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Title BIO-INDICES OF POLLUTION IN THE WILLAMETTE RIVER

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An investigation of the bottom fauna of the Willamette River and several of its larger tributaries was made during July, August, September, and November of 1951. The purpose of the study was to determine the existing bottom fauna in the Willamette River system. This could be used as an index to measure the biological recovery of the river in future years as more and more cities and industries are treating their wastes. Thirteen sampling stations were established on the Willamette River system. These stations were chosen in regard to cities, tributaries, and focal points of pollution. Eight stations were located on the Willamette River; two stations on the McKenzie River; two stations on the South Fork of the Santiam River; and one station on the Clackamas River. At each station, certain chemical and physical tests were made, and biological sampling of the bottom fauna was done. Air and water temperatures were taken, along with hydrogen-ion concentration (pH), and dissolved oxygen content of the water. Biochemical oxygen demand (B.O.D.) readings were taken at some of the stations by the Oregon State Sanitary Authority. River flow measurements were obtained from U.S.G.S. records for the gage at Salem, Oregon. Bottom organisms were collected by hand, and a quantitative and qualitative measurement of the bottom fauna was obtained with a square-foot stream bottom sampler. The bottom organisms in each square-foot sample were classified as clean-water organisms, facultative organisms, and pollutional organisms. The clean-water organisms occur in clean waters, and the pollutional forms occur in polluted waters. The facultative organisms may occur in either polluted or clean waters. The relationship of the pollutional forms to clean-water and facultative forms is shown graphically for each station during each month of the survey. Also shown graphically are the changes in pH, dissolved oxygen, and water temperatures at the various stations. The organisms collected by handpicking were recorded for each station and for each month of the survey. Identification of the organisms was carried to order or family in most cases, and down to genus and species in some cases, particularly the mayflies and stoneflies. Mayfly nymphs, stonefly nymphs, and caddis nymphs were found to be generally clean-water forms. Leeches, red midges, and sludge worms were characteristic of the pollutional zone. Black flies, sponges, snails, and several other forms were facultative organisms. By the presence or absence of these organisms, the biological condition of the stream was determined.

BIO-INDICES OF POLLUTION IN THE WILLAMETTE RIVER

by

GENE DESCHAMPS

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BIO-INDICES OF POLLUTION IN THE WILLAMETTE RIVER

INTRODUCTION

The following is a study of the relationship between pollution and the bottom fauna in the Willamette River and in three of its larger tributaries during the months of July, August, September, and November 1951. The purpose of this investigation is to determine the existing bottom fauna, along with certain chemical and physical conditions, which can be used as indices to measure the recovery of the river in future years as the pollution abatement program progresses.

The usual methods of measuring stream pollution have been by the use of certain chemical, physical, and bacteriological tests. The biochemical oxygen demand, or B.O.D., has been used to determine the oxygen consumption of industrial and sanitary wastes. Coliform counts have been used to detect the presence of human intestinal bacteria, which are found in sanitary wastes. Other tests sometimes used are for dissolved oxygen, free carbon dioxide, hydrogen-ion concentration (ph), alkalinity and acidity, chlorides, grease, total solids, volatile solids, suspended solids, dissolved solids, and settleable solids. River flow measurements along with sewage flow data are invaluable in pollution surveys. (5, pp. 19-26)

The main advantage of the chemical and physical methods of measuring pollution is that these methods follow standard procedures and can be used for all bodies of fresh water. These tests are valuable for indicating stream conditions at the time of sampling, but they do not always show the toxic and other inimical effects of pollution effluents upon aquatic life.

In a normal stream there is an interdependence of organisms upon one another. This is known as the "balance of life", or "biodynamic cycle." For example, bacteria break down proteins into simpler compounds and oxidize sulfur compounds into sulfates. These products are then utilized by other organisms. By photosynthesis, algae build up carbohydrates and release oxygen. The algae itself is consumed as food by other organisms and the oxygen is utilized in respiration by plants and animals. The different groups of animals normally hold the algae, bacteria, fungi, and other animals in check. (7, pp. 379-381)

When a pollution effluent is introduced into a stream, it may temporarily or permanently alter this cycle. Some groups of organisms may be exterminated, some may survive but suffer a reduction in population, while others, with less competition and conditions to their liking may multiply their numbers.

Although a pollution effluent may not be toxic to a particular animal species, it may be toxic to its food organisms or may change the habitat, thereby causing conditions to be unfavorable. By the use of biological surveys, along with chemical and physical surveys, a more complete picture of stream conditions is possible.

One disadvantage in using biological indicators of pollution is that because of different ecological conditions, each stream or different portions of the same river system, may support a different fauna or flora. The aquatic life in a clear, cold mountain stream will be different from that of a deep, slow-moving river. In streams such as the Willamette River, a transition of aquatic life can be seen from the headwaters to the lower stretches because of the wide range of

conditions.

Because of this difference in ecological conditions, a clean, shallow, up-river station should not be strictly compared biologically with a deep, slow-flowing lower river station. However, stations having conditions which are quite similar may be compared. With this idea in mind, 13 sampling stations were selected in regard to similarity of habitat. These were located from just above Eugene downstream to the confluence with the Clackamas below Oregon City.

The scope of this report is limited to the use of bottom fauna as biological indicators of pollution. Identification of organisms was carried to order or family in most cases, and to genus and species in several cases. This work was done in conjunction with Richard E. Noble, graduate student, who used the fishes of the Willamette River as indications of pollution and non-pollution.

A BRIEF REVIEW OF PERTINENT LITERATURE

Although there have been several articles written on the use of aquatic organisms as indicators of pollution, only a few of the most prominent and representative ones will be mentioned here.

One of the most exhaustive investigations was that made by Richardson, (8, pp. 387-475), who made a study of the changes in bottom fauna of the Illinois River from 1913 to 1925. Richardson observed the changes over the years in dissolved oxygen supply, numbers of species, and abundance of the different groups of organisms.

As the result of stream pollution studies in New York state, Suter and Moore, (9, p. 6-21), classified organisms in regard to their tolerance toward pollution. Different zones were proposed, having the following characteristic invertebrates: septic zones; sludge worms, sewage fly, rat-tailed maggot; zone of recovery; bloodworm; tolerant forms; water boatman, pea clam, black flies, snails, water sowbug, crayfish; clean-water forms; dobson, stonefly, caddis worm, mayfly, dragon fly, water penny, freshwater shrimp.

In the determination of water pollution itensity by biological analysis, Hey, (3), proposed the following zones having the characteristic organisms: heavily polluted water; sewage fungus, bloodworm, Charchesium, rat-tailed maggot, and sewage worms; medium polluted water; leech, mussel, tanypodine larvae, alderfly larvae, and freshwater louse; lightly polluted water; flatworm (Turbellaria), leech midge larvae, freshwater snails, freshwater molluscs; unpolluted water; freshwater shrimp, mayfly nymphs, stonefly nymphs, and caddis nymphs.

From studies made in 1949 on the streams of the Conestoga Basin of Pennsylvania, Patrick, (7, pp. 380-399), proposed to measure pollution by comparing the different groups of organisms at healthy stations with those at stations having varying degrees of pollution. Animals and plants were placed into one of seven categories, with the organisms in each category behaving similarly in a given environment. Biological sampling was done at nine healthy stations and the average number of organisms in each category was called 100 percent. This data was shown graphically as a histogram. Thus, by sampling at any location, and by expressing each category in terms of percent of that of the healthy stations, the effect of pollution could be qualitatively and quantitatively shown. Each station was expressed as being either "healthy", "semi-healthy", "polluted", or "very polluted".

In studies of pollution on the Willamette River system, the majority of the work has been of the chemical, physical, and bacteriological nature. The only biological investigation was that of Dimick and Merryfield, (1, pp. 7-54), during August and September 1944. This study was primarily concerned with the effects of pollution on the distribution of fishes. However, square-foot samples of bottom organisms were taken at various locations and the presence and absence of certain aquatic organisms was noted.

LOCATION AND DESCRIPTION ON SAMPLING STATIONS

Thirteen sampling stations were established on the Willamette River system, (Figure 1). These stations were chosen in regard to tributaries and points of pollution, also to coincide somewhat with those of the Oregon State Sanitary Authority, and the stations established by Dimick and Merryfield in their 1944 survey. Eight stations were located on the Willamette River between Oregon City and a point just above Eugene; two stations on the McKenzie River; two on the South Fork of the Santiam River; and one station on the Clackamas River.

Because of the variation in productivity of different types of bottom, an attempt was made to choose sampling stations having quite similar conditions. Shallow riffle areas was the type of habitat most frequently chosen because of the accessibility and ease of collection of the bottom fauna. Most of the stations were quite similar with the exception of the two stations on the lower Willamette River, stations 11 in the "Newberg pool" and 12 below Oregon City. At these places the river is deep and flows slowly and there are few areas comparable to the other stations.

Station one, (Figure 2), was located on the Willamette River about a mile above the Eugene-Springfield bridge and just below the confluence of the Coast Fork and Middle Fork of the Willamette River. The water was fairly turbid at all times and there was some silt on the bottom. This was presumed to be caused by dam construction being carried on upstream. The bottom was composed of gravel and smooth rocks up to a

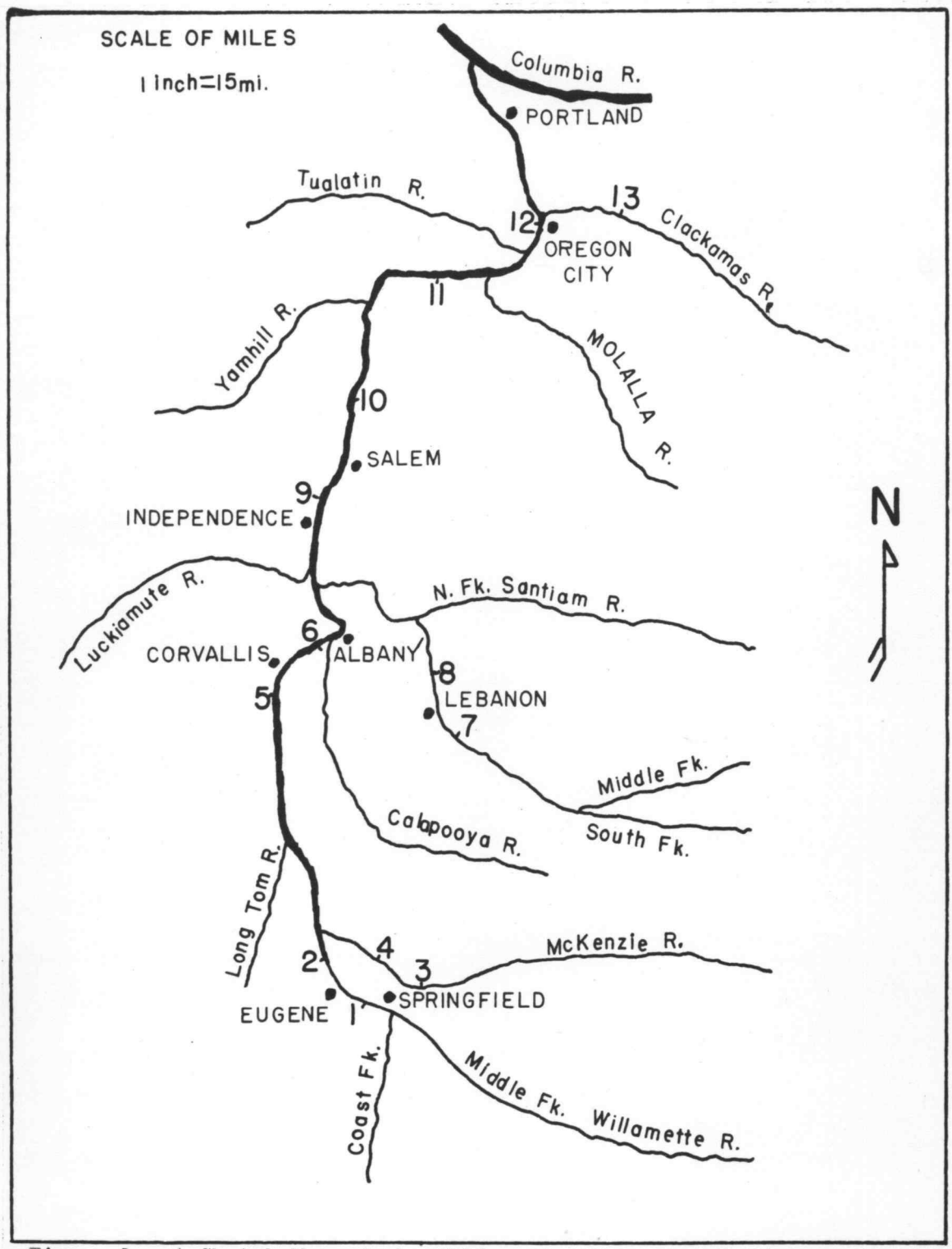

Figure 1: A Sketch Map of the Willamette River System showing the Location of the Sampling Stations.

Figure 2: Station One--Willamette River just above Eugene.

Figure 3: Station Two--Willamette River below Eugene.

foot or more in diameter. At this station rock was being excavated from the river bed by a sand and gravel company, and the bottom of the sampling area was occasionally disturbed.

Station two, (Figure 3), was located on the Willamette River approximately four miles downstream from Eugene and about one mile above the confluence of the Willamette River and the McKenzie River, This station was reached by taking the "old river road" to Eugene and by turning East on River Avenue. Gravel was being taken from the river bed just below this station. In November the bottom at this station had been somewhat disturbed by these operations. The nature of the bottom was very similar to that of station one. However, by visual observation, the water appeared to be quite polluted from upstream sewers. There was much suspended material in the water and the bottom was covered with silt and a slimey growth of micro-organisms. At one time the water was colored red from beet cannery wastes. Human feces were observed in this area at low water during July, August, and September.

Station three, (Figure 4), was located on the McKenzie River approximately 100 yards above the Hayden bridge, and about 200 yards above the point of discharge of Kraft mill wastes and other effluents from the Weyerhaeuser Timber Company mill at Springfield. The bottom was composed mostly of smooth, flat rocks up to one foot in diameter. In July and November, this station appeared abnormally low in productivity of bottom fauna. In November the bottom had been scoured and the gravel was rearranged by a freshet. This was presumed to be the cause of the scarcity of bottom fauna in July. The water at this station was

Figure 4: Station Three--McKenzie River at Hayden Bridge.

Figure 5: Station Four--McKenzie River at old ferry slip.

cold and clear during each sampling trip. The water supply of the city of Springfield is located just above the Hayden bridge.

Station four, (Figure 5), was located on the McKenzie River about three miles downstream from station three. This location was chosen to determine the effects of the Kraft mill effluents from the Weyerhaeuser Timber Company. The bottom was composed of smooth rocks up to one foot in diameter. The river at this station was shallow and swift. At low water, it was possible to wade across to the other side. In July, August, and September, during the period of low water, the rocks were covered with a slimey growth of micro-organisms and "sewage fungus", Sphaerotilus, sp. This undoubtedly resulted from sugars and carbohydrates in the discharge of pulp mill wastes several miles upstream. The effluent was discharged on the south side of the river and it had a tendency to cling to that side. For this reason, the north side of the river at this station did not markedly exhibit the growth of Sphaerotilus, sp. as did the south side. The characteristic odor of Kraft mills could be detected at this station.

Station five, (Figure 6), was located on the Willamette River approximately one mile south of Corvallis just above the confluence with Mary's River. At this station the bottom was composed mostly of small, flat rocks up to eight inches in diameter. The river was fairly swift at this area. The bottom appeared much cleaner at this station than at station two, which is below Eugene. This is caused by the influence of the McKenzie River which enters the Willamette River between stations two and five. The surrounding area was being worked by the Corvallis Sand and Gravel Company.

Figure 6: Station Five--Willamette River above Corvallis.

Figure 7: Station Six--Willamette River above Albany.

Station six, (Figure 7), was located on the Willamette River at Bryant Park in Albany. This is approximately 500 yards upstream from the Willamette River bridge, and 100 yards above the confluence of the Calapooya River with the Willamette River. The appearance and nature of the bottom of this station was very similar to that of station five at Corvallis. However, there was slightly more debris on the bottom at station six.

Station seven, (Figure 8), was located on the South Fork of the Santiam River just below the Lebanon dam. This is approximately three miles southeast and above the city of Lebanon. This dam is about six feet in height and is used to divert water into a ditch which flows through the city of Lebanon. During periods of low water, head boards are installed on this dam to increase the volume of flow into the ditch. A portion of this water is utilized by the Crown Zellerbach Corporation paper mill at Lebanon, and other industrial concerns. By means of another ditch, the sulfite wastes from this mill are carried to the South Fork of the Santiam River. At periods of low water, this ditch becomes extremely foul and has characteristics of the septic zone of pollution. The remainder of the water diverted by the Lebanon dam is carried to Albany where it enters the Calapooya River just above the confluence with the Willamette River. The bottom of station seven, below the dam, is composed of rocks from small gravel up to boulders in size. There is a broad riffle below the dam which enters a long, deep pool.

Station eight, (Figure 9), was located on the South Fork of the Santiam River just below the Crabtree bridge, about five or six miles

Figure 8: Station Seven--South Fork Santiam River at Lebanon Dam.

Figure 9: Station Eight--South Fork Santiam River at Crabtree Bridge.

downstream from Lebanon. The bottom is composed of smooth, flat rocks up to a foot in diameter. This section of the river is characterized by a series of riffles and pools. This was the most grossly polluted of all the stations visited during the survey. This was caused by the sulfite waste liquors from the Crown Zellerbach pulp mill and domestic wastes from the city of Lebanon. The bottom was covered by an extremely heavy, slimey growth of micro-organisms and Sphaerotilis, sp. The water was stained a dark color, and from a distance, the river appeared to be black. These conditions existed from July to November, but were particularly severe during August and September when the water volume was low. Unfortunately, during these critical summer months, about half or more of the flow of the South Fork of the Santiam River is diverted into the ditch above the Lebanon dam.

Station nine, (Figure 10), was located on the Willamette River at Independence just below the old ferry slip and above the outlet of the city sewage treatment plant. Because of high water in November, this area was inaccessible and sampling was done near the old ferry slip. There was a good riffle at the station below the ferry slip, and the bottom was composed of gravel and rocks up to one foot in diameter. At the old ferry slip, the current was much slower and the rocks were much smaller. This station was biologically the richest of all the stations on the Willamette River. The confluence of the Santiam River is located approximately 14 miles upstream from Independence.

