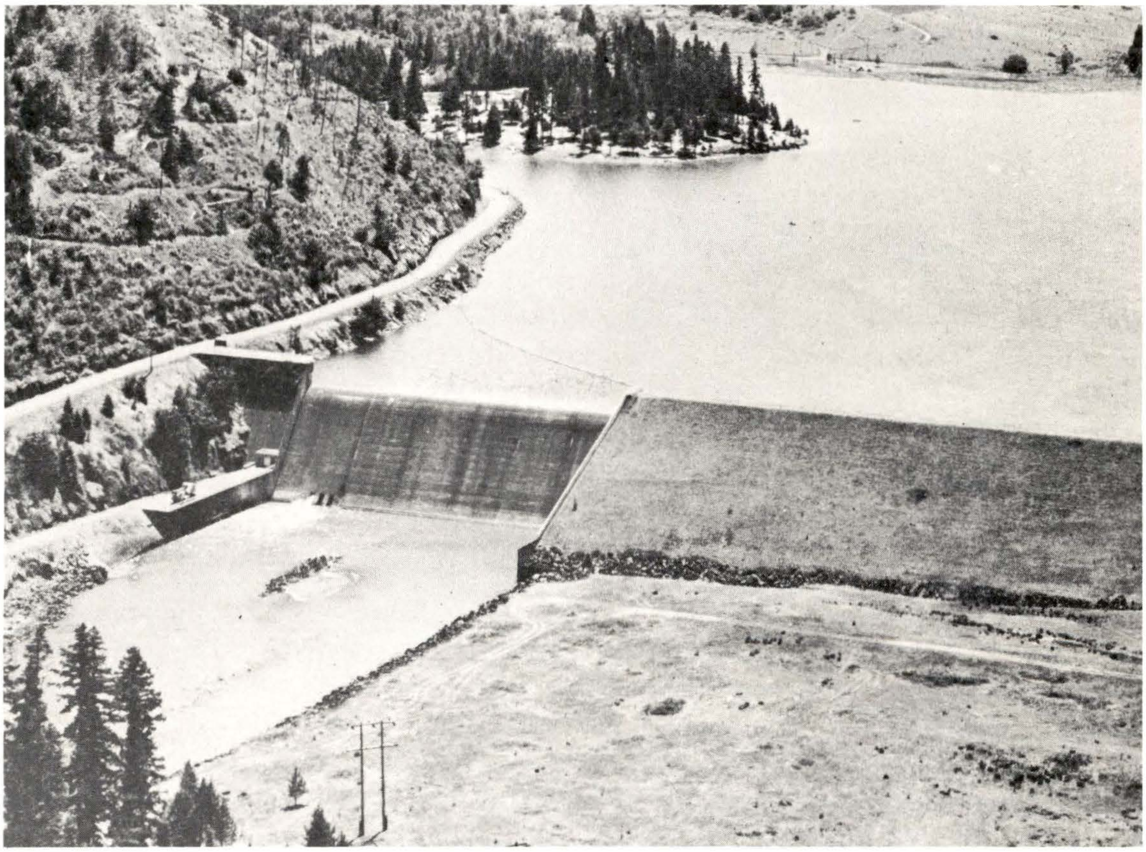


Photo II-12. Cottage Grove Dam on the Coast Fork of the Willamette River. (Corps of Engineers, Portland, Oregon, Photo)

Above Cottage Grove, the river is of good quality, but downstream the effects of waste discharges are noticeable. Increased BOD and bacterial densities are attributable to the waste discharges. Bacterial levels often exceed established standards for water-contact recreation; aesthetic values are diminished by the waste discharges; algae are stimulated by nutrients. Gravel washing results in high sediment loads at times, as does runoff from recently logged forest areas. The two Federal reservoirs in the basin, Cottage Grove and Dorena Dams, have little effect on water quality.

Programs are under way for improving waste treatment facilities, both by municipalities and by riparian dwelling owners.

MIDDLE FORK SUBBASIN

The Middle Fork Willamette River provides spawning and habitat area for both anadromous and resident fish. Salmon spawning occurs as far upstream as Dexter Dam, which forms a block to further migration, and trout are produced throughout the river system. Boating is particularly prevalent on Dexter, Lookout Point, and Hills Creek Reservoirs. The communities of Oakridge and Lowell obtain their water supplies from surface waters of the Middle Fork Subbasin.

Municipal and industrial waste loads are centered at Oakridge, where treated effluent equivalent to about 2,400 population equivalents (PE) of the subbasin total of 2,700 PE is discharged. Over half of the total discharged load comes from the Oakridge municipal treatment plant. This facility is being modified to provide secondary treatment, which will substantially reduce the waste load. The pollution loads to the Middle Fork have little effect on the quality of the river, and uses are not impaired. There are no major water supply withdrawals below the Oakridge diversion on Salmon Creek.

Runoff from areas of new road construction or from areas recently logged contributes to the sediment load. Stable summer flow carries very little sediment, but each significant rainfall is accompanied by increased turbidity and sediment load in the stream.

The four Federal reservoir projects in the subbasin--Hills Creek, Lookout Point, Dexter (re-regulation), and Fall Creek--have had some effects on water quality. Turbidity problems exist in the first three reservoirs with excessive algal growths constituting the major source of turbidity in Lookout Point and Dexter. Algal growths in the reservoirs have an apparent effect, but have not been specifically identified beyond probable taste problems in fish in the lower part of the river. During 1966, releases from Fall Creek Reservoir caused a fish kill, apparently as a result of low dissolved oxygen and the presence of hydrogen sulfide in the released water. Similar but less severe problems occurred in 1967. However, no fish kill resulted.

McKENZIE SUBBASIN

The McKenzie River is uniquely important in that it provides at least half of the spring Chinook salmon-spawning activity in the Willamette Basin. The river also sustains a splendid trout fishery, and its watershed consists almost entirely of thick forest which constitutes a prime scenic and recreational resource. This resource is heavily used, and the recreational needs must be considered to be as relevant towards quality criteria as those of the City of Eugene and of the Weyerhaeuser pulp mill at Springfield.

Blue River Reservoir and the Eugene Water and Electric Board's Carmen-Smith and Leaburg projects do not significantly affect water quality. Cougar Reservoir has adversely affected salmon runs because of the extremely cold water released from late spring through the fall.

Bacterial densities of 700 per 100 ml occur in the river above Springfield. There are no sewered communities in the upper reaches, but watershed developments such as recreation, rural dwellings, agriculture, and other land uses contribute to the bacterial load in the river.

Installation of sewers in the Springfield fringe areas and county-imposed building restrictions are helping to control pollution from these sources. The City of Eugene and the Weyerhaeuser Company both rely upon the McKenzie River as a water source. Their withdrawal points are near Springfield, with Eugene's at Hayden Bridge and Weyerhaeuser's several miles above that point. Recreational activities have not been restricted in the past, and the river is a "clean river."

Weyerhaeuser Company's integrated forest products plant at Springfield discharges about 20,000 PE daily, principally from the unbleached sulfate pulp mill. This mill has very low chemical and fiber loss rates because of careful in-plant control. Existing treatment measures include sedimentation basins, an aerated lagoon, and sprinkler application of strong wastes to land during suitable climatic periods. The discharge of pulp mill wastes below Springfield results in somewhat lowered dissolved oxygen concentrations (down to 88 percent saturation). In the past, discharged wastes have caused aesthetic problems and complaints of odors in the lower reach of the river, have stimulated slime growths, and have damaged the fishery; and recreation and riparian-dwelling values have been diminished as a result. Recent progress in treatment and disposal of these wastes has done much to alleviate interference with downstream water use.

LONG TOM SUBBASIN

Cutthroat trout are found in the upper reaches of the Long Tom River; and Fern Ridge Reservoir, which supports over 300,000 visitor-days of use per year, experiences the highest density of swimmers and boaters per surface acre of any major water body in Oregon. The reservoir, a few miles from Eugene, has been a major recreational attraction for many years; and the growing population of Eugene, spreading westward, may be expected to exert even more demand on the recreational and aesthetic resources of Fern Ridge Reservoir, and the Long Tom River as well. The Long Tom is also more heavily used for irrigation than other Upper Subarea tributaries.

Fern Ridge Reservoir inflow is minor during the summer months, and the large, shallow reservoir has prolific algal production and bottom sediments which are kept in suspension by agitation from wind, boats, and bottom-feeding fish. Even with the poor aesthetic quality, the recreational use of this reservoir ranks among the highest in the Willamette Basin.

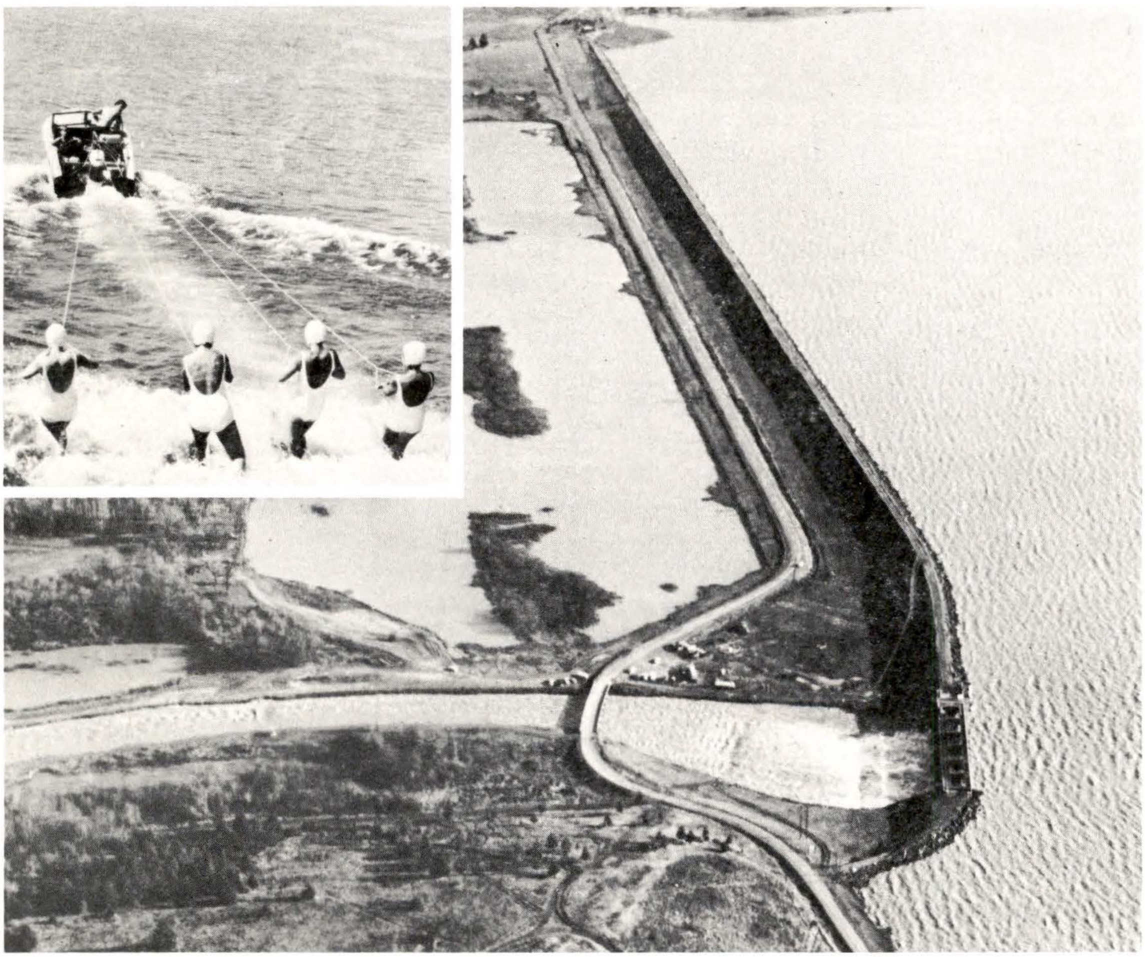


Photo II-13. Heavy recreational use by the nearby residents of the Eugene-Springfield Service Area occurs on Fern Ridge Reservoir. (Corps of Engineers, Portland, Oregon, Photo)

Natural turbidity, high summer temperatures in the lower river, and noticeable algal blooms lessen the attractiveness of the Long Tom River for many purposes.

Below Monroe there is a demand for water for irrigation and recreation, but the quality limits its use to irrigation.

SANTIAM SUBBASIN

The major streams in this subbasin are the North Santiam, South Santiam, Santiam, and Calapooia Rivers.

Both the South Santiam and Calapooia Rivers provide spawning areas for anadromous salmonids, and serve as a habitat for resident trout. The Calapooia is the water supply source for Brownsville. The South Santiam is subject to extremely heavy drafts for municipal supply purposes, serving Albany, Lebanon, and Sweet Home. Limited irrigation and stock-watering use is made of the South Santiam. These functions are important uses of the Calapooia.

The Calapooia River is of acceptable quality. No major uses are restricted by pollution. Records show bacterial concentrations of 600 per 100 ml during the summer season. In addition to serving as a water supply, the river is used for recreation at numerous small areas and for irrigation. The river runs through agricultural land used for grazing as well as for crops; total bacterial control is not presently practical.

The South Santiam River above Lebanon is of good quality, with no restriction of use resulting from pollution. Sweet Home, Lebanon, and Albany rely upon the South Santiam River as a source of water; the withdrawal points are at Sweet Home and just above Lebanon. In a five-mile reach through the Lebanon area, the river receives waste effluents from the City of Lebanon and the Crown Zellerbach mill. The mill has recently installed secondary treatment facilities, and water quality conditions have improved markedly.

In the case of both the Calapooia and the South Santiam, however, low summer water quality in the lower reaches constitutes a severe constraint upon supportable populations; in the case of the Calapooia, temperature is the main limiting factor; with the South Santiam, the limiting effects of unsuitable temperature are aggravated by periodic oxygen deficiency. Neither stream offers a broad recreational appeal, but the South Santiam's opportunities for bankside recreation would be expanded if the floating materials, slimes, and sludges were reduced or eliminated.

The North Santiam River, with quality and appearance materially exceeding those characteristics of other streams in the area, is intensively utilized for quality-demanding water uses. As a recreational resource, in particular, the North Santiam is very intensively used--partially because suitable alternative sites for water-based recreation

Photo II-14. The North Santiam River in this reach demonstrates the features of a river eminently suited for the maintenance of anadromous and resident game fish. (Oregon State Water Resources Board Photo) are lacking. The focus of this recreational activity is Detroit Reservoir, whose annual use--by boaters, swimmers, fishermen, and others--exceeded a half-million visitor-days for the last three years. The North Santiam has a prime habitat for resident and migrant salmonid fish, ranking below only the Clackamas and McKenzie Rivers among the waters of the Willamette Basin in its production of trout and salmon. The North Santiam drainage also provides the water supply for the Salem area, as well as for Stayton, Gates, Lyons, and Mill City. Use of the river as a source of water supply for Salem and smaller communities is not restricted by pollution, nor are other uses.

The Santiam River below the confluence of its major tributaries is only about 12 miles long and is made up primarily of flow from the North Santiam during summer months, although the effects of the South Santiam are noticeable. Bacterial densities of 7,000 coliform organisms per 100 ml are reported at the I-5 highway bridge crossing, and dissolved oxygen concentrations of over 110 percent are recorded. The primary uses in this reach are for irrigation, fisheries, and recreation. A state park is located at the bridge crossing, but recreational use of the river at this point should be limited to fishing, since bacterial concentrations exceed standards for water-contact recreation. Remedial measures recommended by the Oregon State Sanitary Authority for the South Santiam are correcting the situation and will make all uses possible.

Other activities have little adverse effect on the water quality of subbasin streams. Food-processing wastes are handled either by the processor or by municipal plants. Several canneries dispose of their wastes on land and thereby achieve virtually 100 percent effectiveness. Turbidity and sediment are seasonal problems, caused by runoff carrying sediment from construction sites and areas recently logged.

The Federal reservoirs--Detroit, Big Cliff, Green Peter, and Foster--have generally improved the quality of the subbasin's waters. Fisheries biologists have indicated, however, that water in Detroit and Big Cliff is somewhat colder than desirable for optimum fish development below the dams.

COAST RANGE SUBBASIN

The tributary streams of the subbasin are relatively small and subject to great seasonal fluctuation, with nearly total water depletion occurring during the summer months. The nature of the streams and their inadequacy as water sources have precluded substantial development along them, and no major waste loads occur. Little attention has been given to these streams other than to prevent gross pollution in their lower reaches. Bacterial contamination is present in the lower reaches of these streams, where they run through communities and agricultural lands; densities range from 2,300 to 7,000 organisms per 100 ml. Temperatures approach 77 degrees F, and depression of the dissolved oxygen level exists in the sluggish streams. Suitability of the streams for water supply, recreation, and fishery use is restricted by both lack of flow and pollution. Communities along these streams rely upon wells, springs, and upland tributaries for water supply.

The Yamhill River supports both resident and anadromous salmonids in its upper reaches, but in the summer high water temperatures in the lower reach make much of it unsuitable for the more desirable game fish. There are several public parks and boat-launching facilities along the lower Yamhill; use of these facilities for water-contact sports is not practicable because of high bacterial concentrations. Turbidity, floating materials, and algae make this reach unappealing for recreation. Irrigation and stock watering are significant uses of the river.

The major load in the Yamhill River system is at McMinnville on the South Yamhill. Approximately 2,600 PE are discharged from the secondary plant. Minor loads also enter the South Yamhill at Sheridan and Willamina. Less than 500 PE are discharged to the North Yamhill by Carlton and the Yamhill Labor Camp. Lafayette contributes about 100 PE to the Yamhill River from an oxidation pond.

Uses which can be served by the smaller tributaries--Marys River, Luckiamute River, and Rickreall Creek--are sharply limited by low summer flows and high temperatures. Rainbow and cutthroat trout and a limited number of coho salmon utilize the streams, though summer conditions which limit them to headwaters restrict supportable populations. Recreational use is generally curtailed by low flows and turbidity, although some portions of Marys River receive substantial recreational use. Rock Creek, a tributary of Marys River, provides the Corvallis water supply, except during the summer when the city uses water from the Willamette.

Marys River receives only about 200 PE from the secondary treatment plant at Philomath. Other wastes are from land runoff and small sawmills. The Luckiamute River does not receive any municipal wastes. Rickreall Creek serves as a water supply for Dallas, and the Luckiamute drainage provides a water supply for Monmouth. Irrigation and stock watering are important functions in all three drainages. Rickreall Creek receives 1,260 PE from the secondary treatment plant at Dallas. No other major wastes are discharged.

PUDDING SUBBASIN

The Pudding-Molalla system is a habitat for most salmonid fish species found in the Willamette Basin. The Pudding offers trout and coho salmon, and the Molalla includes chinook salmon, steelhead, and trout. Recreational use of the rivers is moderate, due to the sparse local population. Recreational use is increasing, however, due to demand by individuals from the Portland area. Moderate irrigation and stock-watering withdrawals are also made from both the Pudding and the Molalla.

The Molalla River above the Pudding River does not receive wastes of any magnitude and is of good quality, with no use restrictions.

The major water quality problem in this subbasin occurs in the Pudding River, which drains a highly developed farming area. Extremely low flows in summer, coupled with low velocity and brush-choked channels, further contribute to making it a low-quality stream. Food-processing wastes are the primary source of nutrients that have triggered massive algal blooms, causing extreme diurnal fluctuation of dissolved oxygen. Dissolved oxygen concentrations of 160 percent of saturation occur during the day at the lower end of the river, with corresponding values of approximately 50 percent saturation during the early morning hours. Municipal wastes in the subbasin receive secondary treatment; however, these effluents aggravate the problem of algal growth in the Pudding River. No existing uses are impaired, but the river is not desirable for any use requiring aesthetic desirability or stable conditions.

The Birds Eye food-processing plant at Woodburn, with raw wastes of 42,000 PE daily, treats these discharges in an oxidation pond and by application on 150 acres of land. The pond effluent stimulates profuse algal and slime growths, which cause diurnal dissolved oxygen fluctuation from 60 to 160 percent.

TUALATIN SUBBASIN

The upper reaches of the Tualatin River support a substantial salmonid fishery; however, anadromous fish must pass through a reach of the lower main stem where extremely low dissolved oxygen concentrations and high water temperatures occur in the summer. These conditions have severely reduced fish runs, and have virtually eliminated the resident salmonid fishery in this reach. The Portland Service Area occupies much of the subbasin. Not only are the aesthetic values of the stream destroyed by nuisance aquatic growths, but swimming and other water sports are being curtailed each summer because of the high bacterial concentration that accompanies depressed streamflows. Irrigation is a significant water use in the Tualatin Subbasin and is expected to increase.

The poor quality of the Tualatin River and most of its tributaries in the urbanized portion of the subbasin results from diversion of flow for irrigation and other uses, and from discharge of waste effluents into receiving streams with very little flow. As a result, these streams are suitable for only low-quality uses. Recreation areas have been put out of business by poor water quality and low-flow levels unsuitable for swimming, and communities have to go considerable distances for water supply. Portions of the watercourses are subject to gross pollution on an annual basis.

Municipal wastes discharged from 20 treatment plants to the Tualatin River and its tributaries average about 16,000 PE daily, with seasonal peaks of over 50,000 PE. Both values reflect the results of more than 85 percent effective treatment. Industrial wastes with separate discharges add an additional 1,500 PE to the load imposed on the river. Other land uses, particularly agriculture and irrigation, result in contributions of nutrients, sediment, and toxicants to the river. The amounts and damages have not been identified.

