

THE QUALITY OF OREGON'S WATER RESOURCES

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Foreword

The information contained in this publication, The Quality of Oregon's Water Resources, is essentially the same as presented in the report, Environmental Quality in Oregon, 1971. The latter publication was a status report prepared by the Governor's Advisory Committee on Environmental Science and Technology. Most of the information in the status report adapted for this publication was contained in Chapter 2, Water Quality in Oregon.

Chapter 2 of the status report was written and adapted for this report by Robert Alexander, Director of the Water Resources Research Institute at Oregon State University. Much of the information in Chapter 2 of the status report and in this publication was provided by the state Department of Environmental Quality (DEQ). Kenneth Spies, Director of DEQ and a member of the Governor's Advisory Committee, along with DEQ personnel Jack Weathersbee and Glen Carter, participated fully in preparation and review of the material. Oregon State University personnel contributing through assisting in preparation of sections of the report or by review and revision included John Byrne, Head, Department of Oceanography; George Brown, Forest Biologist; John Donaldson, Limnologist; Gerald Davis, Fisheries Biologist; Frank Schaumburg, Sanitary Engineer; Michael Soderquist, Sanitary Engineer; Chih Wang, Director, Institute of Nuclear Science and Engineering; James Witt, Executive Secretary, Environmental Health Sciences Center; and Roy Young, Vice President for Research and Graduate Studies.

This publication is designed to be helpful to those interested in the problems of improving Oregon's water resources. It describes the current pollution sources, considers the effects of this pollution on receiving waters, discusses the principal abatement methods being used, and reviews the progress being made in abatement programs. The final pages briefly outline those problems which are expected to be most troublesome in the future.

WATER QUALITY IN OREGON

The quality of water in a stream or other body of water can be impaired by adding pollutants, including heat, or by withdrawing water. A lower quantity of water reduces dilution capacity for a given volume of pollutants. Increasingly stringent regulations have been imposed to decrease the amount of waste discharge. Withdrawal has not, in the past, generally been a factor of equal concern in regard to maintenance of water quality. The water quality-quantity relation is of most significance in western Oregon due to the poor seasonal distribution of rainfall in this region. Streamflows are drastically reduced in the dry summer months. Some smaller streams dry up entirely. In a few, the major flow comes from sewage and industrial water releases. Flow is augmented materially in a number of streams by water released from upstream dams. During the summer period, around 40 percent of the normal flow of the Willamette River in its middle reaches is water released from storage reservoirs.

The gross water pollution problem associated with sewage, pulp mill and other large sources of organic wastes, which motivated Oregonians in 1938 to establish a water quality enforcement program, is rapidly coming under control. Other problems which caused concern in the past, including siltation, toxic industrial releases, and pathogens from raw sewage are likewise being abated. The year 1972 is regarded as the bench-mark year for completing the task of bringing these gross and obvious water pollutants under control. The task after 1972 will be to maintain this control program and attack the increasing number of small contributors. Some of these small contributors are new and result from the introduction of new science-based technologies.

The principal forces that will bear on the maintenance of water quality in the future include an increasing population with associated economic development; withdrawal of water from streams, particularly for irrigation during low-flow periods, resulting in reduction of their dilution and assimilative capacities; and further demands for multiple uses of Oregon's water resources.

NATURE OF OREGON'S SIGNIFICANT WATER QUALITY PROBLEMS

Organic Wastes, Nutrients, and Oxygen Depletion

The water quality problem which has received principal attention in Oregon since the state enforcement program was established in 1938 has been the discharge of organic wastes and the resultant depletion of dissolved oxygen. The Willamette River and its tributaries have been the focus of most of the attention. In the late 1930's, the problem had reached the critical stage of complete oxygen depletion in the Portland Harbor during the low-flow summer period. Aspects of the problem were foul odors from anaerobic conditions, obnoxious floating sludge rafts, and destruction of fish and other aquatic species of economic importance.

Organic Waste Breakdown: The breakdown of organic matter is a natural and continuing process in the water environment as well as in land and air environments. It is nature's way of "treating" organic wastes. Certain levels of organic material are needed to keep the stream productive, but excessive levels are harmful. When organic material enters a stream or other water body, organisms--principally bacteria--start immediately to break the material into its components--principally nitrates, phosphates and simple carbon compounds. In the presence of free oxygen the breakdown process is aerobic, with this dissolved oxygen (DO) used in respiration by aquatic organisms, including the bacteria that break down the organic wastes. The extent to which the oxygen is used depends upon the amount and potency of the organic material, as assessed by its biochemical oxygen demand (BOD). A second stage in the breakdown process, in which oxygen is again consumed, is nitrification. The nitrogen from the organic material, primarily ammonia, is first changed to the nitrite form then to a nitrate.

If the amount of organic material is high, dissolved oxygen may be exhausted. As this occurs the degradation process becomes anaerobic. Anaerobic bacteria use chemically incorporated, rather than dissolved oxygen. Gases such as methane and hydrogen sulphide with its foul odor are released. Fish and other aquatic life requiring oxygen are harmed in an anaerobic breakdown. Water temperature and the presence of toxic substances can have a bearing on the breakdown process. Toxic substances can harm the bacteria and other organisms which break down organic materials. High water temperatures accelerate breakdown and oxygen depletion and reduce the ability of water to retain dissolved oxygen. Thus, during the summer when air temperatures are high, pollution from organic wastes becomes more critical. Unfortunately, high air temperatures coincide with periods of low streamflow and with removal of high volumes of water for domestic and irrigation use.

The Regeneration Problem: Another aspect of the organic waste problem is that of regeneration of organic material within the body of water itself. The nitrogen, phosphorus, and other plant nutrients, available either through the decomposition of organic materials, through direct nutrient discharge from outfalls, or via land runoff, enrich water bodies and foster plant growth. Lower plant forms such as algae as well as rooted plants may flourish, and animal life then develops to feed on the plant life. As the newly produced plant and animal life die, a new source of organic material is created. If amounts become excessive, an organic pollution problem and loss of dissolved oxygen results.