Station ten, (Figure 12), was located on the Willamette River at Wheatland Ferry which is about 14.5 miles downstream from Salem. At this station, the river starts to assume the characteristics of the

Figure 10: Station Nine--Willamette River at Independence.

Figure 11: Station Nine--Willamette River at Independence, during high water.

Figure 12: Station Ten--Willamette River at Wheatland Ferry.

Figure 13: Station Eleven--Willamette River at Butteville.

deep, slow flowing, lower river. The bottom was composed uniformly of small, flat rocks. There was some evidence of silt on the bottom along with a growth of filamentous plants. Although the water was fairly high during November, the rocks were covered with a slimey growth of micro-organisms. This was presumably caused by the release of pulp mill wastes from a paper mill in Salem, or possibly from some other industrial or domestic wastes. The mill had lagooned the liquors and was releasing it during the period of high water. During this time, there was a newspaper reported fish kill below Salem, but there was no evidence of this at Wheatland Ferry.

Station eleven, (Figure 13), was located on the Willamette River at Butteville. This station lies between Newberg and the Wilsonville Ferry, and is about 48 river miles from the mouth of the Willamette River. Here the river is deep and it flows very slowly. The bottom was composed of sand, silt, small gravel, and bedrock. Because of high water, this area was not visited in November.

Station twelve, (Figure 14), was located on the Willamette River at Oregon City just above the confluence of the Clackamas River. Along the shore, the bottom is composed of large, smooth stones up to a foot or more in diameter. There was much wood fiber and other debris covering the bottom at this station. Growths of micro-organisms caused the rocks on the bottom to have a slippery feeling. In August and September, numerous masses of fermenting sludge deposits rose from the bottom and floated at the surface. The Willamette River at this station is severely polluted. This station was not visited in November because of high water.

Figure 14: Station Twelve--Willamette River at Oregon City.

Figure 15: Station Thirteen--Clackamas River at Oregon Fish Commission Laboratory.

Station thirteen, (Figure 15), was located on the Clackamas River at the Oregon Fish Commission laboratory. This is approximately five miles above the mouth of the river. This station was clear and cold during all of the sampling periods. Because of several dams upstream, there was a slight daily fluctuation of the water level. The bottom at this station was composed of smooth rocks of various sizes. No sampling was done in November because of high water.

PHYSICAL AND CHEMICAL METHODS

During the survey, the following chemical and physical tests were determined: dissolved oxygen content of water; hydrogen-ion concentration, (pH); air temperature; and water temperature.

Air and water temperatures were taken with a Fahrenheit thermometer at each station and the time of day was noted. Air temperatures were taken by wading out in the stream and holding the thermometer waist-high and away from the sun's rays. Water temperatures were determined at the same location in the stream. The thermometer was held in the shade just below the surface of the water for about two minutes. Readings were taken while the bulb was immersed in the water.

For the purpose of determining the dissolved oxygen content of water, water samples were collected with a Kemmerer water sampler. This was accomplished by wading out in the stream and collecting the water about midway between the surface and the bottom. The unmodified Winkler method was used for these determinations. During the month of September, Mr. John Wilson, Regional Biologist with the U. S. Public Health Service, determined the dissolved oxygen at the most polluted stations by the sodium azide modification. These results were compared with the readings from the unmodified Winkler method and were found to be in good agreement.

Part of the remaining water in the Kemmerer water sampler was used in the determination of the hydrogen-ion concentration (pH). The pH was determined colorimetrically by the use of a La Motte block comparator. This apparatus indicates pH values between 3.0 and 10.5.

River flow data were obtained from the United States Geological Survey records from the gage at Salem, Oregon, (Table 3). Biochemical oxygen demand (B.O.D.) readings were furnished by the Oregon State Sanitary Authority, which conducted a chemical and physical survey of the Willamette River system during the summer of 1951, (unpublished). Drought flows, (Table 2), were furnished by the National Council for Stream Improvement, (10, p. 23).

BIOLOGICAL SAMPLING METHODS

Biological sampling consisted of taking square-foot samples of bottom organisms, and by picking organisms by hand. Square-foot counts were accomplished by using a square-foot stream bottom sampler. These samples were taken on representative riffle areas in one to two feet of water. The organisms collected were preserved in 70% ethyl alcohol, and were later measured volumetrically. Gastropods taken in the square-foot sample were measured separately because of their relatively large size and the question as to their value as fish food for the particular fish species inhabiting the Willamette River. Other collection of bottom fauna was done by picking organisms by hand from under stones, on debris, etc. Some larger forms, such as crayfish, stonefly nymphs, and some mayfly nymphs, were occasionally taken when seining for fishes.

These collections of bottom organisms are on file in the Department of Fish and Game Management, Oregon State College for future comparison and for further classification as to species.

RESULTS

In order to facilitate clarity and orderliness, the results are presented by month for each station. Under the Discussion heading a summarized account is presented for each station covering all of the observations made during the survey period, July into November, 1951. Identification of organisms was carried to order or family in most cases, and down to genus and species for some organisms, particularly the mayflies and stoneflies. With the exception of adult Coleoptera, or beetles, particularly of the aquatic insects collected were larvae or nymphs.

The organisms collected in the square-foot samples were classified as clean-water forms, facultative forms, or pollutional forms, as shown in Table 8. As implied, the pollutional forms are characteristic of polluted waters, and the clean-water forms prefer unpolluted waters. The facultative forms may live in either clean or polluted waters. The characteristic organisms of these three categories are as follows: clean-water; mayflies, stoneflies, caddis flies, water penny beetle, and midges (not red in color); facultative; blackflies, beetles, snails, damsel flies, dragon flies, moss animals (Bryozoa), true bugs, sponges, and water mites; pollutional; red midges (bloodworms), white-colored scuds or fresh-water shrimp, sludge worms, leeches, mosquito larvae, water sow bugs, and rat-tailed maggots. The percent, based on the number of these three types taken in each square-foot sample, was calculated and shown graphically for each station during each month of the survey, (Figures 16-19).

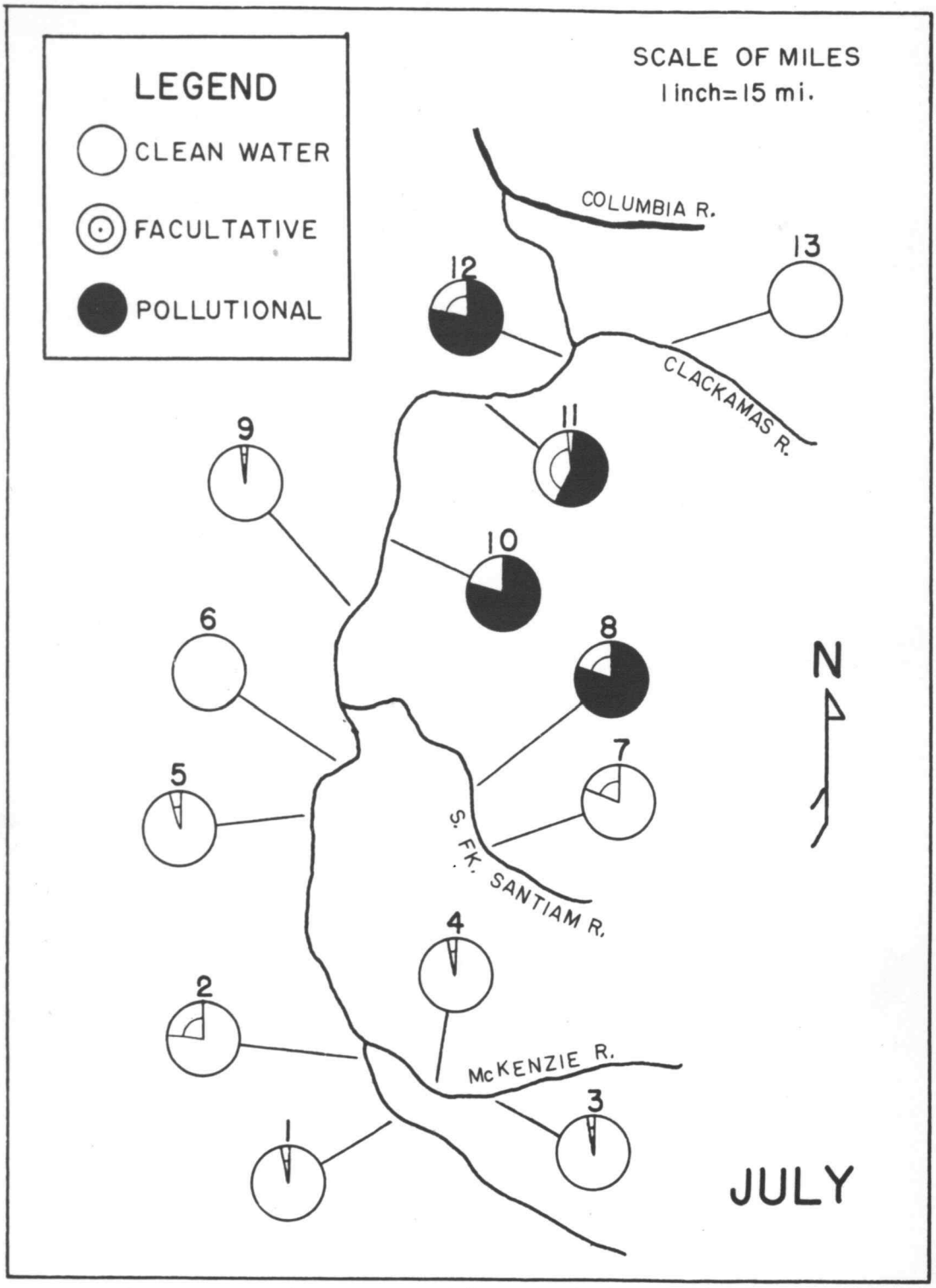

Figure 16: The Ratio of Pollutional to Facultative and Cean-Water Organisms in the Willamette River System during July, 1951.

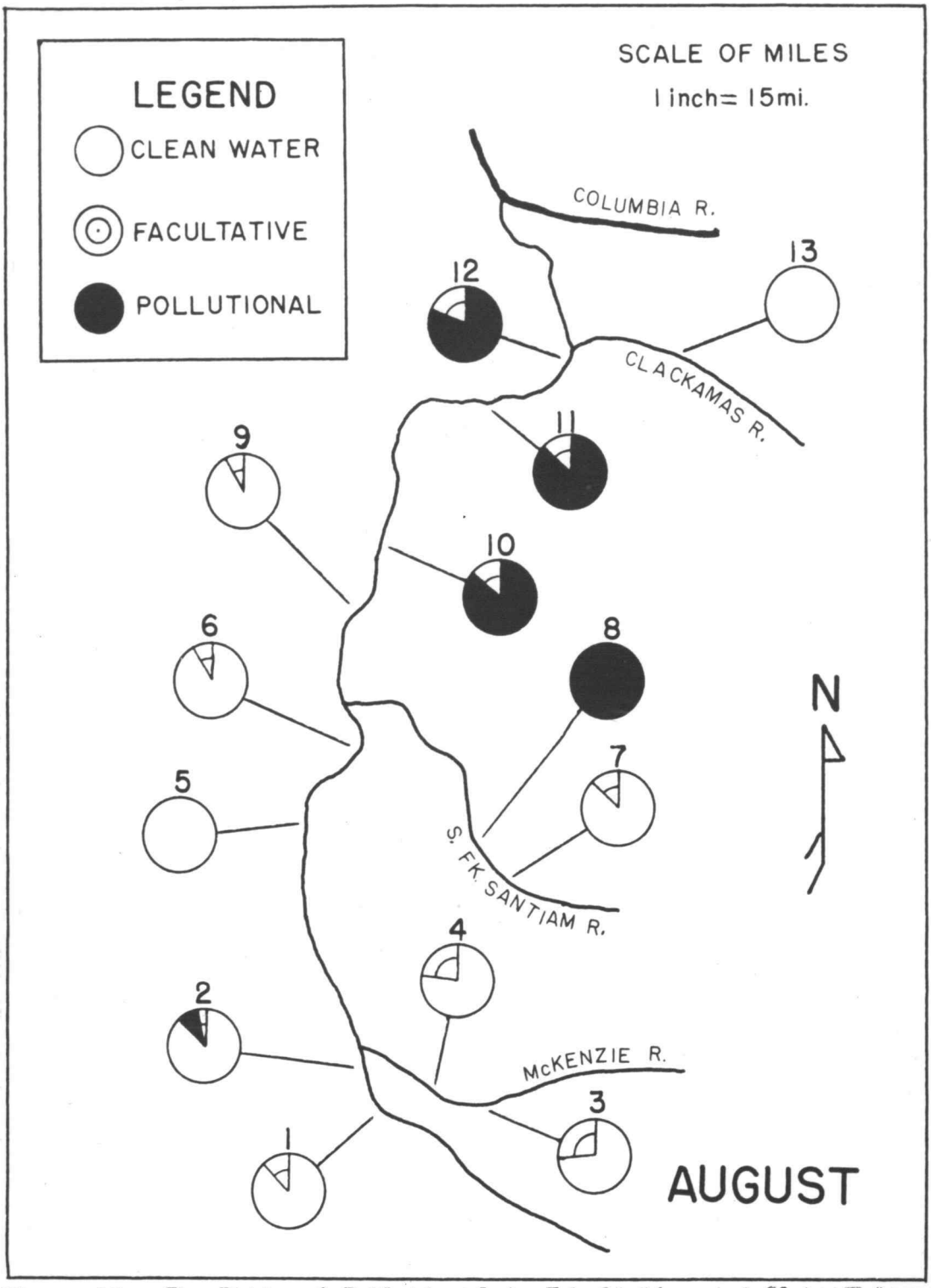

Figure 17: The Ratio of Pollutional to Facultative and Clean-Water Organisms in the Willamette River System during August, 1951.

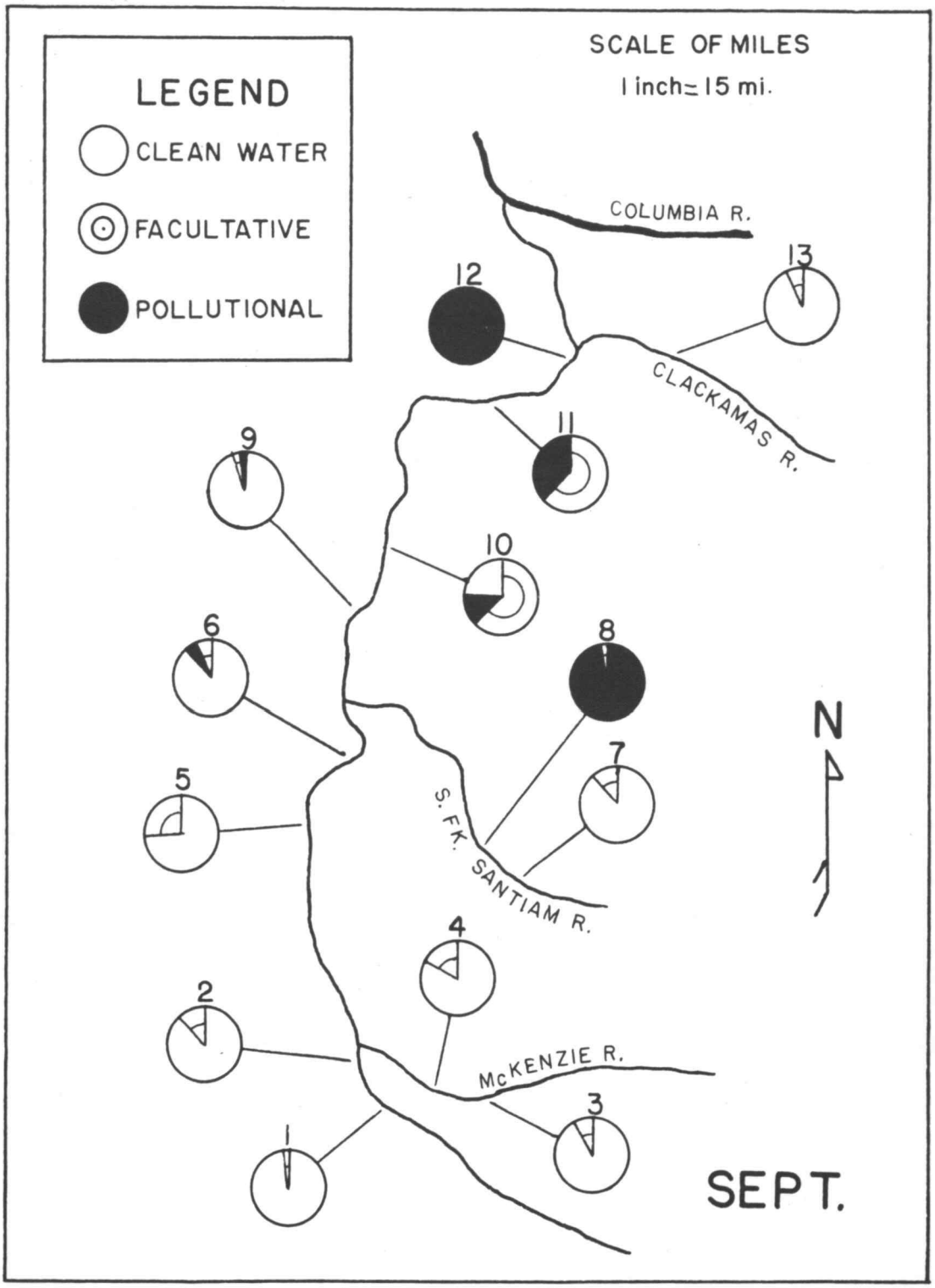

Figure 18: The Ratio of Pollutional to Facultative and Clean-Water Organisms in the Willamette River System during September, 1951.

