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Water-Quality, Streamflow, and Meteorological Data for the Tualatin River Basin, Oregon, 1991–93

By Micelis C. Doyle and James M. Caldwell

U.S. Geological Survey
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Prepared in cooperation with
UNIFIED SEWERAGE AGENCY OF WASHINGTON COUNTY

Portland, Oregon
1996

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PLATE

[Plate is in pocket]

COMPACT DISK (CD-ROM)

[Compact Disk is in pocket]

~~Report text, plate 1, and~~ water-quality, streamflow, and meteorological data

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CONVERSION FACTORS AND VERTICAL DATUM

[SI = International System of units, a modernized metric system of measurement]

Multiply	By	To obtain
A. Factors for converting SI metric units to inch/pound units		
	Length	
centimeter (cm)	0.3937	inch (in)
millimeter (mm)	0.03937	inch
meter (m)	3.281	foot (ft)
meter (m)	1.094	yard (yd)
	Volume	
milliliter (mL)	0.001057	quart (qt)
liter (L)	1.057	quart
liter	0.2642	gallon (gal)
	Mass	
gram (g)	0.03527	ounce (oz avoirdupois)
kilogram (kg)	2.205	pound (lb avoirdupois)

Temperature

Degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) as follows:

°F = 1.8 (°C) + 32

Multiply	By	To obtain
B. Factor for converting inch/pound units to SI metric units.		
	Volume per unit time (flow)	
cubic foot per second (ft^3/s)	0.02832	meter per second (m^3/s)
acre	4,047	cubic meter (m^3)
C. Factors for converting SI metric units to other miscellaneous units		
	Concentration, in water	
milligrams per liter (mg/L)	1	parts per million (ppm)
nanograms per liter (ng/L)	1	parts per trillion (ppt)
nanograms per liter	0.000001	parts per million

Electrical conductivity is measured as specific electrical conductance, in units of microsiemens per centimeter (µS/cm) at 25 degrees Celsius.

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Water-Quality, Streamflow, and Meteorological Data for the Tualatin River Basin, Oregon, 1991–93

By Micelis C. Doyle *and* James M. Caldwell

Abstract

Surface-water-quality data, ground-water-quality data, streamflow data, field measurements, aquatic-biology data, meteorological data, and quality-assurance data were collected in the Tualatin River Basin from 1991 to 1993 by the U.S. Geological Survey (USGS) and the Unified Sewerage Agency of Washington County, Oregon (USA). The data from that study, which are part of this report, are presented in American Standard Code for Information Interchange (ASCII) format in subject-specific data files on a Compact Disk- Read Only Memory (CD-ROM). The text of this report describes the objectives of the study, the location of sampling sites, sample-collection and processing techniques, equipment used, laboratory analytical methods, and quality-assurance procedures. The data files on CD-ROM contain the analytical results of water samples collected in the Tualatin River Basin, streamflow measurements of the main-stem Tualatin River and its major tributaries, flow data from the USA waste- water-treatment plants, flow data from stations that divert water from the main-stem Tualatin River, aquatic-biology data, and meteoro- logical data from the Tualatin Valley Irrigation District (TVID) Agrimet Weather Station located in Verboort, Oregon. Specific infor-mation regarding the contents of each data file is given in the text. The data files use a series of letter codes that distinguish each line of data. These codes are defined in data tables accompanying the text. Presenting data on CD-ROM offers several advantages: (1) the data can be accessed easily and manipulated by computers, (2) the data can be distributed readily over computer networks, and (3) the data may be more easily transported and stored than a large printed report. These data have been used by the USGS to (1) identify the sources, transport, and fate of nutrients in the Tualatin River Basin, (2) quantify relations among nutrient loads, algal growth, low dissolved-oxygen concentrations, and high pH, and (3) develop and calibrate a water-quality model that allows managers to test options for alleviating water-quality problems.

INTRODUCTION

High nutrient concentrations in the Tualatin River Basin (fig. 1, pl. 1) can sometimes lead to nuisance levels of algal growth. These algal blooms may result in low dissolved-oxygen (DO) concentrations and high pH levels, which are potentially hazardous to aquatic organisms. The Tualatin River Basin study is a cooperative project between the U.S. Geological Survey (USGS) and the Unified Sewerage Agency of Washington County (USA) to determine the sources and effects of nutrient loads on the water quality of the Tualatin River during summer low-flow conditions. USA monitors the effluent from its wastewater-treatment facilities as well as the flow and water quality of the Tualatin

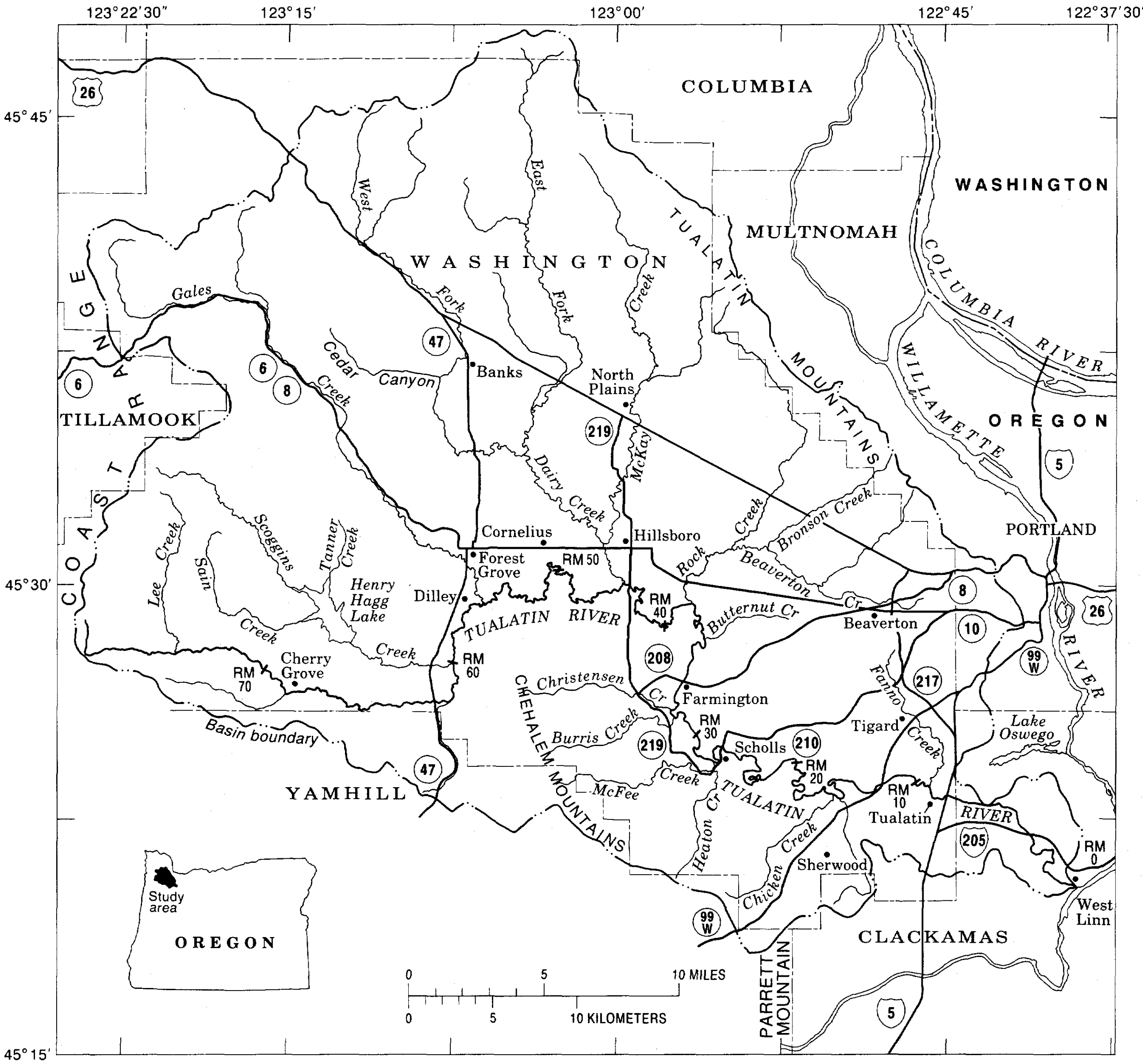

Figure 1. Tualatin River Basin.

River. State and local agencies have implemented water-quality control activities and programs in their efforts to comply with the total maximum daily loads (TMDLs) imposed in compliance with section 303 of the Clean Water Act (CWA) of 1972. TMDLs are established for water when minimum treatment controls for point sources are not stringent enough to meet established instream water-quality standards. To predict the effectiveness of the water-quality-management options available for the Tualatin River, water managers need an understanding of the river's water-quality characteristics and dynamics, as well as a predictive tool that can aid in the decision-making process.

To meet those needs, the project was designed to accomplish the following objectives: (1) identify the sources and fate of nutrients in the river, (2) quantify relations among nutrient loads, algal growth, dissolved-oxygen concentrations, and pH levels, and (3) develop and calibrate a water-quality model that allows managers to test options for alleviating water-quality problems in the Tualatin River.

Purpose and Scope

The purpose of this report is to present the data collected during the cooperative study of the Tualatin River Basin by the USGS and USA. The report documents the sampling sites, field-measurement techniques, sampling techniques, laboratory-analysis techniques, and the results of an ongoing quality-assurance program. The report also contains field measurements and analytical and quality-control data from main-stem Tualatin River sites, major tributary sites, ground-water sites, and USA wastewater-treatment facilities. The data were collected between January 1991 and December 1993; additional ground-water data were collected in 1990 and 1994. Data in this report may be used by State and local authorities in their efforts to measure compliance with the TMDLs established for the Tualatin River. These data may also be used by water managers to determine whether nutrient reduction plans for the Tualatin River are effective.

The data collected during this study are stored in subject-specific data files on a Compact Disk-Read Only Memory (CD-ROM) in American Standard Code for Information Interchange (ASCII) format, readable on DOS, UNIX, and Macintosh platforms. The data files stored on CD-ROM are listed and briefly described in table 1; data formats are detailed in Appendix 1. Presenting the data in digital ASCII files rather than in formatted tables has several advantages: (1) the data can be easily accessed for computer applications, (2) the data can be distributed readily over computer networks, and (3) the data are easier to store and transport on CD-ROM compared to a large, printed report.

