

ANALYSIS OF FIXED-STATION WATER-QUALITY DATA IN THE UMPQUA RIVER BASIN, OREGON

By Joseph F. Rinella

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CONVERSION FACTORS

[For use of those readers who may prefer to use metric (SI) units rather than inch-pound units, the conversion factors for the terms used in this report are listed below.]

Multiply inch-pound units	By	To obtain SI units
<u>Length</u>		
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.60	kilometer (km)
<u>Area</u>		
square mile (mi ²)	2.590	square kilometer (km ²)
<u>Volume</u>		
gallon (gal)	3.785	liter (L)
acre-foot (acre-ft)	1,233	cubic meter (m ³)
<u>Flow</u>		
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second (m ³ /s)
gallon per minute (gal/min)	0.06308	liter per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m ³ /s)
<u>Mass</u>		
ounce, avoirdupois (oz)	28,350	milligram (mg)
pound, avoirdupois (lb)	453.6	gram (g)
ton, short	0.9072	megagram (Mg)
<u>Temperature</u>		
degree Fahrenheit (°F)	°C = 5/9 (°F-32)	degree Celsius (°C)
<u>Specific conductance</u>		
microsiemens per centimeter at 25 degrees Celsius (uS/cm at 25° C)	1.0	micromhos per centimeter at 25 degrees Celsius (umho/cm at 25° C)

ANALYSIS OF FIXED-STATION WATER-QUALITY DATA
IN THE UMPQUA RIVER BASIN, OREGON

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By Joseph F. Rinella

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ABSTRACT

An appraisal of surface-water quality in the Umpqua River basin was made using existing monthly data collected by the Oregon Department of Environmental Quality and the U.S. Geological Survey in cooperation with the Douglas County Water Resources Survey. This appraisal was limited to interpretation of instantaneous monthly water-quality data collected in the Umpqua River basin from water years 1974 to 1983. These data were used to compare water-quality conditions throughout the basin and to determine if data collected from the NASQAN (National Stream Quality Accounting Network) station are representative of upstream basin conditions. In general, data collected at the NASQAN station represent a composite of water quality from the North and South Umpqua Rivers. These river basins account for 82 percent of the NASQAN station drainage. During the winter months, discharge and related water-quality conditions at the NASQAN station represent a uniform composite of both rivers, because 40 to 50 percent of the discharge is from the North Umpqua River and 40 to 50 percent from the South Umpqua River. During summer low flows only about 10 percent of the discharge at the NASQAN station is from the South Umpqua River; consequently, discharge and related water-quality conditions at the NASQAN station do not equally represent those conditions observed in the South Umpqua River.

Water-quality concentrations, loads, yields, and trends were statistically described and related to point-source effluent loads and basin characteristics including hydrogeology, hydrology, population, land use, and water use. Available point- and nonpoint-source data provided minimal information for determining cause-effect relations and for explaining observed trends in water quality; however, the data did indicate that the largest effluent discharges are located in the South Umpqua River basin in the Roseburg-Winston area. Instantaneous and annual flow-weighted levels of specific conductance, phosphorus, organic plus ammonia nitrogen, nitrite plus nitrate, and fecal coliform bacteria are generally highest in the South Umpqua River near Roseburg. These high levels generally occur during the summer months when river flow is extremely low relative to flow in the North Umpqua River. The North Umpqua River has among the lowest constituent concentrations observed in the basin; with its higher summertime base flows, the North Umpqua River mixes with the South Umpqua River at river mile 111.7 and dilutes constituent concentrations in the main stem so that concentrations at the NASQAN station are between those observed in the North and South Umpqua Rivers.

Constituent loads and yields for 1977 WY were computed for nine stations using constituent transport curves based on load versus discharge regressions. Annual loads are reported only for 1977 water year (a lower than normal flow year), because this was the only year during the data-collection period when daily loads could be computed without extrapolations of the load- versus discharge-regression equations. Even though annual loads for 1977 WY are not typical of loads in a normal flow year, they could be used to provide insight to point-source loads and the quality of ground-water contributions.

INTRODUCTION

Purpose and Scope

The U.S. Geological Survey is presently operating NASQAN (National Stream Quality Accounting Network) to define the distribution of the quantity and quality of surface water of the major rivers of the United States. The network consists of fixed-station water-quality sites located at or near the termini of large river basins. Data collected at a NASQAN station represent a composite of natural and man-caused conditions that occur at upstream reaches. These data provide national and regional managers with broad-scale information on the temporal and spatial variability of the quantity and quality of water leaving major river basins. However, these stations, each located at a single downstream point in a basin, are generally inappropriate for identifying localized upstream problems. Instead, data from these stations probably represent an integration of water quality throughout a basin.

The purpose of this report is to (1) describe the spatial and temporal variability of stream-water quality within the Umpqua River basin, upstream of the NASQAN station at Umpqua RM (river mile) 56.9 near Elkton, Oregon; (2) relate water quality to general causes, such as point-source discharges and selected basin characteristics, including land use and water use; (3) assess the adequacy of using water-quality data collected at the NASQAN station to represent water quality at upstream reaches; and (4) describe the minimum data-collection program necessary to represent water quality in the Umpqua River basin.

Data previously collected by the Geological Survey and DEQ (Oregon Department of Environmental Quality) were compiled and compared. In this report, instantaneous monthly data from 12 fixed-station monitoring sites were examined. The water-quality data were collected primarily from 1974 through 1983 WY (water year).

Description of Study Area

The Umpqua River basin is located in southwestern Oregon and drains an area of approximately 4,560 square miles. It is the eleventh largest basin in Oregon (Oregon State Water Resources Board, 1958). The basin boundary is nearly congruent with the boundary of Douglas County (fig. 1), extending from the Pacific Ocean to the Cascade Range.

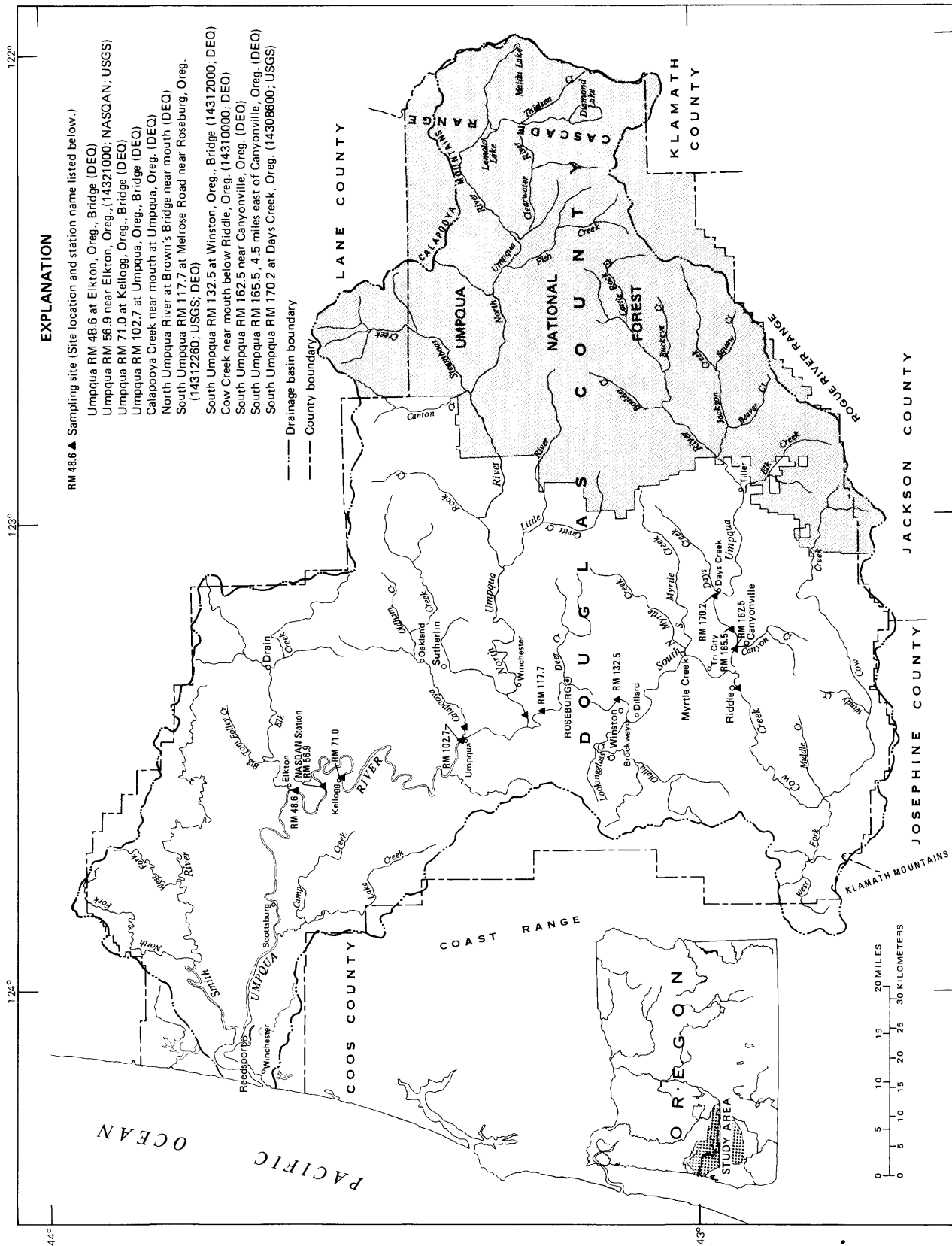


FIGURE 1. — The Umpqua River basin showing water-quality sampling site locations.

The basin is bounded on the west by the Coast Range, on the north by the Calapooya Mountains, on the east by the Cascades, and on the south by the Rogue River Range. The headwaters of both the North and South Umpqua Rivers lie in rugged mountainous terrain where streams flow through steep, narrow canyons surrounded by dense timber-covered ridges. Valley lands, used principally for agriculture, extend along the streams and rivers from Riddle north to Oakland (U.S. Army District Engineer, Portland, 1971). The valley land is characterized by gently rolling topography.

Principal tributaries and drainage areas in the Umpqua River basin are listed in table 1. The approximate length of the Umpqua River is 215 miles from its mouth to its headwaters in the South Umpqua River.

Table 1.--Major tributary locations

(Columbia Basin Inter-Agency Committee, 1966)

Stream and tributary	River mile ¹	Drainage area, square miles
Umpqua River	0.0	4,560
Elk Creek	48.6	290
Calapooya Creek	102.7	247
North Umpqua River	111.7	1,347
Little River	29.1	206
Rock Creek	35.7	99
Steamboat Creek	53.0	227
Fish Creek	71.8	82
Clearwater River	75.4	77
South Umpqua River	111.7	1,762
Deer Creek	123.0	63
Lookingglass Creek	137.0	160
Myrtle Creek	150.7	117
Cow Creek	158.9	496
Canyon Creek	162.9	39
Days Creek	169.9	57
Elk Creek	187.0	80
Jackson Creek	192.6	159

¹ River mileages are upstream from the mouth of Umpqua River, except for the tributaries to the North Umpqua River, which are upstream from the mouth of the North Umpqua River.

The length of the North Umpqua River to its headwater at Maidu Lake in the Cascade Range is about 106 miles. Selected basin features for the NASQAN station, the North Umpqua River, and the South Umpqua River are shown in table 2.

Table 2.--Selected basin features upstream of the NASQAN station at RM 56.9 and in the North and South Umpqua Rivers

[South Umpqua River station located 21.1 miles upstream from confluence with the North Umpqua River; data taken from U.S. Geological Survey WATSTORE Basin Characteristics File]

Basin features	NASQAN Station (14321000) Umpqua River near Elkton, Oregon RM 56.9	North Umpqua River at Winchester, Oregon (14319500) RM 1.8	South Umpqua River near Brockway, Oregon (14312000) RM 132.8
Drainage area, in square miles	3,683	1,344	1,670
Mean elevation, in feet	2,480	3,482	2,230
Range of elevation, in feet	90 - 9,182	370 - 9,182	460 - 8,000
Percent of subbasin that lies above 5,000 feet ^{1/}	9	20	3
Mean annual precipitation, in inches	47	49	46
Lake, pond, and swamp storage in percent of contributing drainage area	0.25	0.65	0.02
Percent forest	85.9	86.9	91.9

^{1/} Data taken from Oregon State Water Resources Board (1958).

HYDROGEOLOGY

Major aquifer units in the Umpqua River basin are shown in figure 2 and described in table 3. An important aquifer unit that is found primarily at the headwaters of the North Umpqua River is the Quaternary-Tertiary volcanic rocks of the High Cascade Range. This permeable volcanic province stores precipitation and snowmelt and gradually releases the water during the summer months, providing the North Umpqua River basin with a relatively uniform seasonal flow (Oregon State Water Resources Board, 1958). The major portion of the South Umpqua River basin consists of aquifer units that are not as permeable; consequently, ground-water flow to the South Umpqua River is comparatively small, resulting in low base flow during the summer months.

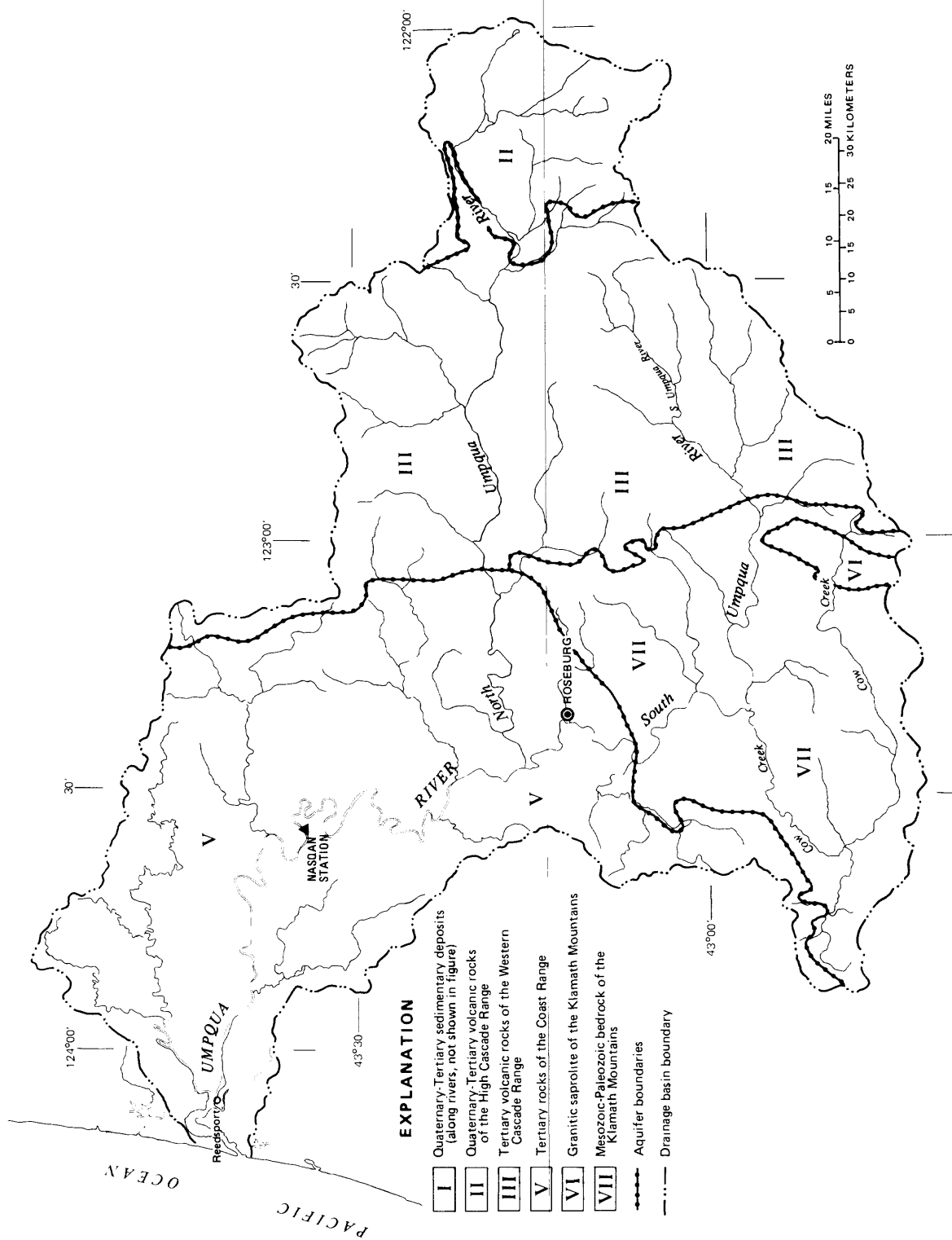


FIGURE 2. — Aquifer units in the Umpqua River basin (modified from McFarland, 1983).

Table 3.--Aquifer units in the Umpqua River Basin (modified from McFarland, 1983)

Aquifer unit and map symbol	Thickness range (feet)	Lithologic description and areal distribution	Hydrogeology
Quaternary - Tertiary sedimentary deposits (I)	0 - 150	Sand, gravel, and silt, well to poorly sorted unconsolidated to semiconsolidated. Alluvium is typically semiconsolidated sand, gravel and silt that occurs along the Umpqua River and its tributaries; thickest accumulations on the Umpqua River near Myrtle Creek and Riddle, OR.	Permeability and recharge are relatively high. Water table generally within 25 feet of land surface. Well yields are generally less than 200 gallons per minute.
Quaternary - Tertiary volcanic rocks of the High Cascade range (II)	0 - 3,000	Andesite and basalt; pyroclastic rock and flow material. Pyroclastic rocks include ash and pumice from Mount Mazama eruption.	Permeability and recharge may be high locally, especially where pyroclastic deposits are present. Well yields in the aquifer unit in southwest Oregon are reported as high as 300 gallons per minute.
Tertiary volcanic rocks of the Western Cascade range (III)	0 - 15,000	Andesite, dacite, and basalt; flow material, tuff, flow breccia, conglomerate and agglomerate.	Permeability and recharge are generally low. Yields of wells completed in these rocks are generally less than 20 gallons per minute.
Tertiary rocks of the Coast range (V)	0 - 10,000	Micaceous, tuffaceous, and basaltic sandstone, claystone, and shale; pillow basalt and basaltic breccia. The Umpqua formation is predominantly marine sedimentary rocks. The base of the Umpqua formation contains abundant pillow basalt.	The rocks are well indurated and typically have low permeability and recharge. Well yields are generally less than 20 gallons per minute.
Granitic saprolite of the Klamath Mountains (VI)	0 - 150	Saprolite derived from diorite, granite, and granodiorite.	Permeability and recharge are high relative to bedrock units. Wells may yield as much as 50 gallons per minute. Unweathered granitic intrusive rocks have low permeability.
Mesozoic - Paleozoic bedrock of the Klamath Mountains (VII)	0 - 30,000	Sandstone, siltstone, graywacke, conglomerate, and shale, with some andesitic flows, agglomerate, and tuff; metasedimentary and metavolcanic rocks; large masses of peridotite and dunite altered to serpentinite; gabbroic intrusives; and schist.	Permeability and recharge are generally small. Well yields in all rocks are typically less than 10 gallons per minute.

HYDROLOGY

Geology, topography, air temperature, water use, and the seasonal distribution of annual precipitation influence surface-water flow in the Umpqua River basin. The Umpqua River basin generally has dry summers and wet winters, with the coastal mountains and the Cascade range receiving between 40 and 80 inches of precipitation annually. The average annual rainfall for Roseburg, Oregon is about 34 inches, with less than five percent of the precipitation occurring in July, August, and September (National Oceanic and Atmospheric Administration, 1982).

About 20 percent of the North Umpqua River basin lies above 5,000 ft, while less than 3 percent of the South Umpqua River basin lies above 5,000 feet (table 2). The larger snowpack that occurs in the North Umpqua River basin provides additional water storage for release later in the year. Due to lower basin elevations and consequently warmer air temperatures, most of the precipitation in the South Umpqua River basin falls as rain, and the relatively impermeable geology causes the river runoff to closely follow rainfall patterns. Table 4 shows that most of the annual discharge in the Umpqua River basin occurs during the 6-month period, November through April. As expected, the North Umpqua River has the lowest percentage of annual runoff occurring during the 6-month period.

Monthly and annual discharge statistics for the NASQAN station and for other gaging stations in the North (RM 1.8) and South (RM 132.8) Umpqua Rivers are shown in table 5. The South Umpqua River basin accounts for 45 percent of the drainage basin upstream of the NASQAN station and contributes about 38 percent of the annual NASQAN discharge. The North Umpqua River accounts for only 36 percent of the drainage basin, but contributes about 50 percent of the annual flow. Annual discharge statistics suggest that discharge and resulting water quality at the NASQAN station are a composite of South Umpqua River water (38 percent by volume), North Umpqua River water (50 percent), and other (12 percent). However, monthly statistics indicate that the summertime contribution of discharge from the South Umpqua River decreases to a low of 11 percent in September and that the North Umpqua contribution increases to about 85 percent. Based on this hydrologic analysis, water-quality data (constituent concentrations and daily loads) collected at the NASQAN station during the summer months are probably not representative of water quality in the South Umpqua River (even though the South Umpqua River comprises more than 45 percent of the NASQAN drainage), because most of the river discharge at the NASQAN station is from the North Umpqua River.

Table 4.--Discharge for selected stations in the Umpqua River basin (Friday and Miller, 1984)

Station	Station number	Period of record	Drainage area (mi ²)	Annual discharge, in ft ³ /s			Percent of annual discharge between Nov. 1 and April 30 in a normal year
				Minimum	Mean	Maximum	
South Umpqua River at Tiller, OR (RM 187.3)	14308000	1910 - 1911 1939 - 1982	449	267	1,034	1,762	83
Cow Creek near Riddle, OR ^{1/}	14310000	1954 - 1982	456	147	888	1,809	92
South Umpqua River at Brockway, OR ^{2/} (RM 132.8)	14312000	1905 - 1912 1923 - 1926 1942 - 1982	1,670	562	2,871	5,567	90
North Umpqua River at Winchester, OR ^{3/}	14319500	1908 - 1913 1923 - 1929 1954 - 1982	1,344	1,639	3,729	6,616	76
Umpqua River near Elkton, OR (RM 56.9; NASQAN)	14321000	1905 - 1982	3,683	2,321	7,480	13,360	82

^{1/} Cow Creek is a tributary to South Umpqua River at RM 158.9.

^{2/} River has minimal regulation by small upstream reservoirs. Many small diversions for irrigation above station.

^{3/} North Umpqua River is a tributary to Umpqua River at RM 111.7. Slight regulation by Lemolo Lake and Diamond Lake. Several small diversions for irrigation above station.

Discharge statistics shown in table 5 are for the period of record at each station; however, the time periods of data collection vary for each station. To ensure that these unequal-sized data sets were not biasing the interpretation of the statistics, monthly flow percentage contributions were calculated for 1975 and 1977 water years (above and below average annual flow years, respectively). Each of these water years showed similar trends, with the lowest contributions of discharge occurring from the South Umpqua River during the summer months (5 percent in August, 1977).

Table 5.--Monthly and annual mean discharges in the South Fork Umpqua River, the North Fork Umpqua River and the main stem Umpqua River at the NASQAN station

[Period of record: South Umpqua River near Brockway (14312000), years 1905 - 1912, 1923 - 1926, 1942 - 1982; North Umpqua River at Winchester (14319500), years 1908 - 1913, 1923 - 1929, 1954 - 1982; Umpqua River near Elkton (14321000; NASQAN), years 1905 - 1982; mean discharges taken from Friday and Miller (1984)]

Month	14312000 South Umpqua River near Brockway RM 132.8		14319500 North Umpqua River at Winchester RM 1.8		14321000 NASQAN - Umpqua River near Elkton RM 56.9
	Mean	Percent of discharge at	Mean	Percent of discharge at	Mean
	(ft ³ /s)	NASQAN station	(ft ³ /s)	NASQAN station	(ft ³ /s)
October	508	27	1,375	72	1,914
November	2,814	40	4,193	60	7,042
December	5,877	44	6,367	48	13,390
January	7,368	55	6,983	44	16,300
February	6,445	43	6,167	41	15,150
March	4,887	40	5,555	45	12,360
April	3,241	34	4,718	49	9,633
May	1,972	30	3,801	58	6,516
June	854	23	2,407	64	3,767
July	255	15	1,336	77	1,740
August	128	11	1,002	85	1,173
September	136	11	984	83	1,188
Annual	2,871	38	3,729	50	7,480
Drainage area, in square miles	1,670		1,344		3,683
Percent of NASQAN drainage area	45		36		100

POPULATION

The population of Douglas County was 93,748 in 1980 (Schick, 1983). The highest population density was located at Roseburg (16,644 people) in the South Umpqua River basin about 11 miles upstream from the confluence with the North Umpqua River. About 60 percent of county's population resides in the South Umpqua River basin, 10 percent in the North Umpqua River basin, and about 20 percent along the main stem of the Umpqua River upstream of the NASQAN station and downstream of the confluence of the North and South Umpqua Rivers. The remaining 10 percent reside downstream of the NASQAN station.

LAND USE

The present economy in Douglas County is based on timber and wood products, agriculture, fishing, and recreation. In the Cow Creek basin near Riddle, nickel was mined and smelted; however, the operation closed temporarily mid-year in 1982. Douglas County contains nearly 2.8 million acres of commercial forest land that provides the region with its main livelihood (Schick, 1983). About 70 percent of the North Umpqua River basin and about 50 percent of the South Umpqua River basin are Federally owned; 60 percent of the North and 30 percent of the South Umpqua River basins lie within boundaries of the Umpqua National Forest.

Agriculture and livestock comprise the second most important industry in Douglas County. Agricultural and livestock lands are estimated to be 487,000 acres, approximately 367,000 acres of non-crop pastureland and 120,000 acres of cropland (Robert E. Meyer Consultants, 1980). Based on consumptive water rights, a major portion of the water withdrawn in the basin is used for irrigation. Under existing water rights more than 13,000 acres of land are irrigated from the South Umpqua River, while only about 4,000 acres are irrigated from the North Umpqua River. Water withdrawal for the relatively large number of irrigated acres in the South Umpqua River basin helps to further reduce base flows, causing most tributaries to the South Umpqua River downstream of Tillier to experience water shortages every summer (Robert E. Meyer Consultants, 1980; Oregon Department of Environmental Quality, 1978). Streamflow in the North Umpqua River is presently adequate to meet the basin's consumptive water-use needs.

POINT-SOURCE EFFLUENT

Point-source effluent data were obtained from DEQ permit files. Industries, STP (sewage treatment plants), WTP (water treatment plants), and other sources of point-source effluent provide DEQ with monthly reports indicating the quantity and quality of their potential effluent discharges into the river. Grab or composited water-quality samples were collected as often as once a day or as infrequently as once a month or less. In some instances, data were not available for the month or even the year. The lack of monthly data indicates that effluent probably had not been discharged into the river. Average monthly discharges and loads for each point source were computed for selected constituents. Tables 9, 10, and 11 show annual tabulations (1977 through 1981 WY) of effluent discharge and loads of fecal coliform bacteria and BOD5 (5-day biochemical-oxygen demand) for 69 point sources (tables are in the supplemental data section). The tables are not inclusive of all point-source data, but are rather a compilation of readily available data from DEQ. Only the number of monthly reports and the median of the monthly mean discharges or loadings are shown for each water year. The frequency of data collection from most of the point sources is inadequate for calculating accurate effluent loadings; therefore, these tabled values are intended to only approximate the order of magnitude of discharge or constituent loads from the specified point sources. The values could be used to help indicate where potential river water-quality problems exist or where additional point-source or river-quality data could be collected.

Loadings of fecal coliform bacteria and BOD5 are listed to help characterize the general quality of the point-source effluent. Nutrient concentrations (such as nitrogen and phosphorus) were not furnished in the monthly reports to DEQ. Based on the tabled values, the location of the largest effluent discharges and loads of BOD5 and fecal coliform bacteria are in the densely populated Roseburg-Winston area (South Umpqua RM's 133 to 111.7).

SURFACE-WATER QUALITY

Description of Available Data Base

Water-quality data used in this study were collected at fixed-station monitoring sites by the U.S. Geological Survey (in cooperation with Douglas County Water Resources Survey) and DEQ. Geological Survey data are stored in the Survey's WATSTORE (National Water Data Storage and Retrieval Computer System) files and DEQ data are stored in STORET (the U.S. Environmental Protection Agency's Storage and Retrieval Computer System). The Geological Survey collected depth- and width-integrated water-quality samples and DEQ collected samples from mid-river flow at about 3 feet of depth. The locations of water-quality sampling stations that were investigated in this report are shown in figure 1 (p. 4). This study is primarily limited to the analysis of instantaneous monthly water-quality data. DEQ stations generally had complete monthly (about one sample per month) water-quality records for 1977 and 1980-1983 WY, and the Geological Survey stations generally had a longer period of record from mid-1960 to present. To place the Geological Survey data and the DEQ data on a comparable time basis, constituent concentrations were compared and analyzed using only the data collected in 1977 and 1980-1983 WY. Constituent transport curves (load versus discharge) for all stations and selected time-trend analyses for Geological Survey stations were developed using all available data collected from 1974 through 1983 WY. Geological Survey and DEQ water-quality data reported as values less than the analytical level of detection were set equal to one-half the level of detection for the statistical analyses in this report.

Instantaneous river discharges for Geological Survey data are stored in the WATSTORE Water-quality File. Discharges for DEQ data were compiled from historical files located at Geological Survey field offices in Eugene and Medford, Oregon. A listing of water-quality sampling stations and of the nearest Geological Survey discharge-gaging stations that were used for determining discharge at the time of the water-quality sampling is shown in table 6.

Table 6.--Water-quality sampling stations and nearest U.S. Geological Survey discharge-gaging stations used for determining discharge at the time of water-quality sampling

[For location of discharge gaging stations, see U.S. Geological Survey (1983)]

Water-quality sampling station	Discharge gaging stations
Umpqua RM 48.6 at Elkton, OR Bridge (DEQ) Umpqua RM 56.9 near Elkton, OR (14321000) Umpqua RM 71.0 at Kellogg, OR Bridge	Umpqua River near Elkton, OR (14321000)
Umpqua RM 102.7 at Umpqua, OR Bridge	South Umpqua River near Brockway, OR (14312000) plus North Umpqua River at Winchester, OR (14319500)
Calapooya Creek near mouth at Umpqua, OR	No representative discharge gaging station available.
North Umpqua River near mouth at Brown's Bridge, OR	North Umpqua River at Winchester, OR (14319500)
South Umpqua RM 117.7 at Melrose Road near Roseburg, OR (14312260; Geological Survey and DEQ); South Umpqua RM 132.5 at Winston, OR Bridge	South Umpqua River near Brockway, OR (14312000)
Cow Creek near mouth below Riddle, OR	Cow Creek near Riddle, OR (14310000)
South Umpqua RM 162.5 near Canyonville, OR South Umpqua RM 165.5 (4.5 mi east of Canyonville) South Umpqua RM 170.2 at Days Creek, OR (14308600)	South Umpqua River at Days Creek, OR (14308600)

Based on available information and on their relative importance to water use for this investigation, the following water-quality constituents were examined:

- (1) Discharge and its relation to chemical and bacterial concentrations.
- (2) Specific conductance and dissolved solids as related to characterizing general water quality in selected basin reaches. A general characterization of major ions is also presented.
- (3) Phosphorus and nitrogen concentrations (primary nutrients essential to plant growth) as related to eutrophication.
- (4) Fecal coliform bacteria as related to fecal contamination from warmblooded animals.

- (5) Suspended sediment relative to erosion and its importance in transporting sorbed chemicals.

The number of priority pollutant analyses for the Umpqua River basin (Callahan and others, 1979) is limited, and interpretation of the few available analyses are not presented in this report. A large percentage of these pollutant concentrations are reported at less than the analytical detection level; quite often detection levels varied between the Geological Survey and DEQ data. Even within the Geological Survey data set, the detection level for a specific pollutant varied with time.

Correlations between Water-quality Constituents and Instantaneous River Discharge

The concentration of suspended and dissolved chemicals in a river is related to many factors; two important factors are (1) the capacity of a stream to transport large concentrations of suspended sediment (including chemicals in the sediment matrix and those chemicals adsorbed onto the sediment) and (2) the volume of water available for diluting dissolved solids. Kendall tau correlations (nonparametric test), between selected water-quality constituents and discharge, using data collected from 1974 through 1983 WY, are shown in table 7. Kendall tau correlations are computed based on the number of concordant and discordant data pairs. Two observations are concordant if both the discharge and constituent value of one observation are larger than their respective members of the other observation (Conover, 1980). If the number of concordant pairs exceeds the number of discordant pairs, Kendall tau is positive, indicating a positive correlation between discharge and the constituent value. If all pairs are concordant, Kendall tau equals 1.0. If all pairs are discordant, the correlation is negative and Kendall tau equals -1.0.

Significant relations between discharge and the specified constituents are examined and theorized as follows:

1. Positive correlation between dissolved oxygen and discharge at most stations

Large discharges occur during the winter months when river temperatures are low and when DO (dissolved oxygen) concentrations at saturation are higher than during the summer months. This assumes that DO concentrations are usually at or near saturation, which may be a good assumption for instantaneous measurements made during daylight conditions. This also assumes that river temperature is influencing DO concentrations more than biological processes (respiration and photosynthesis).

Table 7.--Kendall Tau correlation coefficients between instantaneous discharge
(parameter code 00061) and selected constituents

[Values are listed for those coefficients having a p-level < 0.10; coefficients in parenthesis indicate P-level < 0.01; ND indicates that data were not collected; "-----" indicates that coefficient has a P-level greater than 0.10; dissolved-solid concentrations were computed as follows: total solids residue on evaporation 105° C minus suspended-solids residue at 105° C]

Mile	Water temperature °C	Turbidity NTU	Specific conductance uS/cm at 25° C	Dissolved oxygen mg/L	pH (standard units)	Alkalinity, mg/L as CaCO ₃	Nonfilterable solids residue at 105° C, mg/L	Total organic plus ammonia nitrogen as N, mg/L	Total nitrite plus nitrate as N, mg/L	Total phosphorus as P, mg/L
Umpqua River										
48.6	(-.4)	(+.6)	(-.4)	(+.4)	(-.3)	(-.5)	(+.5)	-----	(+.4)	+0.2
56.9	(-.5)	(+.6)	(-.2)	(+.3)	(-.3)	-.3	ND	-----	+3	-----
71.0	-----	+5	-5	-----	(-.5)	-----	-----	-5	-----	-----
102.7	(-.5)	(+.6)	(-.4)	(+.4)	(-.3)	(-.4)	(+.5)	-2	+3	-----
North Umpqua River										
1.8	(-.5)	(+.6)	(-.5)	(+.4)	(-.3)	(-.6)	(+.4)	-----	(+.4)	-----
South Umpqua River										
117.7 (USGS)	(-.5)	ND	(-.7)	(+.4)	(-.4)	(-.6)	ND	(-.4)	(-.3)	(-.5)
117.7 (DEQ)	(-.5)	(+.6)	(-.7)	-----	(-.6)	(-.6)	(+.4)	(-.5)	(-.3)	(-.5)
132.5	(-.5)	(+.6)	(-.8)	(+.4)	(-.5)	(-.8)	(+.5)	(-.3)	(+.5)	+2
162.5	-----	(+.7)	(-.7)	-----	-----	(-.7)	+5	-4	-5	-----
165.5	(-.6)	(+.7)	(-.7)	(+.6)	-2	(-.8)	(+.6)	(-.2)	+2	(+.4)
170.2	(-.5)	ND	(-.7)	ND	(-.5)	(-.7)	ND	ND	ND	(+.5)
Cow Creek near mouth										
1.0	(-.6)	(+.7)	(-.8)	(+.5)	(-.4)	(-.8)	(+.4)	-2	(+.5)	-----

Mile	Fecal coliform, 0.7 micron, membrane filter, colonies/100 mL	Fecal streptococci, membrane filter, KFAgar, colonies/100 mL	Fecal coliform, at 44.5° C, most probable number	Dissolved solids residue on evaporation at 180° C, mg/L	Suspended sediment mg/L
Umpqua River					
48.6	ND	(+.5)	ND	-----	ND
56.9	(+.4)	ND	-----	(-.3)	(+.5)
71.0	ND	(+.7)	ND	-4	ND
102.7	ND	(+.5)	ND	-----	ND
North Umpqua River					
1.8	ND	(+.2)	ND	(-.3)	ND
South Umpqua River					
117.7 (USGS)	+3	ND	-----	(-.4)	ND
117.7 (DEQ)	ND	(+.4)	ND	(-.5)	ND
132.5	ND	+2	ND	(-.5)	ND
162.5	ND	-----	ND	(-.6)	ND
165.5	ND	-----	ND	(-.6)	ND
170.2	ND	ND	ND	(-.6)	ND
Cow Creek near mouth					
1.0	ND	-----	ND	(-.6)	ND

2. Positive correlation between turbidity, suspended sediment or solids, and discharge

Increases in discharge may be increasing erosion, resuspension of bottom material, and overland runoff of sediments, resulting in increases in turbidity, suspended sediment, and suspended-solid concentrations.