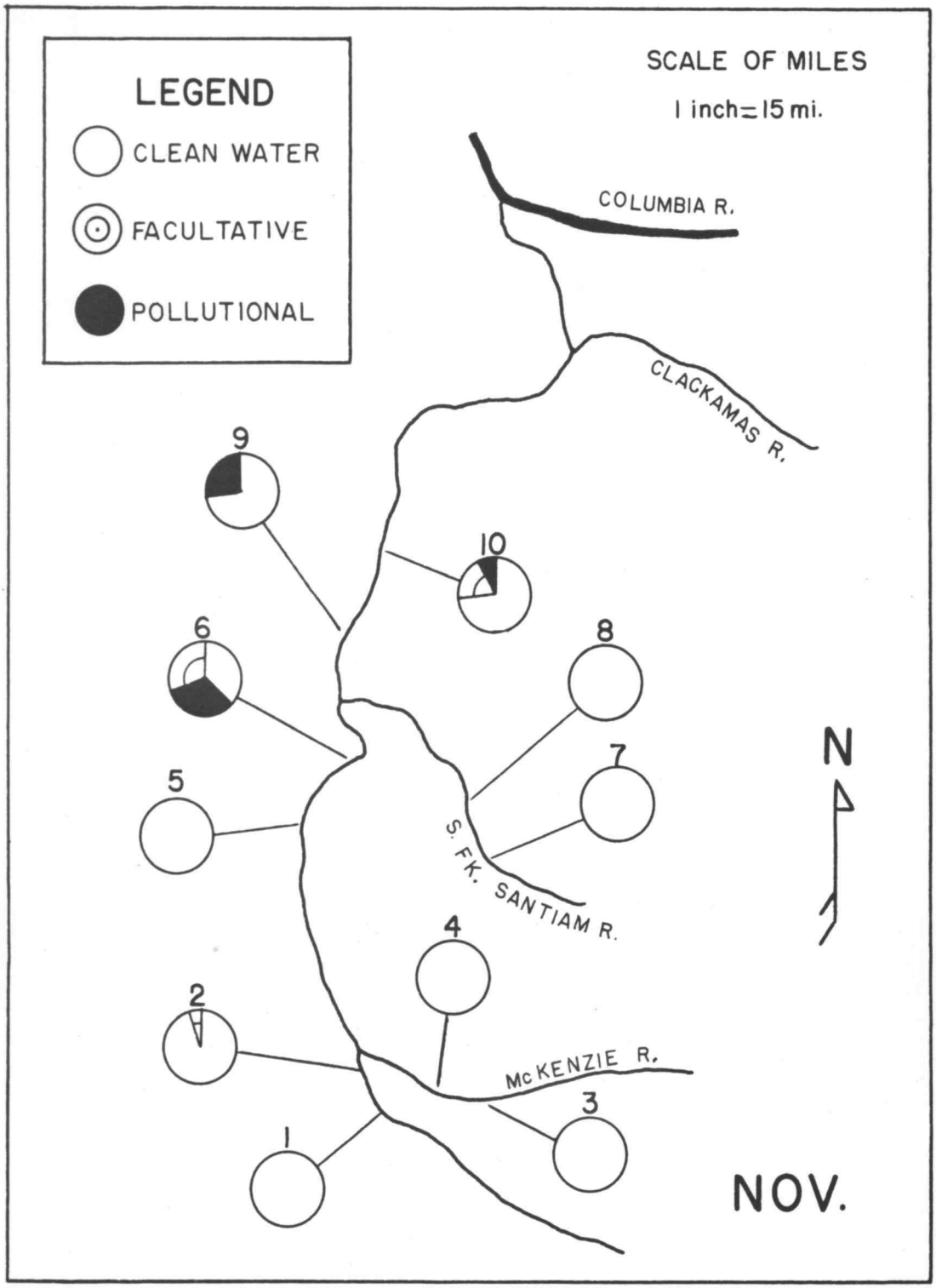

Figure 19: The Ratio of Pollutional to Facultative and Clean-Water Organisms in the Willamette River System during November, 1951.

The mayflies are generally regarded as being clean-water forms, however, Isonychia, sp. and Paraleptophlebia, sp. were found to be quite tolerant. Future studies should be made to ascertain their true indices characteristics.

During the survey, it was evident that the stoneflies definitely prefer clean waters. A distributional list of several mayflies and stoneflies at various stations in the Willamette River system is shown in Table 6.

Other than red midges, which are definitely pollutional organisms, the status of the midges is not too well known. Because of this, the non-red midges were arbitrarily classified as clean-water forms. Further work should be done to determine the true status of the midges in relation to pollution in the Willamette River system. Also, it would be desirable for further work to be done on the Molluscs and Amphipods in the Willamette River system in respect to their use as indicator organisms.

The square-foot and handpicking collections are on file in the offices of the Department of Fish and Game Management at Oregon State College, and will be available for additional investigation and for comparison purposes in future sampling.

In regards to interpretation of the data collected during the survey, the significance of the various tests should be understood.

The amount of dissolved oxygen in the water is of prime importance to aquatic organisms. According to Ellis, (2, p. 365-437), "....5 p.p.m. dissolved oxygen is the lowest value which may reasonably be expected to maintain in good condition varied fish fauna of

warm-water fishes in our inland streams, if the water temperature be 20 degrees C. or above."

In conjunction with dissolved oxygen determinations, percent saturation is frequently used. This refers to the amount of dissolved oxygen in water compared to the amount it is capable of holding.

Another test frequently used is the biochemical oxygen demand, commonly known as B.O.D. According to Merryfield and Wilmot, (5, pp. 19-21), "it is the best indicator of the relative organic strengths of various wastes and of their probable effect when discharged into the receiving stream." Generally speaking, a B.O.D. of less than 1.0 p.p.m. is low, 1.0 p.p.m. to 3.0 p.p.m. intermediate, and above 3.0 p.p.m. is high.

Hydrogen-ion concentration (pH) expresses the intensity of acidity or alkalinity of a substance. The pH values vary from 0 to 14, with a pH of 7 being neutral. Values less than 7 are acidic and those more than 7 are basic. The greater the numerical distance from a pH of 7, the greater the intensity of acidity or alkalinity. Waters generally have a pH between 6 and 8. Decomposition of organic material may lower the pH, while mineral salts in solution may raise the pH, (5, pp. 21-22).

In the interpretation of square-foot sample data, according to Lagler, (4, p. 175), the volume of bottom fauna can be expressed as follows: "food grade 1 (exceptional richness) volume greater than 2 cc. or 2 grams, number greater than 50; food grade 2 (average richness) volume from 1 to 2 cc. (1 to 2 gm.), more than 50 organisms; food grade 3 (poor in food) volume less than 1 cc. (1 gm.) and (or)

fewer than 50 organisms."

All the physical and chemical data collected during the survey are given in Tables 2 to 4, and the biological data are given in Tables 5, 6, and 9.

In the following results, if no parenthesis is indicated behind the name of an organism, this means that only one species was collected, with the exception of the Gastropods and Chironomidae, whose status was not clear.

Station One--Above Eugene

July 12

During the month of July, the water at station one was fairly furbid. This was caused by the construction of dams upstream. At this time, the river flow at Salem was 5.550 cubic feet per second. (Figure 23 and Table 3). The dissolved oxygen was 8.7 p.p.m. (100% saturated); the B.O.D. was 0.2 p.p.m. on July 25; the pH was 7.4; and the water temperature was 73 degrees Fahrenheit at 2:15 p.m. The square-foot count was 1.3 cc. at this station, with 86 organisms displacing this volume. The square-foot sample was made up of the following organisms: 49 Ephemeroptera, (5 species); 5 Plecotera, (2 species); 24 Trichoptera, (3 species); numerous "green" Chironomidae; 8 Gastropods; 5 Simulidae; 3 Coleoptera, and 1 Odonata.

Mayflies belonging to the families Baetidae and Heptageneidae were collected. Stoneflies collected were *Pteronarcys*, sp., *Acroneuria californica*, and *A. pacifica*, (Table 6).

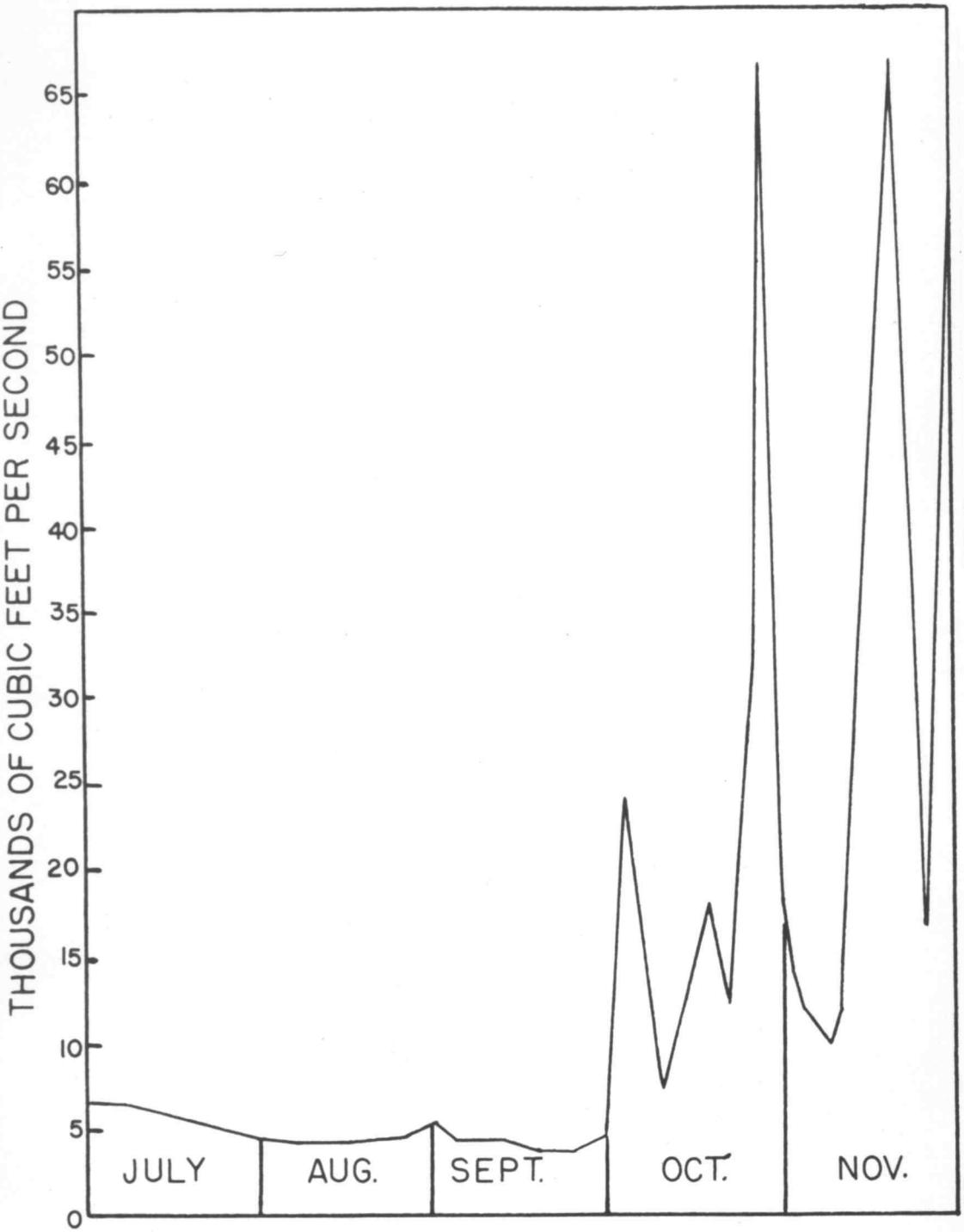

Figure 23: Water Flow Data for the Willamette River at Salem, Oregon, from July to November, 1951.

August 21

At this time the water was still turbid. The dissolved oxygen was 8.3 p.p.m. (95.5% saturation); the B.O.D. was 0.9 p.p.m. on August 14; the pH was 7.8; and the water termperature was 73.5° F. at 1:30 p.m. The water flow at the Salem gage was not taken for August 21, but on August 22 the flow was 4,400 c.f.s. The square-foot count was much lower than the month before, with 33 organisms displacing a volume of 0.2 cc. These organisms were: 11 Ephemeroptera, (5 species); 5 Trichoptera, (1 specie); 3 Colepptera, (2 species); 13 Chironomidae; and 1 Rhagionidae (Diptera). These organisms were classified as 88% clean water forms, and 12% facultative. Handpicking forms were as follows: 32 Ephemeroptera, (5 species); 3 Plecoptera; 48 Trichoptera; numerous "green" Chironomidae; 14 Simulidae; and 3 Coleoptera.

Mayflies collected were Baetidae, Heptageneidae, and Isonychia, sp. (Baetidae). Acroneuria californica was the only stonefly collected during this month.

September 25

The water volume at this time was the lowest during the survey. The flow at the Salem gage was 4,200 c.f.s. The dissolved oxygen was 9.0 p.p.m. (92.9% saturation); the B.O.D. was 0.5 p.p.m. on September 5; the pH was 7.5; and the water temperature was 63° F. at 12:00 noon. The square-foot count was relatively high. One-hundred and thirty-eight organisms displaced a volume of 1.5 cc. Also, the volume of Gastropods was 0.05 cc. The following comprised the square-foot count:

25 Ephemeroptera, (5 species); 22 Plecoptera, (2 species); 62 Trichoptera, (3 species); 3 Coleoptera, (2 species); 26 Chironomidae; and 1 Gastropod. These were classified as 97% clean-water forms and 3% facultative. The results of the handpicking were as follows: 43 Ephemeroptera, (5 species); 39 Plecoptera, (2 species); 86 Trichoptera, (3 species); numerous green Chironomidae, 3 Gastropods; 6 Simulidae; 1 crayfish; and 3 Coleoptera, (2 species).

The following mayflies were collected: Isonychia, sp., Paraleptophlebia, sp., other Baetidae, and Heptageneidae. The stoneflies collected were Acroneuria californica, A. pacifica, and several others which were not identified.

November 6

This sampling period at station one was accomplished after a freshet and after the water volume had dropped. On this day, the flow at Salem was 11,150 c.f.s. On October 25, the flow was 67,500 c.f.s., (Table 3).

The water was not quite as turbid during this month as compared with the preceding months. The dissolved oxygen was up to 11.4 p.p.m. (99% saturation); the pH was 7.4; and the water temperature was 49° F. at 2:30 p.m. No B.O.D. was taken in November. The sampling area was disturbed by the operations of a sand and gravel company. This, along with the high water, was the probable cause of the poor square-foot count. Seventeen organisms displaced a volume of 0.05 cc. These organisms were 12 Ephemeroptera, (2 species); and 5 Trichoptera, (2 species). These were classified as 100% clean water forms. For the

handpicking data, there were as follows: 22 Ephemeroptera, (3 species); 6 Plecoptera, (2 species); 18 Trichoptera, (2 species); 4 Gastropods; and 1 Odonata.

The mayflies collected during this month belonged to the Baetidae and Heptageneidae families. Acroneuria californica was the only stonefly taken.

Station Two--Below Eugene

July 12

The water at this station appeared to be very turbid. Upstream the water was stained a red color from beet cannery wastes. Cannery wastes and human feces were observed in the water. The bottom was covered with silt and growths of fungi and algae. The dissolved oxygen was 8.3 p.p.m. (97.5% saturation); the B.O.D. was 1.7 p.p.m. on July 25; and the water temperature was 74.5° F. at 4:10 p.m. This month had the highest square-foot count for this station during the survey. However, this volume was only 0.2 cc. This was based on 31 organisms. The organisms in the square-foot sample were as follows: 10 Ephemeroptera, (4 species); 1 Plecoptera; 2 Trichoptera, (1 specie); 11 Chironomidae; 2 Coleoptera, (1 specie); and 5 Diptera pupae. These organisms were classified as follows: 77% clean-water forms, and 23% facultative. The handpicking results are as follows: 41 Ephemeroptera, (4 species); 11 Plecoptera, (2 species); 3 Trichoptera; 5 Simulidae; and 2 Coleptera.

The following mayflies were collected: Paraleptophlebia, sp., other Baetidae, and Heptageneidae. The stoneflies collected were

Acroneuria californica, and A. pacifica.

August 21

The water at this time still appeared turbid and there was much suspended debris in the water. The dissolved oxygen was 6.7 p.p.m. (78.8% saturation), which was the lowest reading taken at this station during the survey. The B.O.D. was 2.4 p.p.m. on August 14; the pH was 7.5; and the water temperature was 75° F. at 3:00 p.m. The square-foot count was 0.1 cc., with 29 organisms displacing this volume. These organisms were as follows: 2 Ephemeroptera; 1 Plecoptera; 22 Chironomidae; 1 Rhagionidae (Diptera); and 3 Hirudinea. These forms were classified as follows: 84% clean-water; 4% facultative; and 12% pollutional. The handpicking results are as follows: 26 Ephemeroptera, (4 species); 11 Plecoptera; 5 Trichoptera; 28 Chironomidae; 4 Hirudinea; 4 Gastropods; 1 Coleoptera; and 1 Bryozoan colony (Pectinatella).

The mayflies collected were: Isonychia, sp., Paraleptophlebia, sp., and other Baetidae. Acroneuria californica and A. pacifica were the stoneflies collected.

September 25

The water conditions appeared to be the same for September as for the two previous months. The water was turbid and there was much suspended debris. The dissolved oxygen was 8.0 p.p.m. (83.4% saturation); the B.O.D. was 2.9 p.p.m. on September 18; the pH was 7.4; and the water temperature was 64° F. at 3:15 p.m. The square-foot count was poor, with 28 organisms displacing a volume of 0.05 cc. These organisms

were as follows: 11 Ephemeroptera, (2 species); 1 Plecoptera; 2 Coleoptera, (2 species); 13 Chironomidae; and 1 Diptera pupa. These organisms were classified as 86% clean-water forms, and 14% facultative. Handpicking results are as follows: 40 Ephemeroptera, (2 species); 5 Plecoptera; 2 Trichoptera; 23 Chironomidae; 17 Gastropods; 3 Coleoptera, (2 species); 1 Rat-tailed maggot, Eristalis, sp.; and 2 aquatic Lepidoptera.

The only mayflies collected belonged to the Baetidae family. Acroneuria californica was the only stonefly collected.

November 6

The water during this sampling period was higher and more clean in appearance than during the previous months. The dissolved oxygen was up to 11.2 p.p.m. (99% saturation); the pH was 7.5; and the water temperature was down to 50° F. at 4:30 p.m. The square-foot count, although relatively low, was the second richest of the survey at this station. The volume displaced by 23 organisms was 0.15 cc. The following organisms were taken in the square-foot count: 12 Ephemeroptera, (2 species); 4 Plecoptera, (2 species); 1 Trichoptera; 1 Coleoptera; and 5 Chironomidae. These were classified as 95% clean-water forms, and 5% facultative. The following organisms were collected by handpicking: 14 Ephemeroptera, (2 species); 8 Plecoptera, (2 species); 2 Trichoptera; 5 Chironomidae; 2 Hirudinea; and 1 Coleoptera.