Study Area

The Tualatin River Basin (fig. 1 and pl. 1) is approximately 43 miles long and 29 miles wide and has an area of about 712 square miles. The Tualatin River Basin is a subbasin of the Willamette River Basin and is located west of Portland. The Tualatin River drains most of Washington County and small areas of Multnomah, Clackamas, Yamhill, Tillamook, and Columbia Counties. The basin is bounded by the Coast Range on the west and northwest, the Chehalem Mountains and Parrett Mountain on the south, and the Tualatin Mountains on the east and northeast. For most of its length, the Tualatin River is slow moving and meandering. The river originates in the Coast Range and flows generally eastward for 79.4 miles before emptying into the Willamette River near West Linn, Oregon.

Agricultural and forest lands constitute about 83 percent of the basin's land area in Washington County (S.D. Kelley, Washington County Department of Land Use and Transportation, written commun., 1995). Agricultural commodities include nursery and greenhouse crops, fruits and berries, grain and hay, christmas trees, and other forest products. Urban land accounts for slightly more than 13 percent of the acreage of Washington County. The remaining 4 percent of the acreage in Washington County is classified as public right-of- way, which includes roads, bridges, paths, and sidewalks. The population in Washington County nearly doubled from 157,900 in 1970 to 311,550 in 1990 (Washington County Department of Land Use and Transportation, undated). Recent projections for the year 2010 predict a populace of 439,500. Continued population and economic growth in the Tualatin River Basin has increased discharges of domestic wastewater, urban stormwater, and industrial waste into the Tualatin River; this trend will likely continue in the near future.

Table 1. Data files on CD-ROM
[BOD, biochemical oxygen demand; CBOD, carbonaceous biochemical oxygen demand; USA, Unified Sewerage Agency]

Subdirectory	File name	Bytes	Description
biodata	algal.dat	444213	phytoplankton data from water-quality samples
	algal.hdr	806	header file for above data file
	lightext.dat	6920	light extinction coefficients
	lightext.hdr	545	header file for above data file
	zooplank.dat	334950	zooplankton data
	zooplank.hdr	767	header file for above data file
cont_dat	light.dat	361925	insolation rates from continuous quantum sensors
	light.hdr	824	header file for above data file
	meteoro.dat	24120	meteorological data for 1991–93 (period of this study)
	meteoro.hdr	788	header file for above data file
	qwmonitr.dat	884184	data from four-parameter probe at river mile 3.4
	qwmonitr.hdr	738	header file for above data file
flow	flow.dat	494718	streamflow discharge data
	flow.hdr	926	header file for above data file
	14206990.dat	46032	gage-height readings from Tualatin River at Oswego Canal
	14206990.hdr	1030	header file for above data file
	wwtpflow.dat	172430	discharge data from USA treatment plants
	wwtpflow.hdr	532	header file for above data file
qadata	algalqa.dat	22149	quality-assurance data for phytoplankton samples
	algalqa.hdr	884	header file for above data file
	bodrepl.dat	10070	quality-assurance data for BOD samples
	bodrepl.hdr	1261	header file for above data file
	cbodrepl.dat	2357	quality-assurance data for CBOD samples
	cbodrepl.hdr	1085	header file for above data file
	gwqa.dat	21375	quality-assurance data for ground-water samples
	gwqa.hdr	1056	header file for above data file
	swqa.dat	539035	quality-assurance data for surface-water samples
	swqa.hdr	1231	header file for above data file
qwdata	cbod.dat	23436	CBOD data from water samples
	cbod.hdr	1065	header file for above data file
	cbodwwtp.dat	13104	CBOD data from USA treatment-plant samples
	cbodwwtp.hdr	1065	header file for above data file
	grdwtr.dat	143241	water-quality data from ground-water samples
	grdwtr.hdr	1067	header file for above data file
	mainstem.dat	4679739	water-quality data from sites on Tualatin River
	mainstem.hdr	1853	header file for above data file
	tribs.dat	2267801	water-quality data from Tualatin River Basin tributary sites
	tribs.hdr	1843	header file for above data file
	wwtp.dat	3121042	water-quality data from USA treatment plants
	wwtp.hdr	1856	header file for above data file

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DATA COLLECTION AND LABORATORY ANALYSIS

Data collection involved the following tasks: (1) collecting field-measured water-quality data and samples from surface water, (2) collecting field-measured water-quality data and samples from ground water, (3) collecting streamflow data, (4) analyzing physical and chemical characteristics of water samples, (5) collecting and analyzing aquatic-biology samples, (6) collecting insolation data, (7) maintaining a four-parameter water-quality monitor at river mile (RM) 3.4, (8) calculating light-extinction coefficients for three stations in the lower Tualatin River, (9) transcribing meteorological data from the Tualatin Valley Irrigation District (TVID) Agrimet Weather Station in Verboort, Oregon (pl. 1), and (10) collecting and compiling quality-assurance data from the USA Water Quality Laboratory, the USA Rock Creek Treatment Facility Laboratory, the USA Durham Treatment Facility Laboratory, the USGS National Water Quality Laboratory (NWQL) in Arvada, Colorado, and the USGS District Laboratory in Portland, Oregon.

Water-Quality-Sample Collection

The collection of surface-water-quality samples was a coordinated effort among USGS and USA sampling teams. Main-stem sites, tributary sites, and wastewater-treatment-plant effluent were sampled over the 1991–93 study period. Ground-water samples were collected from late 1990 through the summer of 1994.

Surface Water

The more frequently sampled surface-water sites were sampled one to three times a week during summer or low-flow periods and less frequently during winter or high-flow periods. Some tributary sites were sampled as infrequently as once a month. For locations of surface-water sites, see tables 2–4 and plate 1. A list of selected regularly sampled surface-water-quality sites on the main-stem Tualatin River and the number of data values for various water-quality parameters recorded for each site are listed in table 5. A similar list for the regularly sampled Tualatin River tributary sites is given in table 6. USGS and USA site-numbering systems are explained in Appendix 2.

Water-quality sample-collection methods of the USGS and USA for surface-water samples were not identical during the first year of this study (1991). Both agencies collected samples from the Tualatin River by using a weighted-bottle sampler equipped with one or two rectangular 2-liter sample bottles. The differences in water-sample-collection techniques by both agencies during the first year of this study were as follows: (1) USA personnel sampled at the center of the river, whereas USGS personnel sampled at five points along a cross section of the river, (2) USA personnel lowered their sampler to a depth of 3 feet, whereas USGS personnel lowered their sampler to a depth of 10 feet or to the bottom of the channel (without disturbing the bottom sediments), and (3) USA personnel subsampled from the rectangular 2-liter bottles, whereas USGS personnel composited their samples into a churn splitter and subsampled from the composited sample. At tributary sites with shallow water, where a depth-integrating sampler could not be used, samples were collected by dipping the sample bottle into the stream by hand. USA personnel subsampled from this sample bottle, whereas USGS personnel composited samples into the churn splitter and then subsampled from the composited sample. By May 1992, USA sampling teams had adopted USGS sampling techniques and equipment for collecting surface-water samples. The sample-collection methods for surface-water samples are differentiated in the data files by using a two-letter abbreviation. The definitions for sample-collection methods are listed in table 7. The USGS Water STOrage and REtrieval System (WATSTORE) parameter codes for the surface-water-quality parameters measured are listed in table 8.

Ground Water

Ground-water sites were sampled by the USGS only. Ground-water sites consisted of 15 USGS-installed in-channel piezometers and 51 domestic wells throughout the Tualatin River Basin. Ground-water sites are identified by using a station number consisting of latitude and longitude (rounded to the nearest second) followed by a two-digit sequence number. Ground-water sites sampled for this study are listed in table 9 and shown in plate 1.

In-Channel Piezometers

Ground water just below the sediments of the main-stem Tualatin River was sampled at 15 locations after the installation of in-channel piezometers. Constructed of a stainless-steel sand point screen and a 1.5-inch polyvinyl-chloride (PVC) casing, these piezometers were driven directly into the riverbed to depths ranging from about 5 to 15 feet. Enough PVC casing was attached to allow each piezometer to be sampled from a boat on the river surface.

Ground water within the in-channel piezometers was pumped out 2 to 7 days prior to collecting a sample for analysis. This method was used to avoid collecting water that had been exposed to atmospheric conditions inside the well casing for an extended period of time. In addition, this procedure allowed a more representative sample of the ground water to be collected. Before collecting a sample for analysis, the water level inside the well was measured. A Hydrolab multiparameter instrument with an attached flow-through chamber was used to measure the temperature, pH, dissolved oxygen, and specific conductance of the ground water. Sample-collection methods used for in-channel wells are described in table 7 under the "CW" sample type. The USGS WATSTORE parameter codes for the ground-water-quality parameters measured are listed in table 10.

Domestic Wells

When possible, the water level for each domestic well was measured before obtaining water samples. Water-treatment devices, such as water softeners and water filters, were disconnected before attaching sampling equipment. Sampling equipment was attached as close to the wellhead as possible. Sampling equipment consisted of stainless-steel

Table 2. Main-stem Tualatin River sampling sites
[USA, Unified Sewerage Agency; USGS, U.S. Geological Survey; DDDMMSS, degrees, minutes, seconds; --, no number assigned]