3. Negative correlation between dissolved solids, alkalinity or specific conductance and discharge; negative correlation between organic plus ammonia nitrogen and discharge

Increases in discharge dilute dissolved-solids concentrations, causing the specific conductance and alkalinity to decrease; dilution also seems to be reducing organic- and ammonia-nitrogen concentrations at high flow. This assumes that discharge increases at a higher rate than that of the constituent load in the stream.

4. Negative correlation between pH and discharge

Decreased discharges are associated with summertime conditions, when increased photosynthesis increases daytime river pH. At these low flows, river pH may also be increasing because the percentage contribution of ground-water flow to the river increases (assuming that ground water has a higher pH than the pH of storm-water runoff).

5. Positive correlation between fecal coliform bacteria and discharge

Fecal coliform colonies may be associated with suspended sediment, concentrations of which also increase with increasing discharge. When discharge increases, overland runoff occurs. Overland runoff increases the effective area of fecal-source contamination.

6. Positive correlation between nitrite plus nitrate or phosphorus and discharge; negative correlation between nitrite plus nitrate or phosphorus and discharge downstream of large and (or) relatively constant loadings from point or non-point sources

Nitrite plus nitrate concentrations were positively correlated with discharge except at RM 117.7, where both the Geological Survey and DEQ data show a negative correlation. The negative correlation may result from upstream point or nonpoint sources providing a relatively constant source of nitrite plus nitrate that is diluted during the winter high flows. Phosphorus appears to follow this same trend. Positive correlations may be due to storm-water runoff from fertilized fields or to the biological uptake of nitrite plus nitrate during the biologically productive summer months.

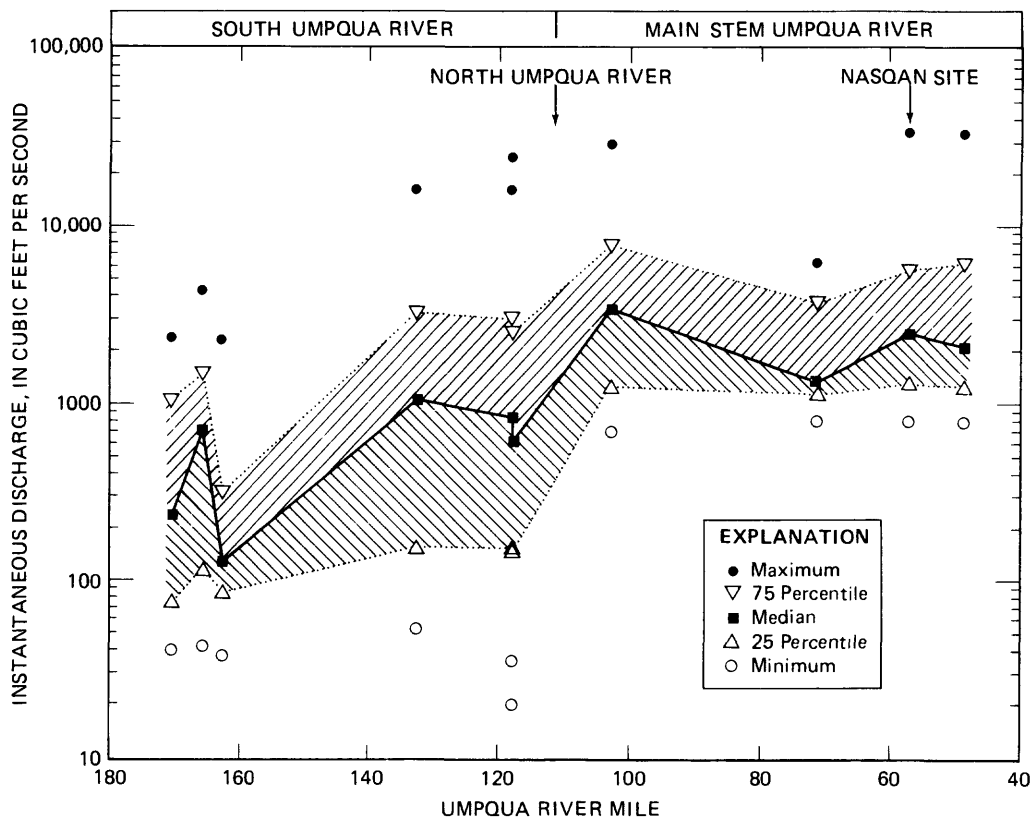


FIGURE 3. — Distribution of instantaneous river discharge using data collected in 1977 and 1980 through 1983 WY. Geological Survey and DEQ data are shown at South Umpqua RM 117.7 (table 12 in the supplemental data section lists these

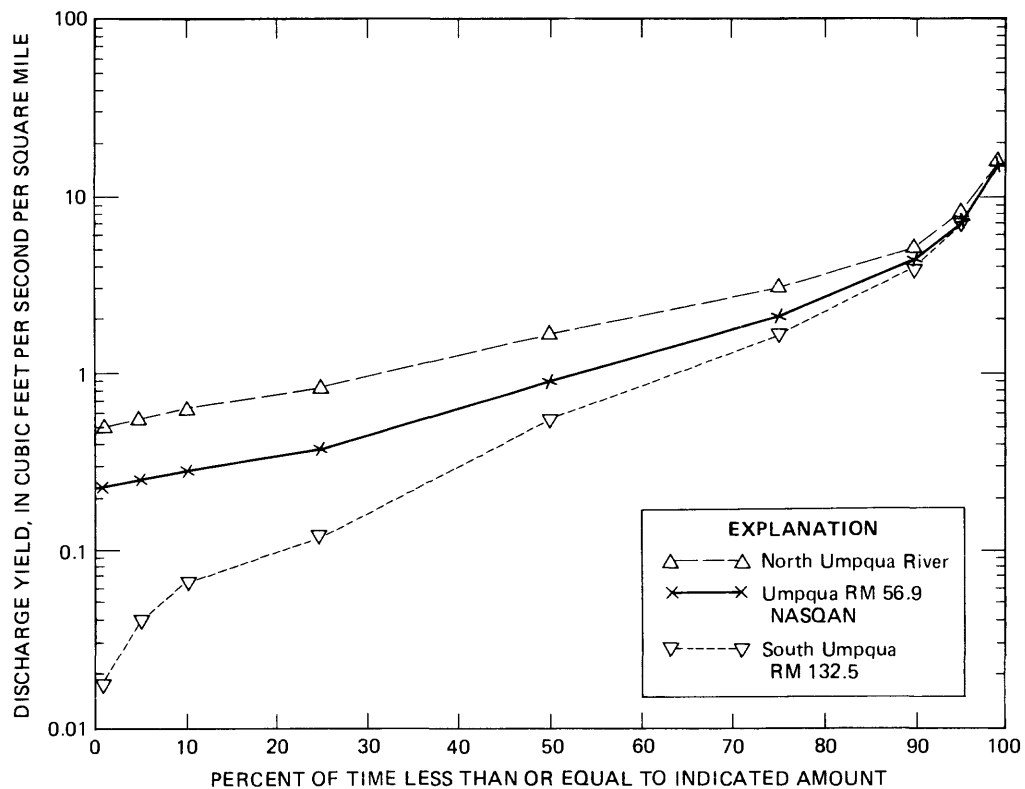


FIGURE 4. — Yield of river discharge from the North, South, and main stem Umpqua Rivers. Yield based on daily mean discharges in 1977 and 1980 through 1983 WY.

River Temperature

Growth of aquatic life (plant and animal) is dependent on many factors, including river temperature and the range over which it can vary (Federal Water Pollution Control Administration, 1968); for each species, an optimum range exists for the greatest growth. Distributions of temperature are shown in figure 5 and listed on table 12 (supplemental data section). Distributions appear to be similar and to vary seasonally with air temperature, with coldest temperatures occurring during the winter and warmest during the summer.

Specific Conductance and Dissolved Solids

Specific conductance measures the ability of a water sample to conduct electrical current and is related to the concentration of charged ionic species in solution. As the ion concentration increases, specific conductance increases. Specific conductance (in microsiemens per centimeter at 25 degrees Celsius) multiplied by a factor can be used to approximate dissolved-solids concentrations (in mg/L).

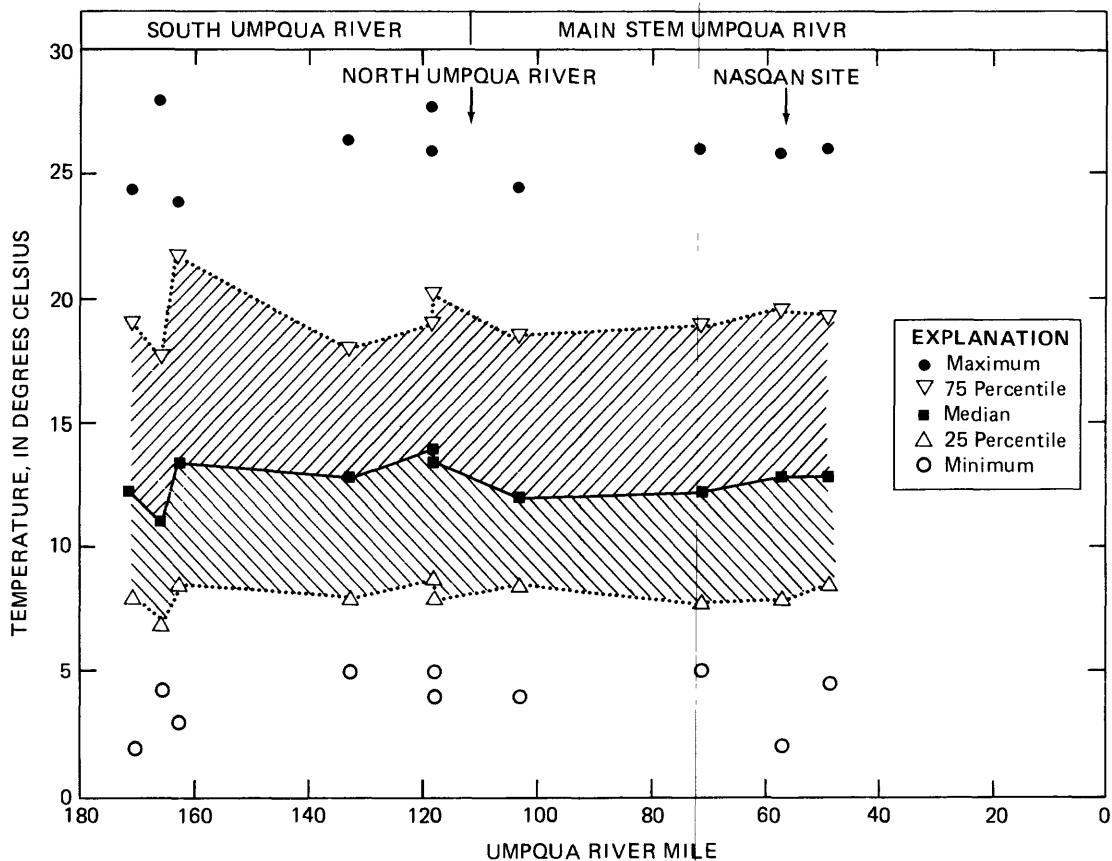


FIGURE 5. — Distribution of instantaneous river temperatures using data collected in 1977 and 1980 through 1983 WY.

Correlations observed for NASQAN data were generally similar to those observed for other stations, except for the negative correlations of nitrite plus nitrate and total phosphorus observed at South Umpqua RM 117.7.

Comparison of Constituent Concentrations, Loadings, and Yields

Descriptive statistics of constituent concentrations were calculated using SAS (Statistical Analysis System) procedures (SAS Institute, Inc. 1979). The number of samples, the minimum and maximum concentrations, and the 10, 25, 50, 75, and 90 percentiles for selected stations in the Umpqua River basin are listed in table 12 (supplemental data section). The median value is the 50 percentile value, which indicates that 50 percent of the samples had a concentration less than or equal to that reported value. The table also lists the frequency distributions of constituent concentrations for selected tributaries to the South and main stem Umpqua Rivers.

Constituent loads (in tons per year; table 13 in the supplemental data section) and yields (in pounds or tons per day per square mile) were computed, using 1977 WY river discharge data. Calculations were made using constituent transport rating curves (based on data collected from 1974 to 1983 WY) in a method similar to that developed by Miller (1951). Transport-rating curves were developed based on regression analysis of constituent loads (in tons per day) versus instantaneous discharge (in ft^3/s). Regression equations were computer generated (using SAS's "PROC REG" procedures) to avoid the subjectiveness of hand-drawn curves. Residuals about each regression line were examined for uniformity and randomness over the observed range of instantaneous discharge. The regression equations for the transport rating curves are shown in table 14 (supplemental data section). Regressions between the logarithms of load and discharge produce negatively biased results when used for prediction of individual load values; therefore, a correction factor (one-half of the square of the root mean square error) has been added to the equation to correct for this bias (Robert M. Hirsch, U.S. Geological Survey, Reston, Virginia, written commun., October, 1983). The reliability of a regression is measured by the root mean square of the error (RME), which is the standard deviation of the distribution (assumed normal) of residuals about the regression line (Riggs, 1969). In table 14, RME's are reported in logarithm units. Median daily loads (using 1977 and 1980 through 1983 WY data), plus and minus one standard deviation (RME) in constituent units, are listed in table 15 (supplemental data section). As RME increase, the reliability of the predicted load or yield decreases.

Daily constituent loads were computed for 1977 WY, using mean daily discharges in the regression equations. These daily loads were then summed to compute annual loads. Because 1977 was a very low-flow year (lower than normal annual runoff), the highest mean daily discharge in 1977 WY was less than the highest instantaneous discharge used in the constituent load versus discharge regression; consequently, daily loads for 1977 WY were interpolated from the regression equations.

Annual loads (table 13) were computed only for 1977 WY, because this was the only year during the data-collection period when daily loads could be computed without extrapolations of the load-versus discharge-regression equations. Extrapolation of daily loads could lead to erroneous annual loads, where only a few days of extrapolated daily loads could account for more than 50 percent of the annual load.

Annual loads and yields for 1977 WY are not typical of a normal flow water year, because 1977 runoff was much lower than normal; however, they could be used to provide some insight to point-source loads and the quality of ground-water contributions. The lack of constituent-concentration data during high flows made the instantaneous monthly water-quality data inappropriate for estimating loads and yields for normal-flow water years. To examine yields for years other than 1977 and still be able to eliminate the need for extrapolation, frequency distributions of constituent yields were computed, using 1977 and 1980 through 1983 WY flow data. Yields for percentiles greater than 90 percent were not calculated because of the lack of monthly data at high flows. The distributions are graphically shown in a downstream station order (in illustrations within the text of the report) and listed in table 16 (supplemental data section); the table includes tributary yields.

River Discharge

The frequency distribution of instantaneous river discharge at the time water-quality samples were collected is shown in figure 3 and is listed in table 12 (supplemental data section). The figure shows the distributions from South Umpqua RM 170.2 downstream to Umpqua RM 48.6. Distributions for Cow Creek and North Umpqua River stations are not included in this figure but are listed in table 12. Discharge generally increases in the downstream direction to the confluence of the North and South Forks at RM 111.7; downstream of this point the rate of increase is slight. Median discharges at South Umpqua RM's 170.2 and 162.5 and at Umpqua RM 71.0 are noticeably lower than medians at adjacent stations, because they are based primarily on monthly data collected in 1977 WY, a relatively low flow year. Median discharges of the furthest downstream stations on the South and North Umpqua Rivers are 608 and 2,190 ft³/s, respectively. Lowest flows are generally observed in the South Umpqua River (RM 170.2 to RM 111.7). Based on these instantaneous measurements that coincide with water-quality samples, the frequency distribution of discharge at the NASQAN station appears to be similar to the flow distribution downstream of RM 111.7. Based on the period of record (Friday and Miller, 1984) and instantaneous discharge (table 5, p. 10), the smallest discharges for the basin occur during the summer months, August and September, and the largest discharges occur during the winter months, January and February. Flow-duration yields (fig. 4) reflect greater water yields from the North Umpqua River, due to larger snowpacks, increased ground water storage, and less consumptive water use. Discharge at the NASQAN station (RM 56.9) reflects a composite of water volume from the North and South Umpqua Rivers.

Median factor values for the North, South, and main stem Umpqua Rivers are 0.9, 0.7, and 0.8, respectively. The larger factors are probably associated with larger un-ionized silica concentrations in the rivers.

Specific-conductance distributions are shown in figure 6 (and table 12 in the supplemental data section). Higher specific conductance values and ranges are observed in the South Umpqua River (RM 170.2 to 111.7), and lower values and ranges are observed in the main stem Umpqua River as a result of dilution by the North Umpqua River. Low seasonal variations of conductance are observed in the main stem Umpqua River, compared to wide seasonal variations in the South Umpqua River (fig. 7). Increased specific conductance during the summer months in the South Umpqua River may be due to a larger percentage contribution of ground water from the igneous and metamorphic rocks of the Klamath Mountains (see major ions section, p. 47). The median specific conductance of 131 samples of water from this aquifer in southwest Oregon is 400 $\mu\text{S}/\text{cm}$ (microsiemens per centimeter) at 25 degrees Celsius (Miller and Gonthier, 1984). This value is in contrast to lower specific conductance in the North Umpqua River water, which comes primarily from snowmelt and volcanic rocks of the high Cascade Range.

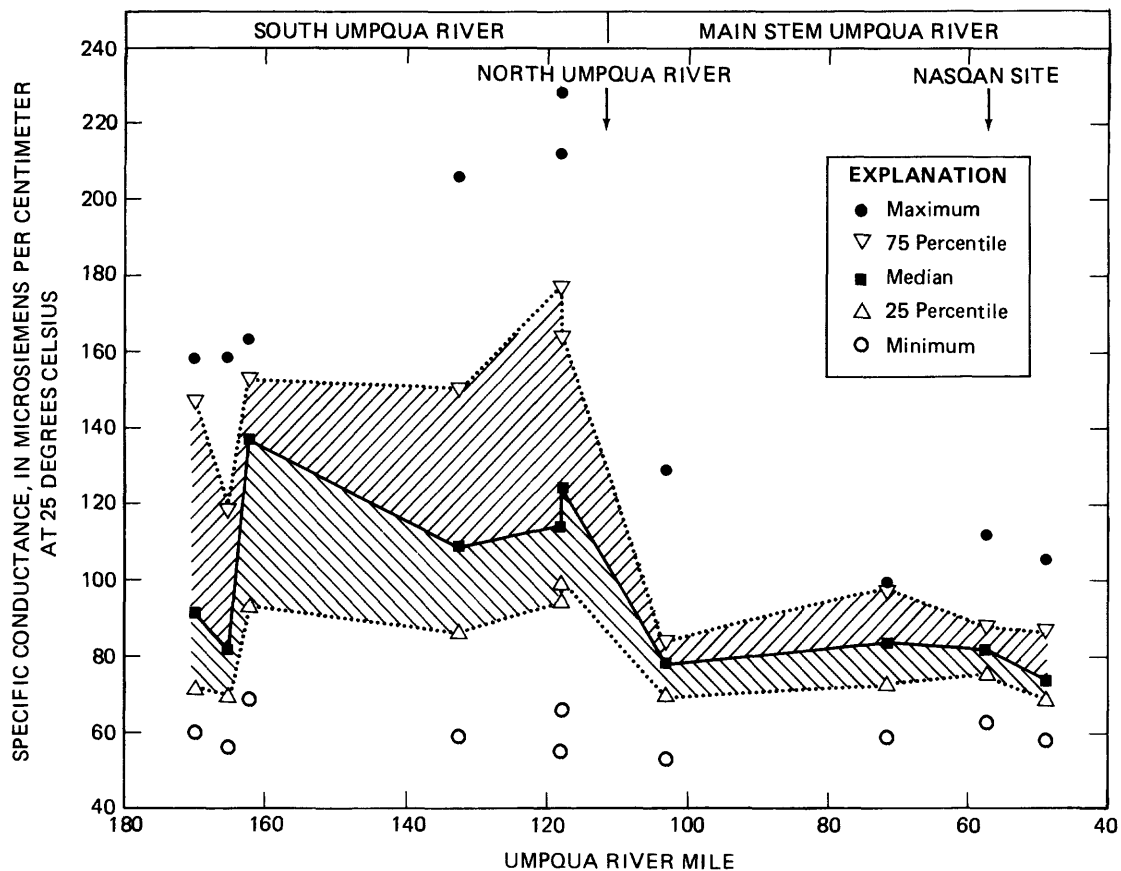


FIGURE 6. — Distribution of instantaneous specific conductances using data collected in 1977 and 1980 through 1983 WY.

The U.S. Environmental Protection Agency (1976) recommends that chloride and sulfate concentrations not exceed 250 mg/L for domestic water supplies. Instantaneous specific conductance values indicate that the surface-water concentrations of dissolved solids are probably less than 250 mg/L; therefore, chloride and sulfate concentrations are probably less than 250 mg/L (see table 12 in supplemental data section for listing of dissolved-solids concentrations).

Specific-conductance and dissolved-solids loads and yields for 1977 water year are shown in table 13. Dissolved-solids concentrations are based on laboratory measurements of dissolved-solids residues remaining after evaporation. Loads and yields are a function of river discharges multiplied by constituent concentrations. The North Umpqua River has the largest annual yields of specific conductance and dissolved solids even though it has the lowest annual flow-weighted concentrations in the basin. This relation indicates, as already shown table 4 (p. 9), that the North Umpqua River must have higher annual yields of discharges.

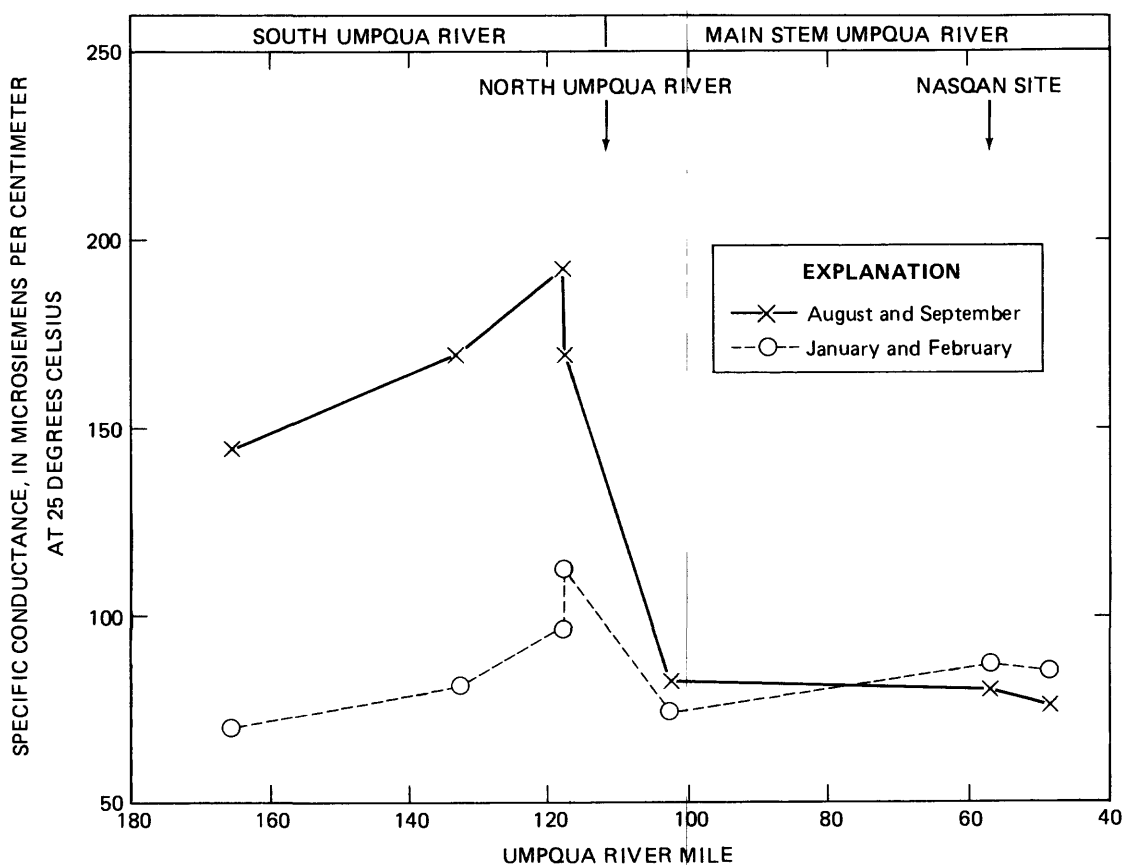


FIGURE 7. — Median instantaneous specific conductances for January-February and August-September.

Specific conductance yields (fig. 8; table 16 in supplemental data section) are similar to river discharge yields in that the highest yields occur in the North Umpqua River, intermediate yields at the NASQAN station, and lowest yields in the South Umpqua River.

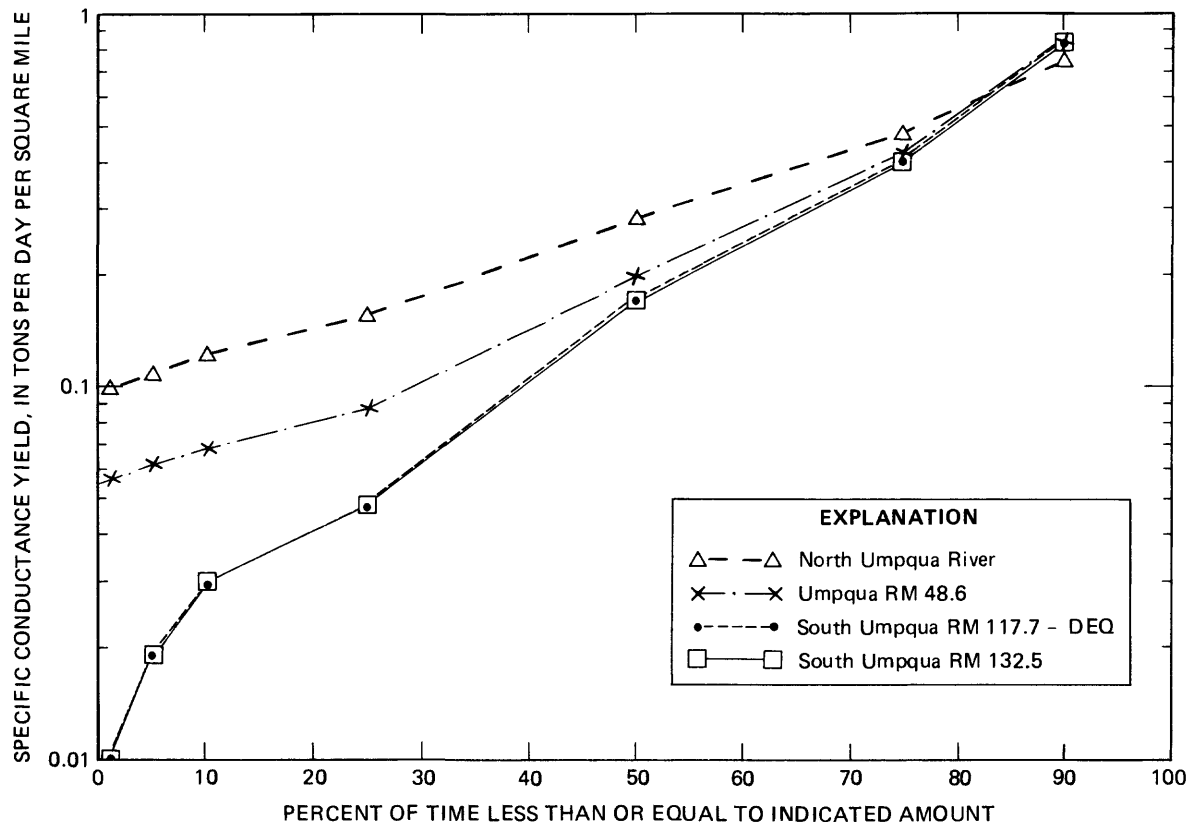


FIGURE 8. — Duration curves for specific conductance yields.
Calculations assume 1 $\mu\text{S}/\text{cm}$ equals 1 mg/L of dissolved solids.

Total Phosphorus

Total phosphorus includes organic and inorganic forms of phosphorus in both the dissolved and suspended state. Sources of phosphorus include the breakdown and erosion of phosphorus-bearing minerals in soils, decaying vegetation, phosphate fertilizers, sewage effluent (including sodium phosphate in household detergents), and metabolic wastes from animals. Phosphorus and nitrogen are essential nutrients for aquatic plant growth. Phosphorus is frequently found to be the limiting constituent, in that increases of phosphorus have been associated with eutrophication, a high rate of production of aquatic growth. Commonly observed characteristics of the South Umpqua River that are also associated with eutrophication are low-river flows, increased temperatures, and seasonal increases in nutrient concentrations.

The distribution of total phosphorus concentrations at the NASQAN station is similar to distributions in the North, South, and main stem Umpqua Rivers, except for high concentrations observed at South Umpqua RM 117.7 (fig. 9; table 12 in the supplemental data section). The North Umpqua River has low phosphorus concentrations and relatively high flows that dilute phosphorus concentrations in the main stem. Between South Umpqua RM's 132.5 and 117.7 several small tributaries and several large point sources of sewage effluent flow into the river (table 9 in the supplemental data section). Sewage treatment plants or other point sources could provide a large and relatively constant load of phosphorus to a river, so that river concentrations of phosphorus decrease during the winter high flows by increased dilution and increase during summer low flows by decreased dilution (fig. 10). Nuisance aquatic plants have been observed in the sluggish reaches of the South Umpqua River from Days Creek to the confluence of the North Umpqua River (Oregon Department of Environmental Quality, 1978), and excessive periphytic plant growth has been observed between RM's 132.5 and 111.7.

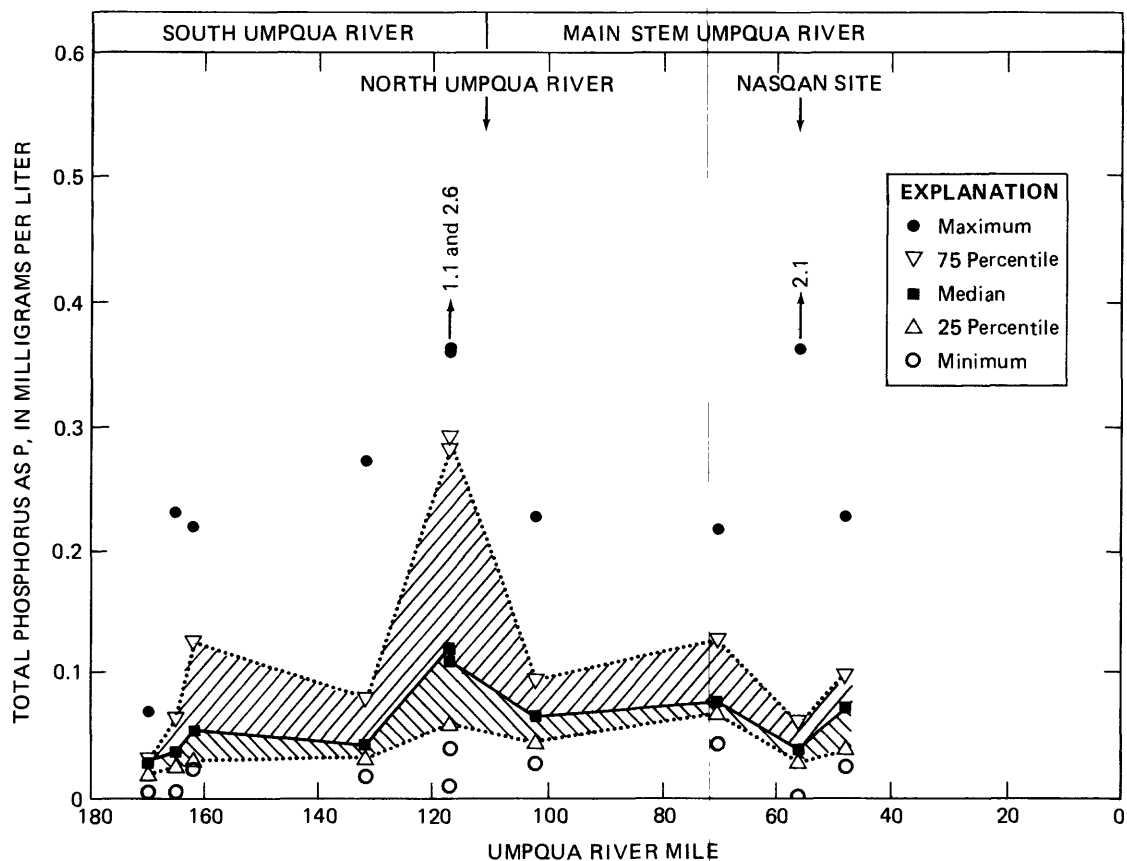


FIGURE 9. — Distribution of instantaneous total phosphorus concentrations using data collected in 1977 and 1980 through 1983 WY.

In 1977 water year, the North Umpqua River had a higher annual load of phosphorus than did the South Umpqua River, due to the higher total annual volume of water (table 13 in supplemental data section; loads computed using constituent transport curve method). The annual load from the North Umpqua River (84 t/d for 1977 WY), plus the load from the South Umpqua River (average load of 60 t/d, using Geological Survey and DEQ data), approximates the downstream load of 140 t/d at Umpqua RM 102.7. Differences in the phosphorus loads between Umpqua RM's 48.6 and 56.9 may be the result of (1) using unequal-sized data sets from different time periods to compute loads, (2) comparing data collected and analyzed under different methods (Geological Survey data and DEQ data), (3) errors that result from using constituent-transport curves to compute loads, or (4) unidentified phosphorus sources entering the reach. Increases in the phosphorus load from South Umpqua RM's 132.5 to 117.7 indicate that about 36 tons of phosphorus per year (about 200 lb/d) are being added in this reach. Higher loads at RM 117.7 are not the result of higher river discharge, because the discharge data used for loads at RM 117.7 were taken from the gaging station at RM 132.8 with no adjustment.