A Federal storage project at the Scoggins Creek site has been authorized for construction by the Bureau of Reclamation. A recommendation of the Federal Water Pollution Control Administration that storage be provided for non-reimbursable quality control releases did not receive favorable action in Congress. Reinclusion of the water quality function is now being investigated by the agencies involved.

CLACKAMAS SUBBASIN

The Clackamas River is used extensively for water supply, power, salmonid fish production, and water-based recreation of all types. Currently, the communities of Oregon City, West Linn, and smaller areas supplied by water districts obtain municipal supplies from the Clackamas. Lake Oswego is currently constructing facilities to also use the river for its supply. Future municipal demands in the Lower Subarea may necessitate additional development of supplies on the Clackamas because of its excellent quality and the absence of waste discharges to the stream. As a spawning and rearing area for salmonid fish, the Clackamas is second only to the McKenzie in the entire Willamette Basin. The Clackamas watershed is probably more intensively used for sport fishing and camping than any other in the basin because of its proximity to the Portland urban area.

There are no major problems of either water quality or pollution in this subbasin. There are occasional complaints that affect only a small area and one or two people. Occasional serious turbidity has resulted from gravel removal and washing. This condition has improved in the last two or three years, but the problem has not been resolved completely. The subbasin has historically been an area of high-quality water, and activities that would change this have been restricted.

Municipal waste from Estacada and Sandy reaches the Clackamas River after secondary treatment reduces the load to an aggregate of 390 PE. No industrial wastes in significant quantities are discharged to the Clackamas River. Restriction of waste discharge to the river has been imposed through the years because it is a major source of water supply, recreation, and fishing.

SANDY SUBBASIN

Similar to the Clackamas in many respects, the Sandy River provides the same water uses. The Sandy has more recreational development than the Clackamas, however. Two state parks--Dabney, and Lewis and Clark--have an annual attendance of well over a half-million visitor-days and show continually increasing trends. The subbasin contains the largest single water supply development in the entire Willamette Basin--the Bull Run Reservoir complex, which supplies Portland. There are no problems of water quality or pollution in this subbasin. The excellent water quality serves to promote all water uses rather than inhibit them, as in the rest of the Lower Subarea. The river supports good populations of chinook and coho salmon, steelhead trout, and resident trout.

COLUMBIA SUBBASIN AND MAIN STEM
WILLAMETTE RIVER

Uses of the upper reach of the Willamette River include salmon passage, a minor amount of salmon spawning, fish habitat, fishing for resident game fish, and bankside recreation. Swimming and other types of water-contact recreation are limited by the excessive bacterial concentrations that occur in the river below Eugene. However, its proximity to a large urban population and the existence of bankside recreation areas result in frequent summer use by swimmers. As in the case of the Long Tom River, considerable water is used for irrigation and stock watering in the agricultural lowlands below Eugene.

The water quality changes throughout the length of the river and seasonally. The dissolved oxygen level in the river generally lessens along the way to Portland, and the bacterial densities increase. The bacterial quality at Springfield is relatively high, with densities ranging from below 100 to 6,000 organisms per 100 ml. Swimming and fishing are the major uses affected, as well as the aesthetic value. Visual degradation in the form of sediment and silt from gravel-washing operations, along with color from raw vegetable wash water, has been the basis of complaints by residents of the area.

Discharge from the Eugene and Springfield sewage treatment plants in the seven-mile reach below Springfield causes an increase in bacterial contamination, BOD, and a slight reduction in dissolved oxygen. Recreation and fishing uses are now restricted by the water quality in this reach.

The main stem of the Willamette River within the Long Tom Subbasin receives significant amounts of waste from both municipal treatment plants and industrial sources. The average daily load discharged by Eugene and Springfield is only about 31,000 PE, but during the canning season peaks of 280,000 PE are reached. Some of these wastes are discharged directly to the river. Present corrective action includes enlargement and improvement of the secondary plant at Eugene; and Junction City and Harrisburg are now providing secondary treatment. Industrial waste loads from plants providing their own treatment are minor in this reach, since most industrial wastes are treated by municipal facilities.

The most obvious degradation of natural quality in this reach is caused by gravel washing, which contributes a visually apparent sediment load. Discharges of wash water, and bottom and bank disturbance at gravel-removal sites are readily apparent from the confluence of the Coast and Middle Forks to the mouth of the Long Tom River. The amount of sediment discharged and its economic damage have not been identified.

At Harrisburg, about 20 miles below the Eugene treatment plant, the quality is relatively stable and suitable for most uses, except

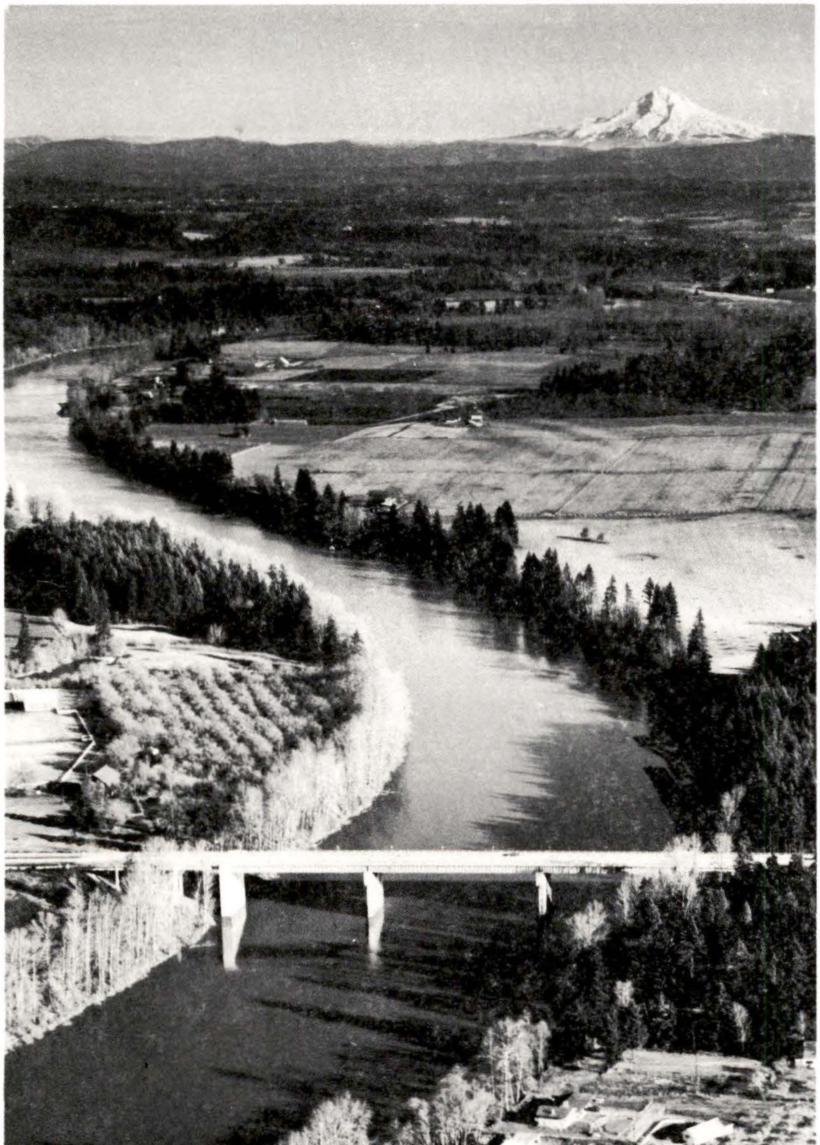


Photo II-15. The main stem Willamette River at Wilsonville.

those limited by poor bacterial quality. Coliform densities of 70,000 per 100 ml indicate that the water is undesirable for any use involving water contact.

The middle reach of the Willamette River is a passageway for migrant fish and a habitat for resident species. Recreational use of the middle Willamette includes water-contact activities as well as boating, fishing, and bankside pursuits. The recreational potential of the main stem is particularly important, in view of the limited availability of water recreation sites on nearby tributaries. Other uses of the middle Willamette include navigation and irrigation, which are economically significant but which have limited quality needs.

At the present time, Corvallis and Adair Air Force Base are the only communities drawing water from the Willamette; future growth may make it increasingly necessary for other communities along the river to turn to the Willamette for water supplies. It is, in any case, the most convenient source.

Corvallis supplements its normal water supply during summer months by diversion from the Willamette River just above the city. The bacterial quality at this point is not completely satisfactory, so that extra care in treatment must be taken to assure a safe supply. Tastes and odors associated with heavy algal blooms in the raw water require periodic use of activated carbon. The Corvallis treatment facility, currently discharging a load of 30,700 PE, is being expanded to provide secondary treatment.

Albany discharges its wastes to the Willamette River, with peak loads of about 48,000 PE. The average daily load discharged is only about 7,600 PE, but food-processing wastes during the harvest season grossly overload the existing facilities. A secondary treatment plant with adequate capacity is under construction.

The Western Kraft pulp mill in Albany discharges about 15,000 PE of pulp mill wastes daily to the Willamette River during the summer. Two earthen ponds provide primary settling with 24-hour waste detention before discharge. Wastes from the unbleached kraft pulp mill add to the other pollutants that influence the quality of the Willamette River below Albany.

The municipal waste load contributed to the river by the City of Salem is approximately 26,000 PE daily. Present treatment facilities are adequate.

A large industrial waste load, from the Boise Cascade calcium-base sulfite pulp and paper mill at Salem, is discharged directly to the Willamette River most of the year. During the summer season these wastes are temporarily held in two lagoons with a combined capacity of 150 million gallons; raw wastes estimated at 800,000 PE are reduced to a discharged load of about 60,000 PE. The mill was ordered by the

Oregon State Sanitary Authority to provide recovery systems and primary treatment.

The Publishers' Paper Company plant at Newberg, which produces unbleached sheet pulp, also uses temporary storage lagoons for waste reduction during the summer low-flow periods. Raw waste production of about 774,000 PE is reduced to 85,000 PE by diverting strong liquor to two storage lagoons with a total capacity of about 200 million gallons. The mill was ordered by the Oregon State Sanitary Authority to install adequate solids and fiber recovery systems, and primary treatment facilities.

At Willamette Falls, the dissolved oxygen level is about 65 percent of saturation and is suitable for use by the two pulp mills at the falls.

In terms of quality needs, the principal water use of the Lower Willamette River, or Portland Harbor, is for passage of migratory fish to the tributary spawning and rearing areas upstream. From June through September, oxygen levels in the harbor fall below anadromous salmonid requirements, and thus inhibit the passage of these species.

The lower Willamette is also used extensively for navigation--both by large commercial vessels and by tugs moving rafted logs. Because of bacterial pollution throughout this stretch, there is only limited water-contact recreation, although some water skiers use the stream. As a source of municipal water supply, the lower Willamette has traditionally been bypassed by adjacent communities in favor of water from protected supplies, in spite of higher transmission costs.

The waste load in this reach depletes the dissolved oxygen supply during periods of low flow, with levels as low as 33 percent of saturation being common. The water is physically, bacteriologically, and aesthetically undesirable in this reach. The resident fish survive only with difficulty, and up- or downstream seasonal migration of searun fish has been seriously inhibited.

Publishers' Paper Company at Oregon City operates a sulfite paper mill, and a refiner and stone groundwood mill. A conversion program changing the sulfite process to magnefite is now complete. A substantial decrease in wastes will result from this conversion and from chemical recovery. The recovery facilities are scheduled to begin functioning in December 1969.

The Crown Zellerbach Corporation pulp and paper mill at West Linn produces paper products from a calcium-base sulfite pulp mill, and a stone and refiner groundwood pulp mill. About one-half of the effluent, carrying about two-thirds of the settleable solids, is diverted to a primary settling tank for solids separation. A 75-million-gallon temporary holding lagoon receives the strong waste during the low-flow season.

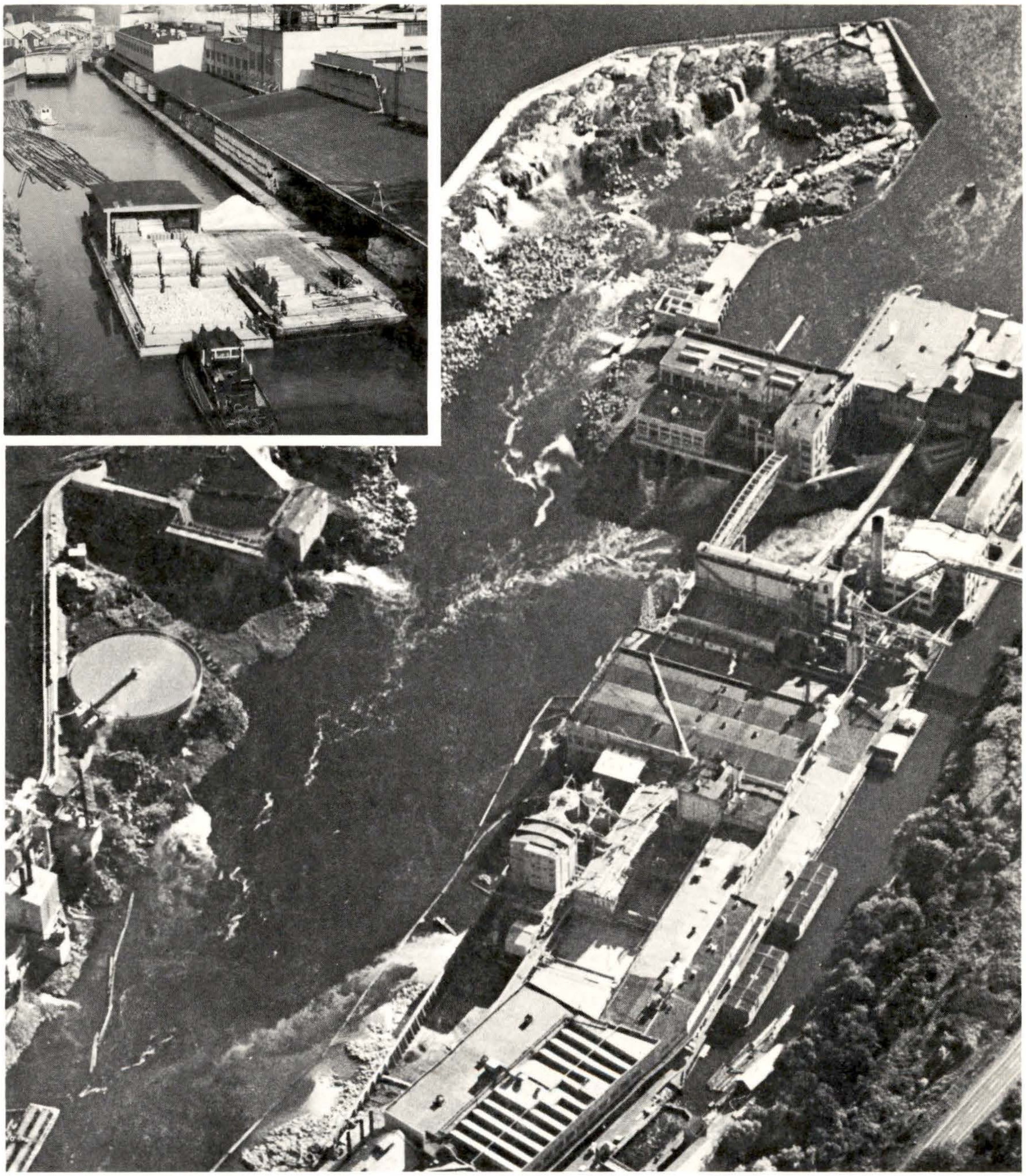


Photo II-16. Visible effluent from pulp and paper mills offends, while discharge of raw waste from shipping in the river escapes public awareness.

Small industries contribute some organic matter and are potential sources of toxicants, oil, grain cleanings, and other harmful materials.

Municipal waste at Oregon City is discharged into the Willamette River after secondary treatment. No particular problem is created by this discharge, except that the detergent foam caused by the discharge has detracted from aesthetic appearances.

Below Oregon City, wastes totaling about 7,200 PE from seven municipal treatment plants are discharged to the Willamette River and tributaries of the Columbia Subbasin. An additional load of raw sewage, estimated at 28,000 PE, is discharged from private and public sewers along the waterfront in Portland. These wastes are being reduced significantly each year.

Below the falls and through the Portland Harbor reach, nearly all of the area is urbanized, and the runoff carries sand, gravel, soil, toxic garden chemicals, oils, animal waste, and other organic litter through the storm sewers to the river. Since most of the storm-sewer flow occurs during higher river flows, adverse quality effects are not readily apparent, but sediment deposited below storm-sewer outfalls, for example, must be dredged from the harbor about every third year.

Although the total organic and bacterial loads are not known, with but rare exception all ships, small craft, and houseboats discharge raw sewage to the river. Other, minor amounts of waste material result from maritime activities, but only oil spills have been specifically identified as problems.

Photo II-17. Raw waste is discharged from houseboats such as these at several locations in the lower Willamette.

PART

III

FUTURE DEMANDS

FUTURE DEMANDS

The future demand for water quality control and management is related to the procedures, both physical and institutional, necessary to assure that water quality is suitable for recognized beneficial water uses. Thus, this "demand" is somewhat different from future "needs" as applied to quantities of water required to satisfy a given use, such as municipal and industrial water supply or irrigation. The quality to be maintained to allow future use must be evaluated in terms of the uses to be protected or enhanced. The demands for water pollution control are, therefore, directly influenced by use-oriented water quality objectives. Such objectives have now been established for the Willamette Basin by the Department of Environmental Quality (DEQ).

While the Federal Water Pollution Control Act, as amended in 1965, requires that water quality standards be established for the tidal stretches of the Willamette, the State of Oregon has adopted water quality standards covering the entire Willamette Basin. Special water quality standards have been established for Multnomah Channel and for the Willamette River. General standards applicable to the remaining public waters of the basin have also been formulated. Excerpts from "Standards of Quality for Public Waters of Oregon" appropriate to the Willamette Basin are presented in the addendum.

W A S T E   P R O J E C T I O N S

The present water quality situation is summarized by major water-service areas and by subbasins within the Upper, Middle, and Lower Subareas to facilitate comparing and projecting future pollution control needs. The major water-service areas are groupings of communities and industries within a common sphere of influence, which constitute a common source of pollution. They are amenable to, and are expected to be the center of, regional planning and development. The four major water-service areas (Figure II-1) include the Eugene-Springfield area, the Albany-Corvallis area, the Salem area, and the Portland area. Together, they contain 80 percent of the total Willamette Basin population and 95 percent of urban and incorporated places.

Water quality in the Willamette Basin will continue to be primarily affected by municipal and industrial wastes. Future water quality management needs are determined, in large part, by the magnitude of such future waste production. Projections of raw waste production have been made by utilizing population and economic data from Appendix C--Economic Base--with the exception of data pertaining to the pulp and paper industry, which were taken from the Columbia-North Pacific Study. Population projections are shown in Table III-1. The projections of raw waste production are given in population equivalents (PE) for the years 1980, 2000, and 2020 in Table III-2. The municipal projections include the projected population plus an additional 25 percent to incorporate the effects of small commercial establishments and other urban activities which add to the municipal waste load. The rural-domestic waste production is projected as equal to the rural population. Industrial waste production is estimated for pulp and paper, lumber and wood products, food products, and other manufacturing industries by service area and subbasin where applicable. For these industries, future waste production is determined by multiplying the present raw waste loads by a growth index. The growth indexes are shown in Figures III-1 and III-2 for each subarea for the years 1980, 2000, and 2020.

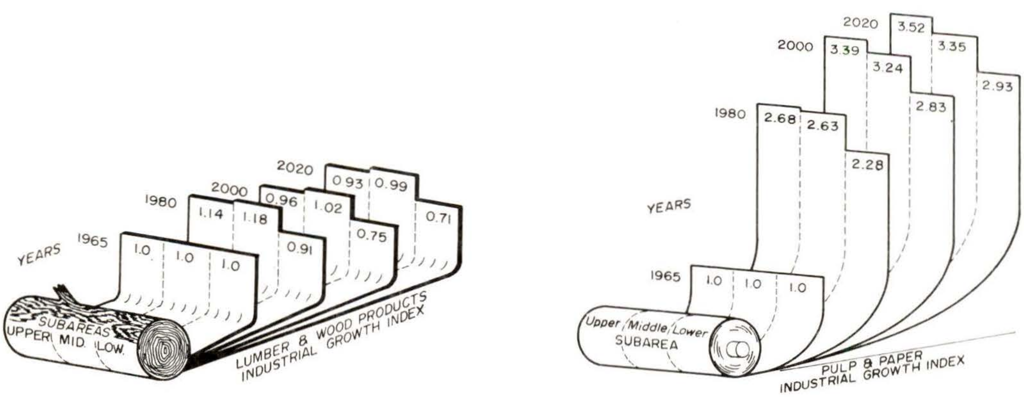


Figure III-1
Growth Indexes for Lumber and Wood Products, and Pulp and Paper.