Map number	USA station number	USGS station number	Station Name	Latitude (DDDMMSS)	Longitude (DDDMMSS)
1	3701715	14202300	Tualatin River at Cherry Grove, Oregon	0452803	1231721
4	3701612	14203500	Tualatin River near Dilley, Oregon	0452830	1230723
12	3701528	14204800	Tualatin River at Golf Course Road near Cornelius, Oregon	0453008	1230318
17	--	14204900	Tualatin River above Dairy Creek near Hillsboro, Oregon	0453006	1225941
21	3701450	14206250	Tualatin River above Jackson Bottom near Hillsboro, Oregon	0452959	1225909
25	--	14206265	Tualatin River above irrigation return flow near Hillsboro, Oregon	0452959	1225846
27	--	14206275	Tualatin River at River mile 43.0 near Hillsboro, Oregon	0452937	1225855
29	3701423	14206285	Tualatin River at Minter Bridge near Hillsboro, Oregon	0452906	1225850
31	3701391	14206440	Tualatin River at Rood Bridge at Hillsboro, Oregon	0452925	1225701
34	3701380	14206460	Tualatin River at Meriwether irrigation pump near Hillsboro, Oregon	0452842	1225624
36	3701336	14206500	Tualatin River at Farmington, Oregon	0452700	1225700
41	3701271	14206690	Tualatin River at Highway 210 bridge, near Scholls, Oregon	0452505	1225511
42	3701233	14206700	Tualatin River near Scholls, Oregon	0452339	1225351
43	3701165	14206740	Tualatin River at Elsner Road near Sherwood, Oregon	0452309	1225149
47	3701116	14206785	Tualatin River at Highway 99W Bridge near King City, Oregon	0452340	1224750
48	--	14206790	Tualatin River at river mile 13.06 near King City, Oregon	0452345	1224919
50	3701087	14206960	Tualatin River at Boones Ferry Road at Tualatin, Oregon	0452310	1224522
52	--	14206975	Tualatin River at river mile 7.3 near Lake Oswego, Oregon	0452301	1224355
53	3701068	14206990	Tualatin River at Oswego Canal at Tualatin, Oregon	0452257	1224312
55	--	14207030	Tualatin River at river mile 6.1 near Lake Oswego, Oregon	0452300	1224232
56	3701054	14207050	Tualatin River at Stafford Road near Lake Oswego, Oregon	0452247	1224148
57	--	14207150	Tualatin River at river mile 4.6 near Lake Oswego, Oregon	0452211	1224125
58	--	14207160	Tualatin River at river mile 4.0 near Lake Oswego, Oregon	0452148	1223830
59	3701018	14207500	Tualatin River at West Linn, Oregon	0452103	1224030
60	3701002	14207600	Tualatin River at Weiss bridge at West Linn, Oregon	0452023	1223912

Table 3. Tualatin River Basin tributary sampling sites
[USA, Unified Sewerage Agency; USGS, U.S. Geological Survey; DDDMMSS, degrees minutes, seconds; --, no number assigned]

Map number	USA station number	USGS station number	Station name	Latitude (DDDMMSS)	Longitude (DDDMMSS)
219	3805048	14202980	Scoggins Creek below Henry Hagg Lake	0452810	1231156
3	3805017	14203000	Scoggins Creek at Old Highway 47	0452732	1230916
5	3809011	14203700	Carpenter Creek near Forest Grove, Oregon	0453012	1230657
6	3810015	14204530	Gales Creek at Highway 47 at Forest Grove, Oregon	0453039	1230652
10	--	14204670	Unnamed Tributary at Geiger Road near Forest Grove, Oregon	0453008	1230459
13	--	14204830	Unnamed Tributary at Golf Course Road near Cornelius, Oregon	0453028	1230336
14	--	14204840	Unnamed Tributary at Golf Course near Cornelius, Oregon	0452912	1230216
15	--	14204860	Unnamed Tributary at Cook Road near Cornelius, Oregon	0453020	1230129
16	--	14204865	Tile drain below Cook Road near Cornelius, Oregon	0452943	1230106
18	3815021	14206200	Dairy Creek at Highway 8 near Hillsboro, Oregon	0453112	1230034
19	--	14206230	Dairy Creek at mouth near Hillsboro, Oregon	0453006	1225940
20	--	14206240	Unnamed Tributary at Highway 219 near Hillsboro, Oregon	0453001	1225924
22	3893007	14206255	Jackson Slough at mouth near Hillsboro, Oregon	0452959	1225906
23	--	14206260	Irrigation seeps to Tualatin at river mile 43.8	0452955	1225902
24	--	14206263	Seep near landfill ponds near Hillsboro, Oregon	0453000	1225846
26	3898004	14206270	Unnamed Tributary (Miller Swale) at river mile 43.5 near Hillsboro, Oregon	0452959	1225846
28	--	14206280	Unnamed Tributary at river mile 42.8 near Hillsboro, Oregon	0452926	1225854
30	--	14206290	Unnamed Tributary at river mile 40.2 Near Hillsboro, Oregon	0452842	1225758
32	3820047	14206445	Rock Creek at Quatama Road near Hillsboro, Oregon	0453126	1225429
33	3820012	14206450	Rock Creek near Hillsboro, Oregon	0453009	1225648
35	3822002	14206490	Butternut Creek at River Road near Farmington, Oregon	0452821	1225646
37	3830018	14206600	Christensen Creek near Farmington, Oregon	0452619	1225827
38	3831005	14206650	Burris Creek near Farmington, Oregon	0452532	1225735
39	3811010	14206670	McFee Creek near Scholls, Oregon	0452405	1225614
40	3813001	14206680	Baker Creek near Scholls, Oregon	0452408	1225536
44	3835020	14206750	Chicken Creek near Sherwood, Oregon	0452230	1225119
45	--	14206755	Rock Creek at Rock Creek Road near Six Corners, Oregon	0452205	1224939
46	3839005	14206760	Rock Creek near Sherwood, Oregon	0452254	1224932
49	3840012	14206950	Fanno Creek at Durham, Oregon	0452413	1224513
51	3838002	14206970	Nyberg Creek at Tualatin, Oregon	0452258	1224421

Table 4. Intermittently sampled Tualatin River Basin tributary sites
[USGS, U.S. Geological Survey; DDDMMSS, degrees, minutes, seconds; "right bank" and "left bank" refer to bank of river as viewed facing downstream]

Map number	USGS station number	Station name	Latitude (DDDMMSS)	Longitude (DDDMMSS)
82	452722122565700	Tile drain on right bank at river mile 40.50	0452843	1225751
83	452724122564400	Tile drain on right bank at river mile 35.92	0452831	1225604
84	452727122564300	Tile drain on left bank at river mile 35.90	0452829	1225603
85	452734122564000	Tile drain on right bank at river mile 35.80	0452824	1225601
87	452746122562800	Unnamed tributary on left bank at river mile 35.65	0452807	1225559
88	452808122555700	Tile drain on right bank at river mile 34.60	0452802	1225634
89	452810122563300	Tile drain on right bank at river mile 35.25	0452803	1225508
90	452820122555800	Unnamed tributary on left bank at river mile 34.20	0452741	1225628
92	452835122560600	Seep on left bank at river mile 36.10	0452835	1225606
94	452840122562400	Seep on right bank at river mile 36.70	0452840	1225619
95	452842123081201	Unnamed tributary to Tualatin River near Dilley, Oregon	0452842	1230812
97	452843122573900	Tile drain on right bank at river mile 39.90	0452843	1225739
98	452845122560600	Tile drain on left bank at river mile 36.30	0452845	1225606
99	452845122562600	Tile drain on right bank at river mile 36.80	0452845	1225626
100	452850122573100	Tile drain on right bank at river mile 39.25	0452857	1225731
101	452851122582600	Tile drain on right bank at river mile 41.10	0452851	1225821
107	452909122561300	Gordon Creek near Hillsboro, Oregon	0452909	1225613
108	452909122590900	Tile drain on right bank at river mile 41.90	0452912	1225905
111	452918122591000	Tile drain on right bank at river mile 42.10	0452913	1225910
112	452919122572400	Tile drain on right bank at river mile 38.80	0452919	1225724
113	452924122570400	Tile drain on right bank at river mile 38.50	0452924	1225704
114	452927122562800	Seep on right bank at river mile 37.80	0452914	1225628
116	452939123015600	Unnamed tributary on right bank at river mile 47.40	0452939	1230156
117	452940123020700	Tile drain on left bank at river mile 47.50	0452940	1230207
118	452940123020800	Tile drain on left bank at river mile 47.60	0452940	1230208
121	452952123003500	Tile drain on right bank at river mile 49.80	0452926	1230247
122	452955122584600	Seep on left bank at river mile 43.35	0452955	1225846
123	452955122590100	Seep on left bank at river mile 43.75	0452955	1225901
125	452958122584500	Seep on left bank at river mile 43.50	0452958	1225845
126	452959122584700	Seep on left bank at river mile 43.65	0452813	1225730
128	453001122592400	Unnamed tributary on right bank at river mile 44.40	0453001	1225924
131	453022123030700	Tile drain on left bank at river mile 51.20	0453022	1230307
132	453028123022100	Seep on left bank at river mile 49.40	0453028	1230221
135	453040123024900	Tile drain on left bank at river mile 50.35	0453040	1230249
137	453041123031100	Seep on left bank at river mile 50.70	0453041	1230311
138	453042123031000	Seep on left bank at river mile 50.65	0453042	1230310
139	453045123030300	Tile drain on left bank at river mile 50.50	0453045	1230303
143	453113122544401	Rock Creek near Hillsboro, Oregon	0453113	1225444
144	453115122535500	Beaverton Creek at 216th Avenue near Orenco, Oregon	0453115	1225355

Table 5. Frequency of analysis of selected water-quality parameters with associated WATSTORE parameter codes at selected sites on the main-stem Tualatin River

[USGS, U.S. Geological Survey; USA, Unified Sewerage Agency; WATSTORE, Water Storage and Retrieval System Codes]

Map number	USA station number	USGS station number	Water Temperature 10	Turbidity 76	Specific conductance, Field 94	Oxygen Dissolved 299	pH, Field 400	Total Solids 500	Total Ammonia 610	Total Nitrite plus Nitrate 630	Total Phosphorus 665	Dissolved Chloride 940	Chlorophyll *a* 32209
1	3701715	14202300	42	28	2	40	2	42	43	43	43	43	0
4	3701612	14203500	210	160	190	192	193	209	211	212	208	206	154
12	3701528	14204800	204	163	174	174	174	204	204	204	201	204	134
21	3701450	14206250	188	135	182	182	186	184	184	187	182	185	142
31	3701391	14206440	145	114	137	140	145	142	142	145	140	139	99
34	3701380	14206460	77	53	78	77	77	78	78	78	76	78	78
41	3701271	14206690	1,377	192	1,366	1,352	1,130	263	263	265	258	259	220
42	3701233	14206700	21	19	0	0	22	68	44	68	67	68	43
43	3701165	14206740	1,199	194	1,132	1,121	1,004	313	265	318	314	311	219
47	3701116	14206785	747	79	740	731	550	126	126	127	122	127	125
50	3701087	14206960	766	193	760	760	666	264	264	273	259	268	219
56	3701054	14207050	1,519	206	1,487	1,493	1,273	277	277	302	285	286	219
59	3701018	14207500	45	12	0	0	46	0	8	19	19	19	0
60	3701002	14207600	143	115	142	143	141	143	143	143	141	139	99

Table 6. Frequency of analysis of selected water-quality parameters with associated WATSTORE parameter codes at selected tributary sites, Tualatin River Basin, Oregon
[WATSTORE, Water Storage and Retrieval System Codes; USA, Unified Sewerage Agency; USGS, U.S. Geological Survey]