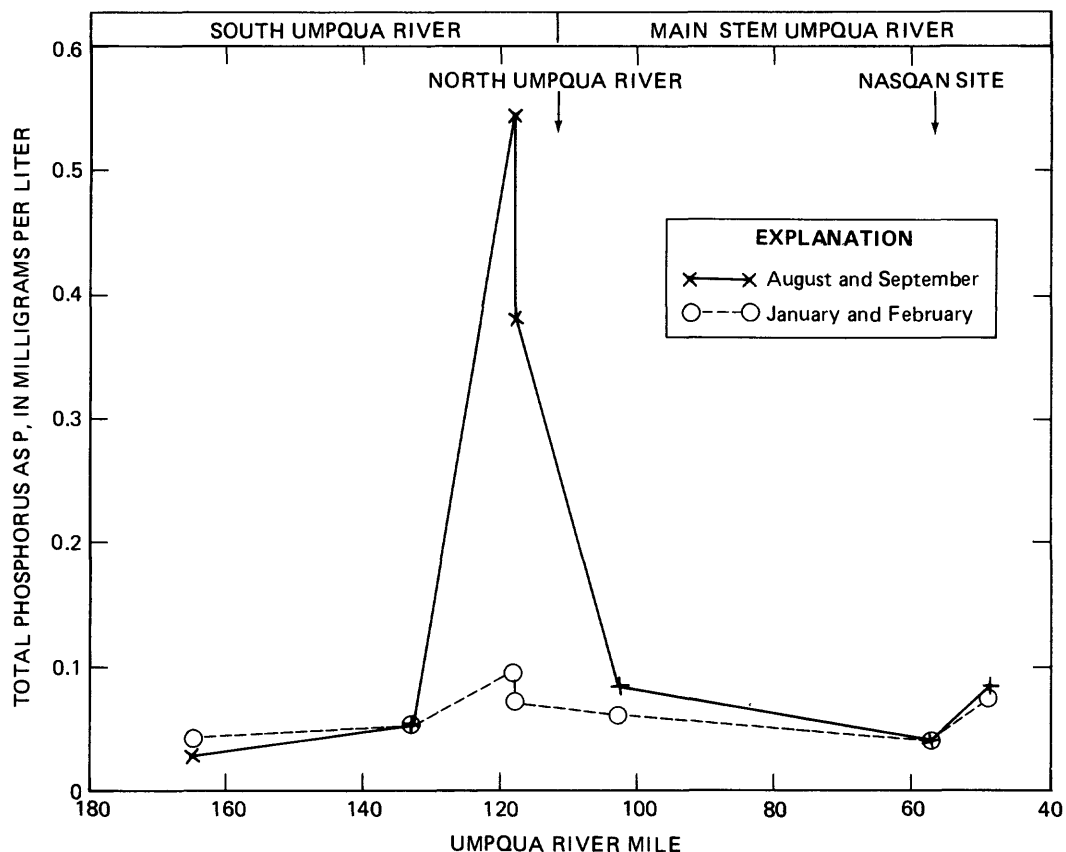


FIGURE 10. — Median total phosphorus concentrations for January-February and August-September.

Each month, the Oregon Department of Environmental Quality collects water-quality data in the Umpqua River basin within a one-day period. Instantaneous loads at RM 132.5 were compared to loads at RM 117.7, using data collected in 1977 and in 1980 through 1983 WY (fig. 11). The median increase in load is 0.084 t/d (about 170 lb/d) which compares closely to the 200 lb/d that was calculated for 1977 WY using the constituent transport-curve method (table 13).

Distributions for phosphorus yields using 1977 and 1980 through 1983 data are shown in figure 12 (and table 16 in the supplemental data section). Lowest phosphorus yields occur at South Umpqua RM 132.5, upstream of the densely populated Roseburg-Winston area, where relatively large point sources of STP effluent flow into the river. Due to large annual discharge yields, the North Umpqua River has the highest total phosphorus yields.

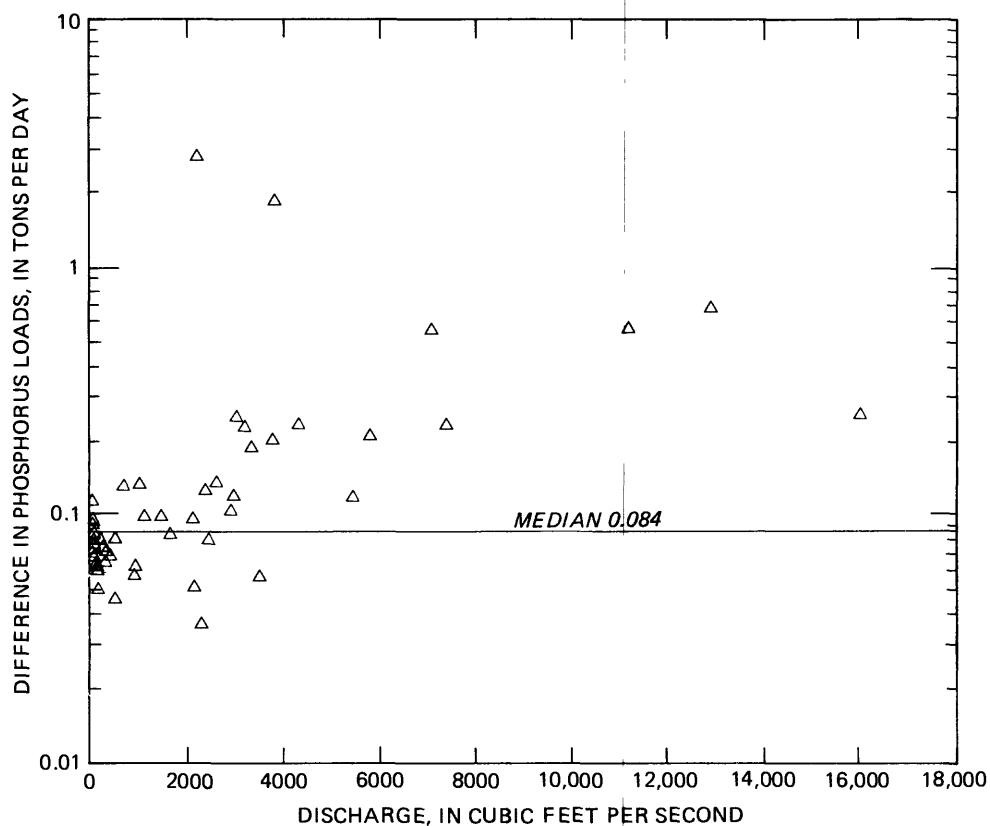


FIGURE 11. — Increase in phosphorus loading (as P) from South Umpqua RM 132.5 to 117.7. Two negative loading differences are not shown.

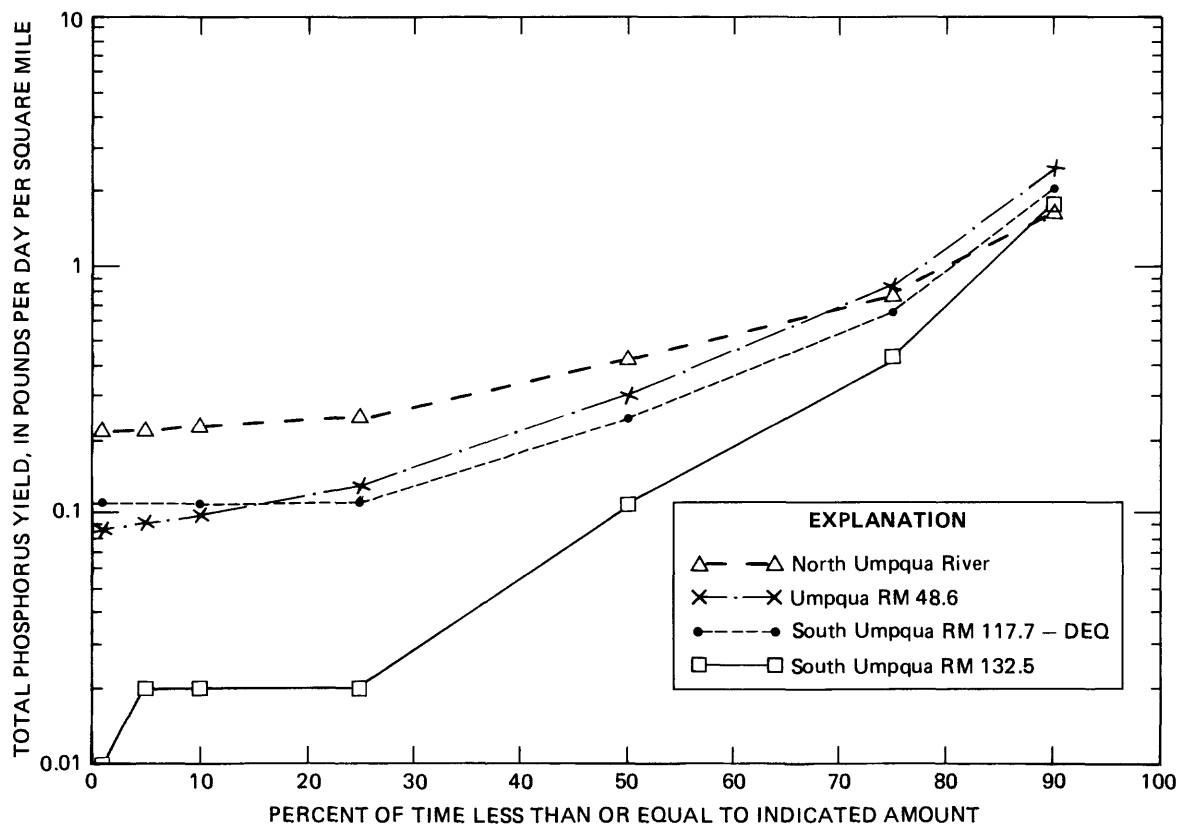


FIGURE 12. - Duration curves for total phosphorus yields.

Total Nitrogen

Total nitrogen includes organic (in plant or animal protein) and inorganic (ammonium, nitrite, and nitrate) forms of nitrogen in both the dissolved and suspended state. Nitrogen is generally concentrated in soils and biological matter and, to a lesser extent, in rocks. Nitrogen sources in the Umpqua River basin include agricultural fertilizers, containing nitrate and ammonium, and organic wastes such as sewage effluent, log-pond effluent, decaying plants, and animal wastes. The breakdown of proteinaceous organic matter and urea results in releases of the ammonium ion (U.S. Environmental Protection Agency, 1976). Ammonium ions undergo bacterial oxidation in soil or water to nitrite and nitrate. Certain types of algae can extract nitrogen from the atmosphere and convert it into nitrate. Nitrate, a readily bioavailable form of nitrogen, is an essential nutrient for plant growth. The maximum contaminant level for nitrate as N in domestic drinking water supplies is 10 mg/L (U.S. Environmental Protection Agency, 1975).

Distributions of organic- and ammonia-nitrogen ($\text{ORG-N}+\text{NH}_4$) concentrations and nitrite plus nitrate (NO_2+NO_3) concentrations in the South and main stem Umpqua Rivers are shown in figures 13 and 14 and in table 12 in the supplemental data section. Total nitrogen is the sum of the $\text{ORG-N}+\text{NH}_4$ and NO_2+NO_3 concentrations. Median concentrations of $\text{ORG-N}+\text{NH}_4$ range from 2 to more than 10 times greater than the median NO_2+NO_3 concentrations. Both $\text{ORG-N}+\text{NH}_4$ and NO_2+NO_3 distributions of concentration show an upward shift at South Umpqua RM 117.7 and Umpqua RM 56.9. The downward shift in both constituent concentrations immediately downstream of South Umpqua RM 117.7 is due to dilution with low concentrations of $\text{ORG-N}+\text{NH}_4$ and NO_2+NO_3 from the North Umpqua River. The slight upward shift at Umpqua RM 56.9 may actually exist or may be the result of (1) comparing distributions having unequal-sized data sets from different time periods or (2) comparing data collected and analyzed by different methods. DEQ and Geological Survey data indicate an upward shift in both constituent concentrations from South Umpqua RM's 132.5 to 117.7. River concentrations of total phosphorus also increase in this reach.

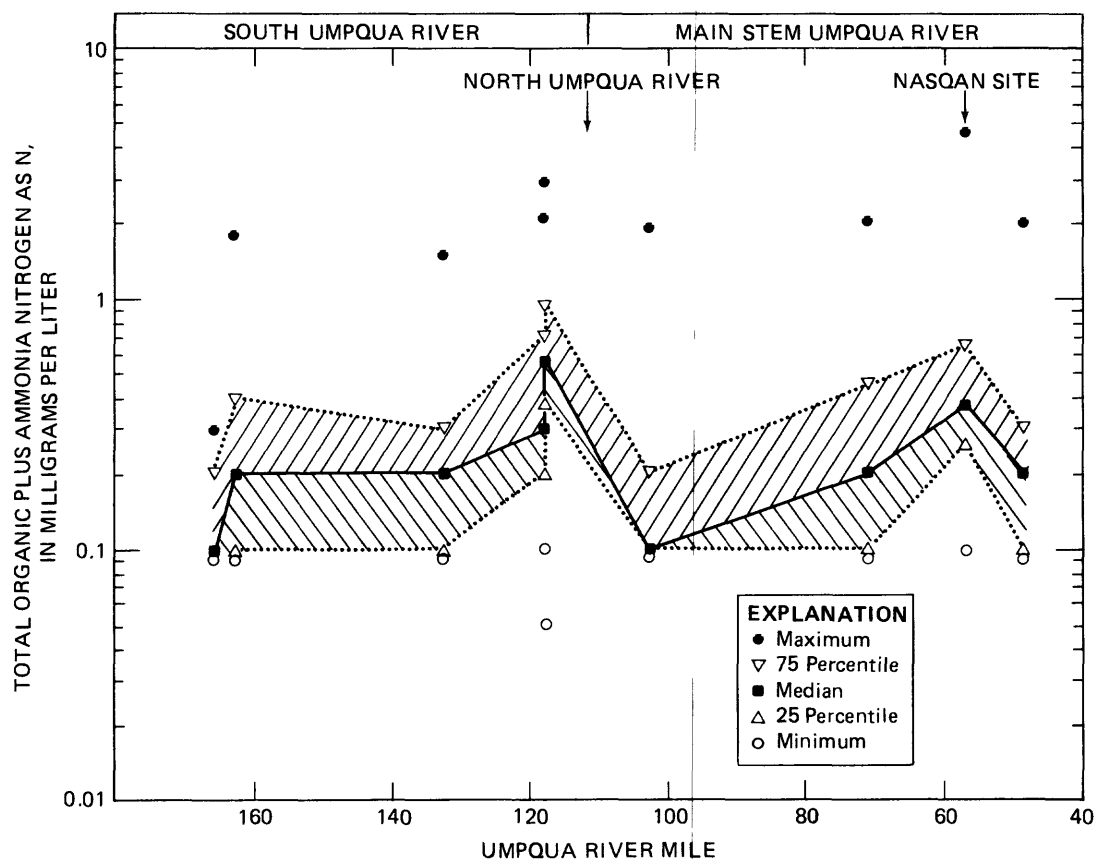


FIGURE 13. — Distribution of instantaneous total organic nitrogen plus ammonia nitrogen concentrations using data collected in 1977 and 1980 through 1983 WY.

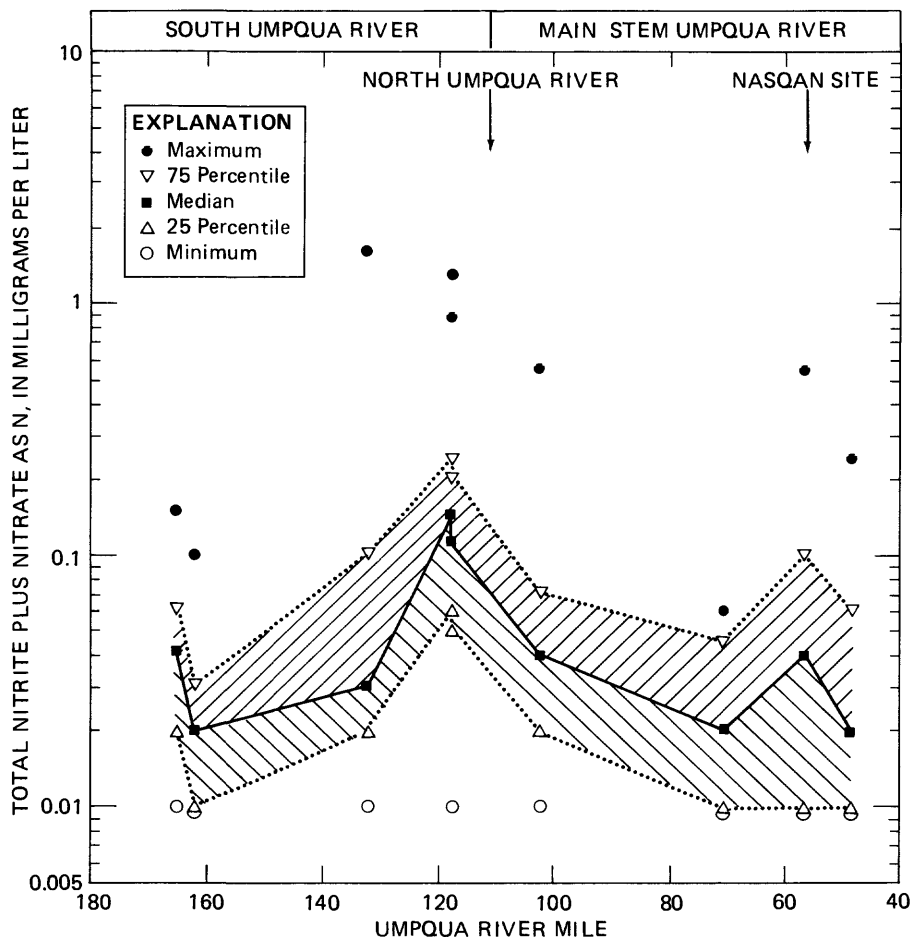


FIGURE 14. – Distribution of instantaneous total nitrite plus nitrate concentrations using data collected in 1977 and 1980 through 1983 WY.

ORG-N+NH₄ concentrations are generally higher during the summer months (fig. 15); NO₂+NO₃ concentrations are generally lower during the summer months, except at South Umpqua RM 117.7. Concentrations of NO₂+NO₃, an essential plant nutrient, may be reduced during the summer months due to increased biological productivity resulting from increased river temperatures and increased sunlight. Excessive aquatic growth observed between RM's 132.5 and 117.7 during the summer is apparently insufficient to reduce NO₂ and NO₃ concentrations to levels lower than those observed during the winter (fig. 16). Ammonium ions may also be entering the reach and undergoing oxidation to NO₂+NO₃.

Loads and yields (using the constituent transport-curve method) for the 1977 low-flow water year are shown in table 13. DEQ data indicate increases in ORG-N+NH₄ and NO₂+NO₃ annual loadings between South Umpqua RM's 162.5 and 132.5 (85 and 26 t/yr, respectively) and between RM's 132.5 and 117.7 (20 and 18 t/yr, respectively). Load increases are due to increases in constituent concentrations and not to increases in streamflow.

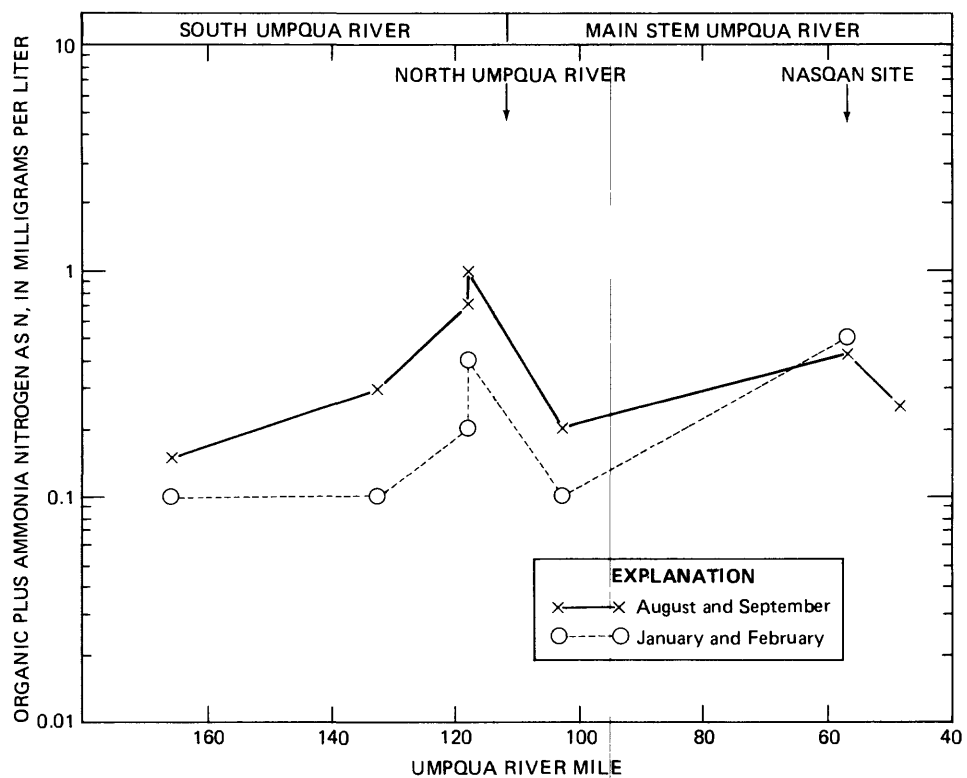


FIGURE 15. — Median total organic plus ammonia nitrogen concentrations for January-February and August-September.

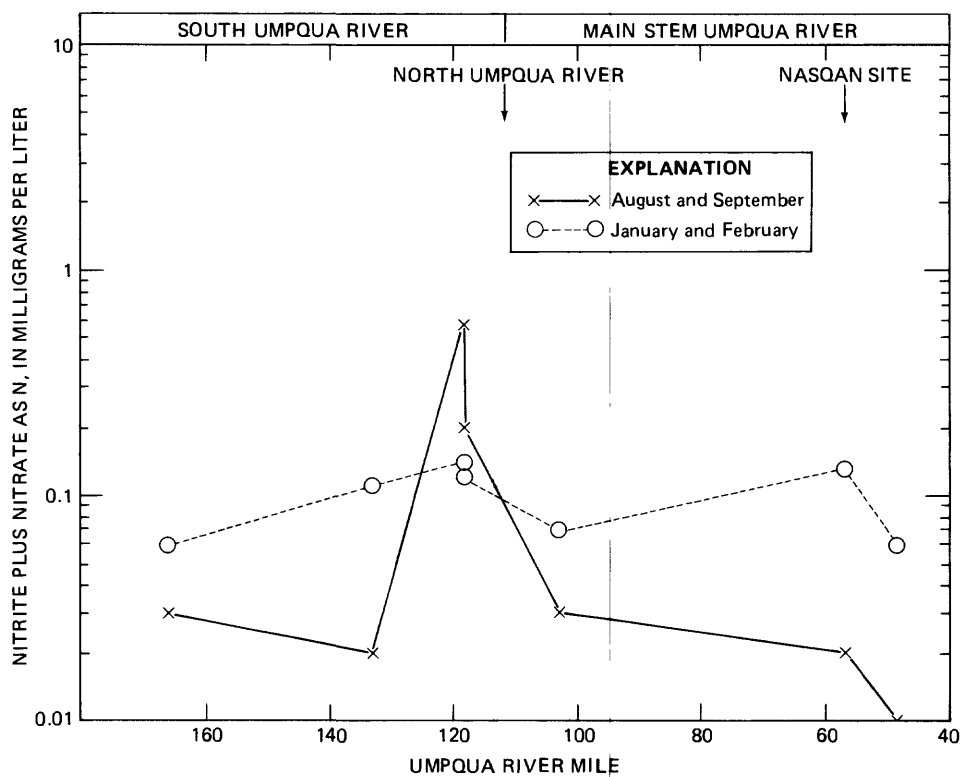


FIGURE 16. — Median total nitrite plus nitrate concentrations for January-February and August-September.

Based on instantaneous monthly DEQ data for 1977 and 1980 through 1983 WY, differences in instantaneous loads between South Umpqua RM's 132.5 and 117.7 are shown in figures 17 and 18. The median increase in load for $\text{ORG-N}+\text{NH}_4$ is 0.073 t/d (27 t/yr); for NO_2+NO_3 , the median increase is 0.061 t/d (22 t/yr). These load increases are very close to the 1977 WY load increases that were estimated by the constituent transport-curve method.

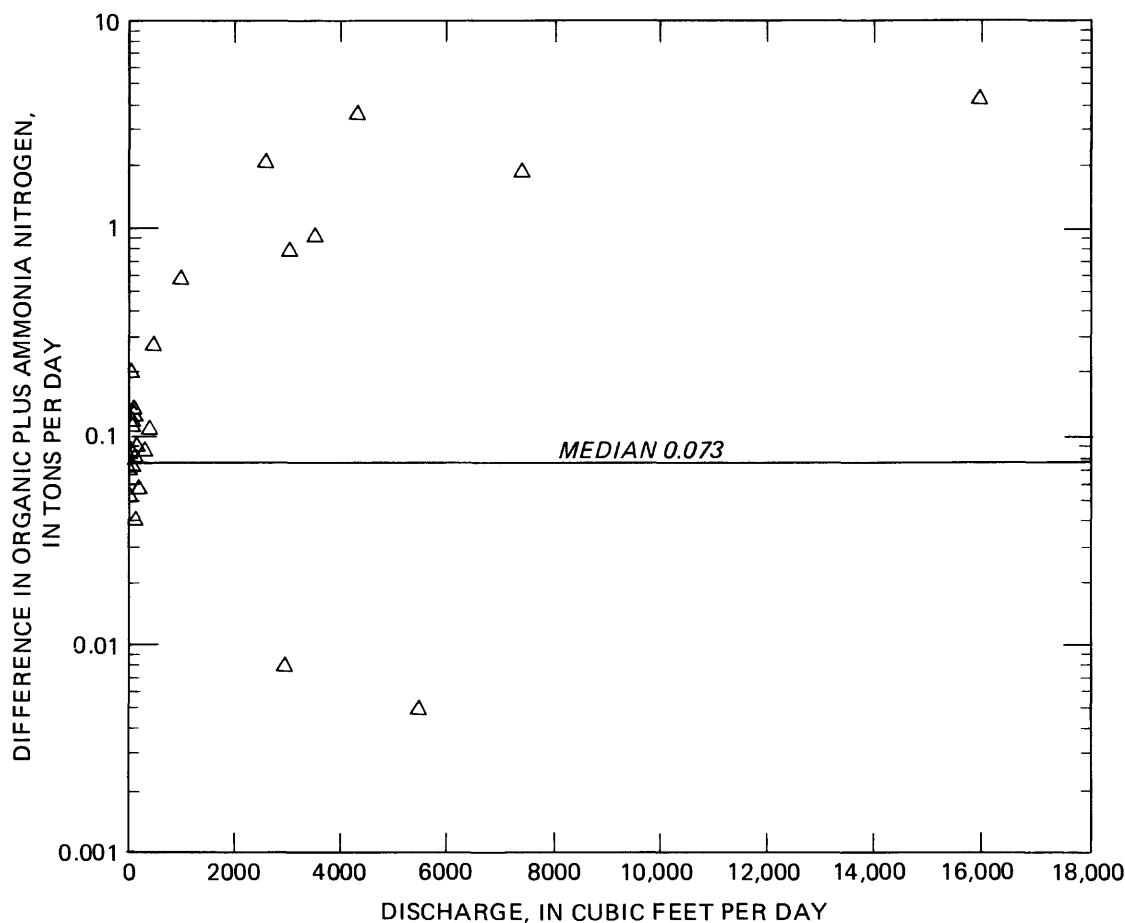


FIGURE 17. — Increase in total organic plus ammonia nitrogen loading (as N) from South Umpqua RM 132.5 to 117.7. Seven negative loading differences are not shown.

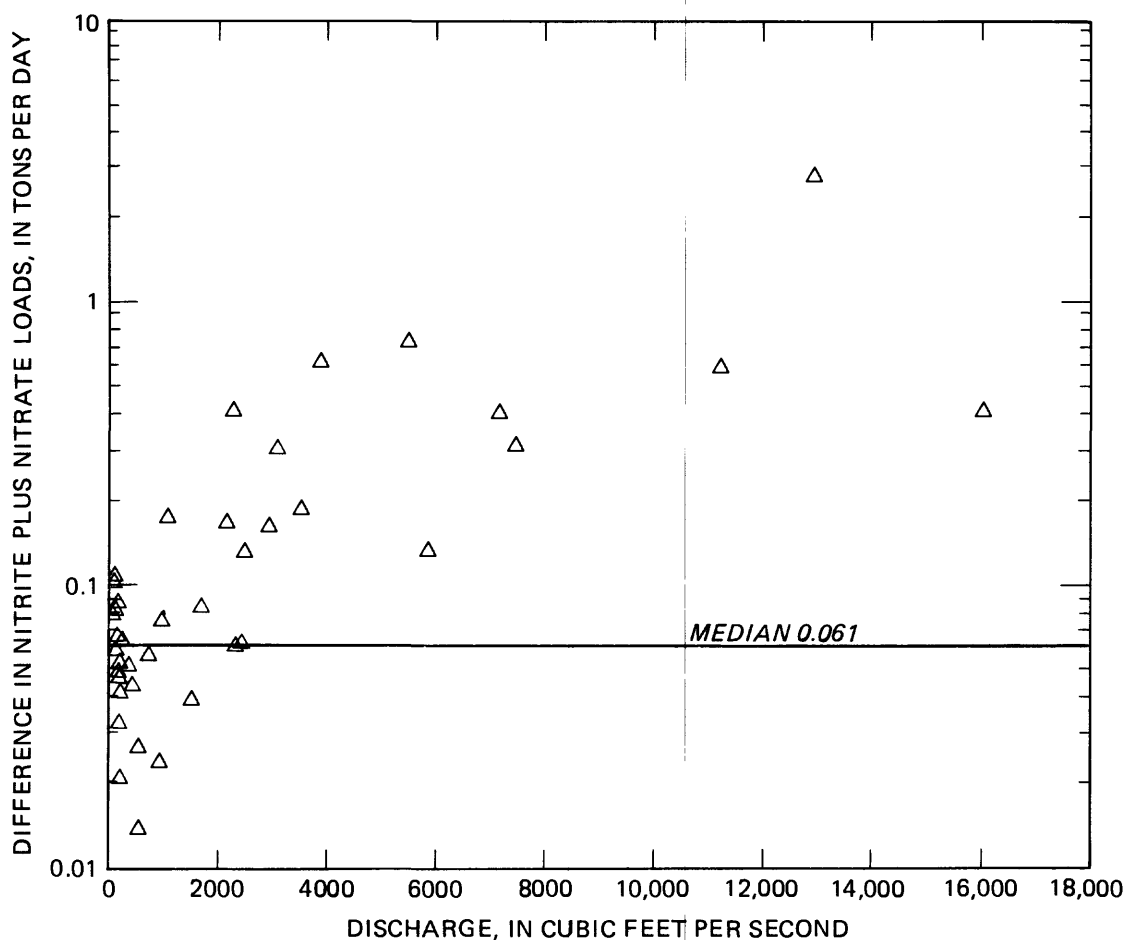


FIGURE 18. — Increase in total nitrite plus nitrate loading (as N) from South Umpqua RM 132.5 to 117.7. Eight negative loading differences are not shown.

Constituent yields at selected sampling stations on the South, North, and main stem Umpqua Rivers are shown in figures 19 and 20 (and table 16 in the supplemental data section). Due to higher stream discharges, the North Umpqua River has among the highest $\text{ORG-N} + \text{NH}_4$ yields; however, South Umpqua RM 117.7 has among the highest $\text{NO}_2 + \text{NO}_3$ yields, because $\text{NO}_2 + \text{NO}_3$ concentrations are about 10 times higher than those in the North Umpqua River. Lowest yields are observed at at South Umpqua RM 132.5 and upstream, where point-source loads are probably reduced.

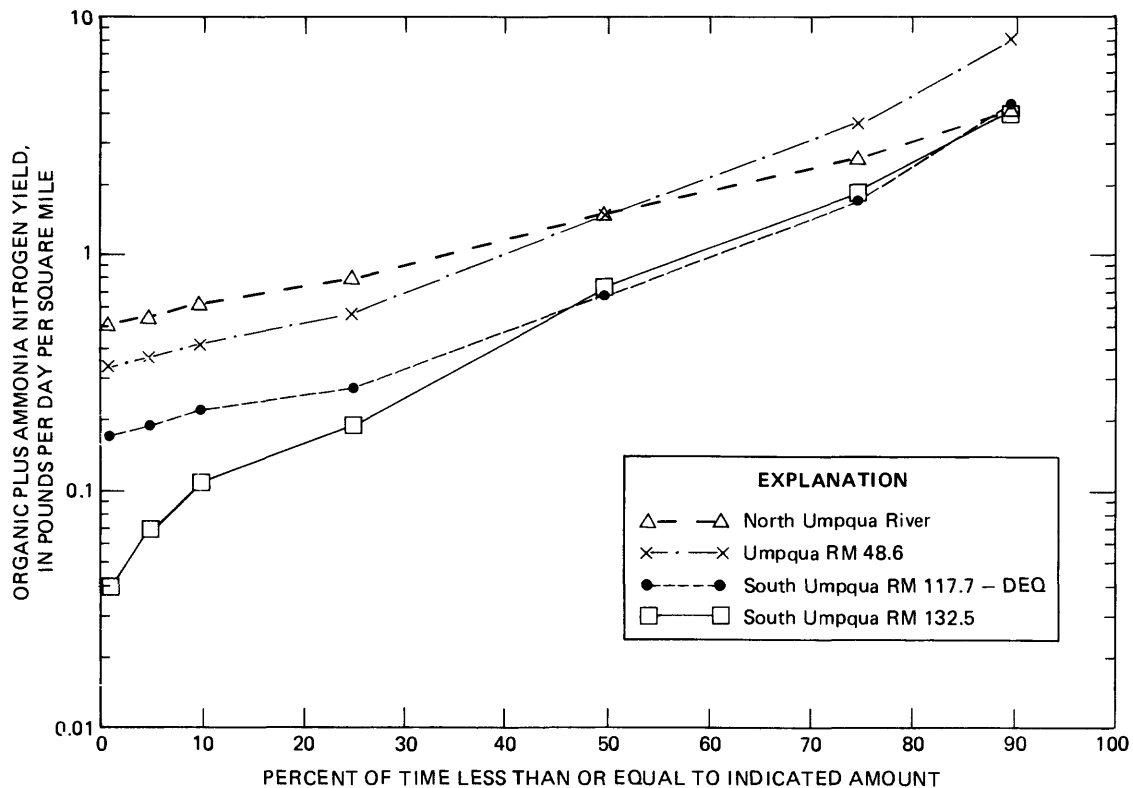


FIGURE 19. — Duration curves for total organic plus ammonia nitrogen (as N) yields.