Mayflies collected belonged to the Baetidae and Heptageneidae families. Stoneflies collected were Pteronarcys, sp., and Acroneuria

californica.

Station Three--Hayden Bridge on McKenzie River

July 12

Station three was one of the cleanest stations encountered in the survey. In July, the dissolved oxygen was 9.6 p.p.m. (96% saturation); the B.O.D. was 0.9 p.p.m. on July 25; the pH was 7.1; and the water temperature was 60° F. at 11:15 a.m. The square-foot count was rather low, with 16 organisms displacing a volume of 0.1 cc. These organisms were as follows: 7 Plecoptera, (3 species); 1 Coleoptera; and 8 Chironomidae. These were classified as 94% clean-water forms, and 6% facultative. No mayflies were taken, although several were seen. They were of the Baetidae type. The handpicking results are as follows: 18 Plecoptera, (3 species); 3 Trichoptera, (2 species); 13 green Chironimidae; and 1 Coleoptera.

The following stoneflies were collected: *Acroneuria californica*, *A. pacifica*, and *Allopera*, sp.

August 21

The water level was not quite as high in August as it was during July. The dissolved oxygen was 8.1 p.p.m. (79.5% saturation), which was the lowest for this station during the survey. The B.O.D. was 0.6 on August 14; the pH was 6.9; and the water temperature was 50° F. at 10:30 a.m. The square-foot count was higher than during July, but it was only 0.25 cc. The 65 small organisms displacing this volume were as follows: 22 Ephemeroptera, (3 species); 8 Plecoptera;

17 Simulidae; 16 Chironomidae; and 2 Coleoptera. These organisms were classified as 73% clean-water forms, and 27% facultative. The following were collected by handpicking: 71 Ephemeroptera, (3 species); 17 Plecoptera, (3 species); 9 Trichoptera; 38 Chironomidae; 37 Simulidae; and 13 Diptera pupae.

All the mayflies taken belonged to the Baetidae and Heptageneidae families. The following stoneflies were collected: Pteronarcys, sp., Acroneuria californica, A. pacifica, and Alloperla, sp.

September 14

The water was still clear and cold at this time. The dissolved oxygen was 10.1 p.p.m. (92.5% saturation); the B.O.D. was 0.7 on September 5; the pH was 7.7; and the water temperature was 55° F. at 11:00 a.m. The square-foot count was the same as for August, with 27 organisms having a volume of 0.25 cc. The following comprised the square-foot count: 9 Ephemeroptera, (4 species); 23 Plecoptera, (3 species); 3 Trichoptera; 8 Chironomidae; and 4 Coleoptera. These were classified as 91% clean-water forms and 9% facultative. The organisms collected by handpicking were as follows: 13 Ephemeroptera, (4 species); 19 Plecoptera, (2 species); 1 Trichoptera; 3 Chironomidae; 2 Gastropods; 3 Simulidae; and 1 Coleoptera.

The mayflies collected belonged to the Baetidae and Heptageneidae families. Acroneuria californica, A. pacifica, and Alloperla, sp., were the stoneflies collected.

November 6

This station was visited after a freshet and after the water had dropped. The sampling area had been scoured and the gravel re-arranged. This was the probable cause of the lack of bottom fauna. The dissolved oxygen was 12.5 p.p.m. (105% saturation), the highest reading for all 13 stations during the survey. The pH was 7.3 and the water temperature was 46° F. at 10:00 a.m. The square-foot count was poor, with 8 organisms having a volume of 0.025 cc. These organisms were as follows: 5 Ephemeroptera, (2 species); 2 Plecoptera; and 1 Trichoptera. These were classified as 100% clean-water forms. The following organisms were collected by handpicking: 19 Ephemeroptera, (3 species); 3 Plecoptera; 1 Trichoptera; 3 Chironomidae; 3 Gastropods; and 11 Simulidae.

Mayflies of the families Baetidae and Heptageneidae were collected. *Acroneuria californica* was the only stonefly taken during this month.

Station Four--McKenzie River, Old Ferry Slip

July 12

At this time, the bottom at this station had not been scoured as was station one several miles upstream. The dissolved oxygen was 9.8 p.p.m. (100% saturation); the pH was 7.4; and the water temperature was 62° F. at 12:50 p.m. With the exception of Gastropods, the square-foot count was poor. Ten organisms displaced a volume of 0.05 cc. Three Gastropods taken in the square-foot sample had a volume of 1.5 cc. The following comprised the square foot sample:

1 Plecoptera; 1 Diptera larvae; 8 Chironomidae; and 3 Gastropods. These were classified as 90% clean-water forms and 10% facultative. The handpicking was as follows: 19 Ephemeroptera, (4 species); 6 Plecoptera, (2 species); 12 Trichoptera, (3 species); 21 Gastropods; 6 Coleoptera, (4 species); 2 Hydarcaurina; 10 Chironomidae; and 3 Diptera pupae. Also, there was a growth of Sphaerotilus, sp., on the bottom. All the mayflies collected belonged to the Baetidae family. Acroneuria californica and A. pacifica were the species of stoneflies taken.

August 21

The water was slightly lower at this time than it was during July. There was a heavier growth of Sphaerotilus, sp. on the bottom. The dissolved oxygen was 7.2 p.p.m. and was 72.8% saturated. This was the lowest reading for this station. The B.O.D. was 1.3 p.p.m. on August 14; the pH was 7.6; and the water temperature was 61° F. at 11:45 a.m. The square-foot count was the same as it was in July. Eighteen organisms had a volume of 0.05 cc. Also, 18 Gastropods displaced a volume of 1.6 cc. The organisms found in the square-foot sample were as follows: 3 Ephemeroptera, (2 species); 1 Plecoptera; 1 Trichoptera; 9 Chironomidae; 4 Simulidae; and 18 Gastropods. These were classified as 77% clean-water forms and 23% facultative. The handpicking organisms are as follows: 25 Ephemeroptera, (5 species); 7 Plecoptera, (3 species); 9 Trichoptera, (4 species); 17 Gastropods; 1 Tipulidae; 15 Chironomidae; 1 Rhagionidae; 4 Simulidae; and 3 crayfish.

The mayflies collected at this time were Paraleptophlebia, sp., and other Baetidae. The following stoneflies were taken: Pteronarcys, sp., Acroneuria californica, A. pacifica, and Alloperla, sp.

September 14

The water flow for September was approximately the same as it was during July. The dissolved oxygen was up to 10.1 p.p.m. (92.5% saturation); the B.O.D. was 2.4 p.p.m. on September 18; the pH was 7.8; and the water temperature was 55° F. at 12:30 p.m. The square-foot count was higher than it was in July or August, with 13 organisms having a volume of 0.1 cc. Also, 3 Gastropods displaced a volume of 1.5 cc. The square-foot count was made up of the following organisms: 7 Ephemeroptera, (2 species); 5 Chironomidae, (not red); 1 Plecoptera. These were classified 81% clean-water forms and 19% facultative. The forms collected by handpicking were as follows: 34 Ephemeroptera, (5 species); 6 Plecoptera, (2 species); 9 Trichoptera, (2 species); 24 Chironomidae; 13 Gastropods; 4 Neuroptera, (Sialis, sp.); 2 crayfish; and 2 Coleoptera. Sphaerotilus, sp. was also abundant during September. Paraleptophlebia, sp. and other Baetidae and Heptageneidae were the kinds of mayflies collected. The stoneflies collected were Pteronarcys, sp., and Acroneuria pacifica.

November 6

This station was visited after a freshet and after the water had receded. However, the bottom had not been scoured as in station one upstream. The dissolved oxygen was the highest at this time, being

11.7 p.p.m. and 98% saturated. The pH was 7.4, and the water temperature was 46° F. at 12:30 p.m. The square-foot count was higher this month than for any other month. Sixty-two organisms displaced a volume of 0.2 cc. These organisms were as follows: 56 Ephemeroptera, (3 species); 2 Plecoptera, (2 species); 3 Trichoptera, (2 species); and 1 Chironomidae. These were classified as 100% clean-water forms. The following organisms were collected by handpicking: 86 Ephemeroptera, (3 species); 51 Plecoptera, (5 species); 3 Trichoptera, (2 species); 4 Chironomidae; 3 Gastropods, (2 species); 2 Neuroptera, (*Sialis*, sp.); 1 Coleoptera; and 1 Tipulidae.

Mayflies of the families Baetidae and Heptageneidae were collected. The following stoneflies were collected: *Pteronarcys*, sp., *Acroneuria californica*, *A. pacifica*, and *Alloperla*, sp.

As in the previous months, there was a growth of *Sphaerotilus*, sp. on the bottom.

Station Five--Above Corvallis

July 13

Because of the effect of the McKenzie River, this station appeared to be much cleaner than station two. There was much less suspended debris and the bottom was much cleaner. The dissolved oxygen was 8.2 p.p.m. (93% saturation); the B.O.D. was 0.6 p.p.m. on July 25; the pH was 7.2; and the water temperature at 3:55 was 71.5° F. The square-foot count was quite high. Fifty-eight organisms had a volume of 1.5 cc. The organisms in the square-foot count were as follows: 44 Ephemeroptera, (3 species); 1 Trichoptera; 1 Odonata; 7 Chironomidae;

3 Simulidae; and 2 Coleoptera. These were classified as 90% clean-water forms and 10% facultative. The handpicking forms were as follows: 89 Ephemeroptera, (6 species); 2 Plecoptera, (1 specie); 1 Trichoptera; 7 Chironomidae; 3 Simulidae; 2 Coleoptera; and 1 Odonata.

Mayflies collected belonged to the Baetidae and Heptageneidae families. No stoneflies were caught at this station during July.

August 17

The water volume was lower at this time than it was during July. The dissolved oxygen was down to 6.6 p.p.m. (73.4% saturation); the B.O.D. was 1.5 p.p.m. on August 15; the pH was 7.6; and the water temperature was 70° F. at 4:45 p.m. The square-foot count was 0.1 cc, with 30 organisms displacing this volume. Twenty Ephemeroptera, (3 species); 9 Chironomidae; and 1 Trichoptera were found in the square-foot sample. These were classified as 90% clean-water forms and 10% facultative. The following were collected by handpicking: 66 Ephemeroptera, (3 species); 3 Trichoptera; and 12 Chironomidae.

Baetidae and Heptageneidae were the mayfly families collected at this time. No stoneflies were found in August.

September 25

Although the water volume was about the same for September as it was for July and August, the water was much cooler during September. The dissolved oxygen was up to 8.7 p.p.m. (87% saturation); the B.O.D. was 1.6 p.p.m. on September 5; the pH was 7.5; and the water temperature was 60° F. at 9:30 p.m. The square-foot count was the same as

that of August. Nineteen organisms displaced a volume of 0.1 cc. These organisms were as follows: 2 Ephemeroptera; 2 Plecoptera; 3 Trichoptera; 1 Turbellarian; 3 Coleoptera, (2 species); 1 Hydracaurina; and 1 Diptera pupae. These were classified as 74% clean-water forms and 26% facultative. The handpicking was as follows: 37 Ephemeroptera, (5 species); 10 Plecoptera; 19 Trichoptera, (2 species); 8 Chironomidae; 1 Gastropod; 3 Coleoptera; 1 Hydracaurina; 4 Tipulidae; 2 Odonata; and 1 Turbellarian.

The mayflies collected included Isonychia, sp., Paraleptophlebia, sp., other Baetidae, and Heptageneidae.

November 9

Station five, at this time, was sampled after a freshet and the water was still quite high and not favorable for sampling. The dissolved oxygen was up to 10 p.p.m. (87% saturation), which was the highest reading for this station. The pH was 7.4, and the water temperature was down to 49° F. at 3:00 p.m. Three organisms were taken in the square-foot sample, with 2 Ephemeroptera and 1 Plecoptera having a volume of 0.05 cc. These were classified as 100% clean-water forms. The handpicking was also quite poor. The only organisms collected were 3 Ephemeroptera; and 3 Plecoptera. The mayflies taken all belonged to the Heptageneidae family. The stoneflies collected were Acroneuria californica, and Alloperla, sp.

Station Six--Above Albany

July 13

This station was quite similar biologically to station five, which is located above Corvallis. The dissolved oxygen was 7.3 p.p.m. (81% saturation); the B.O.D. was 1.4 p.p.m. on July 25; the pH was 7.4; and the water temperature was 70° F. at 9:40 a.m. Although the square-foot count was relatively poor, it was the highest during this month. Twenty-seven organisms had a volume of 0.15 cc. The following organisms comprised the square-foot data: 16 Ephemeroptera, (4 species); 4 Trichoptera, (2 species); and 7 Chironomidae. These were classified as 100% clean-water forms. The handpicking forms were as follows: 52 Ephemeroptera, (5 species); 13 Trichoptera, (3 species); 11 Chironomidae; 1 Oligochaeta; 2 Simulidae; 1 Coleoptera; and 1 Odonata.

The mayflies collected belonged to families Baetidae and Heptageneidae. No stoneflies were collected at this time.

August 17

The water volume during August was lower than it was in July. The dissolved oxygen was 6.8 p.p.m. (75.5% saturation), which was the lowest reading for this station. The B.O.D. was 2.2 p.p.m. on August 14; the pH was 7.5; and the water temperature was 70° F. at 1:40 p.m. The square-foot count was slightly lower than that of July, with 25 organisms displacing a volume of 0.13 cc. Also taken in the square-foot sample were 2 Gastropods with a volume of 0.05 cc.

The organisms found in the square-foot sample were as follows: 17 Ephemeroptera, (2 species); 2 Trichoptera; 6 Chironomidae; and 2 Gastropods. These were classified as 92% clean-water forms and 8% facultative. The following were collected by handpicking: 41 Ephemeroptera, (3 species); 14 Trichoptera, (2 species); 6 Chironomidae; 2 Hirudinea; 5 Gastropods; and 5 Turbellarians.

The mayflies collected belonged to the Baetidae and Heptageneidae families.

September 23

Although the water volume in September was about the same as it was in August, the water was much cooler during September. The dissolved oxygen was up to 9.5 p.p.m. (98% saturation); the B.O.D. was 1.6 p.p.m. on September 18; the pH was 7.6; and the water temperature was 63° F. at 2:00 p.m. The square-foot count was poor, with 23 organisms displacing a volume of 0.05 cc. The organisms taken in the square-foot sample were as follows: 8 Ephemeroptera, (2 species); 6 Trichoptera, (1 specie); 7 Chironomidae; 1 *Hydracaurina*; and 1 Hirudinea. These were classified as 88% clean-water forms, 8% facultative, and 4% pollutional. The handpicking consisted of the following: 8 Ephemeroptera, (3 species); 1 Trichoptera; 7 Gastropods; 3 Chironomidae; 16 Odonata; 1 Coleoptera; 1 Tipulidae; and 2 crayfish.

The mayflies collected were *Isonychia*, sp., other Baetidae, and Heptageneidae. No stoneflies were caught, although some empty larval skins were found along shore.

November 9

This station was visited during November after a freshet when the water volume was low. The dissolved oxygen was highest for this station, 10.4 p.p.m. (92% saturation); the pH was 7.3; and the water temperature was 47° F. at 8:05 a.m. Because of the fairly high water, the square-foot count was rather poor. Six organisms had a volume of 0.05 cc. These were as follows: 4 Ephemeroptera, (2 species); 1 Plecoptera; and 1 Oligochaeta. Also, 1 Gastropod had a volume of 0.05 cc. These organisms were classified as 33% clean-water forms, 33% facultative; and 33% pollutional. The organisms collected by handpicking were as follows: 21 Ephemeroptera, (4 species); 16 Plecoptera, (3 species); 2 Chironomidae; 2 Gastropods; and 4 *Hydracaurina*.

Mayflies of the families Baetidae and Heptageneidae were collected during this month. This was the only month stoneflies were taken at station six. *Acroneuria californica* and several others, not identified, were collected.

Station Seven--South Fork Santiam Above Lebanon

July 13

This station was one of the cleanest stations visited during the four-month survey. The water during July was low and clear. The dissolved oxygen was 8.5 p.p.m. (97.5% saturation); the pH was 6.8; and the water temperature was 73° F. at 1:00 p.m. No B.O.D. was taken by the Oregon State Sanitary Authority at this station. The square-foot count was 0.5 cc, with 64 organisms displacing this volume. The organisms found in the square-foot sample were as

follows: 14 Ephemeroptera, (4 species); 7 Plecoptera, (2 species); 8 Trichoptera, (3 species); 13 Turbellarians; 15 Coleoptera, (4 species); 7 Chironomidae; and 1 Diptera adult. These were classified as 80% clean-water forms and 20% facultative. The following were collected by handpicking: 18 Ephemeroptera, (4 species); 9 Plecoptera, (2 species); 17 Trichoptera, (3 species); 7 Chironomidae; 7 Gastropods; 17 Coleoptera, (4 species); and 13 Turbellarians.

Baetidae and Heptageneidae were the mayfly families collected during this month. The following stoneflies were collected: Pteronarcys, sp; Acroneuria californica, A. pacifica, and several others which were unidentified.

August 15

The water was slightly lower during this month than it was in July. The dissolved oxygen was the lowest during this month, being 7.1 p.p.m. (80.6% saturation); the pH was 7.3; and the water temperature was 72° F. at 12:15 p.m. No B.O.D. reading was taken for this month. The square-foot count for August was the richest for this station during the survey. Ninety organisms displaced a volume of 1.8 cc. The following organisms were taken in the square-foot sample: 13 Ephemeroptera, (3 species); 17 Plecoptera, (2 species); 24 Trichoptera, (2 species); 11 Simulidae; 18 Chironomidae; 3 Turbellarians; 1 Diptera pupa; and 2 Coleoptera. These were classified as 86% clean-water forms and 14% facultative. The forms taken by handpicking were as follows: 17 Ephemeroptera, (3 species); 18 Plecoptera, (2 species); 31 Trichoptera, (3 species); 10 Chironomidae;

6 Gastropods; 11 Simulidae; 5 Coleoptera, (2 species); 3 Turbellarians; 2 Psephenidae (Coleoptera); and 4 aquatic Lepidoptera, (Pyralididae).

