WATER QUALITY IN THE LOWER PUYALLUP RIVER VALLEY AND ADJACENT UPLANDS, PIERCE COUNTY, WASHINGTON

By J. C. Ebbert, G. C. Bortleson, L. A. Fuste', and E. A. Prych

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[Plate in back cover pocket]

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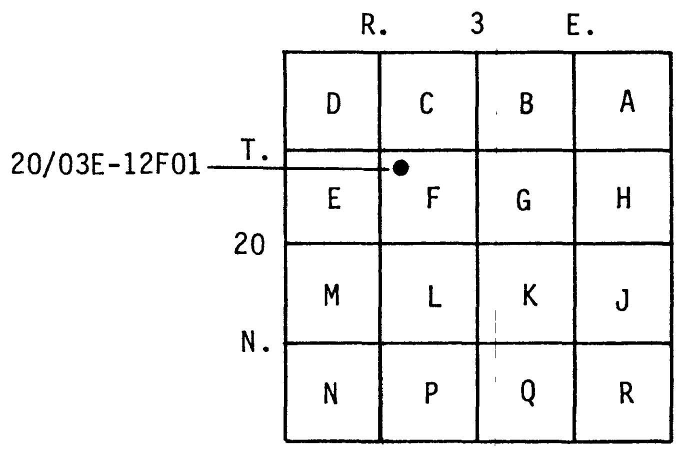
Numbering System for Wells and Springs

Wells in Washington are assigned numbers that identify their location in a township, range, and section. Well number 20/03E-12F01 indicates, successively, the township (T.20 N.) and range (R.3 E.) north and east of the Willamette base line and meridian; the letter indicating north is omitted because all wells in the study area are north of the base line. The first number following the hyphen indicates the section (12) within the township, and the letter following the section gives the 40-acre subdivision of the section, as shown below. The number following the letter is the serial number of the well within the 40-acre subdivision. An "s" following the serial number indicates that the site is a spring.

Sites are additionally identified by one- or two-digit numbers for brevity. These numbers are used in the text for references to specific wells.



Section 12

CONVERSION FACTORS

For the convenience of readers who may prefer to use metric (International System) units rather than the inch-pound units used in this report, values may be converted by using the following factors:

Multiply inch-pound units	By	To obtain SI units
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
acre	4,047	square meter (m^2)
acre	0.4047	hectare
square mile (mi^2)	2.590	square kilometer (km^2)
gallon (gal)	3.785	liter (L)
gallon (gal)	0.003785	cubic meter (m^3)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
ounce, avoirdupois (oz)	28.35	gram (g)
pound, avoirdupois (lb)	453.6	gram (g)
degree Fahrenheit (°F)	°C = 5/9 (°F-32)	degree Celsius (°C)
part per billion (ppb)	1.000	microgram per kilogram (μg/kg)
part per billion (ppb)	1.000	microgram per liter (μg/L)
part per million (ppm)	1.000	microgram per gram (μg/g)
concentration, in percent	10,000	microgram per gram (μg/g)

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level. NGVD of 1929 is referred to as sea level in this report. Mean lower low water datum for Commencement Bay is 6.51 feet below NGVD.

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ABSTRACT

The quality of most ground and surface water within and adjacent to the lower Puyallup River valley is suitable for most typical uses; however, some degradation of shallow ground-water quality has occurred, and the quality of water in some of the small streams has been adversely affected by man's activities.

High concentrations of iron and manganese were found in ground water. sampled at depths of less than 40 feet, from wells tapping alluvial aquifers and in a few wells tapping deeper aquifers. Iron and manganese concentrations were as high as 210,000 and 4,300 micrograms per liter, respectively, in samples from shallow wells. Other trace elements were usually found in low concentrations or below detection limits in both shallow and deep ground water.

Volatile and acid- and base/neutral-extractable organic compounds were not detected in either shallow or deep ground-water samples.

The quality of shallow ground water was generally poorer than that of deep water, indicated in part by the relative concentrations of nitrogen compounds in shallow and deep waters. Concentrations of ammonia nitrogen as high as 19 milligrams per liter were found in the shallow ground water.

The quality of deep ground water (wells set below 100 feet) appears suitable as a supplementary water supply for fish-hatchery needs. The deep ground water is typically low in or devoid of dissolved oxygen and would require aeration before use in hatchery ponds.

Water quality in most of the lower Puyallup River has been only moderately affected by the activities of man; however, some degradation of water quality, as measured by increased concentrations of organic and inorganic compounds, was observed downstream from river mile 1.7 where a municipal waste-water-treatment plant discharges into the river. The reach of the river receiving the discharge from the treatment plant is within the Puyallup River estuary where the tides of Commencement Bay and the salinity of the bay water affect the hydraulics and the water quality of the river. During most of the tidal cycle, the river velocity is in the downstream direction and the effluent plume from the treatment plant is along the left bank.

Organic compounds, including halogenated aliphatic hydrocarbons, phthalate esters, organic acids, ketones, and alcohols were found in water samples collected in the Puyallup River downstream from the waste-water treatment plant at river mile 1.7. At sampling sites upstream of the plant, 1,1,1-trichloroethane was the only organic compound found in the water. Some organic compounds were detected also in waters from small streams, but data indicate that much of the organic material was probably naturally occurring degradation products of plant and animal materials. No organic compounds, including priority pollutants, were found at a concentration known to be acutely toxic.

Trace-element concentrations in bed sediments were used as indicators of trace-element occurrence in streams. In the Puyallup River, the highest concentrations of most trace elements were found in bed sediments collected downstream from river mile 1.7. Median concentrations of arsenic, lead, and zinc were higher in bed sediments from small streams compared with those from the Puyallup River, possibly because the small stream drainages, which are almost entirely within developed areas, receive more urban runoff as a percentage of total flow. High concentrations of arsenic (up to 390 micrograms per gram) were found in bed sediments in lower Hylebos Creek. Cadmium concentrations of 25 to 69 micrograms per gram in bed sediments from Wapato Creek were an order of magnitude above typical concentrations in the study area.

In most streams, dissolved trace elements were at low concentrations or were below detectable limits. The highest concentrations were in some of the small streams, including lower Hylebos Creek (12 μg/L, micrograms per liter, arsenic), upper Swan Creek (48 and 2.8 μg/L, respectively, copper and mercury), and Fife Ditch (12, 25, and 110 μg/L, respectively, arsenic, copper, and zinc).

Total-recoverable trace-element concentrations exceeded water-quality criteria for acute toxicity in the Puyallup River and in some of the small streams. In most cases, high concentrations of total-recoverable trace elements occurred when suspended-sediment concentrations were high.

Temperatures in all streams except Wapato Creek and Fife Ditch were within limits (18 $^{\circ}$Celsius) for Washington State class A waters. Minimum dissolved-oxygen concentrations were relatively low at 5.6 and 2.0 milligrams per liter, respectively, for Wapato Creek and Fife Ditch. The poorest surface-water quality, which can be characterized as generally unsuitable for fish, was in Fife Ditch, a manmade channel and therefore uncharacteristic of other small streams.

INTRODUCTION

Water resources within and adjacent to the lower Puyallup River valley are of vital interest to the Puyallup Indian Tribe. Numerous streams cross present and historical tribal lands that lie within the lower Puyallup River valley and on adjacent uplands (pl. 1). Many of these streams are spawning areas or migration routes to spawning areas for salmon and steelhead trout, which have traditionally been a major part of the tribe's economy and culture. Ground-water resources are important to the tribe because they plan to increase ground-water usage at their Diru fish hatchery and to use ground water to supplement the surface-water supply at a proposed fish hatchery. Because most of the land within the area has been developed for residential, commercial, industrial, and agricultural uses, the tribe is concerned that the quality of surface and ground waters may have become impaired to the extent that fish propagation and human health and esthetics are adversely affected. This concern has recently been intensified because the U.S. Environmental Protection Agency has designated the nearshore and tideflat areas of Commencement Bay, located at the mouth of the Puyallup River, as a top-priority hazardous waste site targeted for remedial action.

In 1981, the U.S. Geological Survey, in cooperation with the Puyallup Indian Tribe, began a study of the water resources of the lower Puyallup River valley and adjacent uplands. This report presents the results of the water-quality investigation and is one of a series of three reports describing surface- and ground-water quality, streamflow characteristics of small streams, and the availability of ground water in the area.

Purpose and Scope

The purpose of this study was to assess the quality of ground and surface waters in and adjacent to the lower Puyallup River valley. Ground-water samples were collected from February through August 1984 and were analyzed for trace elements, organic compounds, major anions and cations, nutrients, and indicator bacteria. Samples were taken from one spring, 15 shallow wells, and 18 deep wells (pl. 1).

Most surface-water-quality data were collected from August 1983 through September 1984. Water and bed-sediment samples were collected from the Puyallup River, the White River, and most small streams in the lower Puyallup River valley (pl. 1). The discharges from the Sumner, Puyallup, and Tacoma No. 1 sewage-treatment plants also were sampled. Water and bed-sediment samples were analyzed for trace elements and organic compounds. Water samples also were analyzed for major anions and cations, nutrients, indicator bacteria, dissolved oxygen, and biochemical oxygen demand. Supended-sediment samples were analyzed for trace elements.

Additional sampling of the Puyallup River estuary, designated as the part of the Puyallup River below river mile 2.2, was conducted in 1982 to determine vertical and longitudinal distributions of salinity during periods of high and low tide that occurred at average and low river discharges. Samples also were collected in the estuary to examine lateral and longitudinal variations of nutrient concentrations.

Because of the importance of surface water as a habitat for fish, water-quality criteria for the protection of freshwater aquatic life are used in the evaluation of surface-water quality. Drinking-water regulations are used for comparative purposes to assess ground-water quality because ground water is used for domestic supply. Drinking-water regulations and water-quality criteria that have been established by Federal and Washington State agencies are shown in table 1.

Description of the Study Area

The 130-square-mile study area is located in the Puget lowland of western Washington State. It includes the part of the lower Puyallup River valley that extends from the city of Sumner to Commencement Bay, and areas of the adjacent uplands on the northeast and southwest of the valley. The study area is within the Puyallup River drainage basin except for parts of the Hylebos and Wapato Creek drainages, which drain directly to Commencement Bay. The Puyallup Indian Reservation is included in the study area (pl. 1).

More detailed descriptions of the study area pertaining to the investigation of ground-water quality, surface-water quality, and the Puyallup River estuary are presented in those sections of the report.

Physiography

The lower Puyallup River valley is a relatively flat flood plain ranging in elevation from near sea level at Commencement Bay to approximately 50 feet at the junction of the White and Puyallup Rivers. Elevations of the adjacent uplands that lie within the study area reach a maximum of about 500 feet (pl. 1).

The lowermost part of the Puyallup River valley, commonly referred to as the Tacoma tideflats, once formed the Puyallup River delta. Since the 1920's, the area has been extensively dredged and filled for port and industrial use. The streams within this area have been channelized.

TABLE 1.--Drinking-water regulations and water-quality criteria

[Value given is the maximum allowed or recommended, unless otherwise specified]

Water-quality characteristic or constituent	U. S. Environmental Protection Agency (1976a;1977a;1977b;1980): Maximum contaminant levels for drinking water	U. S. Environmental Protection Agency (1976a;1977a;1977b;1980): Criteria for freshwater aquatic life	Washington State Board of Health (1978) and Department of Ecology (1977): Maximum contaminant levels for drinking water	Washington State Board of Health (1978) and Department of Ecology (1977): Criteria for freshwater aquatic life
Physicochemical characteristics				
Temperature (degrees Celsius)	--	--	--	[1]<18.0
pH (standard units)	6.5 - 8.5	6.5 - 9.0	--	[1]6.5 - 8.5
Dissolved oxygen (milligrams per liter)	--	5.0	--	[1]>8.0
Inorganic constituents (milligrams per liter)				
Chloride	[2]250	--	250	--
Fluoride	[3]1.4 - 2.4	--	2.0	--
Nitrate (as N)	10	--	10	--
Ammonia (as NH_3)	--	[4]0.02	--	--
Sulfate	[2]250	--	250	--
Total dissolved solids	[2]500	--	500	--

Trace elements (micrograms per liter)

Water-quality characteristic or constituent	EPA: Maximum contaminant levels for drinking water	EPA criteria: 24 hr avg (chronic)	EPA criteria: Maximum at any time (acute)	Washington: Maximum contaminant levels for drinking water	Washington: Criteria for freshwater aquatic life
Arsenic (trivalent)	50	--	[5]440	50	--
Cadmium	10	[5,6]eqn	[5,6]eqn	50	--
Chromium	50	--	--	50	--
Chromium (trivalent)	--	--	[5,6]eqn	--	--
Chromium (hexavalent)	--	[5]0.29	[5]21	--	--
Copper	[2]1,000	[5]5.6	[5,6]eqn	1,000	--
Iron	[2]300	--	--	300	--
Lead	50	[5,6]eqn	[5,6]eqn	50	--
Manganese	[2]50	--	--	50	--
Mercury	2	[5]0.00057	[5]0.0017	2	--
Nickel	--	[5,6]eqn	[5,6]eqn	--	--
Silver	50	--	[5,6]eqn	50	--
Zinc	[2]5,000	[5]47	[5,6]eqn	5,000	--

Bacteria (colonies per 100 milliliters)

Water-quality characteristic or constituent					
Fecal coliform	--	--	--	--	[1]median<100

[1]Criteria for the Puyallup River from river mile 1 to mile 31.6; class A water.

[2]Secondary maximum contaminant level. These "***are not Federally enforceable and are intended as guidelines for the States***" (U.S. Environmental Protection Agency, 1977a).

[3]The exact maximum contaminant level is dependent on the maximum daily air temperature (U.S. Environmental Protection Agency, 1976a).

[4]Un-ionized ammonia.

[5]Total recoverable metal (dissolved plus suspended).

[6]Criteria for some trace elements in freshwater are hardness-dependent and are given by the following equations (eqn) where hardness is in milligrams per liter as calcium carbonate.

Cadmium:	chronic	= e exp (1.05[ln(hardness)]-8.53)
	acute	= e exp (1.05[ln(hardness)]-3.73)
Chromium: (trivalent)	acute	= e exp (1.08[ln(hardness)]+3.48)
Copper:	acute	= e exp (0.94[ln(hardness)]-1.23)
Lead:	chronic	= e exp (2.35[ln(hardness)]-9.48)
	acute	= e exp (1.22[ln(hardness)]-0.47)
Nickel:	chronic	= e exp (0.76[ln(hardness)]+1.06)
	acute	= e exp (0.76[ln(hardness)]+4.02)
Silver:	acute	= e exp (1.72[ln(hardness)]-6.52)
Zinc:	acute	= e exp (0.83[ln(hardness)]+1.95)

Land Use

The distribution of land-use categories within the study area is shown in figure 1. The Tacoma tideflats is the location of a major port facility and numerous types of industry, including oil storage and refining, pulp and paper production, chemical production, alumina refining, and food processing (pl. 1). The designation of the nearshore and tideflat areas of Commencement Bay as a top-priority site for hazardous-waste cleanup was largely because of the industrial activity. Additionally, slag from a nearby copper smelter, which has been used as fill material on the tideflats, has caused concern about potential trace-metal contamination of ground water. An inactive landfill, once used by the city of Tacoma and private industry, is located on the tideflats along the northeast bank of the Puyallup River about 1.5 miles upstream from the mouth.

Historically, much of the lower Puyallup River valley above the tideflats has been used for agriculture. The once-numerous small farms producing vegetables, flower bulbs, and berries are declining in numbers due to the encroachment of residential and commercial development. Most of the upland areas are light- to medium-density residential areas. Gravel is mined commercially at several locations along the northeast and southwest valley walls.

Water Use

Water use can be classified as offstream use, which represents all water withdrawn or diverted from a ground- or surface-water source; and instream use, which is defined as water use taking place within the stream channel for purposes such as fish propagation and recreation (Solley and others, 1983). Both offstream and instream uses of water are important within the study area.

Almost all water withdrawn from within the study area for offstream use is ground water. Offstream uses of ground water include municipal supply and non-municipal withdrawals for domestic and irrigation purposes. Some industries located on the Tacoma tideflats withdraw ground water, but many are supplied by the City of Tacoma. Most water supplied by the City of Tacoma is imported from surface- and ground-water sources outside the study area. A small amount of surface water is withdrawn from within the study area and is used for irrigation and fish rearing.

Instream water uses include fish migration and propagation, commercial fishing, recreation, and dilution of waste water and urban runoff. Sport fishing is one of the most important recreational uses.

Climate

The climate of the area is moderate due to the proximity of the Puget Sound and the Pacific Ocean. Winter temperatures usually remain above freezing and summer temperatures are seldom above 90 degrees Fahrenheit. Most precipitation occurs as rainfall, and the mean annual precipitation at Puyallup is about 40 inches. Approximately 75 percent of the rainfall occurs from October through March.

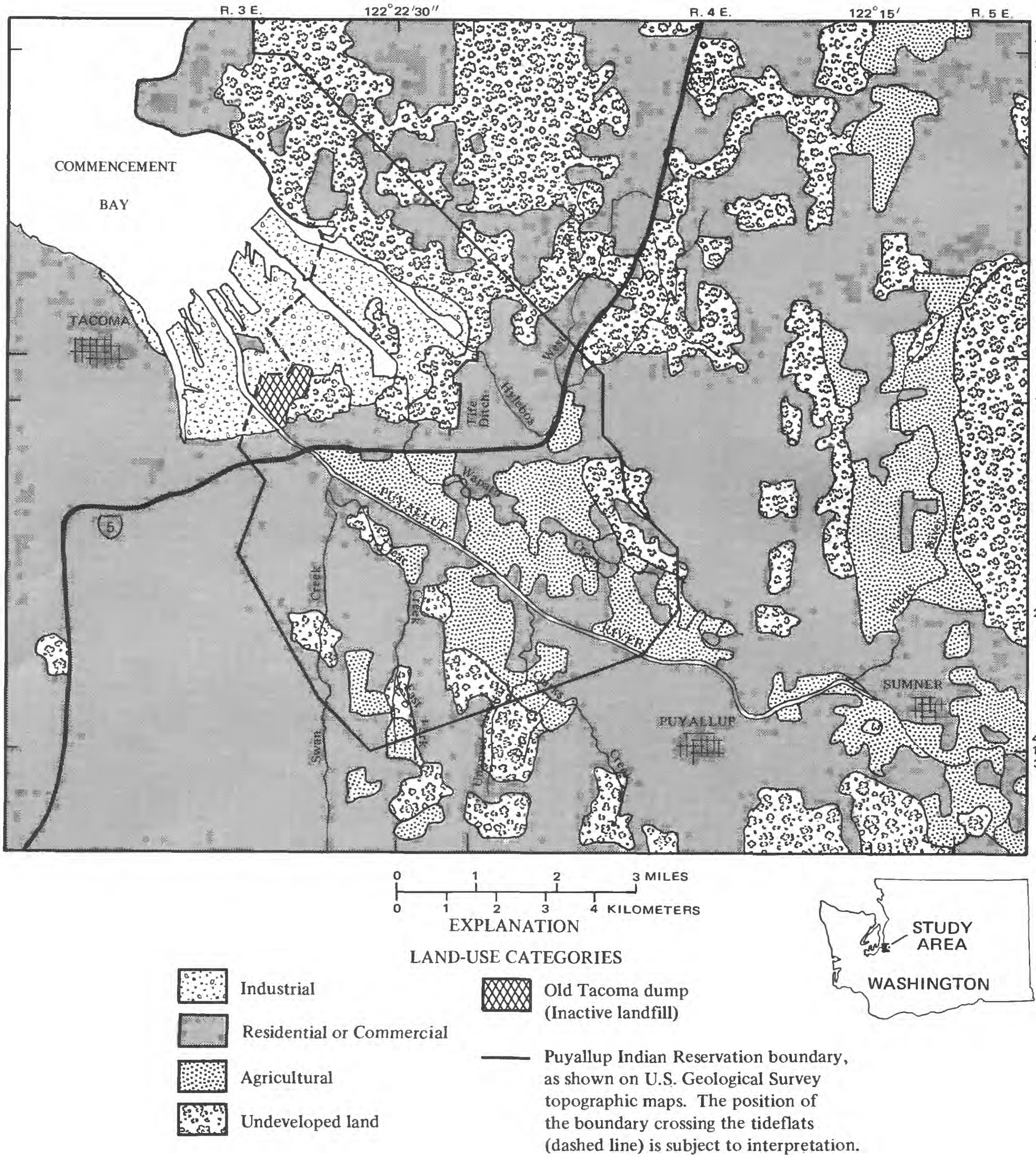

FIGURE 1.--General land-use categories within the study area.

Previous Investigations and Available Data

Information about the quality of ground and surface water in the lower Puyallup River valley and adjacent uplands has been presented by previous investigators. Griffin and others (1962) addressed the quality of surface and ground waters in the Tacoma area. Walters and Kimmel (1968) included a description of ground-water quality in their study of ground water in central Pierce County. A simulation of the effects of waste-water loading on concentrations of dissolved oxygen, nitrogen, phosphorus, and coliform bacteria in the Puyallup River estuary and Commencement Bay was included in a management plan for the Puyallup River basin (Pierce County, 1974). Johnson and others (1983) summarized data for priority pollutants in sediment samples collected in the Puyallup River estuary and nearby areas. Turney (1986) sampled several wells in the lower Puyallup River valley as part of a reconnaissance study of ground-water quality in the Puget Sound region.

Additional water-quality data not found in investigative reports are available from STORET, the computer data files of the U.S. Environmental Protection Agency. These data files include long-term data collected by the State of Washington Department of Ecology and the U.S. Geological Survey at sites on the Puyallup and White Rivers. STORET files contain little information about the quality of small streams and the quality of ground water.

Analytical Methods

Most of the analytical methods used in this study to determine organic and inorganic constituent concentrations in water and sediments are found in Wershaw and others (1983) and in Skougstad and others (1979). Some additional information on the analytical methods used to identify organic compounds is provided because a semiquantitative technique was used to select samples for individual compound analysis. Also, because the methods used to analyze sediments for trace elements are not found in the aforementioned references, some details of the methodologies are given.

Organic Compounds

Water samples were analyzed for volatile organic compounds and for acid- and base/neutral-extractable organic compounds, and sediment samples were analyzed for acid- and base-neutral-extractable organic compounds. The volatile organic compounds, sometimes referred to as purgeable organic compounds, were extracted from water samples with helium, fractionated by gas chromatography, and detected by mass spectrometry. Compounds were identified by matching the mass spectra of the known compounds listed in table 2 to the mass spectra of the sample. Concentrations were determined by comparing the strength of the mass spectral signal of a compound to that of an internal standard. The minimum quantitation limit for this method is approximately 1 μg/L (microgram per liter).

Acid- and base/neutral-extractable organic compounds were extracted from water samples in two sequential steps using methylene chloride as the extracting solvent. The first extraction was done under acidic conditions to remove the acid-extractable compounds, including phenolic compounds and organic acids. The second extraction was done under basic conditions to remove compounds that do not act as acids, such as many polycyclic aromatic hydrocarbons and phthalate esters. The extraction from sediment samples was done using a mixture of methylene chloride and methanol, without altering the pH of the sample. The purpose of the mixed solvent was to remove both the acid- and base/neutral-extractable compounds simultaneously. Once extracted, the compounds were fractionated by gas chromatography and detected using a flame-ionization detector. The resultant chromatogram was a semiquantitative record of organic compounds extracted, and it was used to select samples in which individual compounds would be identified and quantified using the mass spectrometer.

Acid- and base/neutral-extractable compounds were identified using a computer algorithm to match the mass spectra of a sample with the mass spectra of the compounds listed in table 3 and with mass spectral data contained in the National Bureau of Standards library of approximately 32,000 compounds. The laboratory maintains a library of mass spectra for the compounds listed in table 3, and identification and quantification of these compounds in a sample has a higher degree of confidence than those identified using National Bureau of Standards data. The latter group are tentatively identified, and reported concentrations are approximate. Minimum quantitation limits for compounds in water samples are dependent on a number of variables, including interference from other compounds, but can be considered to be approximately 1 μg/L. Some lower concentrations are reported, and they should be considered approximate. No definite quantitation limits are given for sediment samples because of the possibility of incomplete extraction, and all reported concentrations should be considered minimum values.

TABLE 2.--Volatile organic compounds analyzed in this study

[An asterisk indicates priority pollutant.]

*Chloromethane
*Dichloromethane (Methylene chloride)
*Trichloromethane (Chloroform)
*Carbon tetrachloride
*Bromomethane
*Bromodichloromethane
*Chlorodibromomethane
*Tribromomethane (Bromoform)
Dichlorodifluoromethane
Fluorotrichloromethane
*Chloroethane
*1,1-Dichloroethane
*1,2-Dichloroethane
*1,1,1-Trichloroethane
*1,1,2-Trichloroethane
*1,1,2,2-Tetrachloroethane
*Chloroethene (Vinyl chloride)
*1,1-Dichloroethene
*Trans-1,2-dichloroethene
*Trichloroethene
*Tetrachloroethene
*1,2-Dichloropropane
*Cis-1,3-Dichloropropene
*Trans-1,3-dichloropropene
*Benzene
*Chlorobenzene
*Methylbenzene (toluene)
*Ethylbenzene
*2-Chloroethylvinyl ether

TABLE 3.--Acid- and base/neutral-extractable organic compounds used as standard reference materials by the laboratory for identification and quantification of sample mass spectra

Acid-extractable	Base/neutral-extractable
4-Chlor-3-methylphenol	Acenaphthene
2-Chlorophenol	Acenaphthylene
2,4,-Dichlorophenol	Anthracene
2,4,-Dimethylphenol	Benzidine
4,6-Dinitro-2-methylphenol	Benzo(a)anthracene
2,4,-Dinitrophenol	Benzo(b)fluoranthene
2-Nitrophenol	Benzo(k)fluoranthene
4-Nitrophenol	Benzo(g,h,i)perylene
Pentachlorophenol	Benzo(a)pyrene
Phenol	4-Bromophenyl phenyl ether
2,4,6-Trichlorophenol	Butyl benzyl phthalate
	bis(2-Chloroethoxy)methane
	bis(2-Chlororethyl)ether
	bis(2-Chloroisopropyl)ether
	2-Chloronaphthalene
	4-Chlorophenyl phenyl ether
	Chrysene
	Dibenz(a,h)anthracene
	1,2-Dichlorobenzene
	1,3-Dichlorobenzene
	1,4-Dichlorobenzene
	3,3-Dichlorobenzidine
	Diethyl phthalate
	Dimethyl phthalate
	Di-n-butyl phthalate
	2,4-Dinitrotoluene
	2,6-Dinitrotoluene
	Di-n-octylphthalate
	bis(2-Ethylhexyl)phthalate
	Fluoranthene
	Fluorene
	Hexachlorobenzene
	Hexachlorobutadiene
	Hexachlorobyclopentadiene
	Hexachloroethane
	Indeno(1,2,3-cd)pyrene
	Isophorone
	Naphthalene
	Nitrobenzene
	n-Nitrosodimethylamine
	n-Nitrosodiphenylamine
	n-Nitrosodi-n-propylamine
	Phenanthrene
	Pyrene
	1,2,4-Trichlorobenzene

Trace Elements in Sediments

Trace-element concentrations in sediments were determined using atomic emission and atomic absorption spectroscopy. Total elemental concentrations were measured, including elements within the crystal lattice of minerals and those held at the surface in exchange sites, on oxide coatings, or in organometallic complexes.

Inductively coupled argon plasma-atomic emission spectrometry (ICAP-AES) (Crock and others, 1983) was the principal method used to determine most elemental concentrations. Detection limits and precision data for ICAP-AES are given in table 4. Accuracy was monitored by analysis of standard reference materials, and adjustments were made to sample concentrations if corresponding standard reference concentrations were not within ±5 percent of the known value.

A semiquantitative, emission spectrochemical method, known as the 6-step method because results are reported to one-sixth of an order of magnitude (Myers and others, 1961), was used when there was not enough sample for ICAP-AES. Silver determinations were generally made using the 6-step method because detection limits were lower than for ICAP-AES. Detection limits and precision data for the 6-step method are given in table 4.

Atomic absorption spectroscopy (AAS) was used for all determinations of mercury (Huffman and others, 1972). If enough sample material was available, arsenic and cadmium concentrations, which were determined with ICAP-AES, were also determined using AAS to obtain lower detection limits. Detection limits and precision data for AAS are given in table 4.

TABLE 4.--Detection limits and precision data for the determination of selected elements in sediment samples

[Detection limits are in micrograms per gram (parts per million)]

Element	[1]ICAP-AES	[2]6-step	[3]Atomic-absorption
Arsenic	10	1,000	0.1
Cadmium	2	50	.1
Chromium	1	1	--
Copper	1	1	--
Lead	4	10	--
Mercury	--	--	.01
Nickel	2	5	--
Silver	2	.5	--
Zinc	2	300	--

[1]Inductivly coupled argon plasma-atomic emission spectrometry-- At five times the detection limit the coefficient of variation is less than 10 percent.

[2]Results are identified with geometric brackets whose boundaries are 1.2, 0.83, 0.56, 0.38, 0.26, 0.18, 0.12 (as shown for one logarithmic cycle), but are reported arbitrarily as approximate mid-points of these brackets (1.0, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1). Precision of a reported value is approximately plus or minus two brackets at a 68-percent confidence level.

[3]Atomic absorption spectroscopy--The coefficient of variation is usually less than 10 percent.

GROUND WATER

Water samples from alluvial and glacial-drift sediments were obtained two to three times from one spring (Maplewood Spring), 15 piezometers (14.3 to 34.3 feet deep), and 18 pumping wells (90 to 1,050 feet deep). The piezometers and pumping wells are considered 'shallow' and 'deep,' respectively.

Table 12, at the end of the report, is a complete tabulation of ground-water quality data. Subsets of these data are also presented in this section for the convenience of the reader.

Sampling Techniques

Fourteen 2-inch-diameter piezometers were constructed of stainless steel casing and screen. One 2-inch-diameter piezometer was installed by Kaiser Aluminum and Chemical Corporation[1] and constructed of polyvinyl chloride casing and screen. The piezometers were sampled for inorganic constituents using a peristaltic pump. Prior to sampling, water was pumped from a piezometer until stable measurements of temperature, dissolved oxygen, and specific conductance were obtained. In cases where the rate of recharge to a piezometer did not permit continuous pumping, the water in the piezometer was evacuated and allowed to recover three times prior to collecting a sample. Samples for determination of volatile organic compounds were collected in a sample vial that was lowered below the water surface in the piezometer. Samples for determination of non-volatile organics were obtained with a stainless steel bailer. The sampling equipment was decontaminated in the field using standard techniques for sampling organic compounds (Wershaw and others, 1983).

Deep wells were sampled after they had been pumped for a time sufficient to remove the volume of stagnant water in the well borehole. Field measurements of dissolved oxygen, pH, and temperature were made in a flow chamber (Wood, 1976) wherever possible. Samples were filtered immediately by using a peristaltic pump connected to a filtration unit.

Hydrogeology

The study area is predominately composed of two types of sedimentary deposits. The flood plain, formed by the Puyallup River, consists of a fine-grained, alluvial sediment deposited into a valley eroded into glacial material. On either side and underlying the flood plain are undifferentiated glacial-drift deposits. An idealized lithologic cross section perpendicular to the long axis of the valley is shown in figure 2.

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[1]The use of trade, product, or firm names in this report is for identification purposes only, and does not constitute endorsement by the U.S. Geological Survey.

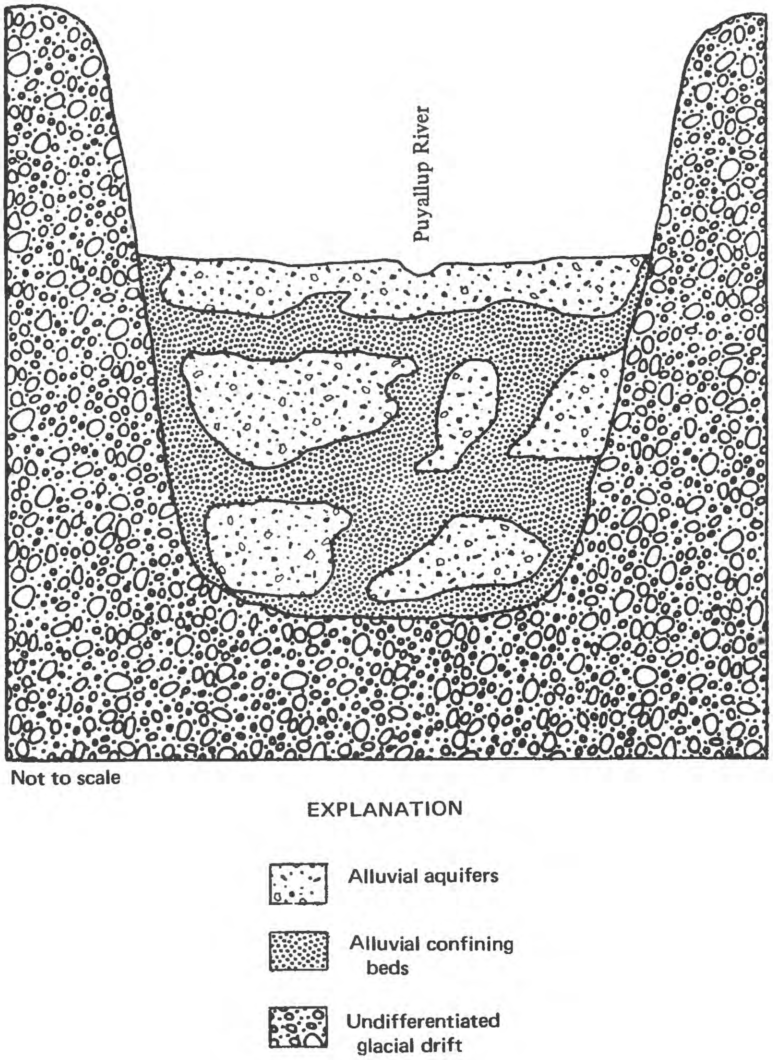


FIGURE 2.--Idealized lithologic cross section of the study area.

Alluvial aquifers in the flood plain are extensively tapped by domestic, municipal and industrial wells. The aquifers in the alluvium are separated by discontinuous confining beds of silt, or silt and clay (fig. 2). Wells tapping the deeper confined aquifers are the most productive (Gary Deeter, U.S. Geological Survey, written commun., 1985). Some of the highest yielding wells in the valley (for example, numbers 16, 32, and 33) penetrate through the alluvial sediments and tap sand-and-gravel glacial sediment (table 5).

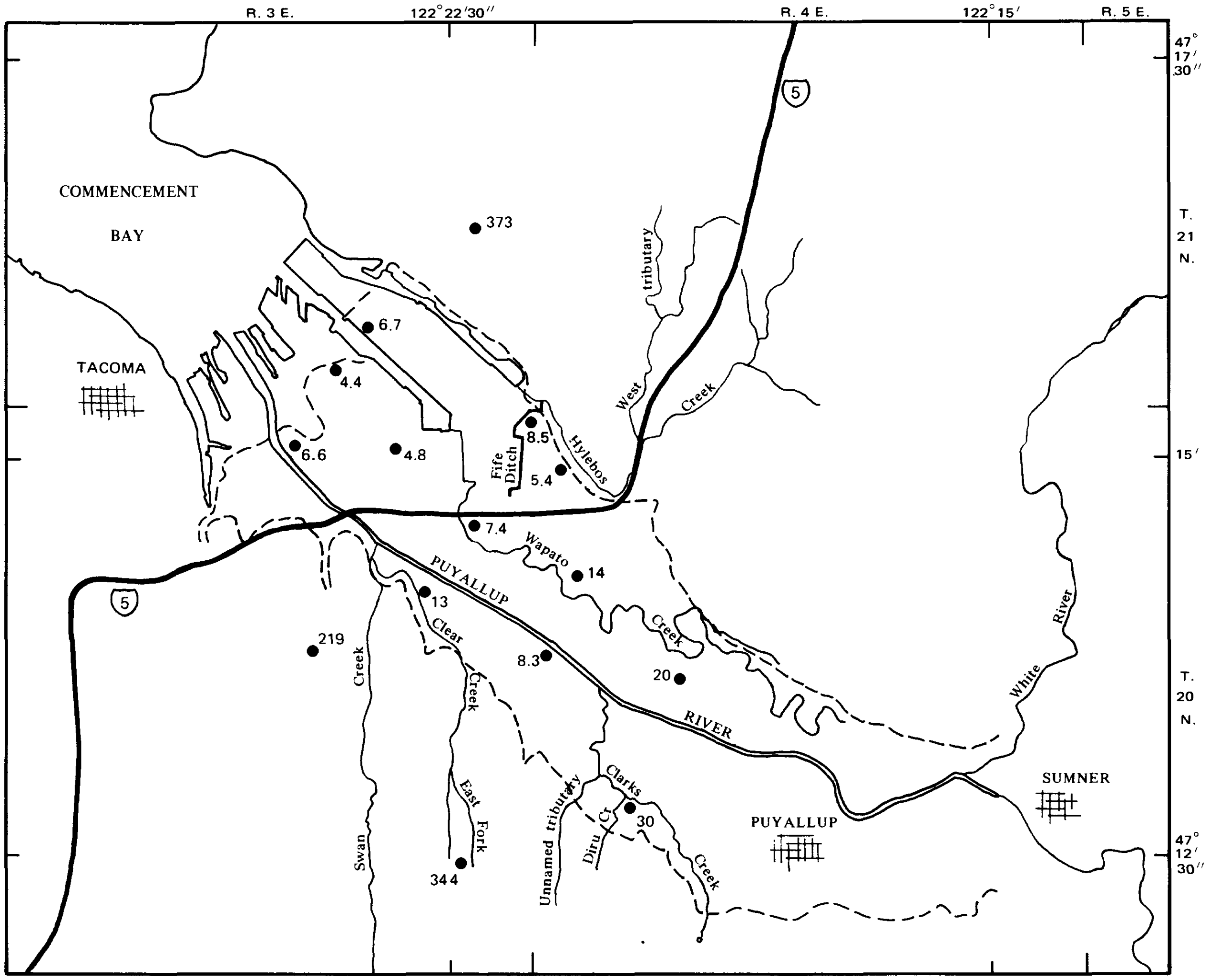
In the alluvial sediments, the water table remains at shallow depths throughout the year. During periods of high river stage, some water moves from the river into alluvial sediments, but during lower river stages, ground water discharges into the river. Some recharge of the shallow, unconfined aquifer occurs by upward leakage from underlying confined aquifers. Shallow water not discharged to the river moves downvalley as shown by water-table heads in figure 3. The deeper aquifers generally have heads slightly higher than shallow alluvial aquifers (Griffin and others, 1962; Molenaar, 1961), indicating the presence of artesian or confined water. Water from eight of the 18 deep wells was under sufficient artesian pressure to flow at the surface (table 5). The deeper artesian aquifers discharge into the alluvial sediments and into Puget Sound at the mouth of the Puyallup River valley. In addition, withdrawals from the deeper aquifers account for a part of the discharge.

The quantity of water pumped from various wells tapping the glacial drift aquifers differs widely. Sand and gravel deposits form the most productive aquifers. Sediments composed of an unsorted till that includes compact mixtures of clay, sand, gravel, cobbles, and boulder-sized materials yield only small amounts of water. The heterogeneous nature of the glacial sediments makes predicting areas of low and high water yields difficult.

Ground water flows generally from the uplands toward the Puyallup River. Most ground water discharges to the alluvial deposits in the valley or directly to Puget Sound. For example, Maplewood Spring (number 30, plate 1) near Puyallup, one of the largest springs in the study area, discharges from glacial deposits in the uplands to the alluvial fill and eventually to the Puyallup River.

Quality of Ground Water

The chemical composition of ground water is determined by several controls, including (1) the composition of the water when it first enters the aquifer systems; (2) the types and solubilities of minerals and materials in the aquifers with which the water is in contact; and (3) the length of time that the water has been in contact with aquifer materials.



0 1 2 3 MILES

0 1 2 3 4 KILOMETERS

EXPLANATION

● 4.8 WATER-TABLE HEADS--Number is altitude of water-table heads, in feet above sea level

– – – EDGE OF ALLUVIUM

FIGURE 3.--Water-table heads measured in September 1984.

TABLE 5.--Selected determinations of major constituents and properties of waters from shallow and deep wells

[Data from sampling in spring 1984;
Values in milligrams per liter unless otherwise indicated;
A, alluvium; G, glacial drift;
Asterisk indicates flowing artesian wells]

Well No.	Local identifier	Water-bearing geologic unit	Date of collection	Depth of well (feet below land surface)	Specific conductance (in microsiemens at 25 degrees C)	pH, in units	Temperature (degrees C)	Dissolved oxygen	Hardness (as $CaCO_3$)
					Shallow wells				
1	20/03E-01A01	A	84-05-31	24.5	1680	6.5	15.2	0.0	450
2	20/03E-02K01	A	84-05-23	14.4	540	6.7	11.7	--	180
3	20/03E-03F01	A	84-05-18	14.3	2350	6.9	11.3	.0	730
4	20/03E-12F01	A	84-05-21	14.6	320	6.8	11.3	.0	88
5	20/03E-14A02	A	84-05-16	24.4	256	7.1	10.7	.2	110
6	20/03E-15K03	G	84-05-29	34.5	180	7.3	11.3	--	59
7	20/03E-25P01	G	84-05-29	24.3	132	6.7	10.8	7.4	42
8	20/04E-06L01	A	84-05-16	14.6	675	6.6	10.8	.0	150
9	20/04E-07Q02	A	84-05-21	14.5	250	6.9	10.9	.5	85
10	20/04E-17Q01	A	84-05-23	14.4	160	6.3	10.3	4.3	53
11	20/04E-18M02	A	84-05-17	24.2	200	6.7	11.6	.0	52
12	20/04E-30H02	A	84-05-17	14.8	130	6.6	12.2	.8	49
13	21/03E-25C01	G	84-05-24	32.3	131	7.3	10.7	--	40
14	21/03E-34J01	A	84-05-22	14.4	1080	6.8	11.2	3.0	410
15	21/03E-35D01	A	84-05-23	14.4	1500	6.8	11.1	.3	600
					Deep wells and spring				
16	20/03E-03L01	G	84-03-27	534	134	7.6	--	.1	32
17*	20/03E-11Q02	G	84-03-27	315	170	7.7	11.7	.0	47
18	20/03E-12J01	A	84-04-02	90	398	7.2	11.0	.0	130
19	20/03E-13C02	G	84-03-29	153	179	7.6	11.7	.1	53
20	20/03E-25C02	G	84-04-02	267	142	6.8	8.9	8.2	59
21	20/03E-36P01	G	84-04-02	597	151	6.5	9.3	8.7	60
22*	20/04E-07G01	A	84-03-29	350	302	7.8	11.9	.1	73
23*	20/04E-08M01	A	84-04-10	168	272	7.5	11.6	1.9	75
24	20/04E-10N01	G	84-04-09	238	185	6.7	9.8	5.6	75
25	20/04E-16G01	G	84-04-09	419	155	7.2	10.7	.2	63
26*	20/04E-18L01	A	84-03-29	237	275	7.2	11.3	.2	74
27*	20/04E-20C01	G	84-04-10	801	260	7.9	12.6	.1	70
28*	20/04E-20C02	A	84-03-28	300	253	7.4	10.9	.4	86
29*	20/04E-30H01	G	84-03-27	332	138	7.6	11.3	.2	49
30	20/04E-32J01S	G	84-05-29	spring	167	6.8	9.1	8.7	66
31	21/03E-25P01	G	84-03-29	417	140	7.6	10.1	.1	56
32	21/03E-26N01	G	84-03-28	785	350	8.1	15.3	.2	67
33	21/03E-36Q01	G	84-03-28	901	270	7.9	13.4	.3	71
34	21/04E-32M01	G	84-03-28	1050	435	8.2	11.9	.0	100

Well No.	Local identifier	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Alkalinity (as $CaCO_3$)	Sulfate (SO_4)	Cloride (Cl)	Fluoride (F)	Dissolved solids
						Shallow wells				
1	20/03E-01A01	53	78	180	25	520	150	170	0.6	1100
2	20/03E-02K01	28	27	30	24	152	110	8.0	2.0	370
3	20/03E-03F01	180	68	140	62	1030	25	38	.7	1400
4	20/03E-12F01	22	8.0	12	2.0	91	12	28	.3	240
5	20/03E-14A02	18	15	13	3.4	135	4.5	2.5	.2	190
6	20/03E-15K03	11	7.6	8.4	2.2	56	16	6.2	.1	120
7	20/03E-25P01	7.9	5.5	7.0	0.9	45	4.4	4.5	.1	89
8	20/04E-06L01	37	15	48	3.2	249	5.9	31	.6	410
9	20/04E-07Q02	20	8.4	16	2.5	113	10	7.3	.4	210
10	20/04E-17Q01	14	4.3	7.3	2.5	69	15	0.8	.2	140
11	20/04E-18M02	12	5.4	9.7	1.9	76	19	3.8	.4	190
12	20/04E-30H02	10	5.8	6.9	2.0	63	2.8	2.1	.2	110
13	21/03E-25C01	11	3.1	6.1	1.0	21	20	4.7	.1	80
14	21/03E-34J01	110	34	67	21	470	84	31	.9	660
15	21/03E-35D01	130	68	87	27	507	330	14	1.2	1000
						Deep wells and spring				
16	20/03E-03L01	7.4	3.3	5.0	2.3	69	.5	1.9	.2	120
17	20/03E-11Q02	11	4.7	7.9	1.5	65	2.7	1.9	.2	110
18	20/03E-12J01	24	18	24	6.5	211	2.3	4.5	.4	260
19	20/03E-13C02	11	6.3	16	2.7	94	2.0	2.2	.2	150
20	20/03E-25C02	13	6.5	5.7	1.4	58	4.9	5.6	.1	100
21	20/03E-36P01	14	6.1	6.3	1.1	54	7.4	6.3	.1	100
22	20/04E-07G01	11	11	38	4.1	161	1.8	7.4	.3	220
23	20/04E-08M01	18	7.3	24	4.4	129	1.0	8.8	.3	190
24	20/04E-10N01	16	8.5	6.5	1.8	65	8.8	6.4	.1	120
25	20/04E-16G01	15	5.9	6.7	1.9	74	2.7	2.3	.1	110
26	20/04E-18L01	13	10	20	3.4	137	3.4	3.6	.4	200
27	20/04E-20C01	20	4.9	25	5.6	127	1.0	7.5	.2	180
28	20/04E-20C02	21	8.2	17	4.8	131	.9	3.6	.2	180
29	20/04E-30H01	11	5.3	7.9	2.2	64	2.1	4.7	.1	110
30	20/04E-32J01S	14	7.6	5.9	2.0	62	4.7	4.5	.1	110
31	21/03E-25P01	13	5.6	6.3	1.8	70	3.3	2.1	.1	110
32	21/03E-26N01	18	5.3	52	2.4	170	2.0	14	.1	240
33	21/03E-36Q01	19	5.7	27	4.6	132	1.2	9.2	.2	190
34	21/04E-32M01	27	8.7	47	2.9	136	.8	60	.1	250

General Characteristics

Plots of the percentages of major dissolved constituents in the alluvial and glacial-drift aquifers depict the chemical character of ground waters sampled (figs. 4 and 5). In the most common type of ground water in alluvial and glacial-drift sediments, calcium and magnesium make up more than half of the cations and bicarbonate makes up more than 80 percent of the anions (figs. 4 and 5). Four of the deep wells (numbers 16, 22, 32, 34) yielded water that contained predominantly sodium and potassium (greater than 50 percentage equivalents), and three of these were in glacial-drift aquifers. For comparison, the major ion composition of water from the surface-water sampling site Puyallup River at Puyallup is shown in figure 4. The river water was calcium and magnesium enriched and thus similar in ionic composition to the shallow ground water.

Four of the shallow wells sampled (1, 3, 14, and 15) had high dissolved-solids concentrations (greater than 500 mg/L; milligrams per liter). In contrast, all of the sampled deep waters and 11 of the shallow waters were low (less than 200 mg/L) to moderate (200 to 500 mg/L) in dissolved solids (table 5). Ground waters with the highest dissolved-solids concentrations were located in the lower valley northwest of Interstate Highway 5 in the vicinity of industrial land use.

Hardness is not a standard adopted for drinking water supplies, but because of its relation to taste and the formation of deposits in distribution systems, hardness is of general concern. Following is a descriptive hardness range (Hem, 1970) and the number of sampled wells that fell within each range. Most of the waters were either soft or moderately hard. Waters that were hard or very hard were generally from shallow wells with high dissolved-solids concentrations.

Range in hardness as $CaCO_3$ (milligrams per liter)	Degree of hardness	Number of sampled wells within each range
0-60	soft (suitable for most uses without softening)	13
61-120	moderately hard (usable except in some industrial uses)	14
121-180	hard (softening required by some industries)	3
Greater than 180	very hard (softening desirable for most uses)	4

The pH of the ground waters ranged from 6.2 to 8.3. The pH range that is not directly lethal to fish is 5.0 to 9.0; however, the toxicity of many compounds is affected by pH. An example is ammonia, which increases in toxicity to fish as the pH increases.

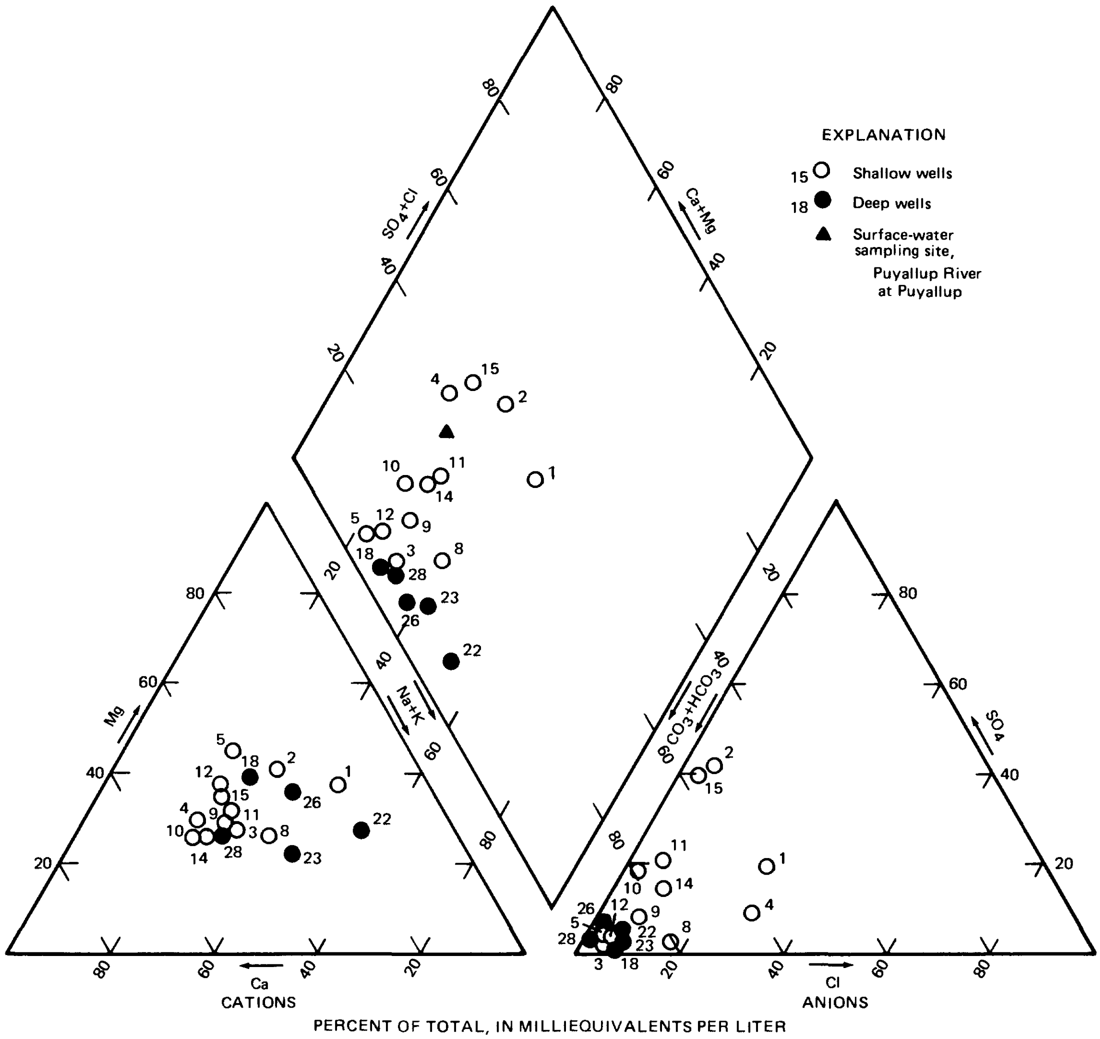


FIGURE 4.--Major-ion percentages in water from wells in alluvial sediments. Well numbers are from table 5.

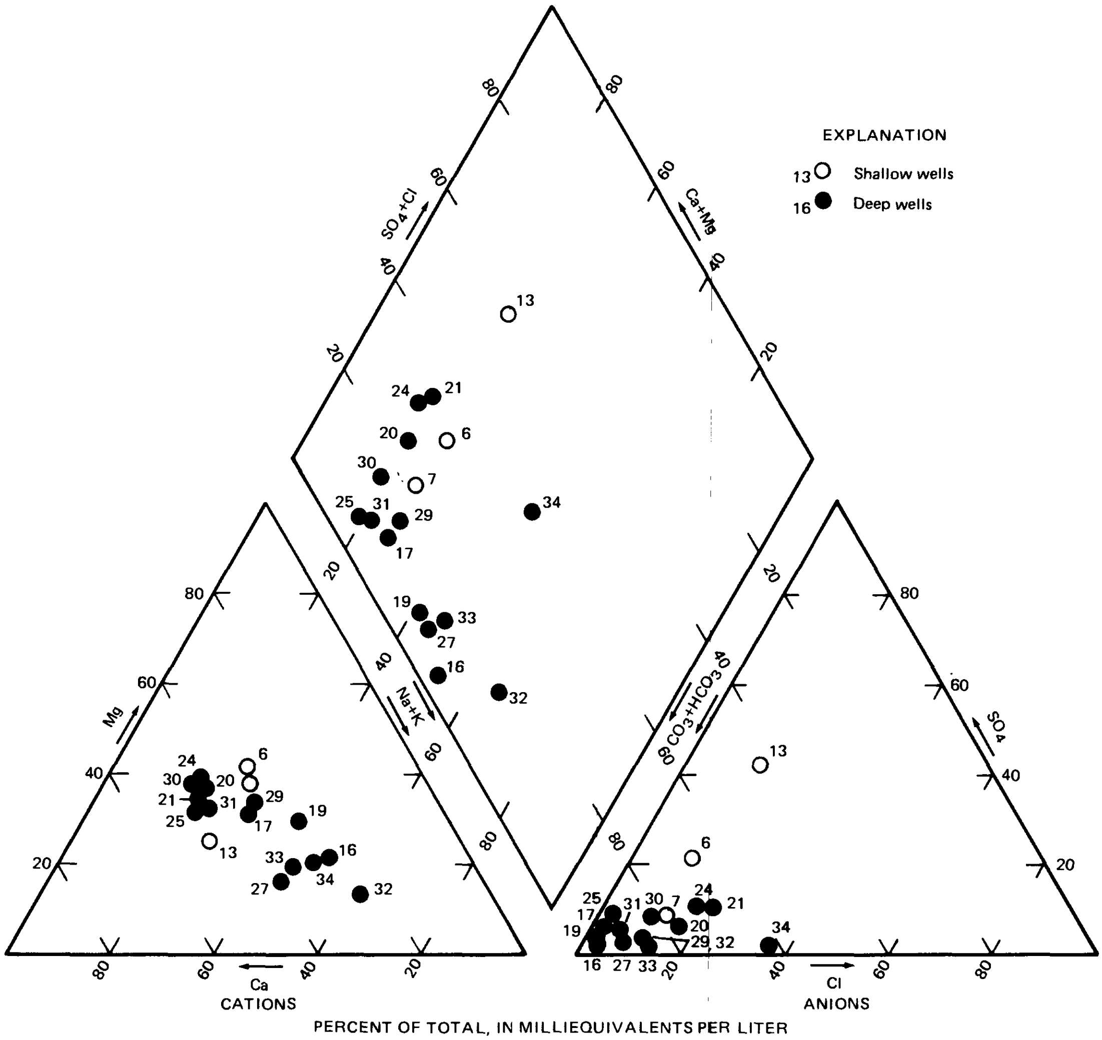


FIGURE 5.–Major-ion percentages in water from wells in glacial-drift sediments. Well numbers are from table 5.

Chloride Concentrations and Saltwater Intrusion of Aquifers

Saltwater intrusion is usually detected by high chloride concentrations in well waters, or by chloride concentrations that increase over a period of time. High concentrations can also result from contamination introduced by disposal of manmade wastes. In well waters near the coast where ground-water heads are at or below sea level, saltwater intrusion would be a probable cause of high chloride concentrations.

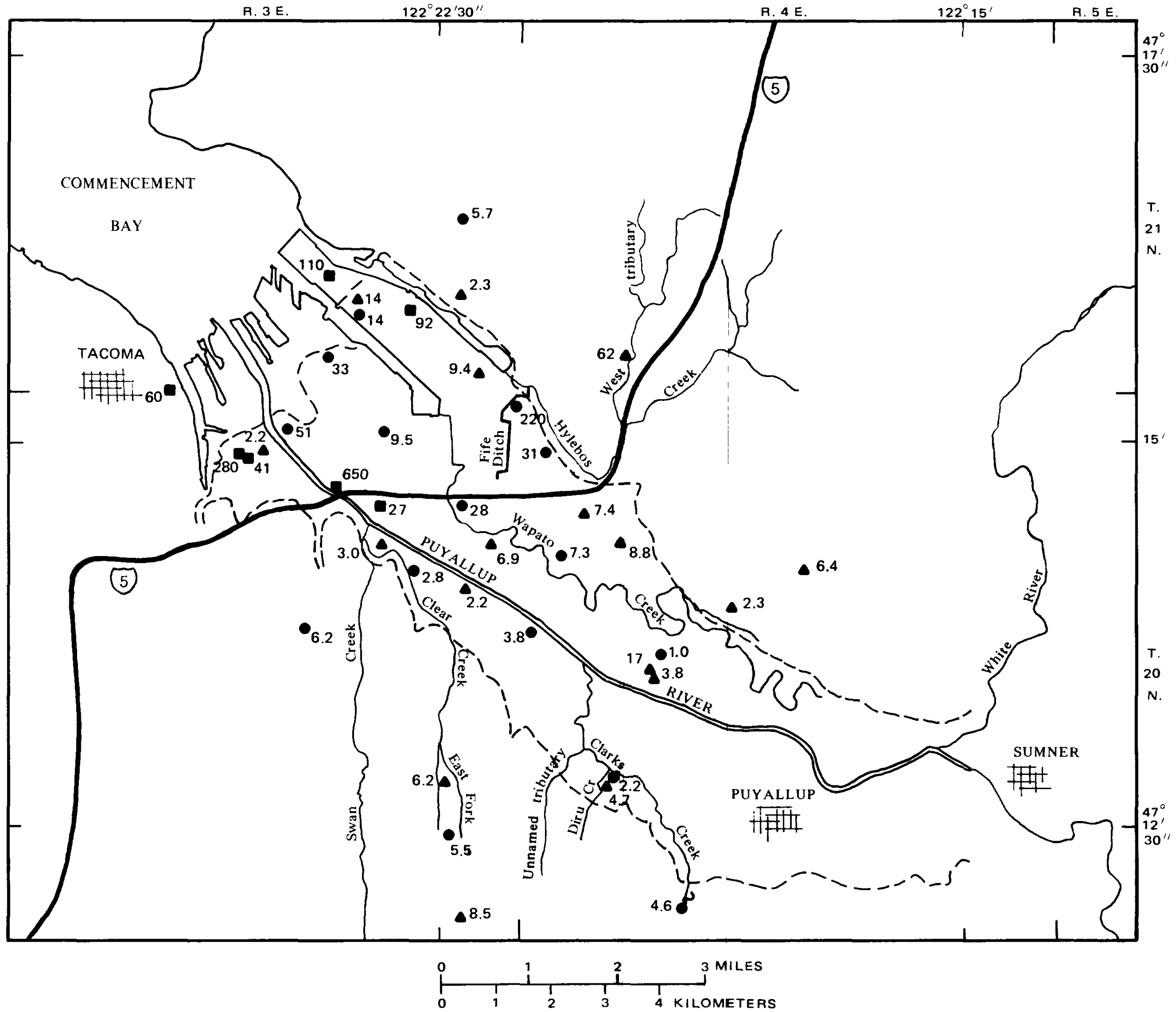
Chloride concentrations were generally less than 10 mg/L in upland areas (fig. 6). The highest chloride concentrations were found in the lower part of the Puyallup River valley, north of Interstate Highway 5. Shallow water from well 20/03E-01A01 had a chloride concentration of 220 mg/L, the maximum value observed. Samples from four other shallow wells in the lower valley had chloride concentrations ranging from 28 to 51 mg/L. These slightly elevated concentrations of chloride in shallow waters may be derived from urban and industrial activities. The deeper pumping wells near Commencement Bay had chloride concentrations of less than 10 mg/L.

Data from two previous saltwater-intrusion studies covering Washington coastal areas (Walters, 1971; Dion and Sumioka, 1984) indicate that there is a potential for saltwater to intrude in lower Puyallup River valley. Seven sampled wells in the lower valley, ranging in depth from 67 to 1,210 feet, had chloride concentrations exceeding 25 mg/L (fig. 6). Saltwater intrusion was suspected as the cause for the localized higher chloride concentrations from these wells.