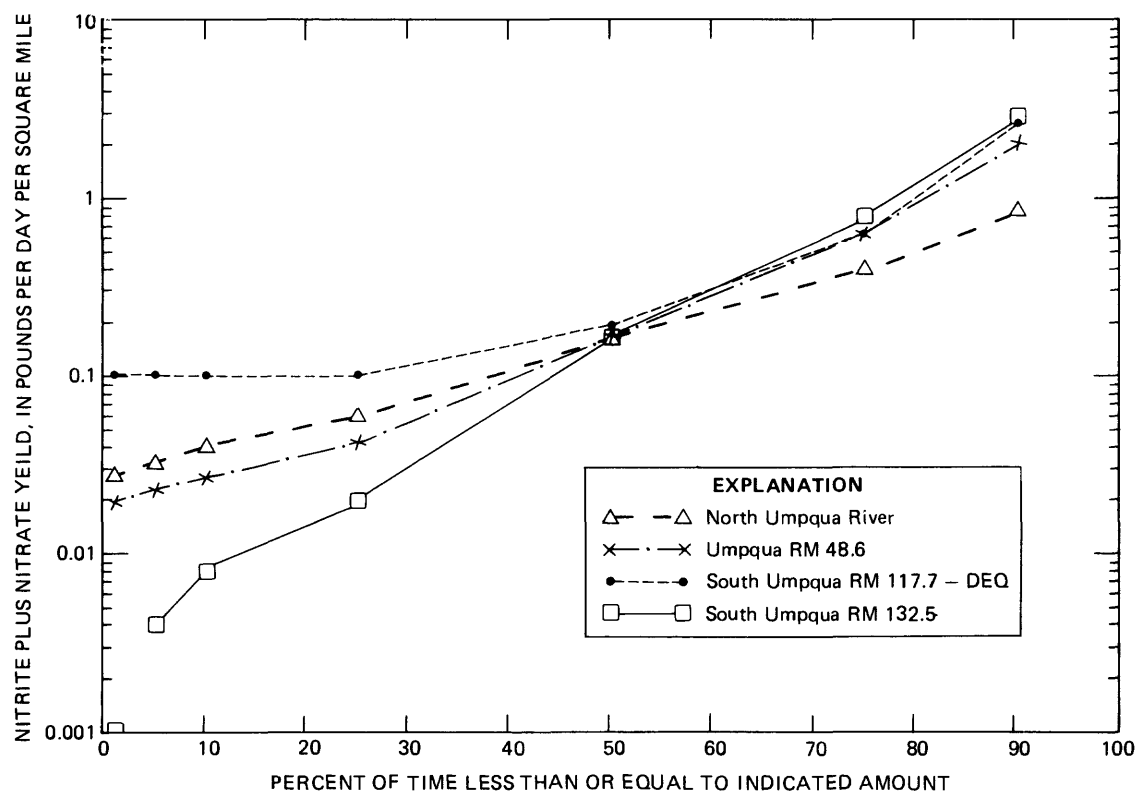


FIGURE 20. — Duration curves for total nitrite plus nitrate (as N) yields.

Fecal Coliform Bacteria

The transmission of disease-producing microscopic organisms can be associated with fecal contamination from warm-blooded animals including man (U.S. Environmental Protection Agency, 1976). Bacterial indicators used to give an indication of the disease-producing potential of water used for drinking or recreation are fecal coliform and fecal streptococci (this report primarily examines the presence of fecal coliform colonies). Indicator bacteria may be found in the gut of warmblooded animals, but they are also associated with soils, vegetation, and insects. The occurrence of indicator bacteria does not conclusively indicate the presence of fecal contamination, because of the possibility of nonfecal bacteria sources. Indicator bacteria are not necessarily disease-producing; however, their presence is often associated with disease-producing organisms. Unless the source of the indicator bacteria has been determined by species identification to be nonfecal, the presence of fecal coliform bacteria indicates a potential health hazard.

Geological Survey and DEQ fecal coliform bacteria counts may not be comparable, due to differences in sample preservation and analytical techniques. The Geological Survey uses the membrane filter method (Greeson and others, 1977) and DEQ uses the multiple-tube procedure (American Public Health Association and others, 1975).

Median fecal coliform colony counts gradually increase in the South Umpqua River from RM's 162.5 to 117.7 (fig. 21; table 12 in the supplemental data section). The North Umpqua River has low fecal coliform counts. Downstream from the confluence of the North and South Umpqua Rivers, the counts gradually decrease and level off near the NASQAN station. The increase between South Umpqua RM's 132.5 and 117.7 may be associated with point-source loadings from STP's (table 11, p. 68) or runoff from pastures and urbanized areas. Quantitative contributions from STP's, small tributaries, and other sources have not been determined. Fecal coliform counts are positively correlated to river discharge and, consequently, higher counts are generally observed during the winter months (fig. 22). DEQ data indicate that the highest loads, yields, and flow-weighted concentrations occur at South Umpqua RM 117.7 (table 13 in supplemental data section).

Annual loading differences between RM's 132.5 and 117.7 (table 13 in supplemental data section), based on the constituent transport-curves of DEQ data, indicate an increase of 4.2×10^9 million colonies per year for 1977 WY. Monthly instantaneous DEQ data indicate that the median increase in instantaneous loads from RM's 132.5 to 117.7 is 0.4×10^9 million colonies per year (for 1977 and 1980 through 1983 WY). Monthly data also indicate a decrease in the loading from RM 132.5 to 117.7 for more than 25 percent of the time. The occurrence of these decreases during low-flow conditions suggests that the increases (or inputs) in the reach are associated with (1) storm-water runoff (differences in loads appear to increase with increasing flow) or (2) STP effluent bypasses (Andrew L. Schaedel, DEQ, oral commun., May 1985), or that chlorinated effluent from STP's are causing these decreases during the low base flows.

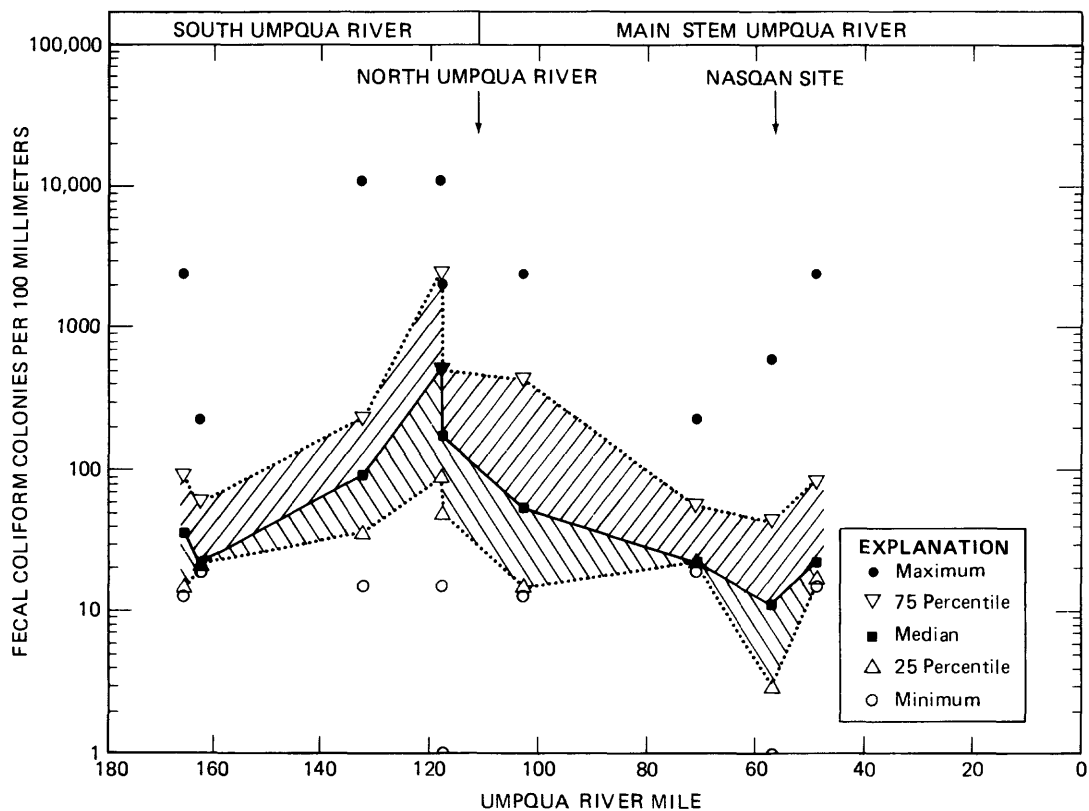


FIGURE 21. — Distribution of instantaneous fecal coliform colony counts using data collected in 1977 and 1980 through 1983 WY.

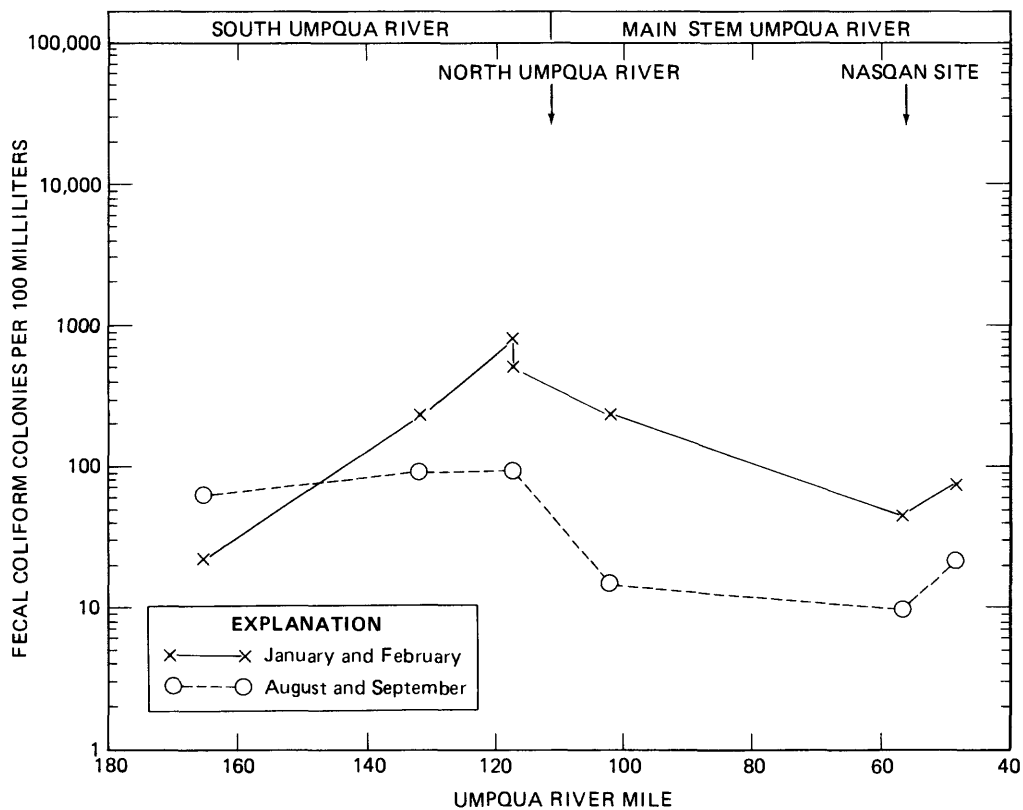


FIGURE 22. — Median fecal coliform colony counts for January-February and August-September.

Suspended Sediment

Suspended-sediment movement in streams is an important factor controlling the transport and fate of chemicals in the environment. Many chemicals, including trace metals, organic compounds, and nutrients, are associated with suspended sediments. High suspended-sediment concentrations may affect water use for domestic water supplies, aquatic-life propagation, and recreation.

DEQ sediment analyses are determinations of nonfilterable (suspended) solid residues at 105° C (STORET parameter code 00530; Kopp and McKee, 1979), and Geological Survey analyses are determinations of suspended-sediment concentrations at 105° C (STORET parameter code 80154; Guy, 1970). DEQ samples are generally collected from midflow at about a 3-foot depth; Geological Survey samples are depth- and width-integrated samples collected isokinetically relative to river velocities. DEQ analytical procedures require that at least a 100-ml aliquot of sample be withdrawn from a well-mixed sample for analyses, whereas Geological Survey procedures require analysis of the entire sediment and water contents of a sample container. As a result of these differences in sampling and analytical procedures, DEQ and Geological Survey data may not be comparable, depending on a river's flow characteristics, suspended-sediment concentration, and particle-size distribution. Greater differences could occur as the sediment concentration increases and the percentage of sand-size particles increases.

Suspended-sediment concentrations for data collected in 1977 and 1980 through 1983 WY range from less than 1 mg/L, at most of the stations, to 154 mg/L at the NASQAN station (table 12 in the supplemental data section). The distributions of sediment concentrations for this timeframe are relatively uniform throughout the basin (fig. 23). Suspended sediment is positively correlated with river discharge, in that the highest concentrations are observed during the winter high flows (fig. 24). Suspended sediment loads and yields for 1977 WY are shown in table 13. Loads and yields were calculated using sediment transport curves based on monthly samples. These results are much lower than those reported by Curtiss (1975), who used flow-duration curves based on 18 years of streamflow data (1956-73). In a normal flow year, the majority of an annual sediment load is transported at high flows; these high flows did not occur in 1977 WY. For this reason 1977 WY loads and yields of suspended sediments and other sediment-associated constituents should be considered lower than those occurring in a normal water year.

The yield distributions of suspended sediments in the Umpqua Basin are shown in figure 25. At lower flows, the North Umpqua River has the highest yields and the South Umpqua River has the lowest yields. Yields at the NASQAN station are midway between those of the North and South Umpqua Rivers. The upper end of the yield-duration curve (fig. 25), above 90 percent, is not defined because of the lack of monthly data at high flows. As the logarithmic scale indicates, this is the portion of the curve where most of the sediment is transported.

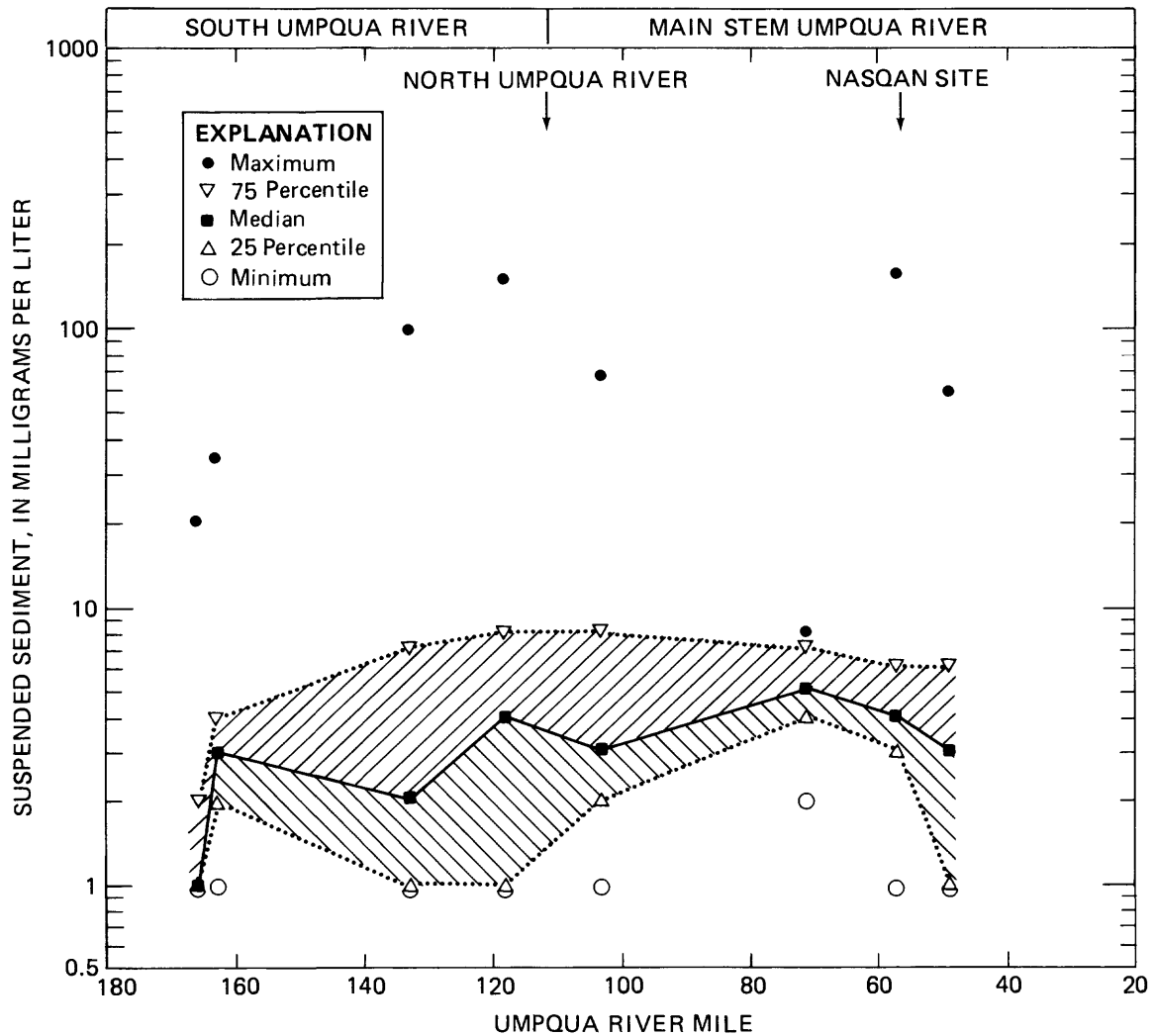


FIGURE 23. — Distribution of instantaneous suspended-sediment concentrations using data collected in 1977 and 1980 through 1983 WY. DEQ analyses are suspended-solid (P00530) concentrations and Geological Survey analyses are suspended-sediment (P80154) concentrations.

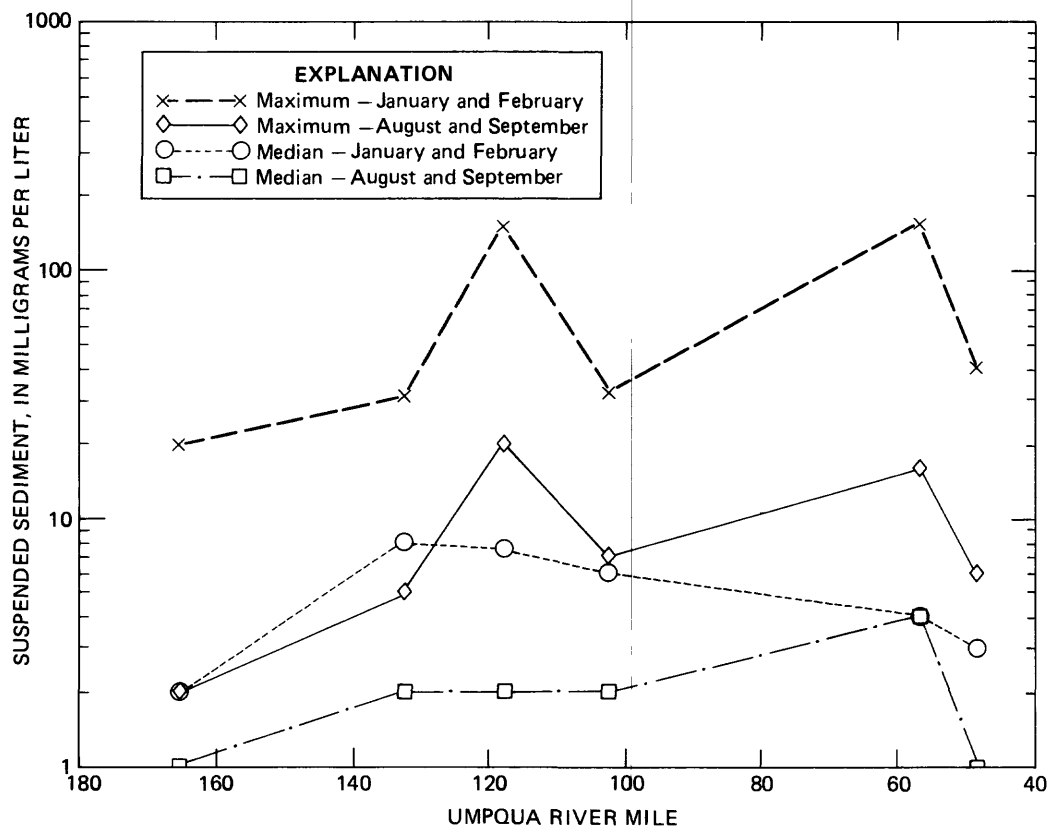


FIGURE 24. — Median and maximum suspended-sediment concentrations for January-February and August-September.

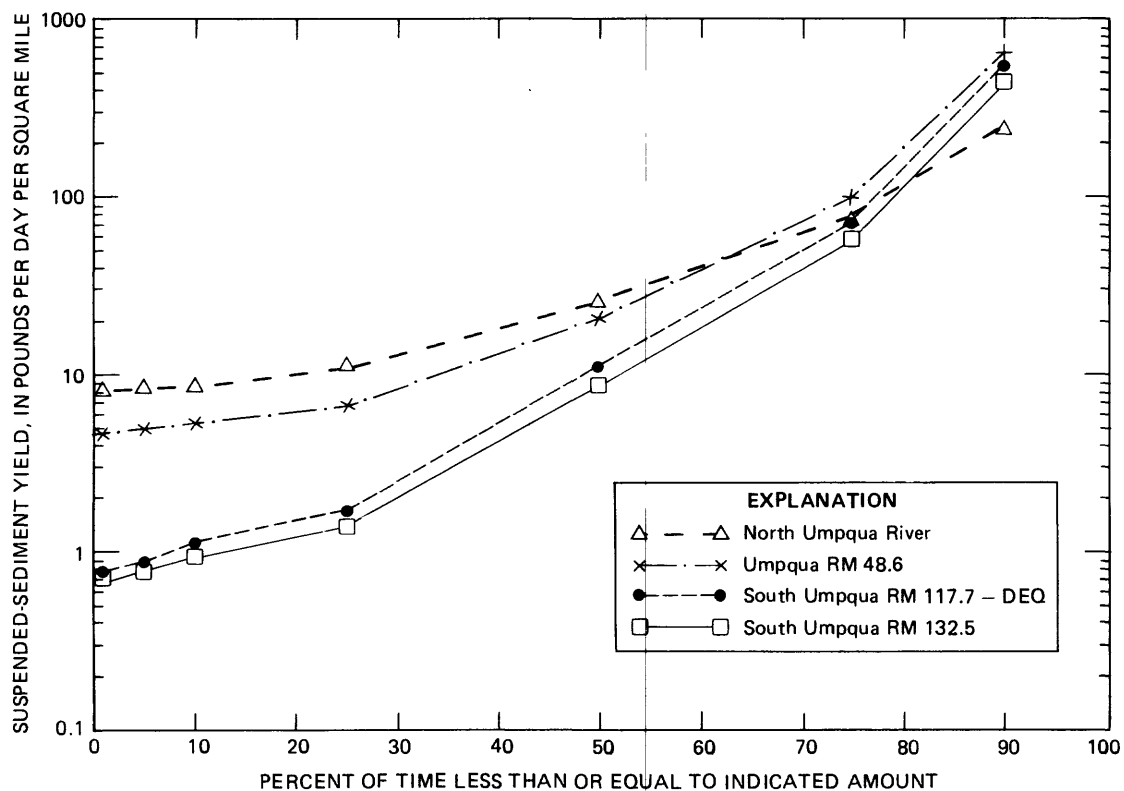


FIGURE 25. — Duration curves for suspended-sediment yields.

Tukey's Studentized Range Test

The distributions of constituent concentrations and values in table 12 (in the supplemental data section) indicate differences of more than one order of magnitude between some constituent ranges and median values. Tukey's studentized range test (SAS Institute, Inc., 1982) was used to determine which distributions of constituent values at the sampling stations were significantly different from one another. One requirement for this test is that the data be normally distributed. Normality testing procedures (SAS, Institute, Inc., 1982), including log transformations of the data, indicated that much of the data was not normally distributed. Because test assumptions for normality were not met, a nonparametric test (Conover, 1980) was performed, using Tukey's studentized range test on the ranks of constituent concentrations or on values collected in 1977 and 1980 to 1983 WY. Ranks of constituent concentrations were computed as follows:

- (1) Concentrations for all sampling stations were placed into one data set and arranged in increasing concentration.
- (2) Concentrations were then assigned a rank from one to N, where N equals the number of concentration values in the data set. The lowest concentration received a rank of one and the highest concentration received a rank of N.
- (3) Mean ranks were then computed for each sampling station by averaging the assigned ranks for each constituent for each station. A station that received the lowest mean rank had among the lowest constituent concentrations, and a station that received the highest mean rank had among the highest constituent concentrations.

As discussed earlier, constituent values often correlated with river discharge (where river discharge correlates with seasons of the year). To examine these seasonal discharge effects, distributions of constituent values were also compared for significant differences between bimonthly periods; January-February data were combined into one period, March-April data were combined into another, and so on. Results of the station and bimonthly comparisons are shown in table 17 (supplemental data section). This table shows which stations or bimonthly periods have mean ranks of constituent concentrations (or constituent concentration distributions) that are significantly different from one another.

Mean ranks of constituent values for each station and for each bimonthly period were then ranked (shown as "Rank of mean ranks" in table 17) for comparison of constituent distributions between stations and between bimonthly periods. A ranking of "1" indicates that the station or bimonthly period had the lowest mean rank of constituent values (higher rankings imply higher mean ranks).

Results of Tukey's studentized range test and the mean rank computation support the following general conclusions:

(1) Specific conductance

- a. Distributions or mean ranks at stations in the main stem Umpqua River were not shown to be significantly different from one another.
- b. Distributions at stations in the South Umpqua River were not shown to be significantly different from one another (highest mean rankings observed in the South Umpqua River); note that the rank of the mean ranks listed in table 17 are greater than or equal to 6 at and upstream of South Umpqua RM 117.7.
- c. Distribution at the North Umpqua River station was significantly different from all other stations (lowest mean ranking observed in the North Umpqua River).
- d. Bimonthly periods of JUL/AUG and SEP/OCT (highest rank of mean ranks) have constituent values that are significantly different from one another and from all other periods. This timeframe is consistent with increased percentage contributions of ground-water flow to the rivers. The bimonthly period of JAN/FEB had constituent distributions that were not significantly different from those in adjacent time periods of NOV/DEC, MAR/APR, and MAY/JUN.

(2) Total phosphorus

- a. Highest mean ranks are observed at South Umpqua RM 117.7 downstream of several large point sources. Highest mean ranks also occur during the summer months, an observation which is consistent with minimal dilution by low summertime flows in the South Umpqua basin.
- b. Lowest means ranks are observed in the upper reaches of the South Umpqua River. Lowest mean ranks occur between January through June.
- c. Distributions between January and June are not significantly different from one another; those between July and December are not significantly different from one another.

(3) Organic plus ammonia nitrogen

- a. Highest mean ranks are observed at South Umpqua RM 117.7, and the North Umpqua station has among the lowest mean ranks. In general the main stem Umpqua stations are not significantly different from the South Umpqua stations, with the exception of South Umpqua RM 117.7.

- b. Highest mean ranks occur during the summer, which is consistent with the constituent being negatively correlated with discharge.

(4) Nitrite plus nitrate

- a. Highest mean ranks are observed in the South Umpqua River at RM's 117.7 and 132.5. Distributions at these stations are significantly different from those of most of the other stations.
- b. Lowest mean rank is observed at the North Umpqua River station. Distribution at this station is significantly different from that of most of the other stations.
- c. With the exception of the three stations mentioned above, distributions at most of the other stations are not significantly different from one another.
- d. Most of the distributions for the bimonthly periods are significantly different from one another.

(5) Suspended sediment

- a. With some exceptions, most of the distributions (comparison of concentrations between stations) are not significantly different from one another.
- b. Highest mean ranks occur during the winter months, and lowest mean ranks occur during the summer months, which is consistent with the positive correlation between suspended-sediment concentrations and discharge.

(6) Fecal coliform bacteria

- a. Highest mean ranks occur at South Umpqua RM 117.7, and lowest mean ranks occur in the main stem Umpqua River at RM 56.9. Both of these stations have distributions that are significantly different from those of most of the other stations.
- b. Highest mean ranks occur during the winter months and lowest mean ranks occur during the summer months.

Generally, the mean constituent ranks of the North Umpqua River were among the lowest of the mean ranks, and the ranks of the South Umpqua RM 117.7 were among the highest mean constituent ranks. Both of these stations tended to have significantly different distributions of constituent values from those at most of the other stations.

Trends in Water-quality Constituents

Seasonal Kendall Test Unadjusted for River Discharge

The Seasonal Kendall Test (Crawford and others, 1983) was used to determine monotonic time trends of water-quality constituents in the Umpqua River basin. This distribution-free test (based on ranking of data values) uses a modified form of Kendall's tau to determine trends. In this analysis, data pairs of constituent values and corresponding times of collection are compared: if the later constituent value (in time) is higher, a plus is scored; if the later value is lower, a minus is scored (Smith and others, 1982). Equal numbers of pluses and minuses would indicate the absence of a trend. If there are significantly more pluses than minuses, an increasing trend in constituent concentration is likely; significantly more minuses than pluses would indicate that a decreasing trend is likely. Seasonal patterns in water-quality data are often observed. For example, higher specific conductances are often observed during the summer low flows and lower conductances are observed during the winter high flows. Comparison of this type of data from one season to another does not provide meaningful information about a trend. The Seasonal Kendall test minimizes this problem by comparing only yearly data pairs of the same month or time period (for example, comparing January 1980 data to January 1981 data and February 1980 to February 1981). If yearly data pairs of the same month are compared, then season equals 12 in the Seasonal Kendall test. Season equals 12 for all Seasonal Kendall tests in this report.

Seasonal Kendall Slope Estimator

To estimate the magnitude of the trend, a Seasonal Slope Estimator is computed (Hirsh and others, 1982). The slope estimator is the median value of the data set containing the differences of the data values (that are compared in the Seasonal Kendall test) divided by the number of years separating the data. The slope is then the median change in the constituent value per year due to the trend. The slope may also be reported in percent change per year as follows: (slope divided by median constituent value) x 100.

Seasonal Kendall Flow-Adjusted Procedure

As indicated earlier in this report, many water-quality constituents are associated with river flow. Trends in water quality may then be associated with fluctuations in climate and flow and also with man-caused changes in basin processes, including land-use practices, point-source loading rates, agricultural and forestry practices. Flow-adjustment procedures (removing constituent-concentration fluctuations due to flow) are used to determine trends that are associated with changes in basin processes.

The following example will demonstrate flow-adjustment procedures. A plot of the monthly DEQ measurements of specific-conductance measurements at South Umpqua RM 117.7 near Roseburg, for water years 1980 through 1983, is shown in figure 26.

The Seasonal Kendall test, unadjusted for flow (table 18 in supplemental data section), indicates a significant ($p = 0.02$) downward trend in specific conductance with the slope estimator equal to -6.1 percent per year (-7 uS/cm per year). The null hypothesis of the test is that no trend exists, or that constituent values in 1980 equal values in 1981, 1982, and 1983 WY. The probability of making an error by rejecting the null hypothesis when a trend actually does not exist is measured by p (probability level). For example, if $p = 0.02$, then there is a 2 percent chance of making an error when rejecting the null hypothesis. To determine whether the downward trend in specific conductance is associated with increasing flow or with a change in a basin process, the relation between specific conductance and flow must be determined so that the effects of flow can be removed from the constituent values.

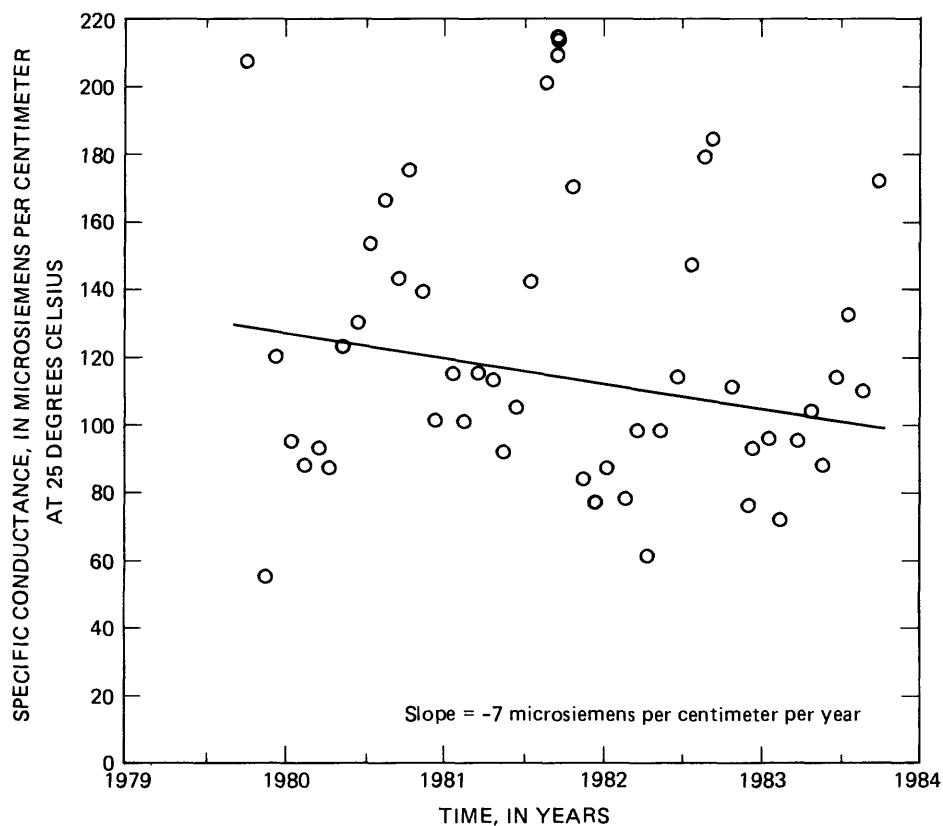


FIGURE 26. — Specific conductances at South Umpqua RM 117.7 (DEQ).
Line shows Seasonal Kendall Slope estimator.

The inverse relation between conductance and flow with time is shown in figure 27. Using model types shown in table 8, the best fit model for relating flow and conductance is determined. The best fit model using SAS's "proc reg" procedures is, $\ln C = 6.06 - 0.190 \ln (Q)$, where r-squared for the log-log model equals 0.85 (if none of the seven models had equation coefficients that were significant at the $p = 0.10$ level, a flow-adjusted trend would not have been calculated). A time series of flow-adjusted concentrations (FAC) or values is now developed. In this example, FAC are the observed conductance values minus the predicted (by the model) conductance values, which are tested versus time. Results of the Seasonal Kendall test on FAC values indicate that a significant trend ($p = 0.84$) does not exist (table 18 in supplemental data section) and that the significant trend observed using the Seasonal Kendall test, unadjusted for flow, was probably a consequence of the particular sequence of sampled flow conditions. These findings are further supported by results of the Seasonal Kendall test on discharge (table 18 in the supplemental data section), which indicate a significant ($p = 0.016$) increase in flow (slope = 8.4 percent per year).