Significant progress has been made in Oregon in reducing the amount of organic matter released, particularly in the Willamette River system. Substantial abatement has been effected in each of the three major problem sources; domestic sewage, pulp and paper mill wastes and food processing

wastes. With reductions in direct organic release, however, release of nutrients from the decomposition process in waste treatment has become more significant. And, this problem will grow proportionately as population and industrial activity increase. The only solution will be advanced or tertiary treatment in which the nutrient materials (as well as such other materials as exotic chemicals) are removed before the effluent is released into the environment. Such a step will be very costly. As a rule of thumb, tertiary treatment to remove essentially all nutrient material will cost three to five times as much as present secondary treatment. The waste water treatment plant at Lake Tahoe in California is such a tertiary plant.

Other nutrient sources for the regeneration of organic materials come from the direct discharge of nutrient materials by certain industrial plants, from phosphorus-containing detergents in sewage, by return flow of irrigation water containing nutrients, by runoff, air transport, and seepage from animal production facilities such as feedlots, and by run-off from urban developments such as streets and parking lots. An example of nutrient release is the substantial volume of ammonia which has been discharged into the Willamette River from industrial operations in the Albany area. A fertilizer production facility being operated by the Wah Chang Albany Corporation has helped materially in reducing this nutrient source.

In regard to nutrient contribution from animal production facilities, recent research indicates that airborne ammonia may contribute more nitrogen enrichment to downwind lakes or streams than runoff or seepage from the land. The water bodies absorb the ammonia from the air. The same situation has occurred with water bodies adjacent to tertiary sewage treatment facilities. Rainfall also brings down nutrients in the form of oxides of nitrogen formed by industrial and automotive combustion. This effect is particularly marked downwind from large industrial cities.

The principal nutrients entering streams from irrigation water return are nitrogen and phosphorus. Phosphorus tends to be tied up in the soil so, typically, enters with soil particles. The Department of Environmental Quality (DEQ) has initiated monitoring and other survey programs to determine the magnitude of nutrient levels in Oregon's streams attributable to agricultural operations. From these preliminary studies it appears that irrigation return may be influencing water quality in a number of Oregon streams. These include the Klamath, Rogue, Deschutes, John Day, Umatilla, Grand Ronde, Powder, Burnt, Owyhee, Malheur, Snake and certain of the lesser streams in the closed basins in interior Oregon.

The Tualatin and Klamath rivers are currently not meeting established water quality standards for organic waste loads. Both of these rivers suffer from extraneous conditions beyond the effects of controllable waste sources. The Klamath Basin is naturally enriched before the addition of manmade wastes. Its flow is also fully controlled and regulated for irrigation and hydroelectric uses. The Tualatin river has suffered a total

flow loss in its middle reaches during the summer period from irrigation withdrawal. Tertiary treatment is being required in the Tualatin basin because of this situation.

Pathogenic Organisms

High concentrations of bacteria from fecal sources, as indicated by coliform organisms, resulting from raw sewage discharges, constituted a significant water pollution problem before sewage treatment was initiated in the state. The most difficult problem existed in the Willamette River system. There, the initial goal was primary treatment plus chlorination for destruction of possible pathogenic organisms with achievement for all cities on the main stem by 1957. With the completion of secondary treatment facilities for all cities along the Willamette, additional improvement has been made.

Even with the effective secondary sewage treatment and disinfection programs in urban communities in Oregon at the present time, the coliform level is still significantly high in a number of streams. This coliform level is higher than can be accounted for through sewage sources alone. Recent studies by the Department of Environmental Quality (DEQ) have revealed two major sources other than sewage. One is land runoff from feedlots, paved surfaces and from storm drains. The second is the regeneration or regrowth that takes place in the stream itself. Enriching materials such as wood sugars from pulp waste serve as an excellent media for the reproduction of coliform bacteria. The extent to which pathogenic forms are reproduced on this basis is not known.

The possibility of release of pathogenic viruses through sewage effluents has been of particular concern nationally in recent years. Technology for their control in conventional sewage treatment systems is considered inadequate at present. Viruses, unlike pathogenic bacteria, are not easily destroyed in sewage treatment processes, including chlorination. Many infections of man such as polio and hepatitis are caused by viruses.

Toxic Materials

Certain inorganic chemicals in addition to a vast number of organic materials can be toxic to plant and animal life in water environments. Refractory materials which are not readily broken down either in the water environment or in treatment processes are particularly troublesome. Among the refractory materials of concern are certain pesticides, a number of industrial chemicals, and even the hexachlorophene used in household products. The toxic material receiving the most attention recently is the heavy metal mercury, which can enter the food chain in a stream upon conversion in the bottom muds to an organic and usable form. There is concern nationally with other toxic metals, such as cadmium, arsenic and beryllium in the water environment.

A factor in the concern regarding synthetic organic chemicals in the environment is that new ones are reported to be entering the market at the rate of 500 per year. While comprehensive toxicity tests are required for classes such as pesticides before they can be licensed for sale, such tests obviously cannot cover all possible potential side effects. A primary worry includes the potential for interactions with other materials, natural or man-made, to produce more harmful toxicants and environmental effects.

The chlorinated hydrocarbon insecticides, principally DDT, have constituted the pesticide class causing the major environmental concern. Initially, concern centered on acute toxicity to aquatic species, such as muscular spasms and loss of equilibrium. Later, emphasis shifted to chronic effects of sublethal levels and buildup in the food chain (bio-magnification). Other problems involved transformation in the environment into more potent forms and the stability -- long time period required for breakdown -- of certain compounds. The bans recently imposed on the use of certain of the chlorinated hydrocarbons should materially reduce the environmental problem from this source.

Principal avenues for pesticides entering water bodies are application to agricultural and forest areas, particularly by aerial methods; release during manufacture; household and home garden use, including pouring of materials into drains and toilets; and use in aquatic pest control, including certain in waste treatment facilities.