Dissolved Oxygen and Temperature

Below the earth's surface, oxygen is consumed by chemical and biochemical reactions. Oxygen depletion and reducing conditions are common in deep aquifers where water is isolated from the earth's atmosphere for long periods of time. Oxygen can also be depleted in shallow ground water by oxidation of organic matter and dissolution of metals. Dissolved-oxygen concentrations were low (less than 1 mg/L) in 13 of 18 deep wells and about half (8 of 15) of the shallow wells (table 12). Low concentrations in shallow wells occurred mostly in wells tapping alluvial aquifers, whereas in those tapping glacial-drift aquifers, concentrations ranged from 1.9 to 7.4 mg/L. The water from Maplewood Spring was well oxygenated at 8.7 mg/L (table 5).

Ground water used to supplement the proposed fish hatchery needs on Hylebos Creek would probably be drawn from deep aquifers. Such water would very likely require aeration to increase the dissolved-oxygen concentration for fish survival and propagation. Water temperatures from wells tapping deep aquifers ranged from 8.9 to 15.3 degrees Celsius (table 5). If waters at these temperatures were aerated to 100-percent saturation for fish hatchery use, the dissolved-oxygen concentrations would range from 7.8 to 8.9 mg/L.



EXPLANATION

CHLORIDE CONCENTRATION

Number is chloride concentration in milligrams per liter

33● SHALLOW WELLS

7.4▲ DEEP WELLS

4.6 SPRING

60■ WELLS

Data from Walters, 1971; and Dion and Sumioka, 1985:

--- EDGE OF ALLUVIUM

FIGURE 6.--Maximum chloride concentrations in water from shallow and deep wells.

Nutrients

Nitrogen

Ground water containing high concentrations of nitrogen species is a potential health hazard because of the presence of nitrate or the convertibility of other nitrogen species such as ammonia and nitrite to nitrate. Nitrate has received the most attention because water with concentrations more than 10 mg/L as nitrogen is considered a health risk for consumption by infants. Analytically, nitrate and nitrite are determined together. As shown in figure 7, most sampled waters had nitrite plus nitrate concentrations of less than 0.10 mg/L, as nitrogen. The highest concentrations of nitrite plus nitrate were found in waters with fairly high concentrations of oxygen (table 12) and ranged from 1.5 to 2.7 mg/L. Nitrite is unstable in nature and only rarely accumulates in significant amounts in water; most of the sampled waters had nitrite concentrations below the detection limits (table 12).

Ammonia dissolved in water is the most reduced inorganic form of nitrogen, and includes un-ionized ammonia (NH_3) and the ammonium ion (NH_4^+). In the pH range of most natural waters, the largest fraction of ammonia in solution would be in the ammonium form (NH_4^+). In concentrations normally found in natural waters ammonia presents no physiological detriment to man or livestock. However, fish cannot tolerate large amounts of un-ionized ammonia, because it reduces the oxygen-carrying capacity of blood, and thus the fish may suffocate. For protection of fish and aquatic life, a level of 0.02 mg/L of un-ionized ammonia should not be exceeded (table 1).

Ammonia can result from the decomposition of nitrogenous organic matter or from the microbial reduction of nitrates or nitrites under anaerobic conditions. Concentrations of dissolved ammonia (NH_3 plus NH_4^+) varied considerably, from values less than 0.01 to 19 mg/L as nitrogen (fig. 8). The highest concentrations of ammonia were found in shallow alluvial aquifers located in the lower valley northwest of Interstate Highway 5 in the industrial area; glacial-drift and deep alluvial aquifers generally had lower concentrations. The maximum observed concentration, 19 mg/L, was sampled from a shallow well (No. 3) located on the inactive Tacoma landfill (pl. 1). Even though the concentrations of ammonia were relatively high for some of the shallow wells, the calculated values for the toxic, un-ionized form of ammonia were less than 0.02 mg/L (calculated conversion not shown) for all samples. This indicates that ammonia toxicity would not likely pose a risk if ground waters were used for fish-hatchery purposes.

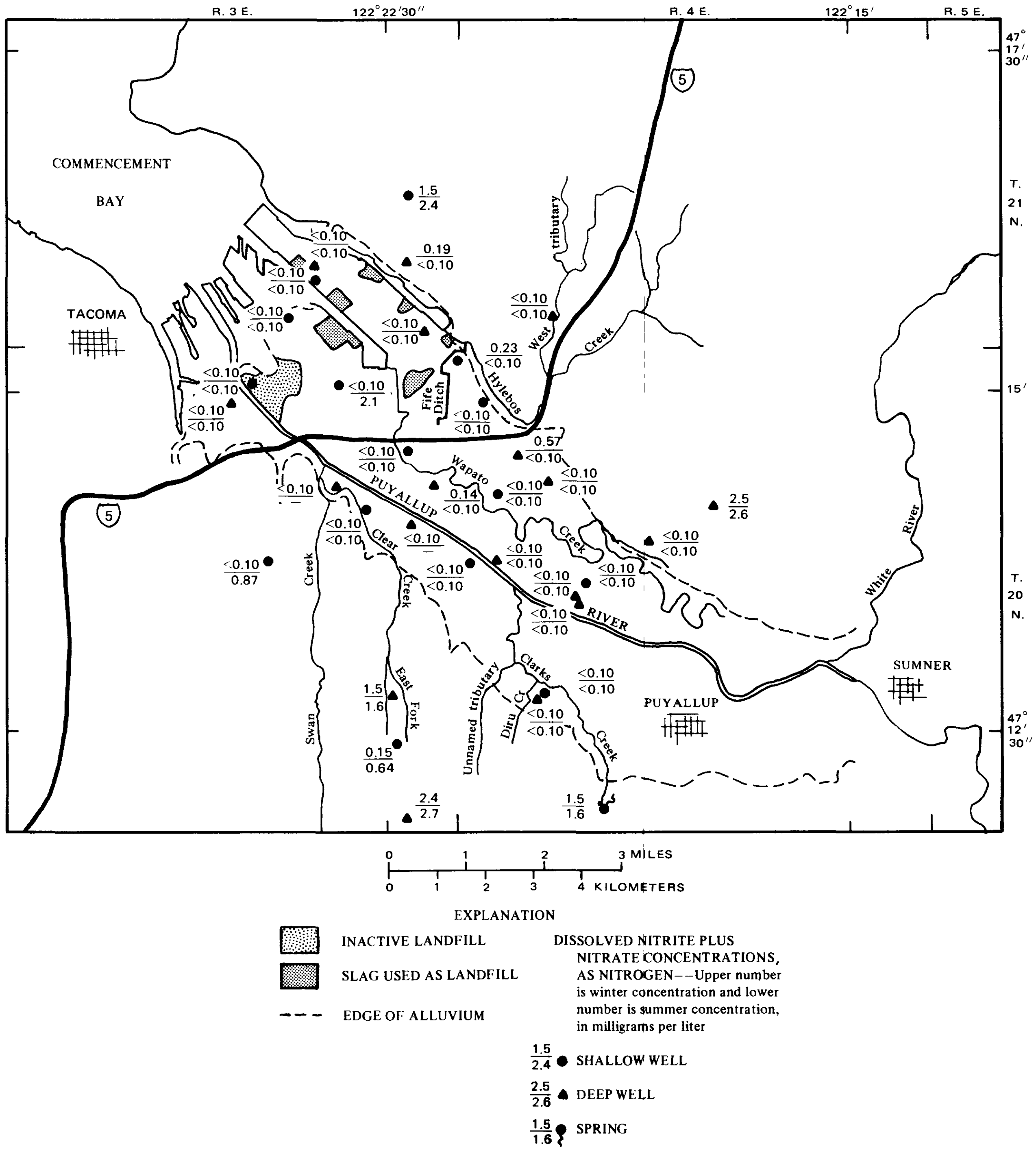


FIGURE 7.--Dissolved nitrite-plus-nitrate concentrations, as nitrogen, in ground waters in winter and summer, 1984.

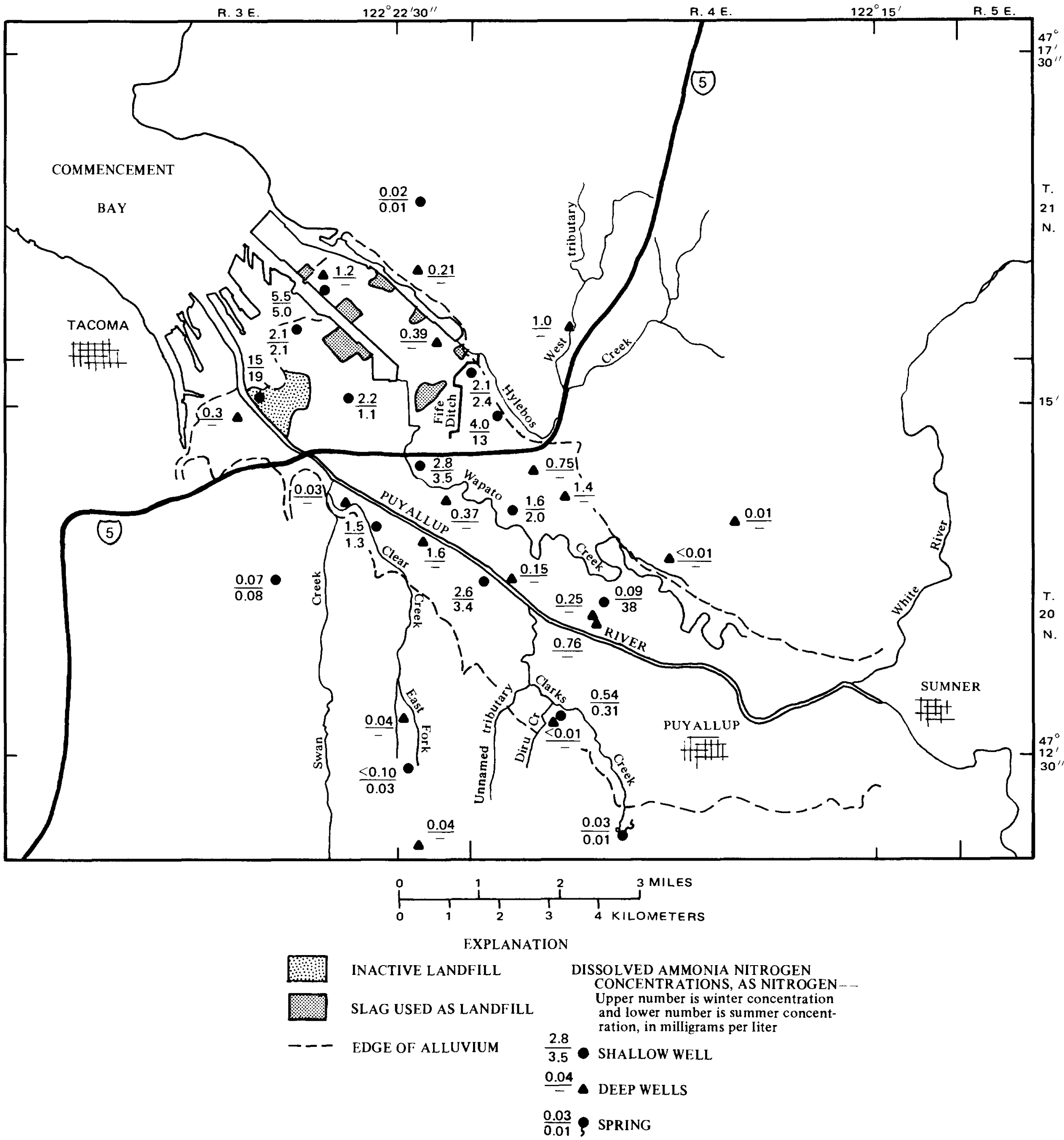


FIGURE 8.–Dissolved ammonia nitrogen concentrations, as nitrogen, in ground waters in winter and summer, 1984.

Phosphorus

Although phosphorus is not a harmful constituent in drinking water, the occurrence and mobility of phosphorus in ground water is important in situations where large quantities of ground water discharge to surface-water impoundments. Phosphorus concentrations, even in small amounts, can in some circumstances produce accelerated growth of algae and aquatic vegetation. The dominant control on phosphorus in the ground water is the solubility of slightly soluble phosphate minerals. Potential manmade sources of phosphorus are domestic sewage, industrial effluents, and agricultural drainage from fertilized land.

No apparent patterns in dissolved phosphorus concentrations were indicated areally or with depth, and the magnitude of the dissolved phosphorus concentrations ranged considerably (fig. 9). Minimum and maximum concentrations, as phosphorus, were 0.01 and 0.95 mg/L (table 12), respectively; the median concentration was 0.15 mg/L. Much of the phosphorus in the ground water, if used in hatchery ponds, would be actively taken up by algae and other plants.

Organic Compounds

Organic compounds, both volatile and non-volatile, can potentially leach through soils into ground water. Transport of organic compounds through soils depends on the rate of infiltration, which is affected by the type of compound, the soil materials, and the hydrologic environment.

None of the 29 volatile organic compounds (table 2) was found above the quantitation limit of 1 μg/L in shallow ground waters sampled in May 1984. The consistently low concentrations suggest that, at the location of the sampled wells, either a large source of these compounds was not present, conditions did not prevail that would cause the compounds to become mobilized, or natural processes of dilution, volatilization, and biodecomposition were sufficiently active to prevent ground-water contamination.

Waters from one deep well (16) and shallow wells (3, 5, 8, and 13) were analyzed for acid- and base/neutral-extractable organic compounds (table 3). None of these organic compounds was found above the quantitation limits.

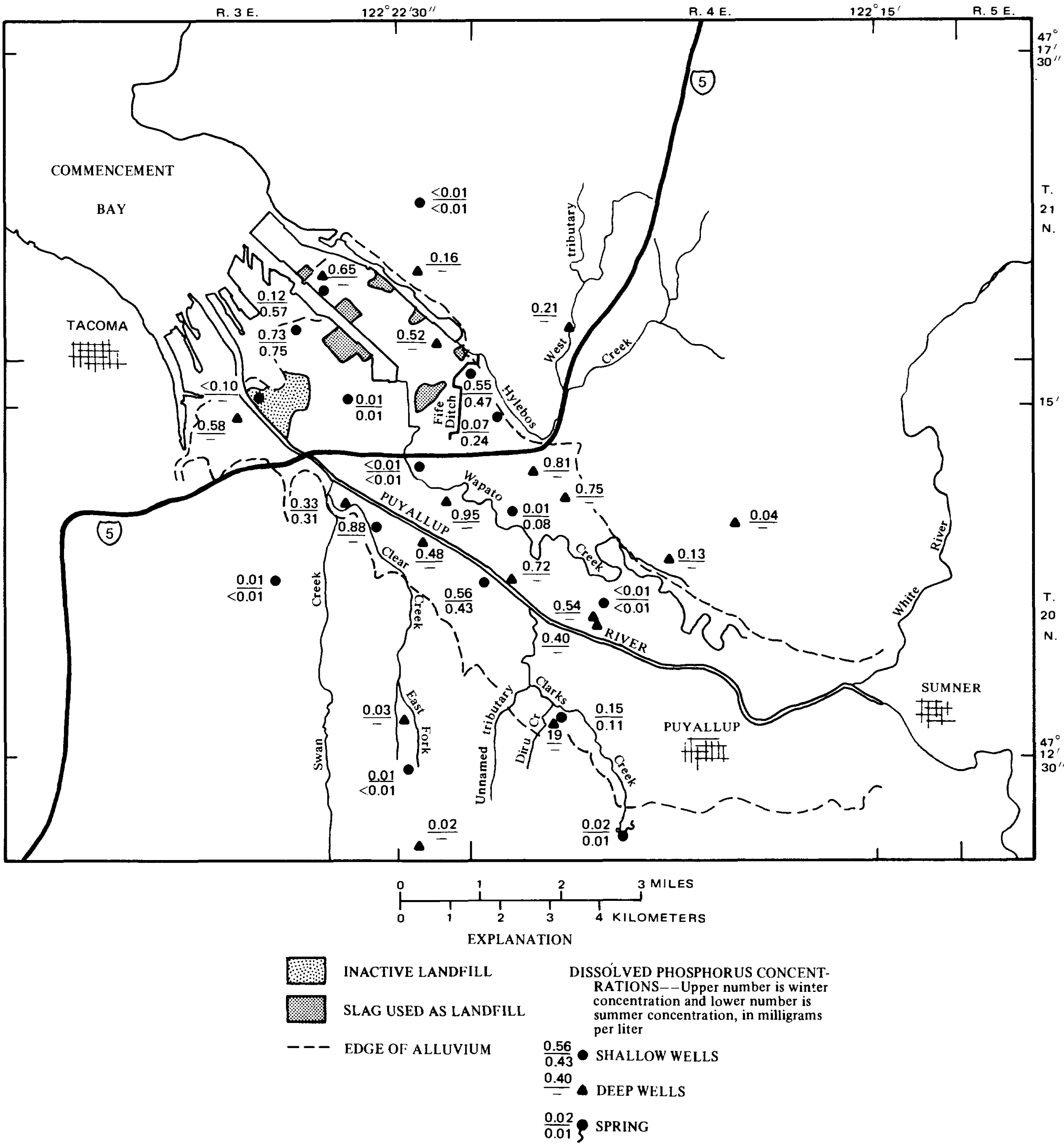


FIGURE 9.--Dissolved phosphorus concentrations in ground waters in winter and summer, 1984.

Trace Elements

Ground-water samples were analyzed for the trace elements arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc, as well as aluminum, iron, and manganese (tables 6 and 12). Although sometimes classified as major elements, aluminum, iron, and manganese are referred to here as trace elements because they are often found at low concentrations. Only iron and manganese were found in significant quantities, the highest concentrations being in most wells tapping shallow alluvial aquifers and in a few wells tapping deeper aquifers (figs. 10 and 11). These metals occur naturally in soil and sediment minerals and as coatings on the sediment deposits that make up the aquifers. Iron may also be leached from the slag used as fill material and from ferrous metals in landfills or scrap-metal piles located above ground. Moreover, reducing conditions, indicated by low concentrations of dissolved oxygen, are effective in solubilizing iron and manganese. These conditions, and a combination of other possible factors, produced iron and manganese concentrations of 210,000 and 4,300 μg/L, respectively, in samples from two separate wells in the Tacoma tideflats area, one located at the inactive Tacoma landfill site (figs. 10 and 11).

Other dissolved trace elements were found below detection limits or at low concentrations in both shallow and deep wells (table 6). Concentrations of all trace elements were plotted areally on maps, but no spatial patterns were observed (data not shown). Furthermore, none of the trace elements except iron and manganese exceeded the maximum contaminant levels for drinking water shown in table 1. However, the concentration of arsenic was 50 μg/L (the maximum contaminant level for drinking water) in a single sample of ground water from the inactive Tacoma landfill site. The source of arsenic is unknown, but the landfill site contains a large variety of waste materials.

Bacteria

Fecal-coliform and fecal-streptococcal organisms have long been used as indicators of probable pollution from such sources as septic systems, landfills and runoff from farmlands, animal feedlots, and soils (Greeson and others, 1977). Under proper conditions soils can filter out many bacteria; however, there are conditions where the ground water may not be adequately protected from bacteria. If a well is poorly sealed from the surface or is poorly located such that the flow of contaminated water is greater than that which the soil can assimilate, then bacteria can enter the ground water. Most of the sampled wells showed an absence of indicator bacteria, and presumably provide water of acceptable sanitary quality for domestic, municipal, fisheries, and irrigation uses.

TABLE 6.--Trace-element concentrations in samples from shallow and deep wells

[Values in micrograms per liter; A, alluvial; G, glacial drift; <, less than; numbers preceding and following comma are values from sampling in the winter and summer of 1984, respectively.]

Well No.	Local identifier	Water-bearing geologic unit	Depth of well (feet below land surface)	Aluminum (as Al)	Arsenic (as As)	Cadmium (as Cd)	Chromium (as Cr)	Copper (as Cu)	Lead (as Pb)	Mercury (as Hg)	Nickel (as Ni)	Silver (as Ag)	Zinc (as Zn)
						Shallow wells							
1	20/03E-01A01	A	24.5	50,50	<1,3	<1,3	<1,7	<1,1	<1,<1	<0.1,<0.1	<1,2	<1,<1	10,6
2	20/03E-02K01	A	14.4	20,40	<1,<1	<1<1	<1,<1	17,27	<1,<11	<.1,<.1	<15,7	2,<1	10,8
3	20/03E-03F01	A	14.3	40,-	50,-	<1,-	<1,-	<1,-	<1,-	.1,-	<1,-	<1,-	10,-
4	20/03E-12F01	A	14.6	10,20	5,2	<1,<1	1,<1	<1,<1	<1,4	<.1,<.1	8,5	<1,<1	<10,<3
5	20/03E-14A02	A	24.4	<10,10	<1,<1	<1,1	<1,4	<1,<1	<1,1	<.1,<.1	15,4	<1,<1	<10,<10
6	20/03E-15K03	G	34.5	10,10	<1,<1	<1,<1	<1,<1	2,16	<1,<1	<.1,<.1	8,40	<1,2	70,19
7	20/03E-25P01	G	24.3	10,20	<1,<1	<1,<1	<1,<1	<1,<1	2,<1	<.1,<.1	2,15	<1,<1	20,120
8	20/04E-06L01	A	14.6	<10,20	1,1	<1,1	<1,1	<1,4	<1,<1	<.1,<.1	<1,4	<1,3	<10,<3
9	20/04E-07Q02	A	14.5	20,30	2,<1	<1,1	<1,3	<1,1	<1,<1	<.1,<.1	<1,2	<1,<1	10,20
10	20/04E-17Q01	A	14.4	<10,20	<1,<1	1,<1	<1,<1	4,7	<1,3	<.1,<.1	22,27	10,33	10,33
11	20/04E-18M02	A	24.2	20,10	3,<1	<1,2	1,<1	<1,32	<1,7	<.1,<.1	7,5	<1,<1	20,10
12	20/04E-30H02	A	14.8	10,10	<1,<1	<1,<1	<1,5	<1,1	<1,3	<.1,<.1	10,15	<1,<1	<10,29
13	21/03E-25C01	G	32.3	<10,10	<1,<1	<1,<1	<1,<1	3,2	<1,1	<.1,<.1	8,15	<1,<1	30,17
14	21/03E-34J01	A	14.4	10,20	<1,<1	<1,<1	<1,<1	<1,<1	<1,<1	<.1, .3	2,6	<1,<1	<10,<3
15	21/03E-35D01	A	14.4	<10,20	<1,<1	<1,<1	<1,1	<1,<1	<1,<1	<.1,<.1	1,2	<1,<1	50,6
						Deep wells and spring							
16	20/03E-03L01	G	534	<10,<10	<1,<1	<1,<1	<1,<1	1,<1	<1,<1	<.1,<.1	2,<1	<1,<1	<10,10
17	20/03E-11Q02	G	315	<10,<10	<1,<1	<1,<1	<1,8	2,<1	<1,<1	<.1,<.1	2,<1	<1,<1	10,9
18	20/03E-12J01	A	90	<10,10	<1,<1	<1,<1	<1,<1	<1,<1	<1,<1	<.1,<.1	2,<1	<1,<1	50,28
19	20/03E-13C02	G	153	<10,-	<1,-	<1,-	<1,-	<1,-	<1,-	<.1, -	1,-	<1,-	10,-
20	20/03E-25C02	G	267	<10,<10	<1,<1	<1,<1	<1,8	3,1	3,4	<.1,<.1	8,1	<1,1	40,6
21	20/03E-36P01	G	597	<10,10	<1,<1	<1,<1	<1,6	4,1	5,<1	<.1,<.1	5,<1	<1,<1	10,8
22	20/04E-07G01	A	350	<10,<10	1,2	<1,<1	<1,<1	<1,<1	<1,3	<.1,<.1	1,<1	<1,<1	20,11
23	20/04E-08M01	A	168	20,20	<1,<1	<1,<1	<1,<1	<1,<1	<1,<1	<.1,<.1	3,2	<1,<1	20,7
24	20/04E-10N01	G	238	20,<10	<1,<1	<1,<1	<1,<1	1,<1	2,<1	<.1,<.1	2,1	<1,<1	10,16
25	20/04E-16G01	G	419	<10,<10	3,2	<1,<1	<1,<1	<1,<1	<1,3	<.1,<.1	3,1	<1,<1	10,15
26	20/04E-18L01	A	237	<10,<10	<1,<1	<1,<1	1,6	<1,<1	<1,3	<.1,<.1	1,1	<1,<1	310,520
27	20/04E-20C01	G	801	10,<10	18,18	<1,<1	<1,10	<1,<1	<1,4	<.1,<.1	3,<1	<1,<1	<10,<3
28	20/04E-20C02	A	300	<10,20	<1,<1	<1,<1	<1,<1	<1,25	3,1	<.1,<.1	2,8	<1,<1	10,12
29	20/04E-30H01	G	332	<10,<10	4,4	<1,<1	<1,4	<1,1	2,4	<.1,<.1	<1,<1	<1,<1	10,9
30	20/04E-32J01S	G	spring	10,<10	<1,1	<1,<1	<1,5	<1,<1	<1,2	<.1,<.1	<1,4	<1,<1	30,9
31	21/03E-25P01	G	417	<10,<10	13,12	<1,<1	<1,<1	<1,<1	<1,5	<.1,<.1	2,1	<1,<1	10,<3
32	21/03E-26N01	G	755	<10,<10	1,<1	<1,<1	<1,3	<1,<1	2,2	<.1,<.1	2,1	<1,<1	<10,<3
33	21/03E-36Q01	G	901	<10,20	12,12	<1,<1	1,<1	<1,<1	2,<1	<.1,<.1	2,2	<1,<1	<10,<3
34	21/04E-32M01	G	1,050	<10,10	8,8	<1,<1	1,5	<1,4	2,5	<.1,<.1	2,1	<1,<1	<10,<3

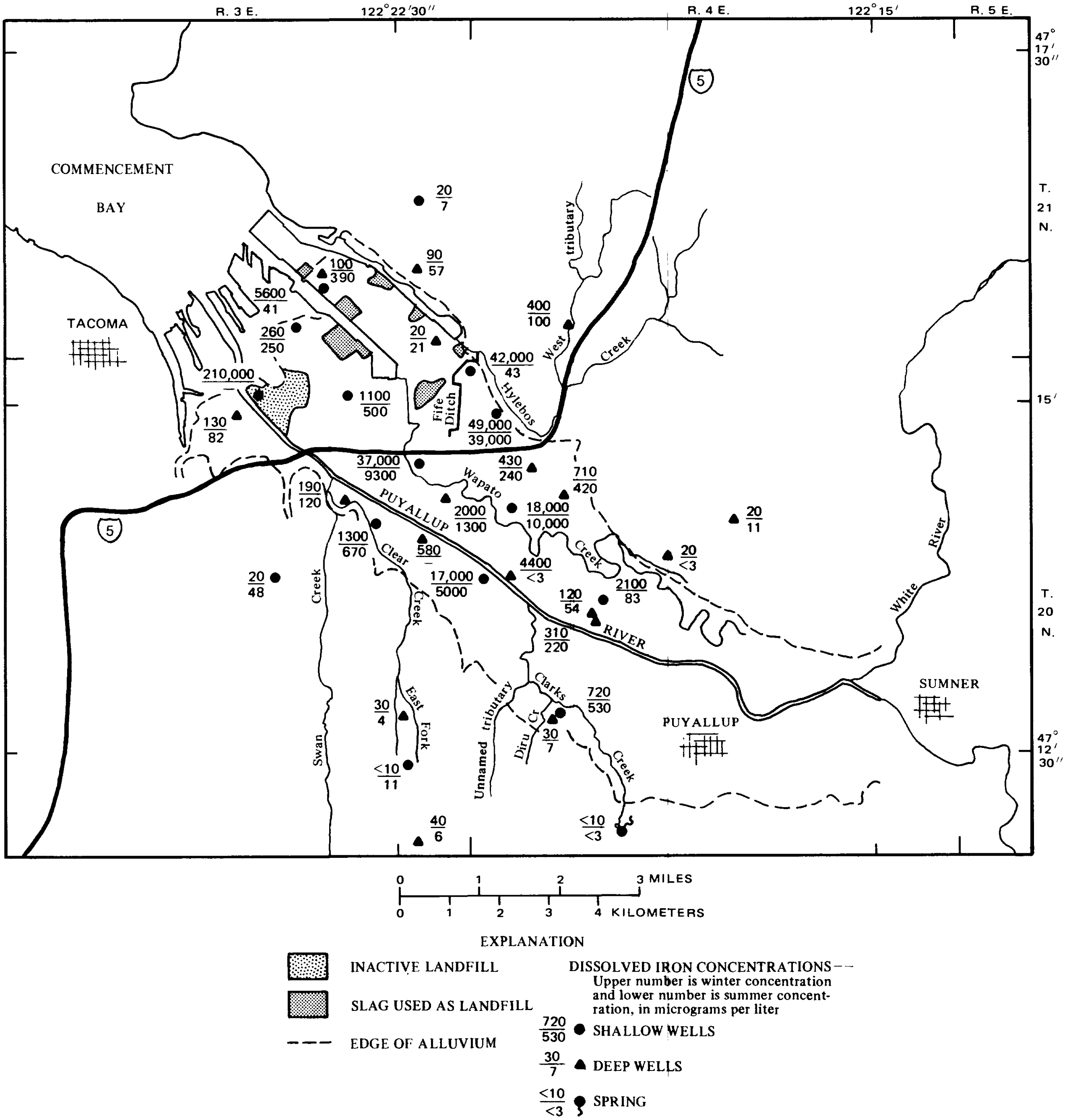


FIGURE 10.--Dissolved iron concentrations in ground waters in winter and summer, 1984.

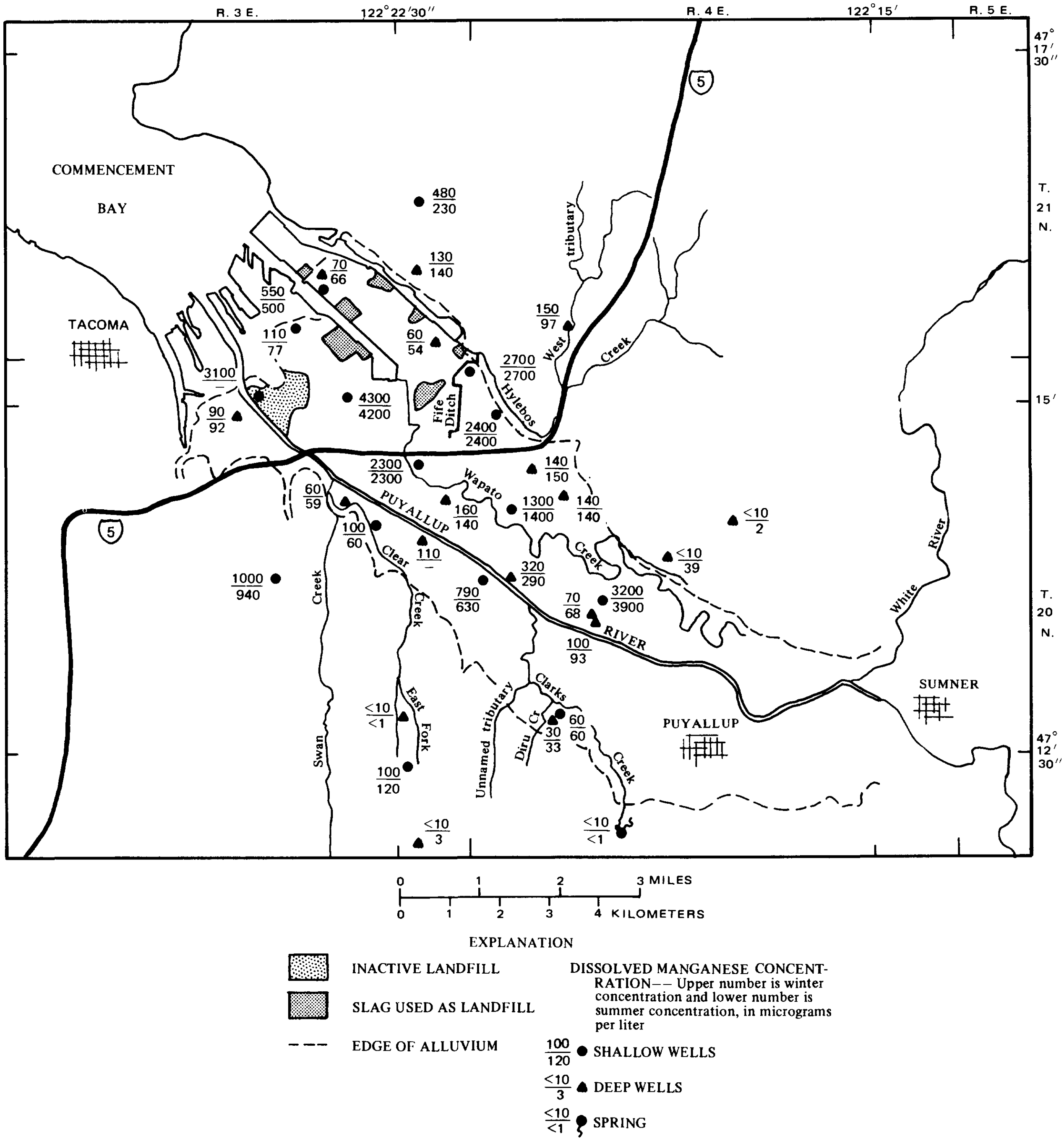


FIGURE 11.–Dissolved manganese concentrations in ground waters in winter and summer, 1984.

Fecal-coliform bacteria were not detected in any of the shallow and deep aquifers sampled (table 7). Fecal-streptococcal bacteria were found at low densities in waters from eight shallow and three deep wells (table 7). The positive tests for fecal-streptococcal bacteria in the shallow wells could be explained by near-surface sources of bacteria and the lack of efficient bacterial removal by soil filtration. The occurrence of fecal streptococci in deep wells is difficult to explain. Even though the densities were low, fecal bacteria generally do not multiply underground and eventually die. It is possible that fecal streptococci may not actually be present despite the positive membrane filter tests, because confirmation tests were not performed. In some waters, using routine testing, fecal-streptococcal bacteria cannot be distinguished from colonies of non-fecal streptococci (Greeson and others, 1977).

Suitability of Ground Water for Fish Hatchery Use

The quality of deep ground water appears suitable as a supplementary water supply for fish-hatchery needs. The presence of confining beds separating the deeper aquifers, and in some cases the upward flow of water beneath the valley floor, may act to retard downward movement of contaminants to deep aquifers. Deep waters are typically low or devoid of dissolved oxygen and would require aeration before use in hatchery ponds.

Shallow ground water analyzed in this study also appears suitable for fisheries use; however, the quality of the shallow ground water is generally poorer than that of the deep ground water. This is indicated by higher concentrations of inorganic constituents in water from some of the shallow wells north of Interstate Highway 5. Additionally, site-specific studies of known waste-disposal sites in the Tacoma tideflats have indicated that shallow ground water can become contaminated by industrial-waste products. One such study for the Pennwalt Corporation has indicated a migration of contaminants from industrial waste ponds to the shallow ground water within a relatively small area at the plant facility (Aware, Inc., 1981).

TABLE 7.--Fecal-coliform and fecal-streptococcal bacteria densities in samples from shallow and deep wells

[A, alluvium; G, glacial drift; numbers preceding and following the comma are values from winter and summer sampling of 1984, respectively; <, less than; K indicates nonideal colony counts.]

Well No.	Local identifier	Water-bearing geologic unit	Depth of well (feet below land surface)	Coliform, fecal, 0.7 UM-MF (colonies per 100 milliliters)	Streptococci, fecal, KF Agar (colonies per 100 milliliters)
			Shallow wells		
1	20/03E-01A01	A	24.5	<1,<2	<1,<2
2	20/03E-02K01	A	14.4	<1,<2	<1,K2
3	20/03E-03F01	A	14.3	<2,<2	K12,<2
4	20/03E-12F01	A	14.6	<2,<2	<2,<3
5	20/03E-14A02	A	24.4	<1,<1	<1,K15
6	20/03E-15K03	G	34.5	<1,<1	<1,K820
7	20/03E-25P01	G	24.3	<1,<1	K16,1
8	20/04E-06L01	A	14.6	<1,-	<1,-
9	20/04E-07Q02	A	14.5	<1,<2	K3,<2
10	20/04E-17Q01	A	14.4	<2,<2	<2,<2
11	20/04E-18M02	A	24.2	<1,<1	<1,<1
12	20/04E-30H02	A	14.8	<1,<1	<1,<1
13	21/03E-25C01	G	32.3	<1,<1	<1,<1
14	21/03E-34J01	A	14.4	<1,<2	K11,<2
15	21/03E-35D01	A	14.4	<1,<1	<1,<1
			Deep wells and spring		
16	20/03E-03L01	G	534	<1,-	<1,-
17	20/03E-11Q02	G	315	<1,-	<1,-
18	20/03E-12J01	A	90	<1,<1	K3,<1
19	20/03E-13C02	G	153	<1,-	<1,-
20	20/03E-25C02	G	267	<1,<1	<1,<1
21	20/03E-36P01	G	597	<1,<1	<1,<1
22	20/04E-07G01	A	350	<1,<1	K6,<1
23	20/04E-08M01	A	168	<1,<1	K2,<1
24	20/04E-10N01	G	238	<1,-	<1,-
25	20/04E-16G01	G	419	<1,<1	<1,<1
26	20/04E-18L01	A	237	<1,-	<1,-
27	20/04E-20C01	G	801	<1,-	<1,-
28	20/04E-20C02	A	300	<1,<1	<1,<1
29	20/04E-30H01	G	332	<1,-	<1,-
30	20/04E-32J01S	G	spring	<1,<1	<1,<1
31	21/03E-25P01	G	417	<1,<1	<1,<1
32	21/03E-26N01	G	785	<1,<1	<1,<1
33	21/03E-36Q01	G	901	<1,<1	<1,<1
34	21/04E-32M01	G	1,050	<1,<1	<1,<1

SURFACE WATER

Two important aspects of the surface-water-quality evaluation are the documentation of water quality in streams during different hydrologic conditions and the examination of spatial variations in stream quality. Water samples were collected during different flow conditions, including base flow and stormflow. Bed sediments were collected at base flow to serve as temporal integrators of stream quality. Many organic and inorganic constituents associate with suspended sediments, which in turn may be deposited on the streambed during periods of base flow. Deposited bed sediments can also sorb dissolved constituents from the water moving over them. Because of these interactions, bed sediments can potentially be used to indicate spatial variations in stream quality.

Surface-water-quality data are given in tables 13 through 24 at the end of the report. Subsets of these data are also presented in this section.

Sampling and Processing Techniques

Most samples were collected and processed according to standard U.S. Geological Survey techniques. Guy and Norman (1970) describe methods for the collection of fluvial sediments, and Greeson and others (1977) provide methodology for collection of microbiological samples. Some additional details regarding sample collection and processing follow.

At most sites on the Puyallup and White Rivers, bed-sediment samples were collected using a US BM-54 bed-material sampler. At all sites on small streams and at sites on the Puyallup and White Rivers where cobbles on the riverbed precluded use of the US BM-54, bed-sediment samples were collected with a stainless steel scoop. Where possible, bed-sediment samples were taken at 5 to 10 places in the stream cross section and combined to form a lateral composite sample representative of a sampling site. At some sites, samples were not a lateral composite, but were collected to represent discrete locations in the stream cross section. All bed-sediment samples were collected to represent the upper layer (approximately 2 inches) of the bed that is in contact with the water.

At the sampling site, bed-sediment samples were composited and sieved using native water to remove particles larger than 2 mm (millimeters). Later, the samples were separated into sand-, silt-, and clay-size fractions for trace-element determinations. Sand-size particles (greater than 62 micrometers) were separated by wet sieving with distilled water. Silt- and clay-size particles were separated by settling and centrifugation in distilled water as described by Jackson (1969). The entire subsample less than 2 mm in size was used for determination of organic compounds.

Discharge-weighted composite samples were collected to represent the cross section of the water column at a site. Samples collected to represent a discrete location in the stream cross section were depth integrated, except for those collected for the determination of volatile organic compounds. They were collected by submerging and capping a septum bottle below the water surface. Samples for the determination of dissolved trace elements were filtered using filters with a pore size of 0.1 micrometer. Water filtered through 0.45 micrometer pore-size filters was used for the determination of other dissolved constituents.

Suspended sediments that were analyzed for trace elements were isolated by allowing them to settle in the sample bottle, after which the supernatant water was withdrawn. A small amount of ultrapure calcium chloride was used, if necessary, to flocculate the clay-size fraction and increase settling velocities. Suspended sediments were separated into size fractions with the methods used to separate bed sediments.

Quality of the Puyallup and White Rivers

The Puyallup River, which drains an area of about 970 square miles, originates as glacial meltwater on the southwestern slope of Mount Rainier (fig. 12). Its principal tributaries, the White River with a drainage area of 494 square miles and the Carbon River with a drainage area of 230 square miles, also originate on Mount Rainier. Within the study area the natural channels of the Puyallup and White Rivers have been altered. Throughout much of the reach the channel walls have been lined with concrete and riprap. The lowermost part of the river is a salt-wedge estuary, and the maximum extent of the tip of the wedge is about 2.2 miles upstream from the river mouth. The composition of the river bottom throughout most of the study area is gravel and cobbles. Sand, with some silt and clay, is found deposited on sand bars and in areas near the riverbank. Below river mile 1.5 the river bottom is mostly sand. Mean annual flows of the Puyallup River at Puyallup and the White River at Sumner (sites 3S and 2S) are 3,456 and 1,755 ft^3/s.

Four sampling sites were located on the Puyallup River and one on the White River (fig. 12). The Puyallup River at Lincoln Avenue (site 4S) and the Puyallup River at the mouth (site 5S) were located in the Puyallup River estuary. Samples were collected in the estuary at low tide to avoid sampling saltwater. Discharges from the Sumner Sewage Treatment Plant (site 1M), which discharges into the White River, the Puyallup Sewage Treatment Plant (site 2M), which discharges into the Puyallup River, and the Tacoma Sewage Treatment Plant No. 1 (site 3M), which discharges into the Puyallup River estuary, were also sampled. The outfall pipe from the Tacoma Sewage Treatment Plant is located on the left bank, upstream from both sampling sites in the estuary. During most of the tidal cycle, the discharge plume from the plant is not well mixed with the river water.

Water samples were collected twice during base flow, in August 1983 and in April 1984, and twice during storm periods, in January and May 1984. In August 1984, samples were collected over a 24-hour period at selected sites to determine diel fluctuations of temperature, dissolved oxygen, and pH. Bed-sediment samples were collected in August 1983 and again in April 1984. For purposes of comparison, bed-sediment samples also were collected once outside the study area in the headwaters of the Puyallup and White Rivers (fig. 12) and were analyzed for trace elements.

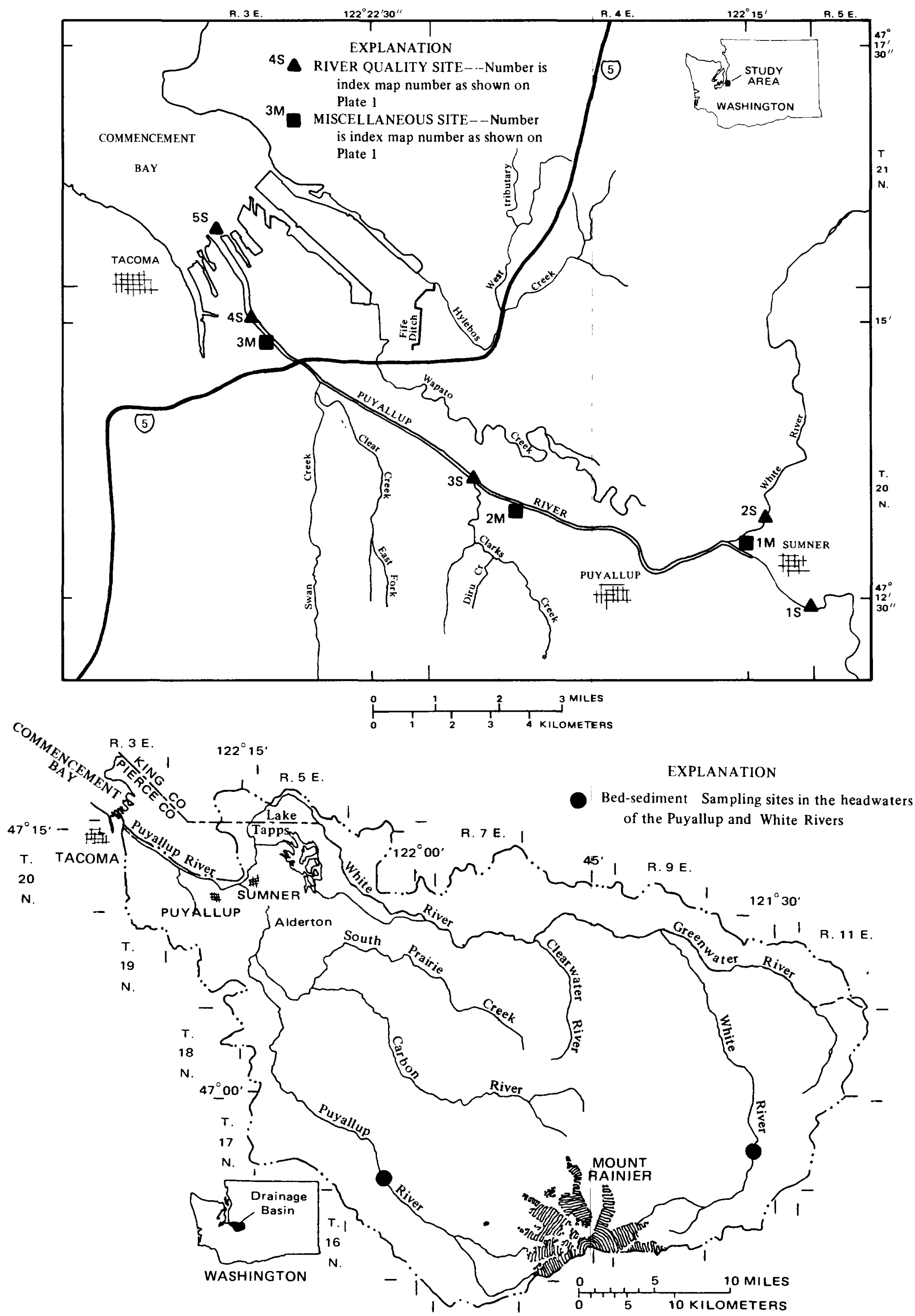


FIGURE 12.--Puyallup River drainage basin showing the study area and surface-water-quality sampling sites.

Distributions of salinity, temperature, nitrogen, and phosphorus in the Puyallup River estuary during different phases of the tidal cycle are presented in the section entitled The Puyallup River Estuary. These data were collected in a separate study of the estuary conducted during 1982.

Major Ions, Dissolved Solids, and Hardness

The dissolved ions in waters from the White River and from the Puyallup River above the estuary were predominantly calcium, magnesium, and bicarbonate. The average ionic composition of water collected at the Puyallup River at Puyallup (site 3S) is shown in figure 4. In the estuary, water often becomes enriched in sodium and chloride after mixing with water from Commencement Bay (table 13).

Dissolved-solids concentrations at sites above the estuary ranged from 48 to 53 mg/L during base flows, and from 31 to 59 mg/L during stormflows (table 13). The lowest dissolved-solids concentrations were observed during the January storm, a time of maximum streamflow during the study. Some mixing of saltwater with river water resulted in dissolved-solids concentrations as high as 920 mg/L in samples collected in the estuary.

All the waters sampled upstream of the estuary were soft, with total hardness ranging from 12 to 28 mg/L. Total hardness values ranging from 52 to 170 mg/L were observed at the mouth of the Puyallup River due to mixing with water from Commencement Bay.

Dissolved Oxygen, Temperature, and pH

Dissolved oxygen, temperature, and pH measurements at surface-water quality sites are given in table 14. The following are ranges of measurements at all sampling sites on the Puyallup and White Rivers: 8.6 to 12.3 mg/L dissolved oxygen; 5.5 to 17.0 $^{\circ}$C; and 6.6 to 7.4 pH units. All values were within limits for Washington State class A waters (table 1). Historical measurements made by the U.S. Geological Survey and the State of Washington Department of Ecology are available for the White River at Sumner and the Puyallup River at Puyallup (U.S. Geological Survey, 1960-68, 1971-73, 1975-82). Almost all of the historical data were within limits for class A waters.

In August 1984, 24-hour fluctuations of dissolved oxygen, temperature, and pH were measured during summer base flow when high temperatures and low dissolved-oxygen concentrations are most likely to be observed (fig. 13). Specific-conductance and biochemical-oxygen-demand data were also collected, to provide additional information on variations in stream quality (table 15). At all sites dissolved-oxygen concentrations, temperatures, and pH values were within limits for class A waters. Small variations in dissolved-oxygen concentrations indicate little photosynthetic-respiratory activity in relation to the volume of water in the river. Dissolved-oxygen concentrations remained above 90 percent of the saturated value at all sites except for the Puyallup

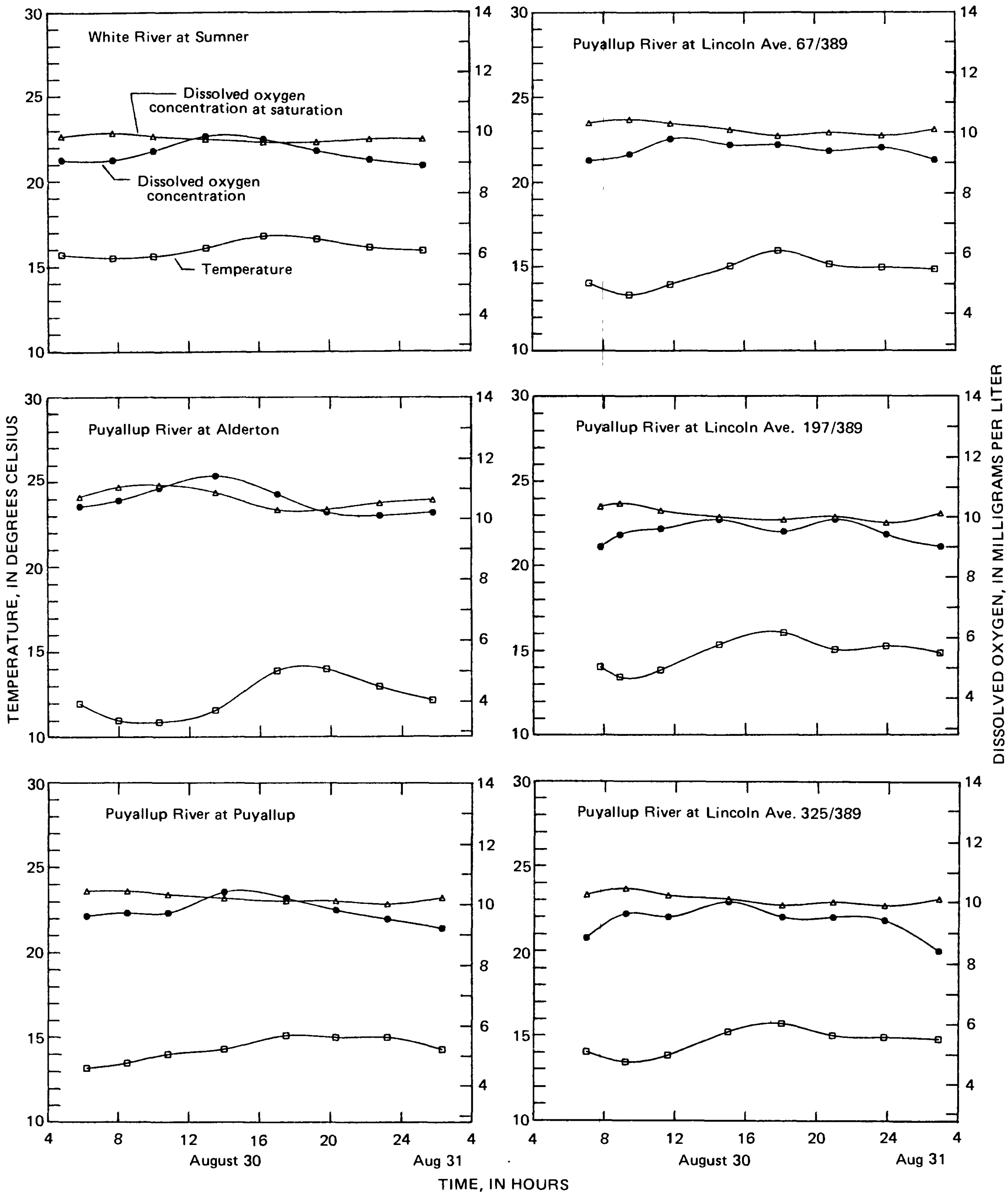


FIGURE 13.--24-hour dissolved oxygen (D.O.) and water-temperature curves, White River at Sumner, Puyallup River at Alderton, Puyallup River at Puyallup, and Puyallup River at Lincoln Avenue, August 30-31, 1984. August 30 was partly cloudy, turning into light rain by 0300 hours, August 31. Samples were collected near centroid of flow except for the Puyallup River at Lincoln Avenue, where cross-section location is given by distance from the left bank/width of river, in feet.

River at Lincoln Avenue, where dissolved-oxygen concentrations ranged from 83 to 99 percent saturation. Most biochemical-oxygen-demand concentrations were less than 4 mg/L, a level found in reasonably unpolluted waters (McNeely and others, 1979). No significant lateral variations of dissolved-oxygen concentrations were observed in the Puyallup River at Lincoln Avenue; however, biochemical oxygen demand concentrations were slightly higher in samples collected nearest the left bank, downstream of the outfall of the waste-water treatment plant.

Bacteria

Samples of river water and sewage-treatment-plant effluent were tested for the presence of fecal-coliform and fecal-streptococcal bacteria (table 14). The treatment plants were sampled because they are a potential source of bacteria; however, the treatment-plant discharges caused no detectable increases in bacterial densities in the river. In many instances, bacterial densities in the treatment-plant effluents were less than those in the river. Other potential sources of bacteria, such as urban runoff, were not investigated, and their effects can only be evaluated indirectly from measurements at river-quality sites.

In August 1983, fecal-coliform densities of 80 and 250 col./100 mL (colonies per 100 milliliters) at the Puyallup River at Alderton and the White River at Sumner were lower than those at most downstream sites, where the median concentration was 900 col./100 mL. During the other sampling periods, fecal-coliform densities in the Puyallup River did not increase in a downstream direction. Except for the August 1983 sampling, fecal-coliform densities at the White River at Sumner, ranging from 1,100 to greater than 4,200 col./100 mL, were higher than those at downstream sites. At all sites the median fecal-coliform densities, which ranged from 300 col./100 mL at the Puyallup River at Alderton to 1,100 col./100 mL at the White River at Sumner, exceeded the Washington State water-quality criteria for class A waters, which is a median value of 100 col./100 mL.

Similar to fecal-coliform densities, fecal-streptococcal densities at the White River at Sumner (median value of 6,450 col./100 mL) were usually higher than those at downstream sites. Fecal-streptococcal densities at all sites, which ranged from 110 to 6,500 col./100 mL during base-flow periods, increased during stormflows, when densities greater than 10,000 col./100 mL were observed. Increases in bacterial densities during storm periods are typical because runoff from urban and agricultural areas is a source of bacteria in receiving waters. Moreover, bacteria in streams tend to associate with particulate matter, and because suspended-sediment concentrations often increase during storm periods, bacterial densities may also increase.

Nutrients

Nutrient concentrations in the Puyallup and White Rivers are given in table 16. Multiple samples were collected across the river channel at the two sampling sites (the Puyallup River at Lincoln Avenue and at the mouth) in the Puyallup River estuary to determine lateral variations of nutrient concentrations. A detailed description of lateral and longitudinal variations in total nitrogen and phosphorus concentrations in the estuary is presented in the estuary section to follow.

Nitrogen

Concentrations of nitrogen compounds (nitrate, ammonia, and organic nitrogen) were low for all sites. None of the nitrogen forms exceeded 2.1 mg/L as nitrogen (table 16). The highest concentrations of nitrogen compounds were usually found during stormflow, in the form of organic nitrogen. The suspended fraction of organic nitrogen usually accounted for the largest part of the increase in nitrogen during stormflow. The concentrations of nitrogen compounds in water sampled at the Puyallup River at Puyallup during different flow conditions (fig. 14) were typical of those observed at other sites.

At base flow the organic nitrogen and ammonia concentrations were higher at the two sites in the estuary than at upstream sites. At the two sites in the estuary, concentrations of nitrogen compounds were usually highest near the left bank due to the incomplete mixing of the treatment-plant effluent. One of the most noticeable effects of the treatment plant appears to be the elevated ammonia and organic nitrogen concentrations on the left bank of the river (table 16). However, concentrations of un-ionized ammonia did not exceed the established water-quality criteria.

Phosphorus

Total phosphorus concentrations at all sites ranged from 0.02 to 1.1 mg/L (table 16). The lowest concentrations of total phosphorus were found during the April base flow when suspended-sediment concentrations were low compared with other sampling periods (table 14). In contrast, during the January storm, phosphorus associated with particulate matter was washed into the river in amounts that were large relative to the volume of flow. The suspended fraction of total phosphorus was usually higher than the dissolved fraction because phosphorus is readily sorbed onto particulate matter in river water (fig. 14). An exception occurs at the two sites in the estuary where samples collected within the sewage plume contained a higher percentage of dissolved phosphorus than did other samples (table 16). The two samples nearest the left bank contained about 50-percent dissolved phosphorus.

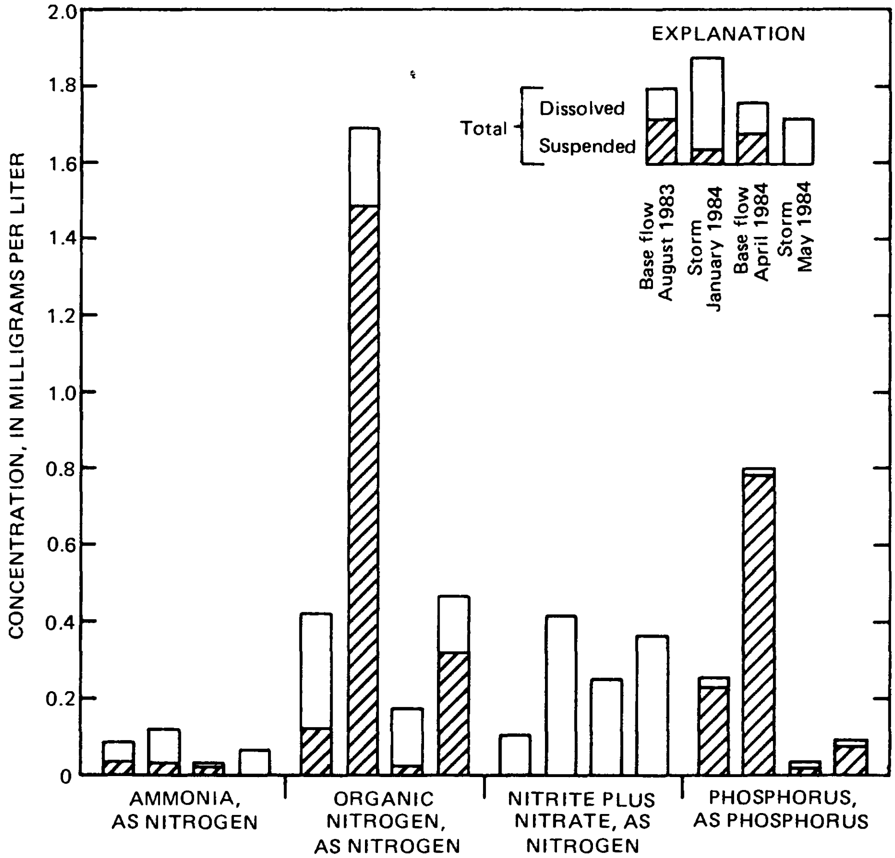


FIGURE 14.--Nitrogen and phosphorus concentrations at the Puyallup River at Puyallup. In August, three samples were collected in the stream cross section at the centroids of equal discharge increments. The concentrations shown for August are the means of the concentrations in the three samples.

Organic Carbon and Organic Compounds

In most natural waters organic carbon is composed primarily of suspended and dissolved, partly degraded, plant and animal materials. In urban or agricultural areas, anthropogenic sources often contribute a significant part of the organic carbon in a stream. Organic carbon concentrations, and the ratio of suspended to dissolved organic carbon, usually vary with hydrologic conditions. During storm periods, concentrations of suspended and dissolved organic carbon in streams usually increase due to the organic carbon carried in surface runoff. During base flow, the concentration of dissolved organic carbon is often higher than suspended organic carbon because there is less particulate matter in the stream.

The determination of organic carbon does not provide compound identification, and it can be an unreliable indicator of the presence of synthetic organic compounds when they are at low concentrations. For this reason, both organic carbon and individual organic compound concentrations were determined in this study.

Organic carbon

Suspended and dissolved organic carbon concentrations in the Puyallup and White Rivers are shown in figure 15 and listed in table 14. The lowest concentrations of total organic carbon (less than 2 mg/L) were observed during base flow in August 1983, at sites upstream of the Puyallup River estuary. During the same sampling period, concentrations of total organic carbon at the Puyallup River at Lincoln Avenue and at the mouth ranged from 1.2 to 5.5 mg/L. At these sites, the highest concentrations were from the left to center part of the channel, an area within the discharge plume from the sewage-treatment plant. The highest concentrations at all sites ranged from 9.0 to 12.8 mg/L total organic carbon and were observed during stormflow in January 1984. At that time, 37 to 53 percent of the organic carbon was in the dissolved phase. In contrast, 56 to 83 percent of the organic carbon in waters collected during the August 1983 base flow was in the dissolved phase. The April 1984 base flow contained approximately twice as much dissolved organic carbon, but not significantly more suspended organic carbon than the August 1983 base flow. All samples in April 1984 contained less than 5 mg/L total organic carbon. Total organic carbon concentrations observed at all sites during a storm in May 1984 ranged from 4.6 to 7.9 mg/L. In contrast to the January storm, most of the organic carbon in May was in the dissolved phase. There are no water-quality criteria for organic carbon concentrations; however, waters containing less than 3.0 mg/L total organic carbon are considered relatively clean (McNeely and others, 1979).