Table III-1

Population Growth, by Subarea and Service Area

	1965	1980	2000	2020
UPPER SUBAREA	198,000	282,500	390,000	564,000
Municipal	149,300	229,400	338,500	516,700
Rural-Domestic	48,700	53,100	51,500	47,300
Eugene-Springfield Service Area	143,300	212,400	301,500	438,900
Municipal	131,300	198,700	288,000	426,500
Rural-Domestic	12,000	13,700	13,500	12,400
Long Tom	15,600	20,200	25,600	35,900
Municipal	4,100	7,500	13,300	24,700
Rural-Domestic	11,500	12,700	12,300	11,200
Coast Fork	19,000	22,900	29,200	40,800
Municipal	7,600	11,500	18,100	30,600
Rural-Domestic	11,400	11,400	11,100	10,200
McKenzie	6,900	10,200	11,600	15,000
Municipal	1,100	3,800	5,800	10,700
Rural-Domestic	5,800	6,400	5,800	4,300
Middle Fork	13,200	16,800	22,100	33,400
Municipal	5,200	7,900	13,300	24,200
Rural-Domestic	8,000	8,900	8,800	9,200
MIDDLE SUBAREA	329,900	437,700	556,000	729,000
Municipal	237,000	347,030	473,700	656,700
Rural-Domestic	92,900	90,670	82,300	72,300
Albany-Corvallis Service Area	63,300	98,700	143,500	210,500
Municipal	63,300	98,700	143,500	210,500
Salem Service Area	107,000	160,700	222,500	311,600
Municipal	107,000	160,700	222,500	311,600
Santiam	38,100	39,500	36,000	35,200
Municipal	9,600	13,300	15,400	18,100
Rural-Domestic	28,500	26,200	20,600	17,100

	1965	1980	2000	2020
Coast Range and Pudding	22,000	25,200	28,300	25,900
Rural-Domestic	22,000	25,200	28,300	25,900
Coast Range	48,900	53,700	59,400	70,100
Municipal	31,300	36,800	45,200	57,800
Rural-Domestic	17,600	16,900	14,200	12,300
Pudding	50,600	59,900	66,300	75,700
Municipal	25,800	37,530	47,100	58,700
Rural-Domestic	24,800	22,370	19,200	17,000
LOWER SUBAREA	811,000	1,047,300	1,476,000	2,298,000
Municipal	750,200	959,200	1,352,500	2,117,800
Rural-Domestic	60,800	88,100	123,500	180,200
Portland Service Area	738,500	939,200	1,320,200	2,065,500
Municipal	738,500	939,200	1,320,200	2,065,500
Tualatin	46,500	74,300	110,000	165,900
Rural-Domestic	46,500	74,300	110,000	165,900
Clackamas	17,900	22,400	29,400	42,000
Municipal	5,800	11,100	18,700	31,100
Rural-Domestic	12,100	11,300	10,700	10,900
Columbia	2,300	3,100	4,800	8,000
Municipal	2,300	3,100	4,800	8,000
Sandy	5,800	8,300	11,600	16,600
Municipal	3,600	5,800	8,800	13,200
Rural-Domestic	2,200	2,500	2,800	3,400
TOTAL WILLAMETTE BASIN	1,338,900	1,767,500	2,422,000	3,591,000
Municipal	1,136,500	1,535,630	2,164,700	3,291,200
Rural-Domestic	202,400	231,870	257,300	299,800

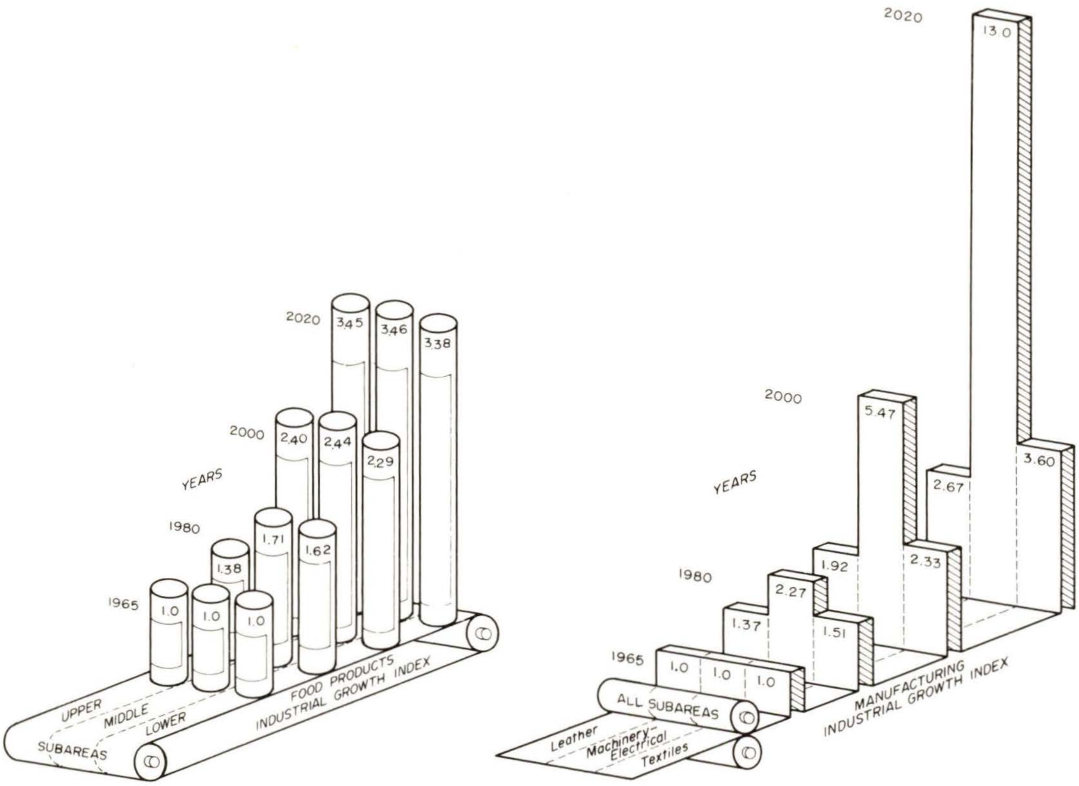


Figure III-2. Growth Indexes for Food Products and Manufacturing.

Municipal, industrial, and rural-domestic raw waste production estimates for 1980, 2000, and 2020 are presented in Table III-2. The projected raw waste loads are expressed in population equivalents to relate different waste sources to a common base. This equivalency applies only to the oxygen-demanding properties of a waste.

The most important quality effect at present and for some time in the future is the demand made on the oxygen resources of the river system. The oxygen demand of organic wastes is the principal drain on the oxygen in water. Although the quantity of inorganic wastes at present is small, these wastes will become more important in the future due to the anticipated growth in diversified manufacturing.

Table III-2

Raw Waste Production

	Waste Loads in PE's		
	1980	2000	2020
UPPER SUBAREA			
Municipal	286,900	423,000	645,800
Industrial			
Pulp & Paper	900,000	1,460,000	1,820,000
Food Products	200,000	336,000	500,000
Lumber & Wood Products	4,600	3,900	3,700
Rural-Domestic	53,100	51,500	47,300
MIDDLE SUBAREA			
Municipal	433,800	592,100	820,800
Industrial			
Pulp & Paper	957,000	1,298,000	1,611,000
Food Products	969,000	1,368,100	1,959,000
Lumber & Wood Products	242,600	304,600	313,600
Manufacturing	2,200	3,100	4,800
Rural-Domestic	90,670	82,300	72,300
LOWER SUBAREA			
Municipal	1,195,100	1,684,600	2,637,300
Industrial			
Pulp & Paper	530,000	728,000	853,000
Food Products	162,000	228,000	338,000
Lumber & Wood Products	167,000	211,000	219,000
Manufacturing	7,500	14,000	30,000
Rural-Domestic	88,100	123,500	180,200
TOTAL WILLAMETTE BASIN			
Municipal	1,915,800	2,699,700	4,103,900
Industrial			
Pulp & Paper	2,387,000	3,486,000	4,284,000
Food Products	1,331,000	1,932,100	2,797,000
Lumber & Wood Products	414,200	519,500	536,300
Manufacturing	9,700	17,100	34,800
Rural-Domestic	231,870	257,300	299,800

PRINCIPAL WASTE SOURCES

Municipal waste sources will tend to become more concentrated in the four large service areas of the basin. The dominant source of municipal wastes will continue to be the Portland Service Area, which includes the urban population of the Tualatin Subbasin. At present, approximately 51 percent of the wastes generated in this service area go directly to the Columbia River, and in the future at least this percentage will continue to be discharged, after treatment, to that river.

In the Willamette Basin, the pulp and paper industry discharges a relatively substantial waste load to the stream system. Since the accuracy of projected flow augmentation needs in the river system rests primarily upon the soundness of industrial production predictions, projections of pulp and paper production rates established by the most recent comprehensive study available (the Columbia-North Pacific Study) were substituted for those of the Willamette Basin Study.

In determining waste loads based upon projected industrial growth, the following assumptions were used:

1. There will be no future growth in sulfite pulping.

2. Groundwood and sulfate pulping will share in future growth in the same proportions they now exhibit.

3. The future mix between bleached and unbleached pulp will equal that expected for the Pacific Northwest by 2020 (90 percent bleached), with the mix over the intervening years determined by linear interpolation from the present mix.

4. The locations of future pulp production will approximate present locations.

5. Future increases in pulp production will be converted to paper. At present, the basin is a net exporter of pulp.

6. The cessation of sulfite pulping at the Crown Zellerbach plant in West Linn, Oregon, will be permanent.

7. The following rates of production of oxygen-demanding raw wastes per unit of product, expressed as pounds of five-day BOD per daily production of paper and pulp and/or groundwood in tons, would be representative of Willamette Valley mills as of 1980 and thereafter. These rates are based on the assumption that proper in-plant controls and chemical recovery will be in operation.

Unbleached Kraft pulp and paper	25
Bleached Kraft pulp and paper	65
Stone groundwood	15
Refiner groundwood	30
Bleached sulfite pulp and paper	85 to 125 1/
Unbleached sulfite pulp and paper	110

1/ The high value of this range was obtained by discussions with consultants to the pulp and paper industry to determine waste production rates assumed representative of future production in the Willamette Valley. This value was used in the analysis.

The oxygen-demanding wastes based on the foregoing assumptions used in the water quality flow analysis for this study represent only the conditions for the assumed economic projections. Pertinent policies of the State of Oregon and consideration of air and water quality parameters as well as land and water availability would result in further refinements in the analysis.

The food products industry will continue to grow throughout the basin, and the canning and preserving sector is expected to increase approximately three and one-half times by the end of the projection period. It should be noted, however, that the food products waste projections shown in Table III-2 do not reflect this expected increase in overall production, because these processing wastes can largely be treated by the same systems used for municipal effluents. Therefore, it is expected that a greater proportion of these wastes will be treated by joint municipal facilities rather than by separate industrial treatment plants.

The lumber and wood products industry is expected to decline over the projection period. Since this industry is also required to provide proper treatment, it is not expected to have much effect on overall water quality in the basin.

The greatest relative increase in industrial activity is expected to occur in the "other" manufacturing industries. The potential waste problems which may result are difficult to quantify. Much of the growth will occur through the establishment of small concerns whose waste output can logically be handled by municipal treatment facilities. Again, great reliance must be placed on the water pollution control authorities to assure that all wastes from these diverse sources will be properly handled.

Presently, five fuel-fired generating plants of 5,000 kilowatts or more are operating intermittently, using river water for cooling purposes. They are operated mainly in the winter when temperatures are low and streamflows are high. These plants pose no water quality problems at present, and are not expected to create any in the future. Potential development of thermal-nuclear power plants needed in the basin will require careful planning to properly preserve water resources and the environment. A number of nuclear power plant sites are being studied. A research project is currently under way to determine the feasibility of using water warmed by thermal plants to beneficially irrigate farm land.

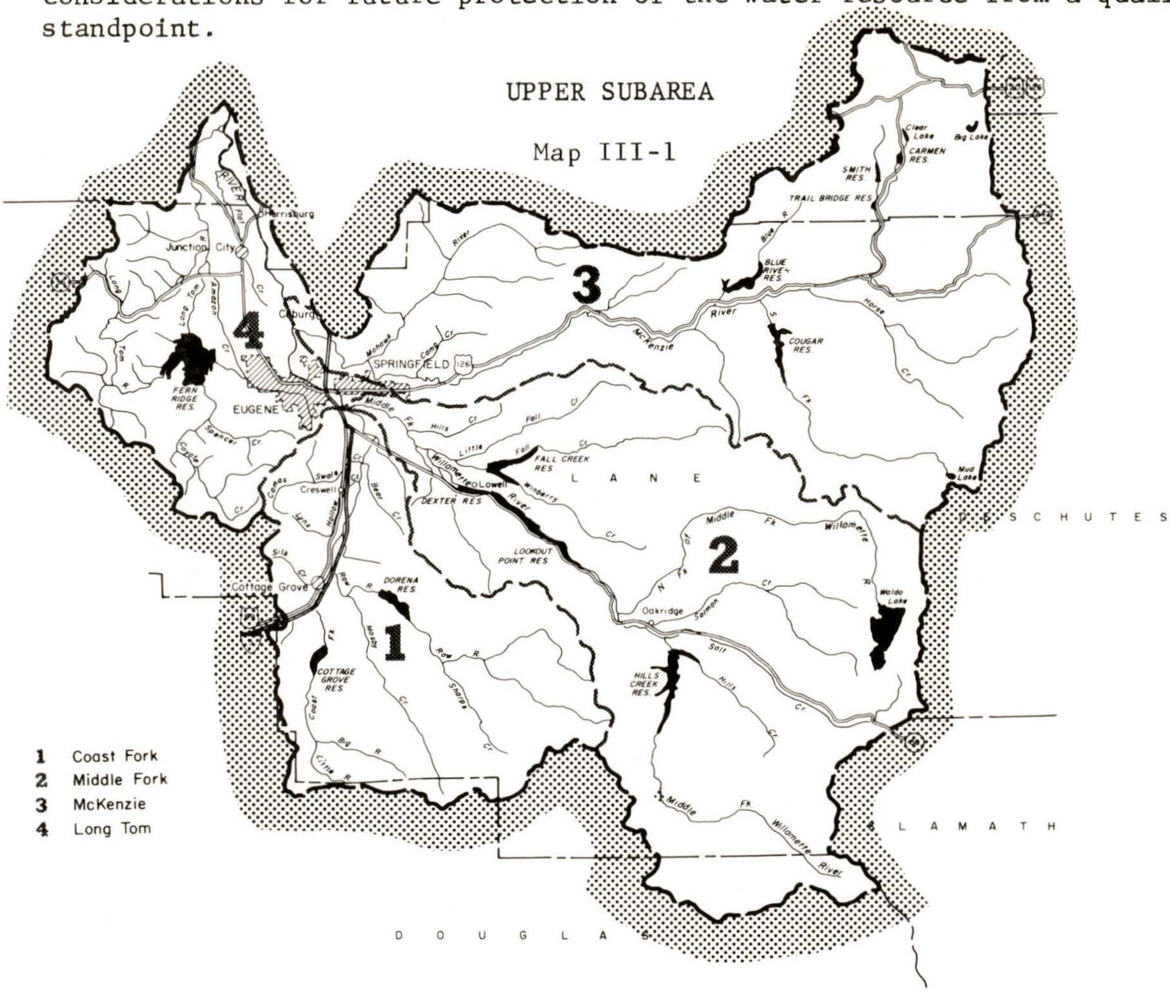
Irrigated acreage is expected to expand significantly throughout the basin. Projections show that the 1965 level of 244,000 acres will expand to 430,000 acres by 1980; 850,000 acres by 2000; and 1,000,000 acres by the year 2020 (see Appendix F--Irrigation). Since the estimated land available for agricultural purposes will be 1,371,000 acres in 2020, a very high dependence on irrigation for agricultural production is envisioned. Diversion requirements from surface-water supplies will reach 1,950,000 acre-feet per year by 2020, and associated return flows are expected to be 890,000 acre-feet. Because of the climatic regime and irrigation practices, water quality problems resulting from return flow should continue to be minimal. However, seasonal low streamflow resulting from depletions of this water may well affect the ability of the water resource to serve the needs of the fishery, recreation, and water quality uses.

S U B A R E A   E V A L U A T I O N

In the Willamette Basin, the protection and enhancement of instream uses, both present and future, determine the necessary future demand for quality control. The following subarea presentations give the primary considerations for future protection of the water resource from a quality standpoint.

UPPER SUBAREA

Map III-1



The Upper Willamette Subarea includes the Coast Fork, Middle Fork, McKenzie, and Long Tom Subbasins. Municipal and industrial water supplies, production of salmonid fish, and recreation are the principal quality-demanding uses. Irrigation and stock watering, uses of lesser extent, are growing fast, but impose no additional quality requirements.

The primary water quality objectives are those relating to dissolved oxygen, temperature, and bacteria. Maintenance of a dissolved oxygen level of at least 7 mg/l throughout the waters of the Upper Subarea is necessary in view of the large part the area plays in maintaining salmon runs. In spawning areas, influences that result in a deviation from oxygen saturation should be eliminated. Except in the lower Long Tom River, where natural conditions are not suitable, summer water temperatures that do not exceed 70 degrees may be considered a desirable fishery objective; the warm-water game fish in the lower Long Tom do not impose as strict a temperature requirement. Bacterial concentrations below 1,000 MPN per 100 ml should be established wherever possible. In reservoirs which have extensive summer water-contact recreation, the bacterial objective is critical. Lowering the bacterial density of the Willamette near Eugene, in particular, would provide desirable water-contact recreation for the large population of the Eugene-Springfield area.

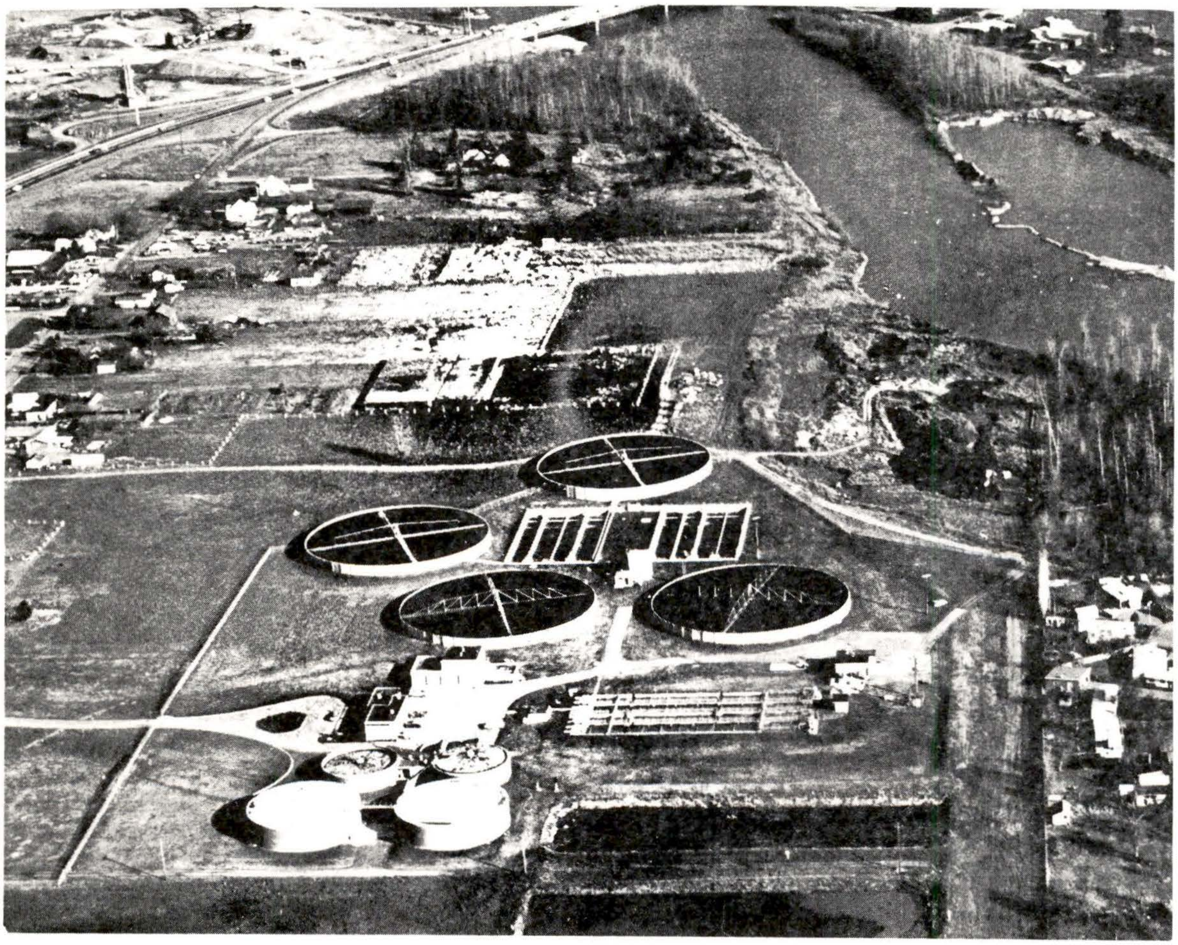


Photo III-1. Continued updating, refinement, and enlargement of waste treatment facilities, such as this installation at Eugene, will be necessary in the future. (Oregon State Sanitary Authority, Portland, Oregon, Photo)

The future needs of the Upper Subarea are the proper control and management of the wastes generated here as spatially distributed, in a manner adequate to maintain high dissolved oxygen levels and low bacterial concentrations. Oxygen-demanding wastes will originate primarily from food-processing plants, with pulp and paper a major secondary source. These developments are expected to be located in and around the Eugene-Springfield area. Similarly, major population growth will center in the Eugene-Springfield area, posing the major bacterial threat to the river. In addition, recreation developments around reservoirs will be another major, growing source of potential bacterial pollution. Thus, the needs for waste management will be concentrated on the Willamette River below Eugene, but needs will also exist on the recreation reservoirs and on the McKenzie below the pulp mill.