Another class of synthetic chemical causing concern in the water environment are the polychlorobiphenyls (PCBS). These are synthetic chemicals which are used as ingredients in a number of industrial products, such as solvents, plasticizers, and brake fluids. Limited monitoring data indicate that these organic compounds are becoming widely distributed in water environments and can have a detrimental effect on some aquatic species and fish-eating birds. They appear to be implicated in the problem of thin-shelled bird eggs and the resultant population decreases. Recent research points to polychlorobiphenyls acting synergistically with chlorinated pesticides such as DDT to enhance their effects.

Sediments

Considerable effort on the part of Oregon's water pollution regulatory agencies has been directed at the gross and obvious sources of man-caused sedimentation in streams. Progress has been made in reducing sediment problems created as a result of such sources as sand and gravel operations. Most of these operations now employ settling facilities and other techniques for reducing sediment loads. Even so, at the present time, nearly every stream in the state has rather heavy sediment loads during periods of heavy runoff from adjacent lands. A high percentage of the sediment loads are related to man's activities rather than a natural source. They can be traced to poor land management practices associated with logging, roadbuilding, over-grazing, mining and urban land development.

Thermal Effects

Debate generated by the proposal for nuclear power plants in the state has directed attention to the problem of thermal pollution, or excess heat, in the water environment.

Man's activities can bring about changes in water temperature in many ways and can add to those produced through such natural forces as air-water interchange and the warming effect of the sun. The principal man-made sources of increased temperature are environmental alteration such as removal of vegetation; impoundment of water for storage; diversion of streamflow for such uses as irrigation and domestic consumption; and addition of heat, principally in coolant waters, from industry and power generation. All these sources of thermal effects are of importance in Oregon. Forestry operations remove vegetation and can lead to higher water temperatures in small streams of the upper watershed. It is clearly recognized that the impoundments on the Columbia, as well as on other streams in the state, have increased water temperatures. Techniques are available for making adjustments in reservoir release to minimize this effect, but most impoundments in the state were not constructed on this basis. The diversion of water from streams during low-flow high temperature periods is of major significance in stream temperature conditions in Oregon, and is a cause of a number of streams exceeding existing temperature standards. Finally, a number of industries utilizing water in their operations return the water to the stream at a higher temperature than when withdrawn.

Present public policy in Oregon under existing water quality standards does not permit once-through cooling with thermal power generating stations. Perhaps the most significant factor in stream temperature in the state, as far as the future is concerned, is diversion of substantial percentage of streamflow volumes during the low-flow periods for irrigation. Flow volume is low in most streams during the summer period in the state. An exception is the Columbia, which flows more heavily in the late spring and summer period due to snowmelt. Thus, withdrawals from the Columbia, during the summer period would have less impact than from other streams in the state as far as water quality maintenance is concerned.

A problem associated with increased water temperatures is the greater incidence of fish diseases occurring under these conditions. Direct effects on fish and shellfish, such as decreased growth rate and reproductive cycle changes, can also be shown. Sudden and pronounced changes in water temperatures can kill certain fish outright, and nontolerant species can be eliminated. More broadly, the entire ecosystem of a body of water can be altered through temperature change. While a specific species of economic significance, such as a sport fish, might not be unduly harmed by increased water temperatures, lower order species in the food chain, upon which higher species are dependent, can be eliminated, leading in turn to removal of the economically important species.

Radioactive Materials in Oregon Waters

The consideration of thermal nuclear-fueled power generating plants has focused increased attention recently on contamination of the environment with ionizing radiation. In the operation of nuclear power plants and fuel reprocessing facilities, low level radioactive wastes have been released into water environments. In earlier reactor operations, releases contained induced radioactive materials (from chemicals made radioactive during the fission process) as well as fission products. Induced radiation was the basis for the radioactive zinc, phosphorus, and chromium, for example, in the Columbia River from the Atomic Energy Commission's Hanford reactors. Modern electric generating reactors avoid most of the induced radioactive releases.

Radiation, in the broadest sense, covers any emission of energy or energetic particles from a point of origin. If the radiation is sufficiently energetic to cause ionization along its path, then it is termed "ionizing radiation." The hazard from an environmental standpoint is derived principally from internal exposure, resulting from disposal of radioactive waste or accidental release of radioisotopes.

Natural background levels of ionizing radiation have always been present, but man's activities--particularly medical x-ray use--have added levels which currently approach those from natural sources. The concern is that of further increases of exposure to ionizing radiation from man-made sources. The average background level of radiation to which people living in the United States are exposed is around 125 millirem (mrem) per year. (The rem, roentgen equivalent man, is considered the best measure of radiation exposure, as it considers both the dose and its biological effect. A millirem is 1/1000 of a rem).

There are three sources of background radiation: cosmic rays; external radiation exposure from radioactive materials in the environment; and internal radiation exposure from inhaling or ingesting naturally occurring radionuclides. The exact amount released through natural sources varies with locality, depending on radioactive materials present and the intensity of cosmic rays, which vary with altitude and latitude.

Radioactive wastes are unique in that they are not detectable by human senses, certain are extremely long-lived, and there is no known process for their destruction. Their hazardous effect is through the release of ionizing radiation. Another unique difference between ionizing radiation and most other environmental pollutants relates to its threshold of damage. Most pollutants have a threshold dose which, it is believed, must be exceeded before harmful effects result. Control measures with these pollutants have typically been aimed at keeping doses or exposures below this level. This is not considered true with at least genetic effects of ionizing radiation. Thus, control (or protection) philosophy is based on the assumption that even the smallest radiation dose may produce harmful effects not only to the individual exposed, but through possible genetic effects to offspring as well.

In the aquatic environment, a prime concern from radioactive materials, as with pesticides, is with biologic concentration or build-up through the food chain, and subsequent passage of concentrated levels to higher forms which, in turn, can be consumed by man. Though the amounts of radioactivity in water may be low--below standards set for safety--certain nuclides can be taken in by plankton and other aquatic organisms and concentrated to levels several orders of magnitude higher than those present in the water. Certain fish and waterfowl exist primarily on these organisms, and can accumulate these nuclides. When used as human food, such fish or waterfowl provide a source of internal radiation.