Map number	USA station number	USGS station number	Water temperature 10	Turbidity 76	Specific conductance, Field 94	Oxygen, Dissolved 299	pH, Field 400	Total solids 500	Total ammonia 610	Total nitrite plus nitrate 630	Total phosphorus 665	Dissolved chloride 940	Chlorophyll *a* 32209
2	3805048	14202980	29	15	0	0	0	29	29	29	29	29	0
3	3805017	14203000	43	28	2	2	3	43	44	44	43	44	0
5	3809011	14203700	15	0	0	0	1	15	15	15	15	15	0
6	3810015	14204530	150	108	116	119	122	148	149	149	147	147	79
18	3815021	14206200	213	162	194	195	200	211	212	214	208	211	155
22	3893007	14206255	23	0	13	0	23	13	13	18	27	27	0
26	3898004	14206270	30	0	18	0	29	18	18	30	34	34	0
33	3820012	14206450	211	161	204	203	207	211	214	216	213	210	167
35	3822002	14206490	51	27	50	48	49	50	50	50	49	51	50
37	3830018	14206600	58	34	57	55	56	57	57	57	56	58	57
38	3831005	14206650	58	34	57	56	54	57	56	57	55	58	57
39	3811010	14206670	58	34	57	53	56	57	57	57	56	58	57
40	3813001	14206680	58	34	57	55	56	57	57	57	56	58	57
44	3835020	14206750	124	97	123	120	122	123	123	122	122	124	81
46	3839005	14206760	59	34	57	56	57	58	58	58	57	59	57
49	3840012	14206950	234	152	210	209	232	211	211	228	226	219	166
51	3838002	14206970	52	27	50	49	48	51	51	50	50	52	50

Table 7. Codes and definitions of sample-collection methods

[USA, Unified Sewerage Agency; USGS, U.S. Geological Survey; NWQL, National Water Quality Laboratory]

Sample-type code	Sample-collection type	Sample-collection method
CW	In-channel well	Water was pumped out of the well 2 to 7 days prior to the sampling date by using a peristaltic pump with Tygon tubing. The water was pumped from the bottom of the well to obtain a more representative ground-water sample. Initially, water was pumped into a flow-through cell attached to a Hydrolab multiparameter instrument to obtain field measurements of temperature, pH, dissolved oxygen, and specific conductance. Samples were then pumped directly into sample bottles or directly filtered, in an effort to reduce ground-water exposure to the atmosphere. Samples were then chilled on ice and shipped overnight to the USGS NWQL. Sample tubing was rinsed with distilled-deionized water before and after sampling.
DC	Discrete composite	Water samples were collected over a 24-hour period. The samples were composited over equal hour time intervals. The sample volumes collected were the same at every interval. This is a USA treatment facility method for collecting effluent samples.
DM	Domestic well	Water from the well was pumped through a flow-through cell attached to a Hydrolab or other multiparameter instrument until field parameter readings were stabilized. After the field readings were stable, the water was considered to be representative of the "actual" ground water. Ground water was then pumped directly into sample bottles or filtered. The sample bottles were chilled and sent overnight to the USGS NWQL.
DS	Depth specific	Depth-specific samples were collected at a known depth in the water column. Depth-specific field measurements were taken at known depths in the water column and primarily at main-stem Tualatin River sites below river mile 30.
ED	Equal-discharge increment	Samples were obtained from the centroids of equal-discharge increments. This method requires some knowledge of the distribution of streamflow in the cross section based on a long period of discharge record or on a discharge measurement made immediately prior to selecting the sampling verticals. A minimum of four and a maximum of nine verticals were composited into a USGS churn splitter and subsampled for analyses[1].
EW	Equal-width increment	This method requires a sample volume proportional to the amount of flow at each of several equally spaced verticals in a cross section. A minimum of 10 verticals and a maximum of 20 verticals were composited into a USGS churn splitter and subsampled for analyses[1].
FC	Flow composite	Water samples were composited over a 24-hour period. These samples were flow proportioned. An example of this would be a sampler that is set up to collect 100 milliliters of effluent for every 10,000 gallons of flow over the 24-hour sampling period. This sampling technique is used by the USA wastewater-treatment facilities for collecting effluent samples.
FM	Field measurement	Measurements of temperature, dissolved oxygen, specific conductance, and pH were made in the field. These values can change after samples have been stored for a period of time. More accurate field values are obtained when such measurements are made on-site. Individual probes or multiparameter probes were used to obtain field measurements.
GS	Grab sample	Samples were acquired at a point in the stream (preferably at midchannel if possible) by dipping a sample bottle into the body of water to be sampled. Grab samples were usually collected when a depth-integrating sampler could not be submerged, or when the flow in the channel was not wide enough to warrant composition of a sample from a cross section of the stream.
HY	Hypolimnion	Depth-specific hypolimnetic water samples were collected using a Van Dorn type sampler and subsampled into individual bottles for analyses.

Table 7. Codes and definitions of sample-collection methods—Continued

[USA, Unified Sewerage Agency; USGS, U.S. Geological Survey; NWQL, National Water Quality Laboratory]

Sample-type code	Sample-collection type	Sample-collection method
IC	Integrated composite	Water samples were collected using a weighted-bottle type sampler equipped with a 2-liter rectangular sample bottle. The sample bottle was fitted with a tube in the lid that allowed the bottle to slowly fill as the weighted sampler was lowered and raised through the water column. The sampler was lowered to the bed sediment, being careful not to disturb the bottom sediment. Five of these samples in a cross section were collected and composited into a USGS churn splitter. The composited sample from the churn splitter was then subsampled for individual analyses.
IS	Integrated sample	Water samples were collected using a weighted-bottle type sampler equipped with two individual 2-liter sample bottles. The sampler was lowered in the centroid of the river to a depth of 3 feet and allowed to fill. The top 3 feet of the water column were integrated. The water samples were then capped, shaken, and subsampled for individual analyses.
IT	Integrated composite (10-foot vertical profile)	Water samples were collected using a weighted-bottle type sampler equipped with a 2-liter rectangular sample bottle. The sample bottle was fitted with a tube in the lid that allowed the bottle to slowly fill as the weighted sampler was lowered and raised through the water column. The sampler was lowered to a depth of only 10 feet to avoid collecting water that may have been trapped in the hypolimnion. Five of these samples in a cross section were collected and composited into a USGS churn splitter. The composited sample from the churn splitter was then subsampled for individual analyses.
RP	Replicate sample	Duplicate samples of similar composition used to test precision.

[1]This technique is explained in greater detail in Edwards and Glysson (1988).

Table 8. Constituents analyzed in surface-water samples from the Tualatin River Basin, Oregon
[WATSTORE, Water Storage and Retrieval System Codes]

WATSTORE code	Parameter name	Unit of measure
00010	Water temperature	degrees Celsius
00061	Discharge, instantaneous	cubic feet per second
00076	Turbidity	nephelometric turbidity units (NTU)
00077	Transparency, Secchi disk	inches
00094	Specific conductance, field[1]	microsiemens per centimeter at 25 degrees Celsius
00095	Specific conductance[1]	microsiemens per centimeter at 25 degrees Celsius
00299	Oxygen, dissolved, analysis by probe[2]	milligrams per liter
00300	Oxygen, dissolved[2]	milligrams per liter
00301	Oxygen, dissolved	percent saturation
00310	Biochemical oxygen demand, 5-day at 20 degrees Celsius	milligrams per liter
00400	pH, water, whole, field	standard units
00403	pH, water, whole, laboratory	standard units
00410	Alkalinity, water, whole, total, fixed endpoint titration, field	milligrams per liter as calcium carbonate ($CaCO_3$)
00500	Solids, residue on evaporation at 105 degrees Celsius	milligrams per liter
00515	Residue, total filterable, dried at 105 degrees Celsius	milligrams per liter
00530	Residue, total nonfilterable	milligrams per liter
00608	Nitrogen, ammonia, dissolved	milligrams per liter as N
00610	Nitrogen, ammonia, total	milligrams per liter as N
00613	Nitrogen, nitrite, dissolved	milligrams per liter as N
00615	Nitrogen, nitrite, total	milligrams per liter as N
00620	Nitrogen, nitrate, total	milligrams per liter as N
00625	Nitrogen, ammonia plus organic, total	milligrams per liter as N
00630	Nitrogen, nitrite plus nitrate, total	milligrams per liter as N
00631	Nitrogen, nitrite plus nitrate, dissolved	milligrams per liter as N

Table 8. Constituents analyzed in surface-water samples from the Tualatin River Basin, Oregon—Continued
[WATSTORE, Water Storage and Retrieval System Codes]

WATSTORE code	Parameter name	Unit of measure
00665	Phosphorus, total	milligrams per liter as P
00666	Phosphorus, dissolved	milligrams per liter as P
00671	Phosphorus, orthophosphate, dissolved	milligrams per liter as P
00915	Calcium, dissolved	milligrams per liter
00925	Magnesium, dissolved	milligrams per liter
00930	Sodium, dissolved	milligrams per liter
00935	Potassium, dissolved	milligrams per liter
00940	Chloride, dissolved	milligrams per liter
00945	Sulfate, dissolved	milligrams per liter as sulfate (SO_4^{2-})
00950	Fluoride, dissolved	milligrams per liter
00955	Silica, dissolved	milligrams per liter as silica (SiO_2)
01045	Iron, total	micrograms per liter
01046	Iron, dissolved	micrograms per liter
01055	Manganese, total	micrograms per liter
01056	Manganese, dissolved	micrograms per liter
01080	Strontium, dissolved	micrograms per liter
32209	Chlorophyll *a*, fluorometric method, corrected	micrograms per liter
32213	Pheophytin *a*, fluorometric method	micrograms per liter
80082	Biochemical oxygen demand, biochemical Carbon 5-day	milligrams per liter
90095	Specific conductance, laboratory	microsiemens per centimeter at 25 degrees Celsius
90410	Alkalinity, titration to pH 4.5, laboratory	milligrams per liter as calcium carbonate ($CaC0_3$)

[1]For the purposes of this report, consider both parameter codes 00094 and 00095 to be identical. When sample-type code is "FM" (field measurement), specific conductance was measured in the field; otherwise specific conductance was measured in the laboratory.

[2]Unified Sewerage Agency typically uses parameter code 299 for dissolved-oxygen measurements obtained in the field. U.S. Geological Survey typically uses parameter code 300 for dissolved-oxygen measurements obtained in the field. For the purposes of this report, consider both parameter codes to be identical.