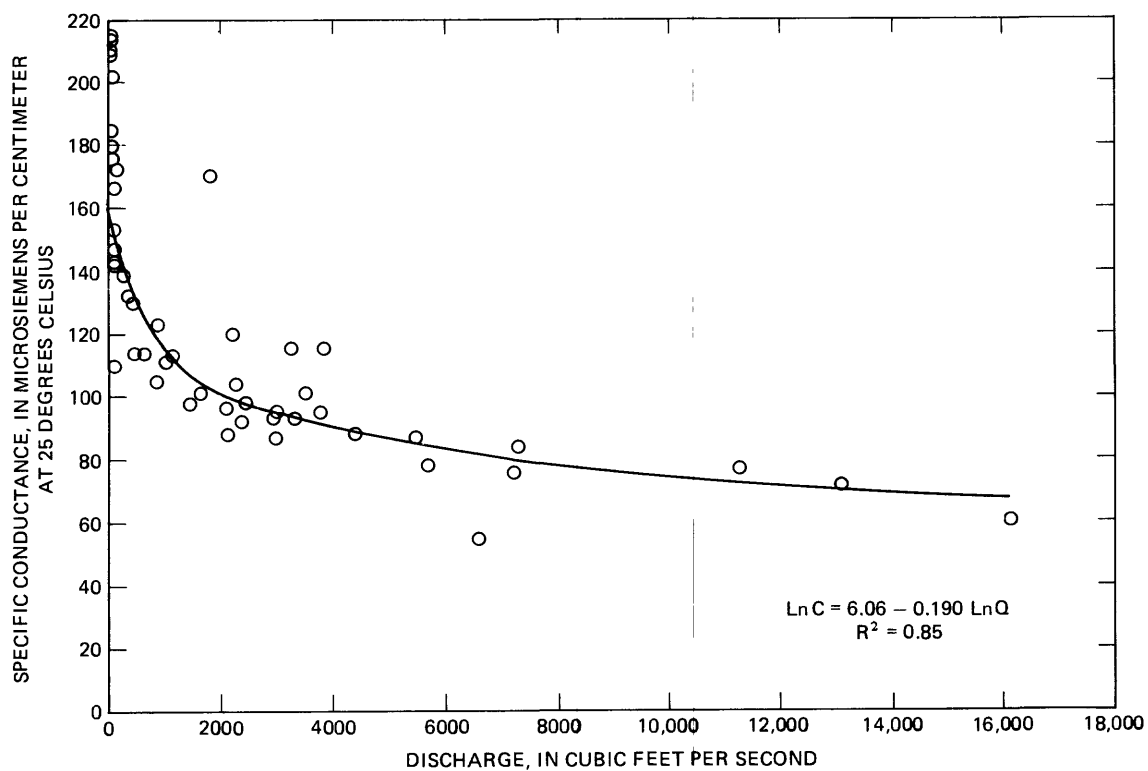


FIGURE 27. — Relationship between discharge and specific conductance, South Umpqua RM 117.7 (DEQ).

Table 8.--Models used to determine the best fit equation for relating flow and constituent values for the flow-adjusted procedure

[C = predicted constituent concentration; a and b are regression coefficients; Q = discharge]

Equation number	Equation	Name
1	$C = a + b (Q)$	Linear
2	$C = a + b (\ln Q)$	Log-linear
3	$C = a + b (1 / (1 + (B)(Q)))$	Hyperbolic, where B is a constant typically in the range between 0.001 times (1/mean Q) and 100 times (1/mean Q)
4	$C = a + b (1 / Q)$	Inverse
5	$C = a + b_1 (Q) + b_2 (Q)^2$	Quadratic
6	$\ln C = a + b \ln (Q)$	Log-log
7	$\ln C = a + b_1 \ln (Q) + b_2 (\ln (Q))^2$	Log-quadratic log

Trends from 1980 through 1983 WY

The results of unadjusted- and flow-adjusted Seasonal Kendall tests are listed in table 18 in the supplemental data section. In addition, tests were run on specific portions of the year to determine if a trend could be related to precipitation events occurring during November through February, snowmelt during March through June, or the period dominated by ground-water inflow during July through October. Trends observed in each of these portions of the year may also be related to basin processes or land uses that occur only during a specific season.

The Seasonal Kendall Slope Estimator (test unadjusted for flow) showed positive increases in stream discharge at all stations; however, significant increases ($p < 0.20$) were observed at most stations only when the entire year of monthly data was included in the test or when the July through October portion of the year was tested (table 18). Significant positive trends in river discharge during July through October could be a resultant combination of the following: increasing ground-water inflow to the river, decreasing consumptive water use, increasing release of water from reservoirs, or increasing precipitation from late summer to early fall.

As discharge increases, constituent values have been shown to decrease or increase (negative or positive correlation coefficients shown in table 7, p. 15). The Seasonal Kendall test also indicates these relations between discharge and selected constituents; for example, the Seasonal Kendall slope estimator shows decreases in specific conductance at all stations, along with increases in discharge. Significant trends for specific conductance and discharge ($p < 0.20$) were observed at most of the stations when the entire year of monthly data was tested and when the July through October portion of the year was tested. However, unlike those for discharge, significant trends in specific conductance were also observed during the November through February and March through July portions of the year. These relations between discharge and specific conductance trends indicate that discharge is probably not the only factor controlling the levels of specific conductance in the river. For most of those constituents that significantly correlated with discharge, the direction (increasing or decreasing) of the observed constituent trends (unadjusted for flow and based on the entire 12 months of data in a year) could be related to increasing trends in stream discharge. Few significant trends were observed for temperature, turbidity, fecal coliform bacteria, suspended solids or sediments, dissolved oxygen, pH, and flow-adjusted concentrations. Reasons for other observed trends could not readily be identified. Trends are difficult to rationalize when water-quality data from point and nonpoint sources are limited. Instantaneous monthly data are probably suitable for describing general changes in water-quality conditions but are inadequate for describing cause-effect relations.

Caution should be exercised when interpreting trend data. A trend indicates an increase or decrease of constituent values with time. These trends could be the result of analytical bias, changes in sample preservation, or even changes in sample-collection techniques, including the time of day the sample was collected. For example, in a biologically productive stream such as the South Umpqua River, DO (dissolved oxygen) concentrations and pH values could increase throughout the day as available sunlight for photosynthesis increases. If, over the first two years of data collection, the field person collects the data in the early morning and then collects data for the next two years in the afternoon, erroneous trends of increasing DO and pH could be observed.

Trends from 1974 to 1983 WY

The results of Seasonal Kendall tests performed on Geological Survey data collected from 1974 to 1983 WY at Umpqua RM 56.9 (NASQAN) and at South Umpqua RM 117.7 are listed in table 19 in the supplemental data section. To examine the effects of reduced sampling, odd-numbered months (such as November = 11, January = 1, March = 3) and even-numbered months (such as October = 10, December = 12, and February = 2) were separately analyzed using the Seasonal Kendall test. Results (table 19) indicate that reducing the size of the data set by 50 percent to odd or even numbered months generally reduces the significance of trends that were observed using all months (odd plus even).

Trends that were observed at the NASQAN station were not necessarily observed at South Umpqua RM 117.7. However, increasing pH and organic plus ammonia nitrogen trends were observed at both stations. Causes for these trends are unknown, but changes in pH measurement techniques and changes in sample preservation techniques could account for these increases.

Major Ions

The composition of major chemical ions dissolved in surface water often may be related to such basin characteristics as agricultural practices, point and nonpoint sources, precipitation quality, soils, and rock types in ground-water aquifers. An analysis of major ions may be helpful in understanding relations between ground- and surface-water quality and hydrology.

Based on Geological Survey and DEQ data collected in 1977 and 1980 through 1983 WY in the Umpqua River basin, the North Umpqua River has the lowest dissolved-solids concentrations, ranging from 40 to 85 mg/L, and the South Umpqua River (RM 117.7) has the highest, ranging from 49 to 138 mg/L (table 12 in the supplemental data section). Upstream from numerous point sources and tributaries in the South Umpqua River near RM 162, dissolved-solids concentrations range from 47 to 107 mg/L, which are still higher than the levels observed at the mouth of the North Umpqua River. As indicated earlier in the report, dissolved-solids concentrations are generally higher during the summer low flows in both rivers. Dissolved-solids concentrations at the NASQAN station are similar to those observed in the North Umpqua River. The North Umpqua River, with substantially higher summertime flows associated with lower concentrations of dissolved solids, dilutes the high dissolved-solid concentrations from the South Umpqua River.

The compositions of major ions for the North and South Umpqua Rivers are shown in figure 28 (based on DEQ data collected between 1974 and 1982 WY). Major ion concentrations were converted to milliequivalents per liter and then converted to percentages of total anion or cation concentrations for figures 29 through 32 (Hem, 1970). Major ions in both rivers are predominantly calcium plus magnesium and alkalinity (bicarbonate). The relative proportion of calcium to magnesium could not be determined using DEQ data, because calcium and magnesium concentrations are reported in terms of total hardness as calcium carbonate. However, Geological Survey data indicate that calcium is the predominant cation in both rivers and that the South Umpqua River has higher percentages of magnesium than those observed in the North Umpqua River. Magnesium percentages increase during the summer in the South Umpqua Basin, possibly due to increases in the relative contribution of ground water from the rocks of the Klamath Mountains, which contain magnesium-rich serpentine (Curtiss, 1969).

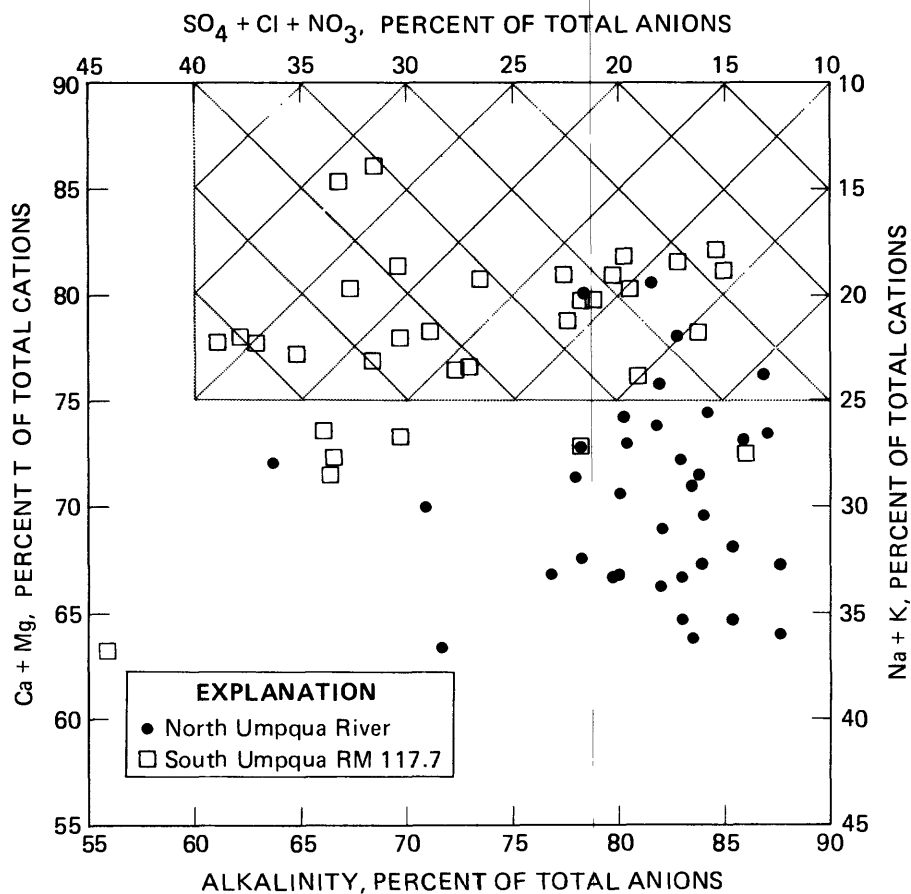


FIGURE 28. — Percentage composition of major ions for North Umpqua River at Brown's Bridge near mouth and South Umpqua RM 117.7 at Melrose Road near Roseburg. Cross-hatched area shows composition of ions for the majority of the ground-water quality sites in the rocks of the Klamath Mountains.

The station at South Umpqua RM 117.7 has a noticeably higher percentage of calcium and magnesium than the North Umpqua station (fig. 28). Ion compositions at South Umpqua RM 117.7, RM's 162.5, and 165.5, are shown in figure 29. These stations have similar major-ion compositions, in that point and nonpoint sources do not appear to be changing the river's major-ion composition from South Umpqua RM 165.5 to 117.7. The data collected at South Umpqua RM 162.5 were collected primarily in 1977 low-flow water year, where the percentage composition of alkalinity was higher than the data values collected at RM 165.5. The fact that the data collected at RM 165.5 were collected after 1977 WY during higher flow years suggests that ground water may be contributing to the increased alkalinity in 1977 WY.

Waters of the North Umpqua River have one of the highest dissolved silica concentrations observed in the basin and one of the lowest of dissolved-solids concentrations. The South Umpqua River water has one of the lowest silica concentrations and one of the highest of dissolved solids. This observation is consistent with the following median concentrations of silica and dissolved solids, reported by Miller and Gonthier (1984) in western Oregon aquifers (these statistics are based on sampling stations in western Oregon and are not limited to just those few stations in the Umpqua River basin):

Ground water from volcanic rocks of the High Cascades --

Median silica is 43 and range is 4 to 130 mg/L

Median dissolved solids is 158 and range is 38 to 2,350 mg/L

Ground water from rocks of Klamath mountains in southwest Oregon --

Median silica is 29 and range is 2.7 to 60 mg/L

Median dissolved solids is 256 and range is 39 to 6,290 mg/L

Ground water from volcanic rocks of Western Cascades --

Median silica is 36 and range is 8.9 to 68 mg/L

Median dissolved solids is 158 and range is 23 to 3,010 mg/L

SUMMARY

The Umpqua River basin is located in southwestern Oregon and drains 4,560 square miles. Two major tributaries are the North and South Umpqua Rivers; drainage areas of these rivers account for about 84 percent (36 and 48 percent, respectively) of the area upstream of the NASQAN station near Elkton, Oregon. More than 90,000 people live in the Umpqua Basin, with the highest population density located in the Roseburg-Winston area near the lower reaches of the South Umpqua River. About 60 percent of the population resides in the South Umpqua Basin and about 10 percent in the North Umpqua Basin.

Available point-source data indicate that the largest effluent discharges are located in the Roseburg-Winston area upstream of South Umpqua RM 117.7. The data are adequate for locating potential problem areas, but are inappropriate for estimating daily effluent loadings that could be related to cause-effect relations in river quality. Nonpoint data for small tributaries in the area are also limited; consequently, the effects of various land uses on water quality could not be separated from the effects of point-source discharges.

On an annual basis, the South Umpqua River normally contributes a significant proportion (38 percent by volume) of the discharge measured at the NASQAN station. However, monthly statistics indicate that the summertime contribution of discharge from the South Umpqua River decreases to as low as 11 percent in September (North Umpqua River contributes as much as 83 percent).

Based on this monthly comparison of discharge, water-quality data collected at the NASQAN station is probably not representative of water quality in the South Umpqua River during the summer, even though the South Umpqua River comprises 48 percent of the NASQAN drainage. River yields and summer baseflows are greater in the North Umpqua River because of the basin's larger snowpacks (higher basin elevation), pervious geology providing greater ground-water storage, and the lower consumptive needs of water for such uses as irrigation.

This study was limited to interpretation of instantaneous monthly water-quality data collected by Geological Survey and DEQ at 12 stations in the Umpqua River basin since 1974. These data were used to compare water-quality conditions throughout the basin and to determine if data collected at the NASQAN station are representative of upstream basin conditions.

Many dissolved and suspended water-quality constituent concentrations correlate with river discharge. Positive correlations were observed with suspended sediment, turbidity, dissolved oxygen, nitrite plus nitrate, total phosphorus, and fecal coliform bacteria. Negative correlations were observed with river temperature, specific conductance, dissolved solids, pH, alkalinity, and organic plus ammonia nitrogen. Correlations observed at the NASQAN station are generally similar to those observed at other stations, except at South Umpqua RM 117.7 where negative correlations of nitrite plus nitrate and total phosphorus existed. These negative correlations are due to low summertime baseflows in the South Umpqua River that are probably associated with relatively large constituent inputs from point or nonpoint sources in the heavily populated area.

Instantaneous concentrations and annual flow-weighted concentrations of specific conductance, phosphorus, organic plus ammonia nitrogen, nitrite plus nitrate, and fecal coliform bacteria are generally highest at South Umpqua RM 117.7, the furthest downstream sampling station on the South Umpqua River. These high concentrations occur during the summer months when river baseflow is extremely low relative to the North Umpqua River flow. The North Umpqua River has among the lowest constituent concentrations observed in the basin; with its higher summertime baseflows, the North Umpqua River mixes with the South Umpqua River at RM 111.7 and dilutes constituent concentrations in the main stem Umpqua River so that concentrations at the NASQAN station are between those values observed in the North and South Umpqua Rivers. With exception of specific conductance, constituent concentrations are generally lower upstream of South Umpqua RM 132.5 and are similar to those observed at the NASQAN station. Higher specific conductances were observed throughout the entire South Umpqua River during the summer months and are probably the result of higher conductance ground-water contributions.

Tukey's studentized range test was used to compare the distributions of constituent concentrations and ranges. Results of this test indicated that the mean ranks of constituent distributions at Umpqua RM 117.7 were among the highest and that the mean ranks of distributions at the North Umpqua station were among the lowest.

Monthly variations in the percentage composition of cations at selected stations in the Umpqua River basin are shown in figure 32. At South Umpqua RM 132.5 the monthly variation in cation composition is low and appears to be a composite of aquifer quality from the Mesozoic-Paleozoic bedrock of the Klamath mountains and the Tertiary volcanic rocks of the western Cascades. At South Umpqua RM 117.7 the percentage of sodium plus potassium increases during the summer low flows. This increase may be associated with the content of sodium in STP effluent. Both the North Umpqua River and Umpqua RM 48.6 show increases in the percentage of sodium and potassium during June through September, an increase which is probably a result of ground water contributions from the Quaternary-Tertiary volcanic rocks of the High Cascades.

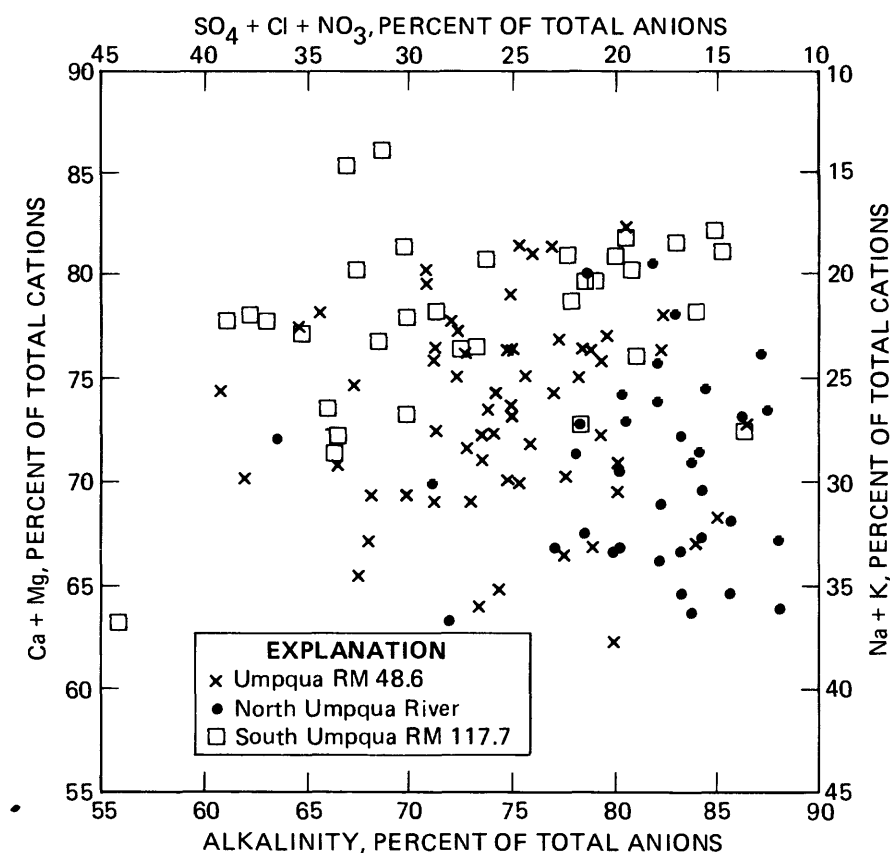


FIGURE 31. — Comparison of the percentage composition of ions for the North, South, and main stem Umpqua Rivers. Umpqua RM 48.6 is about eight miles downstream of the NASQAN station.

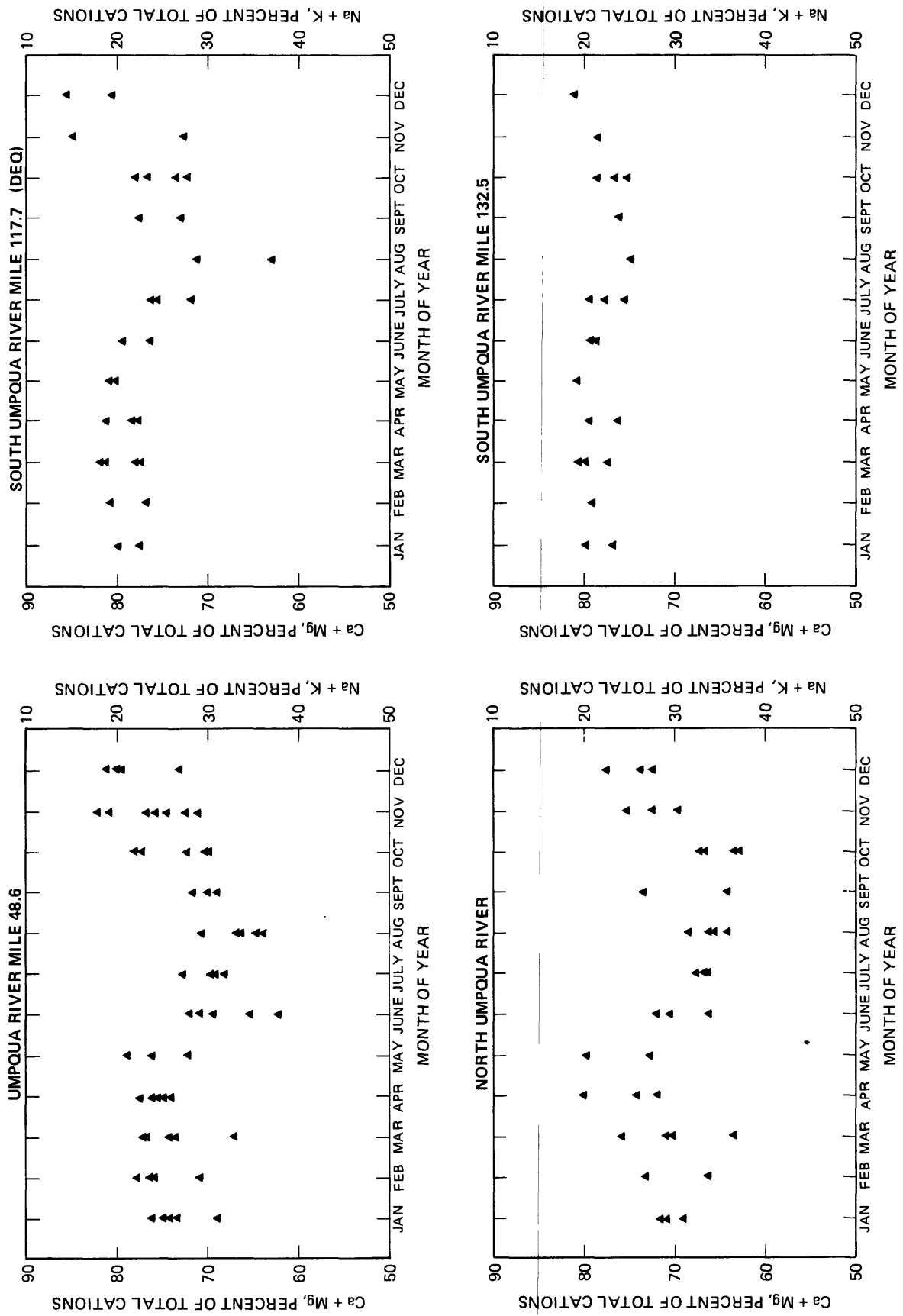


FIGURE 32. — Monthly variations in the percentage composition of cations at selected stations in the Umpqua River basin.

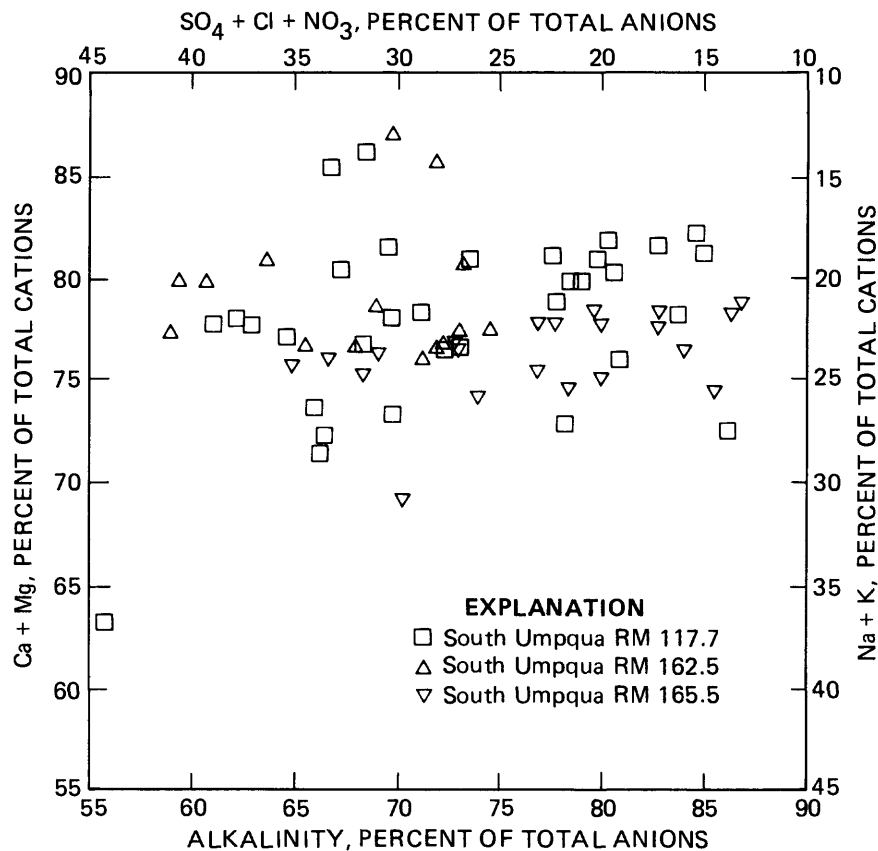


FIGURE 29. — Comparison of the percentage composition of ions for selected stations in the South Umpqua River.

Ion compositions of selected ground-water aquifers in the North and South Umpqua Basins (see fig. 2, p. 6 for location of aquifers) are shown in figure 30. This figure shows that the majority of the water samples from the Klamath aquifer have calcium and magnesium percentages greater than 75 percent and alkalinity percentages greater than 60 percent (see cross-hatched area in fig. 28); in addition, these percentages coincide with the composition of ions in the South Umpqua River. Note that a large number of the stations in the Klamath aquifer also have alkalinities greater than 80 percent, which may account for the increase in percent alkalinity at South Umpqua RM 162.5 during 1977 WY. The High Cascade aquifer has lower percentages of calcium and magnesium, similar to those observed in the North Umpqua River. Chemical characteristics near the NASQAN station at Umpqua RM 48.6 are a combination of the characteristics of the North and South Umpqua Rivers (fig. 31).

QUATERNARY-TERTIARY VOLCANIC ROCKS
OF HIGH CASCADES IN OREGON
(Headwaters of North Umpqua River)

MESOZOIC-PALEOZOIC BEDROCK
OF KLAMATH MOUNTAINS
IN SOUTHWEST OREGON
(Central South Umpqua basin)

TERTIARY VOLCANIC ROCKS
OF THE WESTERN CASCADES
(in both the North and South Umpqua basins)

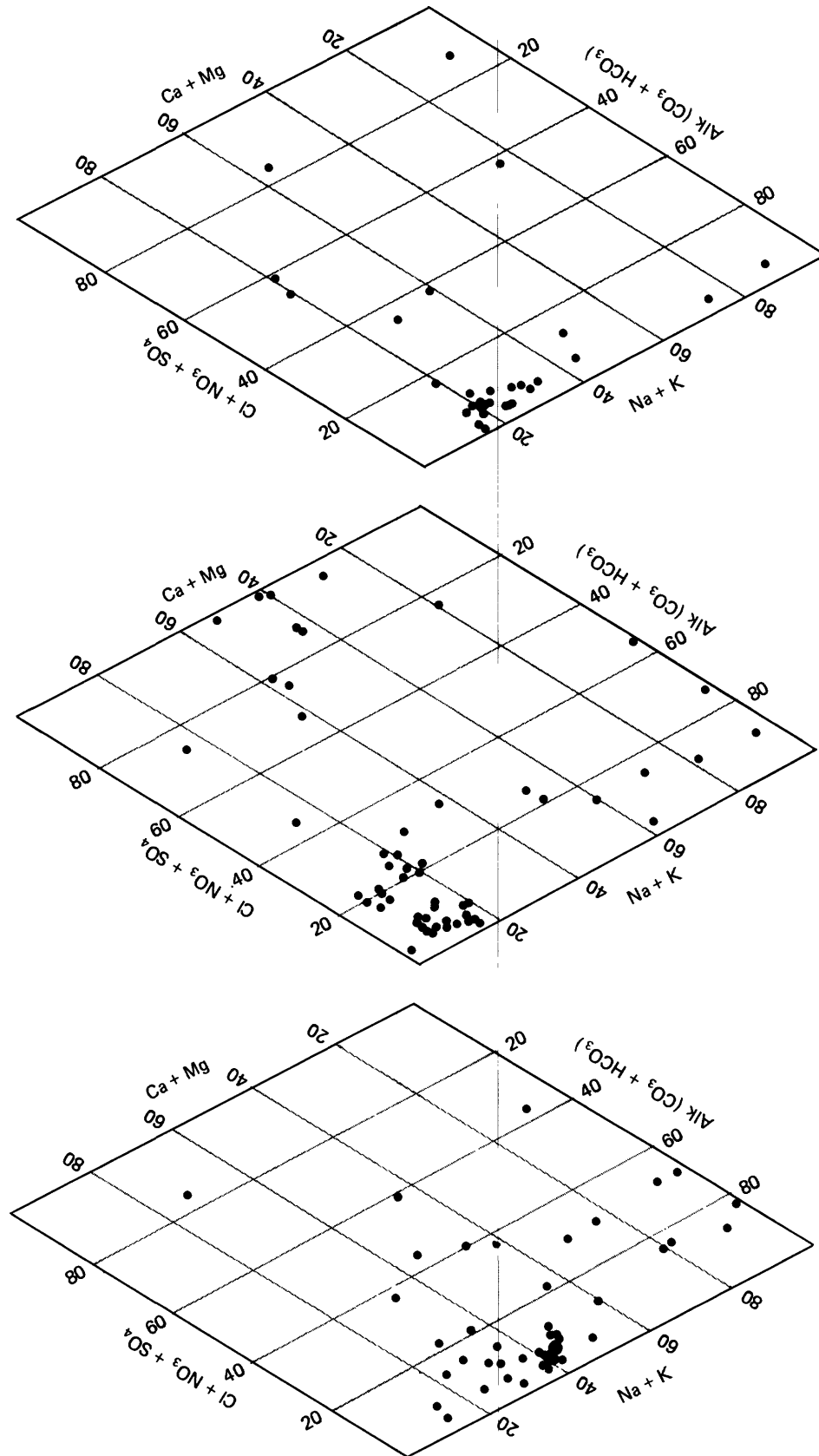


FIGURE 30. — Percentage composition of ions for selected ground-water aquifers in western Oregon. Some of this data was collected in the Umpqua basin (see Miller and Gonthier, 1984, for location of sampling stations).

These two stations, on opposite ends of the spectrum, had constituent distributions that most often were significantly different from distributions of other stations.

Constituent loads and yields for 1977 WY were computed for nine stations, using constituent transport curves based on load versus discharge regressions. Annual loads are reported only for 1977 low-flow water year, because this was the only year during the data-collection period when daily loads could be computed without extrapolations of the load- versus discharge-regression equations. Extrapolation of daily loads could lead to erroneous annual load values, because a few days of extrapolated daily loads could account for more than 50 percent of the annual load. Annual loads for 1977 WY are not typical of loads in a normal flow year; however, they could be used to provide some insight into point-source loads and the quality of ground-water contributions.

The seasonal Kendall test was used to determine monotonic time trends in water-quality constituents. Many significant trends were associated with changes in streamflow; once the data were adjusted for flow, the trends often were not observed. The test was run on specific portions of the year to examine whether a trend could be related to precipitation events occurring during November through February, to snow melt during March through June, or to the period dominated by ground-water inflow during July through October. The lack of adequate point and nonpoint source data made it difficult to explain why certain annual or seasonal trends were occurring. The test was also run on large data sets containing 10 years of data. Reduction of these data sets by 50 percent (examining odd or even months, which is equivalent to bimonthly sampling) generally reduced the significance of the observed trends. Trends that were observed at the NASQAN station were not necessarily observed at other stations.

In general, data collected at the NASQAN station represents a composite of water quality from the North and South Umpqua Rivers. During summer low flows, as much as 80 to 90 percent of the discharge can come from the North Umpqua River, so that NASQAN data do not adequately represent discharge and related water-quality conditions observed in the South Umpqua River. During the winter months when 40 to 50 percent of the discharge is from the North Umpqua and 40 to 50 percent from the South Umpqua River, NASQAN data represent a more uniform composite of both rivers.

FUTURE WATER-QUALITY ACTIVITIES

NASQAN data describe a composite of natural and man-caused effects from upstream reaches, but the data are inadequate for defining the location of upstream problem areas and for quantitatively separating the effects. The addition of DEQ fixed-monitoring stations provides needed information upstream and downstream from major point sources and tributaries; however, the data may be used only to further characterize river-quality conditions. NASQAN and other fixed-station monitoring sites provide minimal information concerning cause-effect relations.

For example, in the Umpqua Basin, high river concentrations of nutrients are observed in the densely populated Roseburg-Winston area and are associated with excessive growth of aquatic plants; however, available point- and nonpoint source data are insufficient to quantitatively assess the source of the nutrients. A synoptic sampling (simultaneous sampling of river stations, tributaries, and point-sources) could provide sufficient data to begin to determine cause-effect relations. The number of synoptic samplings needed to begin to define cause-effect relations will depend on basin characteristics and on the nature and scope of water-quality problems.

Long-term trend analyses will require the continuation of sampling from strategically located fixed-station monitoring sites. If management needs are to monitor water quality before detrimental changes occur, key stations should be operated continuously rather than being operated in an on-off mode (for example, a few years on and a few years off). State and Federal agencies could cooperatively design and operate a water-quality network to minimize sampling replication and meet agency needs. Fixed-station monitoring sites should be located upstream and downstream from locations where water-quality conditions could be expected to significantly change and affect water use (similar to rationale used by DEQ for locating stations). Water use, as defined here, includes consumptive and nonconsumptive uses. Water quality that is suitable for some consumptive uses, such as irrigation or drinking, need not be suitable for nonconsumptive uses, such as fisheries, aesthetics, or recreation. Selection of station locations should be based on the results of synoptic sampling and knowledge of the following:

- o Point sources,
- o Population density,
- o Land uses and related nonpoint sources,
- o Water uses,
- o Geological and topographic features that affect water quality (such as pristine mountain stations sensitive to long-term effects of acid precipitation), and
- o River reaches where maximum measurable changes in water-quality constituents are occurring or expected to occur.

If this information is not readily available, as is the case in the Umpqua River basin (where point and nonpoint source data are limited), reconnaissance or synoptic data should be collected. The Seasonal Kendall test may be used as a tool to determine whether a significant trend in river quality is occurring. However, this test is more meaningful if additional data to determine cause and effect are also collected to explain trends. The Seasonal Kendall test may be helpful for locating river reaches where point and nonpoint sources should be monitored.