From an environmental standpoint, chronic or long-term effects on biological species, including man, are the major concern. Possible effects on man include non-specific life shortening; increased incidence of cancer and leukemia; and genetic abnormalities in offspring. The latter effects are related, it is believed, to irreparable damage to the genetic material of cells, the DNA. Because of the latent period between irradiation and the appearance of chronic effect, damage from exposures can be manifest many years later.

The Columbia River has been the water body in which there has been primary concern in Oregon. Relatively high radioactive levels in the early 1960's resulted principally from releases by the Hanford operation and fallout from testing of nuclear devices around the world. Monitoring has indicated a decline in radioactivity in the Columbia during the past decade. This is due to the nuclear test ban and the closing of seven of the eight original Hanford reactors. This reduction has brought environmental radiation levels in Oregon in line with national figures.

The only new radiation source anticipated in Oregon in the next several years is the Trojan nuclear power plant scheduled to begin operation in 1974. This plant will be of the pressurized water reactor type with minimal radioactive liquid effluent releases projected. The plant at San Onofre, California, using a similar reactor type, has had an experience of liquid radioactive releases of around 2 percent of the Atomic Energy Commission's permissible limits. The Trojan plant projects even lower release rates-- in the one percent range. Based on this level of release, if a person continuously consumed this waste water directly from the discharge outlet (and was exposed to airborne releases) his radiation dose equivalent would be some 5 mrem per year. In Portland, the dose equivalent would be less than 0.01 mrem/year. For comparative purposes, natural background exposure levels in Oregon are between 100 and 125 mrem/year. The average genetic effect exposure from medical diagnosis is estimated at 55 mrem/year. Living at a 5000 foot higher altitude would add some 50 mrem/year. And, living in a granite building, as opposed to a wooden one, could add a like amount due to radium and thorium content of the granite.

The Sphaerotilus Problem

A biological process of significance to water quality in Oregon is the growth of the aquatic bacterium, Sphaerotilus natans. This slime organism, falsely called the sewage fungus, thrives on stream enrichments containing sugars and carbohydrates. Thus, it is found in heaviest concentrations immediately downstream from pulp and paper, food processing and municipal sewage outfalls. It grows in long chains, both on the bottom of streams and attached to floating material in streams. In shallow streams, the growth is conspicuous, attached to rocks and submerged plants. Sphaerotilus also forms directly in the open water, on floating material such as leaves, grass, and bits of wood fiber. As soon as the floating Sphaerotilus body passes the high nutrient area, it dies and sinks to the bottom. Frequently this material is carried in suspension through the swifter regions and is deposited in downstream pools where it adds to the sludge beds. A recent study which identified the type and source of material in the sludge beds on the bottom of the Willamette River found that Sphaerotilus was the principal contributor to these deposits. Surveys have indicated that most Sphaerotilus in both the Columbia and Willamette Rivers is formed in open water. Wood fiber has been implicated as an important attachment material. In the Willamette, practically all Sphaerotilus bodies settle to the bottom, contributing to sludge deposits. Sludges from Sphaerotilus are reported to occur in a few tributaries of the Columbia, but not in the main stream. Fouling by Sphaerotilus becoming attached to fishing nets and other objects is a significant problem. Abatement measures include both reductions in the organic wastes on which the organism feeds and the wood fibers on which it attaches. Present abatement programs of the pulp mills should go far in abating the Sphaerotilus problem by 1972.

POLLUTION SOURCES AND CONTROL MEASURES

Municipal Sewage

In 1938, when the State Sanitary Authority, forerunner of the Department of Environmental Quality, was created, less than 100,000 people were served by 49 sewage treatment plants. Today about 1,500,000 people are served by some 300 domestic sewage plants. These range from small privately owned, aerobic digestion plants serving recreational facilities to major treatment plants in the larger cities and provide sewage treatment service to approximately 65 percent of Oregon's population. The remaining 35 percent are served by individual systems such as septic tanks. There is excess capacity of some 20 percent in these community facilities for expanded population. Of the population served by collection and treatment systems, 62 percent have secondary treatment. All of the cities in Oregon with sewage systems have secondary treatment with the exception of certain ones discharging into the Columbia River or the Pacific Ocean. These are on schedules of compliance to meet Oregon water quality standards to provide secondary treatment systems to all of the remaining communities by July 1972.

Another sewage waste problem that remains in the state is the large number of combined sanitary and storm sewer systems in older sections of many cities. Systems constructed prior to 1940 are nearly all combined; those after that date are nearly all separate.

The problem with such combined systems is that even if the interceptor lines are the standard two or three times larger than the dry season flow requires, they still are generally not large enough to carry all the runoff which occurs during a storm. This runoff, unseparated from domestic sewage, often has to be dumped directly into the river, bypassing the treatment plant. Typically, 2 or 3 percent of the total annual sewage flow in a combined sewage system is so discharged, but during periods of heavy rains, the percentage of untreated sanitary sewage may be large. The BOD and suspended solid content of the bypassing flow is often particularly high because the water's greater velocity has churned up debris in the sewers. In Oregon it is now required that all new systems have separate sanitary and storm sewers, and that all extensions of existing systems be separate if possible. Runoff content varies a great deal, with some high in solids, BOD, and even in coliform count. In western Oregon, where heavy rains occur chiefly in the winter when streamflow is high, storm water released to the river is well diluted except for the first rains of the fall.

Disposal of large volumes of sludge, the solids resulting from sewage and industrial wastes treatment, remains another problem in the state. Older methods of fertilizer use and incineration frequently fail to meet proper public health and air quality requirements. The possibility of large scale combined composting of garbage, other organic municipal refuse and sludge offers an intriguing possibility for the future.