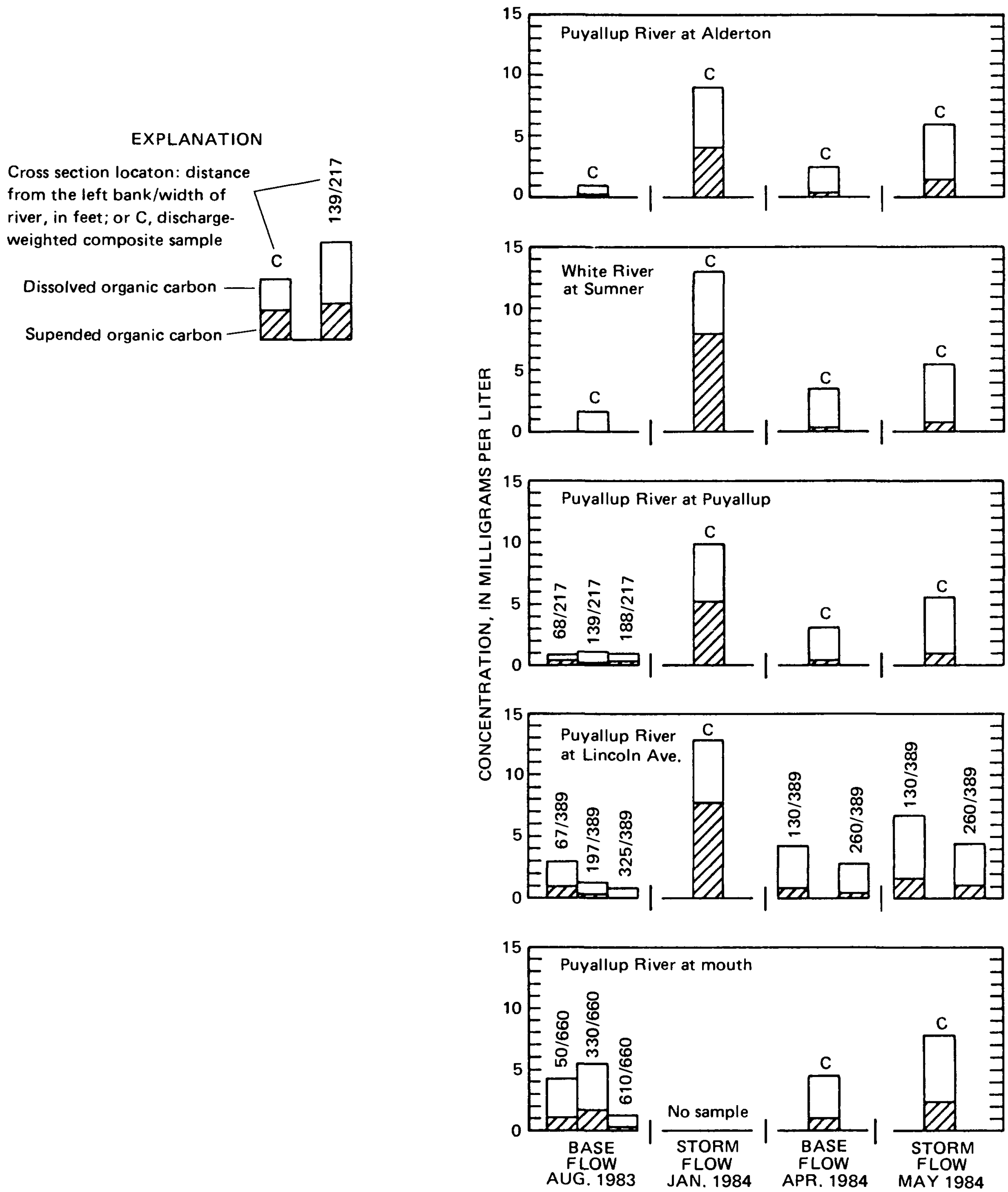


FIGURE 15.--Suspended and dissolved organic carbon concentrations in the Puyallup and White Rivers.

Organic compounds

Organic compounds identified in water and bed-sediment samples collected at the Puyallup and White River study sites are listed in table 8. Except for the volatile organic compounds, these data represent compounds identified in selected water and bed-sediment samples (see the analytical methods section for details). Therefore, the data in table 8 should not be interpreted as an exhaustive representation of organic compounds in water and bed sediments at all sampling sites. Tables 17 and 18 list compound concentrations, sampling dates, and numbers of compounds that were identified only within a general classification, such as a hydrocarbon or phthlate ester.

Organic compounds were identified in bed sediments collected at the Puyallup River at Alderton and at Lincoln Avenue (table 17). In August 1983, methylphenol, bis(2-ethylhexyl) phthalate, and six polycyclic aromatic hydrocarbons were identified in bed sediments collected at the Puyallup River at Lincoln Avenue. Bed sediments collected in August 1983 at the Puyallup River at Alderton contained no identifiable compounds, but six polycyclic aromatic hydrocarbons, methylbenzene, and dimethylbenzene were found in the sample collected in April 1984. Methylphenol was the only compound identified in bed sediment collected at the Puyallup River at Lincoln Avenue, during the April 1984 sampling.

Excluding the effluent from sewage-treatment plants, the compounds identified in water samples were in those collected during base flow in August 1983 (table 8). Volatile organic compounds were not detected in river water sampled during storm periods (January and May 1984), and samples for the determination of organic compounds were not collected during base flow in April 1984. Results of the semiquantitative chromatographic scans for acid- and base/neutral-extractable compounds in samples collected during January and May indicated that the samples contained few extractable compounds. Therefore, these samples were not further analyzed to identify individual compounds.

More organic compounds were found in water sampled from the Puyallup River estuary than in water collected at upstream sites. Types of compounds identified in the estuary waters include halogenated aliphatic hydrocarbons, phthalate esters, organic acids, ketones, and alcohols. The halogenated aliphatic hydrocarbon 1,1,1-trichloroethane was the only compound identified in waters above the estuary. Although no halogenated aromatic hydrocarbons were observed in any samples, a previous study by the Washington Department of Ecology (WDOE) found chlorinated phenolic compounds and dichlorobenzene in the estuary during base flow (Art Johnson and Shirley Prescott, WDOE, written commun., 1982).

The data indicate that the discharges from the sewage-treatment plants within the study area contained organic compounds (table 17). The treatment-plant discharges contained numerous organic compounds, including halogenated aliphatic hydrocarbons, phthalate esters, organic acids, ketones, and alcohols. Many of these compounds were found in the Puyallup River estuary. Compound concentrations in the river were generally less than those in the treatment-plant discharges, indicating dilution or volatilization.

TABLE 8.--Organic compounds identified in water and bed-sediment samples collected at Puyallup and White River study sites

[An '*' indicates priority pollutant; S, sediment sample; W, water sample]

	Compound	Puyallup R. at Alderton	White River at Sumner	Puyallup R. at Puyallup	Puyallup R. at Lincoln Ave.	Puyallup R. at Mouth	Sumner STP	Puyallup STP	Tacoma STP No. 1
	Halogenated aliphatic hydrocarbons								
	*Methylene chloride					W		W	W
	*Chloroform				W	W	W	W	W
	*Bromodichloromethane						W		W
	*Chlorodibromomethane								W
	*1,1-Dichloroethane								W
Volatile organic compounds	*1,1,1-Trichloroethane		W	W					W
	*Trichloroethene				W				W
	*Tetrachloroethene						W	W	W
	Monocyclic aromatic hydrocarbons								
	*Benzene								W
	*Methylbenzene (toluene)	S					W	W	W
	*Ethylbenzene								W
	Dimethylbenzene (xylene)	S							W
	Trimethylbenzene								W
	Tetramethylbenzene								W
	Methylethylbenzene								W
	Dimethylethylbenzene								W
	*Phenol								W
	Methylphenol (cresol)				S				W
	Polycyclic aromatic hydrocarbons								
	*Naphthalene								W
	Methylnaphthalene	S			S				W
	Dimethylnaphthalene	S			S				
	Trimethylnaphthalene				S				
	Alkyl substituted naphthalene	S							
	*Phenanthrene	S			S				
	Dimethylphenanthrene	S							
	Tetramethylphenanthrene	S			S				
	Dodecyltetradecahydrophenanthrene				S				
	Phthalate esters								
	*Diethyl phthalate				W	W			W
	*Bis(2-ethylhexyl) phthalate				S	W			
	*Di-n-butyl phthalate					W			
	Organic acids								
	Hexadecanoic acid							W	
	Benzeneacetic acid								W
	Benzenepropanoic acid								W
	Benzenebutanoic acid				W				
	Ketones								
	2-Cyclohexen-1-one				W				
	Alcohols								
	2-Butoxyethanol								W
	1-(2-Butoxyethoxy) ethanol								W
	2-(2-(2-Methoxyethoxy)ethoxy) ethanol								W
	2-(2-(2-Ethoxyethoxy)ethoxy) ethanol								W
	2-(2-(2-Butoxyethoxy)ethoxy) ethanol				W				W
	Benzenemethanol								W
	2-Cyclohexen-1-ol				W				
	(1,1'-Biphenyl)-2-ol				W				W
	Trans-1,2-cyclohexanediol				W				
	Ethers								
	Tetraoxadodecane								W

Other sources of organic compounds were not investigated; therefore, it should not be assumed that the sewage-treatment plants were the only source of organic compounds found in river water and bed sediments. The polycyclic aromatic hydrocarbons in bed sediments at the Puyallup River at Alderton were not traced to any particular source. Those identified were low-molecular-weight polycyclic aromatic hydrocarbons (containing two or three rings), and they are found in crude oil and its refined products.

There are no water-quality criteria for the organic compounds identified, and many of the compounds, such as some of the alcohols and organic acids, are relatively non-toxic. None of the priority pollutants was found at concentrations known to be acutely toxic (U.S. Environmental Protection Agency, 1980); however, the long-term effects of most priority pollutants are unknown.

Trace Elements

Bed-sediment, suspended-sediment, and water samples were analyzed for arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. Concentrations of these, and other elements sometimes reported as a result of using a particular analytical method, are given in tables 20 through 24.

Trace elements in bed sediments

Figure 16 depicts trace-element concentrations in Puyallup and White River bed sediments as a function of particle size. Data collected in the study area are plotted without reference to a specific site to show the relationship between particle size and elemental concentrations. Concentrations in the size fractions of each of the two samples collected outside the study area in the headwaters of the Puyallup and White Rivers are connected with a line. These samples are included for comparative purposes to represent relatively pristine background conditions. The samples collected at the two headwater sites were separated for trace-element determinations into three sand-size fractions (1,000 to 2,000; 250 to 1,000; and 62 to 250 micrometers), four silt-size fractions (31 to 62, 16 to 31, 8 to 16, and 2 to 8 micrometers), and one clay-size fraction (less than 2 micrometers). Size fractions, for all but the clay-size particles, are represented in figure 16 as the geometric mean of the upper and lower limits of a size fraction; for example, the 8 to 16 micrometer sample is represented as 11.3 micrometers. Samples collected in the study area were separated into one sand-size fraction (62 to 250 micrometers), one silt-size fraction (2 to 62 micrometers), and one clay-size fraction (less than 2 micrometers) for trace-element determinations. Sand- and silt-size fractions for these samples are represented in figure 16 as the geometric mean of the upper and lower limits of a size fraction, or if the particle-size distribution within a size fraction was known, as the mass-weighted mean of the geometric means of the upper and lower limits of the intermediate size intervals within a size fraction. For all samples, clay-sized particles are plotted at 1 micrometer. These conventions also are used to represent size fractions in tables 20 through 23.

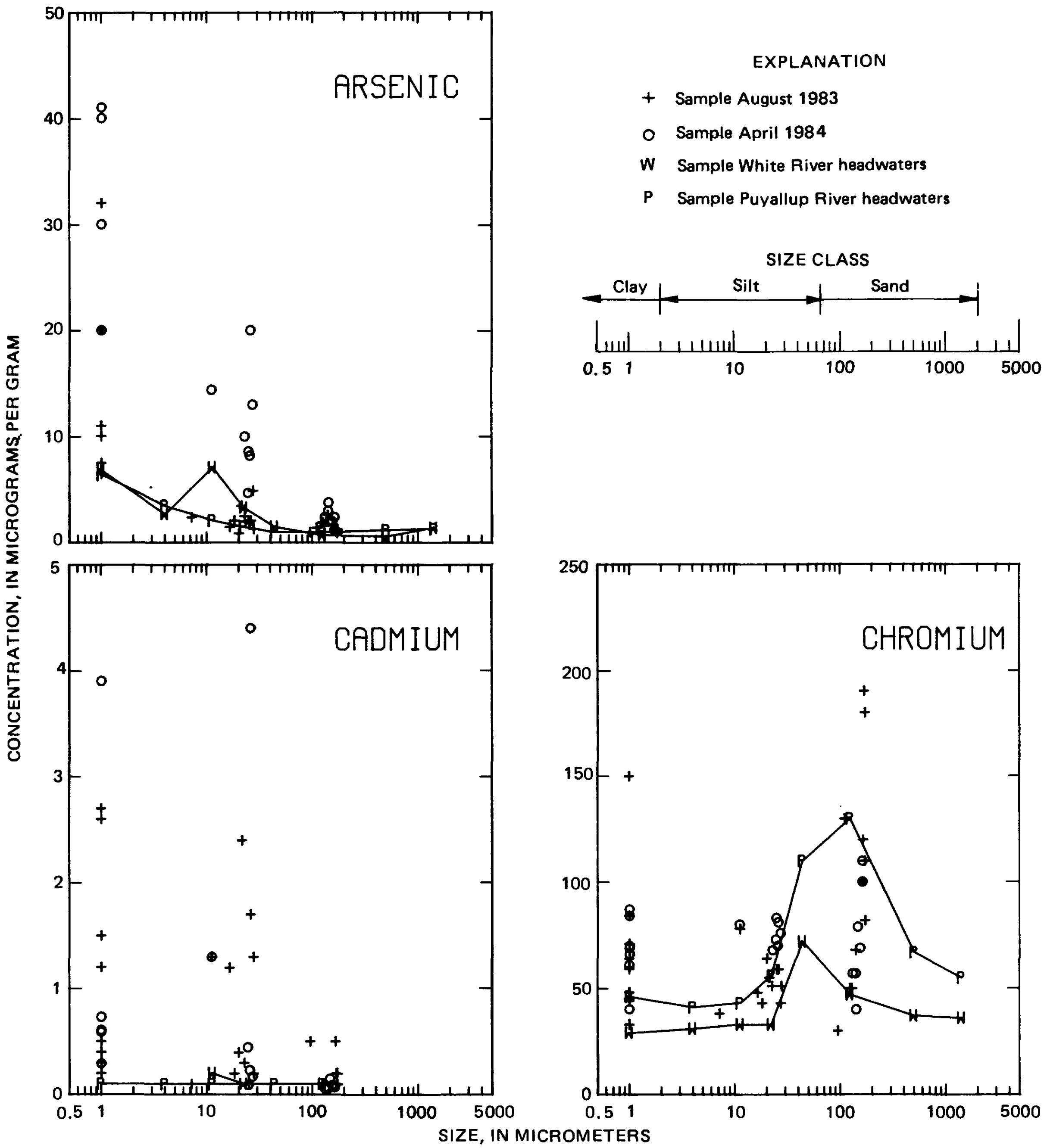


FIGURE 16.–Trace-element concentrations in Puyallup and White River bed sediments as a function of particle size. Values below detectable limits are not shown.

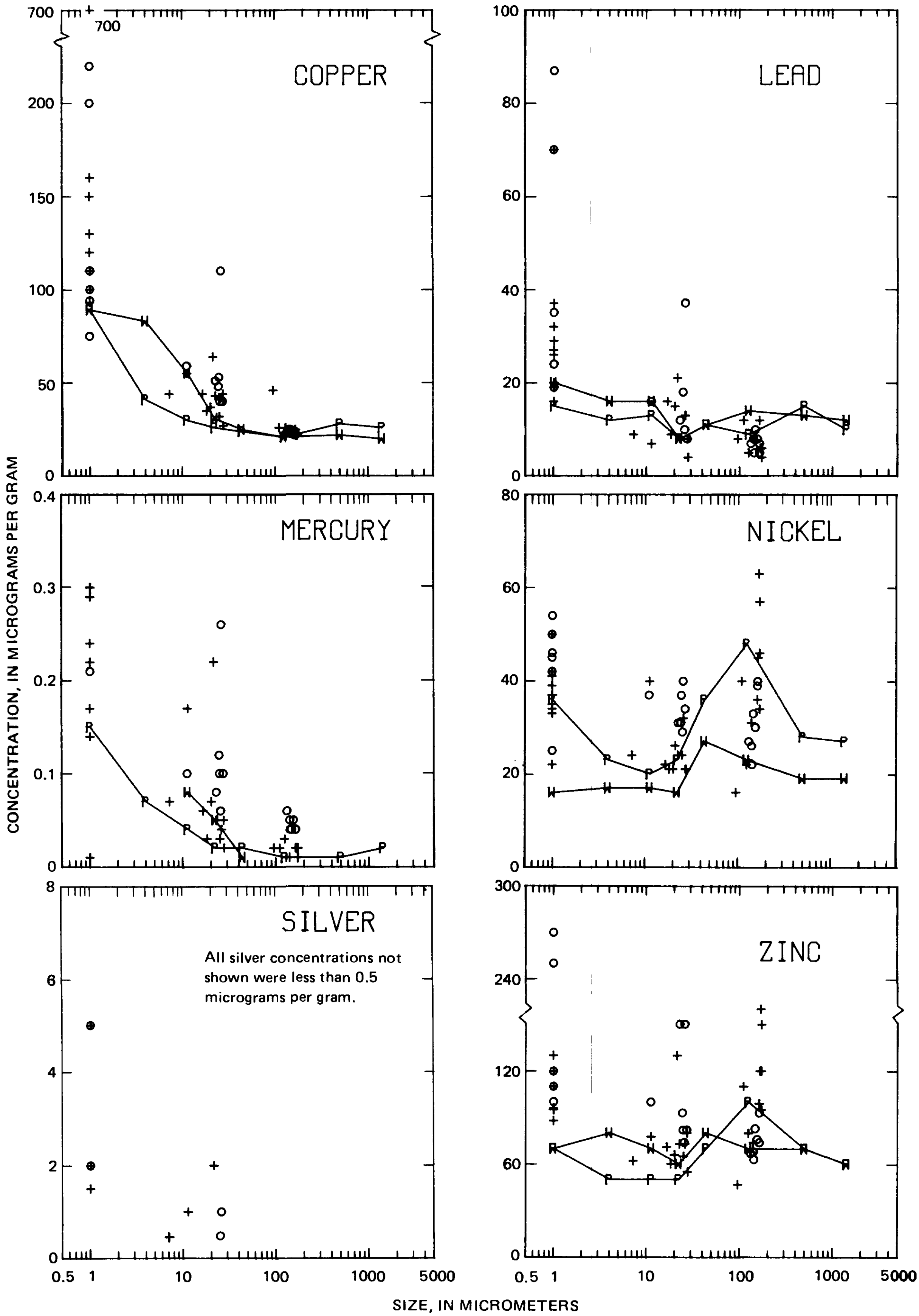


FIGURE 16.--Cont'd

The highest concentrations of most elements were in the silt- and clay-size fractions of samples collected in the study area. An increase in trace-element concentrations with a decrease in particle size is typical because fine-grained sediments provide a relatively large surface area for trace-element adsorption (Horowitz, 1984). The variation of chromium, nickel, and zinc concentrations in sand-size sediments is probably due, in part, to mineralogical differences between sediments. Mineralogical differences are indicated by the dissimilarities between concentrations of these elements in the sand-size fractions of the two samples collected in the headwaters.

Trace-element concentrations in the silt- and clay-size fractions of bed sediments are shown in figure 17, including longitudinal variations downstream and lateral variations at sites with more than one sample in the stream cross section. Concentrations for silt-size sediments of samples collected in the Puyallup and White River headwaters are given in the figure as the geometric means of concentrations in the silt-size fractions. The highest concentrations of cadmium, copper, lead, mercury, silver, and zinc were often observed in the estuary. At the Lincoln Avenue site, the highest concentrations of these elements in either one or both of the size fractions were in samples collected nearest the left bank. Concentrations of chromium and nickel in clay-size sediments collected at the Lincoln Avenue site also were higher in samples collected nearest the left bank. However, except for chromium in August 1983, concentrations near the left bank at the Lincoln Avenue site were not significantly higher than those elsewhere in the river.

The silt-size fraction of samples collected in April 1984 contained more arsenic, chromium, mercury, nickel, and zinc than samples collected in August 1983. This may be due to mineralogical differences between sediments. In August, when most of the fine sediment in the Puyallup River is derived from glacial meltwater, concentrations of these elements in samples collected in the study area more nearly corresponded to concentrations in samples collected in the headwaters of the Puyallup and White Rivers. In April samples, it is probable that a higher percentage of sediments would be from lowland sources due to erosion during winter storms. A source of trace elements affecting lowland sediments could also account for some of the differences between the August and April concentrations. One example is the copper smelter located within the northwest part of the city of Tacoma. Until closing in 1985, it was a major source of airborne arsenic, and although the wind transported most of the smelter's airborne emissions to the northeast of the study area, some local deposition has probably occurred.

Although trace-element concentrations in bed sediments provide useful comparative data, the question of what represents a significant level of enrichment or contamination is difficult to evaluate. There are no established water-quality criteria for trace-element concentrations in bed sediments, and the relation between trace-element concentrations in bed sediments and the potential for aquatic organism toxicity is complex and not fully understood. It is useful, however, to investigate whether enriched trace-element concentrations in bed sediments result from the deposition of enriched particulate matter, or from the adsorption of dissolved trace elements. These relations are examined in the next section.

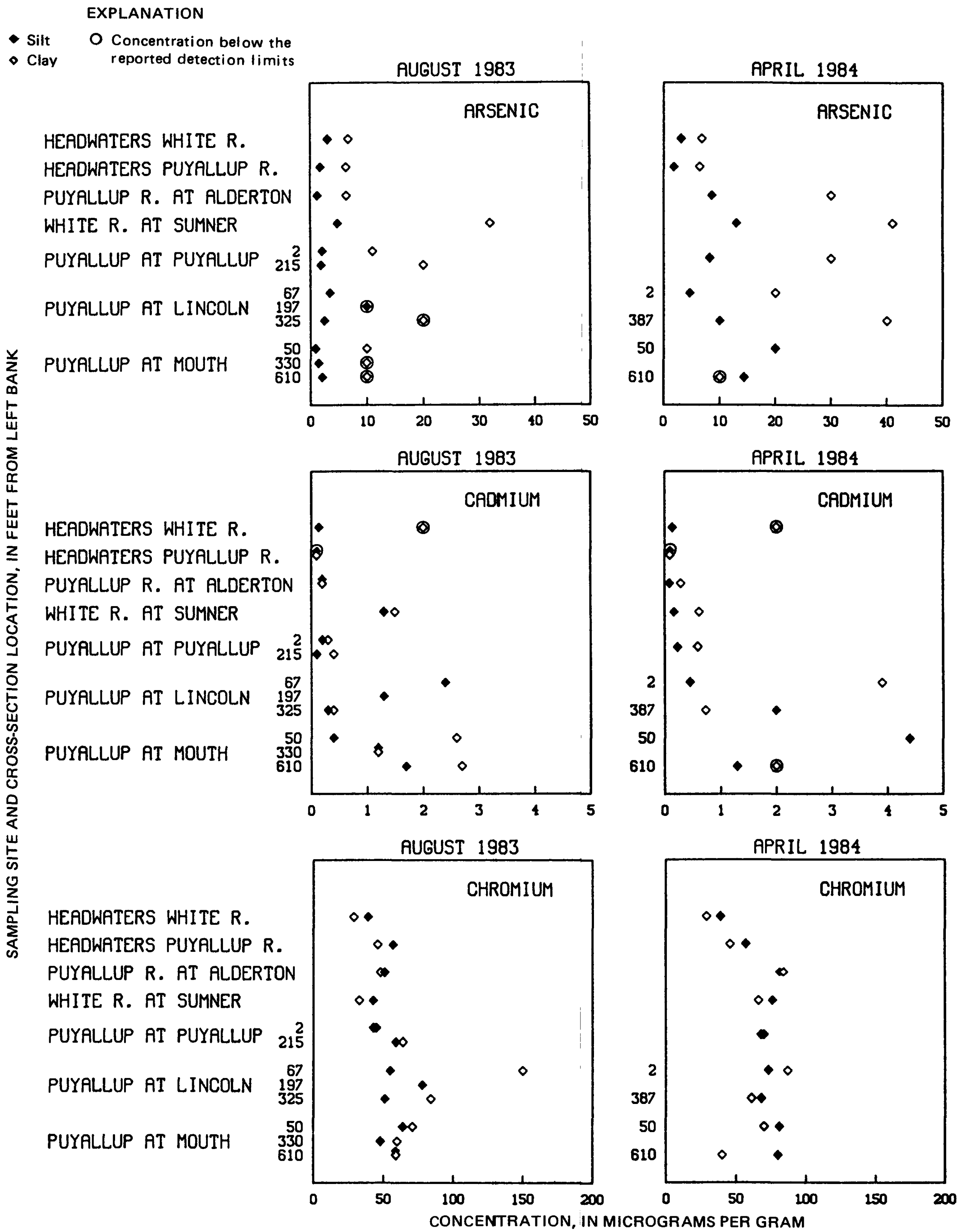


FIGURE 17.–Trace-element concentrations in the silt- and clay-size fractions of bed sediments from the Puyallup and White Rivers.

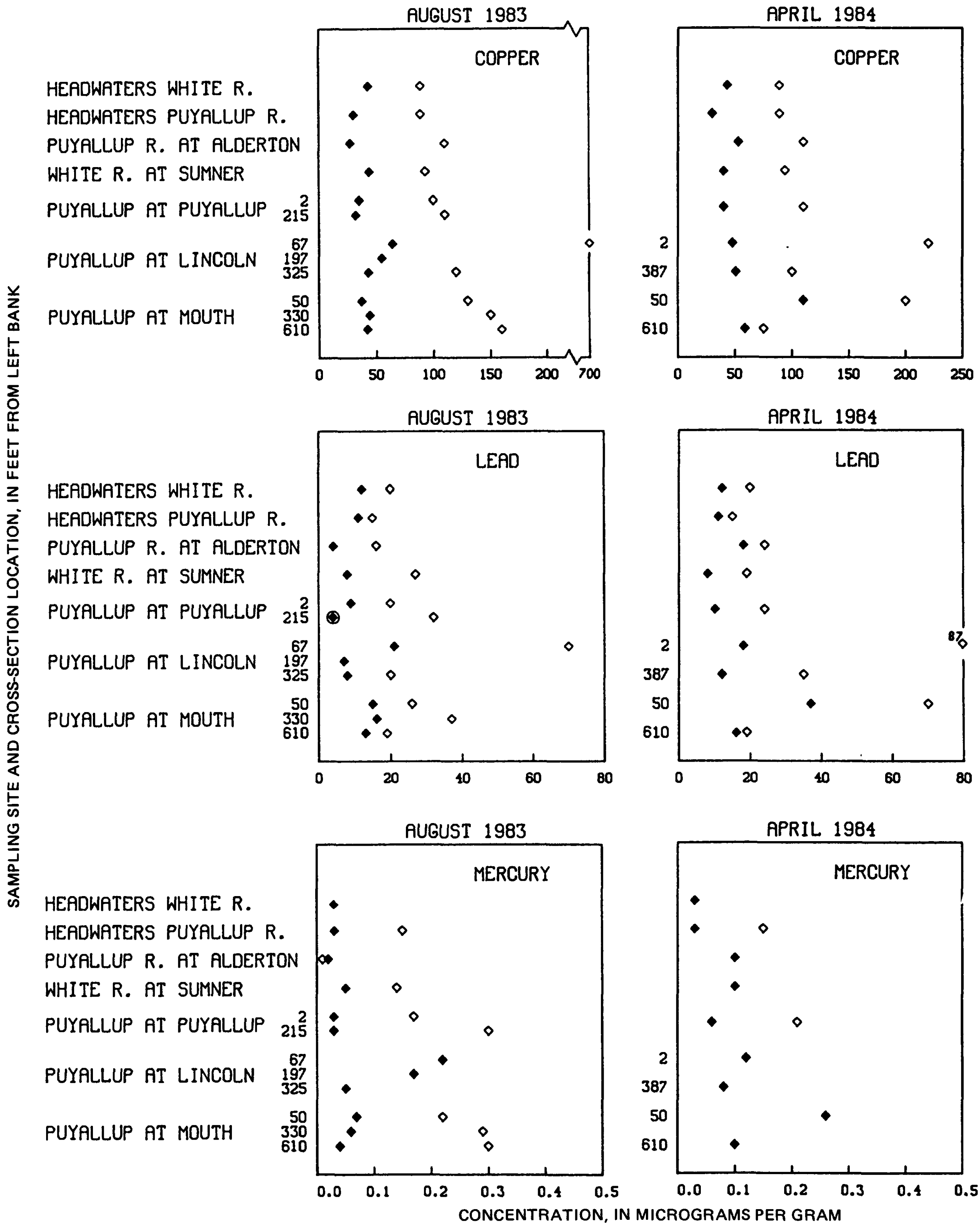


FIGURE 17.–Cont'd

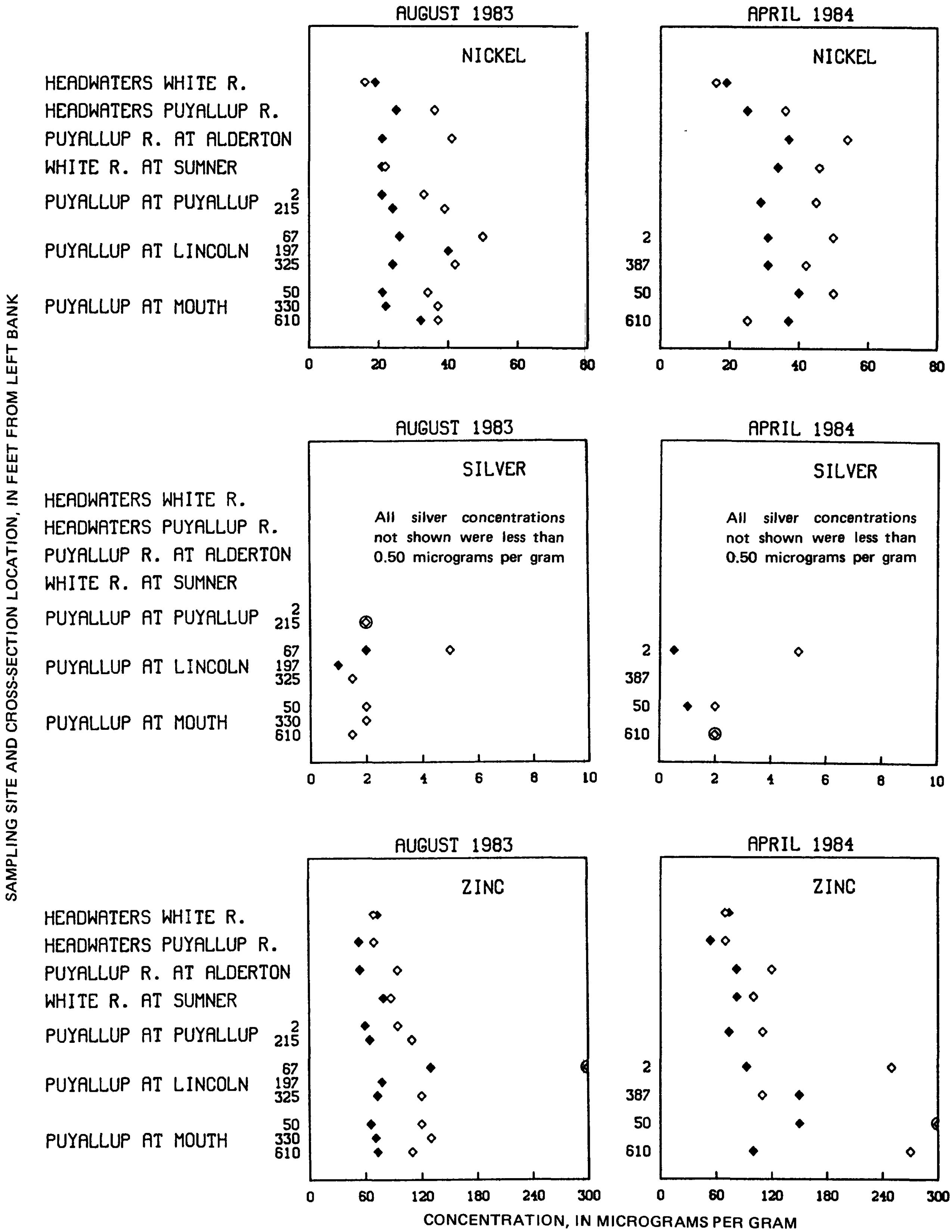


FIGURE 17.--Cont'd

Trace elements in water and suspended sediments

Water and suspended-sediment samples were analyzed for trace elements. All water samples were analyzed for dissolved trace elements, which are defined in this study as those passing through a 0.1 micrometer pore-size filter. The dissolved phase includes hydrated (free) ions, complexed ions, and ions associated with colloidal material. It is generally accepted that the free ion is the form most readily toxic to aquatic life. Some unfiltered water samples were also analyzed for total-recoverable trace elements.

Concentrations of most dissolved trace elements in the Puyallup and White Rivers were often near or below detectable limits and showed little spatial or temporal variability (table 24). All concentrations of arsenic, cadmium, chromium, and silver were at or below 1 μg/L, and mercury was not found at concentrations above 0.1 μg/L. Most concentrations of lead were below 1 μg/L, although concentrations ranging from 1 to 4 μg/L were found. Concentrations of lead were highest during the January storm. Copper and nickel were usually found at concentrations above detectable limits, but still low, usually less than 5 μg/L. Most zinc concentrations were at or below 10 μg/L. Low dissolved trace-element concentrations are often typical in rivers due to the adsorption of trace elements onto suspended sediments.

Figure 18 depicts trace-element concentrations in suspended sediments as a function of particle size and shows locations where samples had relatively high concentrations. Although samples were collected during all four sampling periods, the data are incomplete because sufficient material for analysis could not be obtained when suspended-sediment concentrations were low. For example, in April and May 1984, there was not enough clay in the suspended sediments to obtain an analysis.

During August base flow, most suspended sediment in the Puyallup River is derived from the headwaters due to glacial melting, and trace-element concentrations in the silt-size fractions of suspended-sediment samples collected in August 1983 were similar to concentrations measured in the silt-size fractions of bed sediments collected in the headwaters (table 20). Concentrations of copper, lead, mercury, silver, and zinc in the clay-size fractions of some samples collected in August 1983 were higher than in samples collected in the headwaters. Most of these samples were collected at the Puyallup River at Lincoln Avenue or at the mouth (fig. 18 and table 22).

Compared with the August 1983 samples, the silt-size fractions of samples collected during January, April, and May 1984 contained generally higher concentrations of chromium, lead, nickel, and zinc (fig. 18). Except for the sample collected during April in the left half of the channel at the Lincoln Avenue site, the higher concentrations may be due to mineralogical differences between sediments or indicate a source affecting the entire study area. The sample collected in the left half of the channel at the Lincoln Avenue site was enriched in chromium, copper, lead, nickel, and silver. High concentrations of zinc (fig. 18) were found in the silt-size fraction of samples collected during April and May in the right half of the channel at the Lincoln Avenue site. Because the right half of the channel is usually outside of the plume from the sewage treatment plant, the source of the zinc is unknown.

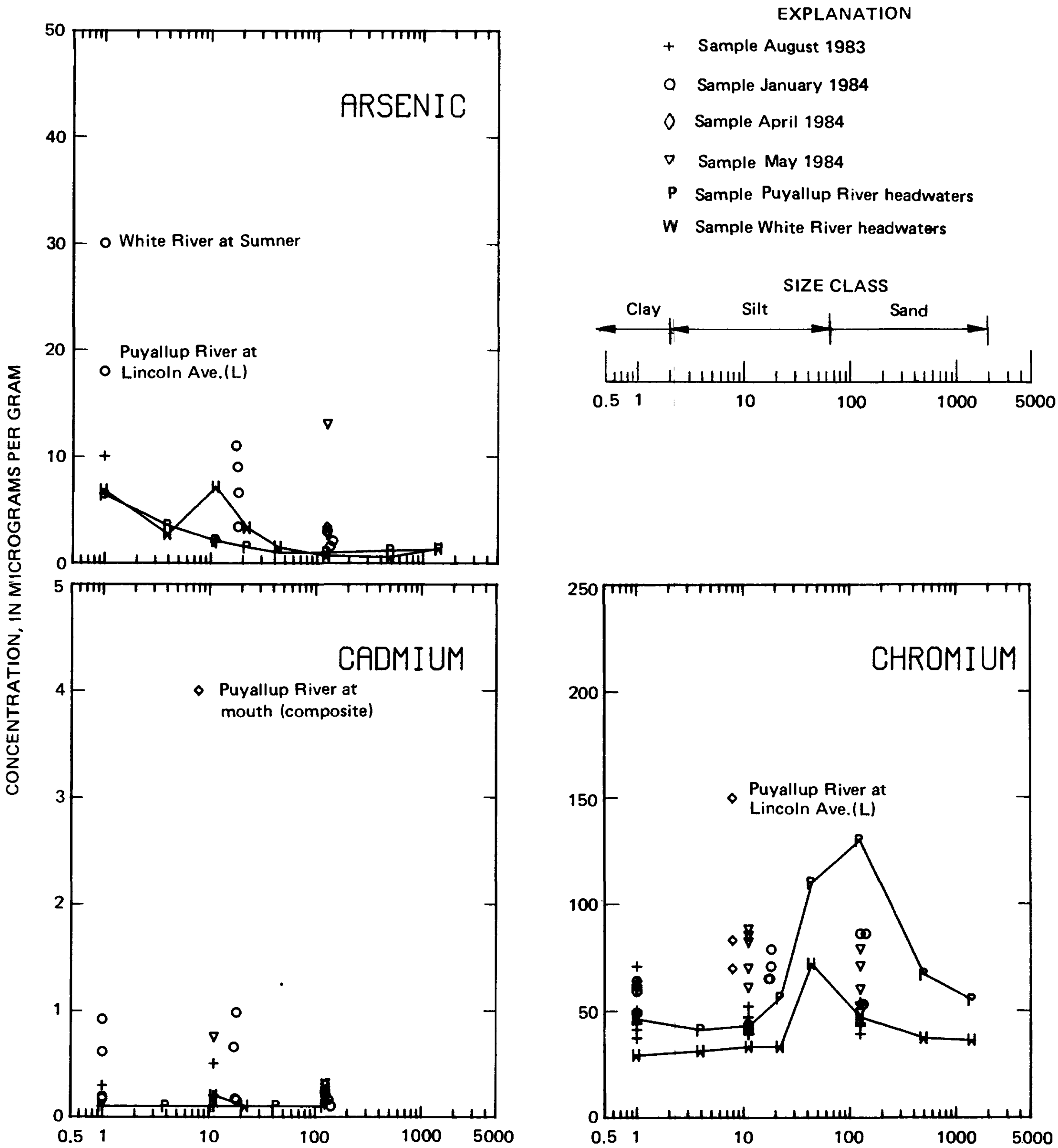


FIGURE 18.–Trace-element concentrations in Puyallup and White River suspended sediments as a function of particle size. Values below quantifiable limits are not shown. Sampling sites are shown for some values: L = left side of channel; ctr. = center of channel; R = right side of channel.

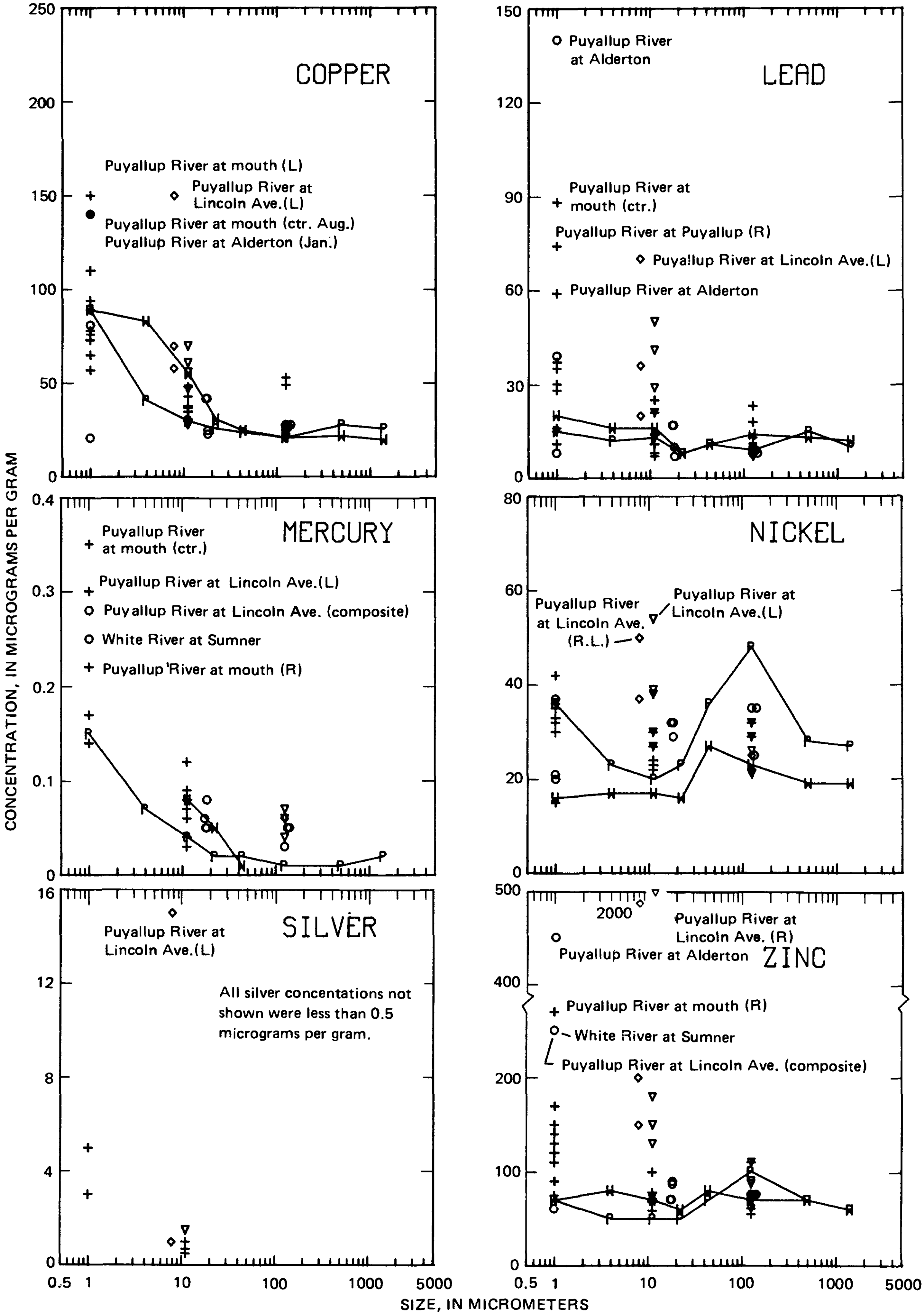


FIGURE 18.–Cont'd

There are no toxicity criteria for trace-element concentrations in suspended sediments. Fine-particle ingestion by aquatic organisms may be harmful; however, data are insufficient to evaluate this.

Selected samples were also analyzed for total-recoverable trace elements, which includes those in the dissolved phase plus those desorbed and solubilized from suspended sediments during an acid digestion. The water-quality criteria in effect during this study were given in terms of total-recoverable concentrations (table 1).

The highest total-recoverable concentrations for all trace elements except silver were measured during the January storm, when suspended-sediment concentrations were highest (table 9). Concentrations of silver were below the detection limit of 1 μg/L during all sampling periods. The relation between suspended-sediment concentrations and total-recoverable trace-element concentrations is illustrated by comparing concentrations of copper. During the January storm, concentrations of 93 μg/L copper and 2,460 mg/L suspended sediment were measured at the Puyallup River at Puyallup. The concentrations of copper and suspended sediment in the May sample at the same site were 6 μg/L and 178 mg/L, respectively. Concentrations of dissolved copper were similar in the two samples (table 24), and the concentration of copper in suspended sediments was somewhat higher in the May sample (table 22).

The water-quality criteria for the protection of aquatic life usually specify both 24-hour average total-recoverable trace-element concentrations that should not be exceeded to provide protection from chronic toxicity and concentrations that should not be exceeded at any time to provide protection from acute toxicity. Because instantaneous samples were collected, the chronic toxicity criteria cannot be applied to data collected in this study. For purposes of illustration, concentrations that would have exceeded chronic toxic concentrations had they been 24-hour averages are shown in table 9, along with those that exceeded acutely toxic concentrations.

The criteria for arsenic and chromium specify toxic concentrations for particular valence states, but because these were not determined, the criteria are not applied to chromium. Arsenic concentrations did not exceed criteria assuming any combination of valence states.

Total-recoverable cadmium, copper, lead, mercury, and zinc were measured at concentrations above acute toxicity criteria at most sites during the January storm. Some of the copper and mercury concentrations were above acute toxicity criteria during other sampling periods (table 9).

The chronic and acute toxicity criteria cannot be regarded as inflexible. In certain circumstances, the criteria may not accurately reflect the toxicity of a pollutant because of the effect of local water-quality characteristics, local hydrologic conditions, or varying sensitivities of local aquatic biota. In many cases, ecosystem adaptation may enable a balanced aquatic population to exist in waters with high natural background levels of certain pollutants. For example, the North Fork Quinault River near Amanda Park, Wash., has long been monitored as a hydrologic benchmark site. This water-quality sampling station is representative of a relatively pristine water body considered to be

TABLE 9.--Total-recoverable trace-element concentrations in water samples from the Puyallup and White Rivers, and concentrations that exceeded water-quality criteria

[C, concentration exceeds chronic toxicity criteria; A, concentration exceeds acute toxicity criteria]

Date	Time	Streamflow, instantaneous (ft^3/s)	Sediment, suspended (mg/L	Hardness (mg/L as $CaCO_3$)	Arsenic total (µg/L as As)	Cadmium total recoverable (µg/L as Cd)	Chromium, total recoverable (µg/L as Cr)	Copper, total recoverable (µg/L as Cu)	Lead, total recoverable (µg/L as Pb)	Mercury total recoverable (µg/L as Hg)	Nickel, total recoverable (µg/L as Ni)	Silver, total recoverable (µg/L) as Ag)	Zinc, total recoverable (µg/L) as Zn)
12096500 - Puyallup River at Alderton, Washington													
Jan. 1984													
25	1220	14,700	3,990	12	5	C,A 3	11	C,A 110	C 12	<0.1	C 21	<1	C,A 120
12101110 - White River at Sumner													
Jan. 1984													
25	0900	20,500	2,640	12	10	C,A 4	11	C,A 110	C,A 20	C,A .2	C 26	<1	C,A 100
12101500 - Puyallup River at Puyallup, Washington													
Jan. 1984													
25	1530	32,400	2,460	12	7	C,A 4	13	C,A 93	C,A 13	< .1	18	<1	C,A 90
May													
02	0815	4,280	178	26	<1	<1	4	C 6	C 3	.1	10	<1	20

Date	Time	Stream width (ft)	Sample location cross section (ft fm L bank)	Sediment, suspended (mg/L)	Hardness (mg/L as ($CaCO_3$)	Arsenic total (µg/L) as As)	Cadmium total recoverable (µg/L as Cd)	Chromium total, recoverable (µg/L as Cr)	Copper total recoverable (µg/L as Cu)	Lead total recoverable (µg/L as Pb)	Mercury total recoverable (µg/L as Hg)	Nickel, total recoverable (µg/L as Ni)	Silver total recoverable (µg/L as Ag)	Zinc, total recoverable (µg/L as Zn)
12102400 - Puyallup River at Lincoln Avenue at Tacoma, Washington														
1984														
Jan.														
25	1530	--	--	3,540	13	7	C,A 6	16	C,A 120	C,A 65	C,A 0.1	18	<1	C,A 140
May														
02	1055	389	130	490	33	2	<1	8	C,A 13	C 2	<.1	11	<1	30
02	0955	389	260	132	36	<1	<1	7	C,A 9	C 2	<.1	11	<1	30

TABLE 9.--Total-recoverable trace-element concentrations in water samples from the Puyallup and White Rivers, and concentrations that exceeded water-quality criteria--Continued

Date	Time	Sediment suspended (mg/L)	Hardness (mg/L as $CaCO_3$)	Arsenic total (μg/L as As)	Cadmium total recoverable (μg/L as Cd)	Chromium total recoverable (μg/L as Cr)	Copper, total recoverable (μg/L as Cu)	Lead, total recoverable (μg/L as Pb)	Mercury total recoverable (μg/L as Hg)	Nickel, total recoverable (μg/L as Ni)	Silver, total recoverable (μg/L as Ag)	Zinc, total recoverable (μg/L as Zn)
12102450 - Puyallup River at mouth at Tacoma, Washington												
1984												
Apr. 05	1230	194	70	1	<1	9	[C] 11	[C] 2	[C,A] 0.1	11	<1	20
May 02	1210	966	*--	6	<1	10	[C,A] 29	[C] 12	[C,A] .1	31	<1	60

*Based on the similarity of specific-conductance measurements made in April (650 mhos/cm) and May (695 mhos/cm) a hardness concentration of 70 mg/L as $CaCO_3$ was used to calculate toxicity criteria.

generally unaffected by anthropogenic activities. Yet, when observed over a period of 9 years (U.S. Geological Survey, 1973-1981), concentrations of cadmium, chromium, copper, lead, mercury, silver, and zinc at times exceed the established criteria for chronic toxicity and, in many instances, the acute toxicity criteria.

Quality of Small Streams

One characteristic common to all of the small streams in the study area is that their drainage areas lie entirely within the Puget lowland and contain a high percentage of land that has been, or is being, developed for residential, commercial, and agricultural purposes (fig. 1). Development within a drainage basin usually results in an increase in the amount of inorganic and organic matter washed into a stream, and small streams, with a limited capacity to dilute constituents, are susceptible to degradation.

Water samples were collected at 14 sites on nine small streams including tributaries, and bed-sediment samples were collected at nine sites (fig. 19). Water samples were collected twice during base flow, in August 1983 and April 1984, and twice during storm periods, in November 1983 and February 1984. Bed-sediment samples were collected in August 1983 and April 1984. Trace elements, major ions, and organic compounds were not determined in water samples at all sites or during all sampling periods, therefore a sampling schedule for these constituents is given in table 10. Nutrient determinations and field measurements were made during all sampling periods. Twenty-four-hour measurements of temperature, dissolved oxygen, and pH were made in August 1984.

Description of the Streams

Diru Creek

Diru Creek originates on the upland area southwest of the city of Puyallup and drains into Clarks Creek. With a drainage area less than 2 square miles, it is one of the smaller streams in the study area. The stream supplies 50 to 75 percent of the water used by the Diru fish hatchery, and the water-quality sampling site on the creek was located approximately 300 feet upstream from the diversion for the hatchery. During the study, discharges measured at the water-quality sampling site ranged from 0.2 to 0.6 ft^3/s. The composition of the riverbed at the sampling site was mostly boulders, cobbles, gravel, and sand.

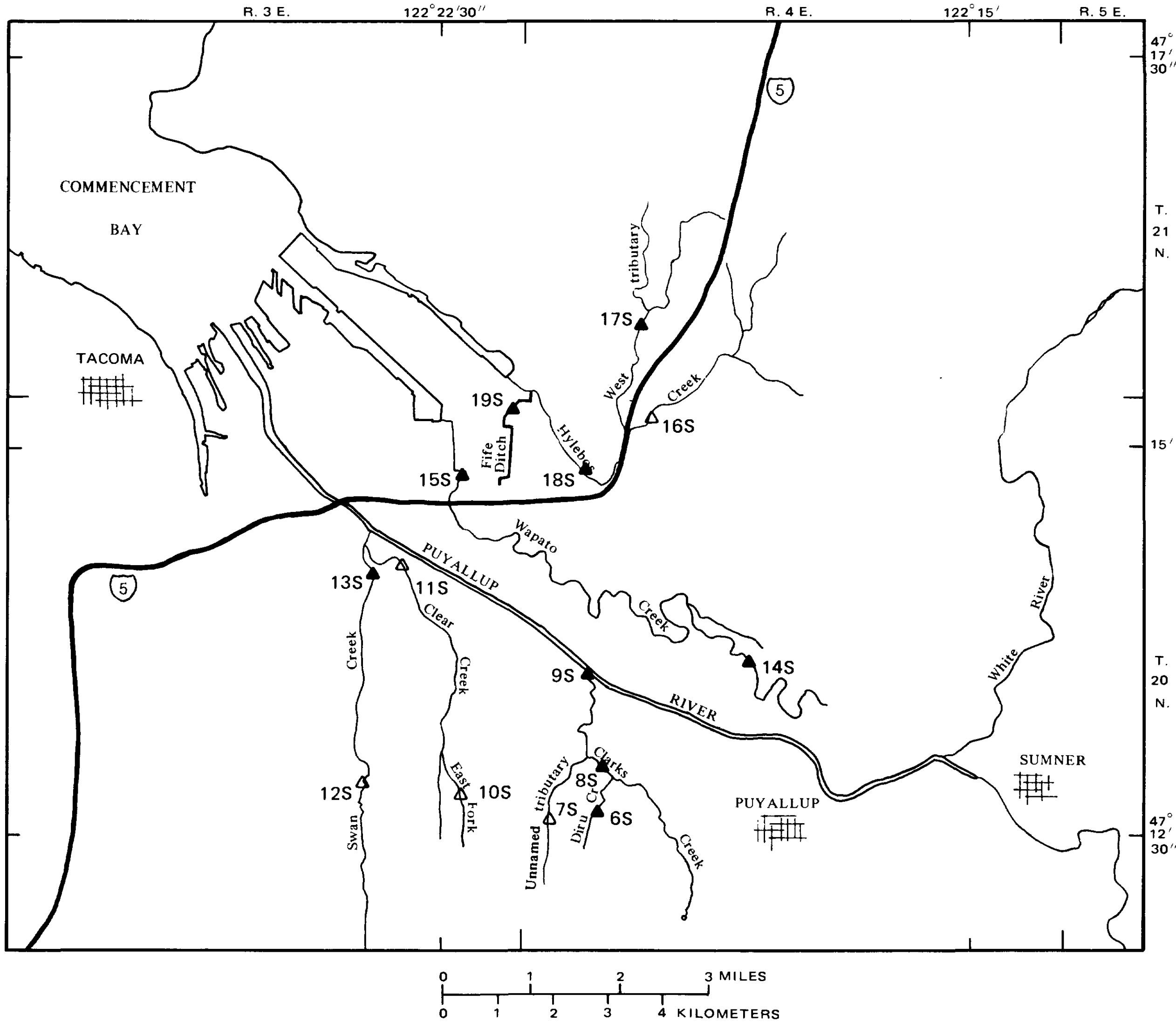
TABLE 10.--Sampling schedule for trace elements, major ions, and organic compounds in small streams

[Aug, base flow, August 1983; Nov, storm, November 1983; Apr, base flow, April 1984.]

Site name	Water-column samples[1]	Bed-sediment samples[2]
Diru Cr at inflow to hatchery nr Puyallup	Aug, Nov, Apr	Aug, Apr
Clarks Cr tributary at Pioneer Way nr Puyallup	--	--
Clarks Cr at reservation boundary at Puyallup	Aug, Nov	Aug
Clarks Cr at River Road nr Puyallup	Aug, Nov, Apr	Aug, Apr
East Fork Clear Cr at 72nd Street E.	--	--
Clear Cr at 31st Avenue Court E.	--	--
Swan Cr at Flume Line Road, Tacoma	Nov	--
Swan Cr at Pioneer Way, Tacoma	Aug, Nov	Aug
Wapato Cr at Union Pacific Railroad nr north Puyallup	Nov	Aug
Wapato Cr at 12th Street E., in Fife	Aug, Nov	Aug
Hylebos Cr abv tributary at 5th Avenue, in Milton	--	--
West tributary to Hylebos Cr nr Milton	Aug, Nov	Aug
Hylebos Cr at 8th Avenue E., in Fife	Aug, Nov, Apr	Aug, Apr
Fife Ditch at 54th Street E., in Fife	Nov, Apr	Apr

[1]Major ions, suspended and dissolved organic carbon, acid- and base/neutral-extractable organic compounds, volatile organic compounds, and dissolved trace elements.

[2]Acid- and base/neutral-extractable organic compounds and trace elements.



EXPLANATION

▲ WATER AND BED - SEDIMENT SAMPLES

△ WATER SAMPLES

Number is index map number as shown on Plate 1

FIGURE 19.–Locations of sampling sites on small streams and types of samples collected.

Clarks Creek

Clarks Creek originates at Maplewood Spring, which is located less than 1 mile south of the city of Puyallup. Two sampling sites were located on Clarks Creek, and one was located on an unnamed tributary to Clarks Creek (fig. 19). The sites on Clarks Creek are on the reach that lies on the Puyallup valley floor where flow is sluggish and silt is deposited on the creek bed. At the upper sampling site the bed is covered with benthic plant growth. The unnamed tributary joins Clarks Creek below the upper sampling site. The composition of the bed at the sampling site on the tributary was mostly cobbles, gravel, and sand. The drainage area of Clarks Creek is 16.3 square miles, and discharges measured at the mouth during the study ranged from 56 to 83 ft^3/s.

Clear Creek

Clear Creek originates southeast of the city of Tacoma and flows into the Puyallup River (fig. 19). The upper sampling site, one of two, was located on the east fork of the creek and was dry during summer months. The bed at the upper site consisted of mostly boulders, cobbles, gravel, and sand; at the lower site, a silty bed was covered with aquatic plant growth. The drainage area of Clear Creek is 12.1 square miles, and discharges measured at the lower site during the study ranged from 13 to 45 ft^3/s.

Swan Creek

Swan Creek originates on the upland south of the city of Tacoma and has a drainage area of 3.16 square miles. Two sampling sites were located on Swan Creek (fig. 19). During the summer months, there was no flow at the upstream site. Discharges measured at the lower site during the study ranged from 2.3 to 28 ft^3/s. The composition of the bed at both sites was mostly cobbles, gravel, and sand. Swan Creek joins Clear Creek before flowing into the Puyallup River.

Wapato Creek

Most of the flow in Wapato Creek, which originates north of the city of Puyallup, drains into Commencement Bay. Some of the flow from the creek is diverted to the Puyallup River downstream from the city of Puyallup. The drainage area of Wapato Creek is 3.5 square miles, and of all the small streams, Wapato Creek drains the most agricultural land. Two sampling sites were located on Wapato Creek (fig. 19). At the upstream site there was ponded water with no measurable flow in August 1983. Discharges measured at the lower site during the study ranged from 1.8 to 16 ft^3/s. The riverbed at both sites on Wapato Creek consisted of mostly silt.

Hylebos Creek

The headwaters of Hylebos Creek and its west tributary are north of the study area in southern King County, an area undergoing urban development (pl. 1). Two sampling sites were located on Hylebos Creek and one on the west tributary. The site on the west tributary is upstream of the location where the Puyallup Indians have tentative plans to construct a fish hatchery. The lowermost site was located above the Hylebos Waterway, which is utilized as a shipping lane to the industrial firms located along its banks. The waterway was not included in this study. The drainage area of Hylebos Creek, excluding the waterway, is 17.1 square miles, and the drainage area of the west tributary is 8.8 square miles. Flows measured during the study ranged from 8.4 to 66 ft^3/s at the downstream site and from 5.0 to 47 ft^3/s at the site on the west tributary. The bed at all sampling sites consisted mostly of cobbles, gravel, and sand.

Fife Ditch

Fife Ditch is a manmade channel that drains the Puyallup Valley lowland southeast of the Tacoma tideflats. Fife Ditch is not typical of the other small streams in that it is essentially a drainage ditch that receives flow from numerous smaller ditches that drain both developed and undeveloped areas. A tide gate is located at the mouth of Fife Ditch where flow from the ditch enters Hylebos Creek. Streamflow in Fife Ditch is sluggish, and the bed consists of mostly silt and clay. The drainage area is 2.03 square miles, and discharges measured at the sampling site ranged from 0.3 to 16 ft^3/s. A nearby drainage ditch also named Fife Ditch (not shown in fig. 19) was not sampled.

Major Ions, Dissolved Solids, and Hardness

The ionic composition of waters sampled during base flow from all small streams except Fife Ditch was similar to the calcium-magnesium bicarbonate water found in most of the shallow wells in the study area (table 13). Sodium plus potassium concentrations in Fife Ditch were higher than those in the other small streams, but did not exceed 50 percent of the total cation milliequivalents. Sulfate, chloride, and nitrate comprised over 50 percent of the total anion milliequivalents in samples from Fife Ditch (fig. 20). Ground water from a shallow piezometer near Fife Ditch (well 1; pl. 1) had an ionic composition similar to the water in Fife Ditch. However, this type of water was not characteristic of other shallow ground water from the Tacoma tideflats area. Possible sources of sodium and chloride in Fife Ditch are leachate from fill material used in the area and saltwater leakage through the tide gate at the mouth of Fife Ditch.