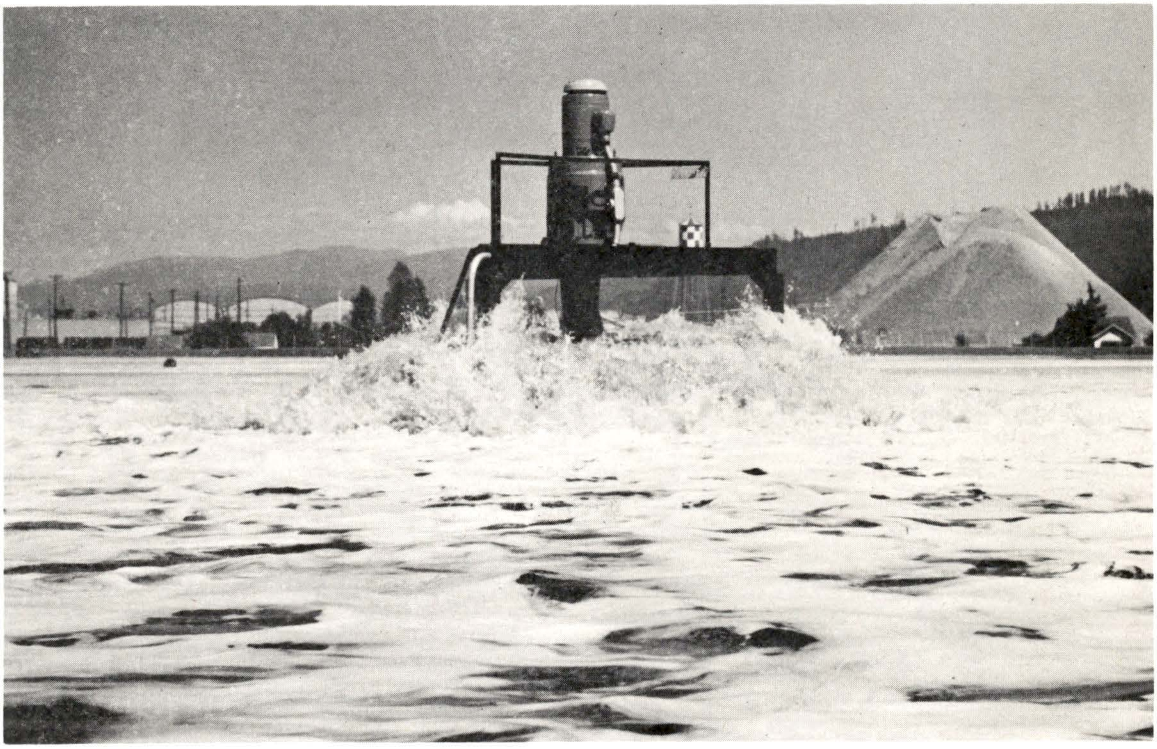
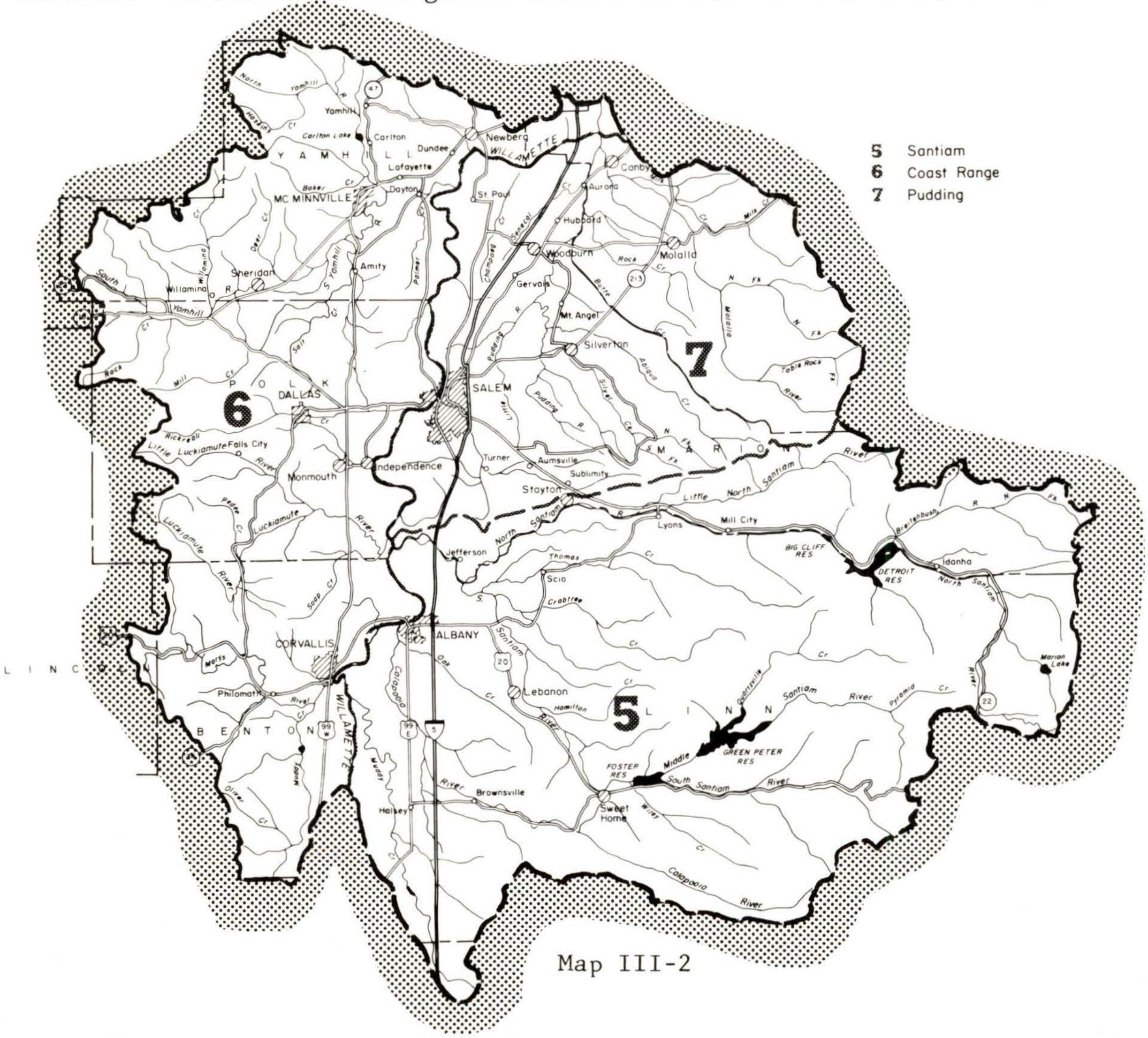


Photo III-2. Use of aeration devices improves the efficiency of waste treatment at this Weyerhaeuser installation in Springfield. (Weyerhaeuser Company Photo)

MIDDLE SUBAREA

The Middle Willamette Subarea includes the Santiam, Coast Range, and Pudding Subbasins. The principal quality-demanding uses of water are for salmonid fish, municipal and industrial water supply, and recreation. Considerable irrigation demand for surface waters also exists.



Map III-2

The primary water quality objectives are those relating to dissolved oxygen, temperature, and bacteria. Maintenance of a dissolved oxygen level of 6 mg/l in all waters not otherwise unsuitable by reason of temperature is necessary to fish production. In the lower stretches of Rickreall Creek and Marys, Luckiamute, Pudding, Yamhill, and Calapooia Rivers, where summer temperatures customarily exceed 70 degrees F, at least 6 mg/l of dissolved oxygen are required in order to accommodate fish passage needs. Streams providing water-contact recreation should maintain bacterial concentrations of less than 1,000 MPN per 100 ml. Attainment of this objective on the Willamette River is highly desirable, because the river has a high potential to meet the Middle Subarea's water recreation needs and because of the concentration of population along its banks.

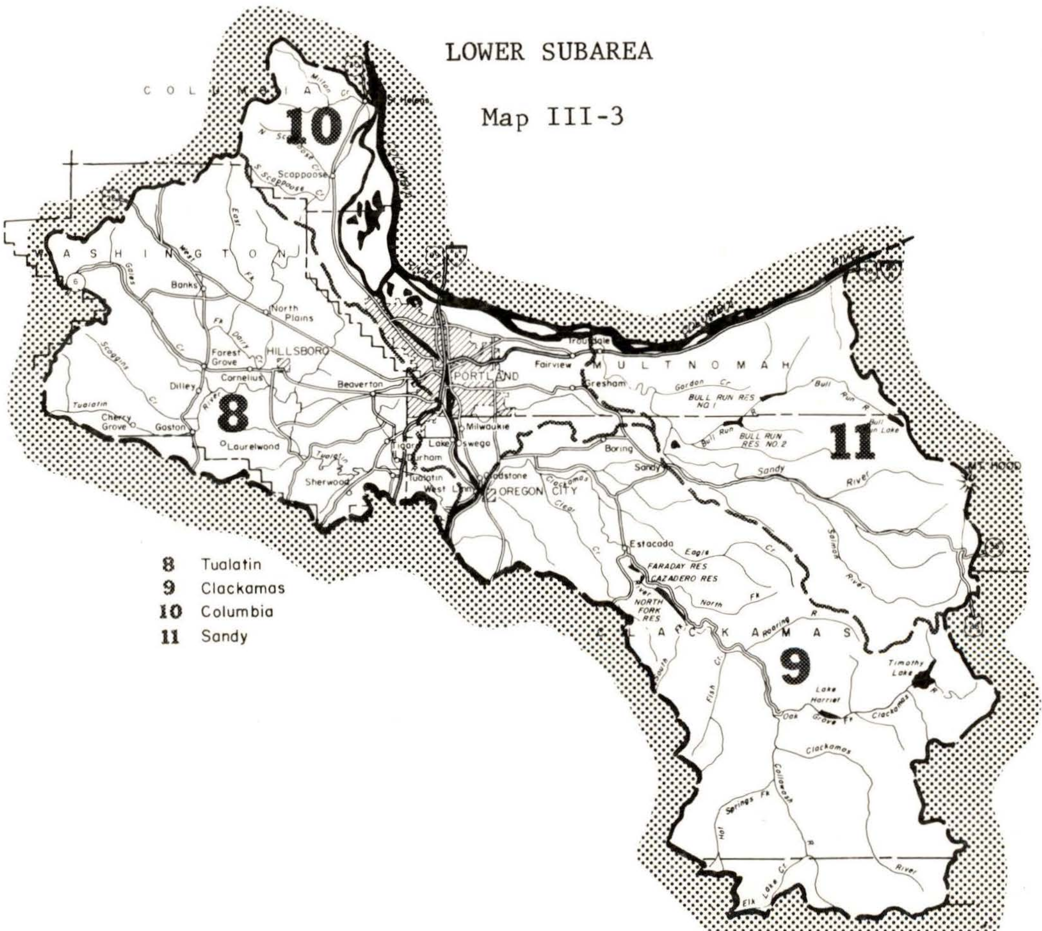
In the future, needs for water quality control will be more widespread in the Middle Subarea than in the Upper Subarea. Pulp and paper wastes will dominate the oxygen-demanding loads to the watercourses, although food-processing wastes will also contribute sizable loads. These wastes will be discharged in several locations, primarily to the Willamette River but also to some tributaries. These wastes must be handled properly and in concert with flow management to meet the oxygen objective throughout the system.

Population growth also will be scattered, with large population concentrations near reservoirs. Wastes from these concentrations will pose a threat to the bacterial and dissolved oxygen standards, and will create a major need for adequate handling.

Stream temperatures become a problem in this subarea. There is a significant need not only to properly manage heated waste discharges but also to manage the quantities of flows and reservoir releases to maintain temperature standards.

LOWER SUBAREA

Map III-3



The Lower Willamette Subarea includes the Tualatin, Clackamas, Columbia, and Sandy Subbasins. As in the Upper and Middle Subareas, the principal quality-demanding uses of water are for the passage of salmonid fish, municipal and industrial water supply, and recreation. Irrigation demands are slight except in local areas.

Because of the nature of uses, the primary water quality objectives for the Lower Subarea are those relating to dissolved oxygen, temperature, and bacteria. Maintenance of at least 6 mg/l dissolved oxygen, and saturation where possible, in the entire Clackamas and Sandy Rivers and in the reach of the Tualatin River above Rock Creek (RM 38) is required for anadromous fish spawning. In reaches such as the Tualatin below Rock Creek and the Willamette, where natural summer temperatures and hydraulic characteristics make such an objective unreasonable, a minimum of 5 mg/l must be maintained to permit anadromous fish passage to higher quality tributaries.

The maximum temperature criterion for anadromous fish life in the lower Willamette and Tualatin Rivers is 70 degrees F. It should be realized, however, that such a temperature level will be difficult to maintain in the lower Tualatin without substantial increases in flow. On all reaches of streams used for water-contact recreation, bacterial concentrations should not be greater than 1,000 MPN. Attainment of this objective in the lower Willamette and lower Tualatin Rivers will help to realize the recreation potential of the Lower Subarea. For decades, the recreation resource has suffered because of poor water quality.

Although no specific objective can be set to eliminate slimes and nuisance growths, reduction of the nutrients and settleable solids must be effected in the lower Tualatin and lower Willamette Rivers to reduce such growths.

P
A
R
T

IV

ALTERNATIVE MEANS TO SATISFY DEMANDS

ALTERNATIVE MEANS TO SATISFY DEMANDS

Providing water quality sufficient to adequately serve the river system's functions of water supply, fish habitat, and recreation will require a coordinated program of waste reduction, flow regulation, application of waste-controlling techniques, and a system of cooperative management of the watershed for pollution control. Following is a summary of all the measures necessary to preserve the basin's water quality--specific statements as to what should be done, and by whom, together with the priority of various requirements, and a generalized estimate of the investment and operating costs that will be required to sustain the envisaged program.

A compelling need is coordination of the activities of all agencies which have a responsibility within the program. Among these, the Department of Environmental Quality (DEQ) and the Federal Water Pollution Control Administration (FWPCA) are the paramount state and Federal agencies among the many groups having either a regulatory or effective interest in pollution control in the Willamette Basin.

The major share of the responsibilities falls on the DEQ, the State of Oregon's regulatory arm in matters involving water pollution. Within the framework of Oregon Law, the Oregon State Water Resources Board is responsible for determining what uses are to be made of the waters of the state. The responsibilities of the Board with respect to water quality, then, include both establishing base flows essential to quality control on heavily used streams, and synthesizing the variety of water demands into goals for water use. These goals ultimately determine water quality objectives.

FWPCA is responsible for obtaining, analyzing, and disseminating information regarding water quality, for advising all Federal water management agencies on necessary practices relevant to pollution control, for reviewing grant applications involving construction of waste treatment facilities, and for providing modifications to the comprehensive plan for pollution control that will maintain its utility in the face of changing conditions.

Each of the private and public interests involved in land use that affects water quality has a responsibility to develop and implement practices which limit water pollution resulting from its activities.

W A S T E   T R E A T M E N T

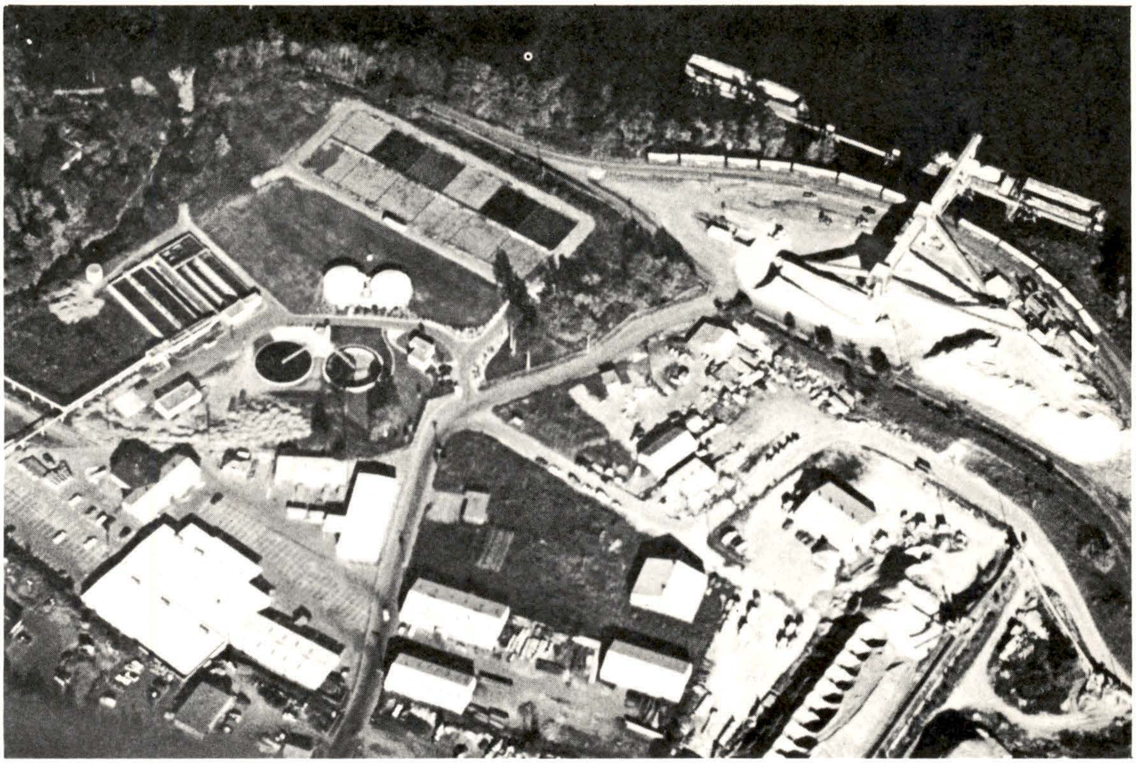
Waste reduction through effective treatment is the critical requirement for an effective water quality management program in the Willamette Basin.

The implementation and enforcement plan for the public waters of the State of Oregon requires that all municipalities and industries in the Willamette Basin provide a high level of waste treatment. For those not already providing secondary treatment or its equivalent, such treatment must be in operation by July 1972. Under state legislation enacted in 1967, a waste discharge permit system was instituted, effective January 1, 1968. This legislation, among other things:

> " . . . prohibits after January 1, 1968, without a permit from the Sanitary Authority (1) the discharge into the waters of the state of wastes from any industrial or commercial establishment or activity, any municipal sewerage system, disposal system or treatment works, or any domestic sewerage system serving more than 25 families or 100 persons, (2) the construction, installation, modification, or operation of any municipal sewerage system, disposal system or treatment works, or domestic sewerage system as defined above, (3) the increase in volume or strength of any wastes in excess of permissive discharges specified under an existing permit, and (4) the construction, installation, operation or conduct of any industrial, commercial or other establishment or activity or any extension or modification thereof, the operation or conduct of which would cause an increase in the discharge of wastes or the alteration of water quality not lawfully authorized;" and " . . . requires each permit holder to report periodically to the Sanitary Authority regarding amount and nature of waste effluent being discharged."

The single, most necessary element to end existing pollution in the Willamette Basin is the immediate installation of waste treatment facilities at all pulp and paper mills presently without them, together with equipment to condense and burn, or otherwise dispose of, sulfite waste liquors.

Long-term waste treatment needs will impose a continuing requirement for treatment plant construction. The substantial growth of population and industrial output will be a source of sustained pressure on treatment capabilities. Obsolescence of existing plants will cause treatment needs to become increasingly acute during the early 1980's when a large number of plants built in the late 1950's and early 1960's will require replacement. In most areas, higher degrees of treatment will be necessary; advanced waste treatment is fast becoming a necessity in the densely populated Tualatin Subbasin.



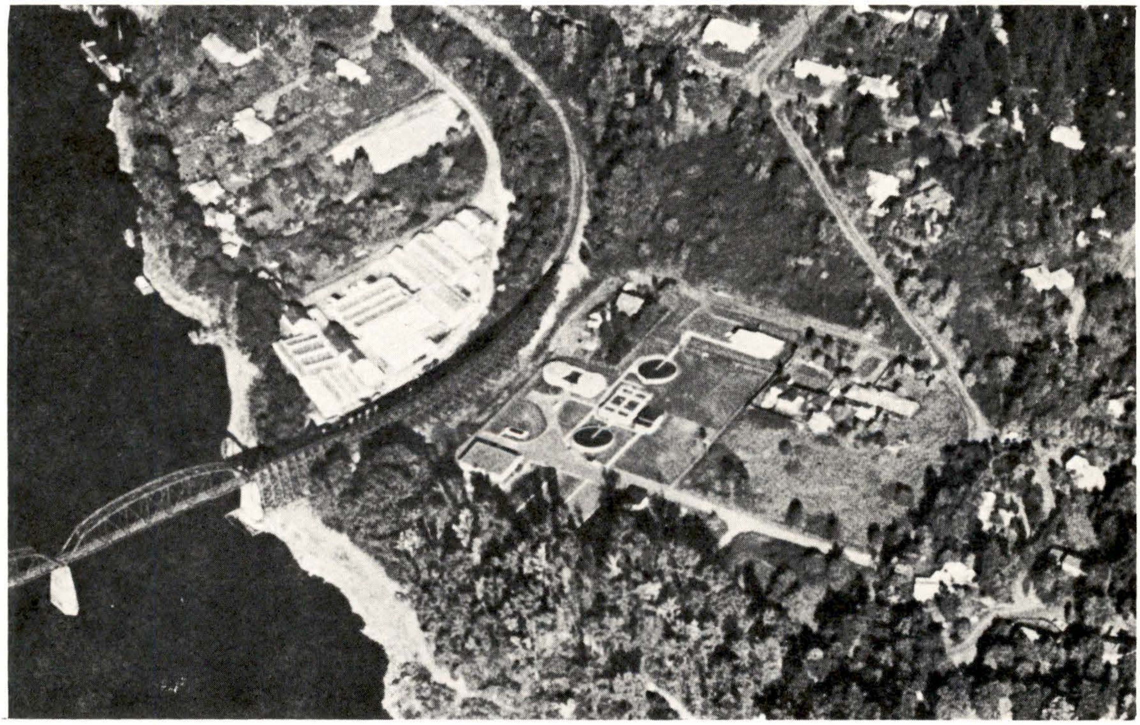


Photo IV-1. Two of the seven treatment plants in the Portland Service Area that discharge into the Willamette River: Lake Oswego (top) and Oak Grove.