Monthly water-quality data may be inadequate for determining annual constituent loads, because water-quality data at high flows are not often collected. In a normal-flow year, more than 50 percent of a constituent load could be transported within a 3- to 4-day period of high flow that is not sampled. Even though 10 years of monthly data had been collected at some stations in the Umpqua Basin, water-quality data had not been collected during the periods of high flow that occur in a normal year. This lack of data requires extrapolation of load versus discharge regressions that could lead to erroneous annual load calculations. Given that the highest daily annual flow occurs in January or February and that a sample is collected once a month, the chance of collecting a water-quality sample on the day of the highest daily annual flow is 1 in 30 (once every 30 years). Our present chance of collecting this high-flow sample is less than 1 in 30, because samples are not collected on weekends. Chances are even less if sampling intervals are decreased to once every other month. If annual loads are important to the NASQAN program, a concerted effort should be made to collect additional water-quality data during major high flows.

In this report only instantaneous monthly water-quality data were examined, even though some hourly and daily data are available. Interpretation of this hourly data along with synoptic studies could provide insight for explaining the occurrence of many problems, including low dissolved-oxygen concentrations in the South Umpqua River during summer nights.

Compositions of major ions are distinctly different for the North and South Umpqua Rivers; these compositions are comparable to those observed in the subbasins' major aquifer units. The major ion composition at the NASQAN station is a composite of ion compositions observed in the North and South Umpqua Rivers.

REFERENCES CITED

- American Public Health Association and others, 1975, Standard methods for the examination of water and wastewater [14th ed.]: Washington, D. C., American Public Health Association, 1193 p.
- Columbia Basin Inter-agency Committee, 1966, River mile index Umpqua River and tributaries, Umpqua River basin, Oregon: Hydrology subcommittee, 25 p.
- Callahan, M., Slimak, M., Gabel, N., May, I., Fowler, C., Freed, P., Jammings, P., Durfee, R., Whitmore, F., Maestri, B., Mabey, W., Hold, B., and Gould, C., 1979, Water-related environmental fate of 129 priority pollutants, Volume 1: U.S. Environmental Protection Agency Report EPA 440/4-79-029a.
- Conover, W. J., 1980, Practical nonparametric statistics (2d ed.): John Wiley and Sons, Inc., New York, 493 p.
- Crawford, G. G., Slack, J. R., and Hirsch, R. M., 1983, Nonparametric tests for trends in water-quality data using the statistical analysis system: U.S. Geological Survey Open-file Report 83-550, 102 p.
- Curtiss, D. A., 1969, Chemical quality of surface water: U.S. Geological Survey Open-file Report, 25 p.
- Curtiss, D. A., 1975, Sediment yields of streams in the Umpqua River basin, Oregon: U.S. Geological Survey Open-file Report.
- Draper, N. R. and Smith, H., 1981, Applied regression analysis, second edition: John Wiley & Sons, Inc., New York, 709 p.
- Federal Water Pollution Control Administration, 1968, Report of the committee on water quality criteria: National Technical Advisory Committee, Washington, D.C., 234 p.
- Friday, John and Miller, S. J., 1984, Statistical summaries of streamflow data in Oregon, Volume 2, Western Oregon: U.S. Geological Survey Open-file Report 84-454, 250 p.
- Greeson, P. E., Ehlke, T. A., Irwin, G. A., Lium, B. W., and Slack, K. V., (revised edition), 1977, Methods for collection and analysis of aquatic biological and microbiological samples: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Chapter A4, 332 p.
- Guy, H. P., and Norman, V. W., 1970, Field methods for measurement of fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chapter C2, 59 p.
- Hem, J. D., 1971, Study and interpretation of chemical characteristics of natural water [2d ed.]: U.S. Geological Survey Water-Supply Paper 1473, 363 p.

- Hirsch, R. M., Slack, J.R., and Smith, R.A., 1982, Techniques of trend analysis for monthly water-quality data, Water Resources Research, 18 (1), p. 107-121.
- Kopp, J. F., and McKee, G. D., 1979, Methods for chemical analysis of water and wastes: U.S. Environmental Protection Agency Report EPA-600/4-79-020.
- McFarland, W. D., 1983, A description of aquifer units in Western Oregon: U.S. Geological Survey Open-file Report 82-165, 35 p.
- Miller, C. R., 1951, Analysis of flow-duration, sediment-rating curve method of computing sediment yield: U.S. Bureau of Reclamation, sedimentation section, Denver, CO, 55 p.
- Miller, T. L. and Gonthier, J. B., 1984, Oregon ground-water quality and its relation to hydrogeologic factors---a statistical approach: U.S. Geological Survey Water-Resources Investigations Report 84-4242, 88 p.
- National Oceanic and Atmospheric Administration, 1982, Climatological data annual summary Oregon 1982: v. 88, no. 13.
- Oregon Department of Environmental Quality, 1978, Oregon's statewide assessment of nonpoint source problems: Water quality program, 71 p.
- Oregon State Water Resources Board, 1958, Umpqua River basin: Salem, Oregon, 200 p.
- Riggs, H. C., 1969, Some statistical tools in hydrology: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 4, Chapter A1, 39 p.
- Robert E. Meyer Consultants, 1980, Douglas County water resources management program report: Beaverton, Oregon, 300 p. [available from Douglas County, County Courthouse, Roseburg, OR 97470].
- SAS Institute, Inc., 1979, SAS user's guide, 1979 edition: SAS Institute, Inc., Cary, North Carolina, 494 p.
- SAS Institute, Inc., 1982, SAS user's guide: statistics, 1982 edition: SAS Institute, Inc., Cary, North Carolina, 584 p.
- Schick, Jordis, [ed], 1983, Oregon blue book 1983-1984: Oregon State Printing Division, Salem, Ore., 436 p.
- Smith, R. A., Hirsch, R. M., and Slack, J. R., 1982, A study of trends in total phosphorus measurements at NASQAN stations: U.S. Geological Survey Water-Supply Paper 2190, 34 p.
- U.S. Army Engineer District, Portland, 1971, Review report on Umpqua River and tributaries, Oregon; Interim report, South Umpqua River, v. III: U.S. Army Corps of Engineers, p. 1-46.

- U.S. Environmental Protection Agency, 1975, National interim primary drinking water regulations: Federal Register, December 24, 1975, v. 40, no. 248, p. 59566-59573.
- U.S. Environmental Protection Agency, 1976, Quality criteria for water: Washington, D.C., U.S. Environmental Protection Agency, 256 p.
- U.S. Geological Survey, 1983, Water resources data, Oregon, Water year 1982, Volume 2, Western Oregon: U.S. Geological Survey Water-Data Report OR-82-2, 419 p.

SUPPLEMENTAL DATA

Table 9.--Effluent discharges from selected point sources in the Umpqua River basin

[N = number of monthly reportings of data; " - " = not applicable; WY = water year]

Source	Median of the monthly mean effluent discharges, in million gallons per day									
	1977 WY		1978 WY		1979 WY		1980 WY		1981 WY	
	N	Median	N	Median	N	Median	N	Median	N	Median
MAIN STEM UMPQUA RIVER										
RM 102.7 Calapooya Creek										
RM 25.7 Sutherlin Nonpariel WTP	12	0.018	12	0.018	12	0.018	9	0.014	11	0.014
RM 19.2 Hakason Sand & Gravel	0	-	0	-	0	-	0	-	0	-
RM 14.5 Oakland WTP	9	.001	12	.002	11	.0025	9	.004	6	.004
RM 13.3 Oakland STP	9	.060	12	.065	12	.070	12	.066	10	.070
RM 10 Sutherlin STP	0	-	0	-	0	-	4	1.1	5	.46
RM 9.0 Cook Creek										
RM 2.0 Sutherlin STP	9	.42	11	.42	12	.38	1	.38	0	-
RM 8.4 Roseburg Lumber-Sutherlin	11	0	9	0	2	0	0	-	0	-
SOUTH UMPQUA RIVER										
RM 187.2 Tiller Ranger Station	12	.0041	11	.0040	6	.0040	12	.0048	12	.0058
RM 184 Coffee Creek										
RM 3-4 William Smith Placer Mine	0	-	0	-	0	-	0	-	0	-
RM 181.2 Milo Academy	0	-	0	-	0	-	0	-	0	-
RM 170.0 Days Creek										
RM 12-13 Saulsberry Placer Mine	0	-	0	-	0	-	0	-	0	-
RM 163.1 Canyonville STP	0	-	0	-	0	-	8	.13	12	.14
RM 158.9 Cow Creek										
RM 46 Dept. of Transportation	0	-	0	-	0	-	0	-	0	-
RM 41.8 Superior Lumber	9	0	7	.072	0	-	3	0	7	.054
RM 41.8 Superior Lumber	9	0	7	0	0	-	3	0	8	0
RM 41 Glendale STP	0	-	7	.10	10	.14	12	.15	12	.099
RM 40 Gregory Timber Resources	12	0	11	.32	10	0	11	.49	0	-
RM 7.3 Crawford Creek										
RM 0.5 Hanna Nickel	0	-	9	.05	11	.77	11	.46	12	.37
RM 0.5 Hanna Nickel	0	-	8	.008	11	.0086	11	.0089	12	.0084
RM 4.4 Roseburg Lumber-Riddle	9	0	7	.10	5	.13	8	.13	10	.18
RM 4.4 Roseburg Lumber-Riddle	9	0	7	.14	5	.14	8	.16	10	.16
RM 2.0 Riddle WTP	7	.020	9	.018	3	.016	0	-	0	-
RM 2.0 Riddle STP	0	-	0	-	10	.20	12	.22	12	.20
RM 156.0 Judd Creek										
RM 0.3 Herbert Lumber	4	0	0	-	1	0	3	0	6	0
RM 150.7 Myrtle Creek										
RM 0.1 Myrtle Creek WTP	9	.0036	8	.0020	0	-	0	-	0	-
RM 0.1 Myrtle Creek STP	0	-	2	.58	11	.62	12	.93	12	.75
RM 143.4 Louisiana Pacific-Round Prairie	0	-	0	-	0	-	0	-	0	-
RM 139.6 Roseburg Lumber-Dillard	9	0	9	0	12	0	10	0	9	0
RM 139.5 Roseburg Lumber-Dillard	9	.03	9	.028	12	.016	9	.020	9	.022
RM 139.3 Roseburg Lumber-Dillard	9	.21	8	.080	12	.13	10	.13	9	.062
RM 137.2 Douglas High School	0	-	4	.027	0	-	0	-	1	-

Table 9.--Effluent discharges from selected point sources in the Umpqua River basin--continued

Source	Median of the monthly mean effluent discharges, in million gallons per day									
	1977 WY		1978 WY		1979 WY		1980 WY		1981 WY	
	N	Median	N	Median	N	Median	N	Median	N	Median
SOUTH UMPQUA RIVER										
RM 137.0 Lookingglass Creek										
RM 7.0 Olalla Creek										
RM 12.3 Coarse Gold Creek										
RM 0-2 Barnes Placer Mine	0	-	0	-	0	-	0	-	0	-
RM 2.2 Dept. of Fish & Wildlife	0	-	0	-	0	-	0	-	0	-
RM 0.5 Bremner Hills Trailer Park	0	-	4	0.0050	0	-	0	-	0	-
RM 136.6 Winston-Dillard WTP	11	0.012	12	.012	12	0.012	12	0.012	5	0.012
RM 136.6 Winston STP	12	.42	12	.43	12	.43	10	.44	0	-
RM 133.4 Roberts Creek WTP	12	.31	11	.31	12	.31	12	.31	7	.31
RM 131.7 Winston-Green STP	0	-	0	-	0	-	0	-	2	.66
RM 127.8 Green STP	0	-	10	.47	9	.20	8	.16	0	-
RM 127.8 Unnamed tributary										
RM 0.5 Roseburg Lumber-Green	9	0	8	.095	12	.52	10	.068	9	.059
RM 126.9 Sun Studs	7	0	12	.017	1	-	0	-	6	0
RM 123 Deer Creek										
RM 6 North Fork Deer Creek										
RM 1.1 Roseburg Lumber-Dixonville	9	0	6	.14	11	0	10	.026	6	.089
RM 3.8 Nordic Veneers	0	-	0	-	0	-	0	-	2	0
RM 1.1 Champion Building Products										
Rifle Range	0	-	7	.061	6	.15	7	.007	12	.046
RM 122.2 Unnamed tributary										
RM 0.5 Champion Building Products-										
Roseburg	0	-	3	.127	7	.076	0	-	0	-
RM 121.5 North Roseburg STP	4	1.3	12	1.3	12	1.3	12	1.3	12	1.2
RM 119.7 Roseburg STP	9	1.9	12	2.1	12	2.3	12	2.7	12	2.9
NORTH UMPQUA RIVER										
RM 88.6 (PP&L) Pacific Power and Light										
Lemolo #1	1	<.05	1	<.05	1	<.05	1	<.05	0	-
RM 77.3 PP&L Lemolo #2	1	<.05	1	<.05	1	<.05	1	<.05	0	-
RM 76.1 PP&L Clearwater #2	1	<.05	1	<.05	1	<.05	1	<.05	0	-
RM 75.4 Clearwater River										
RM 4.9 PP&L Clearwater #1	1	<.05	1	<.05	1	<.05	1	<.05	0	-
RM 73.3 PP&L Toketee	1	<.05	1	<.05	1	<.05	1	<.05	0	-
RM 73.1 PP&L Fish Creek	1	<.07	1	<.07	1	<.07	1	<.07	0	-
RM 71.2 PP&L Slide Creek	0	-	0	-	0	-	0	-	0	-
RM 69.3 PP&L Soda Springs	1	<.05	1	<.05	1	<.05	1	<.05	0	-
RM 53.0 Steamboat Creek										
RM 17.9 City Creek										
RM 3.4 Renfro Placer Mine	0	-	0	-	0	-	0	-	0	-
RM 52.9 Steamboat Ranger Station	12	.0044	10	.0046	6	.044	12	.0063	12	.0062

Table 9.--Effluent discharges from selected point sources in the Umpqua River basin--continued

Source	Median of the monthly mean effluent discharges, in million gallons per day									
	1977 WY		1978 WY		1979 WY		1980 WY		1981 WY	
	N	Median	N	Median	N	Median	N	Median	N	Median
NORTH UMPQUA RIVER										
RM 35.7 Rock Creek										
RM 35.6 Dept. of Fish & Wildlife-										
Domestic	0	-	0	-	0	-	1	-	8	0.00065
RM 0.5 Dept. of Fish & Wildlife-										
Wildlife	9	0	12	0	9	0	12	8.2	4	9.4
RM 29.1 Little River										
RM 12.75 Wolf Creek Job Corp.	12	0.022	10	0.033	6	0.033	12	0.026	12	.024
RM 1.8 Champion Building Products-										
Glide	8	.009	5	.009	0	-	0	-	0	-
RM 29 Glide STP	0	-	0	-	0	-	7	.059	12	.083
RM 7.0 Winchester WTP	8	.012	12	.030	12	.045	9	.090	6	.068
RM 6-7 Winchester Plywood	0	-	0	-	0	-	0	-	0	-
RM 6.5 David Creek										
RM 2 Keller Lumber	0	-	0	-	0	-	0	-	0	-
RM 6.4 Douglas County Lumber	0	-	11	0	11	0	8	0	12	0
RM 4.9 Sutherlin Creek										
RM 9 Mount Mazama Plywood	2	.0018	0	-	0	-	0	-	0	-
RM 6.6 Georgia Pacific Corp.	8	0	1	0	4	0	0	-	2	0
RM 6.9 Cooper Creek										
RM 2.1 Sutherlin WTP	9	.022	11	.022	12	.022	12	.022	11	.022

Table 10.--Effluent loadings of biochemical-oxygen demand (5 day)
from selected point sources in the Umpqua River basin

[N = number of monthly reportings of data; " - " = not applicable; WY = water year]

Source	Median of the monthly mean BOD loadings, in pounds per day									
	1977 WY		1978 WY		1979 WY		1980 WY		1981 WY	
	N	Median	N	Median	N	Median	N	Median	N	Median
MAIN STEM UMPQUA RIVER										
RM 102.7 Calapooya Creek										
RM 25.7 Sutherlin Nonpareil WTP	0	-	0	-	0	-	0	-	0	-
RM 19.2 Hakason Sand & Gravel	0	-	0	-	0	-	0	-	0	-
RM 14.5 Oakland WTP	0	-	0	-	0	-	0	-	0	-
RM 13.3 Oakland STP	9	11	12	18	12	14	12	16	10	9.4
RM 10 Sutherlin STP	0	-	0	-	0	-	4	46	5	21
RM 9.0 Cook Creek										
RM 2.0 Sutherlin STP	9	100	11	40	12	120	1	240	-	-
RM 8.4 Roseburg Lumber-Sutherlin	5	0	2	22	0	-	0	-	0	-
SOUTH UMPQUA RIVER										
RM 187.2 Tiller Ranger Station	12	0.06	11	0.04	6	<0.048	12	0.04	12	0.06
RM 184 Coffee Creek										
RM 3-4 William Smith Placer Mine	0	-	0	-	0	-	0	-	0	-
RM 181.2 Milo Academy	0	-	0	-	0	-	0	-	0	-
RM 170.0 Days Creek										
RM 12-13 Saulsberry Placer Mine	0	-	0	-	0	-	0	-	0	-
RM 163.1 Canyonville STP	0	-	0	-	0	-	2	77	10	4.3
RM 158.9 Cow Creek										
RM 46 Dept. of Transportation	0	-	0	-	0	-	0	-	0	-
RM 41.8 Superior Lumber	0	-	0	-	0	-	0	-	0	-
RM 41.8 Superior Lumber	0	-	0	-	0	-	0	-	0	-
RM 41 Glendale STP	0	-	0	-	5	21	12	18	12	16
RM 40 Gregory Timber Resources	0	-	5	170	3	96	6	140	0	-
RM 7.3 Crawford Creek										
RM 0.5 Hanna Nickel	0	-	4	0	4	0	3	0	5	0
RM 0.5 Hanna Nickel	0	-	2	.46	4	.41	4	.43	11	.13
RM 4.4 Roseburg Lumber-Riddle	0	-	0	-	0	-	4	62	1	-
RM 4.4 Roseburg Lumber-Riddle	0	-	0	-	0	-	0	-	0	-
RM 2.0 Riddle WTP	0	-	0	-	0	-	0	-	0	-
RM 2.0 Riddle STP	0	-	0	-	10	13	12	12	12	16
RM 115.6 Judd Creek										
RM 0.3 Herbert Lumber	0	-	0	-	0	-	0	-	0	-
RM 150.7 Myrtle Creek										
RM 0.1 Myrtle Creek WTP	0	-	0	-	0	-	0	-	0	-
RM 0.1 Myrtle Creek STP	0	-	2	34	11	47	12	60	12	35
RM 143.4 Louisiana Pacific-Round Pr	0	-	0	-	0	-	0	-	0	-
RM 139.6 Roseburg Lumber-Dillard	0	-	0	-	0	-	0	-	0	-
RM 139.5 Roseburg Lumber-Dillard	0	-	0	-	0	-	0	-	0	-
RM 139.3 Roseburg Lumber-Dillard	5	67	3	24	3	18	3	34	2	49
RM 137.2 Douglas High School	0	-	0	-	0	-	0	-	0	-

Table 10.--Effluent loadings of biochemical-oxygen demand (5 day)
from selected point sources in the Umpqua River basin--continued

Source	Median of the monthly mean BOD loadings, in pounds per day									
	1977 WY		1978 WY		1979 WY		1980 WY		1981 WY	
	N	Median	N	Median	N	Median	N	Median	N	Median
SOUTH UMPQUA RIVER										
RM 137.0 Lookingglass Creek										
RM 7.0 Olalla Creek										
RM 12.3 Coarse Gold Creek										
RM 0-2 Barnes Placer Mine	0	-	0	-	0	-	0	-	0	-
RM 2.2 Dept. of Fish & Wildlife	0	-	0	-	0	-	0	-	0	-
RM 0.5 Bremner Hills Trailer Park	0	-	0	-	0	-	0	-	0	-
RM 136.6 Winston-Dillard WTP	0	-	0	-	0	-	0	-	0	-
RM 136.6 Winston STP	4	93	4	82	4	140	4	36	0	-
RM 133.4 Roberts Creek WTP	0	-	0	-	0	-	0	-	0	-
RM 131.7 Winston-Green STP	0	-	0	-	0	-	0	-	2	49
RM 127.8 Green STP	0	-	1	<130	2	18	1	<2.7	0	-
RM 127.8 Unnamed tributary										
RM 0.5 Roseburg Lumber-Green	3	42	4	18	5	14	6	12	6	8.6
RM 126.9 Sun Studs	2	110	5	59	0	-	0	-	6	0
RM 123 Deer Creek										
RM 6 North Fork Deer Creek										
RM 1.1 Roseburg Lumber-Dixonville	9	0	5	2	9	0	7	0	6	0
RM 3.8 Nordic Veneers	0	-	0	-	0	-	0	-	0	-
RM 1.1 Champion Building Products										
Rifle Range	0	-	6	50	6	84	7	0	12	9.3
RM 122.2 Unnamed tributary										
RM 0.5 Champion Building Products										
Roseburg	0	-	3	28	7	4	0	-	0	-
RM 121.5 North Roseburg STP	4	220	12	200	12	200	12	250	12	270
RM 119.7 Roseburg STP	9	220	12	210	12	350	12	420	12	610
NORTH UMPQUA RIVER										
RM 88.6 Pacific Power and Light										
(P&L) Lemolo #1	0	-	0	-	0	-	0	-	0	-
RM 77.3 PP&L Lemolo #2	0	-	0	-	0	-	0	-	0	-
RM 76.1 PP&L Clearwater #2	0	-	0	-	0	-	0	-	0	-
RM 75.4 Clearwater River										
RM 4.9 PP&L Clearwater #1	0	-	0	-	0	-	0	-	0	-
RM 73.3 PP&L Toketee	0	-	0	-	0	-	0	-	0	-
RM 73.1 PP&L Fish Creek	0	-	0	-	0	-	0	-	0	-
RM 71.2 PP&L Slide Creek	0	-	0	-	0	-	0	-	0	-
RM 69.3 PP&L Soda Springs	0	-	0	-	0	-	0	-	0	-
RM 53.0 Steamboat Creek	0	-	0	-	0	-	0	-	0	-
RM 17.9 City Creek										
RM 3.4 Renfro Placer Mine	0	-	0	-	0	-	0	-	0	-

Table 10.--Effluent loadings of biochemical-oxygen demand (5 day)
from selected point sources in the Umpqua River basin--continued

Source	Median of the monthly mean BOD loadings, in pounds per day									
	1977 WY		1978 WY		1979 WY		1980 WY		1981 WY	
	N	Median	N	Median	N	Median	N	Median	N	Median
NORTH UMPQUA RIVER										
RM 52.9 Steamboat Ranger Station	12	.04	10	.04	6	.04	12	.06	12	.05
RM 35.7 Rock Creek										
RM 35.6 Dept. of Fish & Wildlife-Domestic	0	-	0	-	0	-	1	.12	8	.03
RM 0.5 Dept. of Fish & Wildlife-Wildlife	0	-	0	-	0	-	0	-	0	-
RM 29.1 Little River										
RM 12.75 Wolf Creek Job Corp.	7	5.9	9	.75	6	.80	12	.60	12	.50
RM 1.8 Champion Building Products-Glide	6	.07	5	.07	0	-	0	-	0	-
RM 29 Glide STP	0	-	0	-	0	-	6	12	12	11
RM 7.0 Winchester WTP	0	-	0	-	0	-	0	-	0	-
RM 6-7 Winchester Plywood	0	-	0	-	0	-	0	-	0	-
RM 6.5 David Creek										
RM 2 Keller Lumber	0	-	0	-	0	-	0	-	0	-
RM 6.4 Douglas County Lumber	0	-	10	0	12	0	8	0	12	0
RM 4.9 Sutherlin Creek										
RM 9 Mount Mazama Plywood	0	-	0	-	0	-	0	-	0	-
RM 6.6 Georgia Pacific Corp.	0	-	0	-	0	-	0	-	0	-
RM 6.9 Cooper Creek	0	-	0	-	0	-	0	-	0	-
RM 2.1 Sutherlin WTP	0	-	0	-	0	-	0	-	0	-

Table 11.--Effluent loadings of fecal coliform bacteria from selected point sources
in the Umpqua River basin

[N = number of observations; " - " = not applicable; WY = water year]

Sources	Median of the monthly mean effluent fecal coliform load, in million colonies per day									
	1977 WY		1978 WY		1979 WY		1980 WY		1981 WY	
	N	Median	N	Median	N	Median	N	Median	N	Median
MAIN STEM UMPQUA RIVER										
RM 102.7 Calapooya Creek										
RM 25.7 Sutherlin Nonpareil WTP	0	-	0	-	0	-	0	-	0	-
RM 19.2 Hakason Sand & Gravel	0	-	0	-	0	-	0	-	0	-
RM 14.5 Oakland WTP	0	-	0	-	0	-	0	-	0	-
RM 13.3 Oakland STP	9	6.8	12	7.4	12	<8.0	12	<8.0	10	< 8.2
RM 10 Sutherlin STP	0	-	0	-	0	-	3	330	5	540
RM 9.0 Cook Creek										
RM 2.0 Sutherlin STP	5	<63	7	<63	10	<73	1	630	0	-
RM 8.4 Roseburg Lumber-Sutherlin	0	-	0	-	0	-	0	-	0	-
SOUTH UMPQUA RIVER										
RM 187.2 Tiller Ranger Station	11	<.16	11	<.15	6	<.15	12	<.19	12	<.22
RM 184 Coffee Creek										
RM 3-4 William Smith Placer Mine	0	-	0	-	0	-	0	-	0	-
RM 181.2 Milo Academy	0	-	0	-	0	-	0	-	0	-
RM 170.0 Days Creek										
RM 12-13 Saulsberry Placer Mine	0	-	0	-	0	-	0	-	0	-
RM 163.1 Canyonville STP	0	-	0	-	0	-	3	65	11	260
RM 158.9 Cow Creek										
RM 46 Dept. of Transportation	0	-	0	-	0	-	0	-	0	-
RM 41.8 Superior Lumber	0	-	0	-	0	-	0	-	0	-
RM 41.8 Superior Lumber	0	-	0	-	0	-	0	-	0	-
RM 41 Glendale STP	0	-	0	-	6	<64	12	<57	12	<38
RM 40 Gregory Timber Resources	0	-	0	-	0	-	0	-	0	-
RM 7.3 Crawford Creek										
RM 0.5 Hanna Nickel	0	-	0	-	0	-	0	-	0	-
RM 0.5 Hanna Nickel	0	-	1	0	3	<1.1	4	<1.1	11	<.80
RM 4.4 Roseburg Lumber-Riddle	0	-	0	-	0	-	0	-	0	-
RM 4.4 Roseburg Lumber-Riddle	0	-	0	-	0	-	0	-	0	-
RM 2.0 Riddle WTP	0	-	0	-	0	-	0	-	0	-
RM 2.0 Riddle STP	0	-	0	-	5	110	12	160	12	330
RM 156.0 Judd Creek										
RM 0.3 Herbert Lumber	0	-	0	-	0	-	0	-	0	-
RM 150.7 Myrtle Creek										
RM 0.1 Myrtle Creek WTP	0	-	0	-	0	-	0	-	0	-
RM 0.1 Myrtle Creek STP	0	-	2	88	11	290	12	<230	12	103
RM 143.4 Louisiana Pacific-Round Prairie	0	-	0	-	0	-	0	-	0	-
RM 139.6 Roseburg Lumber-Dillard	0	-	0	-	0	-	0	-	0	-
RM 139.5 Roseburg Lumber-Dillard	0	-	0	-	0	-	0	-	0	-
RM 139.3 Roseburg Lumber-Dillard	0	-	0	-	0	-	0	-	0	-
RM 137.2 Douglas High School	0	-	0	-	0	-	0	-	0	-

Table 11.--Effluent loadings of fecal coliform bacteria from selected point sources
in the Umpqua River basin--continued

Sources	Median of the monthly mean effluent fecal coliform load, in million colonies per day									
	1977 WY		1978 WY		1979 WY		1980 WY		1981 WY	
	N	Median	N	Median	N	Median	N	Median	N	Median
SOUTH UMPQUA RIVER										
RM 137.0 Lookingglass Creek										
RM 7.0 Olalla Creek										
RM 12.3 Coarse Gold Creek										
RM 0-2 Barnes Placer Mine	0	-	0	-	0	-	0	-	0	-
RM 2.2 Dept. of Fish & Wildlife	0	-	0	-	0	-	0	-	0	-
RM 0.5 Bremner Hills Trailer Park	0	-	0	-	0	-	0	-	0	-
RM 136.6 Winston-Dillard WTP	0	-	0	-	0	-	0	-	0	-
RM 36.6 Winston STP	12	48	11	50	12	49	10	<50	0	-
RM 133.4 Roberts Creek WTP	0	-	0	-	0	-	0	-	0	-
RM 131.7 Winston-Green STP	0	-	0	-	0	-	0	-	2	<150
RM 127.8 Green STP	0	-	0	-	0	-	0	-	0	-
RM 127.8 Unnamed tributary										
RM 0.5 Roseburg Lumber-Green	0	-	0	-	0	-	0	-	0	-
RM 126.9 Sun Studs	0	-	0	-	0	-	0	-	0	-
RM 123 Deer Creek										
RM 6 North Fork Deer Creek										
RM 1.1 Roseburg Lumber-Dixonville	0	-	0	-	0	-	0	-	0	-
RM 3.8 Nordic Veneers	0	-	0	-	0	-	0	-	0	-
RM 1.1 Champion Building Products										
Rifle Range	0	-	0	-	0	-	0	-	0	-
RM 122.2 Unnamed tributary										
RM 0.5 Champion Building										
Products-Roseburg	0	-	0	-	0	-	0	-	0	-
RM 121.5 North Roseburg STP	4	540	12	<360	12	470	10	24	12	700
RM 119.7 Roseburg STP	9	<790	11	<950	11	1400	12	2400	10	4200
NORTH UMPQUA RIVER										
RM 88.6 Pacific Power and Light										
(PP&L) Lemolo #1	0	-	0	-	0	-	0	-	0	-
RM 77.3 PP&L Lemolo #2	0	-	0	-	0	-	0	-	0	-
RM 76.1 PP&L Clearwater #2	0	-	0	-	0	-	0	-	0	-
RM 75.4 Clearwater River										
RM 4.9 PP&L Clearwater #1	0	-	0	-	0	-	0	-	0	-
RM 73.3 PP&L Toketee	0	-	0	-	0	-	0	-	0	-
RM 73.1 PP&L Fish Creek	0	-	0	-	0	-	0	-	0	-
RM 71.2 PP&L Slide Creek	0	-	0	-	0	-	0	-	0	-
RM 69.3 PP&L Soda Springs	0	-	0	-	0	-	0	-	0	-
RM 53.0 Steamboat Creek										
RM 17.9 City Creek										
RM 3.4 Renfro Placer Mine	0	-	0	-	0	-	0	-	0	-

Table 11.--Effluent loadings of fecal coliform bacteria from selected point sources
in the Umpqua River basin--continued

Sources	Median of the monthly mean effluent fecal coliform load, in million colonies per day									
	1977 WY		1978 WY		1979 WY		1980 WY		1981 WY	
	N	Median	N	Median	N	Median	N	Median	N	Median
NORTH UMPQUA RIVER										
RM 52.9 Steamboat Ranger Station	12	<0.17	10	<0.18	6	<0.16	12	<0.24	12	<0.24
RM 35.7 Rock Creek										
RM 35.6 Dept. of Fish & Wildlife-Domestic	0	-	0	-	0	-	1	0	8	3.3
RM 0.5 Dept. of Fish & Wildlife-Wildlife	0	-	0	-	0	-	0	-	0	-
RM 29.1 Little River										
RM 12.75 Wolf Creek Job Corp.	7	<.87	9	<1.3	6	<1.3	12	6.0	12	<.91
RM 1.8 Champion Building Products-Glide	0	-	0	-	0	-	0	-	0	-
RM 29 Glide STP	0	-	0	-	0	-	6	<36	10	< 6.2
RM 7.0 Winchester WTP	0	-	0	-	0	-	0	-	0	-
RM 6-7 Winchester Plywood	0	-	0	-	0	-	0	-	0	-
RM 6.5 David Creek										
RM 2 Keller Lumber	0	-	0	-	0	-	0	-	0	-
RM 6.4 Douglas County Lumber	0	-	0	-	0	-	0	-	0	-
RM 4.9 Sutherlin Creek										
RM 9 Mount Mazama Plywood	0	-	0	-	0	-	0	-	0	-
RM 6.6 Georgia Pacific Corp.	0	-	0	-	0	-	0	-	0	-
RM 6.9 Cooper Creek										
RM 2.1 Sutherlin WTP	0	-	0	-	0	-	0	-	0	-

Table 12.—Distribution of selected constituents at sampling stations in the Umpqua River basin

[Data collected in 1977, 1980, 1981, 1982, and 1983 WY]