Table 9. Description and locations of ground-water sampling sites, Tualatin River Basin, Oregon
[USGS, U.S. Geological Survey; DDDMMSS, degrees, minutes, seconds; E, estimated; >, greater than]

Map number	USGS station number	Latitude (DDDMMSS)	Longitude (DDDMMSS)	Elevation of land surface (feet)	Primary use of well	Primary use of water	Depth of well (feet)
61	452325122471701	0452325	1224717	167	Withdrawal of water	Irrigation	90
62	452342122470701	0452342	1224707	145	Withdrawal of water	Domestic	66
63	452348122501801	0452348	1225018	168	Withdrawal of water	Domestic	190
64	452349122455101	0452349	1224551	114	Withdrawal of water	Domestic	167
66	452416122541601	0452416	1225416	143	Withdrawal of water	Domestic	102
67	452418122541301	0452418	1225413	145	Withdrawal of water	Domestic	105
68	452421122523101	0452421	1225231	91	Observation	Unused	7.2
68	452421122523102	0452421	1225231	91	Observation	Unused	5.45
69	452424122544301	0452424	1225443	133	Withdrawal of water	Domestic	112
70	452437122453701	0452437	1224537	200	Withdrawal of water	Domestic	76
71	452453122551501	0452453	1225515	96	Observation	Unused	9.2
71	452453122551502	0452453	1225515	96	Observation	Unused	11.5
72	452558122575201	0452558	1225752	145	Withdrawal of water	Domestic	101
73	452610122582901	0452610	1225829	175	Withdrawal of water	Domestic	40
74	452611122591801	0452611	1225918	195	Withdrawal of water	Domestic	165
75	452618122551301	0452618	1225513	159	Withdrawal of water	Domestic	190
76	452623122470801	0452623	1224708	175	Withdrawal of water	Domestic	67
77	452651122565001	0452651	1225650	145	Withdrawal of water	Domestic	72
78	452700122565701	0452700	1225657	103	Observation	Unused	8.25
78	452700122565702	0452700	1225657.	103	Observation	Unused	11.4
79	452700122571001	0452700	1225710	145	Withdrawal of water	Domestic	122
80	452707122572201	0452707	1225722	155	Withdrawal of water	Domestic	83
81	452713122563001	0452713	1225630	150	Withdrawal of water	Stock	68
86	452742122561401	0452742	1225614	155	Withdrawal of water	Domestic	140
91	452831122564501	0452831	1225645	165	Withdrawal of water	Domestic	75
93	452836122555001	0452836	1225550	165	Withdrawal of water	Domestic	66
96	452843122562601	0452843	1225626	107	Observation	Unused	11.75
96	452843122562602	0452843	1225626	107	Observation	Unused	8.55
102	452854122555601	0452854	1225556	155	Withdrawal of water	Domestic	58
103	452856122590201	0452856	1225902	185	Withdrawal of water	Domestic	148
104	452903123022101	0452903	1230221	181	Withdrawal of water	Domestic	138
105	452904123004601	0452904	1230046	155	Withdrawal of water	Irrigation	85
106	452908123025201	0452908	1230252	185	Withdrawal of water	Domestic	110
109	452916122582001	0452916	1225820	185	Withdrawal of water	Domestic	69
110	452917122583201	0452917	1225832	165	Withdrawal of water	Stock	163
119	452941122562701	0452941	1225627	155	Withdrawal of water	Domestic	60
120	452951123042601	0452951	1230406	16	Withdrawal of water	Domestic	80

Table 9. Description and locations of ground-water sampling sites, Tualatin River Basin, Oregon—Continued
[USGS, U.S. Geological Survey; DDDMMSS, degrees, minutes, seconds; E, estimated; >, greater than]

Map number	USGS station number	Latitude (DDDMMSS)	Longitude (DDDMMSS)	Elevation of land surface (feet)	Primary use of well	Primary use of water	Depth of well (feet)
124	452955122591701	0452955	1225917	115	Observation	Unused	7.5
124	452955122591702	0452955	1225917	115	Observation	Unused	12.0
127	452959122584801	0452959	1225848	115	Observation	Unused	7.57
127	452959122584802	0452959	1225848	115	Observation	Unused	14.0
127	452959122584803	0452959	1225848	102	Observation	Unused	8.16
129	453002123025301	0453002	1230253	145	Withdrawal of water	Domestic	65
130	453005123031601	0453005	1230316	130	Observation	Unused	9.17
130	453005123031602	0453005	1230316	130	Observation	Unused	6.80
133	453031123004201	0453031	1230042	165	Withdrawal of water	Domestic	45
140	453050122574501	0453050	1225745	175	Withdrawal of water	Irrigation	63
141	453055122530901	0453055	1225309	185	Withdrawal of water	Domestic	70
142	453106122560601	0453106	1225606	120	Withdrawal of water	Domestic	48
145	453129122561401	0453129	1225614	185	Withdrawal of water	Irrigation	43
146	453138122560201	0453138	1225602	175	Withdrawal of water	Domestic	131
147	453221122594901	0453221	1225949	180	Withdrawal of water	Domestic	105
148	453222122555001	0453222	1225550	185	Withdrawal of water	Domestic	48
149	453244122584701	0453244	1225847	185	Withdrawal of water	Domestic	148
150	453253123054101	0453253	1230541	185	Withdrawal of water	Domestic	80
151	453324122572301	0453324	1225723	185	Withdrawal of water	Domestic	115
152	453401123032401	0453401	1230324	169	Withdrawal of water	Domestic	155
153	453417122572901	0453417	1225729	190	Withdrawal of water	Domestic	70
154	453422123020201	0453422	1230202	184	Withdrawal of water	Domestic	50E
155	453442123035201	0453442	1230352	175	Withdrawal of water	Domestic	71
156	453445123063201	0453445	1230632	171	Withdrawal of water	Domestic	100
157	453446123063301	0453446	1230633	171	Withdrawal of water	Domestic	28E
158	453540123041101	0453540	1230411	170	Withdrawal of water	Domestic	70
159	453545123072501	0453545	1230725	190	Withdrawal of water	Domestic	>100
160	453630122590501	0453630	1225905	215	Withdrawal of water	Domestic	115E
161	453710123012201	0453710	1230122	214	Withdrawal of water	Domestic	>100

Table 10. Constituents analyzed in ground-water samples from the Tualatin River Basin, Oregon
[WATSTORE, Water Storage and Retrieval System Code]

WATSTORE CODE	Parameter name	Unit of measure
00010	Water temperature	degrees Celsius
00095	Specific conductance, field	microsiemens per centimeter at 25 degrees Celsius
00300	Oxygen, dissolved	milligrams per liter
00400	pH, water, whole, field	standard units
00403	pH, water, whole, laboratory	standard units
00452	Carbonate, water, dissolved, incremental titration, field	milligrams per liter as carbonate (CO_3^{2-})
00453	Bicarbonate, water, dissolved, incremental titration, field	milligrams per liter as bicarbonate (HCO_3^-)
00608	Nitrogen, ammonia, dissolved	milligrams per liter as N
00613	Nitrogen, nitrite, dissolved	milligrams per liter as N
00623	Nitrogen, ammonia plus organic, dissolved	milligrams per liter as N
00631	Nitrogen, nitrite plus nitrate, dissolved	milligrams per liter as N
00665	Phosphorus, total	milligrams per liter as P
00666	Phosphorus, dissolved	milligrams per liter as P
00671	Phosphorus, orthophosphate, dissolved	milligrams per liter as P
00915	Calcium, dissolved	milligrams per liter
00925	Magnesium, dissolved	milligrams per liter
00930	Sodium, dissolved	milligrams per liter
00935	Potassium, dissolved	milligrams per liter
00940	Chloride, dissolved	milligrams per liter
00945	Sulfate, dissolved	milligrams per liter sulfate (SO_4^{2-})
00950	Fluoride, dissolved	milligrams per liter
00955	Silica, dissolved	milligrams per liter as silica (SiO_2)
01000	Arsenic, dissolved	micrograms per liter
01020	Boron, dissolved	micrograms per liter
01046	Iron, dissolved	micrograms per liter
01056	Manganese, dissolved	micrograms per liter
01080	Strontium, dissolved	micrograms per liter
01106	Aluminum, dissolved	micrograms per liter
39086	Alkalinity, water, dissolved, total, incremental titration, field	milligrams per liter as calcium carbonate ($CaCO_3$)
90095	Specific Conductance, laboratory	microsiemens per centimeter at 25 degrees Celsius
90410	Alkalinity, titration to pH 4.5, laboratory	milligrams per liter as calcium carbonate ($CaC0_3$)

pipes and metal valves attached to the existing plumbing. Teflon and plastic tubes were subsequently attached to the pipes and valves for collection of water samples. For the constituents sampled in this study, none of the sampling materials presented a risk of contamination. A flow-through chamber with separate probes or a Hydrolab multiparameter instrument with an attached flow-through chamber was used to measure temperature, pH, dissolved oxygen, and specific conductance. Sample-collection methods used for domestic wells are described in table 7 under the "DM" sample type.

Discharge Measurement and Data Collection

Streamflow, wastewater-treatment-plant discharge, and diversion-withdrawal data were collected during the entire period of this study. Records were maintained for seven main-stem Tualatin River sites, four major tributary sites, four wastewater-treatment plants, and three sites where water is diverted from the Tualatin River. Stations with discharge records are listed in tables 11–14. USGS techniques for the computation of streamflow records (Kennedy, 1983) were used in the preparation of discharge data maintained and computed by the USGS. Discharge data from USA treatment plants and flow measurements by other agencies were maintained and (or) computed using their own equipment and techniques. The USGS consulted and assisted in calibrating and installing the flowmeters used by the TVID and by USA at their treatment facilities. All discharge data presented in the data files are mean daily values and are reported in cubic feet per second (ft^3/s).

Streamflow Data

Main-stem stations that have continuous discharge for the entire 1991–93 period are Tualatin River near Dilley (RM 58.8), Tualatin River at Farmington (RM 33.3), and Tualatin River at West Linn (RM 1.8). Tualatin River at Springhill Road (RM 55.3) and Tualatin River at LaFollet Road (RM 53.8) stations were discontinued at the end of the low-flow season of 1991, and a new gaging station with continuous record was installed at Tualatin River at Golf Course Road (RM 51.5) in May of 1992. The Tualatin River at Rood Bridge Road (RM 38.4) gaging station has continuous record from May 1991 through December of 1993. Gage-height record is also measured on the Tualatin River at the Oswego Canal. See table 11 for a list of main-stem Tualatin River sites that have discharge data.