Providing adequate treatment facilities will require a sustained program of investment by the communities and industries of the basin. To abate existing pollution in Portland Harbor will involve an estimated expenditure of $23.6 million, based on current prices and divided almost equally between municipalities and pulp and paper plants. While this level of expenditure should suffice to reduce the most immediate sources of pollution, another $24.5 million will be required to: (1) bring all existing waste treatment plants up to an acceptable degree of efficiency; and (2) provide secondary waste treatment for all pulp mills. Thus, a waste treatment investment of over $48 million by residents and industries of the Willamette Basin will be needed between 1967 and 1972. In addition to the construction and financing costs of these improvements, operation and maintenance costs of about $3.6 million annually for waste treatment facilities may be anticipated.

To maintain a proper level of treatment efficiency through necessary plant replacement and expansion, and to provide the advanced waste treatment that will be required in the Tualatin Subbasin as a result of population growth, an additional investment of about $57 million will be required by 1985. Annual operating and maintenance costs for this system of waste treatment plants may be expected to expand by another $4 million by 1985.

In total, then, an investment in waste treatment amounting to about $105 million over two decades must be provided if the quality of the Willamette is to be restored and maintained. In addition to the average annual increment of more than $5 million to depreciation and amortization expenses, operating and maintenance costs will rise by roughly the same amount. The levels of investment will not be evenly distributed, with close to 30 percent required as soon as possible in order to abate existing pollution. Another large investment will be required in the 1980's, as the inventory of existing waste treatment plants is depleted by obsolescence. Table IV-1 presents generalized capital costs for treatment, based on projected waste production which will be incurred during the period from 1985 to the year 2020.

Several points should be noted in assessing the magnitude of required waste treatment investments. A good portion of the immediate need has already been budgeted--by municipalities constructing and planning additions to treatment works and by pulp and paper mills preparing to meet the DEQ's requirements. Techniques exist to lessen treatment costs. These include the combination of treatment capabilities among communities and industries, and the installation of process controls that lessen waste volumes of industrial plants. Improvements in waste treatment technology which are presently being developed hold the prospect of lower unit costs as well as higher efficiencies; the assessment presented is no more than an estimate, in 1965 dollars, of the costs of providing effective waste treatment with the methods and organizational structure that presently prevail in the Willamette Basin.

Table IV-1

Estimated Treatment Costs for Organic Wastes
Municipal and Industrial Sources
1985-2020

	CAPITAL COSTS	
	Municipal 1/	Industrial
UPPER SUBAREA		
Eugene-Springfield Service Area	$47,700,000	$15,100,000
Remainder of Subarea	11,300,000	-
Subarea Total	$59,000,000	$15,100,000
MIDDLE SUBAREA		
Albany-Corvallis Service Area	$32,200,000	$ 8,860,000
Salem Service Area	42,900,000	1,990,000
Remainder of Subarea	26,900,000	13,160,000
Subarea Total	$102,000,000	$24,010,000
LOWER SUBAREA		
Portland Service Area	$185,000,000 2/	11,830,000 3/
Remainder of Subarea	7,350,000	0
Subarea Total	$192,350,000	$11,830,000
WILLAMETTE BASIN TOTAL	$353,350,000	$50,940,000

1/ Includes industrial wastes which can reasonably be expected to be treated in a municipal plant.

2/ Includes cost of treatment facilities discharging to the Columbia River--approximately $100,000,000.

3/ Does not include industrial treatment facilities discharging directly to the Columbia River.

F L O W   R E G U L A T I O N

Waste treatment alone cannot provide the level of quality that is desired in the Willamette Basin. Because of the association of pollution with depleted summer flows, augmentation of flow by regulated releases from basin reservoirs is necessary for an effective pollution control program.

The Federal Water Pollution Control Act authorizes the inclusion of storage in Federal reservoirs for the purpose of regulating flow for quality control to protect water uses. The area receiving the benefits of such storage must provide adequate waste treatment--interpreted as no less than the waste reduction equivalent of secondary treatment of liquid wastes prior to discharge to the river system.

Flow requirements were determined by mathematically modeling the dissolved oxygen system of the Willamette River. The model essentially computed the oxygen demand that the projected waste loadings exerted on the river through a series of river reaches, and determined the required flows to satisfy the oxygen demand and still meet the state standards for dissolved oxygen in each reach. The model was run for two temperature conditions, the first presuming cold-water releases from the storage reservoirs during the summer operation; the second presuming ambient, warm-water releases during that period. Wastes entering the stream for each projection horizon were calculated by reducing the raw wastes determined from the economic projections by an assumed treatment efficiency level which would be in effect.

To apply this model to future conditions, several assumptions were necessary, certain of which are outlined below to show some of the limitations and areas for future refinement of the present analysis. Growth of the major waste-producing industries was assumed to occur in the same pattern as existed in 1965. Except for the pulp industry, relative unit waste loads were expected to persist as at present. For those industries that presently do not discharge their wastes into the Willamette River because of use of lagoons or land application, it was assumed that future residual wastes, following adequate treatment, would be discharged to the river system. Oxygen content of treated effluents and levels of removal of BOD from domestic and industrial wastes were assumed to be the following:

WILLAMETTE BASIN, EXCEPT FOR TUALATIN SUBBASIN

	1980	2000	2020
BOD removal	85%	90%	90%
DO in effluent	1 mg/1	1 mg/1	5 mg/1

It was assumed that effluents containing industrial wastes would have no dissolved oxygen in 1980.

	1980 BOD Removal	2000 BOD Removal	2020 BOD Removal
NON-URBAN TUALATIN SUBBASIN			
Forest Grove	90%	90%	95%
Hillsboro	90%	90%	95%
Cornelius	90%	90%	95%
Others	90%	90%	95%
URBAN TUALATIN SUBBASIN			
Beaverton area	90%	95%	95%
Fanno Creek area	95%	95%	95%

For non-summer months, it was assumed that only secondary treatment would be provided in the Tualatin Subbasin, and would be equivalent to 90 percent BOD removal.

Where 95 percent BOD removal is indicated, it was assumed that 5 mg/l dissolved oxygen would be present in treated effluent; for 90 per cent BOD removal, 1 mg/l dissolved oxygen would be present. However, for 1980, it was assumed that effluents containing industrial wastes would have no dissolved oxygen.

The projected flows required for water quality for the Willamette system are summarized in Table IV-2. Increased flows are needed in the main stem Willamette in the vicinity of Albany and in Portland Harbor. Tributaries having projected flow needs are the Yamhill, Pudding, South Santiam, and Tualatin Rivers, and Rickreall Creek. These areas are discussed briefly below.

The Yamhill River's flow regulation need is significant in light of an extensive appropriation of water rights and the development of the Red Prairie Project of the U. S. Bureau of Reclamation, which is expected to increase the use of the river for irrigation. Existing water rights, if exercised, would deplete the flow of the river entirely during low-flow periods. Part of the water quality objectives could be achieved from storage in the proposed Red Prairie Project. It is assumed that remaining flows required would be derived from other storage constructed in the Yamhill Basin.

Table IV-2

Water Quality Flow Requirements in the Willamette River and Tributaries 1980-2020

Water Quality Flow Requirements 1/
Willamette River

	1980 (cfs)							2000 (cfs)							2020 (cfs)						
	Nov-Apr 2/	May	June	July	Aug	Sept	Oct	Nov-Apr	May	June	July	Aug	Sept	Oct	Nov-Apr	May	June	July	Aug	Sept	Oct
Eugene	20	20	25	40	40	35	25	25	25	30	45	45	40	30	25	40	45	60	60	50	40
Harrisburg	700- 900	1200	1300	1400	1600	1400	1200	1000-1100	1400	1500	1700	1800	1700	1400	1100-1200	1600	1800	1900	2100	2000	1600
Albany	1300-1600	2000	2000	2400	3000	2800	2500	1700-1900	2400	2400	3200	3500	3200	2900	1800-2100	2500	2700	3300	3900	3600	3000
Salem	1400-1700	2100	2100	3200	3700	3000	2600	1700-2000	2500	2500	4100	4400	3500	3000	2000-2200	2600	2900	4200	4800	4000	3100
Oregon City	1600-1900	2400	3100	5000	5000	4200	2800	2000-2400	2900	3200	5200	5100	4300	3300	2400-3100	3100	3900	6100	6300	5100	3600
Portland Harbor	1600-2400	3200	4200	6200	6200	5100	3000	2000-2500	3300	4300	6300	6300	5200	3300	2700-3100	4100	5100	7500	7500	6200	3700

1/ Summary, more refined breakdown available from FWPCA.
2/ Values shown represent ranges of flow during period.

Water Quality Flow Requirements
Willamette River Tributaries

	1980 (cfs)							2000 (cfs)							2020 (cfs)						
	Nov-Apr 2/	May	June	July	Aug	Sept	Oct	Nov-Apr	May	June	July	Aug	Sept	Oct	Nov-Apr	May	June	July	Aug	Sept	Oct
Coast Fork 1/	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	30	30	30	30	20
Middle Fork	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
McKenzie	110-140	170	190	220	220	190	160	140-180	210	230	270	270	240	200	140-170	210	230	270	270	240	190
No. Fork Santiam	10	10	20	590	590	110	10	10	10	20	760	780	150	10	20	20	20	680	690	130	20
So. Fork Santiam	20- 30	30	40	50	50	50	40	20	20	30	40	40	40	30	20	30	30	40	40	40	30
Santiam	35- 40	50	60	620	640	160	50	40	40	50	810	820	180	50	40	40	50	720	730	160	40
So. Fork Yamhill	20	20	30	60	60	50	20	10	20	30	50	50	40	20	10	10	20	30	40	30	10
Yamhill	20	30	40	80	80	60	30	10	20	30	70	70	60	20	20	20	30	70	70	50	20
Pudding	20	20	40	120	130	100	20	20	20	30	120	140	100	20	20	20	30	150	160	130	20
Tualatin nr Freeway	50-110	60	90	180	180	160	80	80-150	70	100	220	220	200	90	110-190	90	120	210	210	190	100
Tualatin at Mouth	40-130	30	40	140	140	120	30	90-200	50	80	210	210	170	60	110-250	90	140	270	260	200	100

1/ All flows are for lower reach of tributary, except Tualatin River near freeway.
2/ Values shown represent ranges of flow during period.

The proposed level of flow does not assume the development of a major food-processing industry as a result of increased irrigation. Should such an industry be established, a reevaluation of treatment and flow requirements would be needed. As stated earlier, however, it has been assumed that industrial wastes which are not discharged to the stream at present will be discharged to the stream, after treatment, in 1980 and thereafter. Industrial growth indexes for the Middle Willamette Subarea have been applied to such waste loads.

Need for flow augmentation is also indicated for the Pudding River. It has been assumed that the food industry, which currently utilizes land disposal for its wastes, will expand according to the industrial growth index for the Middle Willamette Subarea and by 1980 will discharge treated waste effluent to the Pudding River.

The South Santiam River's flow regulation requirements arise as a result of the waste discharges of a pulp and paper plant at Lebanon. The municipalities and industries along the river--including the pulp and paper plant--provide a high level of waste treatment; the DEQ has instructed the pulp mill to limit its summer waste discharges to about five percent of the original strength of its gross waste production.

Projected flow requirements for the North Santiam are based on the assumption that industry will expand in proportion to the indexes shown for the Middle Willamette Subarea and will discharge treated effluents to the river system. A very substantial industrial waste load presently is retained in lagoons or is used for irrigation of crops. The largest projected waste load in the North Santiam Subbasin is from the cannery industry. If the projected growth is realized, the future minimum flow requirements for the North Santiam will approximate the present one-in-ten-year low flow of the stream.

Rickreall Creek's existing flow needs stem from conditions similar to those of the Yamhill River. Irrigation demands deplete the stream in dry years. Minimum flows are required below the City of Dallas to maintain quality suitable for fish passage. It has been recommended by FWPCA that these flows be provided from the Monmouth-Dallas Project of the Bureau of Reclamation. This plan involves pumping from the Willamette River. Minimum flows of 11.0 cfs in 1980 and 13.5 cfs in 2010 were recommended in a 1962 report of FWPCA.

The Tualatin River's need for augmented summer flows is perhaps the most immediate and pressing in the Willamette Basin. The average level of waste reduction already exceeds 90 percent, but dissolved oxygen in the lower river consistently drops well below 5 mg/1. Depletion of summer flows is a factor contributing to this problem. Examination of other water quality parameters exhibits an equally dismal picture. Any long-term solution to the water quality problems in the Tualatin will result from the integration of waste treatment and a suitable minimum flow regime.

The determination of flow needs through Portland Harbor is far more complex than for the other reaches in the Willamette River system. Among the several factors that defy rigorous analysis are the hydraulic characteristics as affected by tidal fluctuations and the Columbia River flows, the benthic oxygen demand exerted by the long accruing harbor sludge beds, and the unquantified waste discharges into the harbor.

Higher water stages in the Columbia River during the summer low-flow period of the Willamette retard the outflow of the Willamette and hold these flows in the harbor. In addition, the flows are affected by the diurnal tidal influences from the Pacific Ocean. The retardation of flows holds oxygen-demanding wastes in the harbor for longer periods of time, allowing more depletion of minimal summer oxygen resources.

The sludge beds in the harbor have historically used substantial oxygen from the river. This load is especially significant during the low-flow periods. In past years, upstream waste loads have been withheld from the system when flows in the harbor dropped below 6,000 cfs, and yet the oxygen levels remained depressed until flows were again raised. Although the significant effect of these loads is known, quantification with existing surveillance technology is impossible, so the influence cannot be definitively modeled.

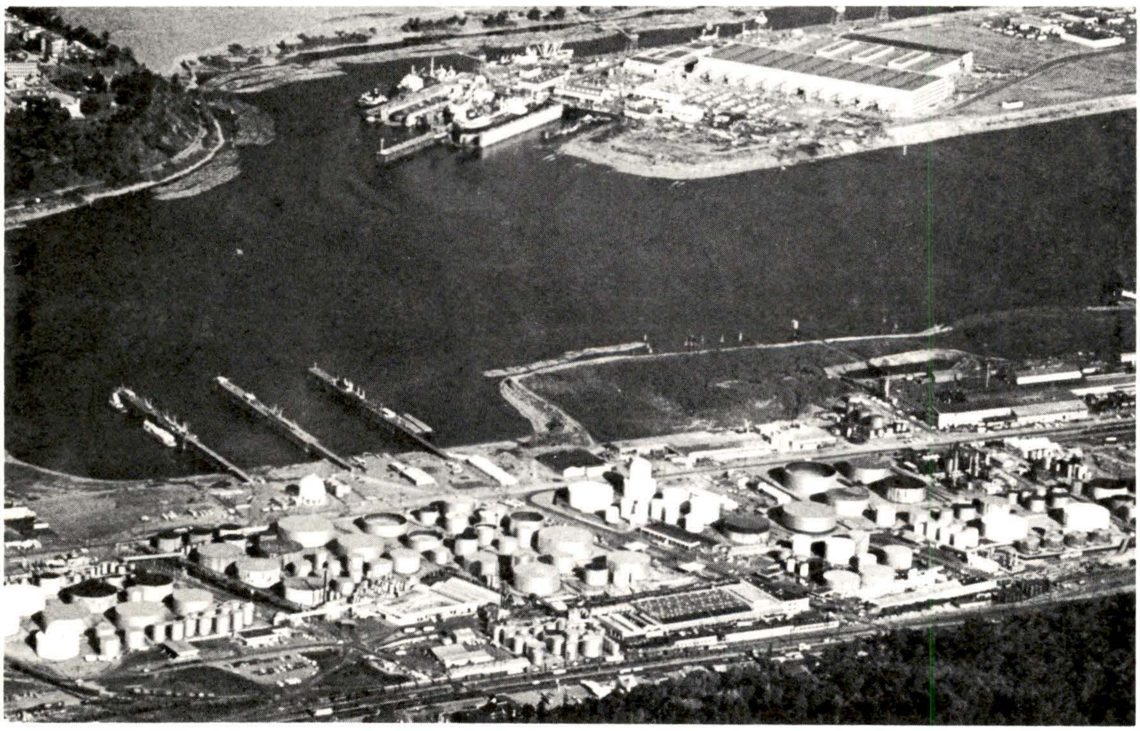


Photo IV-2. Portland Harbor: Rife with sludge beds that keep dissolved oxygen levels depressed for the remainder of the river's travel.

Several other factors obscure the prediction of quality here. Unquantified waste loads are expected to be intercepted some time in the future. Algal and sphaerotilus growths in the stream exert a diurnal oxygen demand, driving the oxygen levels down at night to levels lower than those measured during daylight hours.

Analysis of Portland Harbor showed that required water quality flows were rather insensitive to upstream treatment levels, while the harbor hydraulic characteristics and benthic loading exerted significant effects. Flows derived from the model understated the demands of these undefined factors, requiring further study to account for them in the recommendations. The reanalysis resulted in flow requirements during July and August through Portland Harbor of 6,200 cfs in 1980; 6,300 cfs in 2000; and 7,500 cfs in 2020.

Meeting these flow needs will require storage releases from upstream Willamette reservoirs. Portland Harbor flows will probably control regulation requirements for water quality control in the Willamette system. Achievement will be complex because of conflicting water uses and the operational schedules of reservoirs that came into being before water quality control was a legally sanctioned function of Federal storage projects.

Authorized purposes of the Willamette Basin Project reservoirs are flood control, navigation, power generation, and irrigation. The U. S. Army Corps of Engineers, in their 1947 authorizing report, expressed their intent to manage the system in a manner that would provide a minimum navigation flow at Salem of 6,000 cfs upon completion of all authorized projects. This minimum level of flow has been the basis used by the DEQ in establishing its policies with regard to waste discharges into the Willamette. If maintained in a fashion that provides a comparable flow through Portland Harbor, the intended navigation flow would provide for attainment of water quality objectives for Portland Harbor through the year 2000. In particular, it would assure maintenance of a DO concentration of 5 mg/l, which is needed to maintain salmon runs. Recognition of the water quality needs dependent upon the minimum navigation flow of 6,000 cfs, and providing it with a firm status, would be a major Federal contribution to maintaining Willamette River water quality.

Two desirable provisions could increase the utility of storage for quality control: First, if storage is available for use as it is needed, flow requirements can be determined according to the day-to-day water quality conditions. To use water as it is needed, rather than depend on a sustained level of flow, would effect economies in the use of stored water. Second, releases should be made from reservoirs which maintain high quality during the summer. Augmentation of flows with releases from the North Santiam, Clackamas, McKenzie, or Middle Fork Willamette River provides higher water quality than releases from the warmer, west-side tributaries.

WATER QUALITY BENEFITS

National policy being developed by the Water Resources Council for procedures for evaluation of water and related land resource projects states in part:

"Any regulation of the flow of a water body will affect water quality for any of several uses to some extent. The effects on each use should be calculated according to changes in their pertinent quality dimensions or criteria. Favorable effects on any use shall be ascribed as benefits for that use. Benefits should not be ascribed to water quality *per se*. Therefore, any flow regulation or other hydrologic control to serve a particular use must meet the quality requirement as well as the volume requirements for that use.

"Any favorable quality effects that occur incidental to regulation for other uses, such as from reservoir releases for navigation, power, water supply, and irrigation, should be ascribed as benefits for the particular uses favorably affected. Any adverse quality effects resulting from a project shall be charged against the project as a project cost.

"The measure of the beneficial effects on each water use should reflect the extent to which the usefulness of the particular water use is affected. This measure may be in terms of savings in water treatment in the case of a water supply or in terms of higher levels or degrees of water use for recreational waters.

"Water quality control benefits *per se* will still arise, however, in those instances when it is necessary to provide reservoir storage and releases to reach the water quality standards under the Water Quality Act of 1965 after it has been determined that the combined effects of all the project purposes and wastes and drainage controls are inadequate. Specifically, this situation will arise only in those cases when the full range of feasible waste treatment and control and drainage and land use controls have been analyzed in conjunction with meeting all water use requirements by the project and a potential water quality deficiency from the standards has been revealed. In these situations, reservoir storage and flow regulation for water quality control under section 3-b of the Federal Water Pollution Control Act may be utilized and the benefits ascribed to water quality . . . "

For most streams in the Willamette Basin, flows required to maintain adequate water quality could be satisfied by the flows required by other water use functions. This situation is dependent on the ability of the developed overall water resources plan to meet the needs for other in-stream uses such as fish, recreation, and navigation. Under current national policy, no water quality benefits *per se* are appropriate when flows which would maintain acceptable water quality are provided for other functions.

It appears that flows required to maintain proper water quality through the year 2000 in the main stem Willamette are less than or, in some reaches, equal to those flows required for fish, recreation, and navigation functions. Thus, the increased benefits accruing to these uses as a result of good water quality need to be determined.

An analysis of benefits has been prepared by the Bureau of Commercial Fisheries in the development of the Willamette Falls Fishway Project. The Bureau indicates that an increase in annual benefits of $865,000 will accrue to the fishery in the Willamette system if suitable water quality is present in the Portland Harbor reach. These additional benefits can serve as a justification for maintenance of minimum fishery flows that will also meet water quality standards.