The ionic composition of base flow and stormflow samples is compared in figure 20. In all streams, the sum of sulfate, chloride, and nitrate milliequivalents--as a percentage of the total anions--increased during storms. Increases greater than 20 percent were typical, and in Hylebos Creek

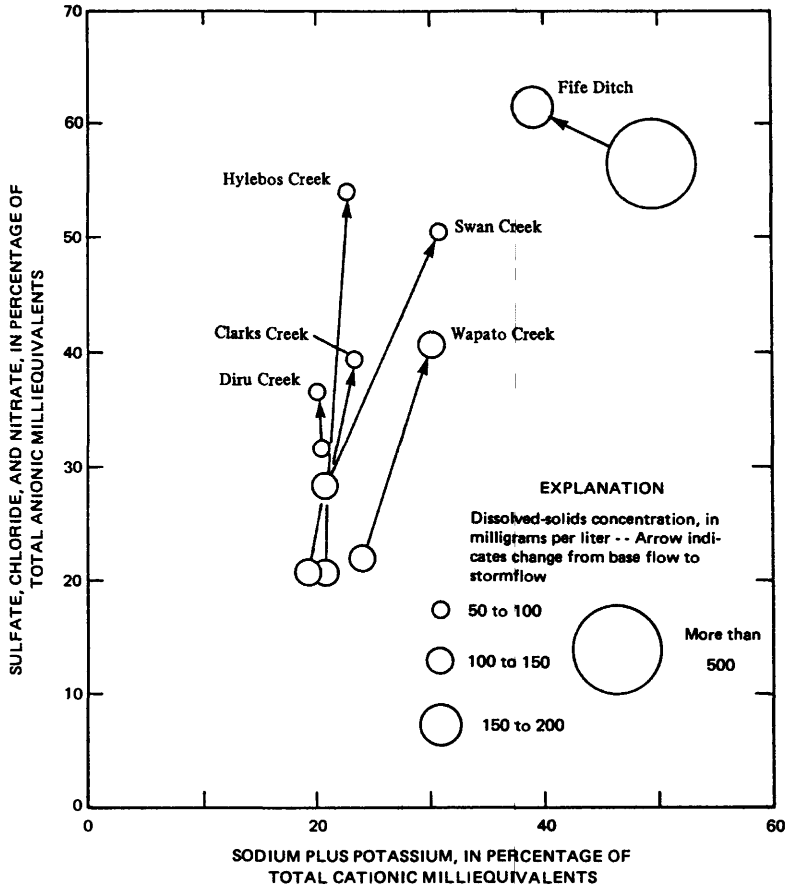


FIGURE 20.--Changes in ionic composition and dissolved-solids concentrations in small streams due to the effects of stormflow. The data represent the downstream sampling sites of the streams studied.

the increase was greater than 30 percent. The change in anionic composition from base flow to stormflow illustrates the effect that surface runoff has on the composition of water in the small streams.

Dissolved-solids concentrations in the small streams except Fife Ditch ranged from 59 to 130 mg/L and were generally higher than those measured in the White River and in the Puyallup River above the estuary (table 13). Very small changes in dissolved-solids concentrations caused by increasing runoff during storms were observed at these sites (fig. 20). At Fife Ditch, the decrease in dissolved-solids concentrations from base flow (640 mg/L) to stormflow (160 mg/L) was greater than at any of the other streams.

Most of the waters in small streams were soft to moderately hard. Water in Fife Ditch was moderately hard (70 mg/L total hardness) to very hard (260 mg/L total hardness).

Dissolved Oxygen, Temperature, and pH

Dissolved-oxygen concentrations, temperatures, and pH values measured at surface-water quality sites on the small streams are shown in table 14. Most of these values were within limits for class A waters (table 1); however, dissolved-oxygen concentrations were consistently below 8 mg/L in Fife Ditch and at the upstream site on Wapato Creek. At all other sites, measurements ranged as follows: dissolved oxygen, 7.1 to 12.0 mg/L; temperature, 7.0 to 17.5 $^{\circ}C$; and pH, 6.3 to 8.0.

Measurements of dissolved oxygen, temperature, pH, specific conductance, and biochemical oxygen demand were made over a 24-hour period during base flow in August 1984 at 11 small stream sites and are listed in table 15. The temperature and dissolved-oxygen data are shown also in figure 21. Dissolved-oxygen concentrations in Diru Creek, Clarks Creek tributary, and Swan Creek remained above 10 mg/L and at or near saturation throughout the study. Variations in temperatures and dissolved-oxygen concentrations at these sites were minimal. Little or no increase in dissolved-oxygen concentrations due to photosynthesis during the daylight hours was observed at sites in the Hylebos Creek system. At all of the Hylebos Creek sites, concentrations decreased during the daylight hours in response to increasing temperature; however, concentrations remained above 8 mg/L at all but the lowermost site, where the minimum was 7.4 mg/L. Temperatures at all sites in the Hylebos Creek system remained below 18 $^{\circ}C$ throughout the study. Photosynthesis and respiration caused the greatest variations in dissolved-oxygen concentrations at both sites on Clarks Creek, the lower site on Clear Creek, the lower site on Wapato Creek, and the site on Fife Ditch. Concentrations measured in Clarks Creek were usually above 8 mg/L, and the maximum temperature observed in Clarks Creek was 13.5 $^{\circ}C$. Dissolved-oxygen concentrations in Clear Creek ranged from 6.9 to 10.0 mg/L, and temperatures ranged from 11.0 to 14.0 $^{\circ}C$. The greatest variations in dissolved-oxygen concentrations and temperatures were observed in Wapato Creek and Fife Ditch. In Wapato Creek, concentrations ranged from 5.6 to 12.4 mg/L reaching 146-percent saturation. Concentrations in Fife

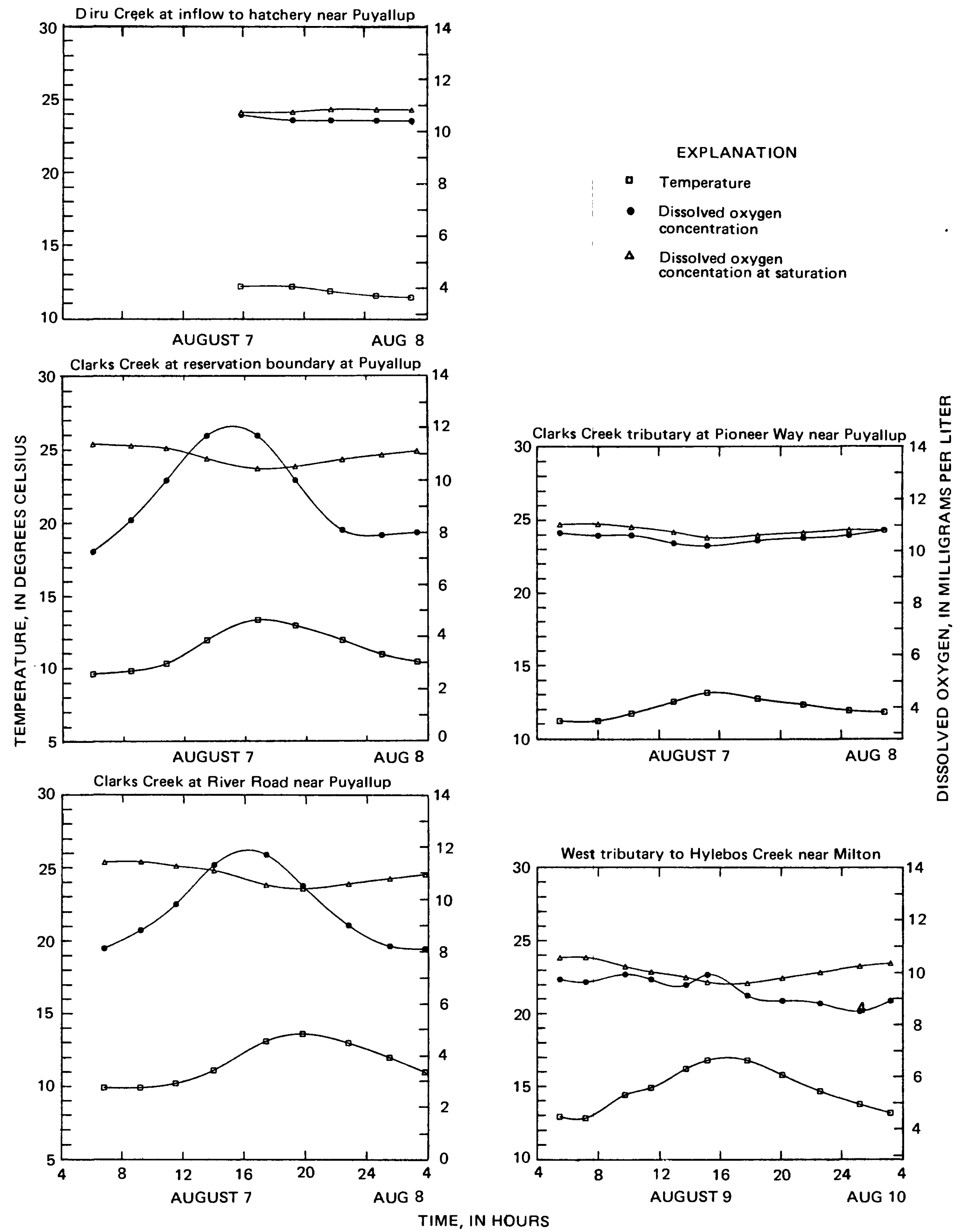


FIGURE 21.–24-hour dissolved oxygen (D.O.) and water-temperature curves for small streams, August 7-10, 1984. The weather was clear and sunny.

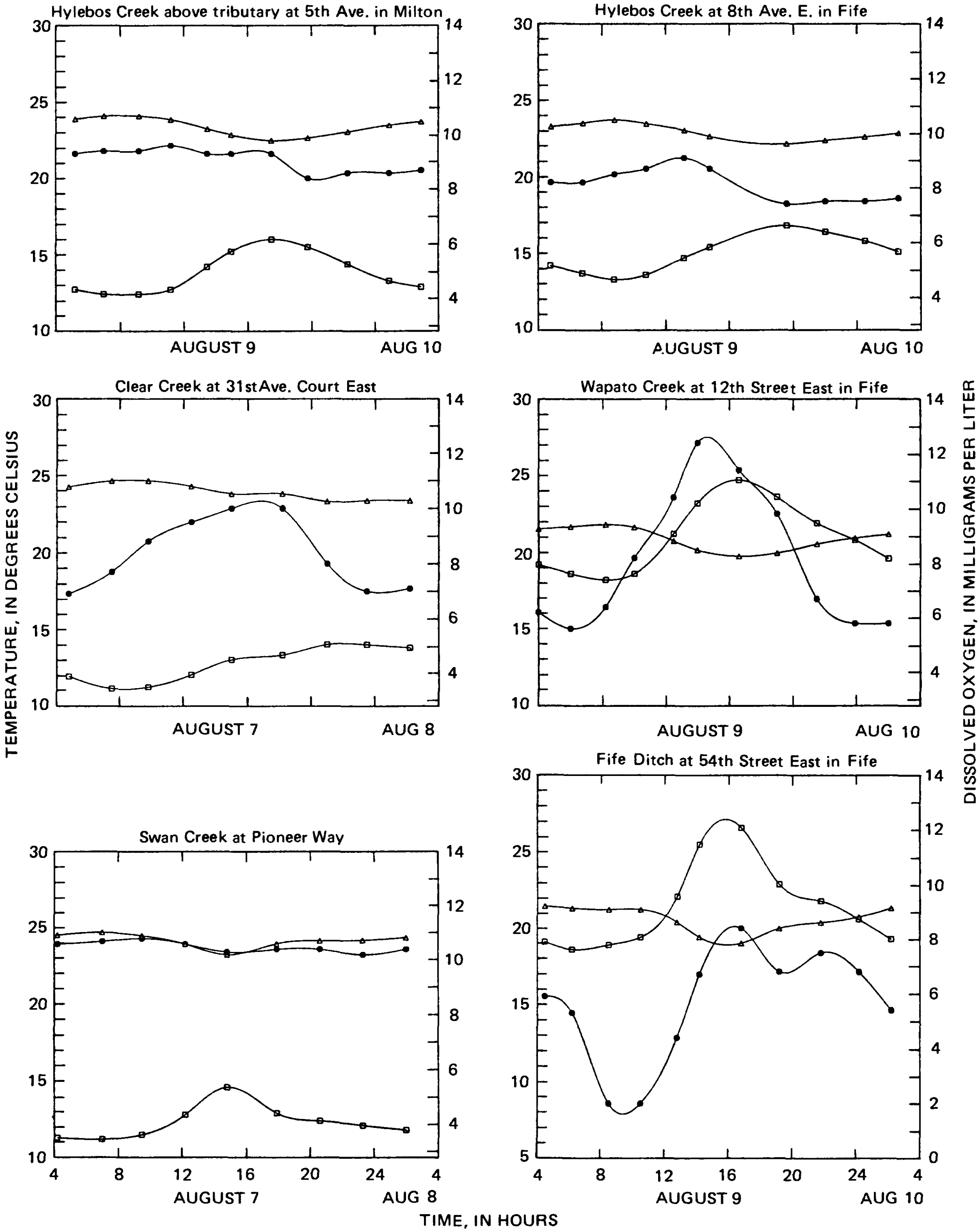


FIGURE 21.–Cont'd

Ditch ranged from 2.0 to 8.0 mg/L. Water temperatures measured in Wapato Creek and Fife Ditch remained above 18.0 °C. The ranges of dissolved-oxygen concentrations and of temperatures in Fife Ditch were comparable to those in Wapato Creek. However, there was a greater biochemical oxygen demand in the overlying waters and possibly in the bed sediments in Fife Ditch. This resulted in a decrease in the mean dissolved-oxygen concentration. Ultimate biochemical-oxygen-demand concentrations were consistently greater than 4 mg/L in waters from Fife Ditch.

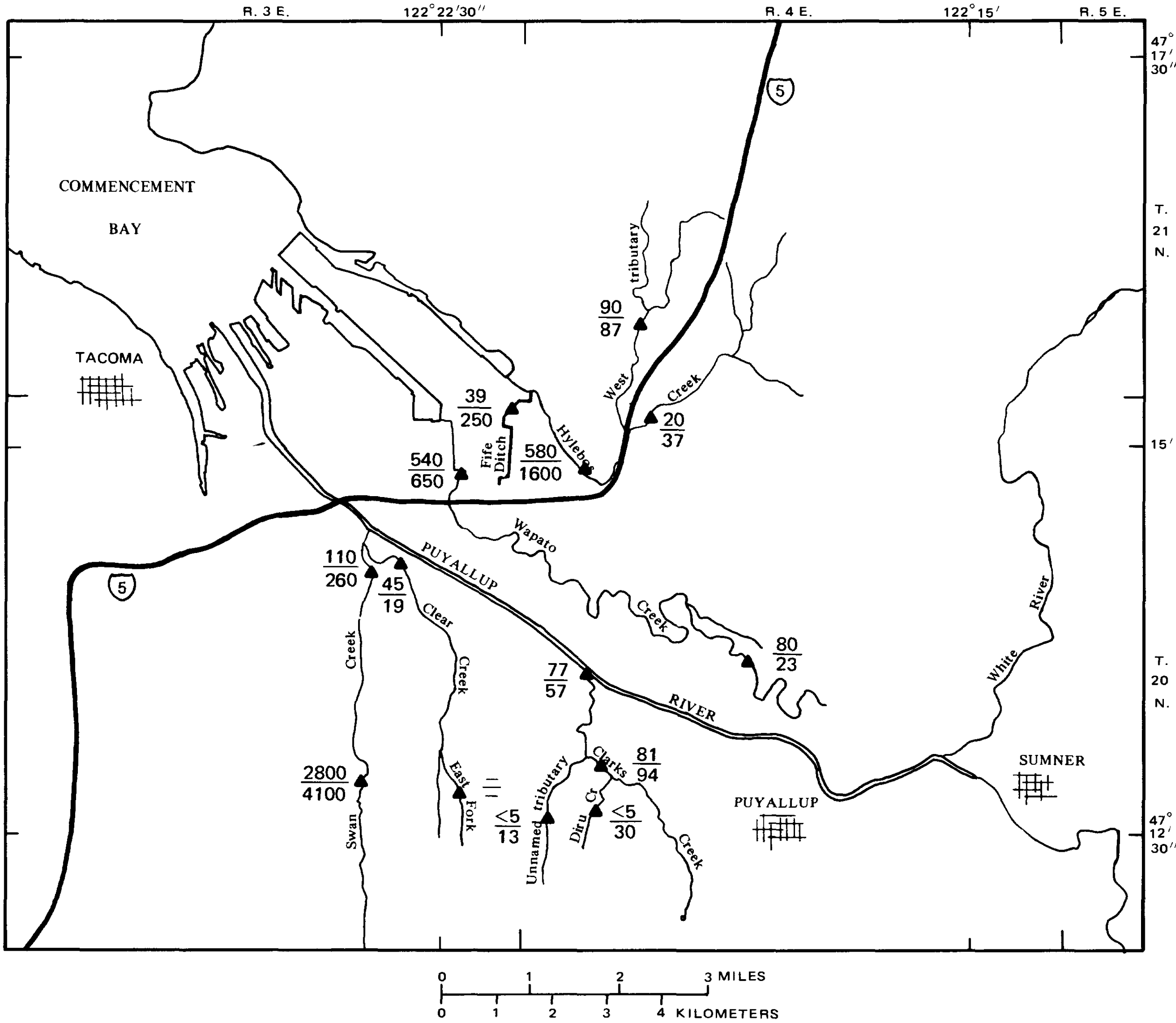
During the sampling over the 24-hour cycle, pH values at all sites were between 6.5 and 8.5, the limits for class A waters. In Wapato Creek pH fluctuated in response to photosynthesis by aquatic organisms. The uptake of dissolved carbon dioxide by these organisms during the daylight hours decreased carbon dioxide concentrations in the stream. This in turn increased the pH in the stream towards the latter part of the day. This was not observed in Fife Ditch, where the water has more buffering capacity due to a higher concentration of dissolved anions.

Bacteria

Fecal-coliform and fecal-streptococcal densities varied between sampling periods (table 14). Higher densities during storms indicate that storm runoff is a source of fecal bacteria to the streams. During storms, surface runoff and fluctuations in suspended-sediment concentrations can cause large temporal variations of bacterial densities in streams. This suggests that densities in base-flow samples are perhaps more suitable than those in stormflow samples to show spatial variation; therefore, bacterial densities measured during base flow are shown in figure 22. Because there was no flow at three of the sites in August 1983, the April 1984 data are shown in figure 22. Fecal-coliform and fecal-streptococcal densities increased downstream in Hylebos and Wapato Creeks and decreased downstream in Swan Creek. Fecal-bacterial densities were similar at the two sites on Clarks Creek, and were higher than densities measured in either Diru Creek or Clarks Creek tributary, both of which drain into Clarks Creek.

Bacterial densities in samples collected in August 1983 were generally higher than those in the April 1984 samples. For example, in April, fecal-coliform and fecal-streptococcal densities of 77 and 57 col./100 mL were observed at Clarks Creek at River Road. In August, the corresponding densities were 280 and 670 col./100 mL. At all sites fecal-coliform and fecal-streptococcal densities measured during base flows were on the order of 1,000 col./100 mL or less.

Fecal-streptococcal densities greater than 10,000 col./100 mL were observed during at least one storm at all sampling sites except the lower site on Clear Creek, Clarks Creek tributary, and the west tributary to Hylebos Creek. Maximum fecal-coliform densities observed during storms were less than 10,000 col./100 mL, except for a measurement of 19,000 col./100 mL in a sample collected at the upper site on Swan Creek. Only in Diru Creek was maximum fecal-coliform density less than 1,000 col./100 mL.



EXPLANATION

Bacterial densities expressed as number of colonies per 100 milliliters of samples

77 — FECAL-COLIFORM BACTERIA

57 — FECAL-STREPTOCOCCAL BACTERIA

▲ SAMPLING SITE

FIGURE 22.--Fecal-coliform and fecal-streptococcal densities in small streams, April 25-27, 1984.

Of all the small streams studied, Diru and Clear Creeks had the lowest fecal-bacterial densities during most flow regimes. Only median fecal-coliform densities measured in Diru Creek did not exceed Washington State water-quality criteria (median value of 100 col./100 mL for class A waters). Median densities in all other streams exceeded the criteria with values ranging from 265 to 2,800 col./100 mL.

Nutrients

Water samples for nutrient analyses were collected from the small streams during base flows and stormflows (table 16). Some sampling sites were dry during base-flow sampling periods.

Nitrogen

The concentrations of nitrogen compounds (nitrate, organic nitrogen, and ammomia) and ratios of nitrogen to phosphorus were generally higher in the small streams than in the Puyallup River. The nitrate concentrations, in particular, were higher in small streams than in the Puyallup River.

The highest concentrations of dissolved and suspended nitrogen compounds were found at many sites during the November storm sampling (fig. 23). At all sites except Fife Ditch, nitrate and organic nitrogen were the predominant nitrogen species. In Fife Ditch the dissolved ammonia concentrations (maximum of 3.3 mg/L, as N) were several orders of magnitude higher than the other small streams. Low dissolved-oxygen concentrations often present in the Fife Ditch (fig. 21) may have slowed the rate of oxidation of organic nitrogen and contributed to the higher ammonia concentrations. At Diru Creek, a tributary to Clarks Creek, nitrate-nitrogen concentrations reached levels of 3.1 mg/L, the highest of the small streams (fig. 23). The high level of nitrates in the upper Clarks Creek drainage is probably caused by the nitrate in ground water discharging to surface water. Well 21, located near the upper part of Diru Creek, had nitrate concentrations of 2.4 to 2.7 mg/L. At Swan Creek, ammonia and organic nitrogen concentrations were relatively high at the upstream site at all flows. The ammonia and organic nitrogen may originate from animal waste, as indicated by the high fecal-coliform densities (fig. 22). Concentrations of un-ionized ammonia did not exceed water-quality criteria at any of the sampling sites.

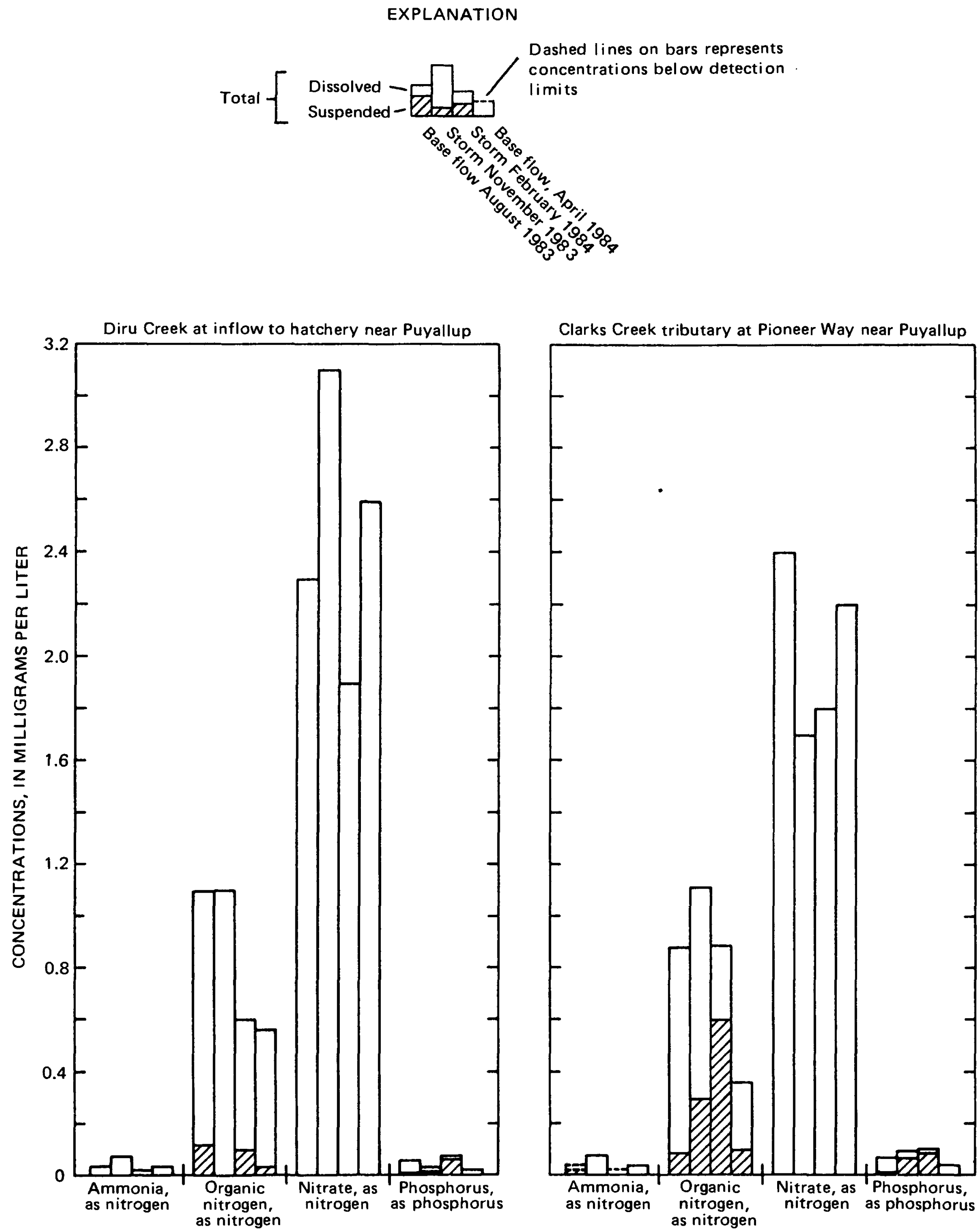


FIGURE 23.--Nitrogen and phosphorus concentrations in small streams.

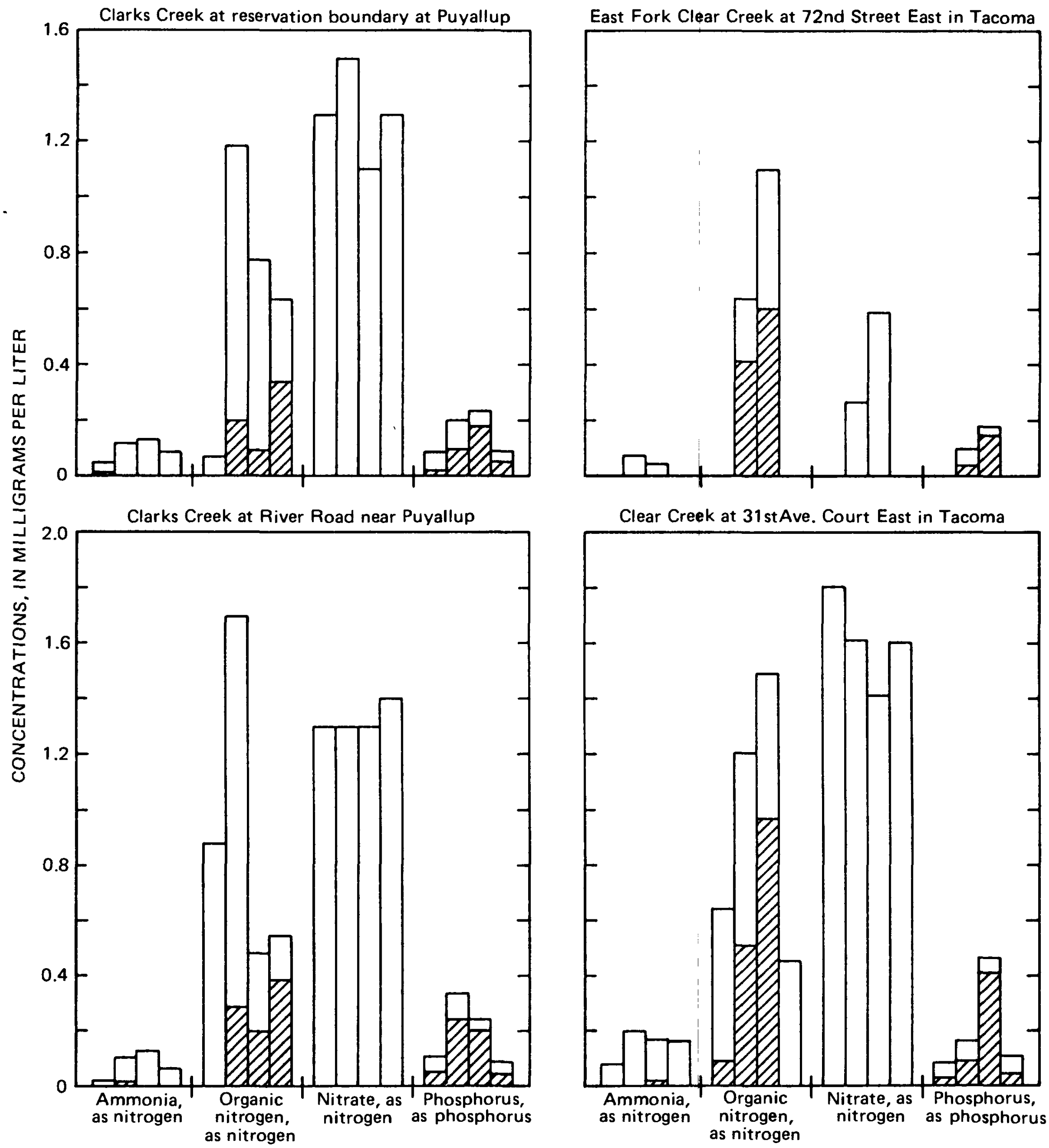


FIGURE 23.--Cont'd

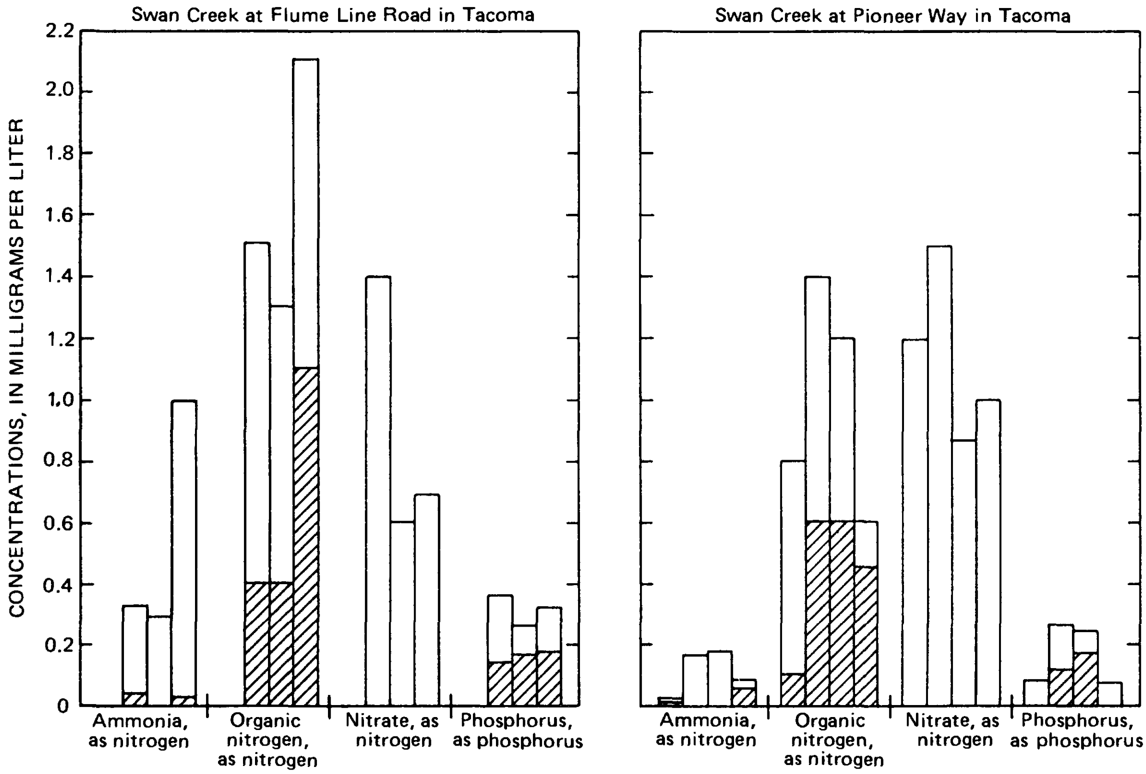
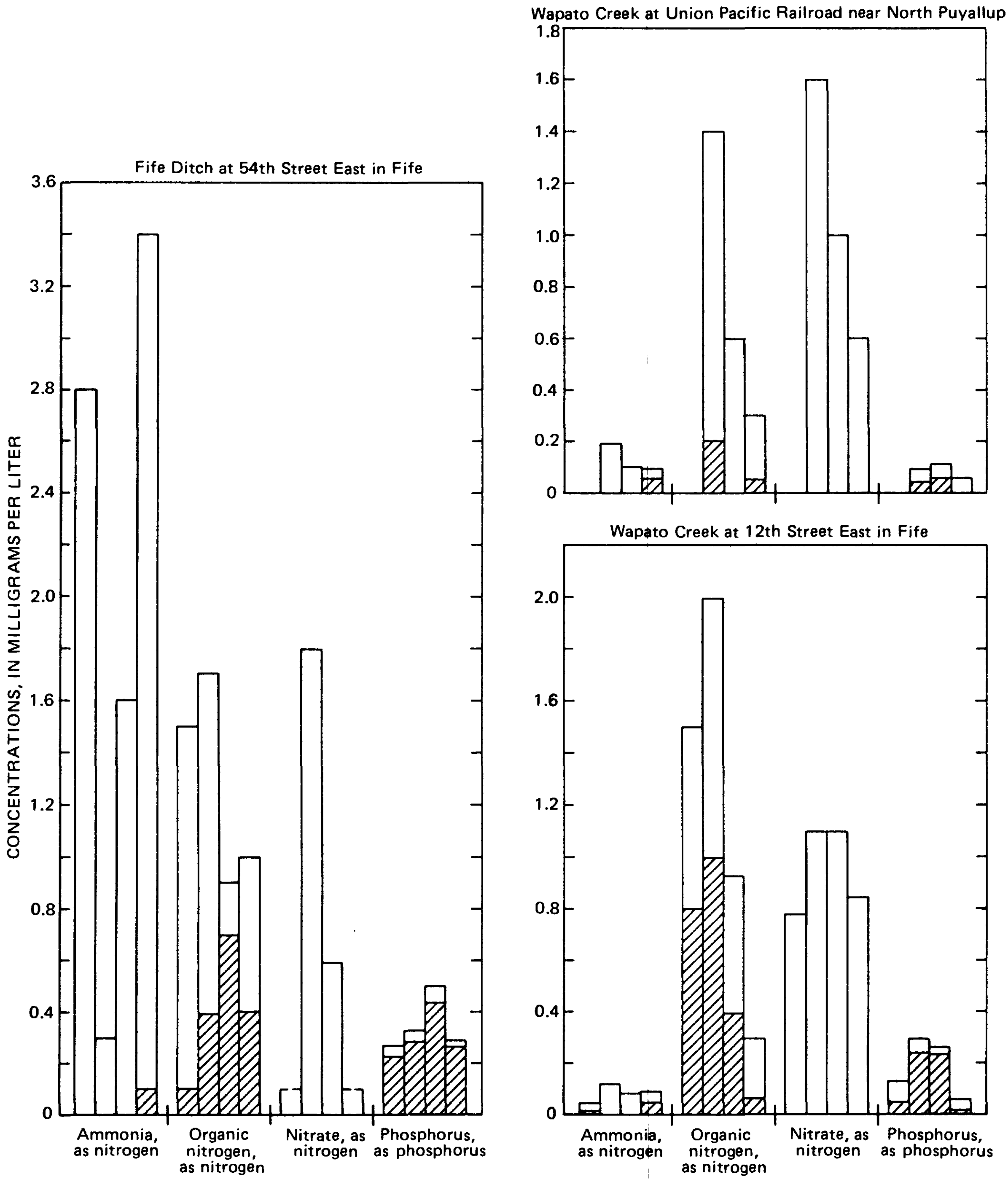


FIGURE 23.--Cont'd



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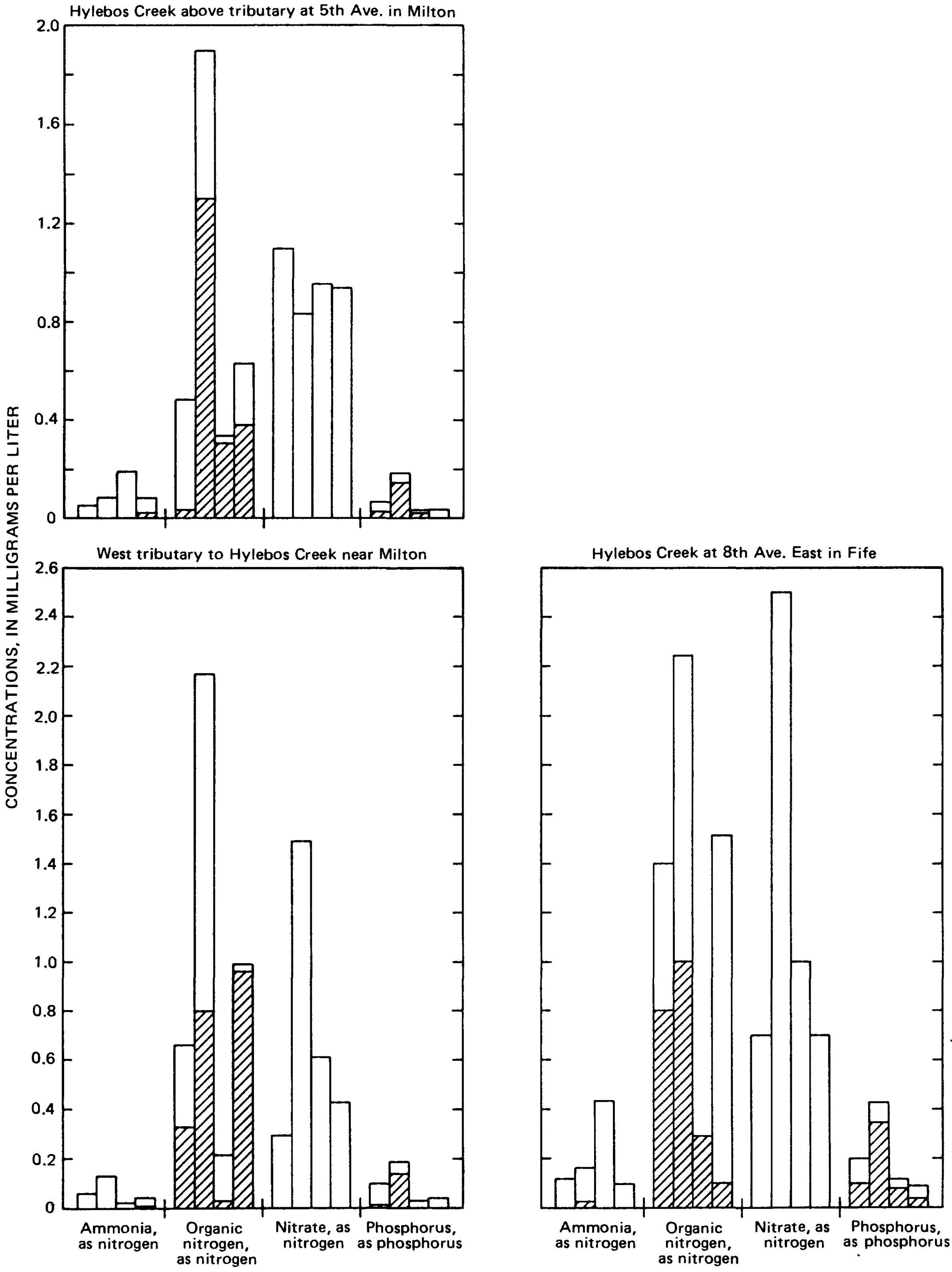

FIGURE 23.--Cont'd

Phosphorus

Total phosphorus concentrations were generally higher during stormflows, and the suspended fraction of total phosphorus usually accounted for the largest part of the increase during storm periods. Total phosphorus concentrations during storms ranged from 0.03 to 0.51 mg/L. Phosphorus concentrations generally increased from upstream to downstream sites within a sampling period at Hylebos, Wapato, Clarks, and Clear Creeks. Urban or agricultural runoff may be a source of phosphorus at the lower sites. At Swan Creek, the highest phosphorus concentrations were at the upstream site. As stated above, animal wastes may be a source of nutrients to upper Swan Creek. The total phosphorus concentrations at Fife Ditch were generally high; the concentrations ranged from 0.26 to 0.51 mg/L.

Organic Carbon and Organic Compounds

Suspended and dissolved organic carbon concentrations in small streams are shown in figure 24 and listed in table 14. During base flow in August 1983, organic carbon concentrations in Diru, Clarks, and Swan Creeks were similar to those in the Puyallup River above the estuary, where concentrations were approximately 1 mg/L. Total organic carbon concentrations in Wapato and Hylebos Creeks during August base flow ranged between 3 and 4 mg/L. A sample was not collected from Fife Ditch in August 1983; however, the total organic carbon concentration in the April 1984 base-flow sample was 11.6 mg/L. For all base-flow samples the organic carbon was predominately in the dissolved phase.

Concentrations of total organic carbon during the November storm ranged from 5.3 mg/L in Diru Creek to greater than 18 mg/L in the west tributary of Hylebos Creek. The increase in total organic carbon concentrations observed during the November storm was due to an increase in concentrations of both suspended and dissolved organic carbon, although most was in the dissolved phase.

Samples for the determination of organic compounds in water were collected concurrently with the organic carbon samples, and the compounds identified are listed in table 19. Although samples contained organic carbon, few compounds were identified. The results of the semiquantitative chromatographic scans for acid- and base/neutral-extractable compounds (not shown), indicate that much of the organic carbon in samples was not extracted. This may indicate the presence of naturally occurring organic degradation products of plant and animal materials.

Of the synthetic organic compounds that were identified in water samples, all were volatile and most were in samples collected during base flow. Benzene, 1,2-dichloroethane, and trichloroethene were found at concentrations of approximately 1 μg/L at the upstream sampling site on Clarks Creek. The compound 1,1,1-trichloroethane was identified at the downstream site on Wapato Creek during August base flow, and at the upstream site during the November storm. The highest concentrations of volatile organic compounds were found in Fife Ditch; trans-1,2-dichloroethene was measured at a concentration of 36 μg/L, and trichloroethene was measured at a concentration of 5 μg/L.

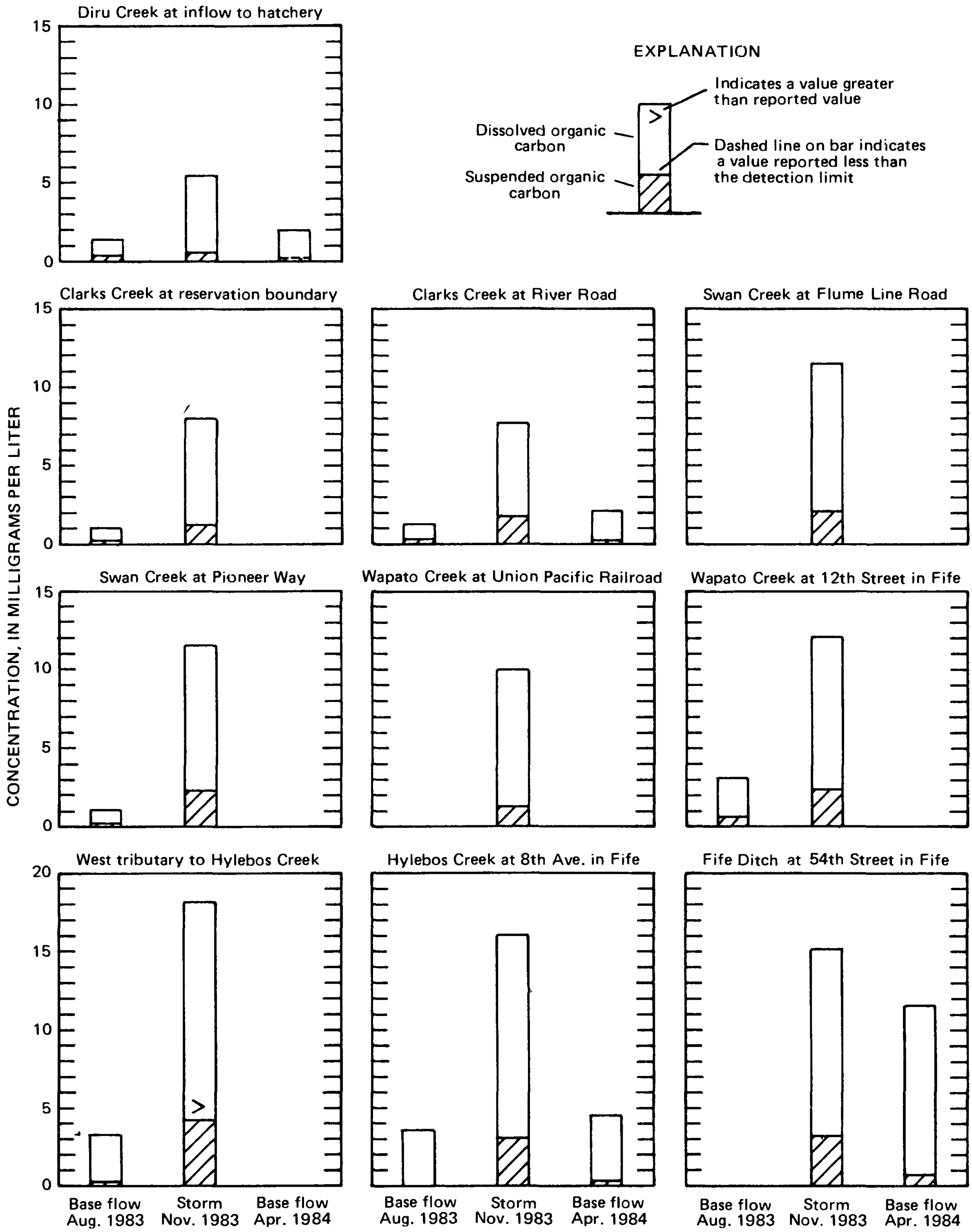

FIGURE 24.--Suspended and dissolved organic carbon concentrations in small streams.

Methylphenol, a compound found in several of the bed-sediment samples from the Puyallup River, was also found in bed sediments at the upstream site on Clarks Creek and at the downstream site on Swan Creek (table 19). The sample from Clarks Creek contained the highest concentration of methylphenol (4,400 micrograms per kilogram) of any bed-sediment sample. This sample also contained several organic acids and two indole compounds, the only other compounds identified in bed sediments from the small streams.

Sources of organic compounds in the small streams were not identified. Many of the volatile compounds have widespread use and are often found in the environment. Methylphenol, which was found in several samples, is one of the compounds in creosote.

Trace Elements

Samples were collected and analyzed for trace elements at 10 sites on small streams (table 10). Data similar to those collected at sites on the Puyallup and White Rivers were used to evaluate trace-element occurrence.

Trace elements in bed sediments

Trace-element concentrations in sand-, silt-, and clay-size bed sediments are shown in figure 25. Concentrations in samples collected in the headwaters of the Puyallup and White Rivers are included for comparison. Bed sediments in the headwaters of the Puyallup and White Rivers are derived from intermediate volcanic rocks, particularly andesite, and differ from the lowland glacial deposits, which contain more basalt. A sample of lowland glacial deposits, collected along an exposed face in a gravel pit near the city of Puyallup, was analyzed to represent relatively uncontaminated material from within the study area. Elemental concentrations in this sample may not be completely typical of all other lowland rocks and soils because glacial deposits are a heterogenous mixture of materials. In the following discussion, the headwater samples and the glacial deposits will be referred to as reference samples.

Concentrations of arsenic, cadmium, lead, and zinc in streambed sediments were typically higher than those in all reference samples. Chromium and nickel concentrations in the silt- and clay-size fractions were higher than corresponding concentrations in sediments from the Puyallup and White Rivers, but were not high compared with concentrations in the glacial deposits.

The increase in concentrations of arsenic, cadmium, lead, nickel, and zinc with a decrease in particle size is an indication that these elements are adsorbed onto particulate surfaces or that they are associated with fine-grained sediments with a different composition than the sand-size sediments. In either case, the association of trace elements with fine-grained sediments may be indicative of the effects of anthropogenic sources.

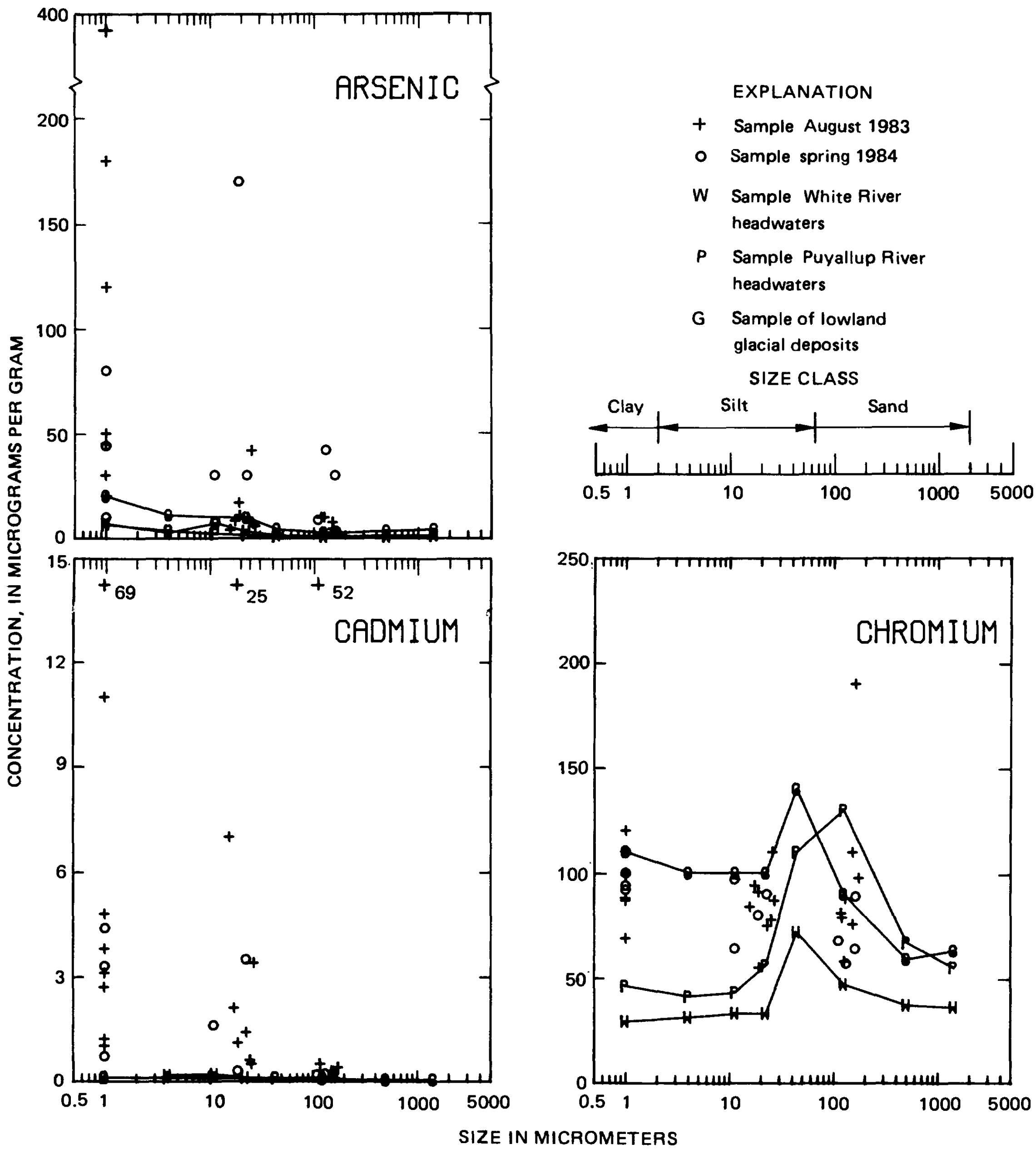

FIGURE 25.--Trace-element concentrations in small streambed sediments as a function of particle size.

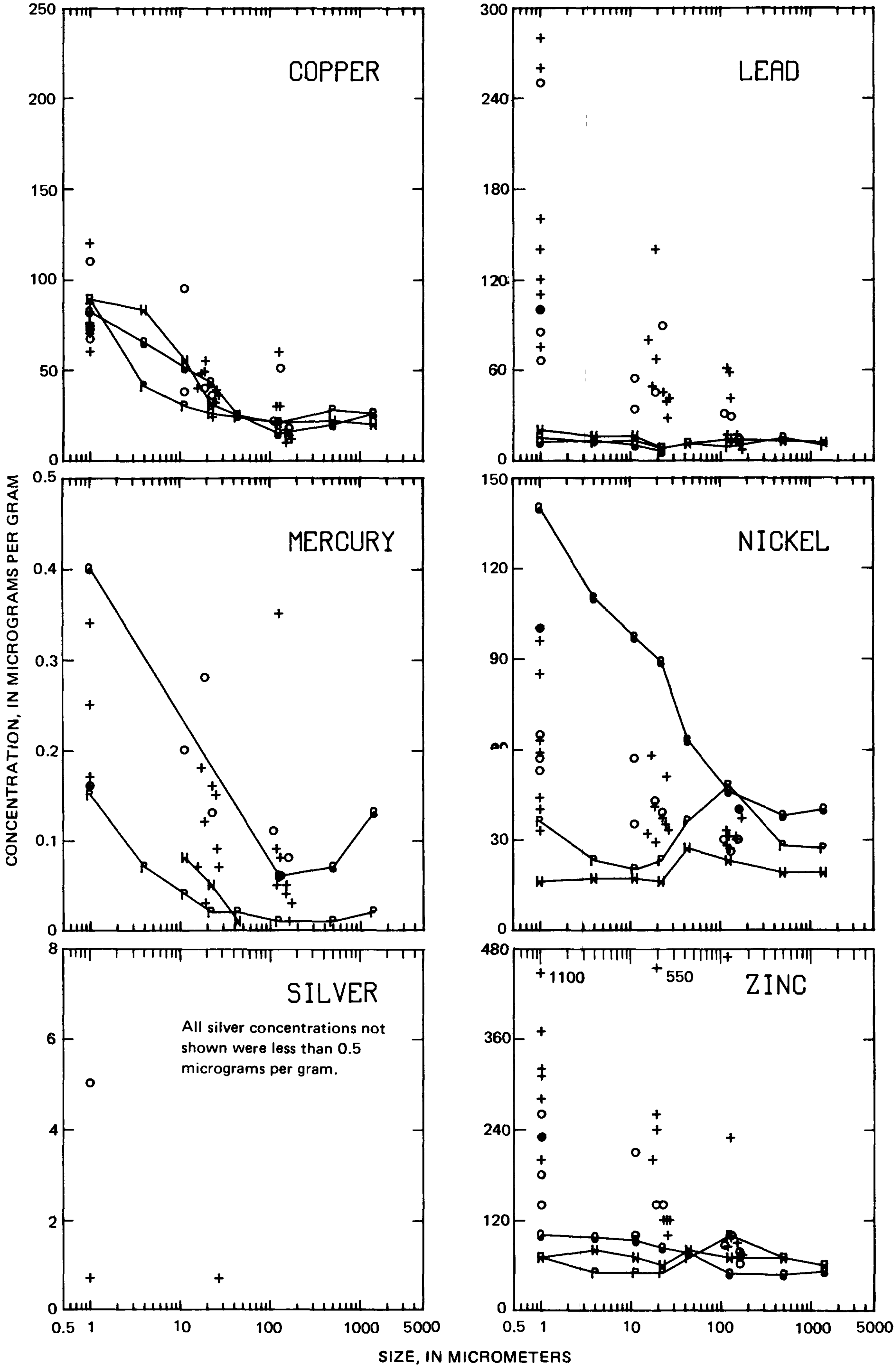

FIGURE 25.--Cont'd

Bed sediments from the small streams generally contained more arsenic, lead, and zinc; about the same amount of cadmium, chromium, mercury, nickel, and silver; and less copper than bed sediments from the Puyallup and White Rivers. The ratio of median concentrations in clay-size bed sediments from small streams to those from the Puyallup and White Rivers were: arsenic 2.2; copper 0.7; lead 4.6; and zinc 2.1. As previously stated, the small streams drain developed areas, and therefore receive more urban runoff as a percentage of flow than the Puyallup River. Urban runoff in the Puget lowland contains arsenic, copper, lead, and zinc (Galvin and Moore, 1982). Higher copper concentrations in Puyallup River bed sediments may be due to the copper in the sewage-treatment-plant effluents (table 24).

Site-to-site comparisons of trace-element concentrations in the silt- and clay-size fractions of bed sediments are shown in figure 26. The highest concentrations of arsenic (as much as 390 μg/g, micrograms per gram, in clay-size sediments) were found at the lower site on Hylebos Creek. Two landfills, located below where Hylebos Creek and its west tributary join, have been identified as sources of arsenic to the reach of the creek below Interstate 5 (Art Johnson and Dale Norton, WDOE, written commun., 1985). Elevated levels of arsenic, copper, lead, and silver were observed in Clarks Creek. No specific source of these elements in Clarks Creek was identified. Cadmium concentrations were highest in Wapato Creek, especially at the downstream site where cadmium concentrations were above 25 μg/g in all size fractions (table 20); this is an indication of contamination by particulate matter containing cadmium rather than cadmium adsorption at particulate surfaces.

Trace elements in water and suspended sediments

Samples for the determination of dissolved trace elements were collected from one to three times at sites on small streams (table 24). Typical trace-element concentrations, except as discussed individually, were: less than 2 μg/L arsenic; less than 1 μg/L cadmium, chromium, lead, and silver; less than 5 μg/L copper and nickel; less than 0.1 μg/L mercury; and less than 20 μg/L zinc.

Relatively high concentrations of dissolved arsenic (12 μg/L), copper (25 μg/L), and zinc (110 μg/L) were observed in Fife Ditch. Dissolved arsenic concentrations of 10 to 12 μg/L at the lower site on Hylebos Creek indicate that some of the arsenic in Hylebos Creek is soluble. Relatively high concentrations of dissolved copper (48 μg/L), lead (8 μg/L), mercury (2.8 μg/L), and zinc (44 μg/L) were found at the upper site on Swan Creek. Because there was no flow at this site during base-flow periods, only one stormflow sample was collected at this location. Dissolved trace-element concentrations at the lower site on Swan Creek were similar to other small streams. The highest concentration of dissolved nickel (14 μg/L) was at the lower site on Hylebos Creek. Dissolved nickel concentrations in Fife Ditch and at the upper sites on Wapato and Swan Creeks ranged from 5 to 10 μg/L. Dissolved cadmium concentrations at the lower site on Wapato Creek were below 1 μg/L, an indication that the cadmium in the bed sediments may not be readily soluble.

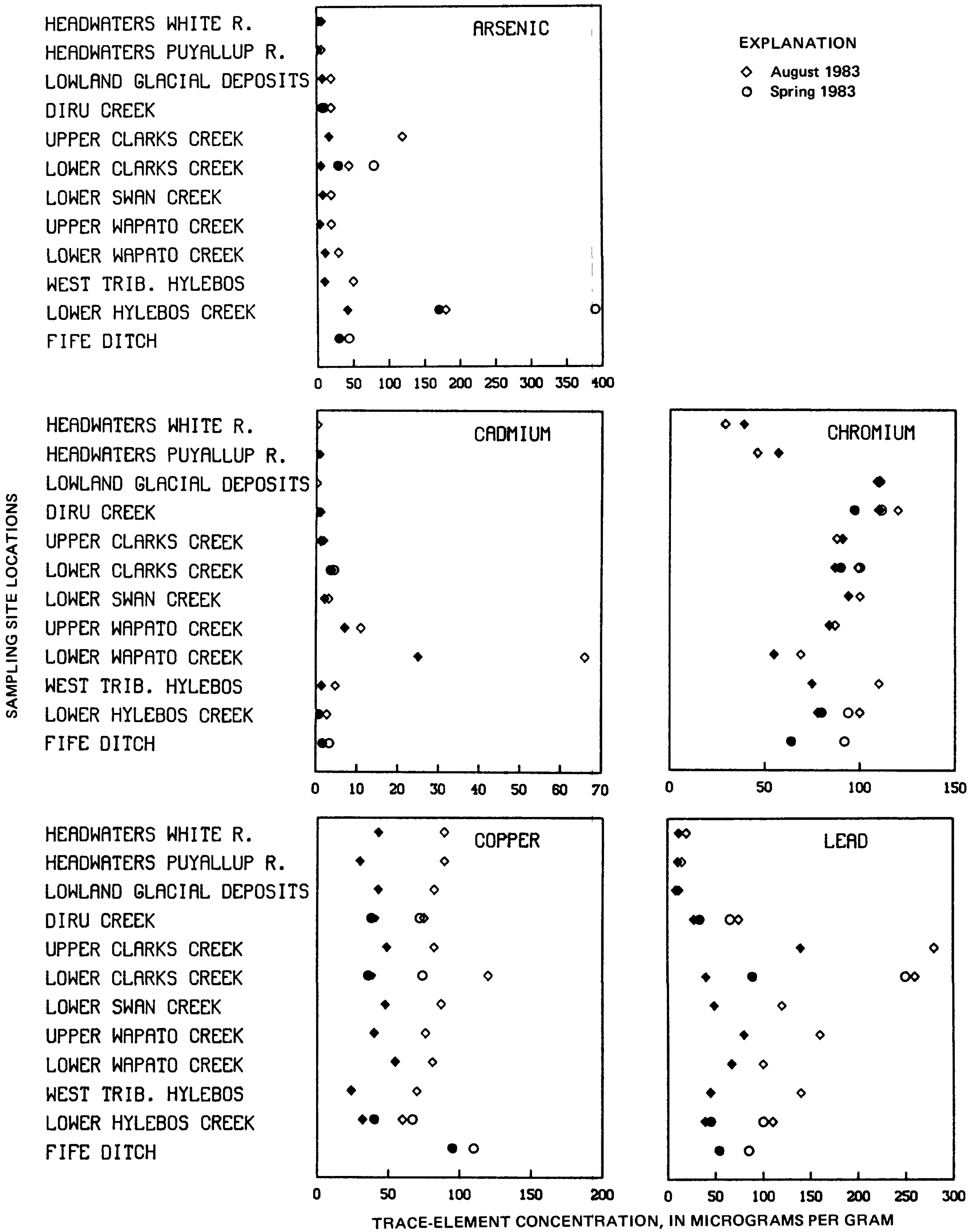

FIGURE 26.–Trace-element concentrations in the silt- and clay-size fractions of bed-sediment samples from small streams. Concentrations in silt-size fractions are shaded, and all concentrations are in micrograms per gram.