Another remaining problem is the contribution of nutrients from treated sewage effluents, particularly phosphorus. During the past two decades, phosphorus content in sewage has increased markedly, attributed primarily to detergents. Some four billion pounds are now used annually in this country. Phosphorus has been used as a base or builder, mostly in the form of polyphosphates. By the time the sewage effluent is released, these polyphosphates have been changed to orthophosphates, a form readily used by plants as a nutrient. Most detergents contain 20 to 40 percent polyphosphates, but some contain as high as 50 percent. At some locations, as much as half the phosphorus in sewage effluents comes from detergents.

Cities in Oregon from 1946 to the present have spent in excess of \$200 million for sewage treatment facilities. The annual cost of constructing facilities approximates \$25 million per year. At present costs, the Department of Environmental Quality estimates that future main-interceptor sewage and sewage treatment needs will cost at least \$170 million.

Forest Industry Wastes

Oregon's wood products industries generate a number of waste disposal problems. Oregon's principal industrial water polluting source

has been the large volumes of organic wastes and wood fibers released from pulp mills. Pulp operations employ, with limited exceptions, the sulfite or the Kraft processes. The initial plants built on the Willamette River system some 75 years ago, utilized the calcium-base sulfite process. They were characterized by large volumes of liquid wastes of high organic (BOD) content and retained the processing chemicals. These wastes contained, dissolved or in suspension, about half the weight of the wood used for pulping. To permit recovery of process chemicals and destroy the organic wastes (about half lignin and half wood sugar), these mills are converting to a magnesium-base process. With this process BOD is reduced by 85 to 90 percent, but there is an increase in sulfur dioxide released into the atmosphere.

The principal pulp industry expansion in the past 30 years -- and now the major segment of the industry -- has been with mills using the Kraft process. This process is based on chemical recovery. While the water pollution problem is less severe, reduced sulfur gases (H_2S and mercaptans) have constituted a major air pollution problem.

The major water pollution problem associated with pulp and paper mills has been in the Willamette River system. The problem is depletion of dissolved oxygen during the low-flow summer period, buildup of the slime growth, Sphaerotilus, and the creation of bottom sludge deposits. The initial abatement program which started in 1952 involved holding wastes during the summer period. The strong pulping wastes were discharged into storage lagoons and released on a metered basis after fall rains provided greater stream volume. One mill, Publishers Paper at Oregon City, because of the lack of space for lagoons, barged its waste liquors to the Columbia River. The next abatement step was a requirement for primary treatment to remove settleable solids and wood fibers which served as a medium for the buildup of Sphaerotilus and added to bottom sludge. All mills on the Willamette system have now installed primary treatment. An estimated 200,000 pounds of solids are removed daily from the waste effluents of these plants.

A third step in the abatement process has been the requirement for secondary treatment or equivalent control on a year-round basis. Three pulp mills - Weyerhaeuser at Springfield, American Can Company at Halsey, and Crown Zellerbach at Lebanon - and one fabricator of pulp products, the Evans Products Plant in Corvallis, have installed secondary facilities. The remaining mills have programs to provide these facilities by July 1, 1972. Compliance schedules are written into the wastes discharge permits of these mills.

In other abatement efforts, the Crown Zellerbach plant at West Linn has closed its pulp manufacturing facilities. The Publishers plants at Oregon City and Newberg have converted pulping processes to a magnesium base, to permit burning of the condensed waste liquor and recovery of the processing chemicals. With the completion of these abatement programs involving secondary treatment and chemical recovery, the wastes discharged to the Willamette River system by the nine pulp mills will have been reduced from an amount

equivalent to that which would be produced by a population of 4 million persons, to the equivalent produced by 250,000 persons.

Other pulp mills in the state discharge into the Columbia River and the Pacific Ocean. The Georgia-Pacific mill at Toledo, and the International Paper Company at Gardner, after primary treatment, discharge into the Pacific Ocean through approved ocean outfalls. The Coos Head Timber Company discharges into Coos Bay. The Menasha Corporation has been discharging pulping wastes into seepage lagoons on a sand spit between Coos Bay and the ocean. Improved discharge practices are being required of the latter two mills. The mills on the Columbia River in both Oregon and Washington provide primary treatment. The St. Helens mill is currently completing (July 1, 1971) secondary treatment facilities and the Wauna mill is scheduled to provide secondary treatment by not later than December 31, 1971.

A primary water pollution problem associated with the plywood industry has been the discharge of glue wastes. These wastes, although of small volume, are high in organic content and are toxic. A number of mills are now recirculating and reusing the glue, and other mills are in various stages of adoption of this procedure.

Another type of water quality problem is associated with the Pacific Northwest practice of storing logs in ponds or streams. This practice is not only convenient but also provides sufficient moisture to prevent drying and splitting of the logs. Unfortunately, this storage practice has some inherent problems relating to the pollution of the storage waters. Soluble leachates from the logs add color and biodegradable organic matter to the water. Studies at Oregon State University have shown that although this source of pollution is measurable, it is not significant in most storage areas. Little toxicity was found to be associated with log leachates.

The loss of bark from the logs during unloading operations and subsequent storage is a more serious problem. Some of the bark floats for a short period of time before it absorbs sufficient water to sink. Surface bark is not only aesthetically displeasing but can give rise to problems at water intakes and with recreational uses of a watercourse. Bark in bottom deposits provide a usable food source for organisms, which in turn use oxygen from the overlying waters. An unanswered question regarding bark deposits concerns the effect this bark deposit has on the movement and function of benthic microorganisms which are important links in the aquatic food chain.

Abatement efforts by the industry are aimed at reducing bark losses by improved log dumping and transport practices. Other abatement measures include storing logs in man-made ponds isolated from natural waterways; debarking logs prior to water storage; and removing all logs from the water and placing them in cold decks on dry land, where water is sprayed over the logs to prevent splitting.