The recreation committee has indicated that benefits to outdoor recreation resulting from increased streamflows for water quality vary tremendously in magnitude. The evaluation of these benefits requires a high degree of familiarization with the particular streams and a great deal of sophisticated hydrologic data. This, plus the time and complexities involved in determining the effects on the proposed reservoirs supplying the additional water and the tributary streams which deliver it to the problem area, have made it impossible to provide downstream recreation benefits for inclusion in this plan. However, it should be recognized that these benefits are real and at least partially measurable. In some instances, the benefits could be highly significant. Therefore, it is important that downstream recreation benefits be considered in planning to insure inclusion of water quality as a project function. As projects proceed to the authorization stage, more information needs to be developed on monetary downstream benefits. The decision may then be made in regard to the extent of downstream benefits relative to the inclusion of water quality as a project purpose. The effect of improved water quality on navigation would not be significant.

In some rivers, such as the Tualatin, the need for flows for water quality control is greater than that for other uses. A determination of benefits for water quality *per se* will be possible as individual projects proceed to the authorization stage. The water quality benefits can be determined only after project flows for all other uses have been defined and evaluated with respect to their effect on water quality. Storage for water quality control must be evaluated on a "last added" basis. As a result, it is not possible to place a monetary value on the water quality benefits until specific projects contained in the overall comprehensive water resources plan have been formulated. This situation makes it very important that the water quality interests be involved in individual project formulation procedures.

For future project formulations, alternative means and higher degrees of waste treatment and drainage controls may be used in the evaluation as a measure of benefits in comparison with reservoir storage costs. It may also be feasible to develop a unit of value to assign to benefits from improved water quality where aesthetics or amenities are involved, particularly in regard to residential and parkland areas along watercourses. Nonquantitative valuations, such as explicit and thorough statements as to salutary effects on human living conditions and enjoyment, may also be used.

The recommendations will include an identification of beneficiaries and a conclusion as to whether the benefits are "widespread or national in scope."

O T H E R   P O L L U T I O N   C O N T R O L   P R A C T I C E S

While waste treatment and flow regulation are the major measures for meeting pollution control needs--as well as the major source of future capital expenditures--additional methods of control should be diligently pursued.

The immediate need in this regard is for the City of Portland to complete its system of trunk sewer interception to eliminate discharges of untreated wastes into Portland Harbor. The municipality is actively working to this end; interception costs compose the major portion of a $14 million waste control budget adopted in 1965.

Measures supporting water quality, which may readily be adopted in the near future, include the stoppage of untreated waste discharges from houseboats and oceangoing commercial vessels to Portland Harbor. The DEQ has statutory authority to prohibit untreated discharges, and the FWPCA has completed a study determining the extent of these wastes and devising means of controlling them. The DEQ has now established requirements with deadlines for the management of wastes from houseboats.

The control of fertilizers and commercial toxicants through careful application practices is of more than passing importance, in view of their increasing use. The U. S. Department of Agriculture, which has the responsibility for regulation of such materials, should make a major effort--ideally through the county extension agents--to insure that use practices which fully reflect the need for protection against all types of environmental pollution are adopted by the individual farmers and commercial applicators. Soil-stabilizing practices must continue to be effectively promoted for agriculture, logging, construction, channel improvements, and other activities that cause or affect deposition of soil in water bodies. In particular, soil stabilization should be included as a condition of all contracts let by Federal agencies and by contractors engaged in work where Federal grants are involved. The responsibility for such actions is imposed upon Federal agencies by the terms of Executive Order 11288: <u>Prevention, Control, and Abatement of Water Pollution by Federal Activities</u>.

Similar controls by state and local agencies would be of great value, particularly if statutory authority for inspection and summary powers of abatement were awarded to the DEQ. Controls should be adopted by the State of Oregon to prevent free access of concentrated animal populations (as at feed lots and dairies) to banks of water bodies. Acceleration of the City of Portland's program to control urban runoff would also be of great value. Economies could be effected by incorporating appropriate design features into the new interceptor sewer systems that will be constructed in the near future.

Over the longer term, a systematic handling of the problems posed by urban storm-water runoff and combined sewer overflow at waste treatment plants must be undertaken. The major need in this regard is development of methods. The cost of separating existing combined sewer systems is so great that it does not at this time represent a practical alternative. Based on costs per person developed in national studies, about $250 million would be required for the Willamette Basin.

M A N A G E M E N T   P R A C T I C E S

Measures necessary to abate water pollution in the Willamette Basin are straightforward, but they are not in themselves sufficient to guarantee the maintenance of water quality. Continuing management decisions and procedures with clearly defined responsibilities among those interests concerned with water quality and water pollution control will also be necessary.

The Department of Environmental Quality and the Federal Water Pollution Control Administration are the agencies with primary responsibility for water pollution control. These two agencies must have full participation in reaching decisions related to water use and management which affect water quality control.

The elements that would enter ideally into a water quality management system would be those that make it possible to make effective day-to-day decisions affecting flow and waste discharges. Given sufficient information about the river system, and given a measure of power to control flows and wastes, such an ideal system is theoretically possible. At the present time, there are some obstacles to putting these procedures into operation.

A clouded water rights picture makes it impossible for finite base natural flows to be established for quality regulation. Adjudication of water rights must be accomplished if finite firm rights for all appropriative uses of water are to be established. The determination of these rights is an essential prerequisite to analyzing the available minimum natural flows set by the Oregon State Water Resources Board that can effectively serve the purpose of quality control. The State Engineer has estimated that an investment of about $1.5 million will be required to complete adjudication and establish priorities of water rights in the Willamette Basin. Should storage for flow regulation be authorized in Federal reservoirs, there is a guarantee that the flows would serve their intended function since the OSWRB has established minimum flows, involving both natural flow and storage release, to support aquatic life and quality control. Further regulations made by the State Engineer on all diversions from the stream under his authority to distribute water insure that the minimum flows set by the OSWRB will be passed down the stream to serve their intended purposes.

Another, less pressing area in which decision-making should be made more effective lies in the realm of relationships among Federal agencies. Clearly defined working arrangements need to be developed, as authorized by Executive Order 11288. Programs of agencies engaged in water resource management and in land management affecting water quality should be reviewed annually by the FWPCA, to evaluate effectiveness of pollution control procedures and to suggest indicated improvements. This type of cooperative relationship will become even more necessary if flow regulation for water quality control is authorized in Federal storage projects in the basin. The FWPCA could then recommend, in a fashion that recognized competing uses of stored water, the storage needed for quality control during the coming year.

Essential to the operation of a management program is the availability of adequate and readily accessible information. Knowledge of the operation of the Willamette River system is far more complete than that of other Pacific Northwest water bodies, but additional information is still needed. The DEQ presently maintains a system of periodic water quality monitoring for the Willamette River. The FWPCA operates three automatic monitoring stations and a water pollution surveillance system station in the Lower Subarea. These complementary systems should be expanded. Periodic sampling of tributaries would add materially to knowledge of the water quality of the river system. In particular, FWPCA water pollution surveillance system stations should be established to record the water quality in any tributary where storage is released from Federal reservoirs for quality control. In addition, a surveillance station at Corvallis would provide a means of both measuring the progression of quality and calibrating mathematical models of the river system to reflect accurately the effects of downstream waste loads. Finally, water quality surveillance at various reservoir levels is necessary to determine the characteristics of the releases as well as the quality of the stored water which is to be used as flow augmentation for quality enhancement. Even with existing forecasting techniques, the combination of the four existing monitors--telemetered to a central computer system--would allow either release of available stored water or curtailment of waste loadings by manufacturing plants in a manner which would avert critical water quality depressions.

To complement the suggested system of water quality monitoring, improvements both in flow-gaging practices and in knowledge of waste discharges are essential. The existing network of gages in the Willamette Basin meets all requirements for extent of flow information, but reporting is delayed and the information is not available in time to meet management needs. Instrumentation to provide regular daily flow reports during the critical season for two points on the Tualatin River and one point on the Clackamas River, in Portland Harbor, and on other streams for which flow regulation storage has been proposed, would require a per-station investment of about $6,000 and would impose a $2,000 annual cost for operation and maintenance.

Dependable data on waste strengths and treatment effectiveness must also be obtained if an equitable and responsive management program is to come into being. Periodic reporting of waste discharges, presently available to the DEQ, should be supplemented by daily reporting from all major waste sources during critical periods. Annual in-plant surveys by the DEQ are made both to provide a check of reporting efficiency and to indicate areas in which waste control improvements might be made.

Another management practice which has the potential for providing direct and significant efficiency increases, consists of methodical upgrading of skills of waste treatment plant operators. The short courses presently conducted by Oregon State University and the DEQ should be continued, and attendance should be encouraged. Perhaps the most direct methods of increasing operator skill would be passage of compulsory certification legislation and raising the admittedly deficient pay scales to attract qualified persons and to reward achievement and encourage professionalism.

Both research and program development should be integral parts of the management plan. The most obvious immediate needs for research involve those problems posed by wastes that are not amenable to collection and treatment, including the wastes of navigation, land use, and urban runoff. The creation of a unified policy for pollution control in an area marked by a plethora of independent jurisdictions, problems of municipal and industrial wastes, intensive agriculture, and urban runoff, would be of more than local utility. Federal grants are available for both research and planning assistance.

A L T E R N A T I V E S

The proposed program for pollution abatement and water quality maintenance is considered to be the optimal solution to the water quality problems of the Willamette Basin. However, it is not considered to be either a final or a maximum solution. Other pollution control possibilities are available, and more should become evident as knowledge of the river system and technology advance.

Other alternatives, although they are not considered to fit into the optimal solution proposed, include reaeration of the lower Willamette River and transmission of wastes from critical areas such as the Tualatin Subbasin.

The significance of reaeration is obvious in any situation where dissolved oxygen (DO) concentrations are less than those demanded by uses. By reaerating the water body, it is possible to maintain a suitable DO level where waste assimilation is continuing and would otherwise result in oxygen depletion. Unlike flow augmentation and waste treatment, reaeration is specific in its operation. Its benefits extend only to dissolved oxygen, whereas the more general operations--waste treatment and flow regulation--provide improvements in several water quality parameters. As waste discharges grow, reaeration might best serve as a supplement in dry years to both flow regulation and waste treatment, rather than as a substitute for a base flow.

There are several ways to accomplish effective reoxygenation of the lower Willamette River by inducing reaeration. The simplest method is to allow the river to pass over Willamette Falls throughout the summer. The turbulence and atmospheric contact occurring at the Falls would provide substantial aeration of the Willamette, whose oxygen supply is partially depleted by upstream waste loads before it enters Portland Harbor. During low flows, the entire river is channeled through a generating plant which serves the two pulp and paper mills situated at the Falls. If diversion through the turbines were to be interrupted during the critical season, the desired dissolved oxygen concentration of 5 mg/l would be maintained through the harbor. The cost to the pulp and paper mills (assuming that purchases of power for 120 days were twice as expensive as captive generation of power) would be about $95,000 a year.

Another reaeration method is now available for use at the Falls. In 1965, Portland General Electric Company fitted one draft tube with an aeration device at its generating plant at Willamette Falls. In 1966, six additional draft tubes were fitted for introduction of air. After test runs in 1967, the aeration system performed well during the critical 1968 late summer period. Crown Zellerbach also installed aeration devices in its turbines at the Falls in 1968.

Reaeration may also be accomplished by installation of mechanical devices to induce turbulence and force oxygen into solution in the water. In the absence of flow regulation and with the level of waste removal recommended in this appendix, emplacement of three 150-horsepower aeration units in series would maintain the DO objective for Portland Harbor under 1944 flow conditions. These devices, placed at the points where DO would be expected to drop to 5 mg/l, should in combination effect a 0.5 mg/l increase in DO. Estimated cost (including ten-year depreciation, operation, and maintenance) would be about $155,000 per year.

Among the considered alternatives to the recommended combination of waste treatment and flows were: (1) collection and conveyance of the wastes out of the basin, and (2) land application of the wastes. Collection and diversion of the wastes was rejected because of high costs, plus loss of waters useful for such purposes as irrigation in a water-short basin. Land application was rejected because of the aesthetic objections and the high cost of sufficient lands suitable for this approach.

U P P E R   S U B A R E A

Maintaining the quality of water necessary to serve uses in the Upper Subarea appears to be largely a matter of providing adequate waste treatment. The high natural quality of the waters and the high degree of assimilative capacity provided by rapid, shallow flows lessen the need for flow regulation or sophisticated management techniques. It is important to remember, however, that wastes discharged to the upper river are rapidly transported to the middle and lower river, where most of the five-day biochemical oxygen demand is exerted.

Eugene's practice of combining municipal and industrial waste treatment appears to be an optimal approach to the problem of providing treatment for expanding industrial wastes, and should be considered as a model by other communities now planning for future industrial growth.

Waste treatment practices of sawmills and plywood mills should receive considerably more attention than in the past. In the operation of such plants, every effort should be made to lessen the amount of solids that reach the watercourses. In particular, plants using hydraulic barkers should provide primary treatment for the wastes of barking. The level of biochemical oxygen demand occurring as a result of barking--about 2.5 pounds per cord--is of little significance presently or potentially to the water quality of the Upper Subarea. However, the suspended solids which occur from barking--up to 25 pounds per cord--can be a potential source of aesthetic damages, and serve as a base for attachment of sphaerotilus, a slime organism.

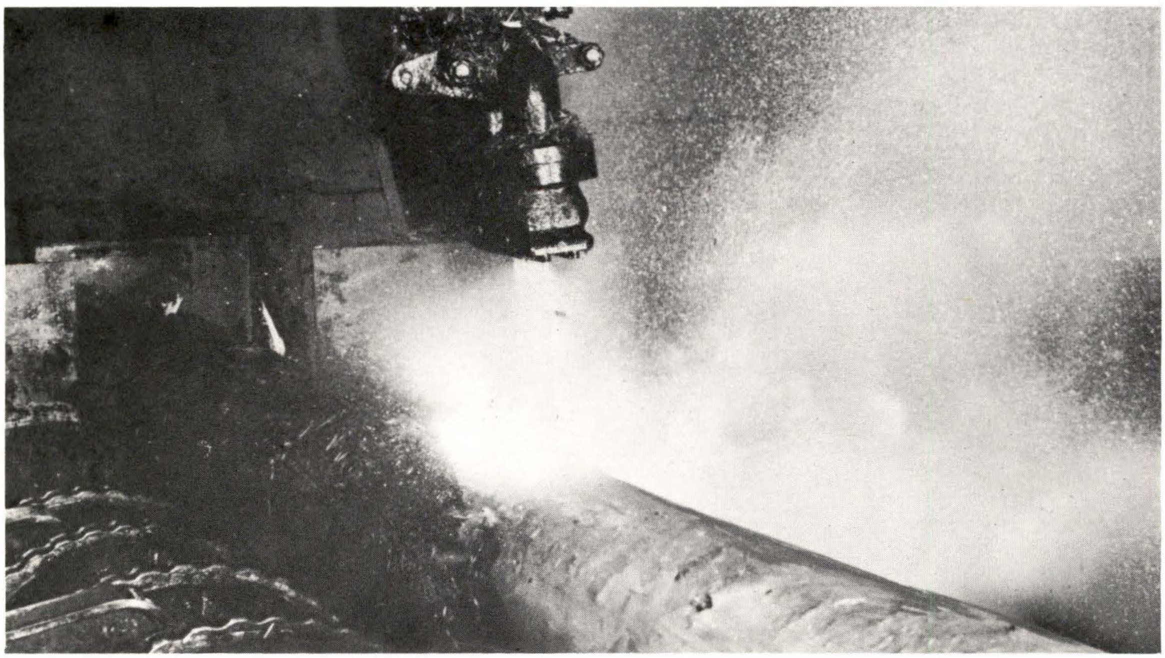


Photo IV-3. Hydraulic barkers produce waste water that is high in suspended solids, but water supplied to these devices must be as free as possible of such particles. (Weyerhaeuser Company Photo)

While it does not appear that waste loads sufficient to require flow regulation will exist in the Upper Subarea within the next two decades, it is probable that flow regulation required downstream will be accomplished in part from upstream storage. Flows for quality regulation might best be released from reservoirs other than Fern Ridge, where high summer temperature makes its waters less suitable for quality control needs than those of upstream reservoirs on the Middle Fork Willamette and on the McKenzie.

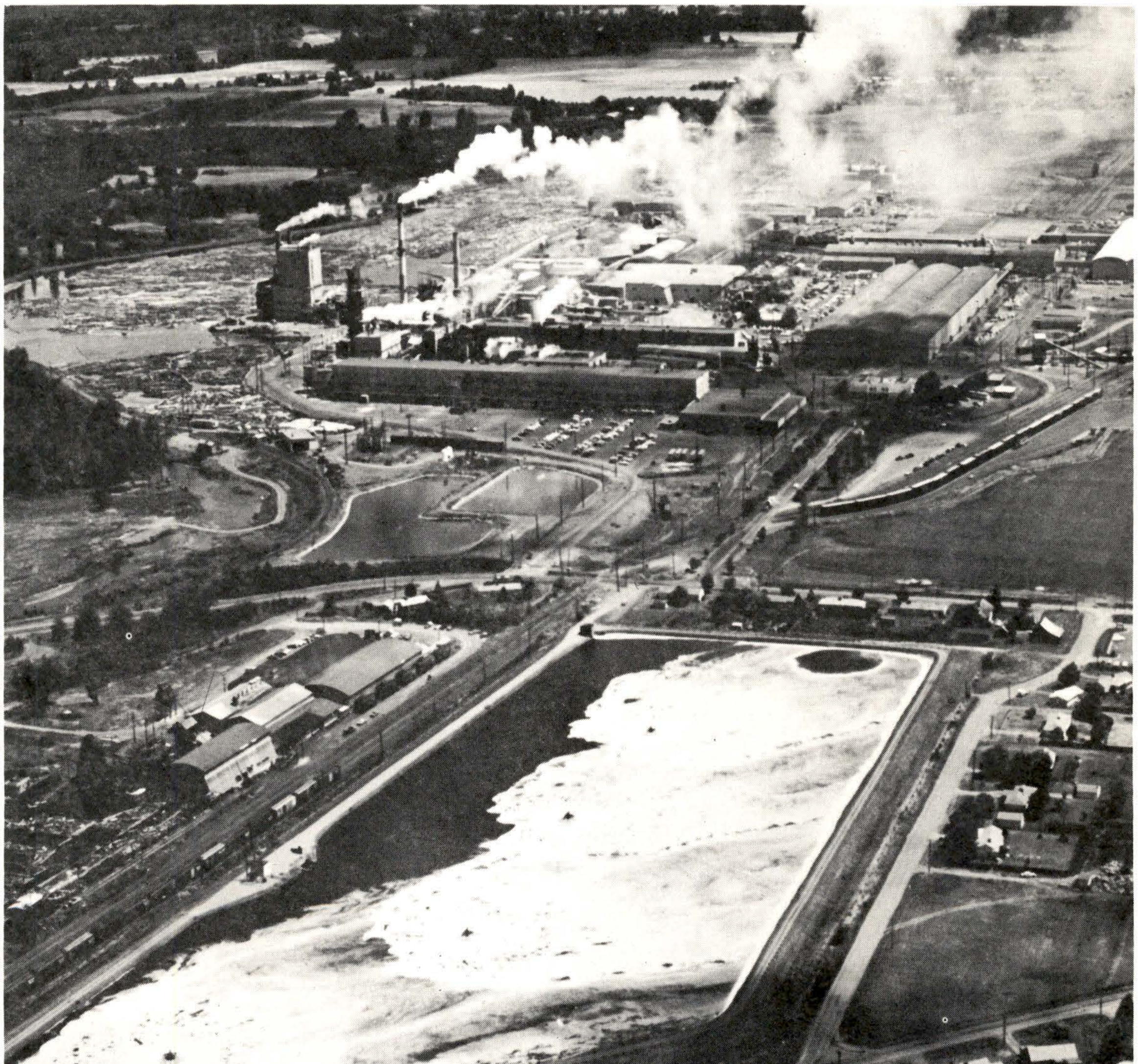


Photo IV-4. The Weyerhaeuser Pulp and Paper Mill in Springfield has one of the most effective on-site waste treatment systems in the basin. (Weyerhaeuser Company Photo)

Practices to control wastes provide a good opportunity to maintain the high water quality by passing it to downstream areas which would also benefit. Such practices include the application of soil conservation measures in agriculture and logging, and keeping animal herds away from the banks of streams. In the Eugene-Springfield area, considerable attention should be given to the effectiveness of waste disinfection, since the bacterial concentrations occurring below Eugene present the principal water quality problem in the Upper Subarea. Related to both soil conservation and disinfection is urban land drainage, which adds to both bacterial concentrations and turbidity. The present requirement of the DEQ for separation of storm-water and sanitary sewers should ultimately alleviate the pressure of urban drainage problems. Acceleration of this program through planned installation of separate storm-water sewers, particularly at Springfield, would probably benefit water quality of the main stem Willamette River.

Because of the generally high quality of the waters, it does not seem necessary to install an extensive water quality monitoring program in the Upper Subarea. The DEQ's program of monitoring the main stem and tributaries in the summer, combined with reservoir sampling and additional sampling when special situations indicate a need, seems adequate to assess the water quality in the subarea and its relation to quality modifications that may occur downstream.

M I D D L E   S U B A R E A

Maintenance of water quality sufficient to serve uses which occur in the Middle Subarea and restoration of the limited areas of degraded water quality are largely dependent on the initiation of superior waste treatment and control measures.

The overriding need in this regard is for facilities providing chemical recovery and secondary treatment by the pulp and paper mills at Salem, Lebanon, and Newberg. This should limit the major problems of pollution in the South Santiam and the degradation of water quality that occurs in the Willamette, especially at the Newberg pool.