Tributary stations that have continuous discharge record include Scoggins Creek below Henry Hagg Lake and Fanno Creek at Durham. The gage at Scoggins Creek below Henry Hagg Lake is maintained year round and has a complete record for the period of this study; the gage on Fanno Creek was installed in December 1991. The gaging stations at Gales Creek near Forest Grove and Dairy Creek at Highway 8 near Hillsboro are stations where discharge is measured only during the low-flow period of the year. See table 12 for a list of tributary stations that have discharge data.

Unified Sewerage Agency Wastewater-Treatment-Plant Discharge Data

USA personnel maintain records of effluent discharge rates from the wastewater-treatment plants. The USA wastewater-treatment plant in Forest Grove and the USA treatment plant in Hillsboro release treated effluent into the Tualatin River only during the high-flow periods of the year, generally November through April. During the low-flow periods, the treated effluent from the Forest Grove and Hillsboro wastewater-treatment plants is not discharged to the Tualatin River. Instead, the treated effluent is used for irrigation or piped to the Rock Creek treatment plant. The USA facilities at Rock Creek and Durham discharge treated effluent year round to the Tualatin River. The Rock Creek and Durham treatment plants maintain continuous records of discharged effluent. The quantity of effluent discharged from these USA treatment plants was measured with flowmeters maintained by USA. See table 13 for a list of USA treatment plants for which there is discharge data.

Withdrawal Rates at Major Diversion Points along the Main-Stem Tualatin River

There are three major points where water is diverted from the main-stem Tualatin River (fig. 2): at the Joint Water Commission (JWC) Plant (RM 56.1), operated by the JWC; at the Springhill Pump Plant (also at RM 56.1), operated by the TVID; and at the Oswego Canal (RM 6.7), operated by the Lake

Table 11. Main-stem Tualatin River sites for which there is continuous discharge record available during 1991–93
[USA, Unified Sewerage Agency; USGS, U.S. Geological Survey; OWRD, Oregon Water Resources Department; DDDMMSS, degrees, minutes, seconds; record is for entire period unless otherwise indicated; "map number" refers to site number on plate 1]

Map number	USA station number	USGS station number	Station name	Latitude (DDDMMSS)	Longitude (DDDMMSS)	Period of record	Station maintained by	Record computed by
4	3701612	14203500	Tualatin River near Dilley, Oregon	0452830	1230723	1991–93	USGS	USGS
9	3701569	14204660	Tualatin River at Springhill Road	0453001	1230517	6/91–10/91	OWRD	USGS
11	3701532	14204700	Tualatin River at LaFollet Road	0452940	1230420	5/91–9/91	OWRD	USGS
12	3701528	14204800	Tualatin River at Golf Course Road near Cornelius, Oregon	0453008	1230318	5/92–12/93	OWRD	USGS
31	3701391	14206440	Tualatin River at Rood Bridge at Hillsboro, Oregon	0452925	1225701	5/91–12/93	OWRD	USGS
36	3701336	14206500	Tualatin River at Farmington, Oregon	0452700	1225700	1991–93	OWRD	USGS
53	3701068	14206990	Tualatin River at Oswego Canal at Tualatin, Oregon (gage height only)	0452257	1224312	1991–93	OWRD	USGS
59	3701018	14207500	Tualatin River at West Linn, Oregon	0452103	1224030	1991–93	USGS	USGS

Table 12. Tualatin River tributary sites for which there is continuous discharge record available during 1991–93
[USA, Unified Sewerage Agency; USGS, U.S. Geological Survey; OWRD, Oregon Water Resources Department; DDDMMSS, degrees, minutes, seconds; record is for entire period unless otherwise indicated; "map number" refers to site number on plate 1]

Map number	USA station number	USGS station number	Station name	Latitude (DDDMMSS)	Longitude (DDDSSMM)	Period of record	Station maintained by	Record computed by
2	3805048	14202980	Scoggins Creek below Henry Hagg Lake	0452810	1231156	1991–93	USGS	USGS
6	3810015	14204530	Gales Creek at Highway 47 at Forest Grove, Oregon	0453039	1230652	5/91–11/91 5/92–10/93	OWRD	USGS
18	3815021	14206200	Dairy Creek at Highway 8 near Hillsboro, Oregon	0453112	1230034	6/91–11/91 6/92–11/92 7/93–10/93	OWRD	USGS
49	3840012	14206950	Fanno Creek at Durham, Oregon	0452413	1224513	12/91–12/93	USGS	USGS

Table 13. Unified Sewerage Agency wastewater-treatment facilities for which there is discharge data available during 1991–93
[USA, Unified Sewerage Agency; USGS, U.S. Geological Survey; DDDMMSS, degrees, minutes, seconds; record is for entire period unless otherwise indicated; "map number" refers to site number on plate 1]

Map number	USA station number	USGS station number	Station name	Latitude (DDDMMSS)	Longitude (DDDMMSS)	Period of record	Station maintained by	Record computed by
65	2110014	452359122454500	Durham Wastewater Treatment Plant	0452359	1224545	1991–93	USA	USA
115	2330014	452938122565500	Rock Creek Wastewater Treatment Plant	0452938	1225655	1991–93	USA	USA
134	2350014	453037123051700	Forest Grove Wastewater Treatment Plant	0453037	1230517	1991–93	USA	USA
136	2370014	453040123052000	Hillsboro Wastewater Treatment Plant	0453050	1225917	1991–93	USA	USA

Table 14. Diversion stations on the main-stem Tualatin River
[USA, Unified Sewerage Agency; USGS, U.S. Geological Survey; OWRD, Oregon Water Resources Department; JWC, Joint Water Commission; TVID, Tualatin Valley Irrigation District; DDDMMSS, degrees, minutes, seconds; record is for entire period unless otherwise indicated; "map number" refers to site number on plate 1]

Map number	USA station number	USGS station number	Station name	Latitude (DDDMMSS)	Longitude (DDDMMSS)	Period of record	Station maintained by	Record computed by
7		14204648	Diversion from Tualatin River JWC Plant	0452935	1230528	5/91–10/91 5/92–11/92 5/93–10/93	JWC	JWC
8	3701580	14204650	Diversion from Tualatin River at Springhill Pump Plant	0452935	1230528	5/91–10/91 5/92–10/92 5/93–10/93	TVID	USGS
54	3960069	14207000	Oswego Canal near Lake Oswego, Oregon	0452320	1224310	1991–93	OWRD	OWRD

Tualatin River Flow Schematic

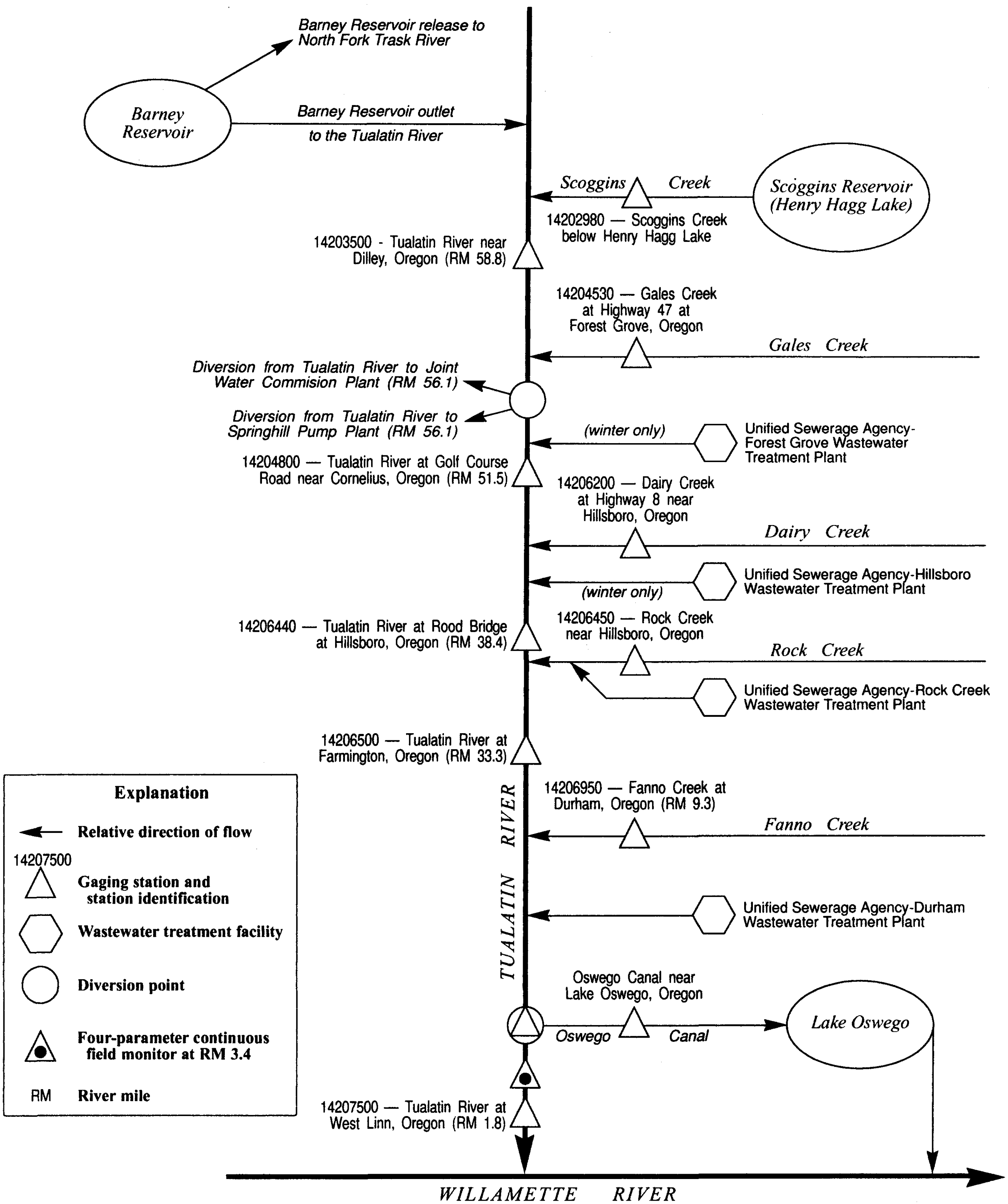

Figure 2. Relative positions of selected tributaries, diversions, and stream-gaging stations in the Tualatin River Basin, Oregon.