Food Processing

Food processing, particularly of vegetables, has been expanding rapidly in Oregon in recent years. The Salem area now supports the largest concentration of food processing plants in the United States. From the standpoint of environmental quality and waste management, the concentration of processed food production can lead to intensification rather than a reduction of waste disposal problems. The consolidation of effluents from several plants can lead to centralized by-product and/or treatment facilities where the economies of size can be realized. On the other hand, the highly organic nature of food processing wastes can easily lead to water quality problems if these wastes are not strictly controlled. The high BOD of organic wastes can contribute to the dissolved oxygen (and possible anaerobic breakdown) problem.

The problem that previously existed, discharge of large volumes of untreated food processing wastes with high BOD loads directly into streams, has been essentially corrected. The three most important abatement programs followed by the industry have been (a) in-plant process changes to both reduce waste production and/or to treat concentrated sources, (b) "joint treatment" through agreements with municipalities for handling wastes at the local sewage treatment plant, and (c) disposal of process waters by irrigating on land.

A potential problem with joint treatment is the possibility of municipal plants becoming more and more dominated by local food processing effluents. The rapid and continued growth of the industry has in several cases led to overloading within 3 to 5 years of start-up of municipal plants designed for operational lives of 15 to 20 years. This has often led to serious operational problems in the plants themselves. Reasons for this are an apparent inability to accurately forecast growth over a 5-to-20-year period, and a lack of familiarity with the characteristics of the wastes themselves. Research is currently underway to correct the deficiency in knowledge about the characteristics of the various waste streams from the processing of specific commodities. The problem of predicting production levels, and therefore processing levels, in the future still remains to be solved.

With the current regulatory emphasis on effluent standards and on the encouragement of industrial cost-sharing on an equal basis, and with the frequent and notable lack of success in designing, building, and operating combined municipal-industrial waste treatment plants for their predicted useful lives, it appears that a greater trend toward at least partial on-site treatment of wastes by the industries themselves is developing. The next 10 years in Oregon should bring a significant increase in the number of these treatment and disposal systems specifically for industrial wastes. These will prove more costly to the industries than the combined treatment systems now being used, but will offer several advantages including complete autonomy of operation and increased opportunity for by-product development.

Metal and Chemical Processing

Toxicity, taste and odor problems in water and in fish flesh, and nutrient enrichment of streams are water pollution problems associated with the processing of metals and chemicals in the state. Those which have come under most consideration have been the Chipman Chemical plant near Portland and the Wah Chang Albany plant.

The problem with the Chipman operation came from the release of residues from herbicide manufacture and other chemicals to impart an undesirable flavor to fish flesh. The installation of an activated carbon adsorption system has brought the release problem under more adequate control. Certain changes have been made in the Wah Chang operation to reduce toxic and enriching discharges, but only partial control has been achieved.

Abatement Enforcing Methods

The two principal enforcement tools utilized by the Department of Environmental Quality (DEQ) in water pollution abatement (or positively in water quality maintenance) have been water quality standards and a waste discharge permit system.

Water Quality Standards: Beginning in 1967 Oregon's water quality standards were redrafted. The first step involved the adoption of general water quality standards which applied broadly to all waters of the state and established minimal acceptable criteria. Also, special standards were adopted for interstate waters and for the main stem of the Willamette River. These standards were adopted in accordance with the Federal Water Quality Act of 1965. Subsequently, special water quality and waste treatment standards were adopted for the Rogue, Umpqua, Clackamas, Sandy, Mollala, Deschutes, McKenzie, North and South Santiam, and Tualatin Rivers. These standards specified numerical limits for pH, temperature, dissolved oxygen, turbidity, coliform bacteria, and certain chemical ions.

Where waste treatment more efficient than conventional secondary treatment is required, the standards also include treatment requirements and effluent standards. Samples are collected and tested on a periodic basis in all of the eighteen river basins of the state and on major lakes and in estuaries.

It has been stated that Oregon's standards and requirements are among the highest in the nation. In two basins in the state, the standards are so high that no effluents, regardless of the degree of treatment that is provided, can be discharged into the river systems. In certain other river basins extremely high degrees of advanced waste treatment are required and, in addition, augmentation of the low streamflow must be provided during the critical summer and fall months.

Waste Discharge Permit Program: A second major tool in Oregon's water quality maintenance program is the waste discharge permit, put into law (ORS 449.083) by the 1967 legislature. The law requires all waste dischargers to obtain a permit to release wastes into Oregon waters. The discharge permits contain specific limits on quantities and strengths of wastes that can be discharged and characteristically include numerical limits on pounds of BOD and suspended solids, pH and bacteria and, where pertinent, temperature, color, turbidity, toxicity and troublesome chemical ions.

Where present treatment or control is inadequate, a specific, detailed program and timetable for providing fully adequate treatment is written into the permit itself. Permits are also issued to all cities as well as to industries ranging from the largest pulp mill to small log pond discharges. To obtain a permit, new industries are required to install the "highest and best practicable" treatment prior to starting production.

At the end of 1970, a total of 865 permits had been issued of which 309 were renewals and 30 modifications of existing permits. The duration of permits issued has varied from 2 months to 5 years. Most have been for less than two years. Short duration permits have been used to force periodic review of progress in cases where water pollution control improvements seem necessary.

EFFECTS AND PRESENT STATUS OF POLLUTION IN OREGON'S WATER RESOURCES

Pollution Effects on Recreation and Fish Life

Water-based recreation, which requires a very high water quality, is a significant activity in Oregon. The state's many streams, lakes, impoundments, and estuaries and the Pacific Ocean are all heavily used for this purpose. Deterioration in quality can impair or destroy this resource use for Oregon residents and will have a detrimental economic effect on the state's important and expanding tourism industry as well.