Additional treatment requirements less significant to an immediate solution of Willamette water quality problems would represent needed additions to the pollution control facilities. These include provision of capabilities for evaporation and burning of pulping liquors at the Salem pulp mill; and enlargement of the Sweet Home, Mt. Angel, Dallas, and McMinnville waste treatment plants. The practice of treating both municipal and industrial wastes in a common waste treatment plant, well established in the subarea, is sound and should be continued where the seasonal quantities of the two types of waste are compatible.

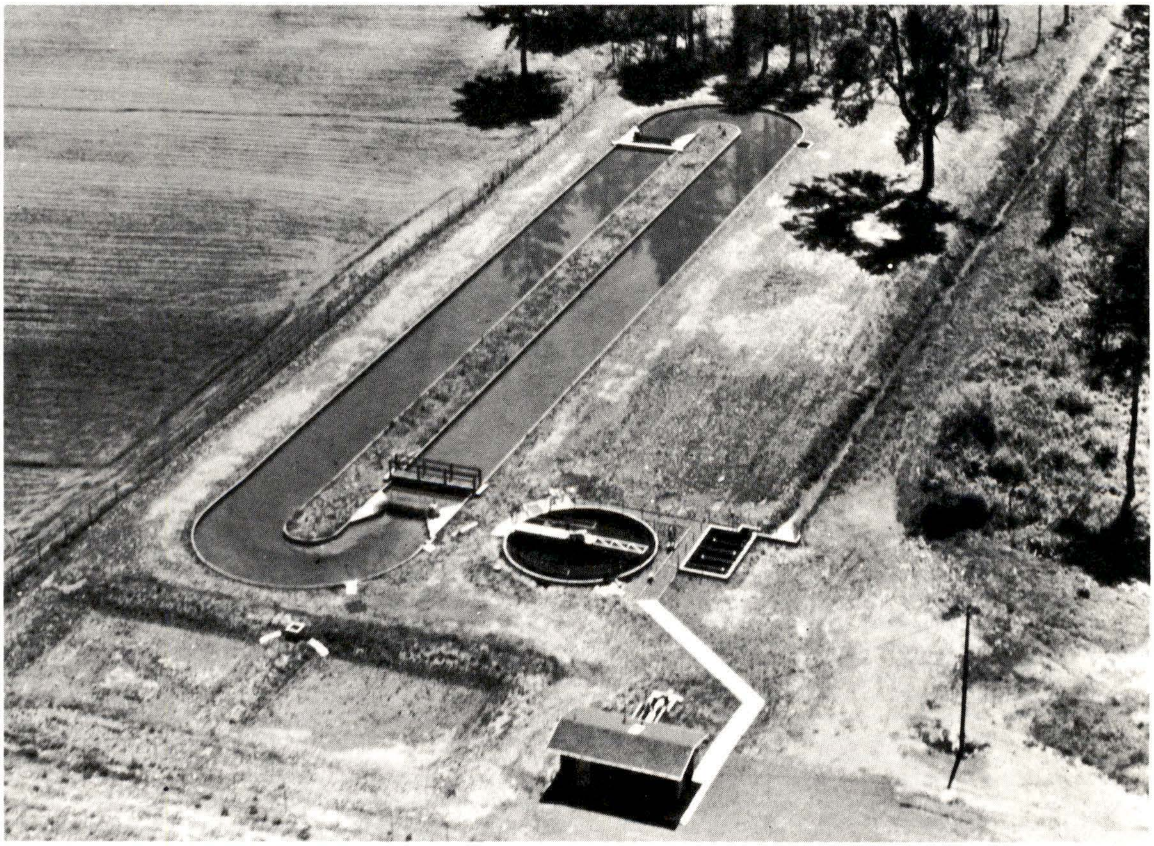


Photo IV-5. An oxidation ditch provides adequate secondary treatment for the City of Stayton. (Department of Environmental Quality, Portland, Oregon, Photo)

Photo IV-6. One of the mechanical aerators in operation at the Stayton treatment plant. (Department of Environmental Quality, Portland, Oregon, Photo)

At several points in the Middle Subarea, water quality can be distinctly improved by using reservoir storage to augment summer streamflows. Under the Federal Water Pollution Control Act, storage to provide such flow regulation can be made a function of Federal reservoirs when adequate waste treatment is practiced within the watershed.

Flow regulation for quality control is essential in the South Santiam from Lebanon to the mouth, in Rickreall Creek, and in the Pudding River from Mt. Angel to the mouth.

A problem of adequate flow quantities occurs in all of the streams used extensively as a source of irrigation water. There are, in many cases, sufficient flows at gaging points to provide the quality objectives set by fishery and waste assimilation needs. However, flows between gaging stations drop well below these levels because of irrigation withdrawals, and are then subsequently augmented by irrigation return flows. Therefore, if water quality is to be maintained, it is essential that base flows be established and protected against such withdrawals. A flow which is said to be required for quality control purposes must be considered as the minimum allowable flow throughout a reach of the river. In the Yamhill River, for example, a base flow of 35 cfs is necessary to meet water quality standards. Present flows generally remain above this level--except in the case of irrigation diversions. Increased irrigation, however, could result in a level of flow well below that necessary to provide a satisfactory dissolved oxygen level. It is essential, then, that any increase in irrigation resulting from completion of the U. S. Bureau of Reclamation's Red Prairie Project should not impinge upon summertime flows to the extent that they drop below 35 cfs.

Because of the widespread turbidity in Middle Subarea watercourses, measures to control erosion should be aggressively promoted. The natural turbidity due to bank caving and erosion by natural runoff may be controlled to some extent by channel improvements. Because of the prevalence of cultivated fields, agricultural practices which reduce wind and water erosion are of great importance to water quality. In headwaters, logging practices--particularly road construction--should be strictly regulated to control erosion. A system of procedural guarantees should be incorporated in all cutting contracts. On privately owned forest lands, it would be well to extend the authority of the DEQ to include inspection of logging practices. In addition, procedures employed in spreading fertilizers and chemical poisons should be carefully monitored by the DEQ; and the U. S. Department of Agriculture should diligently fulfill its responsibilities to determine optimum procedures and application rates for such materials.

Intimate knowledge of the river system and of wastes entering it is an essential part of controlling water quality. It is necessary that flows, waste loads, and water quality be regularly measured and analyzed. To provide sufficient knowledge of the Middle Subarea, the DEQ should continue its program of making spot summer samplings for water quality analyses and should begin measuring reservoir water quality. A water pollution surveillance system station should be established at Corvallis to measure the quality of the Willamette's waters further upstream than is now possible. Flow data for tributaries below Salem are inadequate for the intensive pollution control management that will become necessary as waste loads and the degree of flow regulation increase. Additional flow-gaging stations are needed on the Pudding, Molalla, and Yamhill Rivers.

L O W E R   S U B A R E A

Maintenance of water quality to serve the various uses in the Lower Subarea is largely a matter of providing better waste treatment and control, which must also be supported by flow regulation.

The Tualatin Subbasin is subject to unusually stringent treatment requirements. Although its wastes are currently reduced at least 90 percent by treatment, advanced waste treatment will ultimately be required to correct the severe quality degradation in the lower Tualatin River even with flow regulation. The Tualatin Basin Water and Sewerage Master Plan, recently developed by the consulting firm of Stevens, Thompson and Runyan, must be implemented by local authorities in an orderly manner as soon as possible. Any delay in beginning an orderly approach to solving the problems in the subbasin will result in progressively poorer water quality. Flow regulation for quality control must be an essential part of this plan if adequate dissolved oxygen levels are to be maintained in the lower reaches of the Tualatin.

Portland Harbor requires augmented summer flows to maintain 5 mg/l dissolved oxygen concentrations which are needed for fish passage. Under the DEQ's current policy of requiring basinwide secondary treatment for all wastes, a base flow of 6,000 cfs at Salem will maintain this objective under both present and projected 1985 waste-loading conditions. After 1985, additional treatment may be required if a higher base flow is not established. A total of 584,000 acre-feet of storage is needed to provide a base flow of 6,000 cfs at Salem and maintain an objective of 5 mg/l in the harbor. Such storage could be obtained from existing and planned Willamette Basin reservoirs.

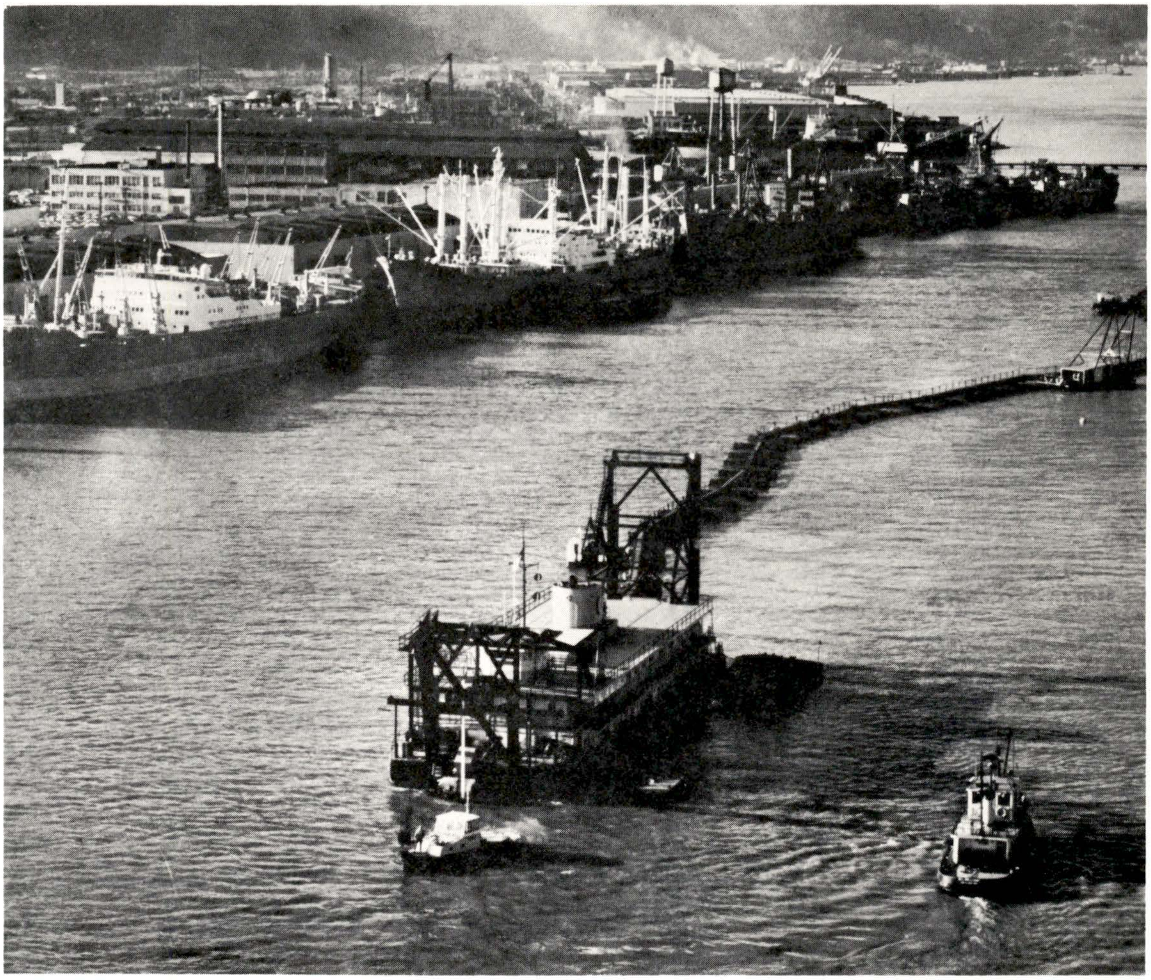


Photo IV-7. Dredging of sediment in Portland Harbor serves the twofold purpose of maintaining navigation channels and providing land fill. (Oregon State Office of Economic Development, Portland, Oregon, Photo)

Effective land management practices are particularly important in the Tualatin Subbasin, and measures to control erosion should be aggressively promoted throughout the Lower Subarea to reduce turbidity. The importance of agriculture in the Tualatin makes reduction of wind and water erosion a necessity, especially since irrigation return flows make up much of the existing streamflows. In the headwaters of all subarea tributaries, logging practices, particularly road construction, must be strictly regulated to control erosion.

Because the hydraulic characteristics of the Willamette River below Willamette Falls reduce the ability of the stream to assimilate wastes, expansion of industries with high volumes of organic wastes should be limited to reaches above Salem.

Urban runoff is more significant in the Lower Subarea than in other parts of the basin. Sewers in the Portland Service Area transmit combined sanitary and storm-water waste, which on occasion results in

PART V

CONCLUSIONS

CONCLUSIONS

As this interagency comprehensive planning effort nears completion, water quality in the Willamette Basin is generally better than it has been for several decades. Even during the course of preparation of this appendix, substantial improvement in water quality has occurred in a number of streams. This improvement has resulted basically from institution of higher levels of waste treatment by both municipalities and industries. The greatest benefit to improved water quality in the Willamette Basin that could come from the comprehensive study is the assurance of an adequate quantity of flow at all times down the Willamette main stem through Portland Harbor. The flows presented in Part IV are required to provide this assimilative capacity.

Presently, the Willamette River is considerably under-utilized for fishery, recreation, and aesthetic purposes. Lack of proper water quality contributes to this situation. As the demand grows in the future, the main stem Willamette and lower tributary reaches will have to provide an increasing portion of the resource supply for these functions, and a significant improvement in water quality will be required. Industries and municipalities are continuing to improve their waste treatment facilities, but upgrading alone will not insure adequate quality.

The existing Willamette Project of the Corps of Engineers, with its many reservoirs, was authorized to provide flood control, power, navigation flows, and irrigation storage. In the authorizing report, water quality and its associated flow requirements were recognized, and it was stated that the navigation flows of 6,000 cfs at Salem would also meet the water quality needs. Since that time, water quality management of the basin has been based upon the assurance of these flows to meet navigation requirements. In recent years, however, power regulation requirements during the summer have resulted in substantially lower flows, adversely affecting water quality and threatening portions of the anadromous fishery. Only through special meetings and on an interim basis when the problem becomes severe have the flows been increased to navigation levels which simultaneously meet water quality requirements.

This plan offers a logical opportunity to recognize water quality as a Willamette Project function and to make the water quality flow requirements an element of the system operation. This would not necessarily mean an unchanging summer flow release for future years. The desirable goal is to make water quality management one of the objectives of the operation team, with flows for water quality called for as needed in conformance with stages of economic growth and waste treatment technology. An estimate of the levels of these flows is given in the table in Part IV. Achieving this type of flexible, team approach, including the water quality function, offers considerable economic as well as non-quantifiable benefits. It means that a more efficient mix of treatment and other waste management measures can be utilized. It means heavier fishery and recreational use of the river. Making the river more aesthetically appealing will draw more people and will increase the value of the river to the state.

Another significant consideration that could affect water quality is land use and land use planning. The projected needs in this appendix were based upon the continued trend of haphazard expansion in the basin. Intelligent guidance of economic growth could be of great benefit to water quality. Location and expansion of large waste-producing industries in areas where their waste products can be accommodated by the environment are an obvious need. Growing discharge of wastes to the river in places where the river cannot assimilate or handle the wastes should not be allowed now that planning tools are available to predict this adverse condition. Uncontrolled urban sprawl with its associated development of inadequate septic tanks and multitudinous small treatment plants, normally inefficient because of inadequate operation, causes numerous problems for the Department of Environmental Quality. Here again, planning and guidance can provide an answer. Land use planning should assume a stronger role in basin-wide economic growth, and water quality management must be an integral part of that planning.

The water quality impact of the comprehensive study is presented in Appendix M--Plan Formulation.

PART VI

ADDENDUM

ADDENDUM

Division 1

WATER POLLUTION

Subdivision 1

STANDARDS OF QUALITY FOR PUBLIC WATERS OF OREGON AND DISPOSAL THEREIN OF SEWAGE AND INDUSTRIAL WASTES

[ED. NOTE: Unless otherwise specified sections 11-005 through 11-070 of this chapter of the Oregon Administrative Rules Compilation were adopted by the Sanitary Authority June 1, 1967, and filed with the Secretary of State June 1, 1967 as Administrative Order SA 26. Repeals Administrative Order SA 8.]

Statutory Authority: ORS 449.080; 449.086

11-005 DEFINITIONS. As used in this subdivision unless otherwise required by context:

(1) "Sewage" means the water-carried human or animal waste from residences, buildings, industrial establishments or other places together with such ground water infiltration and surface water as may be present. The admixture with sewage as above defined of industrial wastes or wastes, as defined in subsections (2) and (3) of this section, shall also be considered "sewage" within the meaning of this division.

(2) "Industrial waste" means any liquid, gaseous, radioactive or solid waste substance or a combination thereof resulting from any process of industry, manufacturing, trade or business, or from the development or recovery of any natural resources.

(3) "Wastes" means sewage, industrial wastes, and all other liquid, gaseous, solid, radioactive, or other substances which will or may cause pollution or tend to cause pollution of any waters of the state.

(4) "Pollution" means such contamination or other alteration of the physical, chemical or biological properties of any waters of the state, including change in temperature, taste, color, turbidity, silt or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive or other substance into any waters of the state which either by itself or in connection with any other substance present, will or can reasonably be expected to create a public nuisance or render such waters harmful, detrimental or injurious to public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational or other legitimate beneficial uses or to livestock, wildlife, fish or other aquatic life or the habitat thereof.

(5) "Waters of the state" include lakes, bays, ponds, impounding reservoirs, springs, wells, rivers, streams, creeks, estuaries, marshes, inlets, canals, the Pacific Ocean within the territorial limits of the State of Oregon and all other bodies of surface or underground waters, natural or artificial, inland or coastal, fresh or salt, public or private (except those private waters which do not combine or effect a junction with natural surface or underground waters), which are wholly or partially within or bordering the state or within its jurisdiction.

(6) "Marine waters" means all oceanic, offshore waters outside of estuaries or bays and within the territorial limits of the state of Oregon.

(7) "Estuarine waters" means all mixed fresh and oceanic waters in estuaries or bays from the point of oceanic water intrusion inland to a line connecting the outermost points of the headlands or protective jetties.

(8) "Standard" or "standards" means such measure of quality or purity for any waters in relation to their reasonable and necessary use as may be established by the Sanitary Authority pursuant to ORS Chapter 449.

(9) "Fish and other aquatic life" means all beneficial fishes, crustacea, mollusks, plankton, higher aquatic plants, and waterfowl.

11-010 HIGHEST AND BEST PRACTICABLE TREATMENT AND CONTROL REQUIRED. Notwithstanding the general and special water quality standards contained in this subdivision, the highest and best practicable treatment and/or control of wastes, activities and flows shall in every case be provided so as to maintain dissolved oxygen and overall water quality at the highest possible levels and water temperatures, coliform bacteria concentrations, dissolved chemical substances, toxic materials, radioactivity, turbidities, color, odor and other deleterious factors at the lowest possible levels.

11-015 RESTRICTIONS ON THE DISCHARGE OF SEWAGE AND INDUSTRIAL WASTES AND HUMAN ACTIVITIES WHICH AFFECT WATER QUALITY IN THE WATERS OF THE STATE. No wastes shall be discharged and no activities shall be conducted such that said wastes or activities either alone or in combination with other wastes or activities will violate or can reasonably be expected to violate, any of the general or special water quality standards contained in this subdivision.

11-020 MAINTENANCE OF STANDARDS OF QUALITY. (1) The degree of waste treatment required to restore and maintain the above standards of quality shall be determined in each instance by the State Sanitary Authority and shall be based upon the following:

(a) The uses which are or may likely be made of the receiving stream.

(b) The size and nature of flow of the receiving stream.

(c) The quantity and quality of the sewage or wastes to be treated, and

(d) The presence or absence of other sources of pollution on the same watershed.

(2) All sewage shall receive a minimum of secondary treatment or equivalent (equal to at least 85% removal of 5-day biochemical oxygen demand and suspended solids) and shall be effectively disinfected before being discharged into any public waters of the state.

11-025 GENERAL WATER QUALITY STANDARDS. The following General Water Quality Standards shall apply to all waters of the state except where they are clearly superseded by Special Water Quality Standards applicable to specifically designated waters of the state. No wastes shall be discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause in any waters of the state:

(1) The dissolved oxygen content of surface waters to be less than six (6) milligrams per liter unless specified otherwise by special standard.

(2) The hydrogen-ion concentration (pH) of the waters to be outside the range of 6.5 to 8.5 unless specified otherwise by special standard.

(3) The liberation of dissolved gases, such as carbon-dioxide, hydrogen sulfide or any other gases, in sufficient quantities to cause objectionable odors or to be deleterious to fish or other aquatic life, navigation, recreation, or other reasonable uses made of such waters.

(4) The development of fungi or other growths having a deleterious effect on stream bottoms, fish or other aquatic life, or which are injurious to health, recreation or industry.

(5) The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life or affect the potability of drinking water or the palatability of fish or shellfish.

(6) The formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation or industry.

(7) Objectionable discoloration, turbidity, scum, oily sleek or floating solids, or coat the aquatic life with oil films.

(8) Bacterial pollution or other conditions deleterious to waters used for domestic purposes, livestock watering, irrigation, bathing, or shellfish propagation, or be otherwise injurious to public health.

(9) Any measurable increase in temperature when the receiving water temperatures are 64° F. or above, or more than 2° F. increase when receiving water temperatures are 62° F. or less.

(10) Aesthetic conditions offensive to the human senses of sight, taste, smell or touch.