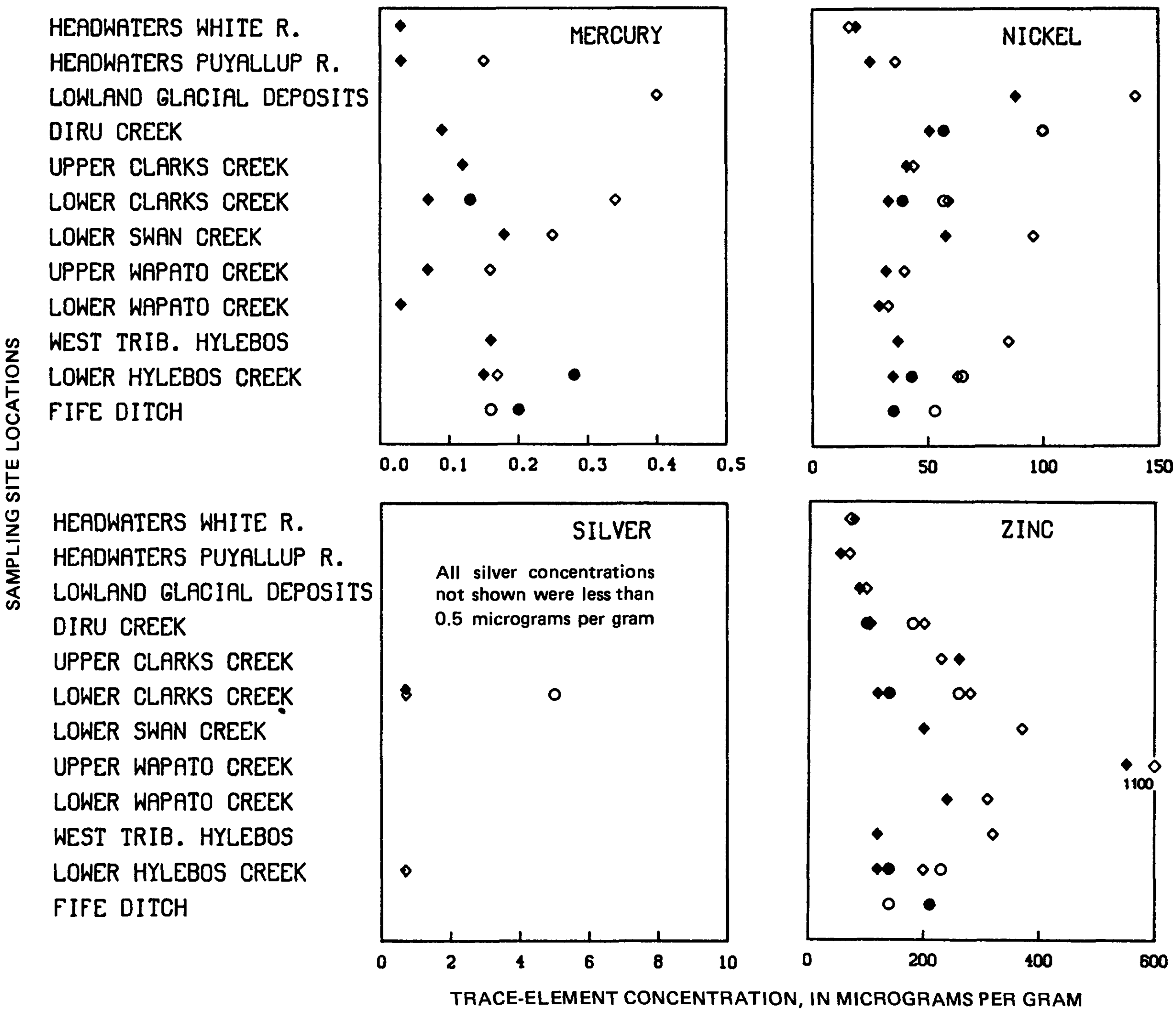

FIGURE 26.--Cont'd

Silt-size, and some clay-size, fractions of suspended sediments collected during the November storm at the lower sites on Clarks, Swan, Hylebos, and Wapato Creeks; at the upper site on Clarks Creek; and at the site on the west tributary to Hylebos Creek were analyzed for trace elements (table 22). Because the amount of sample material collected at each site was small, no mercury determinations were made, all cadmium and silver concentrations were below detectable limits, and all arsenic concentrations, except those in samples from Hylebos Creek, were below detectable limits (table 22).

Trace-element concentrations in suspended sediments generally reflected conditions depicted by the bed-sediment chemistry. Lead concentrations in the silt-size fraction of suspended sediments, ranging from 70 to 520 μg/g, were somewhat higher than concentrations in corresponding bed sediments (fig. 25). The concentration of 70 μg/g arsenic in the silt-size fraction of the suspended-sediment sample collected at the lower site on Hylebos Creek was higher than typical concentrations (less than 20 μg/g) in bed sediments collected throughout the study area. It was, however, lower than the maximum concentration of 170 mg/g found in the silt-size fraction of a bed-sediment sample collected at the lower Hylebos Creek site.

Total-recoverable trace-element concentrations were determined in water samples collected at four sites (table 11). Concentrations of mercury exceeded acute toxicity criteria in Diru Creek, Hylebos Creek, and Fife Ditch. Copper also exceeded acute toxicity criteria in Fife Ditch. Concentrations of dissolved copper and mercury in Swan Creek exceeded acute toxicity criteria (table 24). In lower Hylebos Creek, the concentration of total-recoverable arsenic was 25 μg/L, compared to 1 μg/L and less in Diru and Clarks Creeks. The highest total-recoverable concentrations of arsenic, cadmium, chromium, copper, lead, nickel, and zinc were observed in Fife Ditch.

Suitability of Surface Water for Fisheries Use

A comprehensive evaluation of the adequacy of instream conditions for fish use was beyond the scope of the study; however, a general description of suitability in terms of water quality is possible.

Poor water quality makes Fife Ditch an unsuitable habitat to support a diverse and viable fish population. Fife Ditch is a manmade drainage channel with no present or probable future use for fisheries, and no further evaluation of it with respect to fisheries will be made.

Temperatures measured in all streams except Wapato Creek were within the limits of less than 18 °C for Washington State class A waters. Depending on the time of year, water withdrawn for hatchery use may need to be cooled to bring water temperatures within optimum ranges for spawning and egg development. Also, some surface waters may need aeration before being used. Most waters were well oxygenated; however, in some of the small streams dissolved-oxygen concentrations dropped below 8 mg/L. A minimum concentration of 5.6 mg/L was measured in Wapato Creek.

TABLE 11.--Total-recoverable trace-element concentrations in water samples from small streams, and concentrations that exceeded water-quality criteria

[C, concentration exceeds chronic toxicity criteria;
A, concentration exceeds acute toxicity criteria]

Date	Time	Stream-flow, instan-taneous (ft^3/s)	Sedi-ment, sus-pended (mg/L	Hard-ness (mg/L as $CaCO_3$)	Arsenic total (µg/L as As)	Cadmium total recov-erable (µg/L as Cd)	Chro-mium, total recov-erable (µg/L as Cr)	Copper, total recov-erable (µg/L as Cu)	Lead, total recov-erable (µg/L as Pb)	Mercury total recov-erable (µg/L as Hg)	Nickel, total recov-erable (µg/L as Ni)	Silver, total recov-erable (µg/L) as Ag)	Zinc, total recov-erable (µg/L) as Zn)
						12102020 - Diru Cr at Inflow to Hatchery nr Puyallup, Washington							
Nov. 1983													
04	0800	0.42	4	54	<1	<1	4	C 7	C 2	C,A 0.1	6	<1	20
Apr. 1984													
27	1250	.52	8	48	<1	<1	2	1	<1	<.1	<1	<1	20
						12102100 - Clarks Cr at River Road nr Puyallup, Washington							
Apr. 1984													
26	1220	58	10	69	1	<1	2	3	C 7	<.1	2	<1	10
						12103025 - Hylebos Cr at 8th Ave. E. in Fife, Washington							
Apr. 1984													
27	0830	16	14	79	25	<1	3	C 7	<1	C,A .1	<1	<1	20
						12103035 - Fife Ditch at 54th St. E. in Fife, Washington							
Nov. 1983													
04	1010	23	38	70	39	C 2	14	C,A 90	C 34	< .1	17	<1	C 200
Apr. 1984													
27	0945	.82	73	260	6	<1	5	5	1	C,A .3	7	<1	30

Trace-element concentrations in bed sediments collected in the Puyallup River estuary were often higher than concentrations at upstream sampling sites. Low dissolved trace-element concentrations in water sampled within the plume from the waste-water treatment plant indicate that the trace elements are associated with particulate matter. This association may help to mitigate adverse effects to swimming organisms; however, the effect upon benthic organisms is unknown.

Organic compounds, including priority pollutants, identified in Puyallup River estuary waters were not at concentrations known to be acutely toxic. This may indicate minimal effects to migrating fish that may move rapidly through the estuary, but the long-term effects of the organic compounds, especially on benthic organisms, is unknown.

Upstream of the estuary, water in the Puyallup River is of good quality. Total-recoverable trace-element concentrations that exceeded acute toxicity criteria were associated with high concentrations of suspended sediments.

Dissolved trace-element concentrations in most small streams were low; however, concentrations of dissolved copper and mercury at the upstream site on Swan Creek exceeded acute toxicity criteria. Concentrations of total-recoverable mercury exceeded acute toxicity criteria in Diru and Hylebos Creeks.

Puyallup River Estuary

This section presents and discusses the observations that were made during 1982 in the Puyallup River estuary. They include measurements of longitudinal and vertical distributions of salinity and temperature and longitudinal profiles of water-surface elevations. Also, samples were collected to determine nutrient concentrations in the vicinity of the municipal waste-water treatment plant outfall, which is located on the river's left bank at river mile 1.7 between the Lincoln Avenue and Highway 99 bridges (pl. 1).

Description

The Puyallup River estuary is of the salt-wedge type, which means that it contains a wedge of undiluted bay water that is overlain by a layer of river water. Saltwater has been found to intrude up to about where Interstate Highway 5 crosses the river. The estuarine reach of the Puyallup River follows a nearly straight channeled course across the delta front to Commencement Bay (see fig. 27). Like much of the river downstream from the city of Puyallup the banks are riprapped. At the bay the river mouth is flanked by jetties that extend into the bay about 700 feet and are about 700 feet apart. At low tide sand bars are often exposed in midchannel in the lower one-half mile of the river and along the banks in the lower 2 to 3 miles. Maximum depths in some cross sections in the lower one-half mile may, at extreme low tides, be only a few feet. The bed material in the lower estuary is sandy and is easily transported by tidal and river currents.

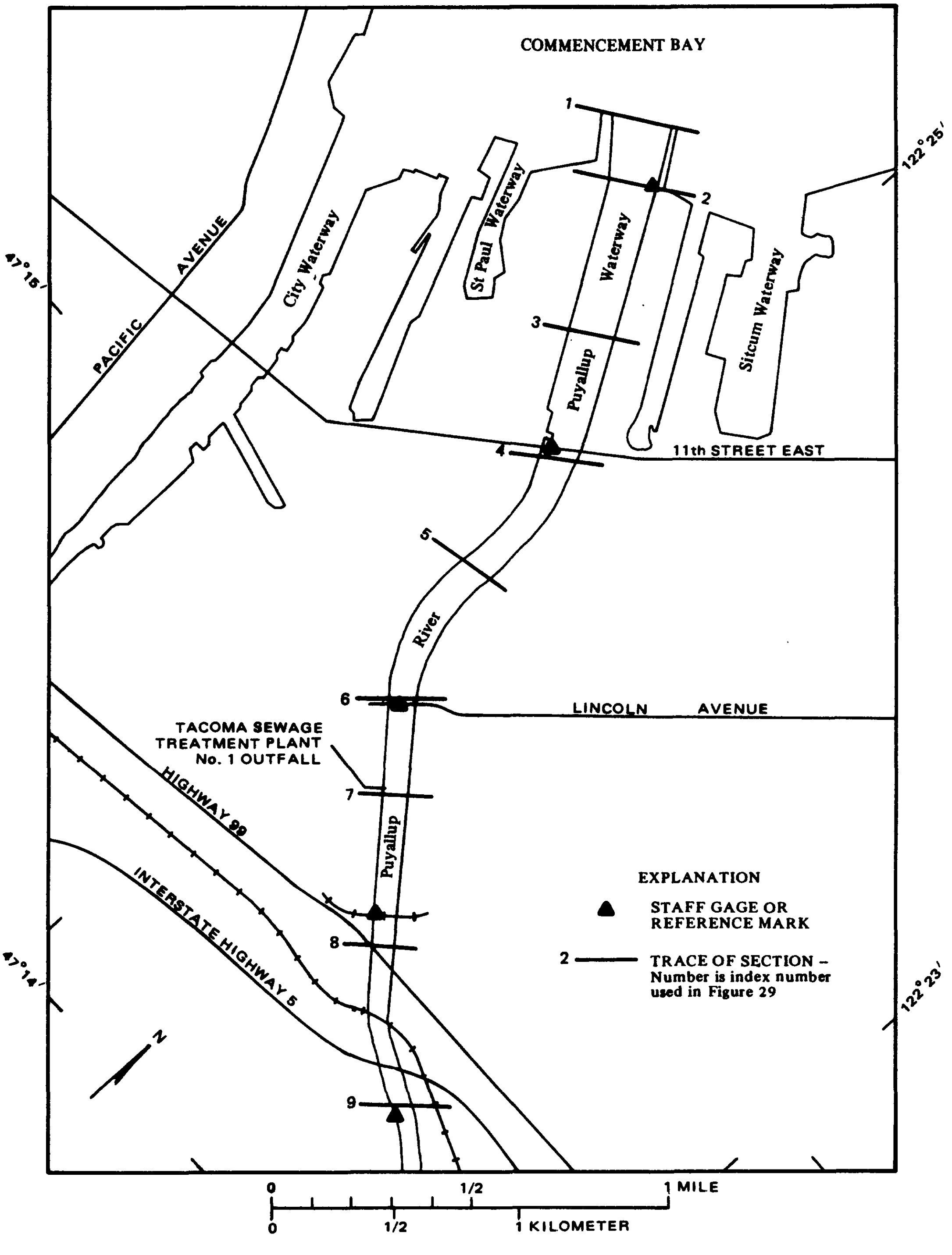

FIGURE 27.--Locations in the Puyallup River estuary where salinity, temperature, and water-surface elevations were measured. Location of estuary is shown on plate 1.

The rise and fall of tides in Commencement Bay and the salinity of the bay water affect the hydraulics and the water quality of the Puyallup River estuary. In Commencement Bay there are two unequal high and two unequal low tides per tidal cycle of about 25 hours. The mean range in tide is 11.8 feet per cycle (U.S. National Oceanic and Atmospheric Administration, 1981). Data presented by Collias and others (1974) show that the salinity of the shallow waters of Puget Sound in the vicinity of Commencement Bay ranges from about 25 to 30 ppt (parts per thousand). Consequently, the density of the bay water ranges from about 2.0 to 2.4 percent greater than that of the Puyallup River water.

Estuary Hydraulics

Because of the combined effects of river discharge, Commencement Bay tides, and difference in density between the bay and river water, velocity distributions in the Puyallup River estuary are different and usually more complex than in the upstream reaches of the river.

Some understanding of the velocity distribution in the estuary is necessary in order to understand the transport of constituents within and through the estuary. Although no velocities were measured in this study, a generalized description of flow patterns can be constructed on the basis of visual observations made while sampling, observed salinity distributions, and hydraulic principles found to be applicable in other estuaries.

The cross-sectionally averaged velocity in the estuary can be considered to be made of an oscillatory tidal component plus a steady river component. The tidal component is in the upstream direction during a rising tide (flood tide), and is downstream during a falling tide (ebbtide), with slack water at times of the high and low tides. The effects of the superposed river flow are to decrease floodflows and increase ebb flows. Also, the times of low and high water slack may be shifted to after the low tide and before the high tide, respectively, or may coalesce into one period of slack or minimum downstream velocity. The effects of tide on flows are greatest near the estuary mouth and decrease in the upstream direction. These effects increase with increasing tidal range and with decreasing river discharge.

Velocity distributions within a cross section can be complex because of the difference in densities between the river water and the bay water in the salt wedge. At times the water in the wedge can move in the upstream direction while the overlying river water is flowing downstream.

Salinity and Temperature

Data on salinity and temperature distributions in the Puyallup River estuary were collected on four different days, chosen to represent the four possible combinations of low and medium discharge with normal and large tide range. The temporal variation in tide stage and upland discharge on the days these observations were made are shown in figure 28. Salinity and temperature were measured by suspending electronic probes from a boat. Measurements were made along single verticals in cross sections spaced about 2,000 feet apart (see fig. 27). The verticals were at or near the deepest point in each cross section. Spacing of measurement points within each vertical depended on the vertical gradient of salinity and ranged from about 0.5 to 3 feet.

The observed distributions of salinity and temperature in the estuary are shown in figure 29. During parts of the tidal cycle, a wedge of dense saline Commencement Bay water extends into the estuary. As is typical for a salt wedge (see for example, Rattray and Mitsuda, 1974), its thickness is greatest at the estuary mouth, and its upper surface slopes downward in the upstream direction. Within the wedge, salinities and temperatures are nearly uniform and equal to those in Commencement Bay. At the water surface is another relatively uniform region consisting of mostly river water with perhaps a small fraction of bay water that is entrained from the top of the wedge. Between this top layer and the wedge is a region with strong vertical salinity and temperature gradients. For example, the salinity in this layer typically changes from 25 to 1 ppt within a vertical distance of 2 to 3 feet.

The observed position of the wedge toe (arbitrarily defined by the 25-ppt contour) at high tide ranged from 1.2 to 2.2 miles from the estuary mouth. One would expect that the position at the toe at high tide is a function of river discharge and tide stage, and that the toe would be farther upstream for lower river discharge and higher tide stages. The observed positions of the wedge support these expectations. On June 2 and August 13, the high tide stages were nearly the same but the river discharge on the former date was consistently higher than was the latter (3,800 ft^3/s compared to 2,100 ft^3/s). As expected, the wedge toe was farther downstream when the river discharge was higher (1.2 miles as compared to 1.8 miles).

A comparison of the salinity distributions at high tide on April 27 and August 13 also shows that the wedge toe was about 0.4 mile farther upstream on the former date when the high-tide stage was about 2 feet higher. However, the distributions may not be strictly comparable because the river discharge on April 27 was about 15 percent higher than on August 13.

The distributions observed on July 6 should not be used for comparisons with the others because of the changing river discharge on that day. The observed salinity distributions at low tide on two of the three days show that the salt wedge was swept completely out of the estuary on the ebbtide. On the low tide on August 13, the day with the highest low-tide stage and smallest river discharge, some salinity is found.

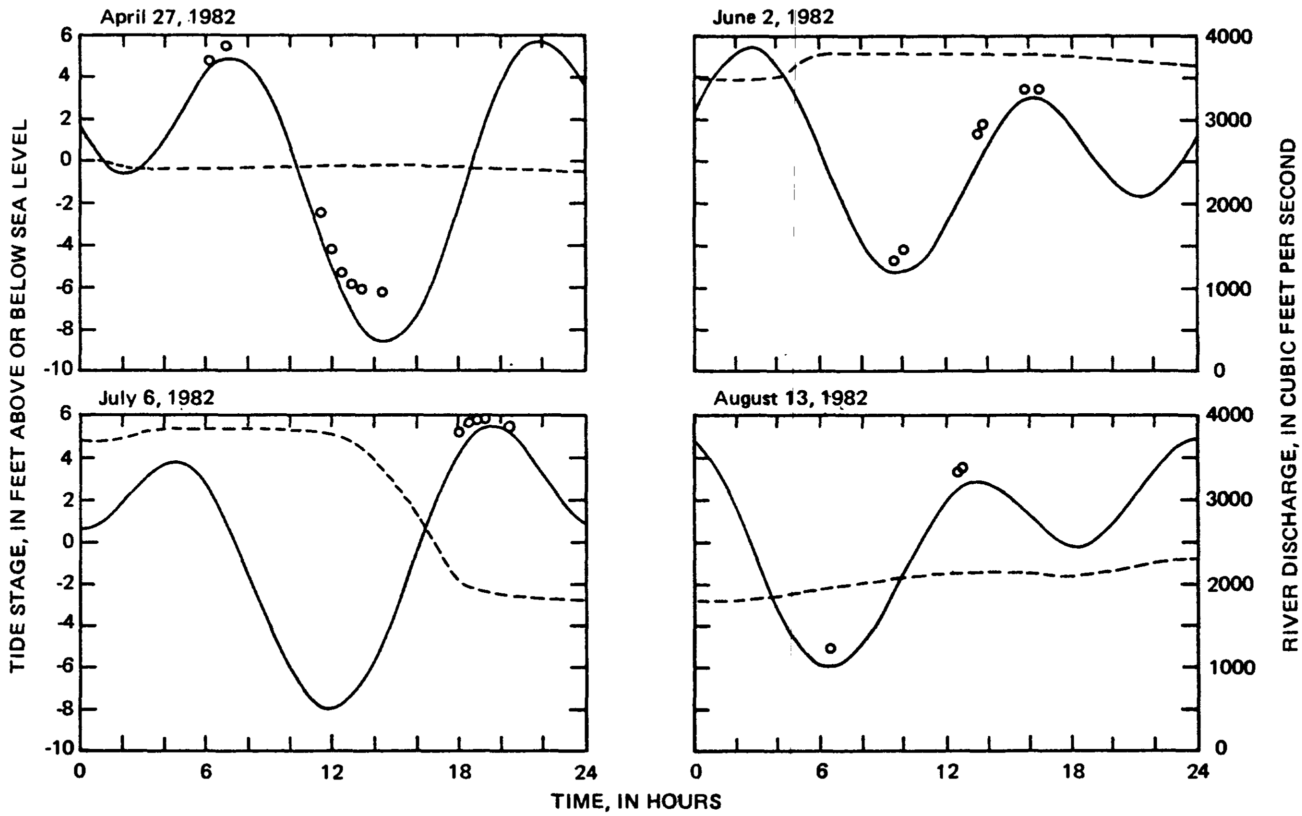

FIGURE 28.--Observed water discharges in the Puyallup River at Puyallup (— —) and observed (o) and predicted (———) tide stages near the mouth of the Puyallup River.

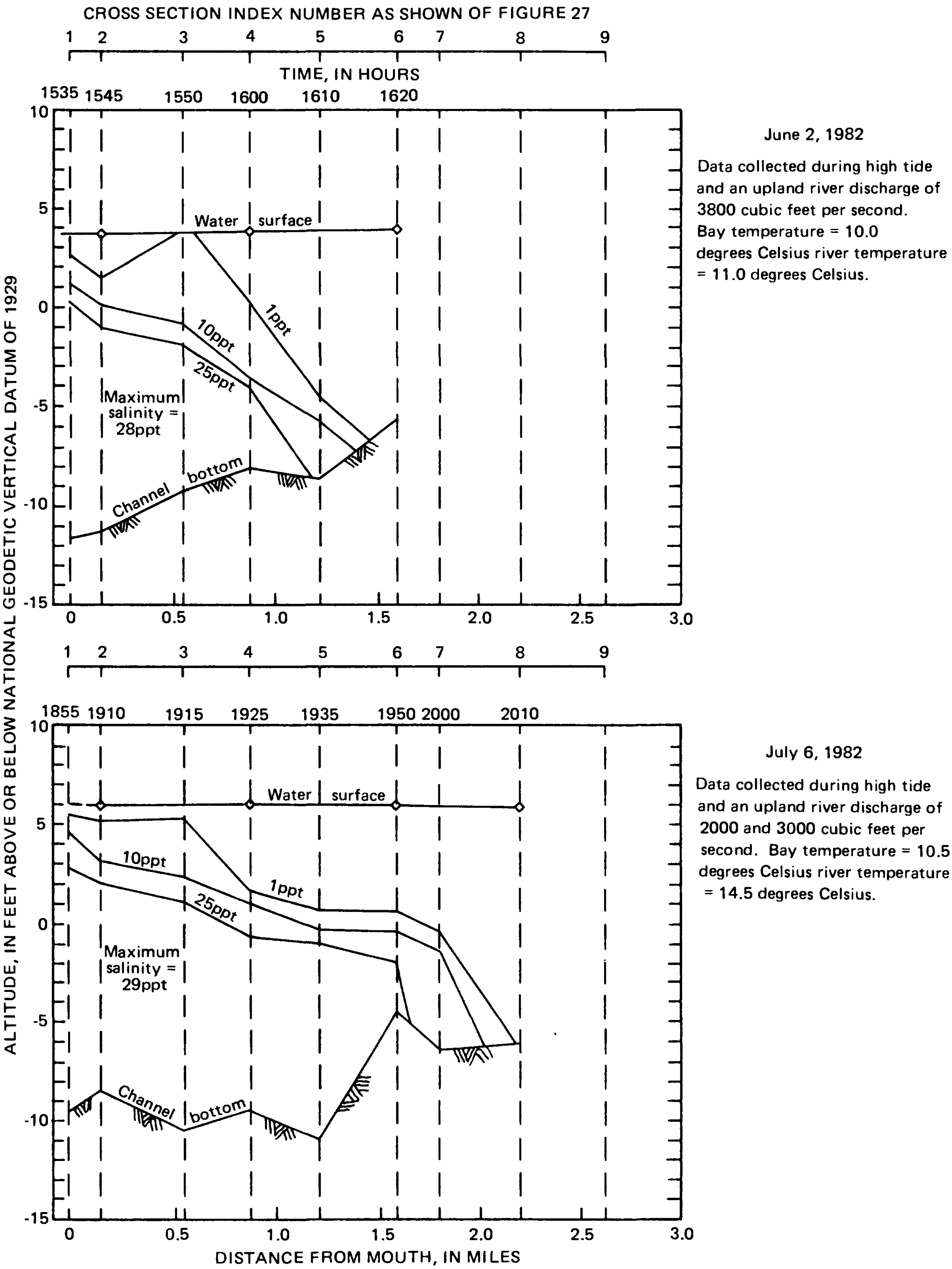

FIGURE 29.–Longitudinal distributions of salinity in the Puyallup River estuary. Temperatures of bay and river water are indicated, and lines of constant temperature approximately follow those of constant salinity.

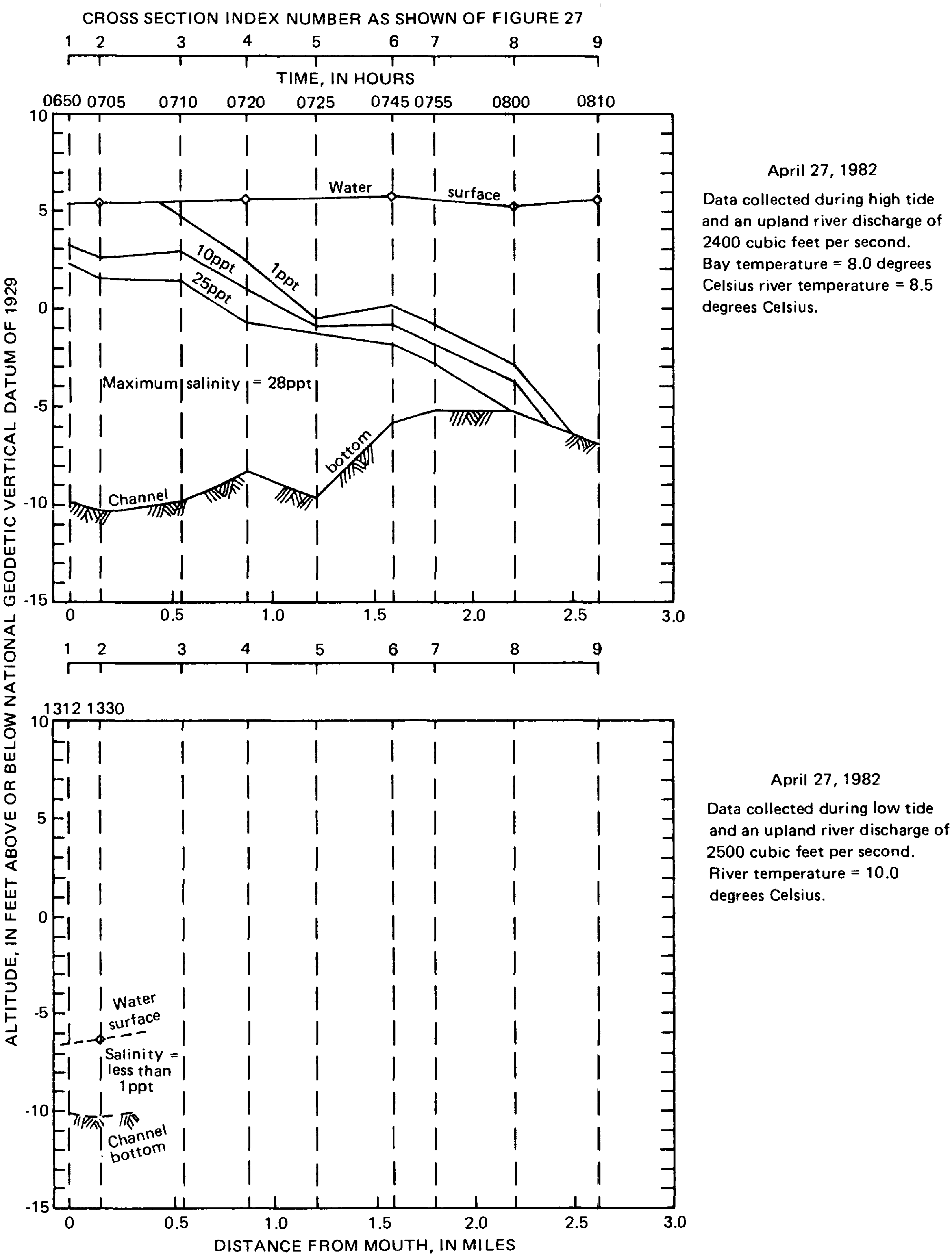

FIGURE 29.--Cont'd

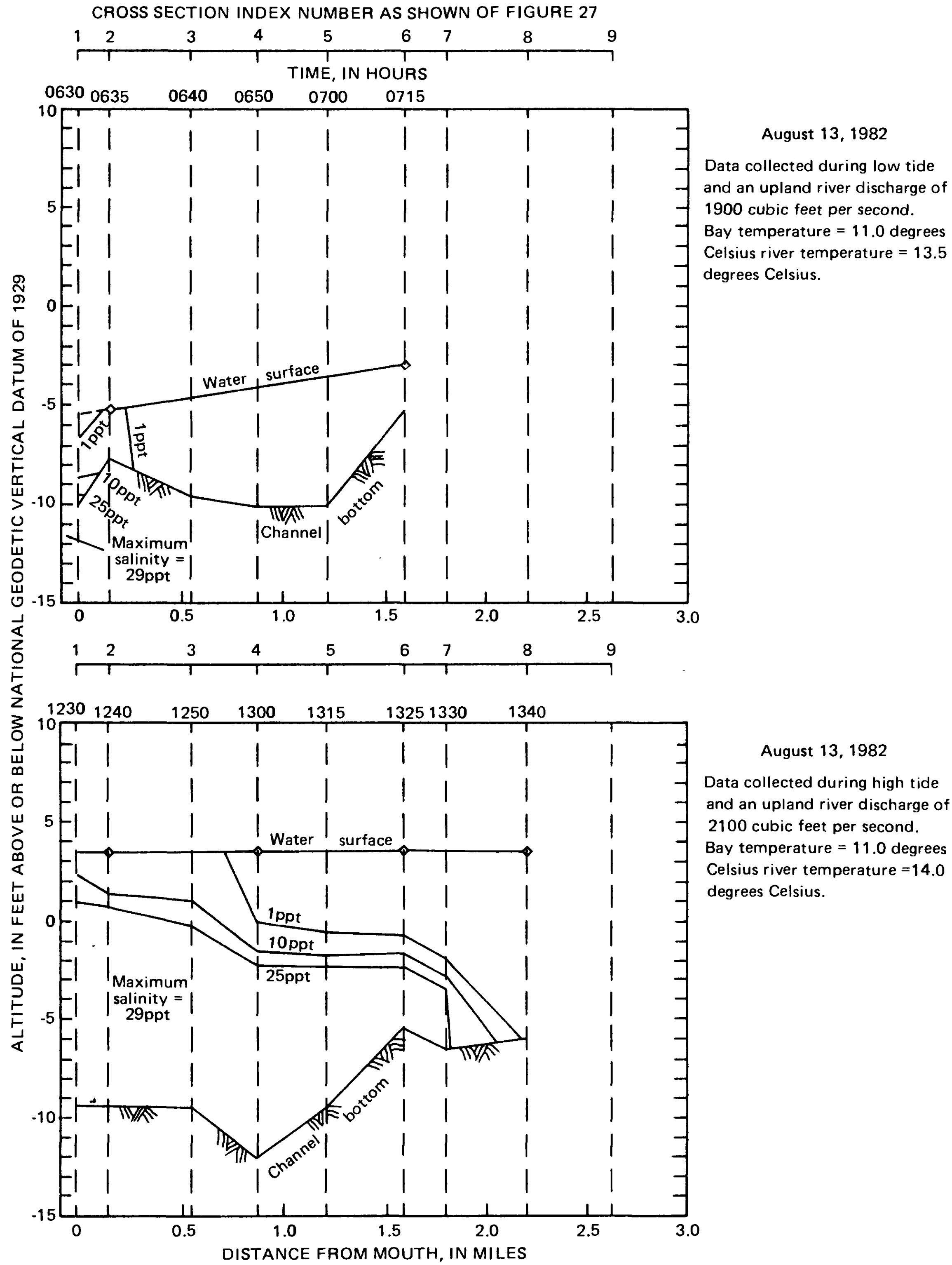

FIGURE 29.--Cont'd

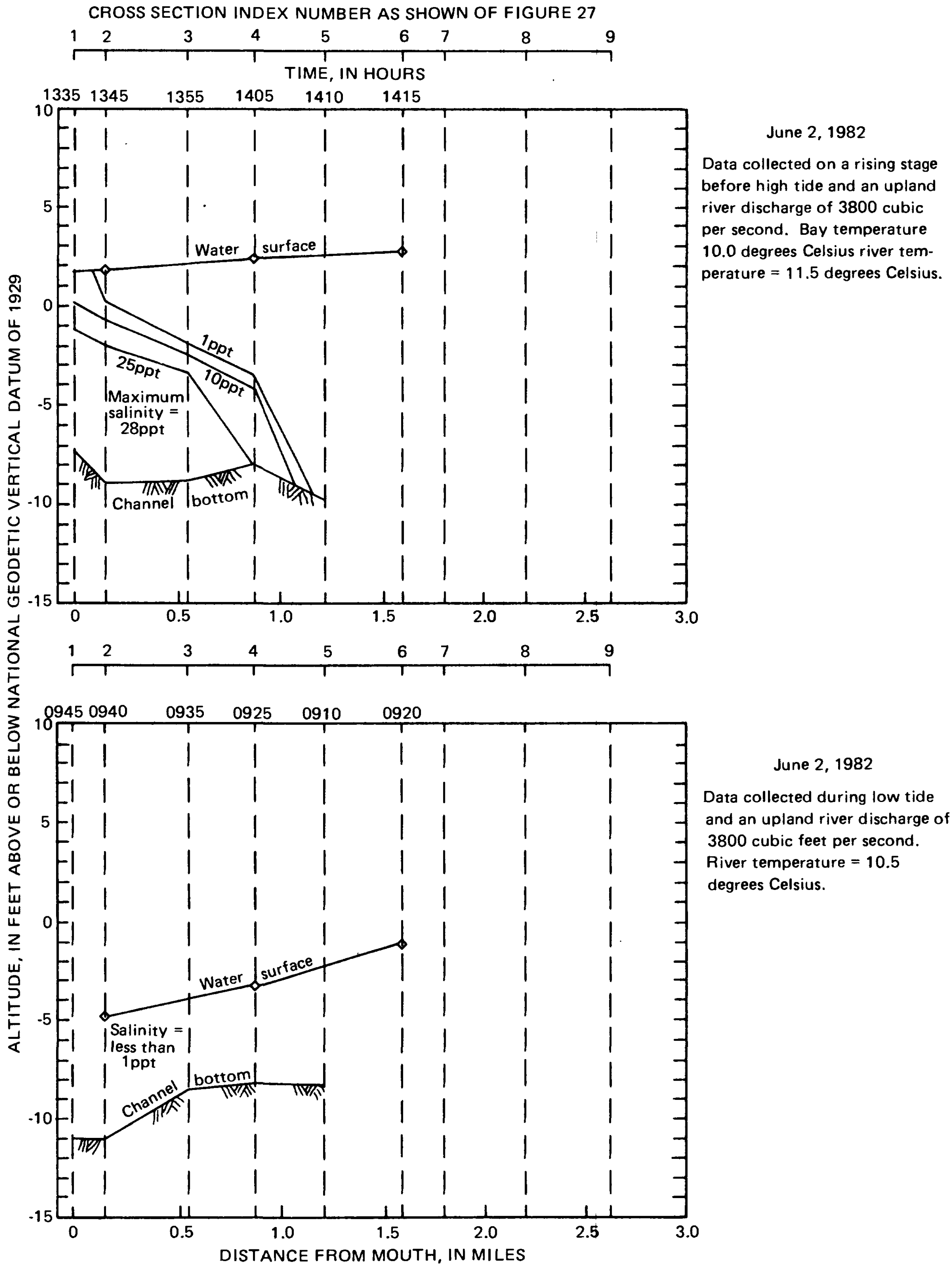

FIGURE 29.--Cont'd

Lines of constant temperature approximately follow those of constant salinity. However, except for the July and August data, the difference between river and bay temperatures was small, and consequently the temperature gradients were not large (fig. 29). The temperature gradients in July and August ranged from about 15 °C at the surface to about 11 °C near the channel bottom during high tides.

Water-Surface Elevations

Data on water-surface elevations in the estuary were collected on the days that salinity and temperature distributions were observed. Water-surface elevations observed at cross-section 2 (see fig. 27) are compared with predicted tide stages for Commencement Bay (U.S. National Oceanic and Atmospheric Administration, 1981) in figure 28. Observed river discharges at the Puyallup River at Puyallup (pl. 1), where flow is not affected by tides, are also shown in figure 28. Longitudinal profiles of water-surface elevations in the estuary are shown in the longitudinal sections of figure 29. Elevations in these figures are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). This datum is 6.51 feet above mean lower low water to which tide stages are normally referenced.

The data on water-surface elevations were obtained at up to five points by reading a staff gage or measuring vertical distances to the water surface from reference points of known elevation on posts driven into the streambank or from bridges. Locations of the reference marks appear in figure 27. The data in figure 29 show that at high tide the water surface is within a few feet of being horizontal. However, at low tide water-surface slopes can exceed 1 foot per mile.

The data in figure 28 show that for predicted tide stages higher than about -6 feet NGVD the observed water levels near the mouth of the estuary were consistently higher than predicted tide stages by about 1 foot. At the lower low tide on April 27 the difference was about 3 feet.

Nutrients

Nitrogen and phosphorus concentrations in samples collected in the vicinity of the waste-water treatment plant at river mile 1.7 provide information on the movement and distribution of the plant effluent in the estuary. During most of a tidal cycle, when the river velocity is in the downstream direction, there is a visible effluent plume along the left bank. During times of the tidal cycle when the water velocity is near zero or perhaps in the upstream direction, the effluent appears to spread across a large area of the river surface. Concentrations in a cross section at Lincoln Avenue bridge at one time in a tidal cycle on June 2, 1982, and at three different times in a tidal cycle on August 13, 1982, are shown in figure 30. In addition, the areal distribution between the Lincoln Avenue and Interstate Highway 5 bridges is shown at the time of high slack water on August 13 (fig. 31). On both days, samples of sewage-treatment-plant effluent were also collected. On August 13 samples were collected from the river sufficiently far upstream to be unaffected by the effluent, and from Commencement Bay at a depth of 14 feet where there is no immediate effect of the Puyallup River on water quality. Salinity also was measured at all sites when sampling.

Figure 30, frames a, b, and d, show the observed distribution of nutrients in the cross section at Lincoln Avenue bridge at times in the tidal cycle when the water velocity at the surface was in the downstream direction. Each of these frames shows a sewage plume adjacent to the left bank.

Concentrations during slack water before high tide are shown in figures 30, frame c, and 31. At this phase of the tide cycle the effluent is less like a plume and is spread more nearly uniformly across the Lincoln Avenue cross section. However, the relatively low nutrient concentrations upstream from the outfall and in the right half of the channel near the outfall indicate that the effluent did not move far upstream at this time.

Most of the concentrations shown in figures 30 and 31 are for samples collected 1 foot below the water surface. However, some were also collected 1 foot above the stream bottom. On June 2 when the depth was relatively shallow, the velocity relatively high, and the wedge did not extend up to Lincoln Avenue bridge, the effluent plume was well mixed vertically (fig. 30, frame a). On August 13 at slack water when the wedge did not yet reach Lincoln Avenue bridge (fig. 30, frame c), the phosphorous data indicate good vertical mixing, but the nitrogen data do not. At high tide on August 13 when the wedge extended above Lincoln Avenue bridge (figs. 29 and 30, frame d) one would expect the effluent plume to be contained in the layer of river water above the wedge and consequently see a large difference between nutrient concentrations at 1- and 8-foot depths. However, such is not the case, as illustrated in figure 30, frame d, probably because the nutrient concentrations in Commencement Bay (1.2 mg/L total nitrogen and 0.18 mg/L total phosphorus), and consequently in the wedge, are nearly the same as in the effluent plume.

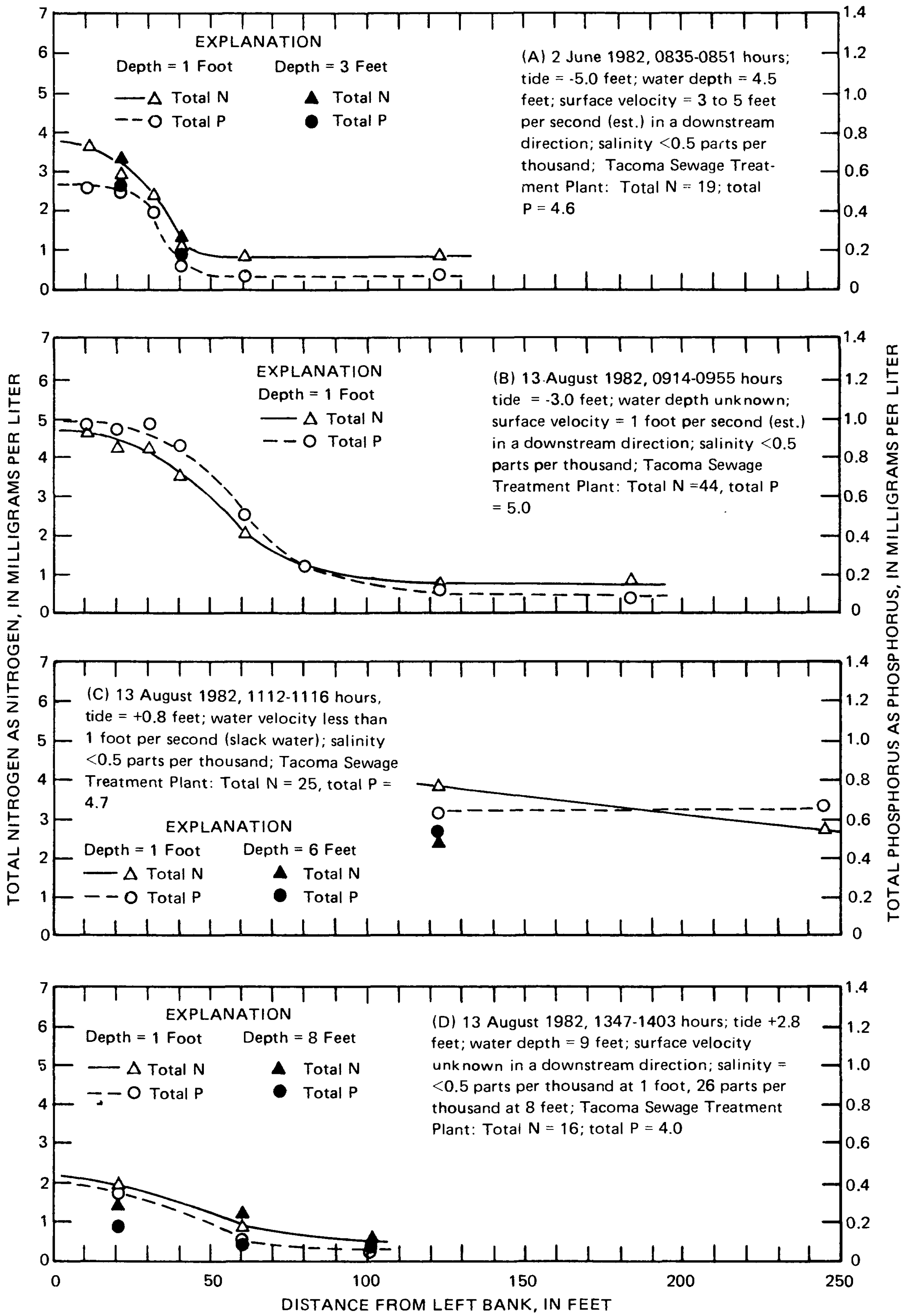

FIGURE 30.--Lateral and vertical variations in concentrations of total nitrogen and total phosphorus in the Puyallup River at the Lincoln Avenue bridge during June-August 1982. Tides shown are predictions for Commencement Bay, the right bank is at 370 feet; nitrogen and phosphorus concentrations in effluent from Tacoma Sewage Treatment Plant No. 1 are given in headnotes.

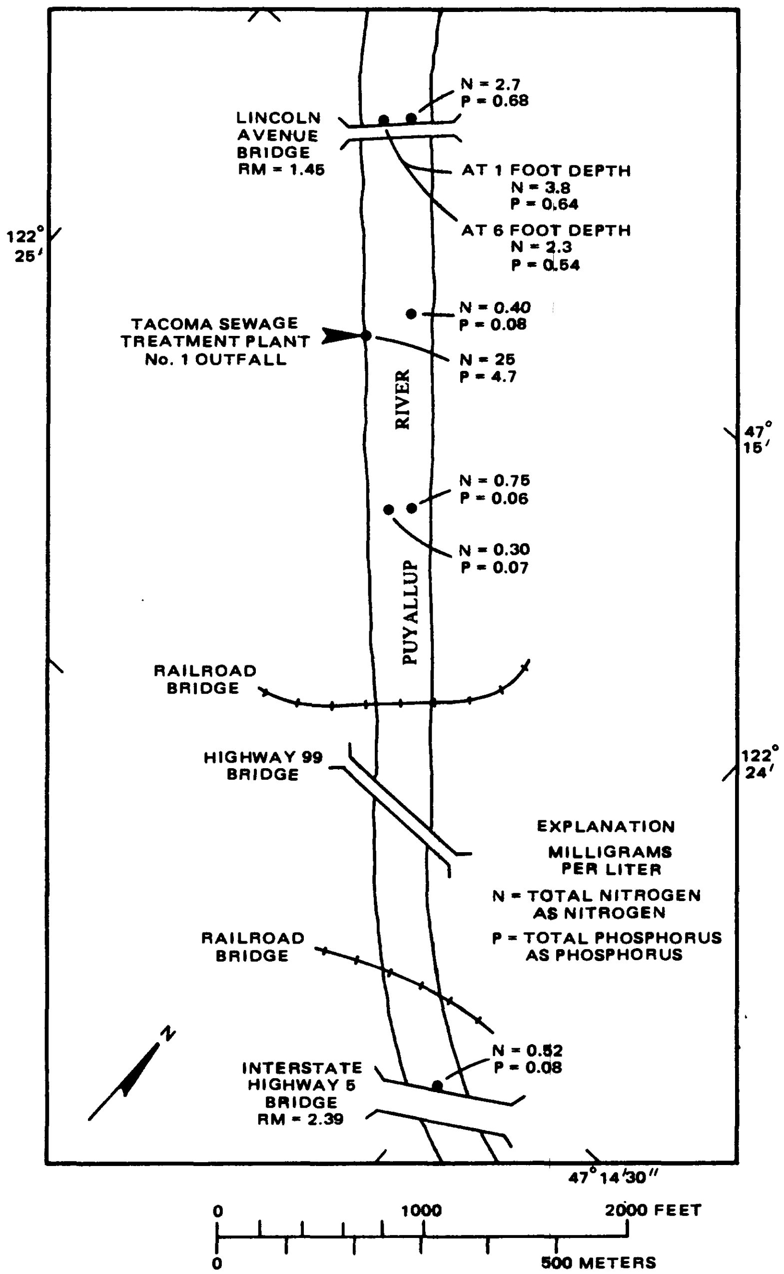

FIGURE 31.--Concentrations of total nitrogen and total phosphorus in the Puyallup River from the Lincoln Avenue bridge to Interstate Highway 5 bridge during August 13, 1982. The tide was +0.8 foot above National Geodetic Vertical Datum of 1929 on a rising stage. All samples were collected from a depth of 1.0 foot, unless otherwise indicated.

SUMMARY AND CONCLUSIONS

Wells in the study area tap a fine-grained, alluvial sediment of the Puyallup River flood plain and a undifferentiated glacial sediment on the shoulders of the flood plain or underlying the alluvial fill.

Most ground waters were predominantly calcium-magnesium bicarbonate waters. Four of the deeper wells yielded a sodium-potassium bicarbonate water.

Five shallow wells sampled in the lower Puyallup River valley, generally north of Interstate Highway 5, had chloride concentrations above typical background levels. One of these wells had a chloride concentration of 220 mg/L, the maximum value observed. Chloride concentrations above typical levels in shallow ground water may be due to the effects of urban and industrial activities. The deeper wells near Commencement Bay had chloride concentrations of less than 10 mg/L. Therefore, saltwater intrusion does not appear to be a water-quality problem.

Most ground waters had nitrate concentrations of less than 0.10 mg/L, as N; the highest concentration observed was 2.7 mg/L. Concentrations of dissolved ammonia, which includes ammonia (NH_3) and ammonium ion (NH_4^+), ranged widely from 0.01 to 19 mg/L, as N. The highest concentrations were found in shallow alluvial aquifers. Even though the concentrations of ammonia were relatively high for some shallow wells, the un-ionized ammonia (NH_3) for all samples was low, indicating that ammonia toxicity would not pose a likely risk if ground waters were used for fish hatchery purposes. Dissolved phosphorus concentrations were all below 1.0 mg/L and should not pose serious water-quality problems.

Concentrations of 29 volatile organic compounds analyzed in shallow ground waters were below quantitation limits. The consistently low concentrations suggest that at the location of the sampled wells either a large source of these compounds was not present, conditions did not prevail to cause the compounds to become mobilized, or natural processes of attenuation were sufficiently active to prevent ground-water contamination.

High concentrations of dissolved iron and manganese were found in most wells tapping shallow alluvial aquifers and in a few wells tapping deeper aquifers. Iron and manganese concentrations were as high as 210,000 and 4,300 μg/L, respectively, in samples from two shallow wells. Both of these wells are in the Tacoma tideflats area, one located on the inactive Tacoma landfill site. Other dissolved trace elements were found at low concentrations or below detection limits in both shallow and deep wells.

Deep ground waters appear to be of a quality suitable for a supplementary water supply for fish-hatchery needs. However, deep waters are typically low in or devoid of dissolved oxygen and would require aeration before use in hatchery ponds. The shallow ground waters were generally poorer in quality than deep waters, indicated mostly by the relative concentrations of nitrogen compounds, iron, and manganese in shallow and deep waters.

In most surface waters, the dissolved ions were predominantly calcium, magnesium, and bicarbonate. In the Puyallup River estuary, river water mixes with water from Commencement Bay and becomes enriched in sodium and chloride. In the small streams, the sum of sulfate, chloride, and nitrate milliequivalents--as a percentage of total anions--increased as much as 30 percent during storms.

Dissolved-solids concentrations in small streams ranged from 59 to 640 mg/L and were generally higher than those in the White River and in the Puyallup River above the estuary, where dissolved-solids concentrations ranged from 31 to 59 mg/L.

Dissolved-oxygen concentrations, temperatures, and pH values in the Puyallup and White Rivers were within limits for class A waters: temperatures less than 18 °C, dissolved-oxygen concentrations greater than 8.0 mg/L, and pH values between 6.5 and 8.5. Small 24-hour variations in dissolved-oxygen concentrations indicated little photosynthetic-respiratory activity in relation to the volume of water in the river. Biochemical-oxygen demand concentrations were generally less than 4 mg/L.

Dissolved-oxygen concentrations and temperatures outside the limits set for Washington State class A waters were observed during summer base flow in some of the small streams. During a 24-hour study, dissolved-oxygen concentrations fell slightly below 8.0 mg/L (minimum 6.9 mg/L) in Clarks, Clear, and Hylebos Creeks. Conditions in lower Wapato Creek and in Fife Ditch were least suitable for fish habitat. During the same 24-hour study, temperatures at both these sites remained above 18 °C and minimum dissolved-oxygen concentrations were relatively low at 5.6 and 2.0 mg/L, respectively, for Wapato Creek and Fife Ditch.

Bacteriological data indicate that the sewage-treatment plants in the study area caused no detectable increases in bacterial densities in the Puyallup or White Rivers. At all sites on the Puyallup and White Rivers the median fecal-coliform densities, which ranged from 300 to 1,100 col./100 mL, exceeded the Washington State water-quality criteria for class A waters (median value of less than 100 col./100 mL). Fecal-streptococcal densities at all Puyallup and White River sites, which ranged from 110 to 6,500 col./100 mL during base-flow periods, increased during stormflows when densities greater than 10,000 col./100 mL were observed.

Fecal-coliform and fecal-streptococcal densities measured during base flows in small streams were on the order of 1,000 col./100 mL or less. During storms, fecal-streptococcal densities greater than 10,000 col./100 mL were observed at most sampling sites. Maximum fecal-coliform densities observed during storms were less than 10,000 col./100 mL, except for a measurement of 19,000 col./100 mL in a sample collected at the upper site on Swan Creek. Of all the small streams studied, Diru Creek and Clear Creek had the lowest fecal-bacterial densities during most sampling periods. Only fecal-coliform densities measured in Diru Creek did not exceed Washington State water-quality criteria for class A waters.

The concentrations of nitrogen compounds (nitrate, ammonia and organic nitrogen) were low for all sites on the Puyallup and White Rivers. None of the nitrogen forms exceeded 2.1 mg/L as nitrogen. The highest concentrations of nitrogen compounds were usually found during stormflow, in the form of organic nitrogen. During base flow, the organic nitrogen and ammonia concentrations were higher at sites in the Puyallup River estuary than at upstream sites. At the sites in the estuary, concentrations of nitrogen compounds were usually highest near the left bank due to the incomplete mixing of the treatment-plant effluent.

Total phosphorus concentrations at sites on the Puyallup and White Rivers ranged from 0.02 to 1.1 mg/L. The suspended fraction of total phosphorus was usually higher than the dissolved fraction because phosphorus is readily sorbed on particulate matter in river water. At all sites the lowest concentrations of total phosphorus were found during the April base flow when suspended-sediment concentrations were low.

The concentrations of nitrogen compounds (nitrate, organic nitrogen, and ammonia) and ratios of nitrogen to phosphorus were generally higher in the small streams than in the Puyallup River. The nitrate concentrations, in particular, were higher in small streams than in the Puyallup River. In Diru Creek, nitrate-nitrogen concentrations reached levels of 3.1 mg/L, the highest of the small streams. In Fife Ditch the dissolved ammonia concentrations (maximum of 3.3 mg/L as nitrogen) were several orders of magnitude higher than in the other small streams. Concentrations of un-ionized ammonia did not exceed water-quality criteria at any of the sampling sites.

Total phosphorus concentrations in small streams ranged from 0.03 to 0.51 mg/L. Phosphorus concentrations generally increased from upstream to downstream sites within a sampling period in Hylebos, Wapato, Clarks, and Clear Creeks. At Swan Creek, the highest phosphorus concentrations were at the upstream site.

The highest concentrations of total organic carbon observed in the White and Puyallup Rivers ranged from 9.0 to 12.8 mg/L, in samples collected in January 1984. During August 1983 base flow, total organic carbon concentrations in the Puyallup River above the estuary were less than 2 mg/L. Concentrations of total organic carbon measured in the estuary during August base flow ranged from 1.2 to 5.5 mg/L. The highest concentration was nearest the left bank within the discharge plume from the treatment plant.

Organic carbon concentrations in small streams also increased during stormflow. The highest concentration, greater than 18 mg/L, was measured in Hylebos Creek. Typical concentrations in small streams during base flow were 1 to 4 mg/L.

Methylphenol, bis(2-ethylhexyl) phthalate, and six polycyclic aromatic hydrocarbons were identified in bed sediments collected in the Puyallup River estuary. At the Puyallup River at Alderton, a site above the estuary, a bed-sediment sample contained six polycyclic aromatic hydrocarbons, methylbenzene, and dimethylbenzene. Methylphenol was also found in bed sediments collected in Clarks and Swan Creeks.

The sewage-treatment plants within the study area were a source of organic compounds to the Puyallup and White Rivers. The treatment-plant discharges contained numerous organic compounds, including halogenated aliphatic hydrocarbons, phthalate esters, organic acids, ketones, and alcohols. Many of these compounds were also found in the Puyallup River estuary. Compound concentrations in the river were generally less than those in the treatment-plant discharges, indicating dilution or volatilization. The halogenated aliphatic hydrocarbon 1,1,1-trichloroethane was the only compound identified in water sampled at sites above the estuary.

Of the synthetic organic compounds that were identified in water samples from the small streams, all were volatile, and most were in waters collected during base flows. Benzene, 1,2-dichloroethane, and trichloroethene were found in Clarks Creek, and 1,1,1-trichloroethane was identified in Wapato Creek. Highest concentrations of volatile organic compounds were observed in Fife Ditch; the concentration of trans-1,2-dichloroethene was 36 $\mu g/L$ and the concentration of trichloroethene was 5 $\mu g/L$. None of the priority pollutant organic compounds was found at a concentration known to be acutely toxic.

Trace-element concentrations in the silt- and clay-size fractions of bed sediments were used as indicators of trace-element occurrence in streams. In the Puyallup River, the highest concentrations of cadmium, chromium, copper, lead, mercury, silver, and zinc were often observed in the Puyallup River estuary.

The silt- and clay-size fractions of bed sediments collected in the small streams generally contained more arsenic, lead, and zinc; about the same amount of cadmium, chromium, mercury, nickel, and silver; and less copper than Puyallup River bed sediments. Because the small stream drainages are almost entirely within developed areas, they receive more urban runoff as a percentage of total flow than the Puyallup River. Urban runoff is one probable source of trace elements in the small streams. Higher concentrations of copper in the Puyallup River bed sediments may be due to the copper in the sewage-treatment plant effluents. The highest concentrations of arsenic (up to 390 micrograms per gram) were found in bed sediments in lower Hylebos Creek. Two landfills have been identified as sources of arsenic in the creek. Cadmium concentrations in the bed sediments in lower Wapato Creek were approximately an order of magnitude higher than concentrations from other streams. No source of cadmium to Wapato Creek was identified.

Dissolved arsenic, cadmium, chromium, mercury, and silver were near or below detection limits in the White and Puyallup Rivers. Most concentrations of dissolved lead and zinc in the Puyallup River were near or below detection limits, and dissolved copper and nickel concentrations were usually less than 5 and 10 $\mu g/L$, respectively. The highest concentrations of dissolved trace elements were observed in the small streams. Relatively high concentrations of dissolved arsenic (12 $\mu g/L$), copper (25 $\mu g/L$), and zinc (110 $\mu g/L$) were observed in Fife Ditch. Dissolved arsenic concentrations up to 12 $\mu g/L$ at the lower site on Hylebos Creek indicate that some of the arsenic in Hylebos Creek is soluble. Comparatively high concentrations of dissolved copper (48 $\mu g/L$), lead (8 $\mu g/L$), mercury (2.8 $\mu g/L$), and zinc (44 $\mu g/L$) were found at the upper site on Swan Creek.

Trace-element concentrations in suspended-sediment samples from the Puyallup River varied somewhat, but trace-element concentrations in water were largely controlled by the concentration of suspended sediment. Therefore, total-recoverable trace-element concentrations were highest when suspended-sediment concentrations were high. Total-recoverable concentrations of cadmium, copper, lead, mercury, and zinc that exceeded acute toxicity levels were observed in the Puyallup River during a storm when suspended-sediment concentrations were approximately 2,000 mg/L.

In the small streams, concentrations of mercury exceeded acute toxicity criteria in Fife Ditch and in Diru, Swan, and Hylebos Creeks. Copper concentrations exceeded acute toxicity criteria in Fife Ditch and Swan Creek.

Water in most streams, including the Puyallup and White Rivers, is suitable in quality, or with minimum treatment could be made suitable, for fish hatchery use. An exception is Fife Ditch, where fish life may not be suitably sustained.

The rise and fall of tides in Commencement Bay and the salinity of the bay water affect the hydraulics and the water quality of the Puyallup River estuary. During most of the tidal cycle, the river velocity is in the downstream direction and the effluent plume from the Tacoma Sewage Treatment Plant No. 1 is along the left bank. During times of the tidal cycle, when the water velocity is near zero or in the upstream direction, the effluent is spread across a larger area of the river surface.