Station name	Number of samples	Minimum	Percentiles					Maximum
			10	25	50 (median)	75	90	
Discharge, in cubic feet per second								
Umpqua RM 48.6	32	796	1,098	1,260	2,110	6,230	16,600	33,600
Umpqua RM 56.9	49	804	910	1,315	2,500	5,670	11,200	34,200
Umpqua RM 71.0	12	796	881	1,145	1,315	3,705	5,696	6,230
Umpqua RM 102.7	64	682	1,026	1,239	3,360	7,730	13,085	28,800
North Umpqua R. at Brown's Bridge	63	662	863	1,070	2,190	4,440	6,767	13,530
South Umpqua RM 117.7 (USGS)	64	35	122	145	608	2,470	7,355	24,300
South Umpqua RM 117.7 (DEQ)	66	20	65	153	828	2,952	5,957	16,000
South Umpqua RM 132.5	55	52	104	153	1,040	3,210	6,766	15,948
Cow Creek below Riddle, OR	69	8	27	56	317	1,040	1,850	7,140
South Umpqua RM 162.5	14	37	48	85	127	314	1,492	2,260
South Umpqua RM 165.5	56	42	77	115	700	1,472	2,495	4,260
South Umpqua RM 170.2	21	40	43	76	235	1,034	2,100	2,330
River temperature, in degrees Celsius								
Umpqua RM 48.6	32	4.5	5.9	8.5	12.8	19.2	23.7	26.0
Umpqua RM 56.9	47	2.0	5.8	7.9	12.8	19.5	22.8	25.8
Umpqua RM 71.0	12	5.0	5.3	7.8	12.2	18.9	24.5	26.0
Umpqua RM 102.7	63	4.0	6.0	8.5	12.0	18.5	21.3	24.5
Calapooya Creek	24	7.0	7.4	8.0	15.0	20.0	23.8	26.0
North Umpqua River at Brown's Bridge	63	4.0	5.4	7.5	11.2	18.0	20.4	24.0
South Umpqua RM 117.7 (USGS)	63	4.0	6.2	8.0	13.5	20.2	23.0	26.0
South Umpqua RM 117.7 (DEQ)	65	5.0	6.0	8.8	14.0	19.0	24.0	27.7
South Umpqua RM 132.5	54	5.0	6.2	8.0	12.8	18.0	22.2	26.4
Cow Creek below Riddle, OR	68	4.0	6.0	7.8	12.8	17.6	23.0	27.0
South Umpqua RM 162.5	14	3.0	3.0	8.6	13.5	21.8	23.2	24.0
South Umpqua RM 165.5	56	4.3	5.4	7.0	11.1	17.7	21.6	28.0
South Umpqua RM 170.2	20	2.0	4.2	8.1	12.2	19.1	21.0	24.5
Specific conductance, in microsiemens per centimeter								
Umpqua RM 48.6	32	58	61	69	74	87	101	106
Umpqua RM 56.9	47	63	70	76	82	88	100	113
Umpqua RM 71.0	12	59	62	73	84	98	100	100
Umpqua RM 102.7	64	53	64	70	78	84	97	130
Calapooya Creek	24	64	68	82	96	112	121	135
North Umpqua River at Brown's Bridge	63	45	50	55	62	70	74	90
South Umpqua RM 117.7 (USGS)	63	66	80	100	125	165	188	230
South Umpqua RM 117.7 (DEQ)	65	55	82	95	115	178	209	214
South Umpqua RM 132.5	55	59	78	87	109	151	174	208
Cow Creek below Riddle, OR	68	57	73	82	114	158	181	211
South Umpqua RM 162.5	14	69	71	94	133	154	165	165
South Umpqua RM 165.5	56	56	61	70	82	119	146	160
South Umpqua RM 170.2	19	60	68	72	92	148	159	160
Dissolved solids, in milligrams per liter								
Umpqua RM 48.6	32	53	55	58	66	73	85	99
Umpqua RM 56.9	45	43	51	54	59	64	73	92
Umpqua RM 71.0	12	50	52	58	68	73	78	79
Umpqua RM 102.7	64	52	56	60	65	70	84	99
Calapooya Creek	24	54	60	70	76	83	87	95
North Umpqua River at Brown's Bridge	63	40	47	53	55	62	68	85
South Umpqua RM 117.7 (USGS)	55	49	57	69	81	93	121	135
South Umpqua RM 117.7 (DEQ)	65	54	71	77	88	116	125	138
South Umpqua RM 132.5	55	57	64	71	92	101	118	128
Cow Creek below Riddle, OR	67	55	58	68	78	99	113	129
South Umpqua RM 162.5	14	57	62	72	95	103	106	107
South Umpqua RM 165.5	55	47	54	62	70	88	98	103

Table 12.--Distribution of selected constituents at sampling stations in the
Umpqua River basin--Continued

Station name	Number of samples	Minimum	Percentiles					Maximum
			10	25	50 (median)	75	90	
Total phosphorus as P, in milligrams per liter								
Umpqua RM 48.6	27	0.026	0.034	0.041	0.072	0.098	0.133	0.227
Umpqua RM 56.9	47	<.001	.02	.03	.04	.06	.08	2.1
Umpqua RM 71.0	9	.044	.044	.069	.078	.127	.217	.217
Umpqua RM 102.7	61	.028	.037	.045	.065	.097	.129	.227
Calapooya Creek	24	.020	.028	.045	.072	.104	.201	.291
North Umpqua River at Brown's Bridge	60	.019	.029	.034	.050	.068	.104	.261
South Umpqua RM 117.7 (USGS)	63	.01	.04	.06	.11	.29	.42	2.6
South Umpqua RM 117.7 (DEQ)	62	.04	.046	.06	.12	.28	.57	1.1
South Umpqua RM 132.5	55	.018	.027	.033	.042	.079	.118	.272
Cow Creek below Riddle, OR	65	.007	.0198	.026	.041	.058	.119	.288
South Umpqua RM 162.5	11	.023	.024	.031	.055	.125	.201	.219
South Umpqua RM 165.5	55	.005	.016	.026	.037	.063	.081	.23
South Umpqua RM 170.2	19	.005	.01	.02	.03	.03	.04	.07
Suspended sediment, in milligrams per liter								
Umpqua RM 48.6	32	< 1	< 1	1	3	6	30	58
Umpqua RM 56.9	40	1	2	3	4	6	16	154
Umpqua RM 71.0	12	2	2	4	5	7	8	8
Umpqua RM 102.7	64	< 1	< 1	2	3	8	22	66
Calapooya Creek	24	< 1	1	2	4	33	81	122
North Umpqua River at Brown's Bridge	63	< 1	< 1	1	2	4	15	31
South Umpqua RM 117.7 (DEQ)	65	< 1	< 1	1	4	8	22	148
South Umpqua RM 132.5	55	< 1	< 1	1	2	7	23	98
Cow Creek below Riddle, OR	68	< 1	< 1	1	2	4	13	86
South Umpqua RM 162.5	14	1	1	2	3	4	19	34
South Umpqua RM 165.5	55	< 1	< 1	1	1	2	8	20
Total organic plus ammonia nitrogen as N, in milligrams per liter								
Umpqua RM 48.6	22	0.1	0.1	0.1	0.2	0.3	0.7	2.0
Umpqua RM 56.9	45	.1	.1	.26	.37	.64	1.0	4.6
Umpqua RM 71.0	9	.1	.1	.1	.2	.45	2.0	2.0
Umpqua RM 102.7	53	.1	.1	.1	.1	.2	0.42	1.9
Calapooya Creek	19	.1	.1	.2	.2	.4	0.5	0.5
North Umpqua River at Brown's Bridge	53	.1	.1	.1	.1	.2	.3	2.1
South Umpqua RM 117.7 (USGS)	61	.05	.29	.38	.56	.93	1.18	2.9
South Umpqua RM 117.7 (DEQ)	55	.1	.1	.2	.3	.7	1.0	2.1
South Umpqua RM 132.5	45	.1	.1	.1	.2	.3	.6	1.5
Cow Creek below Riddle, OR	58	.1	.1	.1	.1	.2	.4	3.0
South Umpqua RM 162.5	11	.1	.1	.1	.2	.4	1.6	1.8
South Umpqua RM 165.5	48	.1	.1	.1	.1	.2	.2	0.3
Total nitrite plus nitrate as N, in milligrams per liter								
Umpqua RM 48.6	32	0.01	0.01	0.01	0.02	0.06	0.10	0.24
Umpqua RM 56.9	41	< .01	< .01	.01	.04	.10	.16	.54
Umpqua RM 71.0	12	.01	.01	.01	.02	.045	.057	.06
Umpqua RM 102.7	64	.01	.01	.02	.04	.07	.135	.55
Calapooya Creek	24	.01	.01	.012	.02	.12	.42	.67
North Umpqua River at Brown's Bridge	63	.01	.01	.01	.01	.02	.06	.14
South Umpqua RM 117.7 (USGS)	63	< .01	.04	.05	.11	.20	.33	1.3
South Umpqua RM 117.8 (DEQ)	65	.01	.03	.06	.14	.24	.62	.88
South Umpqua RM 132.5	55	.01	.01	.02	.03	.10	.18	1.62
Cow Creek below Riddle, OR	68	.01	.01	.02	.03	.06	.10	.90
South Umpqua RM 162.5	14	.01	.01	.01	.02	.03	.07	.10
South Umpqua RM 165.5	55	.01	.01	.02	.04	.06	.08	.15

Table 12.--Distribution of selected constituents at sampling stations in the
Umpqua River basin--Continued

Station name	Number of samples	Minimum	Percentiles					Maximum
			10	25	50 (median)	75	90	
Fecal coliform bacteria, in colonies per 100 milliliters								
Umpqua RM 48.6	32	15	15	17	22	83	720	2,400
Umpqua RM 56.9	46	< 1	1	3	11	44	137	600
Umpqua RM 71.0	12	22	22	22	22	56	224	230
Umpqua RM 102.7	62	15	15	15	53	430	930	2,400
Calapooya Creek	24	15	15	50	120	430	3,500	4,600
North Umpqua River at Brown's Bridge	63	15	15	15	36	91	430	2,400
South Umpqua RM 117.7	54	1	18	50	175	505	610	2,000
South Umpqua RM 117.7	64	15	18	91	525	2,400	4,600	11,000
South Umpqua RM 132.5	55	15	15	36	91	230	630	11,000
Cow Creek below Riddle, OR	68	15	15	15	36	91	230	1,500
South Umpqua RM 162.5	14	22	22	22	22	60	180	230
South Umpqua RM 165.5	55	15	15	15	36	91	310	2,400
Fecal streptococci bacteria, in colonies per 100 milliliters								
Umpqua RM 56.9	45	< 1	2	10	26	98	350	2,200
South Umpqua RM 117.7	54	11	20	70	189	1,000	1,900	4,500

Table 13.--Annual loads and yields of selected constituents for 1977 WY at
sampling stations in the Umpqua River basin

Station name	Total volume of water, in acre-feet	Annual load, in tons per year	Annual yield, in tons per year per square mile	Annual flow-weighted concentration in mg/l	Drainage area, in square miles
<p>Specific conductance [assumes 0.8, 0.9, and 0.7 uS per cm equal, respectively, 1 mg/L of dissolved solids for river water in the main stem, the North, and South Umpqua Rivers]</p>					
Umpqua RM 48.6	1,680,000	149,000	40	65	3,683
Umpqua RM 56.9	1,680,000	146,000	40	64	3,683
Umpqua RM 102.7	1,593,600	137,000	43	63	3,200
North Umpqua River at Brown's Bridge	1,187,000	92,700	69	58	1,344
South Umpqua RM 117.7 (USGS)	406,600	46,600	26	84	1,798
South Umpqua RM 117.7 (DEQ)	406,600	46,300	26	84	1,798
South Umpqua RM 132.5	406,600	43,500	26	78	1,670
Cow Creek below Riddle, OR	106,600	11,500	25	79	456
Composite of South Umpqua RM's 162.5, 165.5, and 170.2	229,800	19,700	31	63	641
<p>Dissolved solids</p>					
Umpqua RM 48.6	1,680,000	154,000	42	67	3,683
Umpqua RM 56.9	1,680,000	133,000	36	58	3,683
Umpqua RM 102.7	1,593,600	140,000	44	65	3,200
North Umpqua River at Brown's Bridge	1,187,000	92,500	69	57	1,344
South Umpqua RM 117.7 (USGS)	406,600	43,900	24	79	1,798
South Umpqua RM 117.7 (DEQ)	406,600	50,200	28	91	1,798
South Umpqua RM 132.5	406,600	47,200	28	85	1,670
Cow Creek below Riddle, OR	106,600	11,700	26	81	456
Composite of South Umpqua RM's 162.5, 165.5, and 170.2	229,800	22,300	35	72	641

Table 13.--Annual loads and yields of selected constituents for 1977 WY at sampling stations in the Umpqua River basin--continued

Station name	Total volume of water, in acre-feet	Annual load, in tons per year	Annual yield, in tons per year per square mile	Annual flow-weighted concentration in mg/l	Drainage area, in square miles
Total organic plus ammonia nitrogen as N					
Umpqua RM 48.6	1,680,000	680	0.19	0.30	3,683
Umpqua RM 56.9	1,680,000	750	.20	.33	3,683
Umpqua RM 102.7	1,593,600	380	.12	.17	3,200
North Umpqua River at Brown's Bridge	1,187,000	270	.22	.17	1,344
South Umpqua RM 117.7 (USGS)	406,600	220	.13	.41	1,798
South Umpqua RM 117.7 (DEQ)	406,600	150	.08	.27	1,798
South Umpqua RM 132.5	406,600	130	.08	.24	1,670
Cow Creek below Riddle, OR	106,600	25	.05	.17	456
Composite of South Umpqua RM's 162.5, 165.5, and 170.2	229,800	45	.07	.14	641
Total nitrite plus nitrate as N					
Umpqua RM 48.6	1,680,000	84	0.023	0.04	3,683
Umpqua RM 56.9	1,680,000	120	.033	.05	3,683
Umpqua RM 102.7	1,593,600	100	.031	.05	3,200
North Umpqua River at Brown's Bridge	1,187,000	26	.019	.02	1,344
South Umpqua RM 117.7 (USGS)	406,600	59	.033	.11	1,798
South Umpqua RM 117.7 (DEQ)	406,600	54	.030	.10	1,798
South Umpqua RM 132.5	406,600	36	.022	.06	1,670
Cow Creek below Riddle, OR	106,600	6	.013	.04	456
Composite of South Umpqua RM's 162.5, 165.5, and 170.2	229,800	10	.015	.03	641

Table 13.--Annual loads and yields of selected constituents for 1977 WY at sampling stations in the Umpqua River basin--continued

Station name	Total volume of water, in acre-feet	Annual load, in tons per year	Annual yield, in tons per year per square mile	Annual flow-weighted concentration in mg/l	Drainage area, in square miles
Total phosphorus as P					
Umpqua RM 48.6	1,680,000	150	0.042	0.067	3,683
Umpqua RM 56.9	1,680,000	100	.028	.046	3,683
Umpqua RM 102.7	1,593,600	140	.043	.064	3,200
North Umpqua River at Brown's Bridge	1,187,000	84	.062	.052	1,344
South Umpqua RM 117.7 (USGS)	406,600	58	.032	.10	1,798
South Umpqua RM 117.7 (DEQ)	406,600	63	.035	.11	1,798
South Umpqua RM 132.5	406,600	24	.014	.04	1,670
Cow Creek below Riddle, OR	106,600	6	.012	.039	456
Composite of South Umpqua RM's 162.5, 165.5, and 170.2	229,800	12	.019	.038	641
Suspended sediment					
Umpqua RM 48.6	1,680,000	13,000	3.5	6	3,683
Umpqua RM 56.9	1,680,000	16,000	4.2	7	3,683
Umpqua RM 102.7	1,593,600	9,800	3.1	4	3,200
North Umpqua River at Brown's Bridge	1,187,000	5,400	4.0	3	1,344
South Umpqua RM 117.7 (DEQ)	406,600	2,900	1.6	5	1,798
South Umpqua RM 132.5	406,600	2,100	1.2	4	1,670
Cow Creek below Riddle, OR	106,600	140	.30	1	456
Composite of South Umpqua RM's 162.5, 165.5, and 170.2	229,800	710	1.1	2	641

Table 13.--Annual loads and yields of selected constituents for 1977 WY at sampling stations in the Umpqua River basin--continued

Station name	Total volume of water, in acre-feet	Annual load, in million, colonies per year	Annual yield, in million colonies per year per square mile	Annual flow-weighted concentration in colonies per 100 ml	Drainage area, in square miles
Fecal coliform bacteria					
Umpqua RM 48.6	1,680,000	1.5×10^9	400×10^3	71	3,683
Umpqua RM 56.9	1,680,000	$.6 \times 10^9$	170×10^3	30	3,683
Umpqua RM 102.7	1,593,600	2.5×10^9	770×10^3	120	3,200
North Umpqua River at Brown's Bridge	1,187,000	1.0×10^9	770×10^3	70	1,344
South Umpqua RM 117.7 (USGS)	406,600	1.3×10^9	700×10^3	250	1,798
South Umpqua RM 117.7 (DEQ)	406,600	5.0×10^9	$2,800 \times 10^3$	1,000	1,798
South Umpqua RM 132.5	406,600	$.8 \times 10^9$	480×10^3	160	1,670
Cow Creek below Riddle, OR	106,600	$.09 \times 10^9$	210×10^3	71	456
Composite of South Umpqua RM's 162.5, 165.5, and 170.2	229,800	$.16 \times 10^9$	250×10^3	56	641

Table 14.--Regression equations used for computing constituent loadings and yields at selected stations in the Umpqua River basin

[Equation for calculating constituent load is as follows:

$$\log_{10} L = A + B [\log_{10} Q] + C [\log_{10} Q]^2 + [RME]^2/2$$

where L = constituent load, in tons per day; bacteria load, in million colonies per day; Q = mean daily discharge, in cubic feet per second; A, B, and C are equation coefficients specified below; RME = root mean square error; r^2 = multiple correlation coefficient squared (Draper and Smith, 1981)]

Constituent	A	B	C	RME	r^2
Umpqua RM 48.6 at Elkton, OR					
Specific conductance	- 0.351	0.911	0	0.0625	0.980
Total nitrogen as N	- 3.53	1.13	0	.277	.779
Organic plus ammonia nitrogen as N	- 3.38	1.07	0	.287	.746
Nitrite plus nitrate as N	- 6.08	1.57	0	.320	.836
Total phosphorus as P	- .0740	- 1.22	0.330	.214	.876
Suspended sediment	6.29	- 4.28	.834	.281	.916
Dissolved solids	- .968	1.063	0	.122	.947
Fecal coliform bacteria	- .452	2.00	0	.431	.832
Umpqua RM 56.9 near Elkton, OR					
Specific conductance	- 0.502	0.952	0	0.0723	0.971
Total nitrogen as N	2.47	- 2.13	0.438	.362	.637
Organic plus ammonia nitrogen as N	2.85	- 2.34	.461	.409	.548
Nitrite plus nitrate as N	- 5.49	1.43	0	.483	.638
Total phosphorus as P	- .0347	- 1.29	.330	.345	.676
Suspended sediment	8.31	- 5.31	.971	.222	.910
Dissolved solids	- .695	.968	0	.0766	.964
Fecal coliform bacteria	- 1.42	2.14	0	.583	.701
Fecal streptococci bacteria	21.4	- 9.65	1.51	.696	.397
Umpqua RM 102.7 at Umpqua, OR					
Specific conductance	- 0.424	0.928	0	0.0607	0.979
Total nitrogen as N	- 3.07	.953	0	.274	.680
Organic plus ammonia nitrogen as N	.932	- 1.27	0.294	.270	.618
Nitrite plus nitrate as N	- 5.63	1.47	0	.388	.729
Total phosphorus as P	4.35	- 3.60	.644	.179	.861
Suspended sediment	7.23	- 4.93	.937	.277	.903
Dissolved solids	- .761	1.00	0	.0696	.977
Fecal coliform bacteria	- .195	1.99	0	.548	.734

Table 14.--Regression equations used for computing constituent loadings and yields at selected stations in the Umpqua River basin--continued

Constituent	A	B	C	RME	r ²
North Umpqua River at Brown's Bridge					
Specific conductance	- 0.358	0.876	0	0.048	0.977
Total nitrogen as N	- 3.26	.972	0	.320	.512
Organic plus ammonia nitrogen as N	- 3.06	.895	0	.337	.444
Nitrite plus nitrate as N	- 5.94	1.48	0	.252	.809
Total phosphorus as P	5.00	- 4.25	0.770	.207	.753
Suspended sediment	7.96	- 5.53	1.05	.286	.825
Dissolved solids	- .675	.958	0	.072	.958
Fecal coliform bacteria	.970	1.635	0	.525	.553
South Umpqua RM 117.7 at Melrose Road near Roseburg, OR (USGS)					
Specific conductance	0.041	0.822	0	0.060	0.989
Total nitrogen as N	- .278	- .544	.222	.232	.856
Organic plus ammonia nitrogen as N	- .394	- .547	.219	.282	.792
Nitrite plus nitrate as N	.211	- 1.42	.370	.361	.722
Total phosphorus as P	.575	- 1.54	.368	.252	.789
Dissolved solids	- .319	.882	0	.0823	.982
Fecal coliform bacteria	1.84	1.54	0	.732	.665
Fecal streptococci bacteria	9.45	- 3.32	.727	.720	.527
South Umpqua RM 117.7 at Melrose Road near Roseburg, OR (DEQ)					
Specific conductance	0.0675	0.812	0	0.070	0.987
Total nitrogen as N	.297	- 1.07	0.312	.240	.810
Organic plus ammonia nitrogen as N	- .399	- .645	.233	.263	.770
Nitrite plus nitrate as N	1.21	- 2.24	.526	.294	.794
Total phosphorus as P	.444	- 1.51	.381	.207	.853
Suspended sediment	.848	- 1.48	.510	.358	.903
Dissolved solids	- .367	.917	0	.104	.978
Fecal coliform bacteria	2.27	1.60	0	.705	.739

Table 14.--Regression equations used for computing constituent loadings and yields at selected stations in the Umpqua River basin--continued

Constituent	A	B	C	RME	r ²
South Umpqua RM 132.5 at Winston, OR					
Specific conductance	0.041	0.812	0	0.045	0.994
Total nitrogen as N	- 2.99	.961	0	.300	.836
Organic plus ammonia nitrogen as N	- 2.80	.854	0	.298	.802
Nitrite plus nitrate as N	- 5.15	1.43	0	.366	.880
Total phosphorus as P	- 1.37	-.915	0.344	.209	.931
Suspended sediment	1.04	- 1.68	.543	.288	.936
Dissolved solids	-.392	.917	0	.088	.982
Fecal coliform bacteria	2.49	1.30	0	.606	.696
South Umpqua RM's 162.5, 165.5, and 170.2					
Specific conductance	- 0.0088	0.777	0	0.0523	0.987
Total nitrogen as N	- 3.09	.913	0	.224	.848
Organic plus ammonia nitrogen as N	- 3.12	.884	0	.242	.816
Nitrite plus nitrate as N	- 4.34	1.10	0	.311	.816
Total phosphorus as P	- 2.89	-.145	.259	.274	.870
Suspended sediment	-.202	-.899	.428	.258	.905
Dissolved solids	-.364	.872	0	.057	.988
Cow Creek near mouth below Riddle, OR					
Specific conductance	- 0.0226	0.795	0	0.0410	0.995
Total nitrogen as N	- 3.20	.977	0	.298	.843
Organic plus ammonia nitrogen as N	- 3.06	.872	0	.296	.813
Nitrite plus nitrate as N	- 4.86	1.33	0	.327	.894
Total phosphorus as P	- 1.94	-.809	0.376	.255	.891
Suspended sediment	-.829	-.527	.394	.274	.929
Dissolved solids	-.401	.892	0	.060	.992
Fecal coliform bacteria	2.76	1.14	0	.516	.719

Table 15.--Median load of constituents plus or minus one root mean square error (RME) at selected sampling stations
in the Umpqua River basin

[Based on streamflow duration using 1977 and 1980 through 1983 WY data; conductance loads assume 0.8, 0.9, and 0.7 microsiemens per centimeter, respectively, equal one mg/L of dissolved solids for river water in the main stem, the North, and South Umpqua Rivers]

Station name	Median load minus one RME	Median load	Median load plus one RME	Station name	Median load minus one RME	Median load	Median load plus one RME
Specific conductance, in tons per day				Total nitrogen as N, in pounds per day			
Umpqua RM 48.6	500	580	660	Umpqua RM 48.6	3,200	6,200	12,000
Umpqua RM 56.9	480	570	670	Umpqua RM 56.9	2,500	5,900	13,000
Umpqua RM 102.7	460	540	700	Umpqua RM 102.7	2,100	4,000	7,400
North Umpqua River at Brown's Bridge	310	340	380	North Umpqua River at Brown's Bridge	1,100	2,200	4,700
South Umpqua RM 117.7	190	210	240	South Umpqua RM 117.7	1,400	2,500	4,100
South Umpqua RM 117.7	180	210	250	South Umpqua RM 117.7	900	1,600	2,700
South Umpqua RM 132.5	180	200	220	South Umpqua RM 132.5	800	1,600	3,200
Cow Creek below	45	48	51	Cow Creek below	130	260	550
Riddle, OR	70	84	91	Riddle, OR	400	670	1,200
Composite of South Umpqua RM's 162.5, 165.5, and 170.2				Composite of South Umpqua RM's 162.5, 165.5, and 170.2			
Dissolved solids, in tons per day				Total phosphorus as P, in pounds per day			
Umpqua RM 48.6	440	590	770	Umpqua RM 48.6	660	1,100	1,800
Umpqua RM 56.9	380	520	630	Umpqua RM 56.9	320	740	1,600
Umpqua RM 102.7	480	560	670	Umpqua RM 102.7	610	900	1,300
North Umpqua River at Brown's Bridge	300	350	420	North Umpqua River at Brown's Bridge	360	1,400	2,200
South Umpqua RM 117.7	160	200	250	South Umpqua RM 117.7	220	380	680
South Umpqua RM 117.7	180	230	290	South Umpqua RM 117.7	270	430	700
South Umpqua RM 132.5	180	220	290	South Umpqua RM 132.5	120	180	300
Cow Creek below	41	48	55	Cow Creek below	18	36	64
Riddle, OR	83	94	110	Riddle, OR	45	83	150
Composite of South Umpqua RM's 162.5, 165.5, and 170.2				Composite of South Umpqua RM's 162.5, 165.5, and 170.2			

Table 15.--Median load of constituents plus or minus one root mean square error (RME) at selected sampling stations
in the Umpqua River basin--Continued

Station name	Median load minus one RME	Median load	Median load plus one RME	Station name	Median load minus one RME	Median load	Median load plus one RME
Total organic plus ammonia nitrogen as N, in pounds per day				Fecal coliform bacteria, in million colonies per day			
Umpqua RM 48.6	2,800	5,400	10,000	Umpqua RM 48.6	1.8×10^6	4.8×10^6	13×10^6
Umpqua RM 56.9	2,000	5,200	13,000	Umpqua RM 56.9	$.52 \times 10^6$	1.9×10^6	7.4×10^6
Umpqua RM 102.7	1,100	2,700	6,400	Umpqua RM 102.7	2.3×10^6	8.3×10^6	34×10^6
North Umpqua River at Brown's Bridge	910	2,000	4,300	North Umpqua River at Brown's Bridge	1.3×10^6	4.4×10^6	15×10^6
South Umpqua RM 117.7	930	1,800	3,400	South Umpqua RM 117.7	$.90 \times 10^6$	4.8×10^6	27×10^6
(USGS)				(USGS)			
South Umpqua RM 117.7	650	1,200	2,200	South Umpqua RM 117.7	3.6×10^6	18×10^6	94×10^6
(DEQ)	600	1,200	2,400	(DEQ)	$.84 \times 10^6$	3.4×10^6	14×10^6
South Umpqua RM 132.5				South Umpqua RM 132.5			
Cow Creek below				Cow Creek below			
Riddle, OR	100	210	410	Riddle, OR	$.11 \times 10^6$	$.36 \times 10^6$	1.2×10^6
Composite of South				Composite of South			
Umpqua RM's 162.5,				Umpqua RM's 162.5,			
165.5, and 170.2	220	380	660	165.5, and 170.2	$.16 \times 10^6$	$.65 \times 10^6$	2.7×10^6
Total nitrite plus nitrate as N, in pounds per day				Suspended sediment, in tons per day			
Umpqua RM 48.6	290	630	1,300	Umpqua RM 48.6	20	40	76
Umpqua RM 56.9	290	920	2,800	Umpqua RM 56.9	28	48	79
Umpqua RM 102.7	320	770	1,900	Umpqua RM 102.7	16	30	56
North Umpqua River				North Umpqua River			
at Brown's Bridge	120	220	400	at Brown's Bridge	9.4	18	35
South Umpqua RM 117.7				South Umpqua RM 117.7			
(USGS)	180	420	970	(DEQ)	4.5	10	23
South Umpqua RM 117.7				South Umpqua RM 132.5	4.2	7.6	15
(DEQ)	180	340	660	Cow Creek below			
South Umpqua RM 132.5	120	280	670	Riddle, OR	.7	1.3	2.5
Cow Creek below				Composite of South			
Riddle, OR	18	40	82	Umpqua RM's 162.5,			
Composite of South				165.5, and 170.2	1.6	3.1	5.8
Umpqua RM's 162.5,							
165.5, and 170.2	45	90	190				

Table 16.--Yields of selected constituents at samplings stations in the Umpqua River basin

[Based on streamflow duration using 1977 and 1980 through 1983 WY data; specific conductance yield assumes 0.8, 0.9, and 0.7 microsiemens per centimeter, respectively, equal one milligram per liter of dissolved solids for river water in the main stem, the North, and South Umpqua Rivers]

Station name	Percent of time yield is less than or equal to					Percent of time yield is less than or equal to						
	5	10	25	50 (median)	75	90	5	10	25	50 (median)	75	90
Specific conductance, in tons per day per square mile												
Umpqua RM 48.6	0.050	0.054	0.069	0.16	0.34	0.67	0.40	0.44	0.60	1.7	4.3	10
Umpqua RM 56.9	.046	.050	.066	.15	.30	.70	.64	.67	.78	1.6	4.0	12
Umpqua RM 102.7	.049	.057	.074	.17	.34	.65	.35	.41	.55	1.2	2.6	5.1
North Umpqua River												
at Brown's Bridge	.10	.11	.14	.25	.43	.68	.58	.66	.85	1.7	3.0	5.0
South Umpqua RM 117.7												
(USGS)	.013	.020	.033	.12	.29	.60	.34	.40	.52	1.4	3.5	9.2
South Umpqua RM 117.7												
(DEQ)	.013	.020	.033	.12	.28	.58	.29	.31	.36	.88	2.4	7.0
South Umpqua RM 132.5	.013	.021	.034	.12	.28	.59	.07	.12	.22	.97	2.7	6.4
Cow Creek below												
Riddle, OR	.015	.020	.037	.10	.31	.70	.06	.08	.16	.58	2.2	6.2
Composite of South												
Umpqua RM's 162.5, 165.5, and 170.2	.022	.026	.039	.13	.31	.47	.13	.16	.26	1.1	2.7	4.8
Dissolved solids, in tons per day per square mile												
Total phosphorus as P, in pounds per day per square mile												
Umpqua RM 48.6	.043	.047	.063	.16	.40	.89	.093	.10	.13	.30	.83	2.5
Umpqua RM 56.9	.041	.046	.059	.14	.32	.66	.069	.074	.09	.20	.53	1.5
Umpqua RM 102.7	.048	.056	.075	.18	.37	.74	.14	.14	.16	.28	.66	1.9
North Umpqua River												
at Brown's Bridge	.090	.10	.13	.26	.46	.75	.22	.23	.25	.43	.78	1.7
South Umpqua RM 117.7												
(USGS)	.010	.017	.028	.11	.28	.64	.12	.11	.11	.21	.50	1.4
South Umpqua RM 117.7												
(DEQ)	.011	.018	.030	.13	.34	.78	.11	.10	.11	.24	.65	2.0
South Umpqua RM 132.5	.011	.018	.031	.13	.34	.79	.02	.02	.03	.11	.44	1.8
Cow Creek below												
Riddle, OR	.012	.016	.033	.10	.35	.91	.02	.02	.03	.08	.38	2.0
Composite of South												
Umpqua RM's 162.5, 165.5, and 170.2	.020	.024	.038	.15	.36	.62	.01	.02	.02	.13	.52	1.4

Table 16.--Yields of selected constituents at samplings stations in the Umpqua River basin--Continued

Station name	Percent of time yield is less than or equal to					Station name	Percent of time yield is less than or equal to					
	5	10	25	50 (median)	90		5	10	25	50 (median)	90	
Total organic plus ammonia nitrogen as N, in pounds per day per square mile												
Umpqua RM 48.6	0.37	0.42	0.56	1.5	3.6	8.0	Umpqua RM 48.6	103	126	216	1,300	6,900
Umpqua RM 56.9	.61	.64	.73	1.4	3.4	9.8	Umpqua RM 56.9	34	43	76	524	3,100
Umpqua RM 102.7	.37	.40	.46	.83	1.6	3.5	Umpqua RM 102.7	185	253	457	2,600	12,000
North Umpqua River							North Umpqua River					
at Brown's Bridge	.55	.63	.80	1.5	2.5	4.0	at Brown's Bridge	481	601	936	3,300	7,700
South Umpqua RM 117.7	.26	.31	.39	1.0	2.5	6.4	South Umpqua RM 117.7	43	97	239	2,700	14,000
(USGS)							(USGS)					
South Umpqua RM 117.7	.19	.22	.27	.66	1.6	4.2	South Umpqua RM 117.7					
(DEQ)	.07	.11	.19	.72	1.8	3.9	(DEQ)	142	329	843	10,000	56,000
South Umpqua RM 132.5							South Umpqua RM 132.5	63	124	267	2,000	8,100
Cow Creek below							Cow Creek below					
Riddle, OR	.06	.075	.15	.46	1.5	3.8	Riddle, OR	50	73	176	782	3,700
Composite of South							Composite of South					
Umpqua RM's 162.5,							Umpqua RM's 162.5,					
165.5, and 170.2	.08	.10	.15	.59	1.4	2.5	165.5, and 170.2	99	123	209	1,000	2,900
Total nitrite plus nitrate yield as N, in pounds per day per square mile												
Umpqua RM 48.6	.023	.027	.042	.17	.63	2.1	Umpqua RM 48.6	5.1	5.5	6.9	22	104
Umpqua RM 56.9	.040	.046	.068	.25	.82	2.4	Umpqua RM 56.9	7.3	7.7	9.5	26	123
Umpqua RM 102.7	.034	.044	.067	.24	.74	2.1	Umpqua RM 102.7	4.4	4.9	6.2	19	82
North Umpqua River							North Umpqua River					
at Brown's Bridge	.033	.041	.061	.17	.41	.88	at Brown's Bridge	9.0	9.1	11.9	27	80
South Umpqua RM 117.7	.09	.09	.10	.23	.64	2.0	South Umpqua RM 117.7	.89	1.1	1.8	11	76
(USGS)							(DEQ)	.79	.97	1.4	9.1	61
South Umpqua RM 117.7	.08	.08	.08	.19	.64	2.7	South Umpqua RM 132.5	.67	.80	1.4	5.8	47
(DEQ)	.004	.008	.02	.17	.80	2.9	Cow Creek below					
South Umpqua RM 132.5							Riddle, OR					
Cow Creek below	.004	.005	.015	.087	.52	2.2	Composite of South					
Riddle, OR							Umpqua RM's 162.5,					
Composite of South							165.5, and 170.2	1.1	1.2	1.8	9.7	49
Umpqua RM's 162.5,	.01	.015	.026	.14	.43	.87						
165.5, and 170.2												

Table 17.--Results of Tukey's Studentized Range Test of relating ranks of selected constituents to station locations and bimonthly periods--Continued

Station location	Umpqua River Mile			Calapooya Creek	North Umpqua River	South Umpqua River Mile			Cow Creek	South Umpqua River Mile		Rank of mean ranks
	48.6	56.9	71.0			102.7	117.7 (GS)	117.7 (DEQ)		132.5	162.5	
Total phosphorus test												
Umpqua River Mile	48.6	NA	X	E	E	E	X	E	X	E	X	7
	56.9	X	NA	X	E	E	X	E	E	E	E	3
	71.0	E	X	NA	E	E	E	X	X	E	X	10
	102.7	E	X	E	E	E	X	X	X	E	X	8
Calapooya Creek		E	X	E	E	E	E	E	X	E	X	9
North Umpqua River		E	E	E	NA	X	X	E	E	E	E	5
	117.7 (GS)	E	X	E	E	NA	E	X	X	E	X	11
	117.7 (DEQ)	X	X	E	X	E	NA	X	X	E	X	12
	132.5	E	E	X	E	X	X	NA	E	E	E	4
Cow Creek		X	E	X	X	X	X	E	NA	E	E	2
	162.5	E	E	E	E	E	E	E	E	E	E	6
	165.5	X	E	X	X	X	X	E	E	E	NA	1
Bimonthly period												
	JAN/FEB	NA			E	E	E	E	E	E	3	
	MAR/APR	E			NA	E	X	X	X	X	2	
	MAY/JUN	E			E	NA	X	X	X	X	1	
	JUL/AUG	E			X	X	NA	E	E	E	5	
	SEP/OCT	E			X	X	E	NA	NA	E	6	
	NOV/DEC	E			X	X	E	E	NA	NA	4	

Table 17.--Results of Tukey's Studentized Range Test of relating ranks of selected constituents to station locations and bimonthly periods--Continued