(11) Radioisotope concentrations to exceed Maximum Permissible Concentra-

7-1-67

tions (MPC's) in drinking water, edible fishes or shellfishes, wildlife, irrigated crops, livestock and dairy products or pose an external radiation hazard.

11-030 BENEFICIAL USES OF WATERS TO BE PROTECTED BY SPECIAL WATER QUALITY STANDARDS. The Special Water Quality Standards contained in this subdivision are adopted for the purpose of protecting, together with pertinent general water quality standards, the beneficial uses of specified waters of the state as set forth in Table A and to conserve the waste assimilative capacity of the waters so as to accommodate maximum development and utilization of the resources of the state.

11-035 SPECIAL WATER QUALITY STANDARDS FOR PUBLIC WATERS OF GOOSE LAKE IN LAKE COUNTY. The provisions of this section shall be in addition to and not in lieu of the General Water Quality Standards contained in Section 11-025, except where this section imposes a conflicting requirement with the provisions of Section 11-025, this section shall govern. No wastes shall be discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause in the waters of Goose Lake:

(1) Dissolved Oxygen. (DO). DO concentrations to be less than 7 milligrams per liter.

(2) Organisms of the Coliform Group Where Associated with Fecal Sources. (MPN or equivalent MF using a representative number of samples). Average concentrations of coliform bacteria to exceed 1000 per 100 ml, with 20% of samples not to exceed 2400 per 100 ml.

(3) Hydrogen Ion Concentration. (pH). pH values to be outside the range of 7.5 to 9.5.

(4) Temperature. Daily average temperatures to exceed 70° F. or the daily mean ambient air temperature, whichever is greater.

11-040 SPECIAL WATER QUALITY STANDARDS FOR PUBLIC WATERS OF THE MAIN STEM KLAMATH RIVER. The provisions of this section shall be in addition to and not in lieu of the General Water Quality Standards contained in Section 11-025, except where this section imposes a conflicting requirement with the provisions of Section 11-025, this section shall govern. No wastes shall be discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause in the waters of the Klamath River:

(1) Dissolved Oxygen. (DO).

(a) (Main stem Klamath River from Klamath Lake to Keno Regulating Dam located approximately 16 river miles above the Oregon-California border). DO concentrations of surface waters to be less than 5 milligrams per liter unless caused by natural conditions.

(b) (Main stem Klamath River from Keno Regulating Dam to Oregon-California border). DO concentrations to be less than 7 milligrams per liter.

(2) Organisms of the Coliform Group Where Associated with Fecal Sources. (MPN or equivalent MF using a representative number of samples). Average concentrations of coliform bacteria to exceed 1000 per 100 ml, with 20% of samples not to exceed 2400 per 100 ml.

(3) Turbidity. (Jackson Turbidity Units, JTU). Turbidities to exceed 5 JTU above natural background values except for certain short-term activities which may be specifically authorized by the Sanitary Authority under such conditions as it may prescribe and which are necessary to accommodate essential dredging or construction where turbidities in excess of this standard are unavoidable.

(4) Temperature. Any measurable increase when river temperatures are 72° F. or above, or more than 2° F. cumulative increase when river temperatures are 70° F. or less.

(5) Dissolved Chemical Substances. (Main stem Klamath River at the Oregon-California border). Conductivity to exceed 400 micromhos at 77° F.

(6) Hydrogen Ion Concentration. (pH). pH values to be outside the range of 7.0 to 9.0.

11-045 SPECIAL WATER QUALITY

STANDARDS FOR THE PUBLIC WATERS OF MULTNOMAH CHANNEL AND THE MAIN STEM WILLAMETTE RIVER. The provisions of this section shall be in addition to and not in lieu of the General Water Quality Standards contained in Section 11-025, except where this section imposes a conflicting requirement with the provisions of Section 11-025, this section shall govern. No wastes shall be discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause in the waters of Multnomah Channel or the Willamette River:

(1) Dissolved Oxygen. (DO).

(a) (Multnomah Channel and main stem Willamette River from mouth to the Willamette Falls at Oregon City, river mile 26.6). DO concentrations to be less than 5 milligrams per liter.

(b) (Main stem Willamette River from the Willamette Falls to Newberg, river mile 50). DO concentrations to be less than 6 milligrams per liter.

(c) (Main stem Willamette River from Newberg to Salem, river mile 85). DO concentrations to be less than 7 milligrams per liter.

(d) (Main stem Willamette River from Salem to confluence of Coast and Middle Forks, river mile 187). DO concentrations to be less than 90% of saturation.

(2) Organisms of the Coliform Group Where Associated with Fecal Sources. (MPN or equivalent MF using a representative number of samples). Average concentrations of coliform bacteria to exceed 1000 per 100 ml, with 20% of samples not to exceed 2400 per 100 ml.

(3) Turbidity. (Jackson Turbidity Units, JTU). Turbidities to exceed 5 JTU above natural background values except for certain short-term activities which may be specifically authorized by the Sanitary Authority under such conditions as it may prescribe and which are necessary to accommodate essential dredging or construction where turbidities in excess of this standard are unavoidable.

(4) Temperature.

(a) (Multnomah Channel and main stem Willamette River from mouth to Newberg, river mile 50.) Any measurable increase when river temperatures are 70° F. or above, or more than 2° F. increase when river temperatures are 68° F. or less.

(b) (Main stem Willamette River from Newberg to confluence of Coast and Middle Forks, river mile 187). Any measurable increase when river temperatures are 64° F. or above, or more than 2° F. increase when the river temperatures are 62° F. or less.

(5) Dissolved Chemical Substances. Guide concentrations listed below to be exceeded except as may be specifically authorized by the Sanitary Authority upon such conditions as it may deem necessary to carry out the general intent of Section 11-010 of this subdivision and to protect the beneficial uses set forth in Table A.

	mg/l
Arsenic (As)	0.01
Barium (Ba)	1.0
Boron (Bo)	0.5
Cadmium (Cd)	0.01
Chloride (Cl)	25.
Chromium (Cr)	0.05
Copper (Cu)	0.005
Cyanide (CN)	0.01
Fluoride (F)	1.0
Iron (Fe)	0.1
Lead (Pb)	0.05
Manganese (Mn)	0.05
Phenols (totals)	0.001
Total dissolved solids	100.
Zinc (Zn)	0.1
Heavy metals (Totals including Cu, Pb, Zn, and others of non-specific designation)	0.5

11-050 SPECIAL WATER QUALITY STANDARDS FOR THE PUBLIC WATERS OF THE MAIN STEM OF THE COLUMBIA RIVER FROM THE EASTERN OREGON-WASHINGTON BORDER WESTWARD TO THE PACIFIC OCEAN. The provisions of this section shall be in addition to and not in lieu of the General Water Quality Standards contained in Section 11-025, except where this section imposes a conflicting requirement with the provisions of Section 11-025, this section shall govern. No wastes shall be

7-1-67

discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause in the waters of the Columbia River:

(1) Dissolved Oxygen. (DO). DO concentrations to be less than 90% of saturation.

(2) Organisms of the Coliform Group where Associated with Fecal Sources. (MPN or equivalent MF using a representative number of samples).

(a) (From the eastern Oregon-Washington boundary downstream to the Interstate Highway 5 bridge between Vancouver, Washington, and Portland, Oregon). Average concentrations of coliform bacteria to exceed 240 per 100 milliliters or to exceed this value in more than 20 percent of the samples.

(b) (From the Interstate Highway 5 bridge between Vancouver, Washington, and Portland, Oregon, to the mouth). Average concentrations of coliform bacteria to exceed 1000 per 100 milliliters, with 20 percent of the samples not to exceed 2400 per 100 milliliters.

(3) Turbidity. (Jackson Turbidity Units, JTU). Turbidities to exceed 5 JTU above natural background values except for certain short-term activities which may be specifically authorized by the Sanitary Authority under such conditions as it may prescribe and which are necessary to accommodate essential dredging or construction where turbidities in excess of this standard are unavoidable.

(4) Hydrogen-Ion Concentration. pH values to fall outside the range of 7.0 to 8.5.

(5) Temperature. Any measurable increase when river temperatures are 68° F. or above, or more than 2° F. increase when river temperatures are 66° F. or less.

(6) Dissolved Chemical Substances. (Above the zone of marine water intrusion, approximate river mile 40). Guide concentrations listed below to be exceeded except as may be specifically authorized by the Sanitary Authority upon such conditions as it may deem necessary to carry out the general intent of Section 11-010 of this subdivision and to protect the beneficial uses set forth in Table A.

	mg/l
Arsenic (As)	0.01
Barium (Ba)	1.0
Boron (Bo)	0.5
Cadmium (Cd)	0.01
Chloride (Cl)	30.
Chromium (Cr)	0.05
Copper (Cu)	0.005
Cyanide (CN)	0.01
Fluoride (F)	1.0
Iron (Fe)	0.1
Lead (Pb)	0.05
Manganese (Mn)	0.05
Phenols (totals)	0.001
Total dissolved solids	200.
Zinc (Zn)	0.1
Heavy metals (Totals including Cu, Pb, Zn, and others of non-specific designation)	0.5

11-055 SPECIAL WATER QUALITY STANDARDS FOR THE PUBLIC WATERS OF THE MAIN STEM OF THE GRANDE RONDE RIVER. The provisions of this section shall be in addition to and not in lieu of the General Water Quality Standards contained in Section 11-025, except where this section imposes a conflicting requirement with the provisions of Section 11-025, this section shall govern. No wastes shall be discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause in the waters of the Grande Ronde River:

(1) Dissolved Oxygen.(DO). DO concentrations to be less than 75% of saturation at seasonal low or less than 95% of saturation in spawning areas during spawning, hatching, and fry stages of salmonid fishes.

(2) Organisms of the Coliform Group where Associated with Fecal Sources. (MPN or equivalent MF using a representative number of samples). Average concentrations of coliform bacteria to exceed 1000 per 100 milliliters, with 20% of these samples not to exceed 2400 per 100 milliliters.

(3) Turbidity. (Jackson Turbidity Units, JTU). Turbidities to exceed 5 JTU above natural background values except for certain short-term activities which may be specifically authorized by the

Sanitary Authority under such conditions as it may prescribe and which are necessary to accommodate essential dredging or construction where turbidities in excess of this standard are unavoidable.

(4) Temperature. Any measurable increase when river temperatures are 68° F. or above, or more than 2° F. increase when river temperatures are 66° F. or less.

(5) Dissolved Chemical Substances. Guide concentrations listed below to be exceeded except as may be specifically authorized by the Sanitary Authority upon such conditions as it may deem necessary to carry out the general intent of Section 11-010 of this subdivision and to protect the beneficial uses set forth in Table A.

	mg/l
Arsenic (As)	0.01
Barium (Ba)	1.0
Boron (Bo)	0.5
Cadmium (Cd)	0.01
Chloride (Cl)	25.
Chromium (Cr)	0.05
Copper (Cu)	0.005
Cyanide (CN)	0.01
Fluoride (F)	1.0
Iron (Fe)	0.1
Lead (Pb)	0.05
Manganese (Mn)	0.05
Phenols (totals)	0.001
Total dissolved solids	200.
Zinc (Zn)	0.1
Heavy metals (Totals including Cu, Pb, Zn, and others of non-specific designation)	0.5

11-060 WATER QUALITY STANDARDS FOR THE PUBLIC WATERS OF THE MAIN STEM OF THE WALLA WALLA RIVER. The provisions of this section shall be in addition to and not in lieu of the General Water Quality Standards contained in Section 11-025, except where this section imposes a conflicting requirement with the provisions of Section 11-025, this section shall govern. No wastes shall be discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause in the waters of the Walla Walla River:

(1) Dissolved Oxygen.(DO). DO concentrations to be less than 75% of saturation at seasonal low or less than 95% of saturation in spawning areas during spawning, hatching, and fry stages of salmonid fishes.

(2) Organisms of the Coliform Group where Associated with Fecal Sources. (MPN or equivalent MF using a representative number of samples). Average concentrations of coliform bacteria to exceed 1000 per 100 milliliters, with 20% of these samples not to exceed 2400 per 100 milliliters.

(3) Turbidity. (Jackson Turbidity Units, JTU). Turbidities to exceed 5 JTU above natural background values except for certain short-term activities which may be specifically authorized by the Sanitary Authority under such conditions as it may prescribe and which are necessary to accommodate essential dredging or construction where turbidities in excess of this standard are unavoidable.

(4) Temperature. Any measurable increase when river temperatures are 68° F. or above, or more than 2° F. increase when river temperatures are 66° F. or less.

(5) Dissolved Chemical Substances. Guide concentrations listed below to be exceeded except as may be specifically authorized by the Sanitary Authority upon such conditions as it may deem necessary to carry out the general intent of Section 11-010 of this subdivision and to protect the beneficial uses set forth in Table A.

	mg/l
Arsenic (As)	0.01
Barium (Ba)	1.0
Boron (Bo)	0.5
Cadmium (Cd)	0.01
Chloride (Cl)	25.
Chromium (Cr)	0.05
Copper (Cu)	0.005
Cyanide (CN)	0.01
Fluoride (F)	1.0
Iron (Fe)	0.1
Lead (Pb)	0.05
Manganese (Mn)	0.05
Phenols (totals)	0.001
Total dissolved solids	200.
Zinc (Zn)	0.1
Heavy metals (Totals	0.5

including Cu, Pb, Zn, and others of non-specific designation)

11-065 WATER QUALITY STANDARDS FOR THE MAIN STEM OF THE SNAKE RIVER IN AND ADJACENT TO OREGON. The provisions of this section shall be in addition to and not in lieu of the General Water Quality Standards contained in Section 11-025, except where this section imposes a conflicting requirement with the provisions of Section 11-025, this section shall govern. No wastes shall be discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause in the waters of the Snake River:

(1) Dissolved Oxygen. (DO). DO concentrations of surface waters to be less than 75% of saturation at seasonal low or less than 95% of saturation in spawning areas during spawning, hatching, and fry stages of salmonid fishes.

(2) Organisms of the Coliform Group where Associated with Fecal Sources. (MPN or equivalent MF using a representative number of samples). Average concentrations of coliform bacteria to exceed 1000 per 100 ml, with 20% of samples not to exceed 2400 per 100 ml.

(3) Turbidity. (Jackson Turbidity Units, JTU). Turbidities to exceed 5 JTU above natural background values except for certain short-term activities which may be specifically authorized by the Sanitary Authority under such conditions as it may prescribe and which are necessary to accommodate essential dredging or construction where turbidities in excess of this standard are unavoidable.

(4) Temperature. Any measurable increase when river temperatures are 70° F. or above, or more than 2° F. increase when river temperatures are 68° F. or less.

(5) Dissolved Chemical Substances. Guide concentrations listed below to be exceeded except as may be specifically authorized by the Sanitary Authority upon such conditions as it may deem necessary to carry out the general intent of Section 11-010 of this subdivision and to protect the beneficial uses set forth in Table A.

	mg/l
Arsenic (As)	0.01
Barium (Ba)	1.0
Boron (Bo)	0.5
Cadmium (Cd)	0.01
Chloride (Cl)	50.
Chromium (Cr)	0.05
Copper (Cu)	0.005
Cyanide (CN)	0.01
Fluoride (F)	1.0
Iron (Fe)	0.1
Lead (Pb)	0.05
Manganese (Mn)	0.05
Phenols (totals)	0.001
Total dissolved solids	750.
Zinc (Zn)	0.1
Heavy metals (Totals including Cu, Pb, Zn, and others of non-specific designation)	0.5

(6) Hydrogen-Ion Concentration. (pH). pH values to fall outside the range of 7.0 to 9.0.

11-070 WATER QUALITY STANDARDS FOR THE MARINE AND ESTUARINE WATERS OF OREGON (excluding estuarine waters of the Columbia River). The provisions of this section shall be in addition to and not in lieu of the General Water Quality Standards contained in Section 11-025, except where this section imposes a conflicting requirement with the provisions of Section 11-025, this section shall govern. No wastes shall be discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause in marine or estuarine waters:

(1) Dissolved Oxygen. (DO). (Outside of zones of upwelled marine waters naturally deficient in DO). DO concentrations to be less than 6 milligrams per liter for estuarine waters, or less than saturation concentrations for marine waters.

(2) Organisms of the Coliform Group. (MPN or equivalent MF using a representative number of samples).

(a) (For marine and shellfish growing waters). The median concentration of coliform bacteria of sewage origin to exceed 70 per 100 milliliters.

(b) (For estuarine waters other than in shellfish growing areas). Average concentrations of coliform bacteria, where associated with fecal sources, to exceed 240 per 100 ml or to exceed this value in more than 20% of samples.

(3) Hydrogen Ion Concentration (pH). pH values to be outside the range of 7.0 and 8.5 over shellfish growing areas.

(4) Turbidity. (Jackson Turbidity Units JTU.) Turbidities to exceed 5 JTU above natural background values except for certain short-term activities which may be specifically authorized by the Sanitary Authority under such conditions as it may prescribe and which are necessary to accommodate essential dredging or construction where turbidities in excess of this standard are unavoidable.

(5) Temperature. Any significant increase above natural background temperatures, or water temperatures to be altered to a degree which creates or can reasonably be expected to create an adverse effect on fish or other aquatic life.

11-075 IMPLEMENTATION AND ENFORCEMENT PLAN. The Implementation and Enforcement Plan for the Public Waters of the State of Oregon, a copy of which is attached hereto and by this reference made a part hereof, is hereby adopted and prescribed by the Oregon State Sanitary Authority.

Hist: Filed 6-19-67 as SA 27

[ED. NOTE: Pursuant to ORS 183.360 (3), the Implementation and Enforcement Plan for the Public Waters of the State of Oregon is not published in the Oregon Administrative Rules Compilation. Copies may be obtained from the Secretary of State as provided by ORS 183.050].

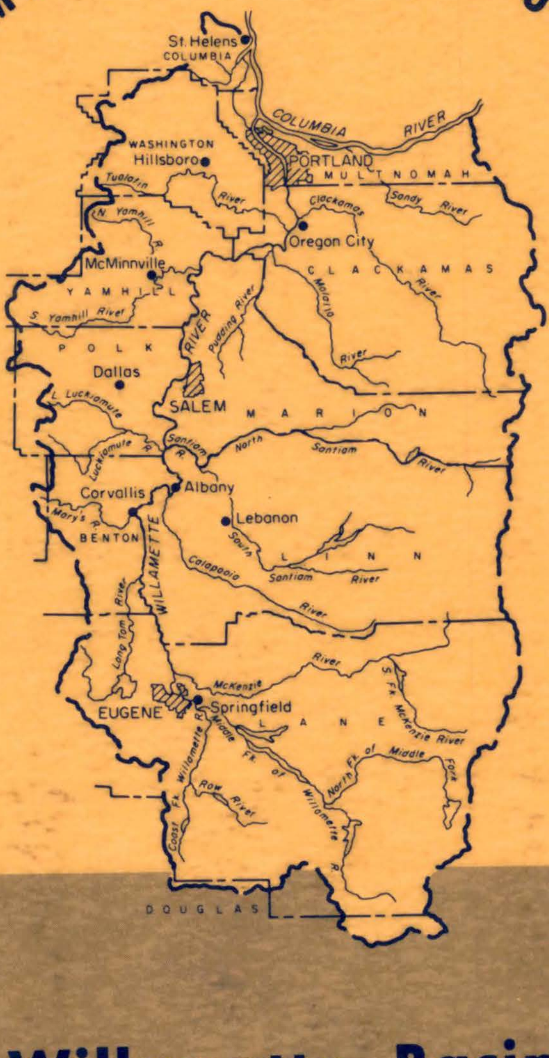
TABLE A

BENEFICIAL USES TO BE PROTECTED

	Domestic Water Supply (1)	Industrial Water Supply (1)	Irrigation	Livestock Watering	Anadromous Fish Passage	Salmonid Fish Rearing	Salmonid Fish Spawning	Resident fish and other Aquatic life	Hunting and Wilflife	Fishing	Water Skiing & Swimming	Pleasure Boating	Aesthetic Qualities	Navigation
GOOSE LAKE				X		X		X	X	X	X	X	X	
GRANDE RONDE RIVER	X	X	X	X	X	X	X	X	X	X	X	X	X	
WALLA WALLA RIVER	X	X	X	X	X	X	X	X	X	X	X	X	X	
SNAKE RIVER	X	X	X	X	X(2)	X	X	X	X	X	X	X	X	
COLUMBIA RIVER	X	X	X	X	X	X	X	X	X	X	X	X	X	X
KLAMATH RIVER														
(Klamath Lake to Keno Regulating Dam)	X(3)	X	X	X				X	X	X	X	X	X	
(Keno Regulating Dam to California Border)	X(3)	X	X	X		X	X	X	X	X	X	X	X	
WILLAMETTE RIVER														
(Mouth to Willamette Falls incl. Mult. Channel)	X(4)	X	X	X	X	X		X	X	X	X(5)	X	X	X
(Willamette Falls to Newberg)	X	X	X	X	X	X		X	X	X	X	X	X	X
(Newberg to Salem)	X	X	X	X	X	X	X	X	X	X	X	X	X	X
(Salem to Coast Fork)	X	X	X	X	X	X	X	X	X	X	X	X	X	
MARINE AND ESTUARINE		X			X	X		X	X	X	X	X	X	X

(1) With adequate pre-treatment
(2) Up to Oxbow Dam (River mile 273)
(3) By agreement of Klamath Compact Commission
(4) If no better source is reasonably attainable
(5) Not to conflict with commercial activities in Portland Harbor

COMPREHENSIVE STUDY



Willamette Basin

USDA-SCS-PORTLAND, OREG. 1968
WBTF-X-1040-L