REFERENCES CITED

Aware Inc., 1981, Hydrogeologic and engineering evaluations of waste management facilities: Aware, Inc., Nashville, Tenn., prepared for Pennwalt Corporation, Tacoma, Washington, 225 p.

Collias, E. E., McGary, Noel, and Barnes, C. A., 1974, Atlas of physical and chemical properties of Puget Sound and its approaches: University of Washington Press, Seattle, 235 p.

Crock, J. G., Lichte, F. E., and Briggs, P. H., 1983, Determination of elements in National Bureau of Standards geological reference materials SRM 278 obsidian and SRM 688 basalt by inductively coupled argon plasma-atomic emission spectrometry: Geostandards Newsletter, v. 7, no. 2, p. 335-340.

Dion, N. P., and Sumioka, S. S., 1984, Seawater intrusion into coastal aquifers in Washington, 1978: State of Washington Department of Ecology Water-Supply Bulletin 56, 13 p., 14 plates.

Galvin, D. V., and Moore, R. K., 1982, Toxicants in urban runoff: Municipality of Metropolitan Seattle, Metro Toxicant Program Report No. 2, 237 p.

Greeson, P. E., Ehlke, T. A., Irwin, G. A., Lium, B. W., and Slack, K.V., 1977, Methods for collection and analysis of aquatic biological and microbiological samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A4, 332 p.

Griffin, W. C., Sceva, J. E., Swenson, H. A., and Mundorff, M. J., 1962, Water resources of the Tacoma area, Washington: U.S. Geological Survey Water-Supply Paper 1499-B, 101 p.

Guy, H. P., and Norman, V. W., 1970, Field methods for measurement of fluvial sediment: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. C2, 59 p.

Hem, J. D., 1970, Study and interpretation of the chemical characteristics of natural water (2d ed.): U.S. Geological Survey Water-Supply Paper 1473, 363 p.

Horowitz, A.J., 1984, A primer on trace metal-sediment chemistry: U.S. Geological Survey Open-File Report 84-709, 82 p.

Huffman, Claude, Jr., Rahill, R. L., Shaw, V. E., and Norton, D. R., 1972, Determination of mercury in geologic materials by flameless atomic absorption spectrometry: U.S. Geological Professional Paper 800-C, p. C203-C207.

Jackson, M. L., 1969, Soil chemical analysis-advanced course: University of Wisconsin, Madison, published by the author, 895 p.

Johnson, Art, Yake, William, and Norton, Dale, 1983, A summary of priority pollutant data for point sources and sediment in inner Commencement Bay: a prelim- inary assessment of data and considerations for future work, part 5, Milwaukee, Puyallup, St. Paul, Middle Waterways and S. W. shore Commencement Bay: Washington State Department of Ecology, 25 p.

McNeely, R. N., Neimanis, V. P., and Dwyer, L., 1979, Water quality sourcebook, a guide to water quality parameters: Inland Water Directorate, Water Quality Branch, Ottawa, Canada, 88 p.

Meyers, A. T., Havens, R. G., and Dunton, P. J., 1961, A spectrochemical method for the semiquantitative analysis of rocks, minerals, and ores: U.S. Geological Survey Bulletin 1084-I, p. 207-229.

Molenaar, Dee, 1961, Flowing artesian wells in Washington State: Washington Division of Water Resources Water-Supply Bulletin 16, 115 p.

Pierce County, 1974, Puyallup River basin water quality management plan: Consoer, Townsend and Associates, Consulting Engineers, 282 p.

Rattray, Jr., Maurice, and Mitsuda, Eugene, 1974, Theoretical analysis of conditions, in a salt wedge: Estuarine and Coastal Marine Science, v. 2, p. 375-394.

Skougstad, M. W., Fishman, M. J., Friedman, L. C., Erdmann, D. E., and Duncan, S. S., editors, 1979, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chapter A1, 626 p.

Solley, W. B., Chase, E. B., Mann, W. B., IV, 1983, Estimated use of water in the United States in 1980: U.S. Geological Survey Circular 1001, 56 p.

Turney, G. L., 1986, Quality of ground water in the Puget Sound region, Washington, 1981: U.S. Geological Survey Water-Resources Investigation 84-4258, 170 p., 2 pls.

U.S. Environmental Protection Agency, 1976a, National interim primary drinking water regulations: U.S. Environmental Protection Agency, 570/9-76-003, 159 p.

-----1976b, Interim primary drinking water regulations--Promulgation of regulations on radionuclides: Federal Register, v. 41, no. 133, Friday, July 9, 1976, pt. II, p. 28402-28409.

-----1977a, National secondary drinking water regulations: Federal Register, v. 42, no. 62, Thursday, March 31, 1977, pt. I, p. 17143-17147.

-----1977b, Quality criteria for water, 1976: U.S. Government Printing Office, 256 p.

-----1980, Water quality criteria documents, availability: Federal Register, v. 45, no. 231, Friday, November 28, 1980.

U.S. Geological Survey, 1960-68, 1971-82, Water resources data for Washington, pt. 2, Water quality records: Tacoma, Wash., annual tabulation for years indicated.

U.S. National Oceanic and Atmospheric Administration, 1981, Tide tables, 1982, West Coast of North and South America: 231 p.

Walters, K. L., 1971, Reconnaissance of seawater intrusion along coastal Washington, 1966-68; Washington Department of Ecology Water-Supply Bulletin 32, 208 p.

Walters, K. L., and Kimmel, G. E., 1968, Ground-water occurrence and stratigraphy of unconsolidated deposits, central Pierce County, Washington: Washington Department of Water Resources Water-Supply Bulletin 22, 428 p.

Washington State Department of Ecology, 1977, Washington State water quality standards: Office of Water Programs, Olympia, Wash., 31 p.

Washington State Department of Social and Health Services, 1978, Rules and regulations of the State Board of Health regarding public water systems: Health Services Division, Water Supply and Waste Section, Olympia, Wash., 48 p.

Wershaw, R. L., Fishman, M. J., Grabbe, R. R., and Lowe, L. E., 1983, Methods for the determination of organic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, Laboratory Analysis, chapter A3, Open-File Report 82-1004, 173 p.

Wood, W. W., 1976, Guidelines for collection and field analysis of ground-water samples for selected unstable constituents: U.S. Geological Survey Techniques of Water-Resources Investigations, book 1, chap. D2, 24 p.

GLOSSARY

Acutely toxic. Causing death or severe damage to an organism by poisoning during a brief exposure period, normally 96 hours or less, although there is no clear line of demarcation between acute and chronic toxicity.

Aliphatic. A large class of organic compounds characterized by an open-chain or non-resonant ring structure.

Alluvium. Deposits of silt, sand, etc., left by water.

Aquifer. A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Anions. Ions in solution that are negative in charge, such as chloride, sulfate, bicarbonate, and fluoride.

Anthropogenic. Relates to, or involves, the impact of man.

Aromatic compound. A large class of organic compounds characterized by one or more resonant ring structures.

Artesian aquifer. An aquifer containing water under sufficient pressure to rise above the top of the aquifer when penetrated by a well; also called confined aquifer.

Biochemical oxygen demand (BOD). A measure of the quantity of dissolved oxygen, in milligrams per liter, necessary for the decomposition of organic matter by microorganisms, such as bacteria.

Cations. Ions in solution that are positive in charge, such as calcium, magnesium, sodium, and potassium.

Confining bed. A body of relatively impermeable material stratigraphically adjacent to one or more aquifers. The hydraulic conductivity may range from nearly zero to some value distinctly lower than that of the aquifer.

Chronically toxic. Causing death or damage to an organism by poisoning during prolonged exposure, which, depending on the organism tested and the test conditions and purposes, may range from several days to weeks, months, or years.

Detection limit. The lowest value at which trace-element concentrations are reported in this study.

Discharge. The processes by which water is depleted from an aquifer. Also, the rate of flow expressed as volume per unit time.

Estuary. The tidal part of a river where freshwater mixes with and dilutes saltwater.

Fecal-coliform bacteria. Bacteria that are present in the intestines or feces of warmblooded animals. They are often used as indicators of the sanitary quality of the water. In the laboratory they are defined as all organisms which produce blue bacteria colonies within 24 hours when incubated at 44.5 degrees Celsius plus or minus 0.2 degrees Celsius on M-FC medium (nutrient medium for bacterial growth). Their concentrations are expressed as number of colonies per 100 mL of sample.

Fecal-streptococcal bacteria. Bacteria found also in intestines of warm-blooded animals. Their presence in water is considered to verify fecal pollution. They are characterized as gram-positive cocci bacteria which are capable of growth in brain-heart infusion broth. In the laboratory they are defined as all the organims which produce red or pink colonies within 48 hours at 35 degrees Celsius plus or minus 1.0 degrees Celsius on M-enterrococcus medium (nutrient medium for bacterial growth). Their concentrations are expressed as number of colonies per 100 mL of sample.

Glacial drift. Sediment deposited by glaciers and predominantly of glacial origin.

Head. The height above a standard datum of the surface of a column of water that can be supported by the static pressure at a given point.

Indole. A heterocyclic organic compound containing nitrogen. It is found in coal tar and in orange blossoms.

Ketone. A class of liquid organic compounds in which a carbonyl group (C=O) is attached to two alkyl groups. Ketones are used primarily as solvents, especially for cellulose derivatives in lacquers, paints, and textile processing.

Organic acid. An organic compound with one or more acid functional groups (COOH). Humic and fulvic acids are typical organic acids naturally occurring in aquatic environments.

Phthalate esters. Colorless, oily, highly stable liquids having very low volatility and solubility. Their primary use is in the production of polyvinyl chloride plastics, industrial oils, defoaming agents in paper, etc. Due to their large production volume and ease of extraction, they are ubiquitous low level pollutants. They are strongly attached to organic particles and in water rapidly settle into bottom sediments.

Piezometer. A piezometer is specially designed to measure the hydraulic head within a zone small enough to be considered a point--as contrasted with a well that reflects the average head of the aquifer for the screened interval.

Quantitation limit. Used in this report as the lowest concentration at which an organic compound can be analytically determined. The quantitation limit may differ from the detection limit, which is the lowest concentration that a compound's signal can be observed, but not necessarily quantified.

Recharge. The process by which water enters an aquifer.

Resonance. Whenever a molecule can be represented by two or more structures that differ only in the arrangement of electrons. The benzene ring is a resonant structure.

Saltwater. Water containing about 35,000 milligrams per liter of dissolved solids including about 19,000 milligrams per liter of chloride.

Saltwater intrusion. The movement of saltwater or brackish water into a freshwater aquifer due to the lowering of the freshwater head below sea level by pumping.

Suspended sediment. Sediment that at any given time is maintained in suspension by the upward components of turbulent currents or that exists in suspension as a colloid.

Total elemental concentration. The true concentration of an element in a sediment sample as determined by the complete dissolution of the sample. In this study, bed- and suspended-sediment samples were analyzed for total elemental concentrations.

Total recoverable. The amount of a given constituent that is extracted after a sample has been digested by a method that results in dissolution of readily soluble substances; complete dissolution is not achieved. In this study, selected water-suspended sediment samples were analyzed for total-recoverable trace elements.

Water table. That surface in an unconfined ground-water body at which the pressure is atmospheric.

D A T A   T A B L E S   12   T H R U   24

TABLE 12--Physical, biological, and chemical data for ground-water samples

[K indicates nonideal colony counts.]

WELL NO.	LOCAL IDENT-I-FIER	STATION NUMBER	DATE OF SAMPLE	TIME	ELEV. OF LAND SURFACE DATUM (FEET) ABOVE NGVD)	DEPTH OF WELL, TOTAL (FEET)	SPE-CIFIC CON-DUCT-ANCE (µS)	PH (STAND-ARD UNITS)	TEMPER-ATURE (DEG C)	OXYGEN, DIS-SOLVED (MG/L)
1	20/03E-01A01	471533122214701	84-02-23	1035	15.00	24.50	1860	6.4	15.0	0.0
			84-05-31	1030	15.00	24.50	1680	6.5	15.0	.0
			84-08-27	1045	15.00	24.50	1870	6.5	15.0	.0
2	20/03E-02K01	471457122230601	84-02-08	1015	13.00	14.40	548	6.3	12.0	2.7
			84-05-23	0830	13.00	14.40	540	6.7	11.5	--
			84-08-23	1030	13.00	14.40	550	6.7	13.0	7.3
3	20/03E-03F01	471504122243801	84-02-08	1115	13.00	14.30	2350	6.4	11.0	.0
			84-05-18	1315	13.00	14.30	2350	6.9	11.5	.0
			84-08-21	1400	13.00	14.30	2450	6.5	12.0	.0
16	20/03E-03L01	471447122244101	84-03-27	1430	10.00	534	134	7.6	--	.1
			84-08-30	1115	10.00	534	134	7.6	12.5	--
17	20/03E-11Q02	471341122224601	84-03-27	1330	18.00	315	170	7.7	11.5	.0
			84-08-29	1500	18.00	315	130	7.6	11.0	.2
4	20/03E-12F01	471419122220401	84-02-03	1145	12.00	14.60	335	6.5	9.0	.7
			84-05-21	1250	12.00	14.60	320	6.8	11.5	.0
			84-08-22	1045	12.00	14.60	318	6.6	15.0	.0
18	20/03E-12J01	471400122212701	84-04-02	1020	15.00	90.00	398	7.2	11.0	.0
			84-08-30	0945	15.00	90.00	408	7.3	11.0	.0
19	20/03E-13C02	471338122221701	84-03-29	1200	10.00	153	179	7.6	11.5	.1
5	20/03E-14A02	471339122224801	84-02-09	1330	18.00	24.40	258	7.2	11.0	.8
			84-05-16	1030	18.00	24.40	256	7.1	10.5	.2
			84-08-21	1245	18.00	24.40	250	7.3	11.0	.3
6	20/03E-15K03	471313122242501	84-02-14	1440	250.00	34.50	168	6.6	11.0	1.9
			84-05-29	1300	250.00	34.50	180	7.3	11.5	--
			84-08-23	1230	250.00	34.50	184	6.8	10.5	3.4
20	20/03E-25C02	471152122222001	84-04-02	1315	300.00	267	142	6.8	9.0	8.2
			84-08-29	1345	300.00	267	157	6.8	9.0	6.7
7	20/03E-25P01	471118122220901	84-02-22	1015	365.00	24.30	140	6.6	--	2.5
			84-05-29	1200	365.00	24.30	132	6.7	11.0	7.4
			84-08-23	1315	365.00	24.30	127	6.4	10.0	6.4
21	20/03E-36P01	471018122221001	84-04-02	1200	440.00	597	151	6.5	9.5	8.7
			84-08-29	1245	440.00	597	164	6.6	9.0	7.9
8	20/04E-06L01	471448122205501	84-02-06	1150	10.00	14.60	670	6.6	10.5	1.3
			84-05-16	0900	10.00	14.60	675	6.6	11.0	.0
			84-08-21	1530	10.00	14.60	695	6.5	--	--
			84-08-22	1530	10.00	14.60	695	6.5	14.5	.0
22	20/04E-07G01	471418122202701	84-03-29	0915	15.00	350	302	7.8	12.0	.1
			84-08-31	1100	15.00	350	312	7.4	12.5	--

TABLE 12.--Continued

WELL NO.	LOCAL IDENT-I-FIER	DATE OF SAMPLE	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	HARD-NESS (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)
1	20/03E-01A01	84-02-23	<1	<1	--	--	--	--	--	--	220
		84-05-31	<1	<1	450	53	78	180	25	520	170
		84-08-27	<2	<2	--	--	--	--	--	--	--
2	20/03E-02K01	84-02-08	<1	<1	--	--	--	--	--	--	9.5
		84-05-23	22	K2	180	28	27	30	24	152	8.0
		84-08-23	<2	K2	--	--	--	--	--	--	--
3	20/03E-03F01	84-02-08	<2	K12	--	--	--	--	--	--	51
		84-05-18	<3	K5	730	180	68	140	62	1030	38
		84-08-21	<2	<2	800	210	68	150	68	1110	39
16	20/03E-03L01	84-03-27	<1	<1	32	7.4	3.3	15	2.3	69	1.9
		84-08-30	--	--	33	7.7	3.3	15	2.1	67	2.2
17	20/03E-11Q02	84-03-27	<1	<1	47	11	4.7	7.9	1.5	65	1.9
		84-08-29	--	--	48	11	4.9	8.1	1.4	63	5.2
4	20/03E-12F01	84-02-03	<2	<2	--	--	--	--	--	--	28
		84-05-21	<1	<1	88	22	8.0	12	2.0	91	28
		84-08-22	<2	<3	--	--	--	--	--	--	--
18	20/03E-12J01	84-04-02	<1	K3	130	24	18	24	6.5	211	4.5
		84-08-30	<1	<1	140	26	19	24	6.6	207	6.9
19	20/03E-13C02	84-03-29	<1	<1	53	11	6.3	16	2.7	94	2.2
5	20/03E-14A02	84-02-09	<1	<1	--	--	--	--	--	--	2.8
		84-05-16	<1	<1	110	18	15	13	3.4	135	2.5
		84-08-21	<1	K15	--	--	--	--	--	--	--
6	20/03E-15K03	84-02-14	<1	<1	--	--	--	--	--	--	--
		84-05-29	<1	K1	59	11	7.6	8.4	2.2	56	6.2
		84-08-23	<1	K820	--	--	--	--	--	--	--
20	20/03E-25C02	84-04-02	<1	<1	59	13	6.5	5.7	1.4	58	5.6
		84-08-29	<1	<1	63	14	6.9	6.0	1.4	59	6.2
7	20/03E-25P01	84-02-22	<1	K16	--	--	--	--	--	--	5.5
		84-05-29	<1	<1	42	7.9	5.5	7.0	.90	45	4.5
		84-08-23	<1	1	--	--	--	--	--	--	--
21	20/03E-36P01	84-04-02	<1	<1	60	14	6.1	6.3	1.1	54	6.3
		84-08-29	<1	<1	64	14	7.0	6.0	1.2	56	8.5
8	20/04E-06L01	84-02-06	<1	<1	--	--	--	--	--	--	30
		84-05-16	<1	<1	150	37	15	48	3.2	249	31
		84-08-21	--	--	--	--	--	--	--	--	--
		84-08-22	<3	<1	--	--	--	--	--	--	--
22	20/04E-07G01	84-03-29	<1	K6	73	11	11	38	4.1	161	7.4
		84-08-31	<1	<1	75	12	11	38	3.6	159	7.4

TABLE 12.--Continued

WELL NO.	LOCAL IDENT-I-FIER	DATE OF SAMPLE	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SULFATE DIS-SOLVED (MG/L AS SO4)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, ORGANIC TOTAL (MG/L AS N)	NITRO-GEN, ORGANIC DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)
1	20/03E-01A01	84-02-23	--	--	--	<0.010	0.23	2.10	1.0	1.9	3.9
		84-05-31	0.60	150	1100	--	--	--	--	--	--
		84-08-27	--	--	--	<.010	<.10	2.40	1.9	1.8	4.3
2	20/03E-02K01	84-02-08	--	--	--	<.010	<.10	2.20	2.8	2.3	5.0
		84-05-23	2.0	110	370	--	--	--	--	--	--
		84-08-23	--	--	--	1.90	2.1	1.10	2.6	2.6	3.8
3	20/03E-03F01	84-02-08	--	--	--	.010	<.10	15.0	3.0	3.0	18
		84-05-18	.70	25	1400	--	--	--	--	--	--
		84-08-21	.70	12	1500	.020	<.10	19.0	1.0	2.0	22
16	20/03E-03L01	84-03-27	.20	.5	120	<.010	<.10	.300	--	--	--
		84-08-30	.20	1.1	120	--	<.10	--	--	--	--
17	20/03E-11Q02	84-03-27	.20	2.7	110	<.010	<.10	.030	--	--	--
		84-08-29	.10	2.2	120	--	<.10	--	--	--	--
4	20/03E-12F01	84-02-03	--	--	--	<.010	<.10	2.80	.40	.20	3.7
		84-05-21	.30	12	240	--	--	--	--	--	--
		84-08-22	--	--	--	<.010	<.10	3.50	1.0	.80	4.5
18	20/03E-12J01	84-04-02	.40	2.3	260	<.010	.14	.370	--	--	--
		84-08-30	.40	2.5	220	--	<.10	--	--	--	--
19	20/03E-13C02	84-03-29	.20	2.0	150	<.010	<.10	1.60	--	--	--
5	20/03E-14A02	84-02-09	--	--	--	<.010	<.10	1.50	.20	.10	1.8
		84-05-16	.20	4.5	190	--	--	--	--	--	--
		84-08-21	--	--	--	<.010	<.10	1.30	.10	.20	1.6
6	20/03E-15K03	84-02-14	--	--	--	.050	<.10	.070	.23	.13	.30
		84-05-29	<.10	16	120	--	--	--	--	--	--
		84-08-23	--	--	--	.030	.87	.080	1.2	.52	1.3
20	20/03E-25C02	84-04-02	<.10	4.9	100	<.010	1.5	.040	--	--	--
		84-08-29	<.10	4.9	120	--	1.6	--	--	--	--
7	20/03E-25P01	84-02-22	--	--	--	.040	.15	<.010	--	--	<.20
		84-05-29	<.10	4.4	89	--	--	--	--	--	--
		84-08-23	--	--	--	<.010	.64	.030	.28	.27	.30
21	20/03E-36P01	84-04-02	<.10	7.4	100	<.010	2.4	.040	--	--	--
		84-08-29	<.10	7.3	110	--	2.7	--	--	--	--
8	20/04E-06L01	84-02-06	--	--	--	<.010	<.10	4.00	6.0	6.0	10
		84-05-16	.60	5.9	410	--	--	--	--	--	--
		84-08-21	--	--	--	--	--	--	--	--	--
		84-08-22	--	--	--	.030	<.10	13.0	.00	-1.0	12
22	20/04E-07G01	84-03-29	.30	1.8	220	<.010	.57	.750	--	--	--
		84-08-31	.30	2.1	220	--	<.10	--	--	--	--

TABLE 12.--Continued

WELL NO.	LOCAL IDENT-I-FIER	DATE OF SAMPLE	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC DIS-SOLVED (μG/L AS AS)	CADMIUM DIS-SOLVED (μG/L AS CD)	CHRO-MIUM, DIS-SOLVED (μG/L AS CR)	COPPER, DIS-SOLVED (μG/L AS CU)	IRON, DIS-SOLVED (μG/L AS FE)
1	20/03E-01A01	84-02-23	4.0	0.620	0.550	--	--	--	--	--	--
		84-05-31	--	--	--	50	<1	<1	<1	<1	42000
		84-08-27	4.2	.580	.470	50	3	3	7	1	43
2	20/03E-02K01	84-02-08	4.5	.030	.010	--	--	--	--	--	--
		84-05-23	--	--	--	20	<1	<1	<1	17	1100
		84-08-23	3.7	.100	.010	40	<1	<1	<1	27	500
3	20/03E-03F01	84-02-08	18	.880	<.010	--	--	--	--	--	--
		84-05-18	--	--	--	40	50	<1	<1	<1	210000
		84-08-21	21	2.20	--	--	--	--	--	--	--
16	20/03E-03L01	84-03-27	--	--	.580	<10	<1	<1	<1	1	130
		84-08-30	--	--	--	<10	<1	<1	<1	<1	82
17	20/03E-11Q02	84-03-27	--	--	.880	<10	<1	<1	<1	2	190
		84-08-29	--	--	--	<10	<1	<1	8	<1	120
4	20/03E-12F01	84-02-03	3.0	1.40	<.010	--	--	--	--	--	--
		84-05-21	--	--	--	10	5	<1	1	<1	37000
		84-08-22	4.3	1.30	<.010	20	2	<1	1	<1	9300
18	20/03E-12J01	84-04-02	--	--	.950	<10	<1	<1	<1	<1	2000
		84-08-30	--	--	--	10	<1	<1	<1	<1	1300
19	20/03E-13C02	84-03-29	--	--	.480	<10	<1	<1	<1	<1	580
5	20/03E-14A02	84-02-09	1.6	.360	.330	--	--	--	--	--	--
		84-05-16	--	--	--	<10	<1	<1	1	<1	1300
		84-08-21	1.5	.360	.310	10	<1	1	4	<1	670
6	20/03E-15K03	84-02-14	.20	.010	.010	--	--	--	--	--	--
		84-05-29	--	--	--	10	<1	<1	<1	2	20
		84-08-23	.60	.570	<.010	10	<1	<1	<1	<1	48
20	20/03E-25C02	84-04-02	--	--	.030	<10	<1	<1	<1	3	30
		84-08-29	--	--	--	<10	<1	<1	8	1	4
7	20/03E-25P01	84-02-22	<.20	.110	.010	--	--	--	--	--	--
		84-05-29	--	--	--	10	<1	<1	<1	<1	<10
		84-08-23	.30	.070	<.010	20	<1	<1	<1	<1	11
21	20/03E-36P01	84-04-02	--	--	.020	<10	<1	<1	<1	4	40
		84-08-29	--	--	--	10	<1	<1	6	1	6
8	20/04E-06L01	84-02-06	10	1.40	.070	--	--	--	--	--	--
		84-05-16	--	--	--	<10	1	<1	<1	<1	49000
		84-08-21	--	--	--	20	1	1	1	4	39000
		84-08-22	12	1.20	.240	--	--	--	--	--	--
22	20/04E-07G01	84-03-29	--	--	.810	<10	1	<1	<1	<1	430
		84-08-31	--	--	--	<10	2	<1	<1	<1	240

TABLE 12.--Continued

WELL NO.	LOCAL IDENT- I- FIER	DATE OF SAMPLE	LEAD, DIS- SOLVED (µG/L AS PB)	MANGA- NESE, DIS- SOLVED (µG/L AS MN)	MERCURY DIS- SOLVED (µG/L AS HG)	NICKEL, DIS- SOLVED (µG/L AS NI)	SILVER, DIS- SOLVED (µG/L AS AG)	ZINC, DIS- SOLVED (µG/L AS ZN)
1	20/03E-01A01	84-02-23	--	--	--	--	--	--
		84-05-31	<1	2700	<0.1	<1	<1	10
		84-08-27	<1	2700	<.1	2	<1	6
2	20/03E-02K01	84-02-08	--	--	--	--	--	--
		84-05-23	<1	4300	<.1	15	2	10
		84-08-23	3	4200	<.1	7	<1	8
3	20/03E-03F01	84-02-08	--	--	--	--	--	--
		84-05-18	<1	3100	.1	<1	<1	10
		84-08-21	--	--	--	--	--	--
16	20/03E-03L01	84-03-27	<1	90	<.1	2	<1	<10
		84-08-30	<1	92	<.1	<1	<1	10
17	20/03E-11Q02	84-03-27	<1	60	<.1	2	<1	10
		84-08-29	<1	59	<.1	<1	<1	9
4	20/03E-12F01	84-02-03	--	--	--	--	--	--
		84-05-21	<1	2300	<.1	8	<1	<10
		84-08-22	<1	2300	<.1	5	<1	<3
18	20/03E-12J01	84-04-02	<1	160	<.1	2	<1	50
		84-08-30	<1	140	<.1	<1	<1	28
19	20/03E-13C02	84-03-29	<1	110	<.1	1	<1	10
5	20/03E-14A02	84-02-09	--	--	--	--	--	--
		84-05-16	<1	100	<.1	15	<1	<10
		84-08-21	1	60	<.1	4	<1	<10
6	20/03E-15K03	84-02-14	--	--	--	--	--	--
		84-05-29	<1	1000	<.1	8	<1	70
		84-08-23	<1	940	<.1	28	2	19
20	20/03E-25C02	84-04-02	3	<10	<.1	8	<1	40
		84-08-29	4	<1	<.1	1	<1	6
7	20/03E-25P01	84-02-22	--	--	--	--	--	--
		84-05-29	2	100	<.1	2	<1	20
		84-08-23	<1	120	<.1	15	<1	120
21	20/03E-36P01	84-04-02	5	<10	<.1	5	<1	10
		84-08-29	<1	3	<.1	<1	<1	8
8	20/04E-06L01	84-02-06	--	--	--	--	--	--
		84-05-16	<1	2400	<.1	<1	<1	<10
		84-08-21	<1	2400	<.1	4	3	<3
		84-08-22	--	--	--	--	--	--
22	20/04E-07G01	84-03-29	<1	150	<.1	1	<1	20
		84-08-31	3	140	<.1	<1	<1	11

WELL NO.	LOCAL IDENT-I-FIER	STATION NUMBER	DATE OF SAMPLE	TIME	ELEV. OF LAND SURFACE DATUM (FEET ABOVE NGVD)	DEPTH OF WELL, TOTAL (FEET)	SPE-CIFIC CON-DUCT-ANCE (μS)	PH (STAND-ARD UNITS)	TEMPER-ATURE (DEG C)	OXYGEN, DIS-SOLVED (MG/L)
9	20/04E-07Q02	471353122204301	84-02-06	0915	20.00	14.50	220	6.5	11.0	--
			84-05-21	1245	20.00	14.50	250	6.9	11.0	.8
			84-08-22	1215	20.00	14.50	243	6.6	14.5	0.5
23	20/04E-08M01	471401122195801	84-04-10	1320	20.00	168	272	7.5	11.5	1.9
			84-08-31	1230	20.00	168	272	7.2	12.0	--
24	20/04E-10N01	471348122173001	84-04-09	1430	365.00	238	185	6.7	10.0	5.6
			84-08-30	1330	365.00	238	188	6.2	10.0	--
25	20/04E-16G01	471325122180601	84-04-09	1330	140.00	419	155	7.2	10.5	.2
			84-08-30	1430	140.00	419	153	7.1	10.5	.3
10	20/04E-17Q01	471251122191801	84-02-03	1045	30.00	14.40	138	6.2	8.0	1.9
			84-05-23	0930	30.00	14.40	160	6.3	10.5	4.3
			84-08-22	1145	30.00	14.40	171	6.5	11.0	4.1
26	20/04E-18L01	471308122205601	84-03-29	1045	20.00	237	275	7.2	11.5	.2
			84-08-28	1500	20.00	237	283	7.1	16.0	.0
11	20/04E-18M02	471312122211201	84-02-09	1015	20.00	24.20	200	6.6	10.5	--
			84-05-17	1200	20.00	24.20	200	6.7	11.5	.0
			84-08-21	1030	20.00	24.20	180	6.5	10.0	.6
27	20/04E-20C01	471241122194001	84-04-10	1230	25.00	801	260	7.9	12.5	.1
			84-08-28	1345	25.00	801	267	7.5	13.0	.1
28	20/04E-20C02	471242122193802	84-03-28	1300	30.00	300	253	7.4	11.0	.4
			84-08-31	0930	30.00	300	262	7.3	12.0	3.4
29	20/04E-30H01	471134122201601	84-03-27	1230	30.00	332	138	7.6	11.5	.2
			84-08-27	1415	30.00	332	135	8.3	11.0	.3
12	20/04E-30H02	471136122201001	84-02-10	1200	30.00	14.80	215	6.7	10.5	2.3
			84-05-17	1100	30.00	14.80	130	6.6	12.0	.8
			84-05-17	1100	30.00	14.80	130	6.6	12.0	.8
			84-08-23	1400	30.00	14.80	137	6.8	13.0	.6
30	20/04E-32J01S	471015122190001	84-02-15	1420	100.00	--	162	7.1	9.0	--
			84-05-29	1000	100.00	--	167	6.8	9.0	8.7
			84-08-27	1345	100.00	--	162	7.3	9.0	7.8
13	21/03E-25C01	471653122220201	84-02-08	1530	400.00	32.30	125	6.7	11.0	5.0
			84-05-24	1000	400.00	32.30	131	7.3	10.5	--
			84-08-23	1130	400.00	32.30	129	6.2	10.0	8.8
31	21/03E-25P01	471629122220501	84-03-29	1330	200.00	417	140	7.6	10.0	.1
			84-08-28	1230	200.00	417	146	7.5	10.0	.2
32	21/03E-26N01	471725122230701	84-03-28	0930	11.00	785	350	8.1	15.5	.2
			84-08-29	0930	11.00	785	351	6.9	15.0	.1
14	21/03E-34J01	471548122235901	84-02-08	1045	13.00	14.40	1260	6.2	11.0	.8
			84-05-22	1405	13.00	14.40	1080	6.8	11.0	3.0
			84-08-22	1430	13.00	14.40	1080	7.1	13.0	1.0

WELL NO.	LOCAL IDENT- I- FIER	DATE OF SAMPLE	COLI- FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP- TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	HARD- NESS (MG/L AS CACO3)	CALCIUM DIS- SOLVED (MG/L AS CA)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG)	SODIUM, DIS- SOLVED (MG/L AS NA)	POTAS- SIUM, DIS- SOLVED (MG/L AS K)	ALKA- LINITY LAB (MG/L AS CACO3)	CHLO- RIDE, DIS- SOLVED (MG/L AS CL)
9	20/04E-07Q02	84-02-06	<1	K3	--	--	--	--	--	--	7.1
		84-05-21	K4	<1	85	20	8.4	16	2.5	113	7.3
		84-08-22	<2	<2	--	--	--	--	--	--	--
23	20/04E-08M01	84-04-10	<1	K2	75	18	7.3	24	4.4	129	8.8
		84-08-31	<1	<1	79	20	7.1	24	4.1	129	8.5
24	20/04E-10N01	84-04-09	<1	<1	75	16	8.5	6.5	1.8	65	6.4
		84-08-30	--	--	78	17	8.7	6.6	1.7	67	6.2
25	20/04E-16G01	84-04-09	<1	<1	62	15	5.9	6.7	1.9	74	2.3
		84-08-30	<1	<1	61	15	5.8	6.5	1.7	75	1.9
10	20/04E-17Q01	84-02-03	<2	<2	--	--	--	--	--	--	1.0
		84-05-23	<1	<1	53	14	4.3	7.3	2.5	69	.80
		84-08-22	<2	<2	--	--	--	--	--	--	--
26	20/04E-18L01	84-03-29	<1	<1	74	13	10	20	3.4	137	3.6
		84-08-28	<1	<1	74	13	10	20	3.1	133	7.4
11	20/04E-18M02	84-02-09	<1	<1	--	--	--	--	--	--	3.5
		84-05-17	<1	<2	52	12	5.4	9.7	1.9	76	3.8
		84-08-21	<1	<1	--	--	--	--	--	--	--
27	20/04E-20C01	84-04-10	<1	<1	70	20	4.9	25	5.6	127	7.5
		84-08-28	<1	<1	73	21	5.0	26	5.7	128	17
28	20/04E-20C02	84-03-28	<1	<1	86	21	8.2	17	4.8	131	3.6
		84-08-31	<1	<1	90	22	8.4	18	4.6	136	3.8
29	20/04E-30H01	84-03-27	<1	<1	49	11	5.3	7.9	2.2	64	4.7
		84-08-27	--	--	52	12	5.4	7.9	2.2	67	2.9
12	20/04E-30H02	84-02-10	K2	<1	--	--	--	--	--	--	2.2
		84-05-17	<1	<1	49	10	5.8	6.9	2.0	63	2.1
		84-05-17	--	--	49	10	5.8	6.9	2.0	63	2.1
		84-08-23	<1	<1	--	--	--	--	--	--	--
30	20/04E-32J01S	84-02-15	<1	<1	--	--	--	--	--	--	4.6
		84-05-29	<1	<1	66	14	7.6	5.9	2.0	62	4.5
		84-08-27	<1	<1	--	--	--	--	--	--	--
13	21/03E-25C01	84-02-08	<1	<1	--	--	--	--	--	--	5.7
		84-05-24	<1	K1	40	11	3.1	6.1	1.0	21	4.7
		84-08-23	<1	<1	--	--	--	--	--	--	--
31	21/03E-25P01	84-03-29	<1	<1	56	13	5.6	6.3	1.8	70	2.1
		84-08-28	<1	<1	58	14	5.6	6.4	1.9	68	2.3
32	21/03E-26N01	84-03-28	<1	<1	67	18	5.3	52	2.4	170	14
		84-08-29	<1	<1	69	19	5.2	52	2.3	166	14
14	21/03E-34J01	84-02-08	<1	K11	--	--	--	--	--	--	33
		84-05-22	<1	<1	410	110	34	67	21	470	31
		84-08-22	<2	<2	--	--	--	--	--	--	--

WELL NO.	LOCAL IDENT-I-FIER	DATE OF SAMPLE	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SULFATE DIS-SOLVED (MG/L AS SO4)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, ORGANIC TOTAL (MG/L AS N)	NITRO-GEN, ORGANIC DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)
9	20/04E-07Q02	84-02-06	--	--	--	<.010	<.10	1.60	.30	.20	1.9
		84-05-21	.40	10	210	--	--	--	--	--	--
		84-08-22	--	--	--	<0.010	<0.10	2.00	0.30	0.10	2.4
23	20/04E-08M01	84-04-10	0.30	1.0	190	<.010	<.10	1.40	--	--	--
		84-08-31	.20	2.0	190	--	<.10	--	--	--	--
24	20/04E-10N01	84-04-09	<.10	8.8	120	<.010	2.5	.010	--	--	--
		84-08-30	<.10	9.1	140	--	2.6	--	--	--	--
25	20/04E-16G01	84-04-09	.10	2.7	110	<.010	<.10	<.010	--	--	--
		84-08-30	<.10	2.9	110	--	<.10	--	--	--	--
10	20/04E-17Q01	84-02-03	--	--	--	<.010	<.10	.090	2.9	.21	3.0
		84-05-23	.20	15	140	--	--	--	--	--	--
		84-08-22	--	--	--	<.010	<.10	.380	.28	.32	.60
26	20/04E-18L01	84-03-29	.40	3.4	200	<.010	<.10	.150	--	--	--
		84-08-28	.40	8.9	200	--	<.10	--	--	--	--
11	20/04E-18M02	84-02-09	--	--	--	<.010	<.10	2.60	.90	.70	3.6
		84-05-17	.40	19	190	--	--	--	--	--	--
		84-08-21	--	--	--	<.010	<.10	3.40	.40	.10	3.6
27	20/04E-20C01	84-04-10	.20	1.0	180	<.010	<.10	.250	--	--	--
		84-08-28	.20	1.8	200	--	<.10	--	--	--	--
28	20/04E-20C02	84-03-28	.20	.9	180	<.010	<.10	.760	--	--	--
		84-08-31	.20	1.7	180	--	<.10	--	--	--	--
29	20/04E-30H01	84-03-27	.10	2.1	110	<.010	<.10	<.010	--	--	--
		84-08-27	.10	2.0	110	--	<.10	--	--	--	--
12	20/04E-30H02	84-02-10	--	--	--	<.010	<.10	.540	.06	.06	.60
		84-05-17	.20	2.8	110	--	--	--	--	--	--
		84-05-17	.20	2.8	110	--	--	--	--	--	--
		84-08-23	--	--	--	<.010	<.10	.310	.25	.19	.40
30	20/04E-32J01S	84-02-15	--	--	--	.010	1.5	.030	.26	.27	.30
		84-05-29	<.10	4.7	110	--	--	--	--	--	--
		84-08-27	--	--	--	<.010	1.6	.010	1.6	.89	1.6
13	21/03E-25C01	84-02-08	--	--	--	.010	1.5	.020	.29	.28	.30
		84-05-24	<.10	20	80	--	--	--	--	--	--
		84-08-23	--	--	--	<.010	2.4	.010	.37	.49	.40
31	21/03E-25P01	84-03-29	.10	3.3	110	<.010	.19	.210	--	--	--
		84-08-28	.10	3.7	110	--	<.10	--	--	--	--
32	21/03E-26N01	84-03-28	.10	2.0	240	<.010	<.10	1.20	--	--	--
		84-08-29	.10	2.2	240	--	<.10	--	--	--	--
14	21/03E-34J01	84-02-08	--	--	--	<.010	<.10	2.10	.70	.70	2.8
		84-05-22	.90	84	660	--	--	--	--	--	--
		84-08-22	--	--	--	<.010	<.10	2.10	.60	.60	2.9

WELL NO.	LOCAL IDENT-I-FIER	DATE OF SAMPLE	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	ALUM-INUM, DIS-SOLVED (µG/L AS AL)	ARSENIC DIS-SOLVED (µG/L AS AS)	CADMIUM DIS-SOLVED (µG/L AS CD)	CHRO-MIUM, DIS-SOLVED (µG/L AS CR)	COPPER, DIS-SOLVED (µG/L AS CU)	IRON, DIS-SOLVED (µG/L AS FE)
9	20/04E-07Q02	84-02-06	1.8	.210	.010	--	--	--	--	--	--
		84-05-21	--	--	--	20	2	<1	<1	<1	18000
		84-08-22	2.1	0.220	0.080	30	<1	<1	3	1	10000
23	20/04E-08M01	84-04-10	--	--	.750	20	<1	<1	<1	<1	710
		84-08-31	--	--	--	20	<1	<1	<1	<1	420
24	20/04E-10N01	84-04-09	--	--	.040	20	<1	<1	<1	1	20
		84-08-30	--	--	--	<10	<1	<1	<1	<1	11
25	20/04E-16G01	84-04-09	--	--	.130	<10	3	<1	<1	<1	20
		84-08-30	--	--	--	<10	2	<1	<1	<1	<3
10	20/04E-17Q01	84-02-03	.30	.070	<.010	--	--	--	--	--	--
		84-05-23	--	--	--	<10	<1	1	<1	4	2100
		84-08-22	.70	.120	<.010	20	<1	<1	<1	7	83
26	20/04E-18L01	84-03-29	--	--	.720	<10	<1	<1	1	<1	4400
		84-08-28	--	--	--	<10	<1	<1	6	<1	<3
11	20/04E-18M02	84-02-09	3.3	.770	.560	--	--	--	--	--	--
		84-05-17	--	--	--	20	3	<1	1	<1	17000
		84-08-21	3.5	.590	.430	10	<1	2	<1	32	5000
27	20/04E-20C01	84-04-10	--	--	.540	10	18	<1	<1	<1	120
		84-08-28	--	--	--	<10	18	<1	10	<1	54
28	20/04E-20C02	84-03-28	--	--	.400	<10	<1	<1	<1	<1	310
		84-08-31	--	--	--	20	<1	<1	<1	2	220
29	20/04E-30H01	84-03-27	--	--	.190	<10	4	<1	<1	<1	30
		84-08-27	--	--	--	<10	4	<1	4	1	7
12	20/04E-30H02	84-02-10	.60	.260	.150	--	--	--	--	--	--
		84-05-17	--	--	--	10	<1	<1	<1	<1	720
		84-05-17	--	--	--	--	--	--	--	--	--
		84-08-23	.50	.190	.110	10	<1	<1	5	1	530
30	20/04E-32J01S	84-02-15	.30	.040	.020	--	--	--	--	--	--
		84-05-29	--	--	--	10	<1	<1	<1	<1	<10
		84-08-27	.90	.030	.010	<10	1	<1	5	<1	<3
13	21/03E-25C01	84-02-08	.30	<.010	<.010	--	--	--	--	--	--
		84-05-24	--	--	--	<10	<1	<1	<1	3	20
		84-08-23	.50	.060	<.010	10	<1	<1	<1	2	7
31	21/03E-25P01	84-03-29	--	--	.160	<10	1	<1	<1	<1	90
		84-08-28	--	--	--	<10	<1	<1	3	<1	57
32	21/03E-26N01	84-03-28	--	--	.650	<10	13	<1	<1	<1	100
		84-08-29	--	--	--	<10	12	<1	<1	<1	390
14	21/03E-34J01	84-02-08	2.8	.830	.730	--	--	--	--	--	--
		84-05-22	--	--	--	10	<1	<1	<1	<1	260
		84-08-22	2.7	1.30	.750	20	<1	<1	<1	<1	250

WELL NO.	LOCAL IDENT-I-FIER	DATE OF SAMPLE	LEAD, DIS-SOLVED (μG/L AS PB)	MANGA-NESE, DIS-SOLVED (μG/L AS MN)	MERCURY DIS-SOLVED (μG/L AS HG)	NICKEL, DIS-SOLVED (μG/L AS NI)	SILVER, DIS-SOLVED (μG/L AS AG)	ZINC, DIS-SOLVED (μG/L AS ZN)
9	20/04E-07Q02	84-02-06	--	--	--	--	--	--
		84-05-21	<1	1300	<.1	<1	<1	10
		84-08-22	<1	1400	<0.1	2	<1	<3
23	20/04E-08M01	84-04-10	<1	140	<.1	3	<1	20
		84-08-31	<1	140	<.1	2	<1	7
24	20/04E-10N01	84-04-09	2	<10	<.1	2	<1	10
		84-08-30	<1	2	<.1	1	<1	16
25	20/04E-16G01	84-04-09	<1	<10	<.1	3	<1	10
		84-08-30	3	39	<.1	1	<1	15
10	20/04E-17Q01	84-02-03	--	--	--	--	--	--
		84-05-23	<1	3200	<.1	22	1	10
		84-08-22	3	3900	<.1	27	2	33
26	20/04E-18L01	84-03-29	<1	320	<.1	1	<1	310
		84-08-28	3	290	<.1	1	<1	520
11	20/04E-18M02	84-02-09	--	--	--	--	--	--
		84-05-17	<1	790	<.1	7	<1	20
		84-08-21	7	630	.1	5	<1	10
27	20/04E-20C01	84-04-10	<1	70	<.1	3	<1	<10
		84-08-28	4	68	<.1	<1	<1	<3
28	20/04E-20C02	84-03-28	3	100	<.1	2	<1	10
		84-08-31	1	93	<.1	8	<1	12
29	20/04E-30H01	84-03-27	2	30	<.1	<1	<1	10
		84-08-27	4	33	.1	9	<1	32
12	20/04E-30H02	84-02-10	--	--	--	--	--	--
		84-05-17	<1	60	<.1	10	<1	<10
		84-05-17	--	--	--	--	--	--
		84-08-23	3	60	<.1	15	<1	29
30	20/04E-32J01S	84-02-15	--	--	--	--	--	--
		84-05-29	<1	<10	<.1	<1	<1	30
		84-08-27	2	<1	<.1	4	<1	9
13	21/03E-25C01	84-02-08	--	--	--	--	--	--
		84-05-24	<1	480	<.1	8	<1	30
		84-08-23	1	230	<.1	15	<1	17
31	21/03E-25P01	84-03-29	2	130	<.1	2	<1	<10
		84-08-28	2	140	<.1	1	<1	<3
32	21/03E-26N01	84-03-28	<1	70	<.1	2	<1	10
		84-08-29	5	66	<.1	1	<1	<3
14	21/03E-34J01	84-02-08	--	--	--	--	--	--
		84-05-22	<1	110	<.1	2	<1	<10
		84-08-22	<1	77	.3	6	<1	<3

WELL NO.	LOCAL IDENT-I-FIER	STATION NUMBER	DATE OF SAMPLE	TIME	ELEV. OF LAND SURFACE DATUM (FT. ABOVE NGVD)	DEPTH OF WELL, TOTAL (FEET)	SPE-CIFIC CON-DUCT-ANCE (µS)	PH (STAND-ARD UNITS)	TEMPER-ATURE (DEG C)	OXYGEN, DIS-SOLVED (MG/L)
15	21/03E-35D01	471619122233601	84-02-03	1250	13.00	14.40	1440	6.8	9.5	1.5
			84-05-23	1115	13.00	14.40	1500	6.8	11.0	1.3
			84-08-22	1345	13.00	14.40	1420	7.0	13.0	0.0
33	21/03E-36Q01	471537122214501	84-03-28	1130	19.00	901	270	7.9	13.5	.3
			84-09-04	1315	19.00	901	270	8.1	13.5	.4
34	21/04E-32M01	471541122200001	84-03-28	1430	75.00	1050	435	8.2	12.0	.0
			84-08-29	1030	75.00	1050	463	7.8	12.5	.1

WELL NO.	LOCAL IDENT-I-FIER	DATE OF SAMPLE	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	HARD-NESS (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)
15	21/03E-35D01	84-02-03	<1	<1	--	--	--	--	--	--	14
		84-05-23	<1	<1	600	130	68	87	27	507	14
		84-08-22	<1	<1	--	--	--	--	--	--	--
33	21/03E-36Q01	84-03-28	<1	<1	71	19	5.7	27	4.6	132	9.2
		84-09-04	<1	<1	73	20	5.7	27	4.8	125	9.4
34	21/04E-32M01	84-03-28	<1	<1	100	27	8.7	47	2.9	136	60
		84-08-29	<1	<1	110	30	8.8	49	2.8	133	62

WELL NO.	LOCAL IDENT-I-FIER	DATE OF SAMPLE	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SULFATE DIS-SOLVED (MG/L AS SO4)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, ORGANIC TOTAL (MG/L AS N)	NITRO-GEN, ORGANIC DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)
15	21/03E-35D01	84-02-03	--	--	--	<.010	<.10	5.50	.50	.50	6.0
		84-05-23	1.2	330	1000	--	--	--	--	--	--
		84-08-22	--	--	--	<0.010	<0.10	5.00	-0.10	-1.0	4.9
33	21/03E-36Q01	84-03-28	0.20	1.2	190	<.010	<.10	.390	--	--	--
		84-09-04	.20	1.6	180	--	<.10	--	--	--	--
34	21/04E-32M01	84-03-28	.10	.8	250	<.010	<.10	1.00	--	--	--
		84-08-29	<.10	.9	260	--	<.10	--	--	--	--

TABLE 12.--Continued

WELL NO.	LOCAL IDENT-I-FIER	DATE OF SAMPLE	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	ALUM-INUM, DIS-SOLVED (μG/L AS AL)	ARSENIC DIS-SOLVED (μG/L AS AS)	CADMIUM DIS-SOLVED (μG/L AS CD)	CHRO-MIUM, DIS-SOLVED (μG/L AS CR)	COPPER, DIS-SOLVED (μG/L AS CU)	IRON, DIS-SOLVED (μG/L AS FE)
15	21/03E-35D01	84-02-03	6.0	1.30	.120	--	--	--	--	--	--
		84-05-23	--	--	--	<10	<1	<1	<1	<1	5600
		84-08-22	4.0	0.950	0.570	20	<1	<1	1	<1	41
33	21/03E-36Q01	84-03-28	--	--	.520	<10	12	<1	1	<1	20
		84-09-04	--	--	--	20	12	<1	<1	<1	21
34	21/04E-32M01	84-03-28	--	--	.210	<10	8	<1	1	<1	400
		84-08-29	--	--	--	10	8	<1	5	4	100

WELL NO.	LOCAL IDENT-I-FIER	DATE OF SAMPLE	LEAD, DIS-SOLVED (μG/L AS PB)	MANGA-NESE, DIS-SOLVED (μG/L AS MN)	MERCURY DIS-SOLVED (μG/L AS HG)	NICKEL, DIS-SOLVED (μG/L AS NI)	SILVER, DIS-SOLVED (μG/L AS AG)	ZINC, DIS-SOLVED (μG/L AS ZN)
15	21/03E-35D01	84-02-03	--	--	--	--	--	--
		84-05-23	<1	550	<.1	1	<1	50
		84-08-22	<1	500	<0.1	2	<1	6
33	21/03E-36Q01	84-03-28	2	60	<.1	2	<1	<10
		84-09-04	<1	54	<.1	2	<1	<3
34	21/04E-32M01	84-03-28	2	150	<.1	2	<1	<10
		84-08-29	5	97	<.1	1	<1	<3

TABLE 13.--Cation and anion concentrations in surface-water samples

12096500 - PUYALLUP RIVER AT ALDERTON, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	HARD-NESS (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)
AUG , 1983								
24...	1500	922	6.9	60	22	5.6	1.9	2.6
JAN , 1984								
25...	1220	14700	6.8	38	12	3.3	.97	2.1
APR								
05...	1045	1550	7.4	76	27	7.2	2.3	3.5
MAY								
02...	1030	3100	6.9	60	22	6.0	1.8	3.0

DATE	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
AUG , 1983							
24...	0.70	17	7.7	--	<0.10	11	--
JAN , 1984							
25...	.80	11	5.8	2.2	<.10	8.9	31
APR							
05...	.80	27	6.0	1.9	<.10	15	53
MAY							
02...	.80	22	6.5	1.7	<.10	13	46

TABLE 13.--Continued

12101110 - WHITE R. AT SUMNER

DATE	TIME	STREAM-FLOW, INSTANTANEOUS (FT^3/S)	PH (STANDARD UNITS)	SPECIFIC CONDUCTANCE (uS)	HARDNESS (MG/L AS CACO3)	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)
AUG , 1983								
24...	1150	862	6.7	65	21	6.2	1.3	3.7
JAN , 1984								
25...	0900	20500	6.6	41	12	3.4	.81	2.3
APR								
05...	0800	1490	7.3	66	23	6.7	1.5	3.4
MAY								
02...	0830	1900	7.0	82	28	8.1	2.0	3.9

DATE	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY LAB (MG/L AS CACO3)	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)
AUG , 1983							
24...	0.70	19	7.3	4.6	<0.10	13	48
JAN , 1984							
25...	1.1	11	8.4	1.3	<.10	10	34
APR							
05...	.80	21	7.7	1.6	<.10	15	49
MAY							
02...	1.6	28	9.2	2.2	.10	15	59

TABLE 13.--Continued

12101500 - PUYALLUP RIVER AT PUYALLUP, WASHINGTON

DATE	TIME	STREAM WIDTH (FT)	SAMPLE LOC-ATION, CROSS SECTION (FT FM L BANK)	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	HARD-NESS (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)
AUG , 1983									
25...	0920	217	68.0	2030	7.3	68	22	6.2	1.7
25...	1000	217	139	2010	7.3	66	23	6.3	1.7
25...	1040	217	188	2000	7.4	66	22	6.1	1.6
JAN , 1984									
25...	1530	--	--	32400	7.1	41	12	3.4	.94
APR									
05...	0830	--	--	3040	7.0	73	26	7.2	2.0
MAY									
02...	0815	--	--	4280	7.1	72	26	7.1	2.0

DATE	SODIUM, DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
AUG , 1983								
25...	3.2	0.90	12	9.2	9.3	<0.10	12	50
25...	3.3	1.0	17	9.4	5.6	<.10	12	50
25...	3.2	.90	18	9.1	4.1	<.10	12	48
JAN , 1984								
25...	2.3	1.0	12	7.0	1.8	<.10	10	34
APR								
05...	3.7	.90	25	7.2	1.9	<.10	15	53
MAY								
02...	3.5	1.0	26	7.5	1.9	<.10	14	53

TABLE 13.--Continued

12102400 - PUYALLUP RIVER AT LINCOLN AVENUE AT TACOMA, WASHINGTON

DATE	TIME	STREAM WIDTH (FT)	SAMPLE LOC- ATION, CROSS SECTION (FT FM L BANK)	PH (STAND- ARD UNITS)	SPE- CIFIC CON- DUCT- ANCE (uS)	HARD- NESS (MG/L AS CACO3)	CALCIUM DIS- SOLVED (MG/L AS CA)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG)
AUG , 1983								
25...	1445	389	67.0	7.3	170	36	9.2	3.2
25...	1615	389	197	7.4	93	26	6.6	2.4
25...	1540	389	325	7.3	112	28	6.8	2.7
JAN , 1984								
25...	1530	--	--	7.0	52	13	3.5	1.1
APR								
05...	1110	389	130	7.2	125	31	7.9	2.7
05...	1000	389	260	7.4	91	28	7.4	2.3
MAY								
02...	1055	389	130	7.1	181	33	7.9	3.3
02...	0955	389	260	6.9	197	36	8.0	4.0

DATE	SODIUM, DIS- SOLVED (MG/L AS NA)	POTAS- SIUM, DIS- SOLVED (MG/L AS K)	ALKA- LINITY LAB (MG/L AS CACO3)	SULFATE DIS- SOLVED (MG/L AS SO4)	CHLO- RIDE, DIS- SOLVED (MG/L AS CL)	FLUO- RIDE, DIS- SOLVED (MG/L AS F)	SILICA, DIS- SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI- TUENTS, DIS- SOLVED (MG/L)
AUG , 1983								
25...	17	1.8	--	11	--	<0.10	14	--
25...	8.2	1.2	24	9.6	9.9	<.10	13	65
25...	10	1.1	24	10	13	<.10	13	71
JAN , 1984								
25...	4.2	1.1	12	8.0	5.0	<.10	10	40
APR								
05...	10	1.2	29	8.8	12	<.10	16	77
05...	6.1	.90	26	8.1	6.2	<.10	16	63
MAY								
02...	19	1.6	30	11	27	<.10	15	100
02...	20	1.5	27	12	33	<.10	14	110

TABLE 13.--Continued

12102450 - PUYALLUP RIVER AT MOUTH AT TACOMA, WASHINGTON

DATE	TIME	STREAM WIDTH (FT)	SAMPLE LOC-ATION, CROSS SECTION (FT FM L BANK)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	HARD-NESS (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)
AUG , 1983								
25...	1328	660	50.0	7.3	1730	170	17	32
25...	1115	660	330	7.2	875	93	11	16
25...	1245	660	610	7.3	462	52	7.5	8.2
APR , 1984								
05...	1230	--	--	7.0	650	70	10	11

DATE	SODIUM, DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
AUG , 1983								
25...	270	12	38	70	480	<0.10	14	920
25...	140	6.4	31	39	250	.10	13	500
25...	68	3.3	24	22	110	<.10	12	250
APR , 1984								
05...	92	4.5	30	28	170	<.10	16	350

TABLE 13.--Continued

12102075 - CLARKS CR AT RESERV BDRY AT PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	HARD-NESS (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)
AUG , 1983								
10...	1250	53	7.3	162	67	14	7.9	6.0
NOV								
03...	1605	115	7.1	125	45	10	4.9	4.4

DATE	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
AUG , 1983							
10...	2.2	68	5.9	4.5	<0.10	31	110
NOV							
03...	3.0	42	13	4.8	<.10	18	90

TABLE 13.--Continued

12102020 - DIRU CR AT INFLOW TO HATCHERY NR PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTANTANEOUS (FT^3/S)	PH (STANDARD UNITS)	SPECIFIC CONDUCTANCE (uS)	HARDNESS (MG/L AS CACO3)	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)
AUG , 1983								
10...	0915	0.26	6.9	143	53	11	6.3	5.7
NOV								
04...	0800	.42	7.5	142	54	11	6.5	5.4
APR, 1984								
27...	1250	.52	7.6	131	48	9.9	5.7	5.6

DATE	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY LAB (MG/L AS CACO3)	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)
AUG , 1983							
10...	1.3	50	8.3	4.2	<0.10	27	94
NOV							
04...	1.5	47	10	3.7	<.10	26	92
APR , 1984							
27...	1.2	39	8.5	4.7	<.10	24	83

TABLE 13.--Continued

12102100 - CLARKS CR AT RIVER ROAD NR PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	HARD-NESS (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)
AUG , 1983								
10...	1515	57	7.4	160	67	14	7.9	6.0
NOV								
03...	1435	113	7.1	119	43	9.5	4.6	4.2
APR , 1984								
26...	1220	58	7.3	172	69	14	8.2	6.4

DATE	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
AUG , 1983							
10...	2.2	70	6.6	4.7	<0.10	31	110
NOV							
03...	3.1	39	13	4.8	<.10	18	87
APR , 1984							
26...	2.0	69	7.0	5.1	<.10	31	120

TABLE 13.--Continued

12102202 - SWAN CR AT FLUME LINE ROAD, TACOMA, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	HARD-NESS (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)
NOV , 1983								
03...	1425	20	6.9	96	26	6.5	2.3	5.1

DATE	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
NOV , 1983							
03...	3.4	19	12	5.7	<0.10	5.9	59

TABLE 13.--Continued

12102212 - SWAN CR AT PIONEER WAY, TACOMA, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	HARD-NESS (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)
AUG , 1983								
09...	0830	2.7	7.4	157	59	12	7.0	6.0
NOV								
03...	1610	25	7.3	105	32	7.3	3.4	5.0

DATE	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
AUG , 1983							
09...	2.0	58	11	5.1	<0.10	28	110
NOV							
03...	2.9	26	13	5.3	<.10	10	70

TABLE 13.--Continued

12102490 - WAPATO CR AT UNION PAC RR NR NO. PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	HARD-NESS (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)
NOV								
04...	0800	1.2	7.0	178	64	15	6.5	7.7

DATE	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
NOV							
04...	4.6	61	12	6.6	<0.10	31	130

TABLE 13.--Continued

12102510 - WAPATO CR AT 12TH STREET E. IN FIFE, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	HARD-NESS (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)
AUG , 1983								
11...	1020	1.8	7.1	191	76	16	8.8	8.6
NOV								
04...	0910	12	7.2	168	55	12	6.1	6.9

DATE	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
AUG , 1983							
11...	2.0	77	10	8.0	<0.10	25	120
NOV							
04...	6.8	49	17	8.4	.10	23	110

TABLE 13.--Continued

12103000 - WEST TRIB TO HYLEBOS CR NEAR MILTON, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	HARD-NESS (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)
AUG , 1983								
12...	0830	5.0	7.6	193	72	13	9.6	5.9
NOV								
03...	1150	47	7.2	128	46	9.0	5.7	3.9

DATE	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
AUG , 1983							
12...	1.7	81	10	5.6	<0.10	28	120
NOV							
03...	2.1	34	16	4.8	.10	16	78

TABLE 13.--Continued

12103025 - HYLEBOS CR AT 8TH AVENUE E. IN FIFE, WASHINGTON

DATE	TIME	STREAMFLOW, INSTANTANEOUS (FT^3/S)	PH (STANDARD UNITS)	SPECIFIC CONDUCTANCE (uS)	HARDNESS (MG/L AS CACO3)	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)
AUG , 1983								
12...	1040	9.1	7.4	197	79	15	10	7.9
NOV								
03...	1030	83	6.9	170	61	14	6.3	6.0
APR , 1984								
27...	0830	16	7.2	202	79	15	10	8.4

DATE	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY LAB (MG/L AS CACO3)	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)
AUG , 1983							
12...	2.4	83	10	6.4	0.10	32	130
NOV							
03...	3.9	39	24	7.9	.20	17	100
APR , 1984							
27...	1.8	83	13	6.1	.10	28	130

12103035 - FIFE DITCH AT 54TH STREET E. IN FIFE, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	HARD-NESS (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)
NOV , 1983								
04...	1010	23	6.8	253	70	16	7.2	17
APR , 1984								
27...	0945	.82	6.9	1120	260	45	35	110

DATE	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
NOV , 1983							
04...	6.2	48	36	22	0.40	15	160
APR , 1984							
27...	10	243	68	170	.60	39	640

TABLE 13.--Continued

471159122150801 - SUMNER SEWAGE TREATMENT PLANT

DATE	TIME	STREAMFLOW, INSTANTANEOUS (FT^3/S)	PH (STANDARD UNITS)	SPECIFIC CONDUCTANCE (uS)	HARDNESS (MG/L AS CACO3)	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)
AUG , 1983								
24...	1245	1.2	7.2	620	66	18	5.0	83
JAN , 1984								
25...	1030	2.9	7.3	580	75	20	6.0	71
APR								
05...	1245	1.8	7.1	950	130	27	15	120
MAY								
02...	1215	2.1	7.2	918	120	25	15	110

DATE	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY LAB (MG/L AS CACO3)	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)
AUG , 1983							
24...	29	24	33	140	0.10	20	340
JAN , 1984							
25...	3.0	119	26	66	<.10	20	310
APR							
05...	34	204	42	160	.20	27	550
MAY							
02...	30	155	36	160	.20	28	500

TABLE 13.--Continued

471220122191201 - PUYALLUP SEWAGE TREATMENT PLANT

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	HARD-NESS (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)
AUG , 1983								
26...	1230	5.0	7.2	420	75	17	7.8	45
JAN , 1984								
25...	1415	14	6.9	225	65	17	5.4	14
APR								
05...	1315	6.7	6.8	302	73	17	7.3	26
MAY								
02...	1250	6.7	7.0	310	68	16	6.7	26

DATE	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
AUG , 1983							
26...	11	83	25	30	0.10	36	270
JAN , 1984							
25...	4.4	57	16	12	.10	28	160
APR							
05...	7.0	66	19	17	.20	37	170
MAY							
02...	7.0	79	19	17	.20	34	180

TABLE 13.--Continued

471452122244001 - TACOMA SEWAGE TREATMENT PLANT NO. 1

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	HARD-NESS (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)
AUG , 1983								
25...	1645	31	6.7	2000	300	110	6.8	110
JAN , 1984								
25...	1645	93	6.9	565	64	18	4.6	80
APR								
05...	1345	34	7.1	2900	850	330	7.1	180
MAY								
02...	1330	37	7.1	4100	1100	410	7.8	340

DATE	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
AUG , 1983							
25...	10	123	23	330	0.50	23	700
JAN , 1984							
25...	6.1	81	31	100	.30	15	320
APR							
05...	11	157	30	820	.60	26	1500
MAY							
02...	13	147	35	1300	.60	26	2200

TABLE 14.--Physical, biological, and selected chemical data for surface-water samples

[K indicates nonideal colony counts.]