Mayflies collected were Isonychia, sp., other Baetidae, and Heptageneidae. Acroneuria pacifica, and A. californica were the stoneflies collected.

September 14

The water volume during September was approximately the same as it was for August. The water was again clear and clean at this station. The dissolved oxygen was 8.0 p.p.m. (88% saturation); the pH was 7.7; and the water temperature was 69° F. at 3:15 p.m. No B.O.D. was taken. The square-foot count was less than those of July and August. Forty-six organisms had a volume of 0.4 cc. These organisms were: 3 Ephemeroptera, (3 species); 1 Plecoptera; 11 Trichoptera; 8 Coleoptera; 12 Turbellarians; and 11 Chironomidae. These were classified as 87% clean-water forms and 13% facultative. The following organisms were taken by handpicking: 16 Ephemeroptera, (5 species); 7 Plecoptera, (3 species); 33 Trichoptera, (3 species); 19 Chironomidae; 1 Oligochaete; 5 Gastropods; 1 Simulidae; 12 Coleoptera, (8 of which are Psephenidae); 1 Bryozoan colony; 22 Turbellarians; and aquatic Lepidoptera, (Pyralididae).

The mayflies collected belonged to the Baetidae and Heptageneidae families. Isonychia, sp., and Paraleptophlebia, sp., were also taken. The stoneflies collected were Acroneuria californica and A. pacifica. Other stoneflies were taken but were not identified.

November 9

The water volume was much greater during this month. The dissolved oxygen was 10.1 p.p.m. (95.0% saturation); which was the highest for this station. The pH was 7.2; and the water temperature was 46° F. at 9:15 a.m. The square-foot count was 0.3 cc, with 29 organisms displacing this volume. These were as follows: 20 Ephemeroptera, (4 species); 2 Plecoptera; and 5 Trichoptera. These were classified as 100% clean-water forms. Handpicking data consisted of the following: 35 Ephemeroptera, (4 species); 15 Plecoptera, (3 species); 11 Trichoptera, (2 species); 12 Gastropods; 1 Simulidae; and 1 Coleoptera.

All the mayflies collected belonged to the Baetidae and Heptageneidae families. *Pteronarcys*, sp., *Acroneuria californica*, and *A. pacifica* were the stoneflies collected.

Station Eight--South Fork Santiam River at Crabtree Bridge

July 13

Station eight at this time was severely polluted. From a distance, the water appeared to be black in color. The bottom was choked with *Sphaerotilus*, sp., and other micro-organisms. The dissolved oxygen was only 2.2 p.p.m. (24% saturation); the B.O.D. was 19.3 p.p.m. on July 26; the pH was 7.5; and the water temperature was 70° F. at 11:00 a.m. The square-foot count was 0.1 cc., with this volume represented by 79 organisms. These were as follows: 2 Ephemeroptera, (2 species); 60 red Chironomidae; 12 Simulidae; 2 Coleoptera; and

2 Diptera pupae. These were classified as 79% pollutional and 21% facultative. The organisms collected by handpicking were as follows: 6 Ephemeroptera, (2 species); 5 Plecoptera, (2 species); 10 Trichoptera, (3 species); 73 Chironomidae (mostly red); 16 Simulidae; and 2 Coleoptera.

Paraleptophlebia, sp., and other Baetidae were the mayflies collected. Pteronarcys, sp. and several other unidentified forms were the stoneflies taken during this month.

August 15

At this time the water volume was lower than it was in July and the water was very foul. There was no trace of dissolved oxygen in the middle of the stream, but along shore where algae was growing, the dissolved oxygen was 1.9 p.p.m. (21.3% saturation). The B.O.D. was 25.8 p.p.m. on August 15; the pH was 6.6; and the water temperature was 70° F. at 10:25 a.m. The square-foot sample was 0.45 cc., with 224 red Chironomidae and 2 Oligochaeta comprising this volume. These were classified as 100% pollutional organisms. The following organisms were collected by handpicking: 5 Ephemeroptera; 238 red Chironomidae; 12 Gastropods; and 2 Coleoptera.

The only mayfly taken was Paraleptophlebia, sp. No stoneflies were collected.

September 13

Conditions at station eight in September were about the same as during August. The water was low and again appeared to be black

in color. As in August, there was no trace of dissolved oxygen in midstream, but along shore there was 2.0 p.p.m. The B.O.D. was 12.0 on September 6; the pH was 6.6; and the water temperature was 65° F. at 10:30 a.m. The square-foot count was 0.1 cc, with 31 red Chironomidae, 1 Oligochaete, and 1 Culex displacing this volume. These were classified as 97% pollutional and 3% facultative. The handpicking results were as follows: 3 Neuroptera, (Sialis, sp.): 1 Tipulidae; 53 red Chironomidae; 1 Oligochaete; 10 Gastropods; 3 Coleoptera; 3 Culex; and 7 miscellaneous Diptera. No mayflies or stoneflies were collected during this month.

November 9

This station was sampled in November after a freshet. There was a definite biological recovery of the river at this time. The dissolved oxygen was up to 8.8 p.p.m. (75.8% saturation); the pH was 6.7; and the water temperature was 48° F. at 10:45 a.m. No B.O.D. reading was taken. Four organisms were taken in the square-foot sample. Three Trichoptera, and 1 Ephemeroptera displaced a volume of approximately 0.025 cc. These were classified as 100% clean-water forms. The following organisms were taken by handpicking: 1 Plecoptera; 7 Trichoptera, (2 species); and 2 Oligochaetes.

Mayflies collected were Isonychia, sp. and several Heptageneidae. The stoneflies taken were Pteronarcys, sp., and Acroneuria californica.

Station Nine--Independence

July 20

Partly because of the influence of the Santiam River, and the presence of an ideal riffle, this station was one of the most productive stations on the Willamette River. The dissolved oxygen was 7.9 p.p.m. (87.6% saturation); the B.O.D. on July 25 was 0.6 p.p.m; the pH was 7.1; and the water temperature was 70° F. at 10:00 a.m. The square-foot count was 0.4cc, with 26 organisms comprising this volume. These were: 3 Ephemeroptera, (2 species); 1 Plecoptera; 7 Trichoptera, (2 species); 14 Chironomidae; and 1 Coleoptera. These were classified as 96% clean-water forms and 4% facultative. The following organisms were collected by handpicking: 11 Ephemeroptera, (4 species); 6 Plecoptera, (3 species); 46 Trichoptera, (3 species); 23 Chironomidae; 7 Gastropods; 1 Coleoptera; 3 Odonata; 1 Turbellarian; and many sponges.

Mayflies collected were *Isonychia*, sp., other Baetidae, and Heptageneidae. *Acroneuria californica* and *Pteronarcys*, sp. were the stoneflies collected.

August 15

The water was slightly lower this month than it was during July. The dissolved oxygen was the lowest this month, being 7.2 p.p.m., (82.7% saturation). The B.O.D. was 1.4 p.p.m. on August 15; the pH was 7.6; and the water temperature was 73° F. at 5:00 p.m. The square-foot count was higher than it was in July, with 40 organisms

having a volume of 0.7 cc. These were : 3 Ephemeroptera, (2 species); 34 Chironomidae; 1 Odonata; 1 Coleoptera; and 1 Simulidae. These were classified as 92% clean-water forms and 8% facultative. The following organisms were collected by handpicking: 10 Ephemeroptera, (5 species); 40 Chironomidae; 6 Odonata; 1 Plecoptera; 14 Trichoptera, (2 species); 1 crayfish; 13 Gastropods; 2 Simulidae; and many sponges.

Isonychia, sp., other Baetidae, and Heptageneidae were the mayflies collected. Pteronarcys, sp., was the only stonefly collected during this month.

September 24

The water flow for this month was about the same as it was during July and August. However, the water at this time was much cooler, being 62° F. at 12:30 p.m. The dissolved oxygen was up to 8.7 p.p.m. (88.8% saturation); the B.O.D. was 0.9 p.p.m. on September 19; and the pH was 7.5. The square-foot count was richer in September than for any other month. A volume of 1.4 cc. was represented by 163 organisms. Also, Gastropods in the square-foot sample had a volume of 0.7 cc. The following organisms comprised the square-foot sample: 4 Ephemeroptera, (2 species); 112 Trichoptera, (2 species); 43 Chironomidae; 2 Simulidae; and 2 Oligochaeta. These were classified as 96% clean-water forms, 2% facultative, and 2% pollutional. The following were collected by handpicking: 6 Ephemeroptera, (2 species); 4 Plecoptera, (2 species); 140 Trichoptera, (2 species); 63 Chironomidae; 28 Gastropods; 2 Simulidae; 4 Crayfish; 2 Coleoptera; 5 Odonata; 6 Turbellarians; 1 aquatic Lepidoptera, (Pyralididae); and many sponges.

Isonychia, sp., other Baetidae, and Heptageneidae were the mayfly forms collected. Pteronarcys, sp., Acroneuria californica, and A. pacifica were the stoneflies collected.

November 9

This station was visited after a freshet and the water volume was still fairly high. Because the gravel bar used for sampling was inaccessible, sampling was done at the old ferry slip several hundred yards upstream. The dissolved oxygen was the highest for this station during the survey, having 10.1 p.p.m. (87.7% saturation). No B.O.D. was taken for this month. The pH was 7.2; and the water temperature was 49° F. at 1:30 p.m. This was the coldest the water had been for this station. The square-foot count was 0.2 cc. with 19 organisms displacing this volume. These organisms were as follows: 8 Ephemeroptera, (2 species); 1 Plecoptera; 4 Trichoptera, (2 species); 1 Coleoptera; and 5 Oligochaetes. These were classified as 73% clean-water forms and 27% pollutional. The handpicking results were as follows: 14 Ephemeroptera, (2 species); 4 Plecoptera; 6 Trichoptera, (2 species); 6 Oligochaete and 1 Coleoptera.

All of the mayflies collected belonged to the Baetidae and Heptageneidae families. Acroneuria californica was the only stonefly taken during November.

Station Ten--Wheatland Ferry

July 19

The water was low and warm during this month. The dissolved oxygen was 6.5 p.p.m. (75.5% saturation); the B.O.D. was 1.9 p.p.m. on July 26; the pH was 6.9; and the water temperature was 74° F. at 12:00 noon. The square-foot count was rather poor, with 5 organisms having a volume of 0.05 cc. The organisms found in the square-foot sample were: 1 Hirudinea; 1 Chironomidae; 1 Amphipod; and 2 Oligochaete. These were classified as 20% clean-water forms and 80% pollutional. The only forms taken by handpicking were 1 crayfish, several Amphipods, and sponges. No mayflies or stoneflies were collected during this month.

August 15

Although water conditions during August were about the same as they were in July, more organisms were collected in July. The dissolved oxygen was 6.2 p.p.m. (72.1% saturation); the B.O.D. was 1.8 p.p.m. on August 15; the pH was 7.2; and the water temperature was 74° F. at 3:15 p.m. The square-foot count was nearly the same as it was in July, with 6 organisms displacing a volume of 0.05 cc. These were as follows: 1 Simulidae; 1 Coleoptera; 1 Oligochaete; and 3 Chironomidae. These were classified as 17% facultative and 83% pollutional. The following organisms were collected by handpicking: 14 Trichoptera; 3 Hirudinea; 1 Gastropod; 7 Chironomidae; 3 Amphipods; 1 Oligochaete; 1 Simulidae; 1 Coleoptera; and several

sponges. No mayflies or stoneflies were collected at this time.

September 15

Although the water was the lowest during this month, the water was much cooler than in July or August. This was probably caused by the releasing of impounded waters from several dams upstream. The dissolved oxygen was 6.1 p.p.m. (66.4% saturation); the B.O.D. was 1.9 p.p.m. on September 19; the pH was 7.1 and the water temperature was 68° F. at 1:30 p.m. The square-foot count contained 8 organisms which had a volume of 0.025 cc. The following organisms were taken in this sample: 1 Ephemeroptera; 1 Plecoptera; 1 Coleoptera; 3 Chironomidae; and 1 Amphipod. These were classified as 25% clean-water forms, 62% facultative, and 13% pollutional. Handpicking results were as follows: 2 Ephemeroptera, (1 specie); 1 Plecoptera; 3 Chironomidae; several Oligochaeta; 1 Hirudinea; 1 Gastropod; 2 crayfish; 1 Coleoptera; 2 Amphipods; and several sponges.

Mayflies collected were Isonychia, sp., other Baetidae, and Heptageneidae. No stoneflies were collected at this station in September.

November 8

At this time, the water was considerably higher than in the previous months. The bottom was covered with a slimey growth of micro-organisms. This was evidently caused by the release of impounded pulp mill liquors at Salem. The dissolved oxygen was up to 9.2 p.p.m. (81.4% saturation); the pH was 7.1; and the water

temperature was 50° F. at 11:00 a.m. The square-foot count was 0.1 cc., with 11 organisms having this volume. These were as follows: 2 Ephemeroptera, (2 species); 2 Plecoptera; 4 Trichoptera, (2 species); 1 Coleoptera; and 2 Amphipods. These were classified as 73% clean-water forms, 18% facultative, and 9% pollutional. The following were collected by handpicking: 3 Ephemeroptera, (2 species); 3 Plecoptera; 7 Trichoptera; 1 crayfish; 1 Coleoptera; and 13 Amphipods.

The mayflies collected all belonged to the Baetidae family. *Acroneuria californica* was the only stonefly collected at this station in November.

Station Eleven--Butteville

July 26

At this station the water was deep and slow moving. The dissolved oxygen was 3.7 p.p.m. (50.6% saturation); the B.O.D. at Champoeg, several miles upstream was 3.7 p.p.m. on July 25; the pH was 6.9; and the water temperature was 73° F. at 2:00 p.m. Because of the absence of a riffle area at this station, no square-foot sample was taken. The following organisms were collected by handpicking; 2 Trichoptera, (2 species); 3 Oligochaeta; 8 Hirudinea; 5 Gastropods; 6 Neuroptera, (*Sisyra*, sp., parasite on sponges); and several sponges. These were classified as 6% clean-water forms, 36% facultative, and 58% pollutional.

No mayflies or stoneflies were taken during this month.

August 16

Water flow at this time was about the same as it was during July. The dissolved oxygen was up to 4.8 p.p.m. (53.2% saturation); the B.O.D. at Champoeg on August 15 was 4.4 p.p.m; the pH was 6.9; and the water temperature was 73° F. at 10:30 a.m. No square-foot sample was taken. The organisms collected by handpicking were as follows: 28 Chironomidae; 15 Hirudinea; 25 Gastropods; 2 crayfish; several sponges; 1 Turbellarian; 5 Amphipods; 10 Cladocerans; and several Bryozoan colonies, (Pectinatella). These were classified as 15% facultative and 85% pollutional. Many crayfish were found dead along shore at this time.

No mayflies or stoneflies were collected in August.

September 17

The water level during September was slightly lower than it was in July and August. The dissolved oxygen was up to 6.2 p.p.m. (71.3% saturation); the B.O.D. at Champoeg was 2.8 p.p.m. on September 19; the pH was 7.1; and the water temperature was 73° F. at 1:00 p.m. No square-foot sample was taken. The organisms collected by handpicking were as follows: 6 Chironomidae; 3 Hirudinea; 15 Gastropods; and several Bryozoan colonies (Pectinatella). These were classified as 62% facultative and 38% pollutional. No mayflies or stoneflies were taken during September.

Station Twelve--Oregon City

July 19

The water level at this station in July was markedly higher than that of August, September or November. This was probably caused by the effect of tides along with high water in the Columbia River. The dissolved oxygen was 2.2 p.p.m. (25.9% saturation); the pH was 6.5; and the water temperature was 75° F. at 1:30 p.m. No B.O.D. was taken by the Oregon State Sanitary Authority at this station. The square-foot count was 0.1 cc. with 12 organisms displacing this volume. These were as follows: 2 Hirudinea; 5 Chironomidae; 1 Amphipod; 1 Cladoceran; and 3 Oligochaeta. Also, 2 Gastropods with a volume of 0.03 cc. were taken in the square-foot sample. These were classified as 20% facultative and 80% pollutional. The handpicking results were as follows: 7 Chironomidae; many Oligochaetes; 4 Hirudinea; 20 Gastropods; 1 Amphipod; and many sponges. No mayflies or stoneflies were collected at this time, however, several *Paraleptophlebia*, sp. were seen, but because of their elusive manner, they escaped collection.

August 16

The water volume during August was much lower than it was in July. The dissolved oxygen was 3.2 p.p.m. (37.2% saturation); the pH was 6.6; and the water temperature was 74° F. at 2:00 p.m. The square-foot count was half the volume of that in July, with 6 organisms having a volume of 0.05 cc. Also there were 4 Gastropods in the

square-foot sample. These had a volume of 0.1 cc. The organisms found in the square-foot sample were: 6 Chironomidae, and 4 Oligochaetes. These were classified as 19% facultative and 71% pollutional. The following organisms were collected by handpicking: 13 Chironomidae; 2 Hirudinea; 13 Gastropods; many Oligochaetes; and several Amphipods.

No mayflies or stoneflies were collected in August.

September 18

The water level during this month was approximately the same as it was during August. The dissolved oxygen was 6.2 p.p.m. (55.2% saturation); the pH was 7.1; and the water temperature was 70° F. at 2:00 p.m. No B.O.D. readings were taken. No organisms were taken in the square-foot sample. The handpicking was very poor, with 1 Amphipod, and 2 leeches being collected. These were classified as 100% pollutional forms. No mayflies or stoneflies were taken during September.

Station Thirteen--Clackamas River

July 19

The water level during July was about the same as that of August and September. There is a daily fluctuation in water level because of several hydro-electric power dams farther upstream. The dissolved oxygen was 9.9 p.p.m. (103% saturation); the pH was 7.0; and the water temperature was 64° F. at 3:00 p.m. The square-foot sample contained 32 organisms which had a volume of 0.1 cc. Twenty

Ephemeroptera, (4 species); 10 Chironomidae; and 2 Trichoptera were taken in this sample. These were classified as 100% clean-water forms. Several Gastropods, having a volume of 0.3 cc. were also taken in the square-foot sample. The handpicking results were as follows: 51 Ephemeroptera, (5 species); 10 Trichoptera, (3 species); 13 Chironomidae; 10 Gastropods; and 1 crayfish. All of the mayflies collected belonged to the Baetidae and Heptageneidae families. No stoneflies were taken during July.