The effect of various pollutants on aquatic life is a complex situation. Impact will vary with physical properties and chemical composition of the water. Sensitivity of fish to toxic materials will vary greatly with altered water conditions. Addition of certain materials may lessen the harmful effect of others. In some cases, combinations may be more harmful than the sum of the same levels of the single materials independently. The time-concentration relationship is another factor in determining tolerance of aquatic life to pollutants. A single or short-term exposure to higher concentrations may show no apparent harmful effect, whereas repeated exposures to the same concentration or continuing exposure at a lower concentration may cause harmful effects or death. Over a period of time, organisms can also develop tolerances for concentrations which, before initial exposure, would have been toxic even at lower levels.

Low levels of dissolved oxygen have posed major problems in waters through which anadromous fish must migrate to spawning areas. Water temperatures above the necessary level for certain species and the effects of toxic substances are now of increasing concern. A great deal of current research is being devoted to the effects of pesticides, detergents, and toxic industrial wastes on development, growth and mortality of important aquatic species. Direct effect on the desired species itself is only a portion of the problem. Bottom fauna and flora on which the species depends for food supplies can also be harmed or destroyed.

Proper levels of both organic and inorganic material can be highly beneficial to aquatic life. Low levels of organic wastes serve as enrichment, and it is only as the levels become high enough to cause oxygen depletion, excess algal growth, or other harmful effects that deleterious pollution occurs.

Special Problems of Small Headwater Streams

Water quality problems on large rivers receive a great deal of attention. Also significant, however, are the problems encountered on small headwater streams. Small streams in the forested mountains of the state provide the source of water for Oregon's major rivers and a significant portion of the spawning and rearing area for anadromous fish. Man's use of headwater areas is increasing. Forest management activities, including logging, roadbuilding, and the use of chemicals, are concentrated in these areas. Increased recreational pressure, demands for better access roads and more campgrounds in these zones from a greater number of users, will continue to grow.

Less is known about man's impact on the quality of small streams or the organisms that reside there than on large rivers. Recently, studies in headwater areas have been initiated. The Logging-Aquatic Resources Study in the Alsea Basin, a cooperative research project involving state, federal, and private agencies, was designed to evaluate the impact of logging on salmon and cutthroat trout populations in small coastal streams. This study demonstrated that while clearcutting followed by burning could cause large changes in water temperature, oxygen, sediment and fish production, clearcutting without burning but with streamside protection such as an uncut narrow buffer strip produced only small changes in water quality and no change in fish production. The Alsea Study also focused attention on several significant gaps in existing knowledge about small streams and the organisms that live there. The wide variations in sediment loads and fish numbers need more study, as does the response of fish to sediment and temperature changes. Variation in natural levels of sediment and the ability of resident fish to withstand environmental changes are but a few of many problems that require the attention of both research organizations and control agencies.

Roads are the greatest source of sediment in the steep, often unstable topography of Oregon's mountain regions. Since landslides triggered by roads can scour small stream channels and add tons of sediment to rivers downstream, such engineering design problems as road location and soil stability in headwater regions have significant water quality implications.

Increasing timber yields from upstream watersheds to meet the growing demand for wood products will continue to foster the use of such chemicals as pesticides and fertilizers. The potential impact of these chemicals is probably greatest in the small streams that drain the treated areas.

The mineral and bacteriological quality of undisturbed headwater streams are generally excellent. Such streams are often used for municipal water supplies. The impact of heavy recreation use of Oregon's headwater streams and lakes has not been determined. Waste handling facilities in many headwater areas are primitive but must accommodate large numbers of people during peak periods of summer weekend and holiday use.

Eutrophication of Lakes

Eutrophication of natural and man-made lakes as a water quality problem has been receiving wide attention recently. Limnologists have classified lakes into two broad types: oligotrophic or underfed, and eutrophic or well-fed. In the normal aging process all lakes pass from oligotrophic to eutrophic and eventually revert to marshes, then to dry land. Under normal conditions, this transition would be measured in geological time, but man's activities in producing additional enrichment are speeding up the process of eutrophication.

Historically, young lakes, either natural or man-made are relatively barren bodies of water. In terms of the amount of biological life they support they are oligotrophic. The continual addition of sediments and nutrients from the natural surroundings enrich the lake so that microscopic plants, generally green bloom phytoplankton, and then microscopic animals, zooplankton, develop and thrive. Higher plant and animal forms emerge as the process develops. Eutrophication continues until deposits from entry of sediment and biological activity fill the lake to the extent that rooted aquatic plants begin the process of conversion to marshland. Man-produced enrichment simply hastens the onset of aging and shortens the lifespan of lakes.

Limnological studies are revealing that Oregon's lakes are generally in good condition. There are many that are actually pristine, including Crater and Waldo lakes and many alpine systems. Diamond, Cultus, Woahink, and Odell Lake are examples of those that are showing signs of change due to man's activities. Klamath Lake and Devil's Lake, on the coast, are considered to have major eutrophication problems.

The Klamath Lake-River system is composed of interconnected marshes, sluggish rivers, irrigation drains, and shallow lakes. The water is used for irrigation, power and industry. These combined needs plus low stream flows in the summer lead to dissolved oxygen depletion and algal blooms. However, the natural BOD loading of the Klamath River from Upper Klamath Lake and subsequent development of algal blooms coupled with water quantity manipulation are the most important factors leading to eutrophication and oxygen depletion. The addition of treated waste materials only aggravates the natural condition of the river system.

Problems of the Coastal Zone

Increasing attention, both in Oregon and on a national basis, is being given to water quality in estuaries and coastal margin waters of the ocean. Intense development is taking place at this interface between the land mass and the ocean to facilitate the ocean's use as a resource for food, minerals, power, transportation, recreation and other benefits. From a fisheries standpoint, seven out of ten of the most important commercial species spend all or an important part of their life cycle in estuarine waters.

Estuaries and the open ocean have been the natural recipients of most of man's liquid-borne wastes, as well as certain air pollutants and solid wastes. The ocean is vast, but its ability to assimilate these wastes without significant degradation is still limited; it is a finite resource. The waste products created by increasing population and associated activity are, in some cases, severely stressing the ecosystems in the waters over the continental shelf. These comprise only 8 percent of the total volume of the ocean but are among the most economically productive areas to man.