12096500 - PUYALLUP RIVER AT ALDERTON, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)
AUG , 1983							
24...	1500	922	12.5	6.9	60	10.2	2.1
JAN , 1984							
25...	1220	14700	5.5	6.8	38	11.7	.8
APR							
05...	1045	1550	8.0	7.4	76	10.1	.8
MAY							
02...	1030	3100	8.0	6.9	60	11.2	--

DATE	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)	CARBON, ORGANIC SUS-PENDED TOTAL (MG/L AS C)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDI-MENT, SUS-PENDED (MG/L)
AUG , 1983						
24...	2.1	0.80	0.20	K80	400	327
JAN , 1984						
25...	--	4.8	4.2	K400	4000	3990
APR						
05...	--	2.3	.30	150	310	8
MAY						
02...	--	4.4	1.5	450	2000	172

TABLE 14.--Continued

12101110 - WHITE R. AT SUMNER

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)
AUG , 1983							
24...	1150	862	17.0	6.7	65	9.2	2.5
JAN , 1984							
25...	0900	20500	5.5	6.6	41	11.8	2.3
APR							
05...	0800	1490	8.5	7.3	66	10.1	1.0
MAY							
02...	0830	1900	9.5	7.0	82	10.9	2.9

DATE	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)	CARBON, ORGANIC SUS-PENDED TOTAL (MG/L AS C)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDI-MENT, SUS-PENDED (MG/L)
AUG , 1983						
24...	2.7	1.7	--	250	440	40
JAN , 1984						
25...	--	4.7	>8.0	--	6400	2640
APR						
05...	--	3.3	.20	K1100	6500	35
MAY						
02...	--	4.6	.90	4200	>10000	70

TABLE 14.--Continued

12101500 - PUYALLUP RIVER AT PUYALLUP, WASHINGTON

DATE	TIME	STREAM WIDTH (FT)	SAMPLE LOC-ATION, CROSS SECTION (FT FM L BANK)	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	OXYGEN, DIS-SOLVED (MG/L)
AUG , 1983								
25...	0920	217	68.0	2030	13.5	7.3	68	9.8
25...	1000	217	139	2010	14.0	7.3	66	9.9
25...	1040	217	188	2000	14.0	7.4	66	9.9
JAN , 1984								
25...	1530	--	--	32400	6.0	7.1	41	12.3
APR								
05...	0830	--	--	3040	8.5	7.0	73	11.0
MAY								
02...	0815	--	--	4280	9.0	7.1	72	11.3

DATE	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)	CARBON, ORGANIC SUS-PENDED TOTAL (MG/L AS C)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDI-MENT, SUS-PENDED (MG/L)
AUG , 1983							
25...	0.5	1.1	0.50	0.40	K1100	280	230
25...	1.3	1.4	1.0	.20	K800	240	252
25...	.8	1.2	.90	.30	2000	K110	255
JAN , 1984							
25...	2.1	--	4.6	5.3	K100	3200	2460
APR							
05...	.8	--	2.7	.40	430	2000	502
MAY							
02...	1.9	--	4.5	1.1	K800	5000	178

TABLE 14.--Continued

12102400 - PUYALLUP RIVER AT LINCOLN AVENUE AT TACOMA, WASHINGTON

DATE	TIME	STREAM WIDTH (FT)	SAMPLE LOC- ATION, CROSS SECTION (FT FM L BANK)	TEMPER- ATURE (DEG C)	PH (STAND- ARD UNITS)	SPE- CIFIC CON- DUCT- ANCE (uS)	OXYGEN, DIS- SOLVED (MG/L)
AUG , 1983							
25...	1445	389	67.0	15.5	7.3	170	10.0
25...	1615	389	197	16.0	7.4	93	9.9
25...	1540	389	325	16.0	7.3	112	10.0
JAN , 1984							
25...	1530	--	--	5.5	7.0	52	11.7
APR							
05...	1110	389	130	9.0	7.2	125	10.8
05...	1000	389	260	8.5	7.4	91	11.0
MAY							
02...	1055	389	130	9.5	7.1	181	10.6
02...	0955	389	260	9.0	6.9	197	10.5

DATE	OXYGEN DEMAND, BIO- CHEM- ICAL, 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON- ACEOUS (MG/L)	CARBON, ORGANIC DIS- SOLVED (MG/L AS C)	CARBON, ORGANIC SUS- PENDED TOTAL (MG/L AS C)	COLI- FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP- TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDI- MENT, SUS- PENDED (MG/L)
AUG , 1983							
25...	5.7	6.5	2.2	1.0	K10	--	256
25...	1.1	1.2	1.0	.20	K900	150	136
25...	.8	.8	.90	--	K900	200	168
JAN , 1984							
25...	2.0	--	5.2	7.6	K500	2100	3540
APR							
05...	3.9	--	3.5	.80	280	3100	183
05...	.8	--	2.5	.30	420	K920	82
MAY							
02...	5.5	--	5.2	1.6	K1400	4600	490
02...	2.2	--	3.6	1.0	K1000	4100	132

TABLE 14.--Continued

12102450 - PUYALLUP RIVER AT MOUTH AT TACOMA, WAshington

DATE	TIME	STREAM WIDTH (FT)	SAMPLE LOC- ATION, CROSS SECTION (FT FM L BANK)	TEMPER- ATURE (DEG C)	PH (STAND- ARD UNITS)	SPE- CIFIC CON- DUCT- ANCE (uS)	OXYGEN, DIS- SOLVED (MG/L)
AUG , 1983							
25...	1328	660	50.0	16.5	7.3	1730	8.6
25...	1115	660	330	15.5	7.2	875	9.0
25...	1245	660	610	15.0	7.3	462	9.7
APR , 1984							
05...	1230	--	--	9.0	7.0	650	10.9
MAY							
02...	1210	--	--	10.0	6.9	695	--

DATE	OXYGEN DEMAND, BIO- CHEM- ICAL, 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON- ACEOUS (MG/L)	CARBON, ORGANIC DIS- SOLVED (MG/L AS C)	CARBON, ORGANIC SUS- PENDED TOTAL (MG/L AS C)	COLI- FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP- TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDI- MENT, SUS- PENDED (MG/L)
AUG , 1983							
25...	11	12	3.1	1.2	K1400	350	119
25...	--	--	3.7	1.8	K600	310	269
25...	1.4	1.6	1.0	.20	K500	260	297
APR , 1984							
05...	--	--	3.2	1.0	250	400	194
MAY							
02...	--	--	5.5	2.4	2100	>10000	966

TABLE 14.--Continued

12102020 - DIRU CR AT INFLOW TO HATCHERY NR PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)	CARBON, ORGANIC SUS-PENDED TOTAL (MG/L AS C)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDI-MENT, SUS-PENDED (MG/L)
AUG , 1983												
10...	0915	0.26	12.0	6.9	143	11.4	0.0	1.1	0.20	K20	71	1
NOV												
04...	0800	.42	10.0	7.5	142	10.5	1.3	5.0	.30	47	330	4
FEB , 1984												
12...	1345	1.2	8.5	6.6	97	10.8	1.1	--	--	K140	K11000	46
APR												
27...	1250	.52	9.5	7.6	131	11.2	1.4	1.9	<.10	<5	K30	8

12102050 - CLARKS CR TRIB AT PIONEER WAY NR PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDI-MENT, SUS-PENDED (MG/L)
AUG , 1983										
09...	1350	0.81	13.0	6.9	176	10.2	1.5	K73	360	2
NOV										
04...	0810	2.2	10.0	7.3	108	10.9	1.7	K1300	7500	36
FEB , 1984										
12...	1325	6.4	9.0	6.5	116	11.0	1.2	580	K2600	188
APR										
26...	1030	1.9	9.0	7.4	162	11.4	.8	<5	K13	7

TABLE 14.--Continued

12102075 - CLARKS CR AT RESERV BDRY AT PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)	CARBON, ORGANIC SUS-PENDED TOTAL (MG/L AS C)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDI-MENT, SUS-PENDED (MG/L)
AUG , 1983												
10...	1250	53	11.5	7.3	162	11.6	0.1	0.80	0.20	560	320	2
NOV												
03...	1605	115	11.0	7.1	125	7.5	.8	6.7	1.2	K6200	>10000	22
FEB , 1984												
12...	1040	74	9.5	6.4	146	8.6	1.2	--	--	K1100	K9000	59
APR												
26...	1000	53	9.0	7.2	172	11.0	1.2	--	--	K81	K94	11

12102100 - CLARKS CR AT RIVER ROAD NR PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)	CARBON, ORGANIC SUS-PENDED TOTAL (MG/L AS C)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDI-MENT, SUS-PENDED (MG/L)
AUG , 1983												
10...	1515	57	11.5	7.4	160	11.1	0.1	0.80	0.30	280	670	6
NOV												
03...	1435	113	--	7.1	119	7.6	.8	5.9	1.7	4500	>10000	80
FEB , 1984												
12...	0945	70	9.0	6.4	165	8.5	1.0	--	--	570	K15000	120
APR												
26...	1220	58	9.5	7.3	172	10.6	.7	1.8	.10	K77	K57	10

TABLE 14.--Continued.

12102115 - E.F. CLEAR CR AT 72ND STREET E, TACOMA, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTANTANEOUS (FT^3/S)	TEMPERATURE (DEG C)	PH (STANDARD UNITS)	SPECIFIC CONDUCTANCE (uS)	OXYGEN, DISSOLVED (MG/L)	OXYGEN DEMAND, BIOCHEMICAL, 5 DAY (MG/L)	COLIFORM, FECAL, 0.7 UM-MF (COLS./100 ML)	STREPTOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDIMENT, SUSPENDED (MG/L)
NOV , 1983										
03...	0905	1.7	12.5	6.7	35	9.6	1.1	3000	>10000	20
FEB , 1984										
12...	1420	11	8.0	6.4	90	10.6	1.6	2100	K8900	96

12102175 - CLEAR CR AT 31ST AVENUE CT. E, TACOMA, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTANTANEOUS (FT^3/S)	TEMPERATURE (DEG C)	PH (STANDARD UNITS)	SPECIFIC CONDUCTANCE (uS)	OXYGEN, DISSOLVED (MG/L)	OXYGEN DEMAND, BIOCHEMICAL, 5 DAY (MG/L)	COLIFORM, FECAL, 0.7 UM-MF (COLS./100 ML)	STREPTOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDIMENT, SUSPENDED (MG/L)
AUG , 1983										
09...	1215	13	12.0	7.2	206	11.5	2.1	50	86	1
NOV										
03...	0845	31	11.0	7.3	156	7.1	1.2	520	4200	26
FEB , 1984										
12...	1505	42	9.0	6.3	155	9.4	2.7	K1600	3400	181
APR										
26...	0845	22	8.0	7.1	183	10.2	1.6	K45	K19	14

TABLE 14.--Continued.

12102202 - SWAN CR AT FLUME LINE ROAD, TACOMA, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)	CARBON, ORGANIC SUS-PENDED TOTAL (MG/L AS C)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDI-MENT, SUS-PENDED (MG/L)
NOV , 1983												
03...	1425	20	12.0	6.9	96	9.2	2.6	9.2	2.2	K19000	>10000	45
FEB , 1984												
12...	1130	30	8.0	6.7	104	10.7	4.2	--	--	2300	K13000	117
APR												
25...	1225	.37	9.0	7.6	208	9.5	9.3	--	--	2800	4100	15

12102212 - SWAN CR AT PIONEER WAY, TACOMA, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)	CARBON, ORGANIC SUS-PENDED TOTAL (MG/L AS C)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDI-MENT, SUS-PENDED (MG/L)
AUG , 1983												
09...	0830	2.7	10.0	7.4	157	10.8	2.0	0.90	0.10	49	K830	E1
NOV												
03...	1610	25	11.5	7.3	105	9.9	1.6	8.9	2.3	>6000	>10000	75
FEB , 1984												
12...	1200	45	8.5	6.8	117	11.3	2.9	--	--	K1100	4800	335
APR												
25...	1340	5.7	10.5	7.8	149	12.0	7.5	--	--	110	260	3

TABLE 14.--Continued

12102490 - WAPATO CR AT UNION PAC RR NR NO. PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)	CARBON, ORGANIC SUS-PENDED TOTAL (MG/L AS C)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDI-MENT, SUS-PENDED (MG/L)
AUG , 1983												
11...	0900	0.00	17.5	6.6	204	0.9	--	--	--	--	--	--
NOV												
04...	0800	1.2	12.0	7.0	178	5.7	1.4	8.7	1.1	2500	K13000	5
FEB , 1984												
13...	0900	2.3	10.0	6.7	160	5.8	1.9	--	--	400	K2400	7
APR												
25...	1045	.55	8.0	7.2	184	5.4	1.4	--	--	K80	K23	10

12102510 - WAPATO CR AT 12TH STREET E. IN FIFE, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)	CARBON, ORGANIC SUS-PENDED TOTAL (MG/L AS C)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDI-MENT, SUS-PENDED (MG/L)
AUG , 1983												
11...	1020	1.8	16.5	7.1	191	8.8	0.4	2.5	0.50	K2000	3400	7
NOV												
04...	0910	12	10.5	7.2	168	7.4	1.9	9.5	2.3	2300	>10000	36
FEB , 1984												
13...	0945	17	9.5	7.1	168	8.0	2.2	--	--	1200	4800	36
APR												
25...	0840	5.7	9.5	7.4	205	10.0	1.5	--	--	540	650	8

TABLE 14.--Continued.

12102900 - HYLEBOS CR ABV TRIB AT 5TH AVENUE IN MILTON, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDI-MENT, SUS-PENDED (MG/L)
AUG , 1983										
12...	0730	1.3	12.0	7.2	158	10.1	0.4	1200	770	E1
NOV										
03...	1135	31	11.5	7.0	93	9.4	2.1	3300	>10000	136
FEB , 1984										
20...	1025	4.5	7.0	7.3	132	11.0	1.2	K70	330	13
APR										
27...	1135	2.2	10.0	7.0	157	10.8	1.0	K20	K37	15

12103000 - WEST TRIB TO HYLEBOS CR NEAR MILTON, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)	CARBON, ORGANIC SUS-PENDED TOTAL (MG/L AS C)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDI-MENT, SUS-PENDED (MG/L)
AUG , 1983												
12...	0830	5.0	12.5	7.6	193	10.1	0.5	3.0	0.20	K750	630	6
NOV												
03...	1150	47	11.5	7.2	128	9.2	2.5	14	>4.0	2300	4500	210
FEB , 1984												
20...	0955	12	7.5	7.2	170	11.2	1.4	--	--	140	340	5
APR												
27...	1210	6.7	11.5	8.0	177	12.0	1.8	--	--	K90	K87	12

TABLE 14.--Continued

12103025 - HYLEBOS CR AT 8TH AVENUE E. IN FIFE, WASHINGTON

DATE	TIME	STREAMFLOW, INSTANTANEOUS (FT^3/S)	TEMPERATURE (DEG C)	PH (STANDARD UNITS)	SPECIFIC CONDUCTANCE (uS)	OXYGEN, DISSOLVED (MG/L)	OXYGEN DEMAND, BIOCHEMICAL, 5 DAY (MG/L)	CARBON, ORGANIC DISSOLVED (MG/L AS C)	CARBON, ORGANIC SUSPENDED TOTAL (MG/L AS C)	COLIFORM, FECAL, 0.7 UM-MF (COLS./100 ML)	STREPTOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDIMENT, SUSPENDED (MG/L)
AUG , 1983												
12...	1040	9.1	13.0	7.4	197	8.7	1.3	3.5	--	K1100	3400	3
NOV												
03...	1030	83	11.5	6.9	170	7.6	2.6	13	2.9	>6000	K17000	164
FEB , 1984												
20...	1145	21	8.0	7.2	196	9.6	1.9	--	--	410	1300	25
APR												
27...	0830	16	7.5	7.2	202	10.2	2.1	4.3	.20	580	K1600	14

12103035 - FIFE DITCH AT 54TH STREET E. IN FIFE, WASHINGTON

DATE	TIME	STREAMFLOW, INSTANTANEOUS (FT^3/S)	TEMPERATURE (DEG C)	PH (STANDARD UNITS)	SPECIFIC CONDUCTANCE (uS)	OXYGEN, DISSOLVED (MG/L)	OXYGEN DEMAND, BIOCHEMICAL, 5 DAY (MG/L)	CARBON, ORGANIC DISSOLVED (MG/L AS C)	CARBON, ORGANIC SUSPENDED TOTAL (MG/L AS C)	COLIFORM, FECAL, 0.7 UM-MF (COLS./100 ML)	STREPTOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDIMENT, SUSPENDED (MG/L)
AUG , 1983												
12...	1155	0.30	17.5	6.8	1080	1.5	8.2	--	--	K430	1600	--
NOV												
04...	1010	23	11.0	6.8	253	4.0	3.2	12	3.2	2100	>10000	38
FEB , 1984												
20...	1230	12	8.5	7.0	548	5.7	6.1	--	--	K1800	600	52
APR												
27...	0945	.82	10.5	6.9	1120	3.8	4.9	11	.60	K39	250	73

TABLE 14.--Continued.

471159122150801 - SUMNER SEWAGE TREATMENT PLANT

DATE	TIME	STREAM-FLOW, INSTANTANEOUS (FT^3/S)	TEMPERATURE (DEG C)	PH (STANDARD UNITS)	SPECIFIC CONDUCTANCE (uS)	OXYGEN, DISSOLVED (MG/L)	OXYGEN DEMAND, BIOCHEMICAL, 5 DAY (MG/L)
AUG , 1983							
24...	1245	1.2	18.0	7.2	620	8.3	7.0
JAN , 1984							
25...	1030	2.9	11.0	7.3	580	<5.0	48
APR							
05...	1245	1.8	14.0	7.1	950	2.6	>77
MAY							
02...	1215	2.1	14.0	7.2	918	2.7	35

DATE	OXYGEN DEMAND, BIOCHEM ULT. CARBONACEOUS (MG/L)	CARBON, ORGANIC DISSOLVED (MG/L AS C)	CARBON, ORGANIC SUSPENDED TOTAL (MG/L AS C)	COLIFORM, FECAL, 0.7 UM-MF (COLS./100 ML)	STREPTOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDIMENT, SUSPENDED (MG/L)
AUG , 1983						
24...	8.2	15	2.4	K5000	<5000	154
JAN , 1984						
25...	--	20	>4.0	K14000	K710	46
APR						
05...	--	39	>8.0	<10	1200	40
MAY						
02...	--	40	>16	K20	2100	34

TABLE 14.--Continued.

471220122191201 - PUYALLUP SEWAGE TREATMENT PLANT

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)
AUG , 1983							
26...	1230	5.0	21.5	7.2	420	5.6	--
JAN , 1984							
25...	1415	14	10.5	6.9	225	8.6	20
APR							
05...	1315	6.7	13.5	6.8	302	7.1	7.8
MAY							
02...	1250	6.7	14.5	7.0	310	6.2	12

DATE	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)	CARBON, ORGANIC SUS-PENDED TOTAL (MG/L AS C)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDI-MENT, SUS-PENDED (MG/L)
AUG , 1983						
26...	14	12	1.6	K2	K7	--
JAN , 1984						
25...	--	8.2	3.6	<10	K80	28
APR						
05...	--	10	2.7	<10	K30	12
MAY						
02...	--	12	2.3	<4	K46	11

TABLE 14.--Continued.

471452122244001 - TACOMA SEWAGE TREATMENT PLANT NO. 1

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	PH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (uS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)
AUG , 1983							
25...	1645	31	22.0	6.7	2000	5.8	180
JAN , 1984							
25...	1645	93	11.0	6.9	565	9.6	86
APR							
05...	1345	34	15.5	7.1	2900	5.4	150
MAY							
02...	1330	37	15.0	7.1	4100	6.4	160

DATE	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)	CARBON, ORGANIC SUS-PENDED TOTAL (MG/L AS C)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	SEDI-MENT, SUS-PENDED (MG/L)
AUG , 1983						
25...	300	27	--	--	--	151
JAN , 1984						
25...	--	25	>4.1	<10	K200	87
APR						
05...	--	44	14	K30	K360	94
MAY						
02...	--	48	15	<5	4500	212

TABLE 15.--24-hour-study data from selected surface-water sites

12096500 - PUYALLUP RIVER AT ALDERTON, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	SPE-CIFIC CON-DUCT-ANCE (uS)	PH (STAND-ARD UNITS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	BOD OXYGEN DEMAND, BIOCHEM CARBON. 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)
AUG , 1984									
30...	0545	986	12.0	63	7.1	10.4	97	.9	1.5
30...	0800	914	11.0	61	7.1	10.6	96	.7	2.0
30...	1020	905	11.0	60	7.1	11.0	99	.8	2.1
30...	1330	878	11.5	62	7.1	11.4	105	1.0	1.4
30...	1700	833	14.0	63	7.2	10.8	105	1.2	1.7
30...	1950	797	14.0	65	7.4	10.2	99	1.3	2.0
30...	2245	788	13.0	67	7.3	10.1	96	.9	1.3
31...	0150	869	12.0	65	7.3	10.2	96	1.2	1.6

12101110 - WHITE R. AT SUMNER, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	SPE-CIFIC CON-DUCT-ANCE (uS)	PH (STAND-ARD UNITS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	BOD OXYGEN DEMAND, BIOCHEM CARBON. 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)
AUG , 1984									
30...	0450	739	15.5	68	6.9	9.1	92	4.7	5.9
30...	0740	739	15.5	67	7.2	9.1	91	.8	1.3
30...	1000	730	15.5	70	7.2	9.4	95	.9	1.5
30...	1300	734	16.0	73	7.1	9.9	101	.6	.8
30...	1620	739	17.0	69	7.2	9.8	101	1.4	2.0
30...	1920	739	16.5	69	7.2	9.4	97	1.3	1.7
30...	2220	690	16.0	70	7.2	9.1	93	1.1	1.8
31...	0120	690	16.0	70	7.2	8.9	91	2.0	2.2

12101500 - PUYALLUP RIVER AT PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	SPE-CIFIC CON-DUCT-ANCE (uS)	PH (STAND-ARD UNITS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	BOD OXYGEN DEMAND, BIOCHEM CARBON. 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)
AUG , 1984									
30...	0615	1720	13.0	70	7.1	9.6	92	1.8	2.4
30...	0830	1690	13.5	70	7.1	9.7	93	1.6	2.1
30...	1050	1670	14.0	69	7.1	9.7	94	.7	1.2
30...	1400	1640	14.5	71	7.0	10.4	102	1.2	1.6
30...	1730	1620	15.0	70	7.2	10.2	101	1.1	1.5
30...	2020	1580	15.0	69	7.2	9.8	97	1.0	1.4
30...	2315	1500	15.0	71	7.2	9.5	95	.8	.9
31...	0220	1570	14.5	71	7.3	9.2	90	.8	1.0

TABLE 15.--Continued

12102400 - PUYALLUP RIVER AT LINCOLN AVENUE AT TACOMA, WASHINGTON

DATE	TIME	SAMPLE LOC-ATION CROSS SECTION (FT FM L BANK)	STREAM WIDTH (FT)	TEMPER-ATURE (DEG C)	SPE-CIFIC CON-DUCT-ANCE (uS)	PH (STAND-ARD UNITS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN DIS-SOLVED (PER-CENT SATUR-ATION)	BOD OXYGEN DEMAND, BIOCHEM CARBON. 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)
AUG , 1984										
30...	0710	67	389	14.0	138	7.3	9.1	88	4.6	9.4
30...	0930	67	389	13.5	655	7.3	9.3	89	1.8	2.4
30...	1145	67	389	14.0	252	7.1	9.8	95	1.6	2.3
30...	1510	67	389	15.0	132	7.2	9.6	95	1.1	1.3
30...	1755	67	389	16.0	210	7.2	9.6	97	5.1	6.4
30...	2050	67	389	15.0	715	7.0	9.4	94	2.4	2.5
30...	2345	67	389	15.0	5000	6.9	9.5	96	1.8	2.5
31...	0250	67	389	15.0	200	7.0	9.1	90	.7	1.5
30...	0700	197	389	14.0	170	7.3	8.8	86	.9	1.5
30...	0910	197	389	13.5	339	7.3	9.6	92	1.7	2.4
30...	1135	197	389	14.0	3400	7.3	9.5	93	1.5	2.0
30...	1500	197	389	15.0	156	7.2	10.0	99	.8	1.3
30...	1800	197	389	15.5	300	7.2	9.5	96	1.9	2.4
30...	2055	197	389	15.0	820	7.0	9.5	95	1.6	2.5
30...	2350	197	389	15.0	3750	6.9	9.4	95	1.6	2.2
31...	0255	197	389	15.0	212	7.0	8.4	83	.8	1.5
30...	0745	325	389	14.0	175	7.1	9.0	87	.8	1.2
30...	0855	325	389	13.5	505	7.2	9.4	90	1.7	2.3
30...	1115	325	389	14.0	3550	7.2	9.6	94	1.4	2.2
30...	1430	325	389	15.5	365	7.0	9.9	99	.6	1.5
30...	1805	325	389	16.0	378	7.2	9.5	96	1.6	2.4
30...	2100	325	389	15.0	1370	7.0	9.9	99	1.8	2.4
30...	2355	325	389	15.0	5750	6.8	9.4	96	1.3	2.2
31...	0300	325	389	15.0	555	6.8	9.0	89	.9	1.7

12102020 - DIRU CR AT INFLOW TO HATCHERY NR PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT3/S)	TEMPER-ATURE (DEG C)	SPE-CIFIC CON-DUCT-ANCE (uS)	PH (STAND-ARD UNITS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	BOD OXYGEN DEMAND, BIOCHEM CARBON. 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)
AUG , 1984									
07...	1545	.31	12.0	141	6.8	10.6	99	1.2	1.7
07...	1910	.31	12.0	141	7.3	10.4	97	1.1	1.3
07...	2140	.30	12.0	141	7.6	10.4	96	.8	1.6
08...	0040	.31	11.5	141	7.6	10.4	96	.9	1.4
08...	0300	.31	11.5	142	7.7	10.4	96	.9	1.4

12102050 - CLARKS CR TRIB AT PIONEER WAY NR PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	SPE-CIFIC CON-DUCT-ANCE (uS)	PH (STAND-ARD UNITS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	BOD OXYGEN DEMAND, BIOCHEM CARBON. 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)
AUG , 1984									
07...	0530	1.0	11.0	173	6.8	10.7	97	1.2	1.9
07...	0800	1.1	11.0	174	6.9	10.6	96	1.0	1.6
07...	1015	1.1	11.5	175	6.8	10.6	97	1.3	1.5
07...	1300	1.1	12.5	175	6.9	10.3	96	1.2	1.5
07...	1515	1.1	13.0	176	7.2	10.2	97	1.9	2.0
07...	1830	1.1	12.5	178	7.5	10.4	98	1.9	2.1
07...	2130	1.1	12.5	175	7.5	10.5	98	2.3	2.5
08...	0030	1.1	12.0	174	7.5	10.6	98	1.9	2.1
08...	0245	1.1	12.0	175	7.6	10.8	100	1.8	2.0

TABLE 15.--Continued

12102075 - CLARKS CR AT RESERV BDRY AT PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	SPE-CIFIC CON-DUCT-ANCE (uS)	PH (STAND-ARD UNITS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	BOD OXYGEN DEMAND, BIOCHEM CARBON. 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)
AUG , 1984									
07...	0600	55	9.5	168	6.9	7.3	64	.8	1.8
07...	0830	55	10.0	171	7.0	8.5	75	1.0	1.6
07...	1045	55	10.5	170	7.0	10.0	89	1.1	2.1
07...	1330	55	12.0	168	7.0	11.7	108	1.2	2.1
07...	1650	55	13.5	171	7.4	11.7	112	1.9	2.4
07...	1920	55	13.0	170	7.3	10.0	95	2.1	2.6
07...	2225	55	12.0	172	7.1	8.1	75	2.0	2.8
08...	0100	55	11.0	172	7.3	7.9	72	1.0	1.9
08...	0320	55	10.5	171	7.4	8.0	72	1.1	1.7

12102100 - CLARKS CR AT RIVER ROAD NR PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	SPE-CIFIC CON-DUCT-ANCE (uS)	PH (STAND-ARD UNITS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	BOD OXYGEN DEMAND, BIOCHEM CARBON. 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)
AUG , 1984									
07...	0645	54	10.0	169	6.9	8.1	71	1.8	2.1
07...	0915	54	10.0	170	7.0	8.8	77	2.1	2.6
07...	1130	54	10.0	172	7.2	9.8	87	2.1	2.4
07...	1400	55	11.0	171	--	11.3	102	--	--
07...	1725	--	13.0	170	7.3	11.7	111	2.7	3.3
07...	1950	53	13.5	170	7.4	10.5	101	2.2	2.4
07...	2250	53	13.0	170	7.3	9.0	85	1.6	2.2
08...	0130	53	12.0	170	7.4	8.2	76	1.9	2.0
08...	0345	--	11.0	170	7.4	8.1	74	1.5	1.9

12102175 - CLEAR CR AT 31ST AVE CT. E. TACOMA, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	SPE-CIFIC CON-DUCT-ANCE (uS)	PH (STAND-ARD UNITS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	BOD OXYGEN DEMAND, BIOCHEM CARBON. 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)
AUG , 1984									
07...	0445	14	12.0	185	7.0	6.9	64	1.6	1.8
07...	0730	14	11.0	184	6.9	7.7	70	1.7	1.9
07...	0945	14	11.0	185	7.2	8.8	80	2.0	2.1
07...	1230	14	12.0	184	7.3	9.5	88	1.9	2.2
07...	1500	15	13.0	185	7.3	10.0	95	2.0	2.4
07...	1810	15	13.5	184	7.4	10.0	95	2.7	3.2
07...	2100	15	14.0	185	7.3	8.0	78	1.9	3.3
07...	2330	--	14.0	184	7.3	7.0	68	1.6	3.0
08...	0215	16	14.0	184	7.4	7.1	69	1.5	2.1

TABLE 15.--Continued

12102212 - SWAN CR AT PIONEER WAY, TACOMA, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT3/S)	TEMPER-ATURE (DEG C)	SPE-CIFIC CON-DUCT-ANCE (uS)	PH (STAND-ARD UNITS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	BOD OXYGEN DEMAND, BIOCHEM CARBON. 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)
AUG , 1984									
07...	0415	2.2	11.5	154	7.2	10.6	97	1.8	2.1
07...	0700	2.2	11.0	153	7.0	10.7	97	1.8	2.0
07...	0930	2.2	11.5	154	7.0	10.8	99	1.2	1.9
07...	1215	2.2	13.0	155	7.0	10.6	100	1.8	2.0
07...	1445	2.1	14.5	154	6.8	10.3	101	2.0	2.2
07...	1755	2.2	13.0	155	7.4	10.4	98	1.6	2.0
07...	2035	2.3	12.5	154	7.5	10.4	97	1.4	1.9
07...	2320	2.3	12.0	154	7.5	10.2	95	1.3	1.8
08...	0200	2.3	12.0	154	7.6	10.4	96	2.4	2.7

12102510 - WAPATO CR AT 12TH ST E. IN FIFE, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT3/S)	TEMPER-ATURE (DEG C)	SPE-CIFIC CON-DUCT-ANCE (uS)	PH (STAND-ARD UNITS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	BOD OXYGEN DEMAND, BIOCHEM CARBON. 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)
AUG , 1984									
09...	0400	3.2	19.0	203	7.3	6.2	67	1.6	2.7
09...	0600	2.8	18.5	205	7.1	5.6	60	1.6	--
09...	0815	2.8	18.0	189	7.2	6.4	68	1.4	2.4
09...	1000	2.7	18.5	185	7.2	8.2	88	1.3	2.3
09...	1230	2.3	21.0	187	7.2	10.4	118	--	--
09...	1400	2.3	23.0	185	7.7	12.4	146	2.8	4.3
09...	1635	2.3	24.5	189	8.1	11.4	138	2.2	4.9
09...	1900	2.1	23.5	197	7.8	9.8	117	2.8	7.9
09...	2130	2.2	22.0	208	7.5	6.7	77	1.9	3.1
09...	2355	2.7	21.0	208	7.3	5.8	65	1.8	4.4
10...	0200	2.8	19.5	207	7.3	5.8	64	2.0	5.0

12102900 - HYLEBOS CR ABV TRIB AT 5TH AVE IN MILTON, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT3/S)	TEMPER-ATURE (DEG C)	SPE-CIFIC CON-DUCT-ANCE (uS)	PH (STAND-ARD UNITS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	BOD OXYGEN DEMAND, BIOCHEM CARBON. 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)
AUG , 1984									
09...	0515	1.1	12.5	180	6.9	9.3	88	1.4	2.3
09...	0700	1.1	12.5	182	7.0	9.4	88	1.4	2.5
09...	0915	1.1	12.5	183	7.0	9.4	88	1.2	2.0
09...	1115	1.1	12.5	185	7.0	9.6	91	1.3	2.0
09...	1330	.80	14.0	184	7.0	9.3	91	--	--
09...	1500	.90	15.0	184	7.0	9.3	93	2.2	3.1
09...	1730	.60	16.0	183	7.3	9.3	95	1.9	2.9
09...	1950	.70	15.5	182	7.4	8.4	85	1.6	2.5
09...	2220	.70	14.5	182	7.2	8.6	85	1.5	2.4
10...	0055	1.0	13.5	181	7.3	8.6	83	1.1	1.7
10...	0255	.90	13.0	182	7.3	8.7	83	1.2	2.4

TABLE 15.--Continued

12103000 - WEST TRIB TO HYLEBOS CR NEAR MILTON, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT3/S)	TEMPER-ATURE (DEG C)	SPE-CIFIC CON-DUCT-ANCE (uS)	PH (STAND-ARD UNITS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	BOD OXYGEN DEMAND, BIOCHEM CARBON. 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)
AUG , 1984									
09...	0530	4.6	13.0	194	7.0	9.7	92	1.8	2.9
09...	0715	4.7	13.0	194	7.0	9.6	91	1.6	2.6
09...	0945	4.7	14.5	195	7.2	9.9	97	1.4	2.3
09...	1130	4.7	15.0	197	7.3	9.7	97	1.7	2.4
09...	1345	4.9	16.0	195	7.3	9.5	97	--	--
09...	1515	4.6	17.0	198	7.4	9.9	103	2.1	3.4
09...	1745	4.6	17.0	196	7.5	9.1	95	2.3	3.6
09...	2005	4.6	16.0	195	7.5	8.9	91	2.1	3.2
09...	2235	4.6	14.5	196	7.2	8.8	88	2.3	4.3
10...	0115	4.6	14.0	196	7.4	8.5	83	1.7	3.7
10...	0315	4.6	13.0	196	7.5	8.9	86	1.9	3.3

12103025 - HYLEBOS CR AT 8TH AVE E. IN FIFE, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT3/S)	TEMPER-ATURE (DEG C)	SPE-CIFIC CON-DUCT-ANCE (uS)	PH (STAND-ARD UNITS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	BOD OXYGEN DEMAND, BIOCHEM CARBON. 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)
AUG , 1984									
09...	0445	--	14.0	205	7.3	8.2	80	1.5	2.5
09...	0645	8.3	13.5	205	7.2	8.2	79	1.4	2.3
09...	0845	8.3	13.5	212	7.1	8.5	81	1.3	2.0
09...	1045	8.3	13.5	207	7.2	8.7	84	1.2	2.2
09...	1315	8.3	14.5	208	7.2	9.1	90	--	--
09...	1445	8.3	15.5	207	7.2	8.7	88	4.9	6.5
09...	1935	--	17.0	208	7.5	7.4	77	8.7	11
09...	2200	--	16.5	208	7.3	7.5	77	2.0	3.6
10...	0030	--	16.0	205	7.4	7.5	76	1.7	2.6
10...	0235	--	15.0	209	7.4	7.6	76	1.2	2.4

12103035 - FIFE DITCH AT 54TH ST E. IN FIFE, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT3/S)	TEMPER-ATURE (DEG C)	SPE-CIFIC CON-DUCT-ANCE (uS)	PH (STAND-ARD UNITS)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	BOD OXYGEN DEMAND, BIOCHEM CARBON. 5 DAY (MG/L)	OXYGEN DEMAND, BIOCHEM ULT. CARBON-ACEOUS (MG/L)
AUG , 1984									
09...	0430	--	19.0	1600	7.0	5.9	64	2.5	5.3
09...	0615	--	18.5	3850	6.9	5.3	58	2.2	7.1
09...	0830	--	19.0	8200	6.9	2.0	22	2.1	5.3
09...	1030	.47	19.5	4100	6.9	2.0	22	2.0	6.2
09...	1245	.47	22.0	4080	6.8	4.4	51	--	--
09...	1415	.47	25.5	4040	6.9	6.7	83	3.0	6.5
09...	1650	--	26.5	3010	6.8	8.4	107	3.9	7.8
09...	1915	--	23.0	3080	6.8	6.8	81	3.7	9.1
09...	2145	--	22.0	3150	6.8	7.5	87	3.0	9.3
10...	0015	--	20.5	2450	6.9	6.8	77	3.6	6.8
10...	0215	--	19.5	2250	6.9	5.4	59	4.2	8.4

TABLE 16.--Nutrient concentrations in surface-water samples

12096500 - PUYALLUP RIVER AT ALDERTON, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, TOTAL (MG/L AS P)
AUG , 1983										
24...	1500	922	0.020	0.050	<0.020	0.100	0.50	0.50	0.030	0.280
JAN , 1984										
25...	1220	14700	.100	.110	<.010	.440	<.20	1.4	.010	.850
APR										
05...	1045	1550	.040	.030	<.010	.260	.20	.20	.020	.020
MAY										
02...	1030	3100	.040	.040	<.010	.370	.20	.70	.020	.120

12101110 - WHITE RIVER AT SUMNER

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, TOTAL (MG/L AS P)
AUG , 1983										
24...	1150	862	0.090	0.080	<0.020	<0.100	0.50	0.50	0.020	0.110
JAN , 1984										
25...	0900	20500	.120	.130	<.010	.310	<.20	1.6	.010	1.10
APR										
05...	0800	1490	.040	.010	<.010	.200	<.20	.20	.010	.020
MAY										
02...	0830	1900	.160	.130	<.010	.260	.20	.80	.050	.120

TABLE 16.--Continued

12101500 - PUYALLUP RIVER AT PUYALLUP, WASHINGTON

DATE	TIME	STREAM WIDTH (FT)	SAMPLE LOC- ATION, CROSS SECTION (FT FM L BANK)	STREAM- FLOW, INSTAN- TANEOUS (FT^3/S)	NITRO- GEN, AMMONIA DIS- SOLVED (MG/L AS N)	NITRO- GEN, AMMONIA TOTAL (MG/L AS N)	NITRO- GEN, NITRITE DIS- SOLVED (MG/L AS N)	NITRO- GEN, NO2+NO3 DIS- SOLVED (MG/L AS N)	NITRO- GEN, AM- MONIA + ORGANIC DIS. (MG/L AS N)	NITRO- GEN, AM- MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS- PHORUS, DIS- SOLVED (MG/L AS P)	PHOS- PHORUS, TOTAL (MG/L AS P)
AUG , 1983												
25...	0920	217	68.0	2030	0.090	0.130	<0.020	0.130	0.40	0.50	0.050	0.260
25...	1000	217	139	2010	.050	.080	<.020	.100	.20	.40	.020	.300
25...	1040	217	188	2000	.060	.110	<.020	<.100	.30	.40	.030	.240
JAN , 1984												
25...	1530	--	--	32400	.090	.120	<.010	.410	.30	1.8	.010	.800
APR												
05...	0830	--	--	3040	<.010	.030	<.010	.250	.20	.20	.020	.040
MAY												
02...	0815	--	--	4280	.060	.040	<.010	.360	.20	.50	.020	.090

12102400 - PUYALLUP RIVER AT LINCOLN AVENUE AT TACOMA, WASHINGTON

DATE	TIME	STREAM WIDTH (FT)	SAMPLE LOC- ATION, CROSS SECTION (FT FM L BANK)	NITRO- GEN, AMMONIA DIS- SOLVED (MG/L AS N)	NITRO- GEN, AMMONIA TOTAL (MG/L AS N)	NITRO- GEN, NITRITE DIS- SOLVED (MG/L AS N)	NITRO- GEN, NO2+NO3 DIS- SOLVED (MG/L AS N)	NITRO- GEN, AM- MONIA + ORGANIC DIS. (MG/L AS N)	NITRO- GEN, AM- MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS- PHORUS, DIS- SOLVED (MG/L AS P)	PHOS- PHORUS, TOTAL (MG/L AS P)
AUG , 1983											
25...	1445	389	67.0	0.520	0.570	<0.020	0.190	0.80	1.5	0.190	0.450
25...	1615	389	197	.080	.100	<.020	.130	.30	.40	.040	.190
25...	1540	389	325	.040	.090	<.020	.110	.30	.50	.040	.210
JAN , 1984											
25...	1530	--	--	.130	.120	<.010	.390	.20	1.6	.010	.850
APR											
05...	1110	389	130	.290	.410	<.010	.340	.60	.90	.090	.170
05...	1000	389	260	.050	.060	<.010	.270	<.20	.50	.010	.040
MAY											
02...	1055	389	130	.040	.040	<.010	.400	1.0	1.2	.120	.240
02...	0955	389	260	.140	.100	<.010	.360	.20	.40	.020	.100

TABLE 16.--Continued

12102450 - PUYALLUP RIVER AT MOUTH AT TACOMA, WASHINGTON

DATE	TIME	STREAM WIDTH (FT)	SAMPLE LOC-ATION, CROSS SECTION (FT FM L BANK)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, TOTAL (MG/L AS P)
AUG , 1983											
25...	1328	660	50.0	1.10	1.10	<0.020	0.190	1.7	2.1	0.260	0.520
25...	1115	660	330	.950	.950	<.020	.160	1.5	2.1	.290	.620
25...	1245	660	610	.050	.080	<.020	.140	.20	.40	.050	.250
APR , 1984											
05...	1230	--	--	.230	.360	<.010	.300	.80	.80	.080	.180
MAY											
02...	1210	--	--	.330	.300	<.010	.400	.60	1.4	.080	.250

12102020 - DIRU CR AT INFLOW TO HATCHERY NR PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, TOTAL (MG/L AS P)
AUG , 1983										
10...	0915	0.26	0.030	<0.010	<0.020	2.30	1.0	1.1	0.060	0.070
NOV										
04...	0800	.42	.110	.100	<.020	3.10	1.2	1.1	.020	.040
FEB , 1984										
12...	1345	1.2	.010	<.010	<.010	1.90	.50	.60	.010	.080
APR										
27...	1250	.52	.070	.040	<.010	2.60	.60	.60	.020	.020

12102050 - CLARKS CR TRIB AT PIONEER WAY NR PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, TOTAL (MG/L AS P)
AUG , 1983										
09...	1350	0.81	0.020	<0.030	<0.020	2.40	0.80	0.90	0.050	0.060
NOV										
04...	0810	2.2	.070	.070	<.020	1.70	.90	1.2	.030	.090
FEB , 1984										
12...	1325	6.4	<.010	<.010	<.010	1.80	.30	.90	.020	.110
APR										
26...	1030	1.9	.040	.030	<.010	2.20	.30	.40	.010	.040

12102075 - CLARKS CR AT RESERV BDRY AT PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, TOTAL (MG/L AS P)
AUG , 1983										
10...	1250	53	0.040	0.050	<0.020	1.30	0.70	0.70	0.060	0.080
NOV										
03...	1605	115	.120	.120	.020	1.50	1.1	1.3	.100	.210
FEB , 1984										
12...	1040	74	.130	.120	<.010	1.10	.80	.90	.040	.230
APR										
26...	1000	53	.090	.060	.010	1.30	.40	.70	.040	.090

12102100 - CLARKS CR AT RIVER ROAD NR PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, TOTAL (MG/L AS P)
AUG , 1983										
10...	1515	57	0.020	0.010	<0.020	1.30	0.90	0.80	0.060	0.110
NOV										
03...	1435	113	.100	.110	.020	1.30	1.5	1.8	.090	.330
FEB , 1984										
12...	0945	70	.130	.120	.010	1.30	.40	.60	.040	.240
APR										
26...	1220	58	.060	.050	.010	1.40	.20	.60	.040	.080

12102115 - E.F. CLEAR CR AT 72ND STREET E. TACOMA, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, TOTAL (MG/L AS P)
NOV , 1983										
03...	0905	1.7	0.070	0.060	<0.020	0.260	0.30	0.70	0.060	0.100
FEB , 1984										
12...	1420	11	.040	.030	<.010	.590	.50	1.1	.030	.180

TABLE 16.--Continued

12102175 - CLEAR CR AT 31ST AVENUE CT. E. TACOMA, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, TOTAL (MG/L AS P)
AUG , 1983										
09...	1215	13	0.070	0.060	0.020	1.80	0.60	0.70	0.060	0.090
NOV										
03...	0845	31	.200	.190	.030	1.60	.90	1.4	.090	.180
FEB , 1984										
12...	1505	42	.160	.170	<.010	1.40	.70	1.7	.050	.470
APR										
26...	0845	22	.160	.160	.020	1.60	.60	.60	.060	.110

12102202 - SWAN CR AT FLUME LINE ROAD, TACOMA, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, TOTAL (MG/L AS P)
NOV , 1983										
03...	1425	20	0.290	0.330	0.020	1.40	1.4	1.8	0.220	0.360
FEB , 1984										
12...	1130	30	.290	.290	.010	.590	1.2	1.6	.090	.260
APR										
25...	1225	.37	.980	1.00	.040	.690	2.0	3.1	.160	.330

TABLE 16.--Continued

12102212 - SWAN CR AT PIONEER WAY, TACOMA, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, TOTAL (MG/L AS P)
AUG , 1983										
09...	0830	2.7	<0.010	0.020	<0.020	1.20	0.70	0.80	0.070	0.070
NOV										
03...	1610	25	.170	.170	.020	1.50	1.0	1.6	.140	.260
FEB , 1984										
12...	1200	45	.180	.130	.010	.860	.80	1.3	.070	.240
APR										
25...	1340	5.7	.030	.080	<.010	1.00	.20	.70	.070	.060

12102490 - WAPATO CR AT UNION PAC RR NR NO. PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, TOTAL (MG/L AS P)
NOV , 1983										
04...	0800	1.2	0.200	0.200	0.020	1.60	1.4	1.6	0.050	0.100
FEB , 1984										
13...	0900	2.3	.110	.110	.010	1.00	.70	.70	.060	.120
APR										
25...	1045	.55	.040	.100	<.010	.610	.30	.40	.060	.050

12102510 - WAPATO CR AT 12TH STREET E. IN FIFE, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, TOTAL (MG/L AS P)
AUG , 1983										
11...	1020	1.8	0.030	0.050	<0.020	0.780	0.80	1.6	0.080	0.130
NOV										
04...	0910	12	.120	.120	.010	1.10	1.1	2.1	.070	.310
FEB , 1984										
13...	0945	17	.080	.080	.020	1.10	.60	1.0	.050	.280
APR										
25...	0840	5.7	.050	.090	<.010	.840	.30	.40	.040	.060

12102900 - HYLEBOS CR ABV TRIB AT 5TH AVENUE IN MILTON, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, TOTAL (MG/L AS P)
AUG , 1983										
12...	0730	1.3	0.050	0.030	<0.020	1.10	0.50	0.50	0.040	0.060
NOV										
03...	1135	31	.090	.090	<.020	.830	.70	2.0	.050	.190
FEB , 1984										
20...	1025	4.5	.180	.170	<.010	.950	<.20	.50	.010	.030
APR										
27...	1135	2.2	.050	.070	<.010	.940	.30	.70	.030	.030

12103000 - WEST TRIB TO HYLEBOS CR NEAR MILTON, WASHINGTON

DATE	TIME	STREAMFLOW, INSTANTANEOUS (FT^3/S)	NITROGEN, AMMONIA DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA TOTAL (MG/L AS N)	NITROGEN, NITRITE DISSOLVED (MG/L AS N)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC DIS. (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC TOTAL (MG/L AS N)	PHOSPHORUS, DISSOLVED (MG/L AS P)	PHOSPHORUS, TOTAL (MG/L AS P)
AUG , 1983										
12...	0830	5.0	0.060	0.040	<0.020	0.500	0.40	0.70	0.080	0.100
NOV										
03...	1150	47	.130	.120	<.020	1.50	1.5	2.3	.040	.180
FEB , 1984										
20...	0955	12	.010	.080	<.010	.620	.20	.30	.030	.030
APR										
27...	1210	6.7	.030	.040	<.010	.440	<.20	1.1	.040	.040

12103025 - HYLEBOS CR AT 8TH AVENUE E. IN FIFE, WASHINGTON

DATE	TIME	STREAMFLOW, INSTANTANEOUS (FT^3/S)	NITROGEN, AMMONIA DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA TOTAL (MG/L AS N)	NITROGEN, NITRITE DISSOLVED (MG/L AS N)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC DIS. (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC TOTAL (MG/L AS N)	PHOSPHORUS, DISSOLVED (MG/L AS P)	PHOSPHORUS, TOTAL (MG/L AS P)
AUG , 1983										
12...	1040	9.1	0.120	0.100	<0.020	0.710	0.60	1.4	0.100	0.200
NOV										
03...	1030	83	.150	.160	<.020	2.50	1.4	2.4	.080	.430
FEB , 1984										
20...	1145	21	.430	.410	.010	1.00	.40	.70	.040	.120
APR										
27...	0830	16	.100	.090	.010	.700	1.5	1.6	.050	.090

TABLE 16.--Continued

12103035 - FIFE DITCH AT 54TH STREET E. IN FIFE, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, TOTAL (MG/L AS P)
AUG , 1983										
12...	1155	0.30	2.80	2.80	0.020	<0.100	4.2	4.3	0.040	0.260
NOV										
04...	1010	23	.310	.310	.070	1.80	1.6	2.0	.050	.330
FEB , 1984										
20...	1230	12	1.60	1.60	.030	.590	1.8	2.5	.080	.510
APR										
27...	0945	.82	3.30	3.40	.010	<.100	3.9	4.4	.020	.280

471159122150801 - SUMNER SEWAGE TREATMENT PLANT

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, TOTAL (MG/L AS P)
AUG , 1983										
24...	1245	1.2	0.140	0.130	<0.020	11.0	3.2	3.8	1.50	3.70
JAN , 1984										
25...	1030	2.9	.150	.170	.260	5.90	2.7	11	.010	1.90
APR										
05...	1245	1.8	--	1.10	.580	3.30	17	23	.590	3.50
MAY										
02...	1215	2.1	1.10	5.40	.510	1.80	14	23	.740	3.10

TABLE 16.--Continued

471220122191201 - PUYALLUP SEWAGE TREATMENT PLANT

DATE	TIME	STREAMFLOW, INSTANTANEOUS (FT^3/S)	NITROGEN, AMMONIA DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA TOTAL (MG/L AS N)	NITROGEN, NITRITE DISSOLVED (MG/L AS N)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	NITROGEN,AMMONIA + ORGANIC DIS. (MG/L AS N)	NITROGEN,AMMONIA + ORGANIC TOTAL (MG/L AS N)	PHOSPHORUS, DISSOLVED (MG/L AS P)	PHOSPHORUS, TOTAL (MG/L AS P)
AUG , 1983										
26...	1230	5.0	4.10	3.80	0.600	9.50	8.0	10	4.00	5.40
JAN , 1984										
25...	1415	14	2.70	2.80	.080	4.80	6.5	6.5	.560	1.40
APR										
05...	1315	6.7	2.50	2.40	.140	9.70	3.5	3.8	1.90	1.90
MAY										
02...	1250	6.7	4.90	5.10	.490	3.70	7.0	13	2.60	3.80

471452122244001 - TACOMA SEWAGE TREATMENT PLANT NO. 1

DATE	TIME	STREAMFLOW, INSTANTANEOUS (FT^3/S)	NITROGEN, AMMONIA DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA TOTAL (MG/L AS N)	NITROGEN, NITRITE DISSOLVED (MG/L AS N)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	NITROGEN,AMMONIA + ORGANIC DIS. (MG/L AS N)	NITROGEN,AMMONIA + ORGANIC TOTAL (MG/L AS N)	PHOSPHORUS, DISSOLVED (MG/L AS P)	PHOSPHORUS, TOTAL (MG/L AS P)
AUG , 1983										
25...	1645	31	13.0	13.0	0.020	0.210	17	22	3.60	6.10
JAN , 1984										
25...	1645	93	3.40	3.40	.050	1.50	6.8	11	1.50	1.40
APR										
05...	1345	34	1.70	1.80	<.010	<.100	32	48	4.00	8.20
MAY										
02...	1330	37	15.0	16.0	.060	.380	38	44	2.80	6.20

TABLE 17.--Organic compound concentrations in water samples collected at Puyallup and White River study sites

[Cross section location: distance in feet from the left bank/width of the river in feet; or C, flow-weighted composite sample. Identification code: A, mass spectrum and retention time match those of a standard run on the instrument; L, spectrum matches are obtained from the National Bureau of Standards library. Identification by class: H, hydrocarbon; OA, organic acid; P, phthlate; NA, no analysis; ND, none detected. All concentrations in micrograms per liter.]

Site	Date	Cross-section location	Identification code	Compound	Concentration	Number of compounds (shown in parenthesis) identified by class only: Acid fraction	Number of compounds (shown in parenthesis) identified by class only: Base/neutral fraction
Puyallup River at Alderton	24 Aug 83	C	--	--	--	NA	P(1)
White River at Sumner	24 Aug 83	79/152	A	1,1,1-Trichloroethane	1.2		
Puyallup River at Puyallup	25 Aug 83	139/217	A	1,1,1-Trichloroethane	1.0		
Puyallup River at Lincoln Avenue	25 Aug 83	67/389	--	--	--	NA	H(1)
		67/389	A	Chloroform	1.0		
		325/389	--	--	--	ND	ND
		325/389	A	Trichloroethene	1.0		
		325/389	A	Diethyl phthalate	3.2		
Puyallup River at mouth	25 Aug 83	330/660	A	Methylene chloride	9.4		
		330/660	A	Chloroform	1.2		
		C	--	--	--	H(3),OA(6)	H(8),OA(1),P(1)
		C	A	Diethyl phthalate	2.4		
		C	A	Bis(2-ethylhexyl) phthalate	1.2		
		C	A	Di-n-butyl phthalate	7.6		
		C	L	Benzenebutanoic acid	0.7		
		C	L	2-Cyclohexen-1-one	1.1		
		C	L	2-(2-(2-Butoxyethoxy)ethoxy) ethanol	0.2		
		C	L	(1,1'-Biphenyl)-2-ol	0.4		
		C	L	2-Cyclohexen-1-ol	1.6		
		C	L	trans-1,2-Cyclohexanediol	1.8		
Sumner Sewage Treatment Plant	24 Aug 83	C	A	Chloroform	6.8		
		C	A	Bromodichloromethane	1.0		
	25 Jan 84	C	A	Chloroform	2.7		
		C	A	Tetrachloroethane	2.4		
	2 May 84	C	A	Chloroform	2.2		
		C	A	Methylbenzene	1.0		

TABLE 17.--Organic compound concentrations in water samples collected at Puyallup and White River study sites--Con.

Site	Date	Cross-section location	Identification code	Compound	Concentration	Number of compounds (shown in parenthesis) identified by class only: Acid fraction	Base/neutral fraction
Puyallup Sewage Treatment Plant	26 Aug 83	C	--	--	--	H(6),OA(1),P(1)	H(1)
		C	A	Chloroform	2.2		
		C	A	Methylbenzene	2.7		
		C	A	Hexadecanoic acid	17		
	25 Jan 84	C	A	Chloroform	1.7		
		C	A	Tetrachloroethene	1.7		
		C	A	Methylbenzene	1.7		
	2 May 84	C	A	Methylene chloride	1.3		
		C	A	Chloroform	1.3		
		C	A	Methylbenzene	1.6		
Tacoma Sewage Treatment Plant No. 1	25 Aug 83	C	--	--	--	H(15),OA(13)	H(36),OA(5),P(1)
		C	A	Methylene chloride	17		
		C	A	Chloroform	14		
		C	A	Bromodichloromethane	3.4		
		C	A	Chlorodibromomethane	1.4		
		C	A	Dichloroethane	1.0		
		C	A	1,1,1-Trichloroethane	8.0		
		C	A	Trichloroethene	2.7		
		C	A	Tetrachloroethene	11		
		C	A	Benzene	1.9		
		C	A	Methylbenzene	14		
		C	A	Ethylbenzene	2.7		
		C	L	Dimethylbenzene	3.1		
		C	L	Trimethylbenzene	51		
		C	L	Tetramethylbenzene	15		
		C	L	Methylethylbenzene	15		
		C	L	Dimethylethylbenzene	26		
		C	A	Phenol	74		
		C	L	Methylphenol	210		
		C	A	Naphthalene	24		
		C	L	Methylnaphthalene	10		
		C	A	Diethyl phthalate	11		
		C	L	Benzeneacetic acid	210		
		C	L	Benzenepropanoic acid	69		
		C	L	2-Butoxyethanol	183		
		C	L	1-(2-Butoxyethoxy)ethanol	52		
		C	L	2-(2-(2-Methoxyethoxy)ethoxy) ethanol	33		
		C	L	2-(2-(2-Ethoxyethoxy)ethoxy) ethanol	71		
		C	L	2-(2-(2-Butoxyethoxy)ethoxy) ethanol	87		
		C	L	Benzenemethanol	152		
		C	L	(1,1'-Biphenyl)-2-ol	12		
		C	L	Tetraoxadodecane	12		

TABLE 17.--Organic compound concentrations in water samples collected at Puyallup and White River study sites--Con.

Site	Date	Cross-section location	Identification code	Compound	Concentration	Number of compounds (shown in parenthesis) identified by class only: Acid fraction	Number of compounds (shown in parenthesis) identified by class only: Base/neutral fraction
Tacoma Sewage Treatment Plant No. 1 --Continued	25 Jan 84	C	A	Chloroform	22		
		C	A	Trichloroethene	4.3		
		C	A	Tetrachloroethene	16		
		C	A	Benzene	1.0		
		C	A	Methylbenzene	16		
		C	A	Ethylbenzene	4.6		
	2 May 84	C	A	Methylene chloride	12		
		C	A	Chloroform	12		
		C	A	1,1,1-Trichloroethane	2.5		
		C	A	Tetrachloroethene	4.8		
		C	A	Benzene	3.9		
		C	A	Methylbenzene	36		
		C	A	Ethylbenzene	6.0		

TABLE 18.--Organic compound concentrations in bed-sediment samples from the Puyallup and White Rivers

[Cross section location: distance in feet from left bank / width of the river in feet; or C, laterally composited sample. Identification code: A, mass spectrum and retention time match those of standard run on the instrument; L, spectrum matches one obtained from the National Bureau of Standards library. Identification by class: H, hydrocarbon; OA, organic acid; P, phthalate. All concentrations are in micrograms per kilogram.]