August 16

At this time, the dissolved oxygen was 9.1 p.p.m. (94.8% saturation); the pH was 7.9; and the water temperature was 64° F. at 4:00 p.m. In the square-foot sample, 35 organisms displaced a volume 0.2 cc. These organisms were: 31 Ephemeroptera, (4 species), and 4 Trichoptera, (3 species). These were classified as 100% clean-water forms. Mayflies collected were Paraleptophlebia, sp., other Baetidae, and Heptageneidae. The following forms were collected by handpicking: 80 Ephemeroptera, (6 species); 15 Trichoptera, (3 species); 1 Chironomidae; and 28 Gastropods.

Mayflies collected were Paraleptophlebia, sp., other Baetidae, and Heptageneidae. No stoneflies were taken at this time.

September 18

The water level during this month was approximately the same as it was during July and August. The dissolved oxygen was 9.4 p.p.m. (94% saturation); the pH was 7.3; and the water temperature was

66° F. at 10:30 a.m. The square-foot count was the highest during this month. A volume of 1.5 cc. was displaced by 18 organisms. These were as follows: 6 Ephemeroptera, (3 species); 2 Plecoptera; 7 Trichoptera; and 3 Tipulidae. These were classified as 90% clean-water forms and 10% facultative. The handpicking results were as follows: 33 Ephemeroptera, (3 species); 8 Plecoptera, (2 species); 11 Trichoptera, (2 species); 8 Chironomidae; 30 Gastropods; 3 crayfish; 4 Tipulidae; and 1 Coleoptera.

The mayflies collected were Paraleptophlebia, sp., other Baetidae, and Heptageneidae. Acroneuria californica and several other unidentified stoneflies were collected.

DISCUSSION

Station One

This station can be classified as a clean-water station. The most unfavorable conditions were the relatively high water temperatures in July and August, (about 73° F.), and some siltation being caused by dam construction upstream. The dissolved oxygen, (Figure 20), was 8.3 p.p.m. or higher for all sampling periods, and the saturation was above 92%. The B.O.D. was relatively low, ranging from 0.2 p.p.m. in July to 1.0 p.p.m. in September. The quality and quantity of the bottom fauna remained about the same throughout the periods of sampling, (Figures 16-19), with somewhat less organisms being found in November because of high water. Mayfly, stonefly, and caddis fly nymphs were common throughout the survey. (Table 6)

Station Two

From a visual basis, this station would be judged to be grossly polluted. However, the chemical tests taken, (Table 4), indicated a slightly polluted condition and the presence of important non-pollutional organisms, as shown in Table 9, would not rate this station as being highly polluted. The bottom was covered with silt and growths of algae and fungi. There was much cannery wastes and other suspended debris in the water. The B.O.D. ranged from 1.7 p.p.m. in July, to 3.3 p.p.m. in September, which was higher than that of station one. There was a slight decrease in dissolved oxygen and pH, compared to station one, (Figures 20 and 21). The lowest dissolved

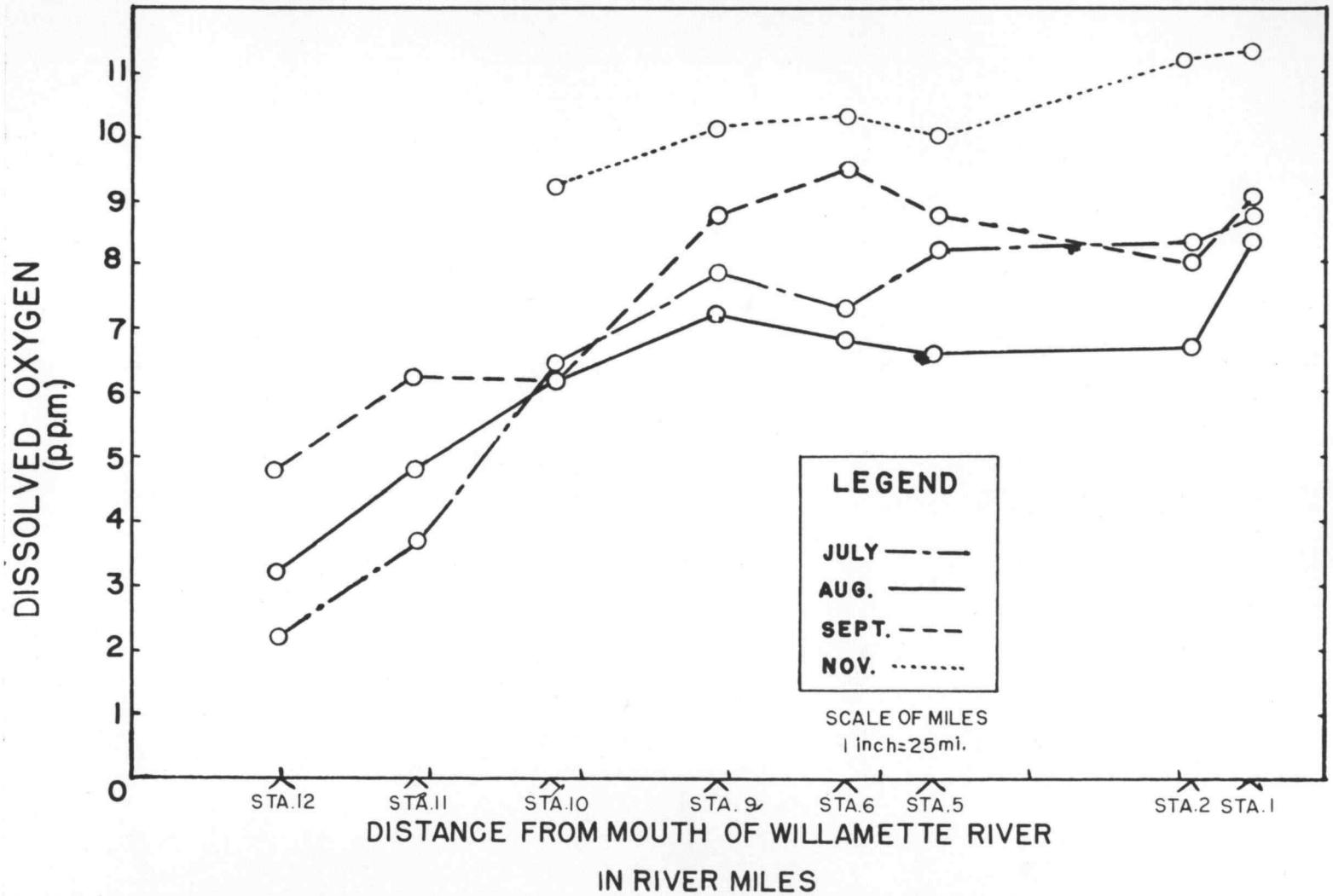

Figure 20: Dissolved Oxygen Content of Water at Stations Located on the Willamette River from July to November, 1951.

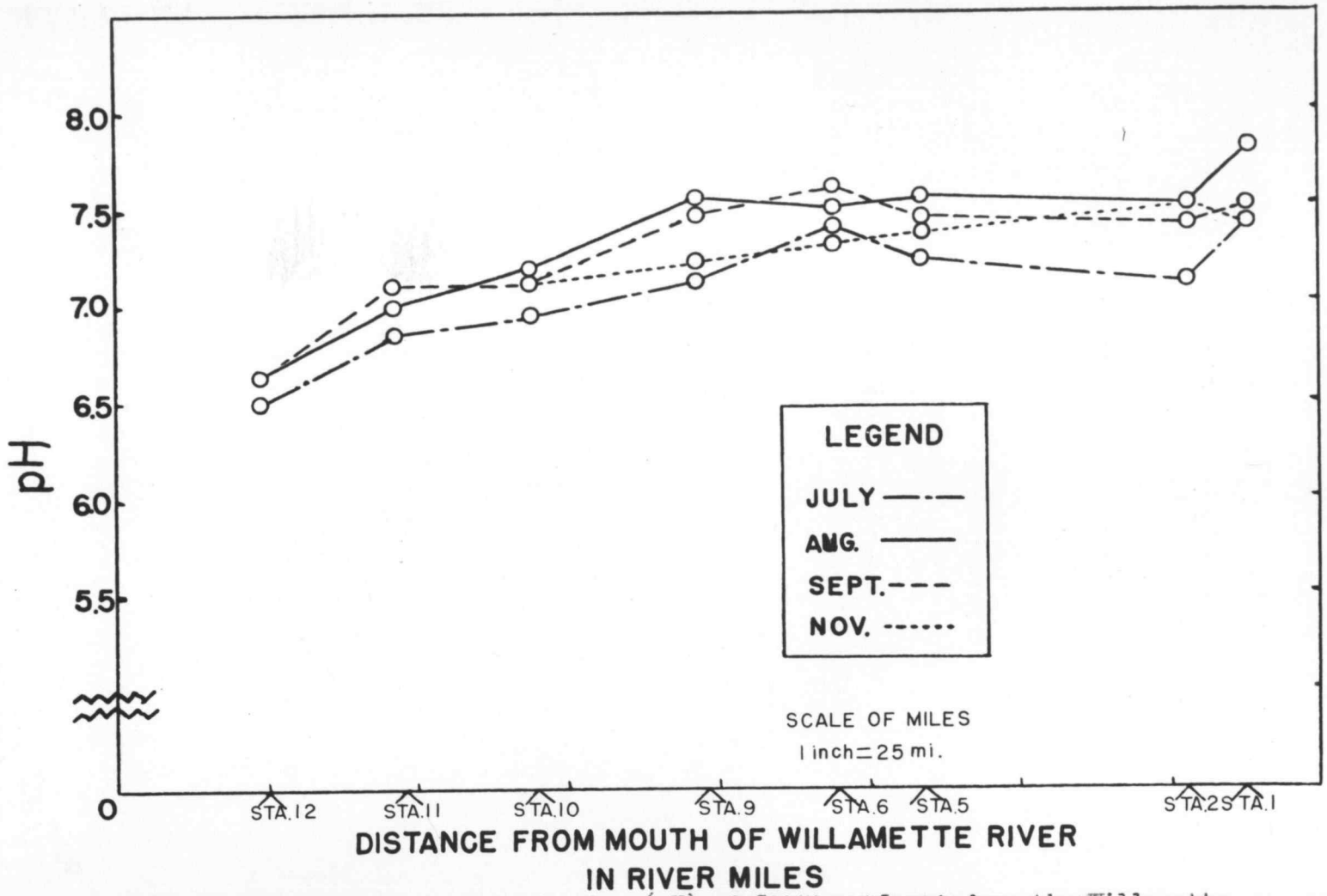

Figure 21: Hydrogen-ion Concentration (pH) of Stations Located on the Willamette River, July to November, 1951.

oxygen reading was 6.7 p.p.m. during August, while the lowest pH reading was 7.1 in July. The water temperatures were slightly higher at station two than at station one, (Figure 22). The square-foot count was correspondingly richer at station one than at station two, (Figure 24 and Table 5). No Heptageneidae mayflies which prefer clean, smooth stones on which to cling were present in August or September. Mayflies, stoneflies and caddisflies were taken during each month of the survey, but these forms were not as abundant as at station one.

Station Three

As shown in Figures 16 to 19, this station can definitely be classified as a clean-water station. The lowest dissolved oxygen reading was 8.1 p.p.m. during August; the percent saturation varied from 79.5% in August to 105% in November. The B.O.D. was 0.9 p.p.m. or less at all times. The water was quite cold, with the warmest reading being 60° F. in July (Table 4). High water had caused changes in the bottom during July and November, which resulted in rather poor sampling. Organisms collected at this station were predominately clean-water forms.

Station Four

This station while being slightly polluted, supported many clean-water organisms. Probably the main effect of the Kraft mill effluent from the pulp mill at Springfield was the "cementing" effect of the gravel bottom, the heavy growths of Sphaerotilus, sp., and the

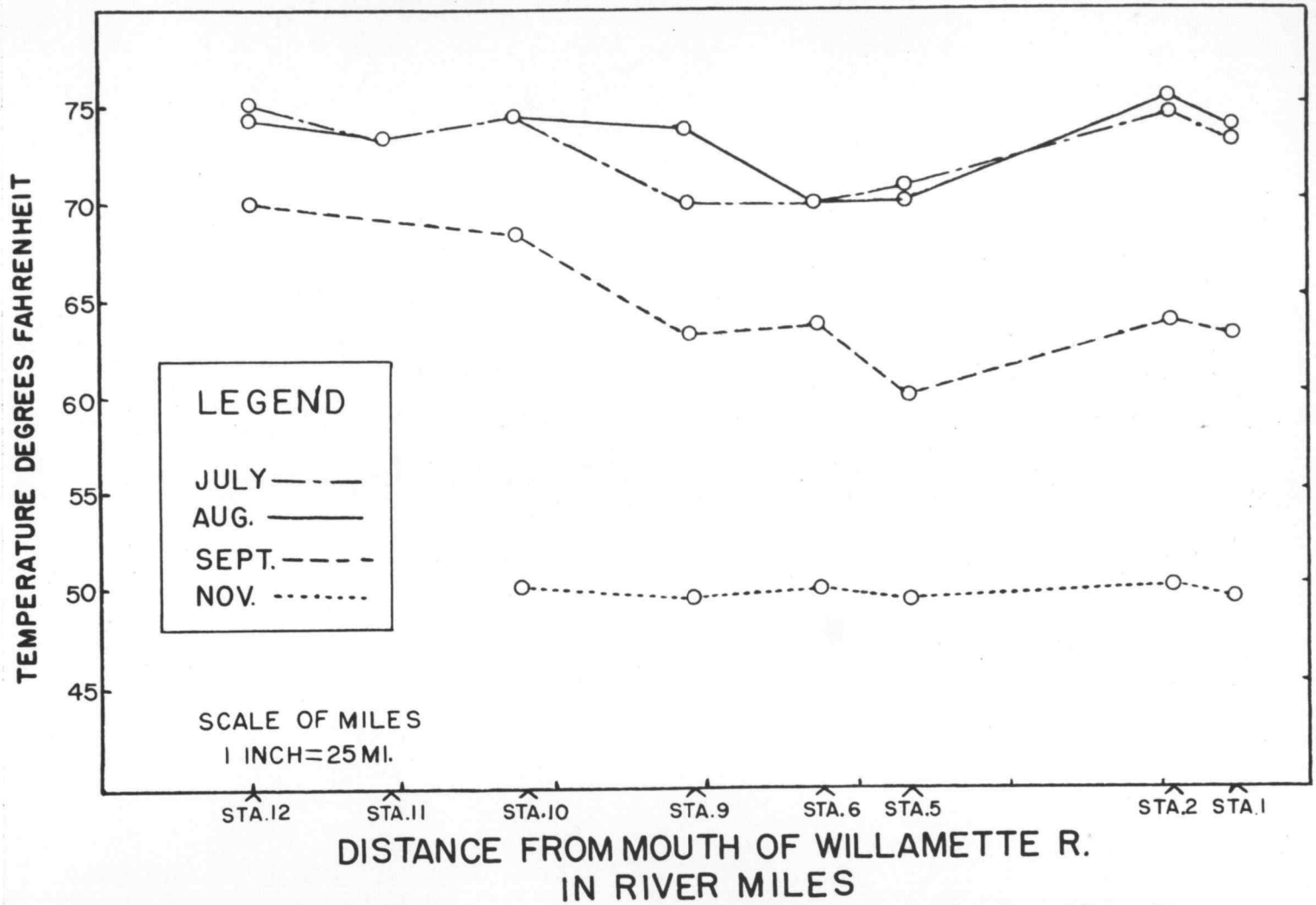

Figure 22: Water Temperatures of Stations Located on the Willamette River from July to November, 1951.

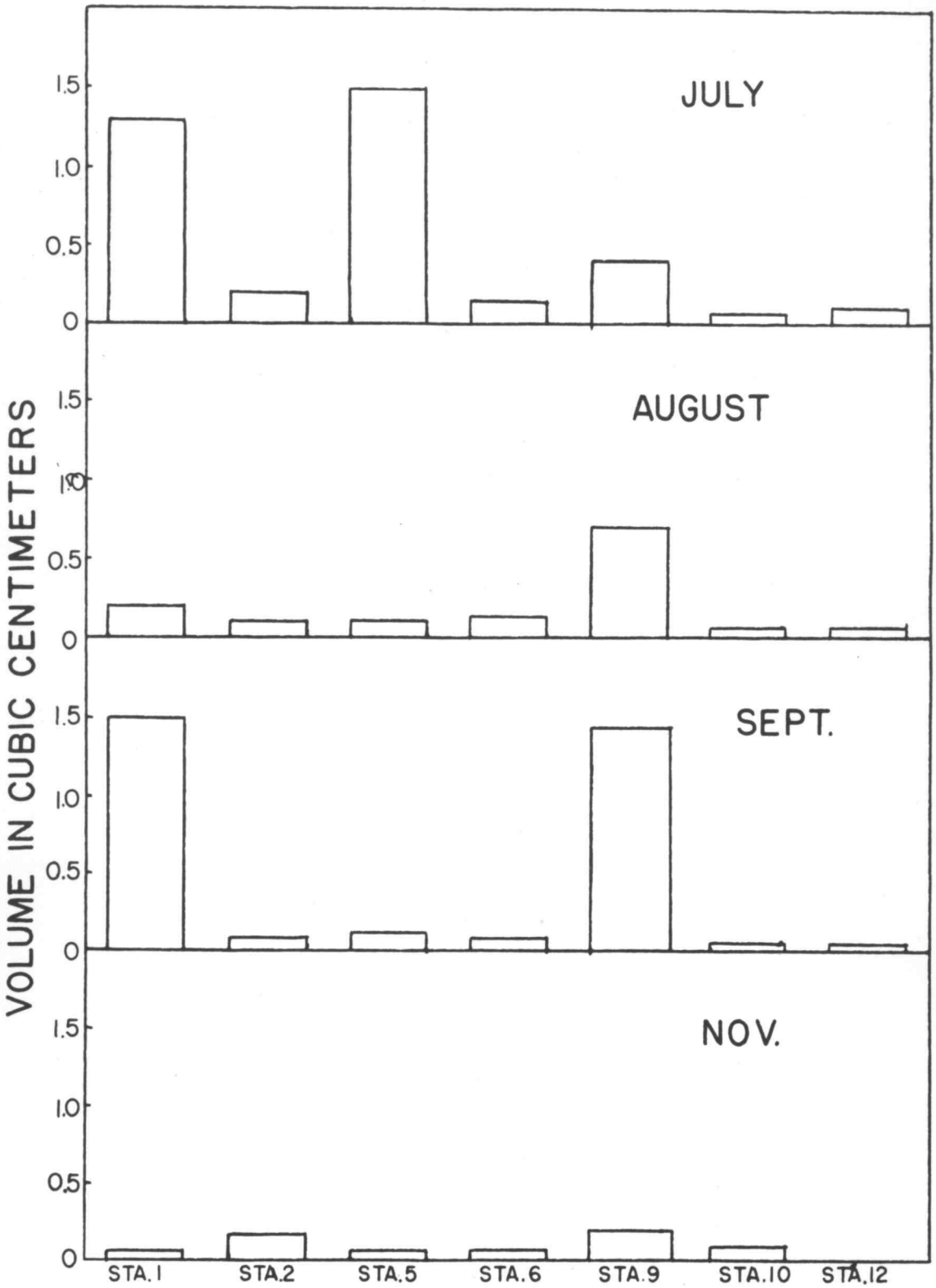

Figure 24: Volume of Square-foot Samples taken at Stations on the Willamette River, from July to November, 1951.