Oswego Corporation. Water diverted from the Tualatin River by the JWC is used to provide drinking water for Hillsboro, Forest Grove, and parts of Beaverton. Water diverted from the Tualatin River at the Springhill Pump Plant is used for irrigation in the Tualatin Valley. Water diverted through the Lake Oswego Canal is used for electric power generation and to augment the water level in Lake Oswego. The JWC and the TVID use flow-meters to measure the volume of water diverted from the main stem of the river. A streamflow station is maintained on the Oswego Canal to monitor flow. See table 14 for a list of diversion stations that have discharge data.

Physical and Chemical Analyses of Water Samples

Physical and chemical analyses were performed on water samples to identify seasonal and long-term temporal changes, spatial variability, and interactions between the water chemistry and the biota. Collectively, these results can be used to provide a conceptual understanding of the river's present water-quality condition. Samples were collected at main-stem sites, major tributary sites, ground-water sites, and from USA treatment-plant effluent.

Water samples collected from Tualatin River sites, tributary sites, and ground-water sites were processed in the field. Whole-water (nonfiltered) subsamples were dispensed into individual sample bottles for analysis. Subsamples for dissolved-constituent analysis were filtered into individual sample bottles. Subsamples for dissolved-constituent analysis that were analyzed by the USA Water Quality Laboratory were filtered through a nylon, 25-millimeter diameter, 0.45 micrometer pore-size syringe filter. Subsamples for dissolved-constituent analysis that were analyzed by the USGS NWQL were filtered through a 142 millimeter diameter, 0.45 micrometer pore-size cellulose nitrate filter. Ground-water samples analyzed for dissolved arsenic were filtered through a 47 millimeter, 0.1 micrometer pore-size cellulose nitrate filter. Nutrient samples analyzed by the USA Water Quality Laboratory were preserved with sulfuric acid (H_2SO_4). Nutrient samples analyzed by the USGS NWQL were preserved with mercuric chloride ($HgCl_2$). Samples analyzed for metals were preserved with nitric acid (HNO_3) and were analyzed only at the USGS NWQL. Samples were chilled on ice and delivered to either the USA Water Quality Laboratory in Tigard, Oregon, or shipped overnight to the USGS NWQL in Arvada, Colorado. Analyzing agencies are identified in the data files by a two-letter code (table 15). Laboratory techniques used to analyze water samples are listed in table 16.

Table 15. Codes for collecting and analyzing agencies

Data files agency code	Agency	Location
G	U.S. Geological Survey	Portland, Oregon
A	All other agencies (non-U.S. Geological Survey)	Various locations in Oregon
WQ	Unified Sewerage Agency Water Quality Laboratory	Tigard, Oregon
NL	U.S. Geological Survey National Water Quality Laboratory	Arvada, Colorado
RC	Unified Sewerage Agency, Rock Creek Facility	Hillsboro, Oregon
DH	Unified Sewerage Agency, Durham Facility	Durham, Oregon
HB	Unified Sewerage Agency, Hillsboro Facility	Hillsboro, Oregon
PD	U.S. Geological Survey Portland District Laboratory	Portland, Oregon
FG	Unified Sewerage Agency, Forest Grove Facility	Forest Grove, Oregon
O	Oregon Water Resources Department	Hillsboro, Oregon
J	Joint Water Commission	Forest Grove, Oregon
T	Tualatin Valley Irrigation District	Forest Grove, Oregon
aa	Aquatic Analysts Laboratory	Tigard, Oregon
os	Dr. David Culver's Laboratory at Ohio State University	Columbus, Ohio

Field Measurements

At most sites, field measurements of temperature, dissolved oxygen, specific conductance, and pH were made concurrently with the collection of water-quality samples. However, in May through November 1993, weekly field measurements were made without concurrent sample collection by the USGS at four main-stem sites: Tualatin River at Stafford Road near Lake Oswego,

Table 16. Laboratory methods used to analyze water samples from the Tualatin River Basin, Oregon

[USA, Unified Sewerage Agency; WWTP, wastewater-treatment plant; USGS, U.S. Geological Survey; µm, micrometer; ASF, automated-segment flow colorimetry; ICP, inductively coupled plasma; AAS, atomic absorption spectrometry; AES, atomic emission spectrometry; MRL, minimum reporting limit; mg/l, milligrams per liter; °C, degrees Celsius]

Analysis	USA Water Quality Laboratory	Durham WWTP Laboratory	Rock Creek WWTP Laboratory	USGS National Water Quality Laboratory	USGS Oregon District Laboratory
Chemical oxygen demand	U.S. Environmental Protection Agency (1983), #410.4 (colorimetric)	U.S. Environmental Protection Agency (1983), #410.3 (titrimetric)	U.S. Environmental Protection Agency (1983), #410.3 (titrimetric)	Analysis not performed for this study	Analysis not done
Biochemical oxygen demand; 5 day	American Public Health Association and others (1985), #507 (probe)	American Public Health Association and others (1985), #507 (probe)	American Public Health Association and others (1989), #5210 (electrode)	Analysis not performed for this study	American Public Health Association and others (1989), #5210
Carbonaceous biochemical oxygen demand	American Public Health Association and others (1985), #507 (probe) Hach Formula 2533 inhibitor	American Public Health Association and others (1985), #507 (probe) Hach Formula 2533 inhibitor	American Public Health Association and others (1989, #5210 (electrode) Hach Formula 2533 inhibitor	Analysis not performed for this study	American Public Health Association and others (1989), #5210 Hach Formula 2533 inhibitor
Total dissolved solids	American Public Health Association and others (1992,) #2540D	American Public Health Association and others (1992), #2540D	American Public Health Association and others (1992), #2540D	Fishman and Friedman (1989), Method # I–1749–85 (0.45 µm filter, gravimetric 105°C)	Analysis not done
Total solids	American Public Health Association and others (1992), #2540B	American Public Health Association and others (1992), #2540B	American Public Health Association and others (1992), #2540B	Fishman and Friedman (1989), Method # I–3750–85 (gravimetric 105°C)	Analysis not done
Total suspended solids	American Public Health Association and others (1985), #209C (gravimetric 105°C)	American Public Health Association and others (1985), #209C (gravimetric 105°C)	American Public Health Association and others (1989), #2540D (gravimetric 105°C)	Fishman and Friedman (1989), Method # I–3765–85 (gravimetric 105°C)	Analysis not done
Alkalinity	American Public Health Association and others (1992), #2320A	American Public Health Association and others (1992), #2320A	American Public Health Association and others (1992), #2320A	Fishman and Friedman (1989), Method # I–1030–85 and I–2030–85	Digital titrator using 0.1600N H_2SO_4, with combination electrode
Calcium (dissolved)	Analysis not performed for this study	Analysis not performed for this study	Analysis not performed for this study	Fishman and Friedman (1989), Method # I–1472–85 (0.45 µm filter, ICP)	Analysis not done

Table 16. Laboratory methods used to analyze water samples from the Tualatin River Basin, Oregon—Continued

[USA, Unified Sewerage Agency; WWTP, wastewater-treatment plant; USGS, U.S. Geological Survey; µm, micrometer; ASF, automated-segment flow colorimetry; ICP, inductively coupled plasma; AAS, atomic absorption spectrometry; AES, atomic emission spectrometry; MRL, minimum reporting limit; mg/l, milligrams per liter; °C, degrees Celsius]

Analysis	USA Water Quality Laboratory	Durham WWTP Laboratory	Rock Creek WWTP Laboratory	USGS National Water Quality Laboratory	USGS Oregon District Laboratory
Magnesium (dissolved)	Analysis not performed for this study	Analysis not performed for this study	Analysis not performed for this study	Fishman and Friedman (1989), Method #I–1472–85 (0.45 µm filter, ICP)	Analysis not done
Sodium (dissolved)	Analysis not performed for this study	Analysis not performed for this study	Analysis not performed for this study	Fishman and Friedman (1989), Method #I–1472–85 (0.45 µm filter, ICP)	Analysis not done
Silica (dissolved)	Analysis not performed for this study	Analysis not performed for this study	Analysis not performed for this study	Fishman and Friedman (1989), Method #I–1472–85 (0.45 µm filter, ICP)	Analysis not done
Iron (dissolved)	Analysis not performed for this study	Analysis not performed for this study	Analysis not performed for this study	Fishman and Friedman (1989), Method #I–1472–85 (0.45 µm filter, ICP)	Analysis not done
Iron (Total)	Analysis not performed for this study	Analysis not performed for this study	Analysis not performed for this study	Fishman and Friedman (1989), Method, #I–5474–85, AAS	Analysis not done
Manganese (dissolved)	Analysis not performed for this study	Analysis not performed for this study	Analysis not performed for this study	Fishman and Friedman (1989), Method #I–1472–85 (0.45 µm filter, ICP)	Analysis not done
Manganese (Total)	Analysis not performed for this study	Analysis not performed for this study	Analysis not performed for this study	Fishman and Friedman (1989), Method #I–5474–85, AAS	Analysis not done
Aluminum (dissolved)	Analysis not performed for this study	Analysis not performed for this study	Analysis not performed for this study	Fishman and Friedman (1989), Method #I–1051–85 (0.45 µm filter, AES)	Analysis not done
Arsenic (dissolved)	Analysis not performed for this study	Analysis not performed for this study	Analysis not performed for this study	Fishman and Friedman (1989), Method #I–2062–85 (0.1 µm filter, AAS)	Analysis not done
Boron (dissolved)	Analysis not performed for this study	Analysis not performed for this study	Analysis not performed for this study	Fishman and Friedman (1989), Method #I–1114–85 (0.45 µm filter, AES)	Analysis not done

Table 16. Laboratory methods used to analyze water samples from the Tualatin River Basin, Oregon—Continued

[USA, Unified Sewerage Agency; WWTP, wastewater-treatment plant; USGS, U.S. Geological Survey; µm, micrometer; ASF, automated-segment flow colorimetry; ICP, inductively coupled plasma; AAS, atomic absorption spectrometry; AES, atomic emission spectrometry; MRL, minimum reporting limit; mg/l, milligrams per liter; °C, degrees Celsius]