Global concern is being expressed about the contamination of oceans in general, by nuclear wastes, oily materials of both shore and offshore origin, the persistent pesticides and other synthetic chemicals and toxic metals, particularly mercury and lead. So far no major oil spills have occurred in the open ocean off Oregon. Two spills have occurred in the Portland areas. There is evidence, however, of the release of oil and oil slop from the cleaning of tankers and other activities in Oregon's marine waters. Among other sources, pulp and paper wastes are being released through several ocean outfalls. In addition, there is still some discharge of sewage which has not undergone secondary treatment into the marine environment.

Recent studies by Oregon State University have shown that ultimate disposal of properly treated waste materials can be accomplished through ocean outfalls under proper conditions of design and management with minimal side effects. Such practice is regarded as more desirable than discharge into estuaries.

The coastal waters will continue to be the ultimate recipient of the residual, nonreclaimable fraction of the wastes from man's activities; however, it is recognized that waste management systems must be made more effective and new concepts and practices developed. The narrow coastal margin environment must be maintained in a healthy and aesthetically attractive condition if the ocean is to continue to satisfy multipurpose requirements.

Present Status of Oregon's Estuaries

Estuaries have long provided harbors which serve as the junction of overland and overseas trade routes, furnish breeding grounds for open ocean fish, produce extensive shell fisheries, and are areas for recreational and industrial development. Many estuarine environments, however, are suffering severe degradation as population and economic activities expand. The harbors are becoming less navigable; breeding grounds and shell fisheries are being destroyed; wastes discharges are fouling the estuaries and damaging the aesthetic quality; and alterations of river systems and the drainage basins of the estuaries are changing circulation patterns within the estuaries themselves.

Oregon is not blessed with an abundance of estuarine areas. The total area of our estuaries is only slightly more than 58,000 acres, which can be divided into equally valuable tidelands, those portions of the estuaries with six feet or less of water, and channel areas.

In general, the major factors responsible for degradation of Oregon's estuarine environment include increased pollution by industrial and domestic wastes; sedimentation resulting from erosion due to logging or fires in the watershed; filling of the tidal flats for industrial and domestic development; dredging and filling operations; and log storage. Fisheries production, including shellfish has been harmed in certain estuaries. Aesthetic and recreational values have been lowered and water quality in general has been decreased in most Oregon estuaries through man's activities.

OUTLOOK

As stressed throughout this report, the primary concern in abatement of water pollution in Oregon has been the heavy loadings of streams with organic wastes, principally from the pulp and paper industry and domestic sewage, certain toxic releases, and possible contamination with pathogenic organisms from sewage wastes. Major progress has been made with all of these problems. Implementation of existing abatement directives will further reduce waste loadings from these sources. The year, 1972, is regarded as the benchmark--the time when these gross sources will have been brought under control.

While progress is being made with abatement of gross and obvious organic and toxic wastes and possible pathogenic organisms, the magnitude of certain other problems has been increasing. Newer problems are associated with such new technologies as atomic energy, pesticides, detergents, confinement rearing of livestock and forest fertilization. Other mounting water quality problems are simply functions of an expanding population, its concentration in urban centers and associated activities that impinge on environmental quality.

In assessing future problems of water pollution in Oregon, the following points would appear to be of significance:

▼ Organic wastes from municipal and industrial sources will continue as a significant problem in the future. Material progress is being made in abating organic waste sources and should continue. However, population and industry growth will partially offset the progress. Requirements for more efficient and sophisticated treatment facilities indicate that more and better trained plant operators are needed.

▼ The nutrients or enrichment from the breakdown of organic wastes, from detergents and from other sources will pose an increasingly difficult problem. These nutrients will foster the regeneration of organic material in water bodies. The need for advanced and tertiary treatment will become more acute to remove nutrients as well as chemicals, viruses, and other materials not fully removed at the present time.

▼ Toxic materials from industrial sources, from agricultural and forestry practices, and from municipal sources will continue to be a problem of major import. Several forces are at work here. Human inventiveness will keep new materials entering the market and the environment. Humans tend also to overuse and to be careless about the use of many toxic materials. Synergistic effects of new products with other man-made materials and with natural environmental components can magnify this problem.

▼ Uncontrolled runoff from parking lots, streets and other surfaced areas poses a special problem. In most Oregon municipalities the storm sewers are connected to the domestic sewer system. During times of high flow, as in the winter, the runoff plus part of the city's untreated raw sewage may have to be directly discharged into the river.

▼ Thermal pollution or increased water temperature will become a water pollution problem of considerably increasing concern and could well become a more limiting factor in salmonid production than oxygen depletion in certain streams.

▼ Withdrawals of water for irrigation and for other consumptive uses will continue to have a major effect on water quality. The progress made to date with abating organic wastes and nutrients for regeneration could be easily reversed by significant diversions.

▼ Higher agricultural productivity has been based on irrigation and use of chemical fertilizers and pesticides. The runoff from farm lands, coupled with that from concentrated feed lot operations, will become of greater relative significance. These diffuse waste sources are most difficult to control or treat. The problems of runoff and waste treatment will be compounded if urban sprawl and the proliferation of septic tanks and poorly planned sewage connections are permitted to continue. Improved land use planning is an essential ingredient to the prevention of many water quality problems.

▼ Although the estuaries of Oregon have not suffered to the extent that those elsewhere in the United States have, increased demands due to population growth have, and will continue to have, an increasing effect on the use and thereby on the quality of the estuaries in Oregon. It has been estimated that by the year 2000 the population density along the Oregon Coast will increase by 50 percent over what it is today.

▼ To date, only limited development has taken place along the Oregon Coast. It can be expected that further developments will occur with expanding population, industry, and tourism-recreation activities. With such development, pressures increase for such alterations to the ecosystem as dredging and filling of estuaries. Stress may also increase on the estuarine watershed. Management programs, involving planning and zoning, will be vital to avoid excessive deterioration of these resources as such economic expansion takes place.