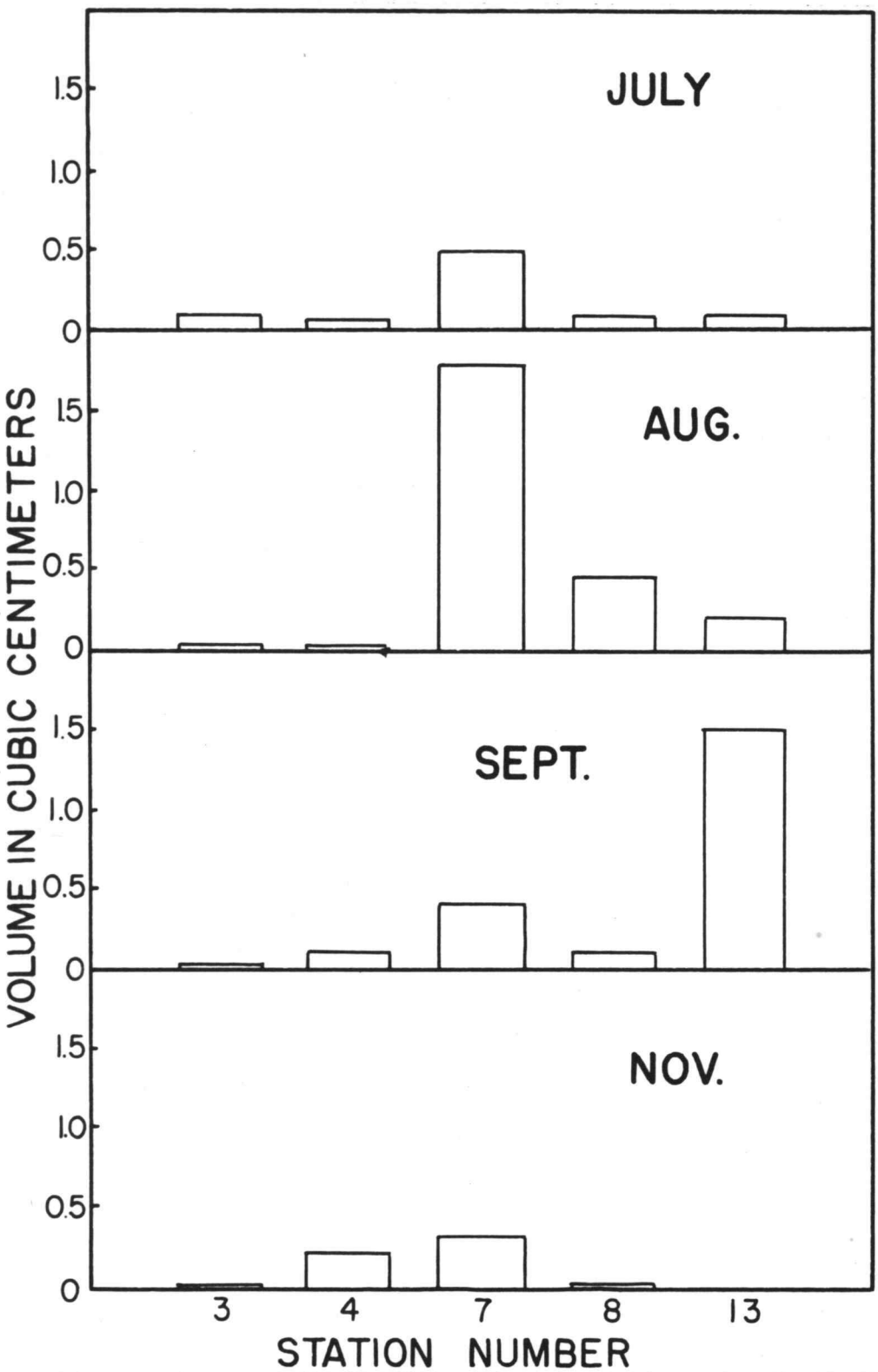

Figure 25: Volume of Square-foot Samples taken at Stations on Tributaries of the Willamette River, from July to November, 1951.

lack of Heptageneidae mayflies, as shown in Table 6, during July and August. These forms require clean, smooth stones on which to cling. The effluent seemed to hang near the south shore, as there was hardly any Sphaerotilus, sp. on the north side, and the bottom was much looser. Also, Heptageneidae mayflies were common on the north side of the river. The dissolved oxygen was about the same as at Station three, (Figure 20), as was the percent saturation of the dissolved oxygen. As shown in Figure 21, the pH was slightly higher at station four because of the alkaline nature of the Kraft mill effluents. The square-foot sample was about half that of station three for all months except November. The water temperatures were about the same as for station three, with the warmest reading being 62° F. in July, (Table 4).

Station Five

Because of the influence of the McKenzie River, the Willamette River appeared to be much cleaner at station five, above Corvallis, than at station two. The dissolved oxygen was about the same as that of station two, (Figure 20), with 6.6 p.p.m. (71% saturation) being the lowest reading. The B.O.D. ranged from 0.6 p.p.m. in July to 1.8 p.p.m. in September. The pH was slightly higher than it was at station two, (Figure 21), for all months except November when it was the same. As shown in Figure 22, the water temperatures were all cooler than those of station two, because of the cooling effect of the McKenzie River. The highest reading for Station five was 71.5° F.

in July. The square-foot counts were about the same as those of station two, with the exception of July, when station five had 1.5 cc. compared to 0.2 cc. for station two, (Figure 14). Clean-water organisms were common at all times, with the exception of November, when high water made sampling difficult.

Station Six

This station is physically, chemically and biologically similar to station five. The lowest dissolved oxygen reading was taken in August, with 6.8 p.p.m. being 73.5% saturated, (Figure 10). The B.O.D. ranged from 1.4 p.p.m. in July to 2.2 p.p.m. in August. The pH varied from 7.3 in November to 7.6 in September, as indicated in Figure 21. The highest water temperatures, (Figure 22), were observed in July and August, with the readings being 70° F. for both months. Mayflies and caddisflies were common throughout the sampling period, but no stoneflies were collected until November, (Table 6). There is a possibility that the effluents from Corvallis may have resulted in the absence of stoneflies. Because of the habitat, they might reasonably be expected to be present at this station.

Station Seven

This station was a typical clean-water station. Mayflies, stoneflies, and caddis flies were abundant at all times. The lowest dissolved oxygen reading was 7.1 p.p.m. in August. The pH ranged from 6.8 in July to 7.7 in September. The highest temperature reading was 73° F. in July. The square-foot samples were quite rich,

ranging from 0.3 cc. in November, to 1.8 cc. in August.

Station Eight

This station was the most severely polluted of all the stations in the survey (Figures 16 to 19). This was caused by pulp mill effluents and other industrial and domestic wastes from the city of Lebanon, coupled with inadequate water conditions. In July conditions were starting to get bad, with the dissolved oxygen being 2.2 p.p.m. (24.4% saturation). The B.O.D. was very high, ranging from 12.0 p.p.m. in September to 25.8 p.p.m. in August. A few mayflies, stoneflies, and caddis flies were present at this time. In August and September, all the mayflies, stoneflies and caddis flies were gone, except Paraleptophlebia, sp. which was present in August. Insonychia, sp. was present in November (Table 6). There was no trace of dissolved oxygen in the middle of the river, but there was a trace near shore where green algae was growing (Table 4). Nearly all the aquatic life was found near the shore at this time. Red Chironomidae were exceedingly abundant during July, August, and September. In November, after a freshet, there was a biological recovery at this station. The water volume had increased and the dissolved oxygen was up to 8.8 p.p.m., being 75.8% saturated. A few mayflies and stoneflies were collected at this time and caddis fly nymphs were quite numerous.

Station Nine

There was very little evidence of pollution at this station.

This station was one of the richest stations on the main Willamette River. The lowest dissolved oxygen reading (Figure 20) was 7.2 p.p.m. (82.7% saturation) in August. The pH ranged from 7.1 in July to 7.6 in August, (Figure 21). The B.O.D. was lower, during all months, at this station than at station six at Albany. These readings varied from 0.6 p.p.m. in July to 1.4 p.p.m. in August. The highest water temperature, (Figure 22) was 73.5° F. in August. The square-foot counts were relatively high, as shown in Figure 24, with 1.4 cc. in September being the highest, and 0.2 cc in November the lowest. Mayflies, stoneflies, and caddis flies were common at all times. There was a great variety of aquatic life at this station.

This station was located below the confluence of the Santiam River with the Willamette River, which probably was partly the cause of its high biological productivity.

Station Ten

This station, being below Salem, begins to show the effects of pollution. The dissolved oxygen was approximately 6 p.p.m. in July, August, and September. After a freshet, in November the dissolved oxygen was up to 9.2 p.p.m., (Figure 20). The pH was starting to drop, as shown in Figure 21, ranging from 6.9 in July, to 7.2 in August. The highest water temperatures were recorded in July and August, with the reading for both months being 74° F. The B.O.D. was higher at this station than at Station Nine at Independence, with the values ranging from 1.8 p.p.m. in August to 2.5 p.p.m. in September. The square-foot sample was very poor from July to September, varying

0.025 cc. to 0.05 cc. There was a slight increase during November, with the volume being 0.1 cc, (Figure 24). White Amphipods were a common pollutional organism at this time.

No mayflies or stoneflies were collected in July or August. Caddis flies were absent in July and September, but were present in August. Several mayflies, (Isonychia, sp., and one other Baetidae) were present in September. In November there was a freshet and the river showed some recovery. As mentioned before, there was an increase in dissolved oxygen. Mayflies, stoneflies, and caddis flies were collected in November.

The lack of mayflies and stoneflies in July and August corresponded to the 1944 survey of Dimick and Merryfield, (1 p. 51). However, the presence of mayflies and stoneflies during September, compared to the lack of these organisms in 1944, indicates some biological recovery.

Station Eleven

It can be said that this station was quite polluted. The dissolved oxygen dropped below 5 p.p.m. during July and August, and rose to 6.2 p.p.m. in September, (Figure 20). The B.O.D. at Champoeg, several miles upstream, ranged from 3.4 p.p.m. in September to 4.4 p.p.m. in August. The lowest pH value was 6.8 in July and the highest was 7.1 in September, (Figure 21). The water temperatures for all three months was 73° F.

No square-foot sample was taken because of the absence of a riffle area. No mayflies, stoneflies, or caddis flies were taken

at any time, with the exception of two caddis nymphs being collected in July. Midges, sludge worms, leeches and Gastropods were the predominate forms of bottom life. No sampling was done in November because of high water. In comparing this survey with that of Dimick and Merryfield in 1944, (1, p. 16), conditions have improved slightly.

Station Twelve

This station was the most polluted station on the Willamette River. The dissolved oxygen was always under 5 p.p.m., varying from 2.2 p.p.m. in July to 4.8 p.p.m. in September, (Figure 20). No B.O.D. readings were available for this station. The pH was on the acid side, averaging 6.6 for each month. The water temperatures were high, with 75° F. in July, and 70° F. in September being the extremes. The square-foot count was poor (Figure 24), being zero in September and 0.1 cc. in July. No mayflies, stoneflies, or caddis flies were taken, with the exception that several *Paraleptophlebia*, sp., were seen, but not captured in July. Midges, sludge worms, leeches, Gastropods and white Amphipods were the most prevalent forms present.

Station Thirteen

This station, along with stations three and seven, was one of the cleanest stations visited during the survey. The dissolved oxygen never fell below 9.1 p.p.m., which was the reading for August. The pH ranged from 7.0 to 7.9. The water temperatures were a uniform 64-66° F. The square-foot count was the lowest in July,

(0.1 cc), and the highest in September (1.5 cc). No B.O.D. readings were available for this station. Mayflies and caddis flies were exceedingly abundant during each sampling period. September was the only month in which stoneflies were collected. The water was not too swift at this station and the habitat may not have been suitable for the stoneflies.

SUMMARY

Station One--Above Eugene

Station one was chemically and biologically a clean-water station. Fairly high water temperatures during periods of low water, and siltation were the only unfavorable conditions.

Station Two--Below Eugene

This station was classified as moderately polluted. In general, fewer kinds of clean-water organisms were found than at station one. Also, more kinds of facultative and pollutional organisms were collected at station two. Further comparison with station one showed a decrease in dissolved oxygen, pH and square-foot count, while there was an increase in B.O.D. and water temperature. The bottom was covered with a growth of micro-organisms. Because of the relatively high dissolved oxygen supply, the effects of the industrial and domestic wastes were minimized.

Station Three--McKenzie River at Hayden Bridge

Station three was chemically, physically and biologically unpolluted during each month of the survey.

Station Four--McKenzie River at Old Ferry Slip

This station was classified as slightly polluted. Although the bottom fauna was predominately made up of clean-water forms, there was evidence of pollution in that growths of *Sphaerotilus*, sp.,

covered the bottom. This caused conditions to be unfavorable for mayflies of the family Heptageneidae, which prefer to cling to smooth, clean stones. These forms were absent during periods of low water in August and September. Comparing this station with station three, several miles upstream, conditions were approximately the same, with the exceptions of the lower square-foot count and the increase in pH at station four. The increase in pH was probably caused by the alkaline nature of the Kraft mill wastes, which were discharged between stations three and four.

Station Five--Above Corvallis

This station was classified as unpolluted. The bottom fauna was predominately of the clean-water type, with some facultative organisms being present. Because of the influence of the McKenzie River, the water temperature and B.O.D. were lower than at station two below Eugene.

Station Six--Above Albany

This station was classified as on the verge of being polluted. Biological, chemical and physical conditions were fairly similar to those of station five, with the exceptions of a slightly higher B.O.D. and fewer stoneflies at station six.

Station Seven--South Fork Santiam River at Lebanon Dam

This station was definitely a clean-water station. There was an abundance of clean-water organisms at all times during the survey.

Station Eight--South Fork Santiam River at Crabtree Bridge

This was the most severely polluted of all the stations. This was caused by pulp mill wastes and other industrial and domestic wastes of the city of Lebanon. The dissolved oxygen was down to 2.2 p.p.m. in July and zero in August and September. The B.O.D. was very high, reaching 25.8 p.p.m. in August. A few mayflies, stoneflies and caddis flies were collected in July and November, when the water was high. The tolerant mayflies were *Isonychia*, sp., and *Paraleptophlebia*, sp. The only organisms present during August and September were red Chironomidae, Gastropods, and a few other pollutional forms. After a freshet in November, the river had partially recovered. The dissolved oxygen was up to 8.8 p.p.m. and mayflies, stoneflies and caddis flies were collected.

Station Nine--Independence

This station was classified as unpolluted. There was a great variety of aquatic life here. The Santiam River enters the Willamette River above this station. The B.O.D. was lower at this station than at station six at Albany.

Station Ten--Wheatland Ferry

This station was classified as being polluted. During periods of low water, clean-water organisms were lacking with facultative and pollutional forms being dominant. The B.O.D. was higher at this station than at station nine at Independence.

Station Eleven--Butteville

This station was also classified as polluted. Clean-water organisms were practically absent, with facultative and pollutional forms predominating. The B.O.D. was higher than at station ten.

Station Twelve--Oregon City

Next to station eight, this was the most polluted station visited during the survey. The dissolved oxygen was always below 5 p.p.m. and the pH was on the acid side of neutrality. The organisms collected were mostly pollutional and facultative forms. Clean-water organisms were absent.

Station Thirteen

This was definitely a clean-water station. At no time was there any evidence of pollution, as shown by the bottom fauna.