Station location	Umpqua River Mile			Calapooya Creek	North Umpqua River	South Umpqua River Mile			Cow Creek	South Umpqua River Mile		Rank of mean ranks	
	48.6	56.9	71.0			102.7	117.7 (GS)	117.7 (DEQ)		132.5	162.5		165.5
Total organic plus ammonia nitrogen test													
Umpqua River Mile	48.6	NA	X	E	E	E	X	E	E	E	E	X	5
	56.9	X	NA	E	X	E	E	E	E	X	E	X	11
	71.0	E	E	NA	E	E	X	E	E	E	E	E	6
Calapooya Creek	102.7	E	X	E	NA	E	X	X	E	E	E	E	4
		E	E	E	E	NA	X	E	E	E	E	X	9
		E	X	E	E	NA	X	X	X	E	E	E	2
South Umpqua River Mile	117.7(GS)	X	E	X	X	X	NA	X	X	X	X	X	12
	117.7(DEQ)	E	E	E	X	E	X	NA	E	E	E	X	10
	132.5	E	X	E	E	E	X	E	NA	E	E	X	8
Cow Creek		E	X	E	E	E	X	X	E	NA	E	E	3
		E	E	E	E	E	X	E	E	E	E	E	7
South Umpqua River Mile	162.5	E	E	E	E	E	X	E	E	E	NA	E	1
	165.5	X	X	E	E	X	X	X	X	X	E	NA	1
Bimonthly period													
	JAN/FEB	NA			X			E		X	E		4
	MAR/APR	X			E		X	X		X	E		2
	MAY/JUN	X			NA		X	X		X	E		1
	JUL/AUG	E			X		NA			E	X		5
	SEP/OCT	X			X		X	E		NA	X		6
	NOV/DEC	E			E		X	X		X	NA		3

Table 17.--Results of Tukey's Studentized Range Test of relating ranks of selected constituents to station locations and bimonthly periods--Continued

Station location	Umpqua River Mile				Calapooya Creek	North Umpqua River	South Umpqua River Mile			Cow Creek	South Umpqua River Mile			Rank of mean ranks
	48.6	56.9	71.0	102.7			117.7 (GS)	117.7 (DEQ)	132.5		162.5	165.5		
Total nitrite plus nitrate test														
Umpqua River Mile	48.6	NA	E	E	E	E	X	X	X	E	E	E	E	4
	56.9	E	NA	E	E	E	X	X	X	E	E	E	E	6
	71.0	E	E	NA	E	E	X	X	X	E	E	E	E	2
	102.7	E	E	E	NA	E	X	X	E	E	E	E	E	8
Calapooya Creek		E	E	E	E	NA	X	X	X	E	E	E	E	9
North Umpqua River		E	X	E	X	X	NA	X	X	X	E	X	X	1
		X	X	X	X	X	X	NA	X	X	X	X	X	12
		X	X	X	X	X	X	E	NA	X	X	X	X	11
		X	E	X	E	E	X	X	NA	E	X	X	E	10
Cow Creek		E	E	E	E	E	X	X	X	NA	NA	E	E	5
South Umpqua River Mile	162.5	E	E	E	E	E	E	X	X	E	NA	E	E	3
	165.5	E	E	E	E	E	X	X	X	E	E	NA	NA	7

Bimonthly period	Rank of mean ranks									
	JAN/FEB	MAR/APR	MAY/JUN	JUL/AUG	SEP/OCT	NOV/DEC				
JAN/FEB	NA	X	X	X	X	E				
MAR/APR	X	NA	X	E	X	X				
MAY/JUN	X	X	NA	X	X	X				
JUL/AUG	X	E	X	NA	X	X				
SEP/OCT	X	X	X	X	NA	X				
NOV/DEC	E	X	X	X	X	NA				

Table 17.---Results of Tukey's Studentized Range Test of relating ranks of selected constituents to station locations and bimonthly periods--Continued

Station location	Umpqua River Mile				Calapooya Creek	North Umpqua River	South Umpqua River Mile				Cow Creek	South Umpqua River Mile		Rank of mean ranks
	48.6	56.9	71.0	102.7			117.7 (GS)	117.7 (DEQ)	132.5	162.5		165.5		
Fecal coliform bacteria test														
Umpqua River Mile	48.6	NA	E	E	E	X	X	X	E	E	E	E	E	2
	56.9	E	NA	E	X	X	X	X	X	X	X	E	X	1
	71.0	E	E	NA	E	E	E	X	E	E	E	E	E	4
Calapooya Creek	102.7	E	X	E	NA	E	E	X	E	E	E	E	E	8
		X	X	E	E	NA	X	E	E	E	X	E	X	11
		E	X	E	E		E	X	E	E	E	E	E	
North Umpqua River		E	X	E	E	X	E	X	E	E	E	E	E	7
		X	X	E	E	E	NA	E	E	E	E	E	X	
	117.7(GS)	X	X	E	E	E	NA	E	E	E	X	X	X	10
South Umpqua River Mile	117.7(DEQ)	X	X	X	X	E	E	NA	X	NA	X	X	X	12
	132.5	E	X	E	E	E	E	X	E	NA	E	E	E	9
		E	X	E	E		X	X	E	E	E	E	E	
Cow Creek		E	X	E	E	X	X	X	E	E	E	E	E	6
		E	E	E	E	E	E	X	E	E	E	NA	E	
	162.5	E	E	E	E	E	E	X	E	E	E	E	E	5
South Umpqua River Mile	165.5	E	X	E	E	X	X	X	E	E	E	E	NA	3

Bimonthly period	Rank of mean ranks											
	JAN/FEB	MAR/APR	MAY/JUN	JUL/AUG	SEP/OCT	NOV/DEC						
JAN/FEB	NA	E	X	X	E	E						5
MAR/APR	E	NA	X	X	E	E						6
MAY/JUN	X	X	NA	E	E	X						2
JUL/AUG	X	X	E	NA	X	X						1
SEP/OCT	E	E	E	X	NA	E						3
NOV/DEC	E	E	X	X	E	NA						4

Table 17.--Results of Tukey's Studentized Range Test of relating ranks of selected constituents to station locations and bimonthly periods--Continued

Station location	Umpqua River Mile			Calapooya Creek	North Umpqua River	South Umpqua River Mile			Cow Creek	South Umpqua River Mile			Rank of mean ranks
	48.6	56.9	71.0			102.7	117.7 (GS)	117.7 (DEQ)		132.5	162.5	165.5	
Suspended sediment test													
Umpqua River Mile	48.6	NA	E	E	E	E	E	E	E	E	E	E	4
	56.9	E	NA	E	E	X	E	E	E	X	E	X	9
	71.0	E	E	NA	E	E	E	E	E	E	E	X	11
Calapooya Creek	102.7	E	E	E	NA	E	E	E	E	E	E	X	7
		E	E	E	E	E	E	E	E	E	E	E	
		E	E	E	NA	E	E	E	E	X	E	X	10
North Umpqua River													
		E	X	E	E	NA	E	E	E	E	E	E	3
		E	E	E	E	E	NA	E	E	E	E	E	NA
South Umpqua River Mile	117.7(GS)	E	E	E	E	E	NA	E	NA	E	E	X	8
	117.7(DEQ)	E	E	E	E	E	E	E	E	E	E	E	5
	132.5	E	E	E	E	E	E	E	NA	E	E	E	
Cow Creek		E	X	E	E	E	E	E	E	NA	E	E	2
		E	E	E	E	E	E	E	E	E	NA	E	6
		E	E	X	X	X	E	E	X	E	E	NA	1
Bimonthly period													
	JAN/FEB	NA			E	X		X	X		E		6
	MAR/APR	E			NA	X		X	X		E		4
	MAY/JUN	X			X	NA		E	E	X	X		2
	JUL/AUG	X			X	E		NA	E	X	X		1
	SEP/OCT	X			X	E		E	NA	X	X		3
	NOV/DEC	E			E	X		X	X	NA	NA		5

Table 18.--Results of the Seasonal Kendall analysis for selected sampling stations using 1980-1983 WY data

[Underlining indicates trend is significant at P = 0.10 level; median values are reported in the indicated constituent units; slope values are reported in percent change of median per year; NA = not applicable; NC = not calculated; value in parenthesis indicates the number of the equation from table 9 that was used for flow adjustment.]

Constituent names	Median	NOT FLOW ADJUSTED						FLOW ADJUSTED					
		ENTIRE YEAR			YEAR DIVIDED INTO THIRDS			ENTIRE YEAR			ENTIRE YEAR		
		1980 - 1983 WY (All months included)	1980 - 1983 WY (Months = Nov. - Feb.)	1980 - 1983 WY (Months = Mar. - June)	1980 - 1983 WY (Months = July - Oct.)	1980 - 1983 WY (Months = Nov. - Feb.)	1980 - 1983 WY (Months = Mar. - June)	1980 - 1983 WY (All months included)	1980 - 1983 WY (Months = July - Oct.)	1980 - 1983 WY (Months = Nov. - Feb.)	1980 - 1983 WY (Months = Mar. - June)	1980 - 1983 WY (All months included)	1980 - 1983 WY (Months = July - Oct.)
		Slope	P Level	Slope	P Level	Slope	P Level	Slope	P Level	Slope	P Level	Slope	P Level
Umpqua RM 56.9 near Elkton (NASQAN station)													
Instantaneous discharge, in cfs	2,990	9.7	0.27	0.3	1.0	9.7	1.0	15	0.11	NA	NA	NA	NA
Temperature in °C	12.8	- 3.1	.33	- 3.1	.11	5.5	.29	- 8.6	.35	2.7	.78 (4)	2.7	.78 (4)
Specific conductance, in uS/cm	85	- 2.0	.48	2.9	.81	- 3.5	1.0	- 4.5	.16	- .2	.78 (6)	- .2	.78 (6)
Dissolved oxygen, in mg/L	10.7	.9	.20	1.6	.11	.9	.78	.0	1.0	NC	NC	NC	NC
pH, in standard units	7.5	.0	.77	1.3	.26	.0	1.0	- 2.4	.048	NC	NC	NC	NC
Alkalinity as CaCO ₃ , in mg/L	32	2.1	1.0	6.2	1.0	5.3	1.0	- 2.1	.48	NC	NC	NC	NC
Total nitrogen as N, in mg/L	.58	- 5.2	1.0	- 12	1.0	- 1.7	1.0	- 10	1.0	.2	1.0 (7)	.2	1.0 (7)
Total organic plus ammonia nitrogen as N, in mg/L	.42	- 12	.33	- 20	.64	2.4	1.0	- 48	.26	- 2.0	.89 (7)	- 2.0	.89 (7)
Total nitrite plus nitrate as N, in mg/L	.05	40	.04	50	.33	56	.24	44	.49	118	.16 (6)	118	.16 (6)
Total phosphorus as P, in mg/L	.04	- 12	.17	.0	1.0	.0	1.0	- 30	.031	- 4.1	.099 (7)	- 4.1	.099 (7)
Suspended sediment, in mg/L	4	.0	1.0	12	1.0	30	.70	- 25	.49	- .7	1.0 (7)	- .7	1.0 (7)
Dissolved solids, in mg/L	60	- 2.8	.18	- .9	.78	- 4.8	.78	- 4.2	.26	- 20	.68 (7)	- 20	.68 (7)
Fecal coliform colonies/100 mL	11	- 10	.67	- 6.1	1.0	- 14	.78	- 7.5	1.0	136	.03 (7)	136	.03 (7)
Fecal streptococci colonies/100 mL	26	81	.36	142	.29	320	.74	30	1.0	NC	NC	NC	NC
Turbidity, in NTU	2.5	.0	1.0	.0	1.0	.0	1.0	.0	1.0	NC	NC	NC	NC
Umpqua RM 102.7													
Instantaneous discharge, in cfs	4,052	7.6	0.005	53	0.27	7.5	0.61	6.0	0.004	NA	NA	NA	NA
Temperature, in °C	12.2	- 2.0	.54	.0	1.0	- 3.1	.60	- 3.9	.61	2.1	.32 (3)	2.1	.32 (3)
Specific conductance, in uS/cm	76	- 3.3	.16	- 7.5	.13	- 3.9	.86	- 1.1	.61	- 1.6	.16 (7)	- 1.6	.16 (7)
Dissolved oxygen, in mg/L	11.0	.0	1.0	.0	1.0	1.8	.73	- 1.1	.49	NC	NC	NC	NC
pH, in standard units	7.5	.0	.6	- .9	.46	1.1	.20	.23	.72	NC	NC	NC	NC
Alkalinity as CaCO ₃ , in mg/L	31	- 3.9	.003	- 8.1	.005	- 3.9	.49	- 3.2	.19	NC	NC	NC	NC
Total nitrogen as N, in mg/L	.22	- 2.3	.31	- 18	.24	.0	1.0	- 8.6	.6	NC	NC	NC	NC
Total organic plus ammonia nitrogen as N, in mg/L	.10	.0	.38	.0	1.0	.0	.78	- 12	.46	1.0	1.0 (6)	1.0	1.0 (6)
Total nitrite plus nitrate as N, in mg/L	.04	.0	1.0	- 38	.35	.0	.57	.0	.71	- 7.1	.23 (6)	- 7.1	.23 (6)
Total phosphorus as P, in mg/L	.06	33	.76	10	.71	.0	.86	5	.73	3.2	.55 (7)	3.2	.55 (7)
Nonfiltrable residue at 105° C, in mg/L	2.5	.0	.76	6	.58	.0	1.0	10	1.0	- 17	.16 (7)	- 17	.16 (7)
Dissolved solids, in mg/L	65	.0	1.0	- .5	1.0	.3	1.0	.0	1.0	NC	NC	NC	NC
Fecal coliform colonies/100 mL	82	.0	.35	76	.83	15	.72	.0	.49	- 4.8	.67 (7)	- 4.8	.67 (7)
Turbidity, in NTU	3.5	.0	.33	71	.58	.0	.86	.0	.55	NC	NC	NC	NC

Table 18.---Results of the Seasonal Kendall analysis for selected sampling stations using 1980-1983 WY data--Continued

Constituent names	Median	NOT FLOW ADJUSTED						FLOW ADJUSTED					
		ENTIRE YEAR			YEAR DIVIDED INTO THIRDS			1980 - 1983 WY			ENTIRE YEAR		
		1980 - 1983 WY			1980 - 1983 WY			1980 - 1983 WY			1980 - 1983 WY		
		(All months Included)			(Months = Mar. - June)			(Months = July - Oct.)			(All months Included)		
		Slope	P Level		Slope	P Level		Slope	P Level		Slope	P Level	
North Umpqua River at Brown's Bridge near mouth													
Instantaneous discharge, in cfs	2,485	11	0.003		60	0.27		11	0.40		8.1	0.006	
Temperature, in °C	11.3	.0	.92		.0	1.0		- 1.1	1.0		- 2.5	.86	
Specific conductance, in uS/cm	59	- 4.6	.003		- 3.4	.53		- 7.1	.023		- 3.7	.13	
Dissolved oxygen, in mg/L	11.2	- .6	.76		- .9	.85		1.2	.86		- 8.9	.61	
pH, in standard units	7.5	.0	.68		- .3	.70		1.6	.23		.0	1.0	
Alkalinity as CaCO ₃ , in mg/L	25	- 4.0	.001		- 8.0	.04		- 4.0	.17		- 4.0	.04	
Total nitrogen as N, in mg/L	.12	.0	1.0		- 17	.49		.0	1.0		.0	.55	
Total organic plus ammonia nitrogen as N, in mg/L	.1	.0	.36		.0	.54		.0	.75		.0	.81	
Total nitrite plus nitrate as N, in mg/L	.01	.0	.027		.0	.85		.0	.34		.0	.021	
Total phosphorus as P, in mg/L	.045	8.8	.19		8.8	1.0		4.4	.73		30	.13	
Nonfiltrable residue at 105° C, in mg/L	2	.0	.92		.0	1.0		.0	1.0		.0	.85	
Dissolved solids, in mg/L	54	.5	.54		.9	.71		.5	1.0		.4	.73	
Fecal coliform colonies/100 mL	36	19	.17		.0	1.0		14	.46		58	.12	
Turbidity, in NTU	2	.0	.12		16	.42		16	.36		.0	.56	
South Umpqua RM 117.7 near Roseburg (USGS)													
Instantaneous discharge, in cfs	701	9.7	0.12		180	0.23		3.1	1.0		9.1	0.27	
Temperature, in °C	13.5	- .1	.67		- 2.2	.49		.7	.85		.0	.84	
Specific conductance, in uS/cm	124	- 7.1	.029		- 9.7	.23		- 6.4	.13		- 4.2	.46	
Dissolved oxygen in mg/L	10.9	.6	.47		1.4	.40		.5	.45		- 1.1	.71	
pH, in standard units	7.7	.0	.83		.0	.86		.4	.56		.6	.70	
Total nitrogen as N, in mg/L	0.75	- 2.0	1.0		8.0	.61		4	.84		- 31	.31	
Total organic plus ammonia nitrogen as N, in mg/L	.7	1.0	.91		8.6	.13		3.5	.84		- 16	.07	
Total nitrite plus nitrate as N, in mg/L	.1	- 2.0	.59		- 20	.016		5.0	.018		- 10	.58	
Total phosphorus as P, in mg/L	.09	.0	1.0		11	.61		.0	1.0		- 44	.46	
Dissolved solids, in mg/L	79	- 6.3	.038		- 6.6	.16		- 8.9	.066		- 2.5	1.0	
Fecal coliform colonies/100 mL	205	5.9	.91		38	.55		- 9.0	.84		.0	1.0	
Fecal streptococci colonies/100 mL	340	42	.027		66	.009		6.8	.31		16	1.0	
											34	.015	

Table 18.--Results of the Seasonal Kendall analysis for selected sampling stations using 1980-1983 WY data--Continued

Constituent names	Median	NOT FLOW ADJUSTED						FLOW ADJUSTED					
		ENTIRE YEAR			YEAR DIVIDED INTO THIRDS			ENTIRE YEAR			YEAR DIVIDED INTO THIRDS		
		1980 - 1983 WY (All months Included)			1980 - 1983 WY (Months = Nov.-Feb.)			1980 - 1983 WY (Months = Mar.-June)			1980 - 1983 WY (Months = July-Oct.)		
		Slope	P Level		Slope	P Level		Slope	P Level		Slope	P Level	
South Umpqua RM 117.7 near Roseburg (DEQ)													
Instantaneous discharge, in cfs	1,105	8.4	0.016	91	0.27	19	0.40	5.6	0.06	NA	NA	NA	NA
Temperature, in °C	14.5	-7	.46	.0	1.0	-1.3	.60	-.3	.72	1.5	.55 (2)		
Specific conductance, in uS/cm	114	-6.1	.02	-5.2	.27	-3.3	.49	-12	.052	-1.6	.84 (6)		
Dissolved oxygen, in mg/L	11.3	-.4	.84	.9	1.0	1.0	.86	-2.6	.40	NC	NC		
pH, in standard units	7.9	.0	.92	-.6	.58	.9	.38	.0	1.0	NC	NC		
Alkalinity as CaCO ₃ , in mg/L	45	-2.2	.16	6.7	.11	-2.7	.73	-2.2	.85	NC	NC		
Total nitrogen as N, in mg/L	.42	-14	.033	2.3	1.0	-7.1	.25	-24	.062	-1.4	.35 (7)		
Total organic plus ammonia nitrogen as N, in mg/L	.3	-17	.021	.0	1.0	-10	.31	-27	.026	-.4	1.0 (7)		
Total nitrite plus nitrate as N, in mg/L	.13	-5.4	.12	-12	.33	.0	1.0	-35	.13	-6.2	.55 (7)		
Total phosphorus as P, in mg/L	.117	-5.1	.27	1.7	.71	26	1.0	-38	.011	3.1	.42 (7)		
Nonfiltrable residue at 105 °C, in mg/L	3	10	.61	150	.46	5.7	.86	.0	1.0	-.4	.84 (7)		
Dissolved solids, in mg/L	86	-2.3	.48	.4	.85	.0	1.0	5.8	.13	2.0	.044 (7)		
Fecal coliform colonies/100 mL	430	-4.9	.21	-39	.70	-136	.17	.0	1.0	-58	.016 (6)		
Turbidity, in NTU	5	6	.19	50	.85	5	.72	3.4	.16	NC	NC		
South Umpqua RM 132.5													
Instantaneous discharge, in cfs	1,095	8.1	0.016	91	0.27	21	0.40	5.2	0.062	NA	NA	NA	NA
Temperature, in °C	12.8	.2	.84	3.9	1.0	-.6	1.0	1.1	.73	3.0	0.027 (6)		
Specific conductance in uS/cm	108	-5.6	.019	-4.6	.093	-6.3	.40	-8.8	.22	.0	1.0 (6)		
Dissolved oxygen, in mg/L	10.6	1.9	.42	1.9	.71	2.2	.86	5.6	.61	NC	NC		
pH, in standard units	7.7	.6	.41	-.9	.45	1.0	.29	1.3	.30	NC	NC		
Alkalinity as CaCO ₃ , in mg/L	40	-2.5	.056	-2.5	.04	-3.2	.49	.0	.85	NC	NC		
Total nitrogen as N, in mg/L	.30	-10	.15	-13	.33	-10	.45	-6.0	.60	-9.0	.062 (7)		
Total organic plus ammonia nitrogen as N, in mg/L	.2	-10	.049	-10	.71	-15	.22	-6.0	.25	-8.3	.24 (7)		
Total nitrite plus nitrate as N, in mg/L	.03	.0	.66	.0	.84	.0	1.0	.0	.86	-6.9	.16 (6)		
Total phosphorus as P, in mg/L	.042	.17	.16	31	.46	9.5	.61	14	.40	13	.23 (7)		
Nonfiltrable residue at 105 °C, in mg/L	2.5	.0	.52	120	.46	20	.37	.0	.56	1.3	1.0 (7)		
Dissolved solids, in mg/L	82	-3.0	.086	-1.8	.71	-1.8	.61	-5.1	.085	.7	.55 (7)		
Fecal coliform colonies/100 mL	91	.0	1.0	106	.046	22	.16	4.2	.86	-11	.69 (6)		
Turbidity, in NTU	3.5	.0	.28	100	.35	14	.48	.0	.28	NC	NC		

Table 18.--Results of the Seasonal Kendall analysis for selected sampling stations using 1980-83 WY data--Continued

Constituent names	Median	NOT FLOW ADJUSTED						FLOW ADJUSTED					
		ENTIRE YEAR		1980 - 1983 WY		YEAR DIVIDED INTO THIRDS		1980 - 1983 WY		ENTIRE YEAR			
		1980 - 1983 WY (All months Included)		1980 - 1983 WY (Months = Nov. - Feb.)		1980 - 1983 WY (Months = Mar. - June)		1980 - 1983 WY (Months = July - Oct.)		1980 - 1983 WY (All months Included)			
		Slope	P Level	Slope	P Level	Slope	P Level	Slope	P Level	Slope	P Level		
Cow Creek near mouth													
Instantaneous discharge, in cfs	431	8.8	0.003	97	0.27	16	0.23	4.6	0.011	NA	NA	NA	NA
Temperature, in °C	11.1	3.6	.26	3.6	.70	4.0	.30	5.0	.86	5.4	0.07	5.4	0.07
Specific conductance, in uS/cm	94	- 9.6	.000	- 2.1	.27	- 9.6	.016	- 18	.027	- 2.0	.16	- 2.0	.16
Dissolved oxygen, in mg/L	10.9	.9	.92	- .5	1.0	- .7	1.0	2.1	.61	NC	NC	NC	NC
pH, in standard units	7.6	.4	.48	- 1.3	.46	1.0	.22	1.0	.49	NC	NC	NC	NC
Alkalinity, as CaCO ₃ , in mg/L	39	- 5.1	.005	- 5.1	.27	- 4.4	.22	- 7.7	.028	NC	NC	NC	NC
Total nitrogen as N, in mg/L	.19	- 2.6	.32	- 16	.74	.0	.68	- 18	.12	- 1.8	.48	- 1.8	.48
Total organic plus ammonia nitrogen as N, in mg/L	.10	.0	.23	.0	.66	.0	.78	- 33	.12	- 1.0	1.0	- 1.0	1.0
Total nitrite plus nitrate as N, in mg/L	.03	.0	.32	17	.85	.0	.32	.0	.85	.6	.94	.6	.94
Total phosphorus as P, in mg/L	.04	7.5	.22	20	.46	12	.22	- 2.5	1.0	17	.23	17	.23
Nonfilterable residue at 105 °C, in mg/L	2.0	15	.21	125	.093	8.5	.98	.0	1.0	14	.16	14	.16
Total dissolved solids, in mg/L	76	- 3.9	.052	.9	.85	- 3.7	.38	- 11	.011	- .5	1.0	- .5	1.0
Fecal coliform colonies/100 mL	36	.0	.44	18	.85	.0	1.0	26	.46	23	.32	23	.32
Turbidity, in NTU	3.0	17	.011	100	.13	17	.10	.0	.41	NC	NC	NC	NC
Composited data from South Umpqua RM's 162.5, 165.5, and 170.2													
Instantaneous discharge, in cfs	700	3.6	0.16	82	0.27	4.6	0.86	1.4	0.40	NA	NA	NA	NA
Temperature, in °C	11.2	2.7	.31	.0	1.0	3.4	.49	4.9	.40	5.5	.027	5.5	.027
Specific Conductance, in uS/cm	82	- 7.3	.006	- 7.3	.27	- 4.3	.30	- 8.3	.027	- 3.4	.016	- 3.4	.016
Dissolved oxygen, in mg/L	10.6	.9	.10	- .9	.85	.3	1.0	4.7	.003	NC	NC	NC	NC
pH, in standard units	7.5	.7	.10	- 1.3	.70	1.1	.054	2.4	.23	NC	NC	NC	NC
Alkalinity as CaCO ₃ , in mg/L	32	- 5.6	.003	- 6.2	.066	- 5.6	.12	- 3.1	.19	NC	NC	NC	NC
Total nitrogen as N, in mg/L	.14	- 6.9	.12	28	.33	.0	1.0	28	.085	- 7.2	.16	- 7.2	.16
Total organic plus ammonia nitrogen as N, in mg/L	.10	.0	.043	- 20	.19	.0	.75	- 20	.17	- 1.0	.82	- 1.0	.82
Total nitrite plus nitrate as N, in mg/L	.04	.0	1.0	12	.35	10	.14	- 25	.013	- 14	.42	- 14	.42
Total phosphorus as P, in mg/L	.035	11	.034	23	.71	11	.73	14	.011	10	.044	10	.044
Nonfilterable residue at 105 °C, in mg/L	1.0	.0	.83	120	.70	.0	1.0	.0	1.0	- 1.6	1.0	- 1.6	1.0
Dissolved solids, in mg/L	70	- 1.4	.27	1.4	1.0	1.1	1.0	- 7.9	.023	.3	1.0	.3	1.0
Fecal coliform colonies/100 mL	36	.0	.90	.0	.62	.0	1.0	.0	1.0	NC	NC	NC	NC
Turbidity, in NTU	4.0	8.2	.25	52	.52	.0	1.0	.0	.28	NC	NC	NC	NC

Table 19.--Results of the Seasonal Kendall analysis for selected stations using data collected in 1974 through 1983 WY

[Underlining indicates trend is significant at $p = 0.10$ level; median values are reported in the indicated constituent units; slope values reported in percent change of median per year; NA = not applicable; NC = not calculated; value in parenthesis indicates the number of the equation from table 9 that was used for flow adjustment]

Constituent names	Median	NOT FLOW ADJUSTED				FLOW ADJUSTED			
		1974 - 1983 WY (All months included)		1974 - 1983 WY (Even numbered months included)		1974 - 1983 WY (All months included)		1974 - 1983 WY (All months included)	
		Slope	P Level	Slope	P Level	Slope	P Level	Slope	P Level
Unpqua RM 56.9 near Elkton (NASQAN station)									
Instantaneous discharge, in cfs	3,080	- 0.6	0.69	1.1	0.49	- 2.3	0.096	NA	NA
Temperature, in °C	12.9	.0	.60	.0	1.0	.8	.37	- 2.0	0.98 (3)
Specific conductance, in uS/cm	80	1.8	.003	1.0	.11	2.5	.007	1.5	.001 (6)
Dissolved oxygen, in mg/L	10.8	.9	.031	1.2	.018	.0	.84	NC	NC
pH, in standard units	7.4	.7	.003	.5	.04	.8	.03	NC	NC
Alkalinity as CaCO ₃	30	.0	.80	.8	.25	.4	.40	NC	NC
Total nitrogen as N, in mg/L	.35	11	.001	11	.000	6	.26	13	.000 (7)
Total organic plus ammonia nitrogen as N, in mg/L	.28	14	.000	14	.000	11	.11	14	.000 (7)
Total nitrite plus nitrate as N, in mg/L	.05	.0	.72	.0	.53	.0	1.0	1.4	.92 (6)
Total phosphorus as P, in mg/L	.04	- 5	.001	- 5	.008	- 8	.049	- 4.8	.003 (7)
Suspended sediment, in mg/L	5	- 10	.002	- 6	.091	- 20	.007	- 7.1	.001 (7)
Dissolved solids, in mg/L	57	.5	.34	.0	.86	1.9	.04	NC	NC
Fecal coliform colonies/100 mL	11	- 1.8	.58	- 7.3	.28	1.8	.51	NC	NC
Fecal streptococci colonies/100 mL	28	.7	1.0	3.6	.83	6.8	.84	NC	NC
Turbidity, in NTU	2	.0	.33	.0	.15	.0	.80	NC	NC
South Unpqua RM 117.7 near Roseburg (USGS)									
Instantaneous discharge, in cfs	976	1.0	0.26	1.2	0.20	0.5	0.77	NA	NA
Temperature, in °C	13	.0	.94	.0	1.0	.0	.91	1.6	.85 (2)
Specific conductance, in uS/cm	120	.8	.28	.8	.59	.8	.35	.4	.22 (6)
Dissolved oxygen, in mg/L	10.9	.3	.54	.5	.52	.1	.88	NC	NC
pH, in standard units	7.6	.5	.000	.7	.001	.4	.008	NC	NC
Alkalinity as CaCO ₃ , in mg/L	43	.9	.100	1.1	.18	.9	.35	NC	NC
Total nitrogen as N, in mg/L	.57	4.0	.018	2.3	.32	5.3	.022	6.3	.004 (7)
Total organic plus ammonia nitrogen as N, in mg/L	.45	6.7	.000	4.4	.064	8.9	.000	9.9	.000 (7)
Total nitrite plus nitrate as N, in mg/L	.11	- 1.8	.084	- 2.7	.13	- .9	.37	- 3.8	.16 (7)
Total phosphorus as P, in mg/L	.09	- 1.1	.32	- 5.6	.036	.0	.53	1.6	.19 (7)
Dissolved solids, in mg/L	78	- .5	.62	.0	1.0	- .9	.52	NC	NC
Fecal coliform colonies/100 mL	110	14	.12	17	.031	- .6	1.0	NC	NC
Fecal streptococci colonies/100 mL	150	22	.004	37	.013	15	.14	NC	NC

Table 19.--Results of the Seasonal Kendall analysis for selected sampling stations using data collected in 1974 through 1983 WY--Continued

Constituent names	Median	TRENDS - NOT FLOW ADJUSTED									
		YEAR DIVIDED INTO THIRDS				YEAR DIVIDED IN HALVES					
		1974 - 1983 WY		1974 - 1983 WY		1974 - 1983 WY		1974 - 1983 WY		1974 - 1983 WY	
		(Months = Nov. - Feb.)	(Months = Mar. - June)	(Months = July - Oct.)	(Months = Oct. - March)	(Months = April - Sept.)	(Months = Oct. - March)	(Months = April - Sept.)	(Months = Oct. - March)	(Months = April - Sept.)	(Months = Oct. - March)
		Slope	P Level	Slope	P Level	Slope	P Level	Slope	P Level	Slope	P Level
Unpqua RM 56.9 near Elkton (NASQAN station)											
Instantaneous discharge, in cfs	3,080	- 25	0.13	3.8	0.54	0.5	0.88	- 2.1	0.47	0.3	0.93
Temperature, in °C	12.9	.0	.75	1.1	.12	.0	.88	.0	.93	.8	.40
Specific conductance, in uS/cm	80	1.9	.40	3.3	.007	.9	.13	1.2	.32	2.1	.002
Dissolved oxygen, in mg/L	10.8	1.9	.009	.7	.19	- 1.8	.86	1.8	.016	.4	.98
pH, in standard units	7.4	.3	.28	.7	.010	.9	.15	.3	.29	.9	.003
Alkalinity as CaCO ₃ , in mg/L	30	- .7	.50	1.1	.29	.0	.94	- .7	.34	1.1	.201
Total nitrogen as N, in mg/L	.35	11	.12	8.6	.038	17	.025	11	.030	8.6	.008
Total organic plus ammonia nitrogen as N, in mg/L	.28	14	.17	11	.009	14	.008	14	.021	14	.002
Total nitrite plus nitrate as N, in mg/L	.05	16	.24	.0	1.0	.0	.59	6	.50	.0	.92
Total phosphorus as P, in mg/L	.04	- 12	.002	.0	.60	- 5	.053	12	.000	.0	.36
Suspended sediment, in mg/L	5	- 8	.20	- 10	.13	- 10	.017	- 8	.085	10	.011
Dissolved solids, in mg/L	57	.1	.84	1.9	.13	.0	.95	- 5	.54	.5	.49
Fecal coliform colonies/100 mL	11	- 11	.41	.0	.92	.0	1.0	.0	1.0	- 2.7	.44
Fecal streptococci colonies/100 mL	28	6.8	.50	- .2	1.0	- 11	.63	11	.19	- 18	.22
Turbidity, in NTU	2	- 5	.42	5	.05	.0	.64	.0	.96	.0	.15
South Umpqua RM 117.7 near Roseburg (USGS)											
Instantaneous discharge, in cfs	976	- 7.1	0.75	2.7	0.31	0.7	0.20	0.5	1.0	1.2	0.12
Temperature, in °C	13	.3	.65	- .4	.58	.0	.81	.8	.28	- .3	.54
Specific conductance, in uS/cm	120	1.2	.29	1.3	.16	- 1.2	.55	.8	.4	.8	.52
Dissolved oxygen, in mg/L	10.9	- .5	.86	.3	.71	1.4	.35	- .5	.58	.9	.14
pH, in standard units	7.6	.5	.001	.4	.21	.8	.006	.4	.01	.9	.001
Alkalinity as CaCO ₃ , in mg/L	43	.7	.42	3.5	.008	- 1.7	.47	.7	.49	1.7	.12
Total nitrogen as N, in mg/L	.57	3.5	.046	5.3	.077	1.8	.84	3.5	.064	5.3	.15
Total organic plus ammonia nitrogen as N, in mg/L	.45	4.4	.020	8.9	.011	11	.092	4.4	.004	9.6	.012
Total nitrite plus nitrate as N, in mg/L	.11	.0	.89	.0	.80	- 18	.012	- 1.8	.55	- 2.7	.071
Total phosphorus as P, in mg/L	.09	.0	1.0	1.1	.24	- 6.7	.63	.0	.69	- 2.2	.33
Dissolved solids, in mg/L	78	- 1.7	.57	.8	.36	9.1	.20	- 2.2	.14	.5	.58
Fecal coliform colonies/100 mL	110	23	.68	6.3	.46	- 1.5	.14	34	.18	5.3	.42
Fecal streptococci colonies/100 mL	150	21	.096	13	.038	13	.17	47	.005	11	.21