Site	Date	Cross Section Location	Identification code	Compound	Concentration	Number of compounds (shown in parenthesis) identified by class only
Puyallup River at Alderton	24 Aug 83	C	--	--	--	H(4),OA(3)
	5 APR 84	C	--	--	--	H(19),OA(2)
		C	L	Methylbenzene	53	
		C	L	1,4-Dimethylbenzene	42	
		C	L	2-Methylnaphthalene	51	
		C	L	Alkyl-substituted napthalene	92	
		C	L	1,7-Dimethylnaphthalene	49	
		C	L	1,8-Dimethylnaphthalene	71	
		C	L	Phenanthrene	75	
		C	L	2,7-Dimethylphenanthrene	91	
		C	L	2,4,5,7-Tetramethylphenanthrene	98	
White River at Sumner	5 Apr 84	C	--	--	--	H(2)
Puyallup River at Puyallup	24 Aug 83	215/217	--	--	--	H(3),OA(1)
Puyallup River at Lincoln Avenue	24 Aug 83	67/389	--	--	--	H(15),OA(2)
		67/389	L	Methylphenol	210	
		67/389	L	Methylnaphthalene	260	
		67/389	L	Tetramethylphenanthrene	650	
		197/389	--	--	--	H(10),OA(2)
		197/389	L	Methylnaphthalene	130	
		197/389	L	Dimethylnaphthalene	180	
		197/389	A	Phenanthrene	33	
		197/389	L	Tetramethylphenanthrene	310	
		325/389	--	--	--	H(16),OA(2)
		325/389	L	Methylnaphthalene	170	
		325/389	L	Dimethylnaphthalene	360	
		325/389	L	Trimethylnaphthalene	220	
		325/389	A	Phenanthrene	59	
		325/389	L	Tetramethylphenanthrene	300	
		325/389	L	Dodecyltetradecahydro-phenanthrene	160	
		325/389	A	Bis(2-ethylhexyl) phthalate	350	
	5 Apr 84	2.0/389	--	--	--	H(10),OA(16)
		2.0/389	L	3-Methylphenol	2900	
		387/389	--	--	--	H(3)
Puyallup River at mouth	25 Aug 83	50/660	--	--	--	H(5),OA(1)

TABLE 19.--Organic compound concentrations in water and bed-sediment samples from small streams

[Identification code: A, mass spectrum and retention time match those of a standard run on the insturment; L, spectrum matches are obtained from the National Bureau of Standards library. Identification by class: H, hydrocarbon; OA, organic acid; P, phthalate; ND, none detected.]

Site	Date	Identification Code	Compound	Concentration	Number of compounds (shown in parenthesis) identified by class only	
					Acid fraction	Base/neutral fraction
Water samples [Samples were collected near the centroid of flow. All concentrations are in micrograms per liter]						
Clarks Cr at reservation boundary	10 Aug 83	A	Benzene	1.3		
		A	1,2-Dichloroethane	1.0		
		A	Trichloroethene	1.0		
Wapato Cr at Union Pacific Railroad nr N. Puyallup	4 Nov 83	A	1,1,1-Trichloroethane	1.7		
Wapato Cr at 12 St. E. in Fife	11 Aug 83	A	1,1,1-Trichloroethane	1.0		
Hylebos Cr at 8th. Ave. E.	12 Aug 83	--	--	--	H(2),OA(1)	ND
Fife ditch at 54th. St. E. in Fife	27 Apr 84	A	trans-1,2-Dichloroethene	36		
		A	Trichloroethene	5.0		
Bed-sediment samples [Acid and base/neutral compounds are not extracted separately. All concentrations are in micrograms per kilogram.]						
Diru Cr at inflow to hatchery nr Puyallup	10 Aug 83	--	--	--	H(5),OA(3)	
Clarks Cr at reservation boundary	10 Aug 83	--	--	--	H(2),OA(1)	
		L	Methylphenol	4,400		
		L	3-Hydroxy-butanoic acid, methyl ester	400		
		L	3-Hydroxy-pentanoic acid, methyl ester	190		
		L	Methyl,1H-indole	210		
		L	2,3-Dihydro-4-methyl-1H-indole	390		
Clarks Cr at River Road	10 Aug 83	--	--	--	H(4),OA(1)	
Swan Cr at Pioneer Way	9 Aug 83	--	--	--	H(5),OA(2)	
		L	Methylphenol	440		

TABLE 20.--Trace-element concentrations in bed sediments

[Cross-section location: distance in feet from left bank;
or C, laterally composited sample.
Ag, silver; As, arsenic; Cd, cadmium; Cr, chromium;
Cu, copper; Ni, nickel; Pb, lead; Zn, zinc; Hg, mercury]

Site name	Date	Cross-section location	Size (micrometers)	Ag	As	Cd	Cr	Cu	Ni	Pb	Zn	Hg
				(concentrations in micrograms per gram)								
Puyallup River at Alderton	24 Aug 83	C	95.0	<0.5	1.0	0.50	30	46	16	8	47	0.02
			27.8	<.5	1.3	.20	51	27	21	4	55	.02
			1.0	<.5	6.5	.20	48	110	41	16	95	.01
	4 Apr 84	C	162.1	<.5	1.2	.07	110	22	40	5	74	.04
			24.8	<.5	8.6	.09	83	53	37	18	82	.10
			1.0	<.5	28.0	.29	84	110	54	24	120	--
White River at Sumner	24 Aug 83	C	123.9	<.5	1.9	.10	50	23	22	5	80	.03
			27.4	<.5	4.9	1.30	43	44	21	8	80	.05
			1.0	<.5	32.0	1.50	33	93	22	27	88	.14
	4 Apr 84	C	142.2	<.5	3.8	.06	40	23	22	5	63	.04
			27.2	<.5	13.0	.17	76	40	34	8	82	.10
			1.0	<.5	41.0	.61	66	94	46	19	100	--
Puyallup River at Puyallup	24 Aug 83	2	129.7	<.5	1.6	.10	50	26	23	< 4	68	.01
			18.3	<.5	2.1	.20	43	35	21	9	60	.03
			1.0	<.5	11.0	.30	45	100	33	20	95	.17
		215	110.2	<.5	1.4	<.10	130	26	40	12	110	.02
			25.1	<.5	1.9	.10	59	32	24	< 4	65	.03
			1.0	<2.0	20.0	.40	64	110	39	32	110	.30
	4 Apr 84	C	131.0	<.5	2.4	.06	57	23	27	7	67	.06
			25.5	<.5	8.2	.23	70	40	29	10	74	.06
			1.0	<.5	30.0	.59	69	110	45	24	110	.21
Puyallup River at Lincoln Ave. at Tacoma	24 Aug 83	67	165.1	<.5	1.2	.50	120	25	45	6	120	.02
			21.4	2.0	3.5	2.40	55	64	26	21	130	.22
			1.0	5.0	<1000.0	<50.00	150	700	50	70	<300	--
		197	171.7	<.5	1.3	.10	110	23	46	4	120	.01
			11.1	1.0	2.8	1.30	78	55	40	7	78	.17
	25 Aug 83	325	171.7	<.5	1.3	.10	82	22	34	6	95	.01
			22.7	<.5	2.5	.30	51	43	24	8	73	.05
			1.0	1.5	<20.0	.40	84	120	42	20	120	--
	4 Apr 84	2	146.3	<.5	2.1	.15	79	25	33	10	83	.04
			24.5	.5	4.7	.45	73	48	31	18	93	.12
			1.0	5.0	20.0	3.90	87	220	50	87	250	--
		387	140.5	<.5	3.0	.07	57	25	26	8	68	.05
			22.8	<.5	10.0	2.20	68	51	31	12	150	.08
			1.0	<.5	40.0	.73	61	100	42	35	110	--
Puyallup River at mouth at Tacoma	25 Aug 83	50	171.3	<.5	.9	.20	180	22	57	< 4	150	.02
			20.1	<.5	.9	.40	64	37	21	15	66	.07
			1.0	2.0	10.0	2.60	71	130	34	26	120	.22
		330	167.9	<.5	1.1	.20	190	22	63	6	160	.02
			16.5	<.5	1.5	1.20	48	44	22	16	71	.06
			1.0	2.0	<10.0	1.20	60	150	37	37	130	.29
		610	162.5	<.5	1.3	<.10	100	23	36	12	99	.02
			26.1	<.5	2.1	1.70	59	42	32	13	73	.04
			1.0	1.5	<10.0	2.70	59	160	37	19	110	.30

TABLE 20.--Trace-element concentrations in bed sediments--Continued

Site name	Date	Cross-section location	Size (micrometers)	Ag	As	Cd	Cr	Cu	Ni	Pb	Zn	Hg
				(concentrations in micrograms per gram)								
Puyallup River	4 Apr 84	50	162.1	<0.5	2.4	0.08	100	24	39	7	93	0.04
at mouth--Con.			25.8	1.0	20.0	4.40	81	110	40	37	150	.26
			1.0	2.0	<1000.0	<50.00	70	200	50	70	<300	--
		610	154.1	<.5	2.0	.09	69	24	30	8	76	.05
			11.1	<.5	14.4	1.30	80	59	37	16	100	.10
			1.0	<2.0	<10.0	<2.00	40	75	25	19	270	--
Diru Creek at	10 Aug 83	C	162.1	<.5	2.0	.10	190	14	40	11	76	.01
inflow to hatchery			25.6	<.5	7.2	.50	110	39	51	28	100	.09
nr Puyallup			1.0	<2.0	20.0	1.00	120	75	100	75	200	--
	12 Jun 84	C	160.4	<.5	3.4	<2.00	89	18	40	14	62	--
			11.1	<.5	7.5	<2.00	97	38	57	34	100	--
			1.0	<2.0	10.0	<2.00	110	72	100	66	180	--
Clarks Creek at	10 Aug 83	C	116.7	<.5	10.0	.50	81	30	33	61	470	.09
Reserv Bdry at			18.9	<.5	17.0	1.10	91	49	41	140	260	.12
Puyallup			1.0	<.5	120.0	1.20	88	82	44	280	230	--
Clarks Creek at	10 Aug 83	C	118.2	.5	2.3	.10	79	20	28	17	85	.05
River Road nr			26.9	.7	5.8	3.40	87	36	33	41	120	.07
Puyallup			1.0	.7	45.0	3.80	99	120	59	260	280	.34
	26 Apr 84	C	108.6	<.5	8.7	.19	68	22	30	31	87	.11
			22.6	<.5	30.0	3.50	90	36	39	89	140	.13
			1.0	5.0	80.0	4.40	100	74	57	250	260	--
Swan Creek at	9 Aug 83	C	172.7	<.5	2.2	.40	98	12	37	7	74	.03
Pioneer Way,			17.4	<.5	8.3	2.10	94	48	58	49	200	.18
Tacoma			1.0	<.5	20.0	3.10	100	87	96	120	370	.25
Wapato Creek at	11 Aug 83	C	128.0	<.5	2.0	<2.00	88	30	27	41	97	.08
Union Pac RR nr			15.6	<.5	4.0	7.00	84	40	32	80	550	.07
No. Puyallup			1.0	<.5	20.0	11.00	87	76	40	160	1100	.16
Wapato Creek at	11 Aug 83	C	124.5	<.5	10.0	52.00	58	60	31	58	230	.35
12th St. E. in			19.1	<.5	11.0	25.00	55	55	29	67	240	.03
Fife			1.0	<4.0	30.0	66.00	69	81	33	100	310	--
West Tributary to	12 Aug 83	C	150.7	<.5	4.5	.30	110	10	30	17	71	.05
Hylebos Creek nr			22.9	<.5	10.0	1.40	75	24	37	45	120	.16
Milton			1.0	<.5	50.0	4.80	110	70	85	140	320	--
Hylebos Creek at	12 Aug 83	C	150.0	<.5	7.6	.10	76	17	31	12	90	.04
8th Ave. E. in			24.9	<.5	42.0	.60	78	32	35	39	120	.15
Fife			1.0	.7	180.0	2.70	100	60	63	110	200	.17
	27 Apr 84	C	158.3	<.5	30.0	.26	64	14	30	14	78	.08
			18.8	<.5	170.0	.30	80	40	43	45	140	.28
			1.0	<.5	390.0	.70	94	67	65	100	230	--
Fife Ditch at	27 Apr 84	C	129.8	<.5	42.0	.22	57	51	26	29	100	.06
54th. St. E. in			11.1	<.5	30.0	1.60	64	95	35	54	210	.20
Fife			1.0	<.5	44.0	3.30	92	110	53	85	140	.16
Headwaters	19 Apr 84	C	1414.2	<.5	1.4	<.10	36	20	19	12	60	<.01
White River			500.0	<.5	.6	<.10	37	22	19	13	70	<.01
			124.5	<.5	.7	<.10	47	21	23	14	70	<.01
			43.8	<.5	1.5	<.10	72	25	27	11	80	.01
			22.3	<.5	3.3	.10	33	31	16	8	60	.05
			11.3	<.5	7.1	.20	33	55	17	16	70	.08
			4.0	<.5	2.7	.17	31	83	17	16	80	--
			1.0	<.5	6.8	<2.00	29	89	16	20	70	--

TABLE 20.--Trace-element concentrations in bed sediments--Continued

Site Name	Date	Cross-section location	Size (micrometers)	Ag	As	Cd	Cr	Cu	Ni	Pb	Zn	Hg
					(concentrations in micrograms per gram)							
Headwaters Puyallup River	7 Apr 84	C	1414.2	<0.5	1.3	<0.10	55	26	27	10	60	0.02
			500.0	<.5	1.2	--	67	28	28	15	70	.01
			124.5	<.5	1.0	.10	130	21	48	9	100	.01
			43.8	<.5	1.0	.10	110	24	36	11	70	.02
			22.3	<.5	1.5	<.10	56	26	23	8	50	.02
			11.3	<.5	2.1	.10	43	30	20	13	50	.04
			4.0	<.5	3.5	.10	41	41	23	12	50	.07
			1.0	<.5	6.4	.10	46	89	36	15	70	.15
Lowland glacial material	15 Jun 84	C	1414.2	<.5	4.3	.05	63	26	40	<4	52	.13
			500.0	<.5	3.5	.04	59	20	38	<4	48	.07
			124.5	<.5	2.6	.08	90	15	46	<4	49	.06
			43.8	<.5	4.4	<2.00	140	25	63	<4	76	--
			22.3	<.5	9.8	<2.00	100	43	89	6	83	--
			11.3	<.5	<10.0	<2.00	100	51	97	10	93	--
			4.0	<.5	11.0	<2.00	100	65	110	13	97	--
			1.0	<.5	20.0	.10	110	82	140	12	100	.40

TABLE 21.--Major-element and selected trace-element concentrations in bed sdiments

[Cross-section location: distance in feet from left bank; or C, laterally composited sample.
Al, aluminum; Ca, calcium; Fe, iron; K, potassium; Mg, magnesium; Na, sodium; Ti, titanium; Mn, manganese; Sr, strontium. All concentrations are in percent, except for manganese (Mn) and strontium (Sr) which are in micrograms per gram.]

	Date	Cross-section location	Size (micro-meters)	Al	Ca	Fe	K	Mg	Na	Ti	Mn	Sr
Puyallup River at Alderton	24 Aug 83	C	95.0	10.0	4.4	2.6	1.3	1.2	3.2	0.33	450	620
			27.8	9.5	4.4	3.3	1.2	1.6	3.0	.43	570	610
			1.0	8.4	2.8	4.9	1.0	2.4	1.4	.31	600	300
	4 Apr 84	C	162.1	7.0	3.6	4.9	1.0	2.7	2.3	.51	870	450
			24.8	8.5	3.7	4.6	1.1	1.5	2.3	.55	780	430
			1.0	9.3	2.7	6.1	1.0	1.5	1.0	.44	1000	190
White River at Sumner	24 Aug 83	C	123.9	9.2	4.2	4.4	1.4	2.3	3.0	.51	820	560
			27.4	9.4	4.2	4.0	1.3	1.6	3.0	.48	700	590
			1.0	8.8	3.5	5.3	1.3	1.3	2.5	.35	690	470
	4 Apr 84	C	142.2	9.1	4.1	3.8	1.3	1.7	3.0	.46	640	610
			27.2	8.5	3.6	4.8	1.1	1.7	2.4	.59	750	490
			1.0	8.0	2.4	5.4	1.0	1.4	1.0	.39	790	200
Puyallup River at Puyallup	24 Aug 83	2	129.7	9.4	4.2	3.7	1.4	1.9	3.0	.44	690	550
			18.3	9.5	4.1	3.3	1.3	1.5	3.0	.42	570	570
			1.0	8.4	3.1	5.0	1.2	2.0	1.9	.37	580	370
		215	110.2	8.4	4.1	7.1	1.0	3.1	2.7	.99	1100	490
			25.1	9.4	4.3	3.8	1.0	1.7	2.9	.48	610	580
			1.0	8.5	3.7	5.9	1.0	1.9	1.9	.42	830	350
	4 Apr 84	C	131.0	8.8	4.0	4.1	1.3	1.9	2.9	.48	680	570
			25.5	8.7	3.6	4.4	1.1	1.6	2.5	.55	700	500
			1.0	9.0	2.2	5.9	1.1	1.4	1.1	.45	750	230
Puyallup River at Lincoln Ave. at Tacoma	24 Aug 83	67	165.1	7.9	4.1	6.5	1.2	4.1	2.6	.67	1300	450
			21.4	9.1	4.0	3.6	1.2	1.7	2.9	.45	630	550
			1.0	7.0	7.0	3.0	1.5	1.5	3.0	.30	500	300
		197	171.7	7.6	4.0	6.7	1.3	4.4	2.6	.60	1400	430
			11.1	9.2	3.9	3.8	1.4	1.6	3.1	.44	770	540
	25 Aug 83	325	171.7	8.4	4.0	5.4	1.3	3.2	2.8	.57	1100	490
			22.7	9.3	4.1	3.6	1.3	1.7	3.0	.44	680	560
			1.0	8.1	4.4	5.0	1.2	2.0	3.0	.39	1200	350
	4 Apr 84	2	146.3	8.3	3.8	5.0	1.3	2.4	2.7	.58	850	530
			24.5	8.8	3.6	4.2	1.1	1.6	2.6	.54	650	510
			1.0	7.9	2.5	4.6	.9	1.3	1.0	.45	470	160
		387	140.5	9.0	4.0	4.1	1.3	1.9	2.9	.48	680	580
			22.8	8.9	3.4	4.5	1.2	1.6	2.5	.52	710	490
			1.0	8.7	3.2	5.6	1.1	1.3	1.9	.42	1500	240
Puyallup River at mouth at Tacoma	25 Aug 83	50	171.3	7.0	4.0	9.2	1.0	5.0	2.3	1.10	1600	400
			20.1	9.3	4.0	3.3	1.3	1.5	2.9	.42	470	570
			1.0	8.3	2.8	4.8	1.2	2.0	2.0	.36	390	370
		338	167.9	6.8	4.0	9.5	1.0	5.4	2.2	1.10	1700	380
			16.5	9.4	4.1	3.4	1.3	1.6	2.9	.43	490	570
			1.0	8.4	2.8	4.8	1.2	2.1	2.6	.38	460	410
		610	162.5	8.5	4.1	5.8	1.2	3.2	2.8	.70	1000	500
			26.1	9.5	4.3	3.7	1.3	1.9	3.0	.46	600	580
			1.0	8.1	3.2	4.4	1.2	2.0	3.6	.37	600	400
	4 Apr 84	50	162.1	8.2	4.0	5.7	1.2	2.8	2.8	.66	950	540
			25.8	8.4	3.1	4.3	1.2	1.6	2.8	.49	620	460
			1.0	7.0	2.0	3.0	2.0	2.0	10.0	.20	1500	1000

TABLE 21.--Major-element and selected trace-element concentrations in bed sdiments--Continued

	Date	Cross-section location	Size (micro-meters)	Al	Ca	Fe	K	Mg	Na	Ti	Mn	Sr
Puyallup River		610	154.1	8.4	3.9	4.7	1.3	2.3	2.9	0.54	780	540
at mouth--Con.			11.1	8.5	3.2	4.6	1.1	1.7	2.3	.54	750	460
			1.0	3.7	.9	2.4	.6	.8	2.7	.20	770	110
Diru Creek at	10 Aug 83	C	162.1	7.0	2.7	4.9	.8	1.7	2.2	.72	1100	300
inflow to			25.6	7.7	2.4	3.8	.8	1.3	1.9	.50	900	280
hatchery			1.0	9.1	2.5	5.9	.6	1.0	.7	.38	1400	110
	12 Jun 84	C	160.4	6.9	2.2	2.7	1.0	1.1	2.2	.30	580	290
			11.1	7.5	2.2	3.5	.8	1.1	1.8	.44	750	260
			1.0	8.7	1.8	4.7	.7	.9	.7	.36	960	110
Clarks Creek	10 Aug 83	C	116.7	8.4	3.5	4.7	1.0	1.7	2.6	.44	630	450
at Reserv. Bdry.			18.9	7.4	2.5	5.7	.9	1.3	1.9	.39	690	320
at Puyallup			1.0	5.0	2.8	13.0	.6	.8	.7	.22	390	120
Clarks Creek	10 Aug 83	C	118.2	9.2	4.3	4.2	1.2	2.2	3.0	.52	700	550
at River Road			26.9	8.7	3.9	4.3	1.1	1.9	2.7	.53	670	490
nr Puyallup			1.0	7.4	2.1	9.5	.8	1.1	.9	.27	530	160
	26 Apr 84	C	124.5	8.8	4.4	4.1	1.1	1.7	2.8	.45	670	530
			22.6	7.5	3.2	5.6	.8	1.3	2.0	.44	870	370
			1.0	5.7	2.6	12.0	.6	.8	.9	.29	980	130
Swan Creek at	9 Aug 83	C	172.7	7.0	2.7	3.3	.9	1.7	2.4	.39	770	320
Pioneer Way,			17.4	7.5	2.3	3.9	.8	1.3	1.8	.45	1400	270
Tacoma			1.0	7.7	2.0	5.3	.6	1.1	.7	.36	2100	110
Wapato Creek	11 Aug 83	C	128.0	8.6	3.8	3.9	1.1	1.9	2.6	.44	600	490
at Union Pac. RR			15.6	8.3	3.0	3.7	1.1	1.4	2.3	.43	480	410
nr No. Puyallup			1.0	7.5	2.1	5.6	.9	1.1	1.3	.31	430	210
Wapato Creek	11 Aug 83	C	124.5	6.4	2.8	9.4	.8	1.4	1.7	.33	2300	340
at 12th. St. E.			19.1	6.6	2.6	10.0	.8	1.2	1.7	.32	2300	330
in Fife			1.0	4.9	3.0	14.0	.6	.7	1.0	.22	2800	170
West Tributary	12 Aug 83	C	150.7	6.7	2.6	3.0	.8	1.2	2.3	.39	1300	310
to Hylebos Cr			22.9	6.6	2.4	2.5	.8	.9	2.2	.34	3600	290
nr Milton			1.0	7.0	2.4	4.6	.8	1.2	.8	.34	4100	110
Hylebos Creek	12 Aug 83	C	150.0	8.5	3.8	4.1	1.2	2.3	2.8	.52	810	480
at 8th. Ave. E.			24.9	8.1	3.3	3.9	.9	1.5	2.4	.44	1400	420
in Fife			1.0	6.9	2.0	7.8	.8	1.1	.9	.33	1500	140
	27 Apr 84	C	124.5	8.1	3.8	3.5	1.1	1.6	2.7	.40	690	470
			18.8	7.5	3.0	4.3	.9	1.1	2.0	.41	1400	350
			1.0	6.8	2.5	7.6	.8	1.0	1.1	.33	1500	160
Fife Ditch	27 Apr 84	C	124.5	8.0	3.9	4.1	1.1	1.3	2.5	.37	510	470
at 54th St. E.			11.1	9.0	3.1	4.5	1.4	1.3	2.4	.42	520	450
in Fife			1.0	9.2	2.5	6.2	1.1	1.7	1.5	.37	500	340
Headwaters	19 Apr 84	C	1414.2	8.8	3.7	4.0	1.6	1.60	3.0	.54	710	500
White River			500.0	8.9	3.9	4.3	1.5	1.90	3.1	.53	800	540
			124.5	8.9	4.0	4.7	1.3	2.20	3.1	.56	900	550
			43.8	9.3	4.6	5.6	1.1	2.10	3.0	.72	940	620
			22.3	9.5	4.3	3.7	1.2	1.30	3.1	.48	630	610
			11.3	9.0	3.7	4.0	1.2	1.20	2.8	.48	690	530
			4.0	8.4	3.0	4.3	1.3	1.30	2.5	.44	750	430
			1.0	8.3	2.5	4.1	1.2	1.20	2.1	.35	570	370

TABLE 21.--Major-element and selected trace-element concentrations in bed sdiments--Continued

	Date	Cross-section location	Size (micro-meters)	Al	Ca	Fe	K	Mg	Na	Ti	Mn	Sr
Headwaters Puyallup River	7 Apr 84	C	1414.2	8.8	3.6	4.1	1.5	1.70	2.9	0.57	650	480
			500.0	8.4	3.6	4.3	1.5	2.00	2.9	.56	740	470
			124.5	7.8	4.0	6.7	1.1	3.40	2.6	.86	1200	460
			43.8	9.3	5.0	5.1	1.0	2.30	2.9	.72	760	620
			22.3	9.4	4.3	3.8	1.2	1.40	3.0	.49	490	610
			11.3	9.1	3.8	3.9	1.4	1.20	3.0	.48	450	560
			4.0	8.8	3.3	4.0	1.4	1.20	2.9	.46	480	500
			1.0	8.3	2.7	5.2	1.2	1.80	2.0	.36	500	350
Lowland glacial deposit	15 Jun 84	C	1414.2	6.3	2.0	3.2	1.0	1.10	2.3	.36	640	210
			500.0	6.3	1.8	2.6	1.1	.90	2.1	.28	540	240
			124.5	6.8	2.1	3.0	.7	1.10	2.3	.34	580	290
			43.8	8.3	2.6	4.6	.8	1.50	2.1	.58	820	310
			22.3	10.0	1.9	4.8	.8	1.30	1.7	.47	860	290
			11.3	11.0	1.8	5.2	.9	1.30	1.6	.51	1000	290
			4.0	12.0	1.7	5.4	.9	1.20	1.7	.50	1200	320
			1.0	14.0	1.2	6.1	.6	.87	.8	.51	1200	140

TABLE 22.--Trace-element concentrations in suspended sediments

[Cross-section location: distance in feet from left bank; or C, laterally composited sample. Ag, silver; As, arsenic; Cd, cadmium; Cr, chromium; Cu, copper; Ni, nickel; Pb, lead; Zn, zinc; Hg, mercury]

	Date	Cross-section location	Size (micrometers)	Ag	As	Cd	Cr	Cu	Ni	Pb	Zn	Hg
				(concentrations in micrograms per gram)								
Puyallup River at Alderton	24 Aug 83	C	124.5	<0.5	<10.0	0.23	44	49	32	13	55	--
			11.1	<.5	<10.0	<.10	39	43	23	21	59	0.08
			1.0	<.0	<20.0	<4.00	62	110	36	59	120	--
	25 Jan 84	C	133.3	<.5	1.6	.16	53	27	25	9	75	.05
			18.2	<.5	3.4	.98	71	25	29	10	90	.05
			1.0	<.5	6.5	.92	64	140	20	140	450	.25
	2 May 84	C	11.1	<.5	<20.0	.75	82	56	39	29	130	--
White River at Sumner	24 Aug 83	C	1.0	<.0	<20.0	<4.00	37	65	15	11	90	--
	25 Jan 84	C	124.6	<.5	3.0	.21	86	28	35	8	76	.03
			17.3	<.5	11.0	.66	65	42	32	17	71	.06
			1.0	<.5	30.0	.61	59	81	37	39	250	.25
	2 May 84	C	11.1	<.5	<1000.0	<50.00	70	70	30	50	<300	--
Puyallup River at Puyallup	25 Aug 83	68	11.1	<.5	2.0	<.10	44	30	23	7	69	.03
			1.0	<.5	<10.0	<.10	44	57	30	15	75	.17
		139	124.5	<.5	<10.0	.13	39	25	22	18	61	--
			11.1	<.5	2.0	<.10	40	31	22	< 4	100	.04
			1.0	<.5	<10.0	<.10	41	73	32	16	110	.14
		188	11.1	<.5	2.2	.20	52	48	30	25	71	.06
			1.0	<.5	<20.0	<.10	61	110	33	74	170	--
	25 Jan 84	C	18.2	<.5	6.6	.16	79	23	32	7	87	.08
			1.0	<.5	<10.0	.19	49	21	21	8	61	.25
	2 May 84	C	124.5	<.5	2.7	.16	71	25	29	10	90	.07
			11.1	<4.0	<20.0	<4.00	88	47	38	21	150	--
Puyallup River at Lincoln Ave. at Tacoma	25 Aug 83	67	124.5	<.5	<10.0	.25	43	27	22	9	70	--
			11.1	.5	2.1	.10	43	35	24	11	70	.04
			1.0	3.0	<10.0	.10	48	89	33	28	130	.30
		197	11.1	<.5	<10.0	<2.00	41	38	27	14	78	.09
			1.0	<.5	<20.0	<.10	64	78	35	37	140	--
		325	11.1	<.5	<10.0	.10	39	35	24	11	68	.08
			1.0	<.5	<20.0	<.10	60	76	33	35	120	--
	25 Jan 84	C	140.8	<.5	2.1	.10	86	28	35	8	76	.05
			17.8	<.5	9.0	.17	65	42	32	17	71	.05
			1.0	<.5	18.0	.17	59	81	37	39	250	.28
	5 Apr 84	138	7.9	15.0	<1000.0	<50.00	150	150	50	70	200	--
		260	7.9	1.0	<1000.0	<50.00	70	70	50	20	2000	--
	2 May 84	130	124.5	<0.5	2.8	.24	79	23	32	7	87	.04
			11.1	<4.0	<20.0	<4.00	85	61	54	41	180	--
		260	124.5	<.5	<10.0	.31	60	24	26	9	110	--
			11.1	1.5	<1000.0	<50.00	70	70	30	50	500	--
Puyallup River at mouth at Tacoma	25 Aug 83	50	1.0	3.0	<1000.0	<50.00	50	150	30	30	<300	--
		330	11.1	1.0	2.0	<2.00	47	38	27	8	70	.07
			1.0	5.0	10.0	<2.00	71	140	42	88	150	.35
		610	124.5	<4.0	<20.0	<4.00	54	53	29	23	110	.00
			11.1	.7	2.0	.50	42	37	24	14	78	.12
			1.0	<.5	<10.0	.30	45	94	35	37	270	.22
	5 Apr 84	C	124.5	<.5	3.4	.31	53	27	25	9	75	.06
			7.9	<4.0	<20.0	4.00	83	58	37	36	150	--
	2 May 84	C	124.5	<.5	13.0	.12	49	21	21	8	61	.06
			11.1	<.5	<10.0	<3.00	61	28	27	13	74	--

TABLE 22.--Trace-element concentrations in suspended sediments--Continued

	Date	Cross-section location	Size (micro-meters)	Ag	As	Cd	Cr	Cu	Ni	Pb	Zn	Hg
				(concentrations in micrograms per gram)								
Clarks Creek at Reserv Bdry at Puyallup	3 Nov 83	C	11.1	<0.5	<1000.0	<50.00	150	70	70	150	<300	--
Clarks Creek at River Road nr Puyallup	3 Nov 83	C	11.1	<4.0	< 20.0	<4.00	120	75	80	520	250	--
			1.0	<.5	<1000.0	<50.00	70	70	70	200	<300	--
Swan Creek at Pioneer Way, Tacoma	3 Nov 83	C	11.1	<4.0	<20.0	<4.00	140	78	110	120	300	--
Wapato Creek at 12th. St. E. in Fife	4 Nov 83	C	11.1	<.5	<1000.0	<50.00	70	70	30	70	<300	--
West Tributary to Hylebos Creek nr Milton	3 Nov 83	C	11.1	<2.0	30.0	<2.00	84	83	70	120	300	--
Hylebos Creek at 8th Ave. E. in Fife	3 Nov 83	C	11.1	<4.0	70.0	<4.00	110	62	69	76	300	--
			1.0	<4.0	20.0	<4.00	54	35	30	24	96	--
Sumner Sewage Treatment Plant	24 Aug 83	C	11.1	<.5	3.1	.10	36	46	21	14	130	0.15
	25 Jan 84	C	11.1	5.0	<1000.0	<50.00	15	70	15	30	<300	--
	5 Apr 84	C	11.1	5.0	<1000.0	<50.00	15.	100	7	20	<300	--
	2 May 84	C	11.1	2.0	<10.0	.68	15	110	11	40	220	--
Puyallup Sewage Treatment Plant	25 Jan 84	C	11.1	50.0	<1000.0	<50.00	30	200	30	100	700	--
	5 Apr 84	C	11.1	50.0	<1000.0	<50.00	70	150	15	100	700	--
	2 May 84	C	11.1	20.0	<1000.0	<50.00	50	150	100	100	200	--
Tacoma Sewage Treatment Plant	25 Aug 83	C	11.1	20.0	<10.0	9.00	87	220	25	190	720	--
	25 Jan 84	C	11.1	30.0	19.0	13.00	150	340	77	330	1100	--
	5 Apr 84	C	11.1	30.0	<10.0	18.00	110	290	38	270	840	--
	2 May 84	C	11.1	30.0	25.0	9.10	64	140	20	140	450	2.80

TABLE 23.--Major-element and selected trace-element concentrations in suspended sediments

[Cross-section location: distance in feet from left bank;
or C, laterally composited sample.
Al, aluminum; Ca, calcium; Fe, iron; K, potassium; Mg, magnesium; Na, sodium; Ti, titanium;
Mn, manganese; Sr, strontium. All concentrations are in percent, except for manganese (Mn)
and strontium (Sr) which are in micrograms per gram.]

	Date	Cross-section location	Size (micrometers)	Al	Ca	Fe	K	Mg	Na	Ti	Mn	Sr
Puyallup River at Alderton	24 Aug 83	C	124.5	8.9	3.8	2.9	1.2	1.3	2.9	0.38	500	550
			11.1	9.7	4.3	3.2	1.6	1.3	3.2	.42	560	600
			1.0	8.8	4.2	4.0	1.4	1.7	2.3	.36	550	430
	25 Jan 84	C	133.3	8.7	4.0	4.3	1.2	2.1	2.8	.50	710	560
			18.2	9.0	3.5	4.2	1.3	1.5	2.6	.53	710	510
			1.0	14.0	4.0	6.8	2.2	2.1	2.8	.65	1100	510
	2 May 84	C	11.1	8.5	2.9	4.5	1.0	1.4	2.2	.53	1300	390
White River at Sumner	24 Aug 83	C	1.0	9.4	6.0	2.2	1.5	.9	2.9	.26	530	600
	25 Jan 84	C	124.6	8.6	3.8	4.4	1.3	1.9	2.8	.51	750	540
			17.3	8.8	3.3	4.1	1.2	1.3	2.5	.48	750	460
			1.0	9.0	2.7	5.6	1.3	1.4	1.6	.48	930	270
	2 May 84	C	11.1	10.0	2.0	3.0	1.5	1.5	2.0	.30	1500	700
Puyallup River at Puyallup	25 Aug 83	68	11.1	9.6	4.3	3.4	1.4	1.4	3.1	.42	570	600
			1.0	8.8	3.5	3.9	1.4	1.6	2.2	.35	450	430
		139	124.5	9.3	4.3	2.9	1.2	1.2	3.2	.37	530	620
			11.1	9.6	4.2	3.3	1.5	1.3	3.1	.42	560	590
			1.0	8.9	3.5	3.9	1.5	1.6	2.2	.35	610	450
		188	11.1	9.6	4.1	3.3	1.5	1.3	3.0	.41	550	590
			1.0	8.9	4.6	3.8	1.4	1.6	2.2	.34	570	450
	25 Jan 84	C	18.2	8.9	3.4	4.1	1.2	1.4	2.6	.50	710	490
			1.0	8.6	3.8	4.8	1.3	1.4	1.7	.43	780	290
	2 May 84	C	124.5	8.3	3.6	4.5	1.4	2.0	2.8	.53	820	510
			11.1	8.3	3.1	4.8	1.0	1.5	2.1	.51	1400	400
Puyallup River at Lincoln Ave. at Tacoma	25 Aug 83	67	124.5	9.0	4.0	3.2	1.3	1.3	3.0	.40	570	570
			11.1	9.5	4.1	3.4	1.5	1.4	3.0	.45	580	580
			1.0	8.7	3.8	4.0	1.4	1.7	2.2	.36	640	420
		197	11.1	9.5	3.9	3.2	1.6	1.2	3.0	.41	550	560
			1.0	9.2	3.7	3.9	1.5	1.7	2.4	.35	620	460
		325	11.1	9.6	4.0	3.3	1.6	1.3	3.0	.41	560	570
			1.0	9.2	3.6	4.0	1.4	1.7	2.3	.36	640	460
	25 Jan 84	C	140.8	8.5	3.9	4.8	1.2	2.3	2.8	.56	790	540
			17.8	9.0	3.4	4.2	1.3	1.5	2.6	.51	710	490
			1.0	9.3	2.7	5.2	1.5	1.5	1.8	.47	770	310
	5 Apr 84	130	7.9	>10.0	3.0	5.0	2.0	2.0	5.0	.30	1500	2000
		260	7.9	>10.0	3.0	5.0	1.5	2.0	3.0	.50	1000	1000
	2 May 84	130	124.5	8.6	3.8	4.2	1.3	1.8	2.8	.50	810	510
			11.1	>10.0	3.0	5.0	1.5	2.0	3.0	.30	1000	1000
		260	124.5	8.1	3.7	5.0	1.4	2.4	2.8	.58	880	510
			11.1	8.3	3.0	4.7	1.0	1.4	2.2	.52	1300	400
Puyallup River at mouth at Tacoma	25 Aug 83	50	1.0	7.0	5.0	3.0	1.5	1.0	3.0	.30	300	300
		330	11.1	9.5	4.1	3.4	1.5	1.4	3.0	.43	590	590
			1.0	8.4	3.5	4.1	1.4	1.7	2.0	.36	540	400

TABLE 23.--Major-element and selected trace-element concentrations in suspended sediments--Continued

	Date	Cross-section location	Size (micro-meters)	Al	Ca	Fe	K	Mg	Na	Ti	Mn	Sr
Puyallup River at mouth at Tacoma--Con.	25 Aug 83	610	124.5	9.3	4.0	3.1	1.3	1.3	3.0	0.35	660	580
			11.1	9.5	4.1	3.4	1.5	1.3	3.0	.44	580	590
			1.0	8.8	3.6	4.1	1.4	1.7	2.3	.36	620	430
	5 Apr 84	C	124.5	8.9	3.9	3.9	1.4	1.8	3.0	.47	680	580
			7.9	8.3	3.8	4.5	1.1	1.8	3.8	.55	1300	500
	2 May 84	C	124.5	7.0	3.0	3.4	1.2	1.5	2.4	.41	570	440
			11.1	8.6	3.6	3.9	1.6	1.7	2.9	.52	650	490
Clarks Creek at Reserv Bdry at Puyallup	3 Nov 83	C	11.3	7.0	.7	3.0	1.5	.7	1.0	.30	700	300
Clarks Creek at River Road nr Puyallup	3 Nov 83	C	11.3	9.0	2.6	5.9	1.1	1.4	1.8	.40	1500	330
			1.0	3.0	>10.0	3.0	.7	.7	.3	.20	300	100
Swan Creek at Pioneer Way, Tacoma	3 Nov 83	C	11.3	8.1	2.0	4.5	.9	1.2	1.7	.40	1500	240
Wapato Creek at 12th. St. E. in Fife	4 Nov 83	C	11.3	7.0	1.0	5.0	1.5	.7	1.5	.20	700	300
West Tributary to Hylebos Creek nr Milton	3 Nov 83	C	11.3	6.7	2.1	3.8	.8	1.0	1.7	.35	6800	240
Hylebos Creek at 8th. Ave. E. in Fife	3 Nov 83	C	11.3	7.9	2.5	4.6	1.0	1.2	1.8	.40	2900	300
			1.0	2.3	19.0	1.6	.3	.4	.3	.11	530	110
Sumner Sewage Treatment Plant	24 Aug 83	C	11.1	9.4	4.1	3.6	1.5	1.30	2.9	.43	680	560
	25 Jan 84	C	11.1	.5	1.5	.3	--	.50	5.0	.03	150	100
	5 Apr 84	C	11.1	.5	1.5	.5	2.0	.70	7.0	.07	200	150
	2 May 84	C	11.1	.4	3.0	.8	3.5	1.70	11.0	.05	390	130
Puyallup Sewage Treatment Plant	25 Jan 84	C	11.1	2.0	2.0	3.0	.7	.70	1.5	.15	700	300
	5 Apr 84	C	11.1	.7	3.0	5.0	.7	.70	2.0	.15	3000	300
	2 May 84	C	11.1	1.5	7.0	3.0	3.0	3.00	>10.0	.10	1500	700
Tacoma Sewage Treatment Plant	25 Aug 83	C	11.1	2.0	5.6	.8	.2	.34	.5	.19	110	100
	25 Jan 84	C	11.1	4.4	2.1	2.2	.6	.80	2.3	.26	320	150
	5 Apr 84	C	11.1	1.1	7.4	.8	.6	.29	2.9	.16	140	130
	2 May 84	C	11.1	.8	9.1	.5	.4	.30	6.5	.09	85	130

TABLE 24.--Dissolved and total-recoverable trace-element concentrations in surface-water samples

12096500 - PUYALLUP RIVER AT ALDERTON, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)
AUG , 1983									
24...	1500	922	--	90	--	<1	--	<1	--
JAN , 1984									
25...	1220	14700	60000	50	5	<1	3	<2	11
APR									
05...	1045	1550	--	20	--	<1	--	<1	--
MAY									
02...	1030	3100	--	30	--	<1	--	<1	--

DATE	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)
AUG , 1983									
24...	<1	--	1	--	60	--	<1	--	20
JAN , 1984									
25...	<1	110	2	44000	60	12	<1	870	10
APR									
05...	<1	--	1	--	60	--	<1	--	20
MAY									
02...	1	--	2	--	30	--	<1	--	30

DATE	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	NICKEL, TOTAL RECOV-ERABLE (UG/L AS NI)	NICKEL, DIS-SOLVED (UG/L AS NI)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG)	SILVER, DIS-SOLVED (UG/L AS AG)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)
AUG , 1983								
24...	--	<.1	--	1	--	<1	--	<10
JAN , 1984								
25...	<.1	<.1	21	2	<1	<2	120	10
APR								
05...	--	<.1	--	6	--	<1	--	20
MAY								
02...	--	<.1	--	2	--	<1	--	<10

TABLE 24.--Continued

12101110 - WHITE R. AT SUMNER

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)
AUG , 1983									
24...	1150	862	--	<10	--	1	--	<1	--
JAN , 1984									
25...	0900	20500	63000	40	10	<1	4	<1	11
APR									
05...	0800	1490	--	20	--	<1	--	<1	--
MAY									
02...	0830	1900	--	20	--	<1	--	<1	--

DATE	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)
AUG , 1983									
24...	<1	--	1	--	30	--	<1	--	10
JAN , 1984									
25...	<1	110	3	42000	40	20	2	900	10
APR									
05...	<1	--	4	--	70	--	<1	--	10
MAY									
02...	1	--	2	--	20	--	<1	--	30

DATE	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	NICKEL, TOTAL RECOV-ERABLE (UG/L AS NI)	NICKEL, DIS-SOLVED (UG/L AS NI)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG)	SILVER, DIS-SOLVED (UG/L AS AG)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)
AUG , 1983								
24...	--	<.1	--	2	--	<1	--	<10
JAN , 1984								
25...	.2	<.1	26	1	<1	<1	100	<10
APR								
05...	--	<.1	--	5	--	<1	--	<10
MAY								
02...	--	<.1	--	1	--	<1	--	<10

TABLE 24.--Continued

12101500 - PUYALLUP RIVER AT PUYALLUP, WASHINGTON

DATE	TIME	STREAM WIDTH (FT)	SAMPLE LOC-ATION, CROSS SECTION (FT FM L BANK)	STREAM-FLOW, INSTAN-TANEOUS (CFS)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
AUG , 1983										
25...	0920	217	68.0	2030	--	<10	--	1	--	<1
25...	1000	217	139	2010	--	--	--	<1	--	<1
25...	1040	217	188	2000	--	10	--	<1	--	<1
JAN , 1984										
25...	1530	--	--	32400	48000	40	7	1	4	<1
APR										
05...	0830	--	--	3040	--	20	--	<1	--	<1
MAY										
02...	0815	--	--	4280	2600	20	<1	<1	<1	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)
AUG , 1983									
25...	--	<1	--	1	--	20	--	<1	--
25...	--	<1	--	2	--	--	--	1	--
25...	--	<1	--	2	--	20	--	<1	--
JAN , 1984									
25...	13	1	93	2	36000	50	13	<1	710
APR									
05...	--	<1	--	4	--	70	--	<1	--
MAY									
02...	4	<1	6	1	1900	50	3	<1	60

DATE	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	NICKEL, TOTAL RECOV-ERABLE (UG/L AS NI)	NICKEL, DIS-SOLVED (UG/L AS NI)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG)	SILVER, DIS-SOLVED (UG/L AS AG)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)
AUG , 1983									
25...	20	--	<.1	--	1	--	<1	--	10
25...	20	--	<.1	--	2	--	<1	--	<10
25...	20	--	<.1	--	2	--	<1	--	<10
JAN , 1984									
25...	10	<.1	<.1	18	3	<1	<1	90	10
APR									
05...	20	--	<.1	--	3	--	<1	--	10
MAY									
02...	20	<.1	<.1	10	2	<1	<1	20	<10

TABLE 24.--Continued

12102400 - PUYALLUP RIVER AT LINCOLN AVENUE AT TACOMA, WASHINGTON

DATE	TIME	STREAM WIDTH (FT)	SAMPLE LOC-ATION, CROSS SECTION (FT FM L BANK)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
AUG , 1983									
25...	1445	389	67.0	--	50	--	<1	--	<1
25...	1615	389	197	--	<10	--	<1	--	<1
25...	1540	389	325	--	<10	--	<1	--	1
JAN , 1984									
25...	1530	--	--	51000	50	7	1	6	<1
APR									
05...	1110	389	130	--	20	--	<1	--	<1
05...	1000	389	260	--	20	--	<1	--	<1
MAY									
02...	1055	389	130	7500	20	2	1	<1	<1
02...	0955	389	260	6300	20	<1	<1	<1	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)
AUG , 1983									
25...	--	<1	--	2	--	20	--	<1	--
25...	--	<1	--	2	--	10	--	<1	--
25...	--	<1	--	2	--	10	--	<1	--
JAN , 1984									
25...	16	<1	120	8	52000	60	65	4	960
APR									
05...	--	<1	--	2	--	80	--	<1	--
05...	--	<1	--	1	--	80	--	<1	--
MAY									
02...	8	<1	13	3	4500	60	2	<1	100
02...	7	1	9	2	4100	20	2	<1	90

DATE	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	NICKEL, TOTAL RECOV-ERABLE (UG/L AS NI)	NICKEL, DIS-SOLVED (UG/L AS NI)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG)	SILVER, DIS-SOLVED (UG/L AS AG)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)
AUG , 1983									
25...	10	--	<.1	--	2	--	<1	--	10
25...	10	--	--	--	4	--	<1	--	10
25...	<10	--	--	--	3	--	<1	--	10
JAN , 1984									
25...	10	.1	<.1	18	3	<1	<1	140	10
APR									
05...	30	--	<.1	--	3	--	<1	--	10
05...	20	--	<.1	--	2	--	<1	--	10
MAY									
02...	30	<.1	<.1	11	2	<1	<1	30	<10
02...	20	<.1	<.1	11	1	<1	<1	30	10

TABLE 24.--Continued

12102450 - PUYALLUP RIVER AT MOUTH AT TACOMA, WASHINGTON

DATE	TIME	STREAM WIDTH (FT)	SAMPLE LOCATION, CROSS SECTION (FT FM L BANK)	ALUMINUM, TOTAL RECOVERABLE (UG/L AS AL)	ALUMINUM, DISSOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DISSOLVED (UG/L AS AS)	CADMIUM TOTAL RECOVERABLE (UG/L AS CD)	CADMIUM DISSOLVED (UG/L AS CD)
AUG , 1983									
25...	1328	660	50.0	--	<10	--	<1	--	<1
25...	1115	660	330	--	10	--	1	--	<1
25...	1245	660	610	--	20	--	1	--	<1
APR , 1984									
05...	1230	--	--	4400	10	1	<1	<1	<1
MAY									
02...	1210	--	--	23000	20	6	<1	<1	<1

DATE	CHROMIUM, TOTAL RECOVERABLE (UG/L AS CR)	CHROMIUM, DISSOLVED (UG/L AS CR)	COPPER, TOTAL RECOVERABLE (UG/L AS CU)	COPPER, DISSOLVED (UG/L AS CU)	IRON, TOTAL RECOVERABLE (UG/L AS FE)	IRON, DISSOLVED (UG/L AS FE)	LEAD, TOTAL RECOVERABLE (UG/L AS PB)	LEAD, DISSOLVED (UG/L AS PB)	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)
AUG , 1983									
25...	--	<1	--	3	--	<10	--	<2	--
25...	--	<1	--	2	--	30	--	<1	--
25...	--	<1	--	1	--	20	--	<1	--
APR , 1984									
05...	9	<1	11	2	3400	50	2	<1	80
MAY									
02...	10	<1	29	1	14000	30	12	<1	270

DATE	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	MERCURY DISSOLVED (UG/L AS HG)	NICKEL, TOTAL RECOVERABLE (UG/L AS NI)	NICKEL, DISSOLVED (UG/L AS NI)	SILVER, TOTAL RECOVERABLE (UG/L AS AG)	SILVER, DISSOLVED (UG/L AS AG)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	ZINC, DISSOLVED (UG/L AS ZN)
AUG , 1983									
25...	60	--	--	--	<3	--	<1	--	20
25...	70	--	<.1	--	2	--	<1	--	10
25...	30	--	<.1	--	<2	--	<1	--	<10
APR , 1984									
05...	30	.1	<.1	11	4	<1	<1	20	10
MAY									
02...	70	.1	<.1	31	1	<1	<1	60	<10

TABLE 24.--Continued

12102020 - DIRU CR AT INFLOW TO HATCHERY NR PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)
AUG , 1983									
10...	0915	.26	--	10	--	<1	--	<1	--
NOV									
04...	0800	.42	80	10	<1	<1	<1	<1	4
APR , 1984									
27...	1250	.52	60	10	<1	<1	<1	<1	2

DATE	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)
AUG , 1983									
10...	<1	--	1	--	14	--	<1	--	<1
NOV									
04...	<1	7	<1	100	19	2	<1	20	4
APR , 1984									
27...	<1	1	<1	50	20	<1	<1	<10	<10

DATE	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	NICKEL, TOTAL RECOV-ERABLE (UG/L AS NI)	NICKEL, DIS-SOLVED (UG/L AS NI)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG)	SILVER, DIS-SOLVED (UG/L AS AG)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)
AUG , 1983								
10...	--	<.1	--	<1	--	<1	--	4
NOV								
04...	.1	<.1	6	2	<1	<1	20	<3
APR , 1984								
27...	<.1	<.1	<1	2	<1	<1	20	<10

TABLE 24.--Continued

12102075 - CLARKS CR AT RESERV BDRY AT PUYALLUP,WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, DIS-SOLVED (UG/L AS CU)
AUG , 1983							
10...	1250	53	<10	2	<1	<1	2
NOV							
03...	1605	115	10	1	<1	<1	2

DATE	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY DIS-SOLVED (UG/L AS HG)	NICKEL, DIS-SOLVED (UG/L AS NI)	SILVER, DIS-SOLVED (UG/L AS AG)	ZINC, DIS-SOLVED (UG/L AS ZN)
AUG , 1983							
10...	6	<1	17	<.1	<1	<1	<3
NOV							
03...	83	<1	19	<.1	4	<1	9

12102100 - CLARKS CR AT RIVER ROAD NR PUYALLUP, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)
AUG , 1983									
10...	1515	57	--	10	--	1	--	<1	--
NOV									
03...	1435	113	--	20	--	1	--	<1	--
APR , 1984									
26...	1220	58	130	<10	1	<1	<1	<1	2

DATE	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)
AUG , 1983									
10...	<1	--	1	--	42	--	<1	--	13
NOV									
03...	<1	--	2	--	110	--	3	--	22
APR , 1984									
26...	<1	3	<1	700	40	7	<1	50	40

DATE	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	NICKEL, TOTAL RECOV-ERABLE (UG/L AS NI)	NICKEL, DIS-SOLVED (UG/L AS NI)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG)	SILVER, DIS-SOLVED (UG/L AS AG)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)
AUG , 1983								
10...	--	<.1	--	1	--	<1	--	<3
NOV								
03...	--	<.1	--	4	--	<1	--	6
APR , 1984								
26...	<.1	<.1	2	3	<1	<1	10	<10

TABLE 24.--Continued

12102202 - SWAN CR AT FLUME LINE ROAD, TACOMA, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, DIS-SOLVED (UG/L AS CU)
NOV , 1983							
03...	1425	20	50	1	<1	<1	48

DATE	IRON, DIS-SOLVED (UG/L AS FE) (01046)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	MANGA-NESE, DIS-SOLVED (UG/L AS MN) (01056)	MERCURY DIS-SOLVED (UG/L AS HG) (71890)	NICKEL, DIS-SOLVED (UG/L AS NI) (01065)	SILVER, DIS-SOLVED (UG/L AS AG) (01075)	ZINC, DIS-SOLVED (UG/L AS ZN) (01090)
NOV , 1983							
03...	65	8	29	2.8	7	1	44

12102212 - SWAN CR AT PIONEER WAY, TACOMA, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, DIS-SOLVED (UG/L AS CU)
AUG , 1983							
09...	0830	2.7	<10	2	<1	<1	1
NOV							
03...	1610	25	30	1	<1	<1	4

DATE	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY DIS-SOLVED (UG/L AS HG)	NICKEL, DIS-SOLVED (UG/L AS NI)	SILVER, DIS-SOLVED (UG/L AS AG)	ZINC, DIS-SOLVED (UG/L AS ZN)
AUG , 1983							
09...	10	<1	2	<.1	1	<1	<3
NOV							
03...	41	<1	2	<.1	5	<1	5

12102490 - WAPATO CR AT UNION PAC RR NR NO. PUYALLUP,WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, DIS-SOLVED (UG/L AS CU)
NOV , 1983							
04...	0800	1.2	30	1	<1	<1	4

DATE	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, DIS-SOLVED (UG/L AS PB)	MANG-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY DIS-SOLVED (UG/L AS HG)	NICKEL, DIS-SOLVED (UG/L AS NI)	SILVER, DIS-SOLVED (UG/L AS AG)	ZINC, DIS-SOLVED (UG/L AS ZN)
NOV , 1983							
04...	110	<1	26	<.1	7	<1	15

TABLE 24.--Continued

12102510 - WAPATO CR AT 12TH ST E. IN FIFE, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, DIS-SOLVED (UG/L AS CU)
AUG , 1983							
11...	1020	1.8	20	<1	<1	<1	6
NOV							
04...	0910	12	10	1	<1	<1	3

DATE	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY DIS-SOLVED (UG/L AS HG)	NICKEL, DIS-SOLVED (UG/L AS NI)	SILVER, DIS-SOLVED (UG/L AS AG)	ZINC, DIS-SOLVED (UG/L AS ZN)
AUG , 1983							
11...	36	1	94	<.1	1	<1	12
NOV							
04...	100	<1	84	<.1	5	1	5

12103000 - WEST TRIB TO HYLEBOS CR NEAR MILTON, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, DIS-SOLVED (UG/L AS CU)
AUG , 1983							
12...	0830	5.0	10	4	<1	<1	2
NOV							
03...	1150	47	60	2	<1	<1	4

DATE	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY DIS-SOLVED (UG/L AS HG)	NICKEL, DIS-SOLVED (UG/L AS NI)	SILVER, DIS-SOLVED (UG/L AS AG)	ZINC, DIS-SOLVED (UG/L AS ZN)
AUG , 1983							
12...	77	<1	33	<.1	<1	<1	4
NOV							
03...	130	<1	110	<.1	4	<1	11

TABLE 24.--Continued

12103025 - HYLEBOS CR AT 8TH AVE E. IN FIFE, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)
AUG , 1983									
12...	1040	9.1	--	20	--	12	--	<1	--
NOV									
03...	1030	83	--	80	--	10	--	<1	--
APR , 1984									
27...	0830	16	260	20	25	12	<1	<1	3

DATE	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)
AUG , 1983									
12...	<1	--	2	--	140	--	1	--	210
NOV									
03...	<10	--	4	--	240	--	<1	--	190
APR , 1984									
27...	<1	7	<1	980	80	<1	2	140	100

DATE	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	NICKEL, TOTAL RECOV-ERABLE (UG/L AS NI)	NICKEL, DIS-SOLVED (UG/L AS NI)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG)	SILVER, DIS-SOLVED (UG/L AS AG)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)
AUG , 1983								
12...	--	<.1	--	1	--	<1	--	20
NOV								
03...	--	<.1	--	14	--	<1	--	13
APR , 1984								
27...	.1	<.1	<1	3	<1	<1	20	<10

TABLE 24.--Continued

12103035 - FIFE DITCH AT 54TH ST E. IN FIFE, WASHINGTON

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)
NOV , 1983									
04...	1010	23	1300	20	39	12	2	<1	14
APR , 1984									
27...	0945	.82	460	10	6	2	<1	<1	5

DATE	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)
NOV , 1983									
04...	<1	90	25	3500	130	34	<1	240	210
APR , 1984									
27...	1	5	<1	16000	4800	1	<1	2700	2600

DATE	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	NICKEL, TOTAL RECOV-ERABLE (UG/L AS NI)	NICKEL, DIS-SOLVED (UG/L AS NI)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG)	SILVER, DIS-SOLVED (UG/L AS AG)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)
NOV , 1983								
04...	<.1	<.1	17	8	<1	<1	200	110
APR , 1984								
27...	.3	<.1	7	3	<1	<1	30	10

TABLE 24.--Continued

471220122191201 - PUYALLUP SEWAGE TREATMENT PLANT

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)
AUG , 1983									
26...	1230	5.0	--	<10	--	2	--	<1	--
JAN , 1984									
25...	1415	14	570	30	2	<1	<1	<1	5
APR									
05...	1315	6.7	--	<10	--	<1	--	<1	--
MAY									
02...	1250	6.7	--	10	--	1	--	<1	--

DATE	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)
AUG , 1983									
26...	<1	--	20	--	470	--	<1	--	50
JAN , 1984									
25...	<1	18	7	3300	70	18	<1	160	120
APR									
05...	<1	--	9	--	140	--	11	--	100
MAY									
02...	<1	--	8	--	130	--	<1	--	140

DATE	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	NICKEL, TOTAL RECOV-ERABLE (UG/L AS NI)	NICKEL, DIS-SOLVED (UG/L AS NI)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG)	SILVER, DIS-SOLVED (UG/L AS AG)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)
AUG , 1983								
26...	--	--	--	<1	--	<1	--	32
JAN , 1984								
25...	<.1	<.1	3	3	2	<1	80	20
APR								
05...	--	<.1	--	4	--	<1	--	20
MAY								
02...	--	<.1	--	3	--	<1	--	20

TABLE 24.--Continued

471159122150801 - SUMNER SEWAGE TREATMENT PLANT

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)
AUG , 1983									
24...	1245	1.2	--	10	--	1	--	<1	--
JAN , 1984									
25...	1030	2.9	200	<10	2	1	2	<1	7
APR									
05...	1245	1.8	--	<10	--	<1	--	<1	--
MAY									
02...	1215	2.1	--	<10	--	<1	--	<1	--

DATE	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)
AUG , 1983									
24...	<1	--	21	--	100	--	<1	--	17
JAN , 1984									
25...	<1	20	6	1100	210	13	<1	190	160
APR									
05...	<1	--	14	--	290	--	1	--	240
MAY									
02...	1	--	12	--	300	--	<1	--	190

DATE	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	NICKEL, TOTAL RECOV-ERABLE (UG/L AS NI)	NICKEL, DIS-SOLVED (UG/L AS NI)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG)	SILVER, DIS-SOLVED (UG/L AS AG)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)
AUG , 1983								
24...	--	<.1	--	1	--	<1	--	24
JAN , 1984								
25...	.1	<.1	10	6	<1	<1	60	20
APR								
05...	--	.1	--	3	--	<1	--	40
MAY								
02...	--	<.1	--	3	--	<1	--	40

471452122244001 - TACOMA SEWAGE TREATMENT PLANT NO. 1

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)
AUG , 1983									
25...	1645	31	--	10	--	1	--	<1	--
JAN , 1984									
25...	1645	93	1700	70	5	5	5	2	26
APR									
05...	1345	34	--	30	--	3	--	4	--
MAY									
02...	1330	37	1100	40	22	13	4	2	18

DATE	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)
AUG , 1983									
25...	3	--	2	--	210	--	<1	--	140
JAN , 1984									
25...	1	49	15	2200	430	40	4	120	80
APR									
05...	4	--	41	--	140	--	5	--	160
MAY									
02...	9	90	31	1900	100	55	<1	190	150

DATE	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	NICKEL, TOTAL RECOV-ERABLE (UG/L AS NI)	NICKEL, DIS-SOLVED (UG/L AS NI)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG)	SILVER, DIS-SOLVED (UG/L AS AG)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)
AUG , 1983								
25...	--	--	--	16	--	<1	--	10
JAN , 1984								
25...	.6	<.1	8	9	5	<1	180	70
APR								
05...	--	.2	--	11	--	<1	--	90
MAY								
02...	.5	.1	30	6	2	<1	260	110

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