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APPENDIX

TABLE 1

THE RATIO OF CLEAN-WATER ORGANISMS TO
FACULTATIVE AND POLLUTIONAL ORGANISMS

Willamette River and tributaries
Based on Square-Foot Samples

	July % Organisms			August % Organism			September % Organisms			November % Organisms		
Sta.	Poll.	Fac.	Clean	Poll.	Fac.	Clean	Poll.	Fac.	Clean	Poll.	Fac.	Clean
1	0	6	94	0	12	88	0	3	97	0	0	100
2	0	23	77	12	4	84	0	14	86	0	5	95
3	0	6	94	0	27	73	0	9	91	0	0	100
4	0	10	90	0	23	77	0	19	81	0	0	100
5	0	10	90	0	0	100	0	26	74	0	0	100
6	0	0	100	0	8	92	4	8	88	33	33	33
7	0	20	80	0	14	86	0	13	87	0	0	100
8	79	21	0	100	0	0	97	3	0	0	0	100
9	0	4	96	0	8	92	2	2	96	27	0	73
10	80		20	83	17	0	13	62	25	9	18	73
11*	58	36	6	85	15	0	38	62	0	-	-	-
12	80	20	0	71	19	0	100	0	0	-	-	-
13	0	0	100	0	0	100	0	10	90	-	-	-

*These ratios were based on handpicking

TABLE 2

DROUGHT FLOWS WILLAMETTE RIVER
U.S.G.S. GAGE AT SALEM, OREGON

Summer--Fall Period, May Through October

Year	Minimum Monthly Average CFS	Month	Minimum Weekly Average CFS	Month	Minimum Daily Average CFS	Month
1928	3590	Sept	3390	Sept	3200	Sept
1929	3290	Oct	3200	Sept	3200	Sept
1930	3030	Sept	2860	Aug	2860	Aug
1931	2680	Sept	2520	Sept	2500	Sept
1932	3330	Sept	3170	Sept	3170	Sept
1933	5100	Aug	3750	Oct	3700	Oct
1934	2947	Sept	2730	Sept	2760	Sept
1935	3397	Sept	3130	Sept	3080	Sept
1936	3214	Oct	3140	Oct	3110	Oct
1937	4133	Sept	3790	Sept	3680	Sept
1938	3461	Sept	3250	Sept	3240	Sept
1939	3300	Sept	2950	Sept	2890	Sept
1940	2653	Aug	2520	Aug	2480	Aug
1941	3445	Aug	3140	Aug	3100	Aug
1942	3365	Oct	2980	Oct	2930	Oct
1943	4585	Sept	4210	Oct	4150	Oct
1944	3194	Aug	2750	Sept	2730	Sept
1945	3466	Aug	3170	Aug	3090	Aug
1946	4159	Aug	3650	Sept	3460	Sept
1947	4328*	Sept	3800*	Sept	3730*	Sept
1948	5271*	Aug	4400*	Sept	4280*	Sept
1949	4298*	Aug	3670*	Sept	3590*	Sept

*Subject to Revision

TABLE 3

WATER FLOW WILLAMETTE RIVER
U.S.G.S. GAGE AT SALEM, OREGON

July Through November, 1951

Date	July	August	September	October	November
1	-	4400	5300	4800	16000
2	6050	4400	5300	10500	14000
3	6050	4400	4860	17200	12900
4	6300	--	4600	24170	12550
5	6300	4200	4400	19740	11850
6	6550	4200	4400	13250	11150
7	6300	4200	4400	10800	10500
8	6300	4200	4600	8700	9900
9	6050	4400	4600	7800	9600
10	6050	4400	4600	7050	9900
11	6050	4200	4600	6800	12200
12	5550	4200	4600	6800	27460
13	5550	4200	4400	9600	55460
14	5550	4200	4400	12200	65140
15	5300	4400	4400	12560	66900
16	5300	4400	--	18040	55460
17	5300	4400	4400	17620	48320
18	5300	--	4400	--	33920
19	5050	--	4200	12550	26990
20	5050	--	4000	13250	24170
21	5050	--	4000	26260	22380
22	5050	4400	--	28400	21500
23	5050	4400	4000	31900	19740
24	4800	4400	4000	58260	17620
25	4600	4400	4200	67500	16400
26	4600	4400	4200	57140	17620
27	4600	4400	4400	40220	33400
28	4600	4400	4400	31900	36000
29	4400	4600	--	26990	48320
30	4600	4800	4600	22380	61660
31	4400	5300	--	18460	--

TABLE 4

PHYSICAL AND CHEMICAL DATA
WILLAMETTE RIVER AND TRIBUTARIES, 1951

Sta.	Ac.No.[x]	Date	D.O.	% Sat.	pH	Temperatures °F. Air	Water	Time*
1	3	7-12	8.7	100.0	7.4	66.0	73.0	2:15
1	25	8-21	8.3	95.5	7.8	76.0	73.5	1:30
1	38	9-25	9.0	92.9	7.5	59.0	63.0	12:00
1	42	11-6	11.4	99.0	7.4	55.0	49.0	2:30
2	4	7-12	8.3	97.5	7.1	66.0	74.5	4:10
2	26	8-21	6.7	78.8	7.5	88.0	75.0	3:00
2	39	9-25	8.0	83.4	7.4	64.0	64.0	3:15
2	43	11-6	11.2	99.0	7.5	54.0	50.0	4:30
3	1	7-12	9.6	96.0	7.1	66.0	60.0	11:15*
3	23	8-21	8.1	79.5	6.9	70.0	59.0	10:30*
3	29	9-14	10.1	92.5	7.7	69.0	55.0	11:00*
3	40	11-6	12.5	105.0	7.3	55.0	46.0	10:00*
4	2	7-12	9.8	100.0	7.4	64.0	62.0	12:50
4	24	8-21	7.2	72.8	7.6	80.0	61.0	11:45*
4	30	9-14	10.1	92.5	7.8	57.0	55.0	12:30
4	41	11-6	11.7	98.0	7.4	56.0	46.0	12:30
5	8	7-13	8.2	93.0	7.2	70.0	71.5	3:55
5	22	8-17	6.6	73.4	7.6	80.0	70.0	4:45
5	37	9-25	8.7	87.0	7.5	56.0	60.0	9:30
5	49	11-9	10.0	87.0	7.4	49.0	49.0	3:00
6	5	7-13	7.3	81.0	7.4	59.0	70.0	9:40*
6	21	8-17	6.8	75.5	7.5	74.5	70.0	1:40
6	36	9-24	9.5	98.0	7.6	63.0	63.0	2:00
6	45	11-9	10.4	92.0	7.3	47.0	50.0	8:05*
7	7	7-13	8.5	97.5	6.8	66.0	73.0	1:00
7	15	8-15	7.1	80.6	7.3	76.0	72.0	12:15
7	28	9-14	8.0	88.0	7.7	88.0	69.0	3:15
7	46	11-9	11.3	95.0	7.2	55.0	46.0	9:15*
8	6	7-13	2.2	24.4	7.5	59.0	70.0	11:00*
8	14	8-15	0.0	0.0	6.6	66.0	70.0	10:25*
8	27	9-13	0.0	0.0	6.6	61.0	65.0	10:30*
8	47	11-9	8.8	75.8	6.7	53.0	48.0	10:45*
9	11	7-20	7.9	87.6	7.1	62.0	70.0	10:00*
9	17	8-15	7.2	82.7	7.6	80.0	73.5	5:00
9	35	9-24	8.7	88.8	7.5	63.0	62.0	12:30
9	48	11-9	10.1	87.7	7.2	50.0	49.0	1:30

TABLE 4
(Continued)

Sta.	Ac.No.[x]	Date	D.O.	% Sat.	pH	Temperatures° F. Air	Water	Time*
10	12	7-19	6.5	75.5	6.9	67.0	74.0	12:00
10	16	8-15	6.2	72.1	7.2	76.0	74.0	3:15
10	31	9-15	6.1	66.4	7.1	76.0	68.0	1:30
10	44	11-8	9.2	81.4	7.1	56.0	50.0	11:00*
11	13	7-26	3.7	50.6	6.8	78.0	73.0	2:00
11	18	8-16	4.8	53.2	6.9	69.0	73.0	10:30*
11	32	9-17	6.2	71.3	7.1	78.0	73.0	1:00
12	9	7-19	2.2	25.9	6.5	66.0	75.0	1:30
12	19	8-16	3.2	37.2	6.6	76.0	74.0	2:00
12	34	9-18	4.8	55.2	6.6	72.0	70.0	2:00
13	10	7-19	9.9	103.0	7.0	65.0	64.0	3:00
13	20	8-16	9.1	94.8	7.9	80.0	64.0	4:00
13	33	9-18	9.4	94.0	7.3	70.0	66.0	10:30*

[x] Accession number--the numerical order in which the stations were visited.

* Stations were visited during the morning.

TABLE 5

SQUARE-FOOT DATA
WILLAMETTE RIVER AND TRIBUTARIES, 1951

Sta.	Mo.	Volume cc.	Volume Gastro-pods	Total No. Organ-isms	Sta.	Mo.	Volume cc.	Volume Gastro-pods	Total No. Organ-isms
1	July	1.3	0	86	7	J	0.5	0	64
1	Aug.	0.2	0	33	7	A	1.8	0	90
1	Sept.	1.5	0.05	138	7	S	0.4	0	46
1	Nov.	0.05	0	17	7	N	0.3	0	29
2	J	0.2	0	31	8	J	0.1	0	79
2	A	0.1	0	29	8	A	0.45	0	226
2	S	0.05	0.05	28	8	S	0.1	0	33
2	N	0.15	0	23	8	N	0.025	0	4
3	J	0.1	0	16	9	J	0.4	0	26
3	A	0.25	0	65	9	A	0.7	0	40
3	S	0.25	0	27	9	S	1.4	0.7	163
3	N	0.025	0	8	9	N	0.2	0	19
4	J	0.05	1.5	10	10	J	0.05	0	5
4	A	0.05	1.6	18	10	A	0.05	0	6
4	S	0.1	1.5	13	10	S	0.025	0	8
4	N	0.2	0	62	10	N	0.1	0	11
5	J	1.5	0	58	12	J	0.1	0.03	12
5	A	0.1	0	30	12	A	0.05	0.1	6
5	S	0.1	0	19	12	S	0.0	0	0
5	N	0.05	0	3	13	J	0.1	0.3	32
6	J	0.15	0	27	13	A	0.2	0	35
6	A	0.13	0.05	25	13	S	1.5	0.95	18
6	S	0.05	0	23					
6	N	0.05	0.05	6					

TABLE 6

DISTRIBUTION OF MAYFLY AND STONEFLY
NYMPHS AT VARIOUS STATIONS IN THE
WILLAMETTE RIVER SYSTEM, JULY TO NOVEMBER, 1951

		EPHEMEROPTERA					PLECOPTERA				
Sta.	Month	Isonychia	Siphlonurus	Paraleptophlebia	Other Baetidae	Heptageneidae	Pteronarcys	Acroneuria californica	Acroneuria pacifica	Alloperla	Others
	July				x	x	x	x	x		
1	Aug.	x			x	x		x			
	Sept.	x		x	x	x		x	x		x
	Nov.				x	x		x			
	J			x	x	x		x	x		
2	A	x		x	x			x	x		
	S				x			x			
	N				x	x	x	x			
	J							x	x	x	
3	A				x	x	x	x	x	x	
	S				x	x		x	x	x	
	N				x	x					
	J				x			x	x		
4	A		x	x	x		x	x	x	x	
	S		x	x	x	x	x		x		
	N				x	x	x	x	x	x	
	J				x	x					
	A				x	x		x			
5	S	x		x	x	x					
	N					x		x		x	
	J		x		x	x					
6	A				x	x					
	S	x			x	x					
	N				x	x		x			x
	J				x	x	x	x	x		x
7	A	x			x	x		x	x		x
	S	x		x	x	x		x	x		x
	N				x	x	x	x	x		
	J			x	x		x		x		x
8	A			x							
	S										
	N	x				x	x				
	J	x			x	x	x	x			
9	A	x			x	x	x				
	S	x			x	x	x	x	x		
	N				x	x		x			
	J										
10	A										
	S	x			x	x					
	N				x			x			
	J				x	x					
13	A			x	x	x					
	S			x	x	x		x			x
	N										

Note: No Ephemeroptera or Plecoptera were collected at Stations 11 or 12.

TABLE 7

APPROXIMATE RIVER MILEAGES FROM THE MOUTH OF THE WILLAMETTE RIVER

Location	Mileage
Mouth of Clackamas River	25
Mouth of Tualatin River	28
Mouth of Molalla River	36
Butteville	48
Mouth of Yamhill River	55
Wheatland Ferry	71
Salem	85
Independence	98
Rickreall Creek	99
Mouth of Santiam River	99.5
Albany	120
Corvallis	133
Mouth of Long Tom River	150
Harrisburg	163
Mouth of McKenzie River	177
Eugene	182.5

TABLE 8

A LIST OF THE CLEAN-WATER, FACULTATIVE, AND POLLUTIONAL ORGANISMS

Clean-Water Organisms

Plecoptera - stoneflies
Ephemeroptera - mayflies
Trichoptera - caddis flies
Psephenidae (Coleoptera) - Water penny
Chironomidae (other than red Chironomidae) - midges

Facultative Organisms

Simulidae - black flies
Coleoptera (in general) - beetles
Gastropods - snails
Odonata - damsel flies and dragon flies
Bryozoa - moss animals
Hemiptera - true bugs
Porifera - sponges
Hydracaurina, sp. - water mites

Pollutional Organisms

Chironomidae (red) - bloodworms or red midges
Amphipods (*Hyallela* or *Gammarus*) - freshwater shrimp or scuds
Oligochaeta (in general) - sludge worms
Hirudinea - leeches
Eristalis - rat-tailed maggot
Asillus - water sow bug
Culex - mosquito

TABLE 9

DISTRIBUTION AND NUMBERS OF AQUATIC INVERTEBRATES IN THE WILLAMETTE RIVER SYSTEM, 1951

Sta.	Date	Ephemeroptera	Plecoptera	Trichoptera	Chironomidae	Oligochaeta	Hirudinea	Gastropods	Neuroptera	Simulidae	Astacus
1	7-12	59(6)	5(2)	39(3)	6			8		5	0
1	8-21	32(5)	3	48(3)	18			0		14	0
1	9-25	43(5)	39(2)	86(3)	33			3		6	1
1	11-6	22(3)	6(2)	18(2)	0			4		0	0
2	7-12	41(4)	11(2)	3	12		0	0		5	
2	8-21	26(4)	11	5	28		4	4		0	
2	9-25	40(2)	5	2	23		0	17(4)		0	
2	11-6	14(2)	8(2)	2	5		2	0		0	
3	7-12	0	18(3)	3(2)	13			0		0	
3	8-21	71(3)	17(3)	9	38			0		37	
3	9-14	13(4)	19(2)	1	3			2		3	
3	11-6	19(3)	3	1	3			3		11	
4	7-12	19(4)	6(2)	12(3)	10(1 red)			21(3)	0	0	0
4	8-21	25(5)	7(3)	9(4)	15			17(2)	0	4	3
4	9-14	34(5)	6(2)	9(2)	24			13(2)	4	0	2
4	11-6	86(3)	51(5)	3(2)	4			3(2)	2	0	1
5	7-13	89(6)	2	1	7			0		3	
5	8-17	66(3)	0	3	12			0		0	
5	9-25	37(5)	10	19(2)	8			1		0	
5	11-9	3	3	0	0			0		0	
6	7-13	52(5)	0	13(3)	11	1	0	0		2	0
6	8-17	41(3)	0	14(2)	6	0	2	5		0	0
6	9-24	16(3)	0	7	10	0	1	8(3)		0	2
6	11-9	21(4)	16(3)	0	2	0	0	2		0	0

TABLE 9: (Continued)

Sta.	Date	Coleoptera	Bryozoa	Odonata	Turbellaria	Porifera	Amphipoda	Psephenidae	Lepidoptera (Pyralididae)	Hydracarina	Miscellaneous Diptera
1	7-12	3		1							
1	8-21	3		0							
1	9-25	3(2)		0							
1	11-6	0		1							
2	7-12	2	0						0		0
2	8-21	1	1						0		0
2	9-25	3(2)	0						2		1
2	11-6	1	0						0		0
3	7-12	1									0
3	8-21	0									13
3	9-14	1									0
3	11-6	0									0
4	7-12	6(4)								2	0
4	8-21	0								0	0
4	9-14	2								0	0
4	11-6	1								0	1
5	7-13	1		1	0					0	0
5	8-17	0		0	0					0	0
5	9-25	3(2)		2	1					1	4
5	11-9	0		0	0					0	0
6	7-13	1	0	1						0	
6	8-17	0	0	0						0	
6	9-24	1	1	16						1	
6	11-9	0	0	0						4	

TABLE 9: (Continued)

Sta.	Date	Ephemeroptera	Plecoptera	Trichoptera	Chironomidae	Oligochaeta	Hirudinea	Gastropoda	Neuroptera	Simulidae	Astacus
7	7-13	18(4)	9(2)	17(3)	7	0		7		0	
7	8-15	17(3)	18(2)	31(3)	18	0		6		11	
7	9-14	16(5)	7(3)	33(3)	19	1		5		1	
7	11-9	35(4)	15(3)	11(2)	0	0		12		1	
8	7-13	6(2)	5(2)	10(3)	73 red	0		0		16	
8	8-15	5(1)	0	0	238 red	0		12(2)		0	
8	9-13	0	0	0	53 red	1		10		0	
8	11-9	1	1	10(2)	0	0		0		0	
9	7-20	11(4)	6(3)	46(3)	23	0		7(2)		0	0
9	8-15	10(5)	1	14(2)	40	0		13(2)		0	0
9	9-24	6(2)	4(2)	140(2)	63	0		28(2)		2	1
9	11-9	14(3)	4(1)	6(2)	0	6		0		2	4
10	7-19	0	0	0	1	2	1	0		0	1
10	8-15	0	0	14(2)	7	1	3	1		1	0
10	9-15	2	1	0	3	6	1	1		0	2
10	11-8	3(2)	3	7(2)	0	0	0	0		0	1
11	7-26			2(2)	0	3	8	5(4)	6		0
11	8-16			0	28	0	15	25(3)	0		2
11	9-17			0	6	0	3	15(5)	0		0
12	7-19				7	many	4	20			
12	8-16				13	many	2	13(3)			
12	9-18				0	0	2	0			
13	7-19	51(5)	0	10(3)				10(2)			1
13	8-16	80(6)	0	15(3)				28(2)			0
13	9-18	33(3)	8(2)	11(2)				30(2)			3

TABLE 9: (Continued)

Sta.	Date	Coleoptera	Bryozoa	Odonata	Turbellaria	Porifera	Amphipoda	Psephenidae	Lepidoptera (Pyralididae)	Hydracaurina	Miscellaneous Diptera
7	7-13	17(4)	0		13			0	0		
7	8-15	5(2)	0		3			2	4		
7	9-14	12	1		22			8	1		
7	11-9	1	0		0			0	0		
8	7-13	9(2)	0								0
8	8-15	2	0								0
8	9-13	3	1								11
8	11-9	0	0								0
9	7-20	1		3	1	several			0		
9	8-15	2		6	0	several			0		
9	9-24	2		5	6	several			1		
9	11-9	1		0	0	0			0		
10	7-19	0				0	2			0	
10	8-15	1				0	3			0	
10	9-15	1				several	2			1	
10	11-8	1				0	13			0	
11	7-26		0	0	0	several	0				
11	8-16		several	1	1	several	5				
11	9-17		several	0	0	0	0				
12	7-19					several	1				
12	8-16						many				
12	9-18						1				
13	7-19	0									0
13	8-16	0									0
13	9-18	1									4

Numbers in parentheses indicate the number of different species.