Analysis	USA Water Quality Laboratory	Durham WWTP Laboratory	Rock Creek WWTP Laboratory	USGS National Water Quality Laboratory	USGS Oregon District Laboratory
Strontium (dissolved)	Analysis not performed for this study	Analysis not performed for this study	Analysis not performed for this study	Fishman and Friedman (1989), Method #I–1472–85 (0.45 µm filter, ICP)	Analysis not done
Potassium (dissolved)	Analysis not performed for this study	Analysis not performed for this study	Analysis not performed for this study	Fishman and Friedman (1989), Method #I–5474–85 (0.45 µm filter, AAS)	Analysis not done
Ammonia as nitrogen	American Public Health Association and others (1985), #417G (colorimetric)	American Public Health Association and others (1985), #417G (potentiometric)	U.S. Environmental Protection Agency (1983), #350.1 (colorimetric)	Fishman and Friedman (1989), Method #I–2522–85 (0.45 µm filter, colorimetric, salicylate-hypochlorite, ASF)	Analysis not done
Total Kjeldahl nitrogen as nitrogen	U.S. Environmental Protection Agency (1983), #351.2 (colorimetric)	U.S. Environmental Protection Agency (1983,)#351.2 (potentiometric)	U.S. Environmental Protection Agency (1983) #351. 2 (colorimetric)	Fishman and Friedman (1989), Method #I–4552–85 (colorimetric, salicylate-hypochlorite, ASF)	Analysis not done
Nitrite-plus-nitrate nitrogen	U.S. Environmental Protection Agency (1983), #353.2 (colorimetric cadmium reduction)	U.S. Environmental Protection Agency (1983), #353.2 (colorimetric cadmium reduction)	U.S. Environmental Protection Agency (1983), #353.1 (colorimetric hydrazine reduction)	Fishman and Friedman (1989), Method #I–4545–85 (0.45 µm filter, cadmium reduction, hydrazine reduction-diazotization method colorimetric ASF)	Analysis not done
Total phosphorus	U.S. Environmental Protection Agency (1983), #365.4 (colorimetric)	U.S. Environmental Protection Agency (1983, #365.4 (colorimetric)	U.S. Environmental Protection Agency (1983), #365.4 (colorimetric)	Fishman and Friedman (1989), Method #I–4599–85 (potassium persulfate wet digestion, phosphomolybdate method colorimetric)	Analysis not done
Soluble orthophosphate as phosphorus	U.S. Environmental Protection Agency (1983), #365.1 (0.45 µm filter, colorimetric)	U.S. Environmental Protection Agency (1983), #365.1 (0.45 µm filter, colorimetric)	U.S. Environmental Protection Agency (1983), #365.4 (0.45 µm filter, colorimetric)	Fishman and Friedman (1989), Method #I–2601–85 (0.45 µm filter, colorimetric, phosphomolybdate, ASF)	Analysis not done
Chloride (dissolved)	American Public Health Association and others (1992), #4500-Cl (Chloride)-E	U.S. Environmental Protection Agency (1983), #325.3 (0.45 µm filter, titrimetric)	U.S. Environmental Protection Agency (1983), #325.3 (0.45 µm filter, titrimetric)	Fishman and Friedman (1989), Method # I–2057–85(0.45 µm filter)	Analysis not done

Table 16. Laboratory methods used to analyze water samples from the Tualatin River Basin, Oregon—Continued

[USA, Unified Sewerage Agency; WWTP, wastewater-treatment plant; USGS, U.S. Geological Survey; µm, micrometer; ASF, automated-segment flow colorimetry; ICP, inductively coupled plasma; AAS, atomic absorption spectrometry; AES, atomic emission spectrometry; MRL, minimum reporting limit; mg/l, milligrams per liter; °C, degrees Celsius]

Analysis	USA Water Quality Laboratory	Durham WWTP Laboratory	Rock Creek WWTP Laboratory	USGS National Water Quality Laboratory	USGS Oregon District Laboratory
Sulfate (dissolved as SO_4)	Analysis not performed for this study	Analysis not performed for this study	Analysis not performed for this study	Fishman and Friedman (1989), Method # I–2057–85 (0.45 µm filter)	Analysis not done
Fluoride (dissolved)	Analysis not performed for this study	Analysis not performed for this study	Analysis not performed for this study	Fishman and Friedman (1989), Method # I–2057–85 (0.45 µm filter)	Analysis not done
Chlorophyll *a*	American Public Health Association and others (1992), #10200 H. 3 (fluorometric)	Analysis not done	Analysis not done	American Public Health Association and others (1989), #10200 H. 2 (spectrophotometric)	Strickland and Parsons (1972) (fluorometric)
Pheophytin *a*	American Public Health Association and others (1992), #10200 H. 3 (fluorometric)	Analysis not done	Analysis not done	American Public Health Association and others (1989), #10200 H. 2 (spectrophotometric)	Strickland and Parsons (1972) (fluorometric)

Tualatin River at Boones Ferry Road at Tualatin, Tualatin River at Elsner Road near Sherwood, and Tualatin River at Highway 210 Bridge near Scholls. Field measurements made in the main stem below RM 30 were taken in vertical profiles to document thermal stratification and its effects on water quality. Readings were taken at depths of 1-foot, 3-foot, and at subsequent 3-foot intervals. USGS personnel used calibrated Hydrolab multiparameter instruments to obtain field measurements. USA personnel used single parameter meters to obtain field measurements from January 1991 through November 1992. In November 1992, USA personnel began using Hydrolab multiparameter instruments to obtain field measurements of temperature, dissolved oxygen, specific conductance, and pH.

Insolation Rates

A continuous-reading LI-COR LI-190SA model quantum sensor was installed on the roof of the Durham wastewater-treatment plant during the low-flow sampling season. The quantum sensor was controlled by a Campbell CR-21 Micrologger. The data were stored in a Campbell SM-192 storage module and later downloaded to a personal computer. The quantum sensor measured photosynthetically active radiation (PAR) on a flat surface in the 400 to 700 nanometer wavelength range. The data on the CD-ROM are averages of 60 instantaneous measurements taken at 1-minute intervals over the previous hour and are reported in microeinsteins per square meter per second ($\mu E/[m^2 s]$).

Light-Extinction Coefficients

A submersible LI-COR LI-193SA spherical quantum sensor was used to measure the underwater PAR at three main-stem sites on the Tualatin River. The quantum sensor was controlled by a Campbell CR-21 Micrologger. A measurement was taken at the water surface, with the sensor totally submerged, to obtain the initial reading. Subsequent readings were taken at several depths within a vertical profile. The light-extinction coefficient was calculated using Beer's Law:

$$I_z = I_0 e^{-kz},$$

where

I_z = irradiance at depth z,
I_0 = irradiance at river surface,
e = the irrational number 2.71828
k = extinction coefficient, and
z = depth distance in meters, (Wetzel, 1983).

Four-Parameter Continuous Field Monitor at River Mile 3.4

A continuous-reading, four-parameter USGS field monitor was installed at RM 3.4. This monitor measured water temperature, pH, dissolved oxygen, and specific conductance on an hourly basis. The electronics unit was housed in a cylindrical watertight container 10 inches high by 10.5 inches in diameter. The probes were mounted in a perforated PVC pipe on the upstream side of the fish ladder at the Oswego Dam (RM 3.4). There is sufficient flow at this location for the probes to be fully submerged even during low-flow periods of the year. The continuous field monitor was controlled by a Campbell CR-21 Micrologger, and the data were stored in a Campbell SM-192 storage module. Data collected by the storage module were later downloaded to a USGS database. Depth of probe deployment was dependent on the water level of the river. Probes were never less than 10 inches below the water surface and were never more than 5 feet below the water surface. The monitor was installed in May 1991 and continually recorded data during the study period.

Meteorological Data from Tualatin Valley Irrigation District Agrimet Weather Station

Meteorological data from the TVID Agrimet Weather Station located in Verboort, Oregon (pl. 1), are included in this report. This weather station measures and records air temperature, dewpoint, windspeed, wind direction, and precipitation (rainfall). The measurements were made at 15-minute intervals over the 24-hour period from 11:00 p.m. to 11:00 p.m. the following day. A total of 96 values, therefore, were used to determine a daily mean value. Recorded maximum and minimum air temperatures are the maximum and minimum readings over the 24-hour period. Dewpoint is calculated from the mean relative humidity for the 24-hour period and the mean daily air temperature for the 24-hour period. Windspeed is reported as a mean velocity determined from the 96 individual windspeed readings during the 24-hour period. Wind direction is a mean value determined from an average of all 96 wind-direction readings over the 24-hour period and is reported in compass degrees, where zero degrees represents true north. Rainfall is reported as a total value for the 24-hour period, measured in inches.

Biological Data

Biological data collected during this study included benthic-macroinvertebrate identification and enumeration, phytoplankton identification and enumeration, and zooplankton identification and enumeration. All biological data were collected by the USGS during the low-flow sampling season (usually from May to November).

Benthic Macroinvertebrates

Benthic-macroinvertebrate samples were collected by the USGS at 10 sites in May 1992 and at 4 sites in November 1992. Samples were acquired by using either an Ekman dredge sampler, a Surber sampler, or by scraping samples from submerged material in the Tualatin River. All samples were preserved in formalin. Macroinvertebrate specimens were separated from associated debris and examined with a dissecting microscope. Specimens were differentiated by functional group and were enumerated and taxonomically classified to order, family, or genus level. Identifications and enumerations are presented in the supplemental data tables 18, 19, and 20 at the back of the report.

Phytoplankton

Phytoplankton samples were collected weekly by the USGS on the Tualatin River during the low-flow season. Samples were subsampled from a USGS churn splitter concurrent with other water-quality samples. Samples were collected in a 250-milliliter brown-opaque plastic bottle with 2.5 milliliters of Lugol's solution added as a preservative (Wetzel and Likens, 1979). Phytoplankton samples preserved in Lugol's solution have a shelf life of more than 1 year. Analyses were performed by Aquatic Analysts Laboratory of Tigard, Oregon.

Slides for identification and enumeration were prepared by filtering an aliquot of sample through a 0.45 micrometer filter. A section of the filter was cut out and placed on a glass slide with immersion oil added to make the filter transparent. A coverslip was placed on top of the slide. Nail polish was applied to the periphery of the coverslip to adhere the coverslip to the slide. By using this method, slides can be archived indefinitely.

Algal units (cells, colonies, or filaments) were counted along a measured transect of the microscope slide. Only algae that were believed to be alive at the time of collection (those with intact chloroplasts) were counted. A minimum of 100 algal units were counted. Abundances are reported in number per milliliter for each species.

Zooplankton

In 1991, zooplankton samples were collected using a 12-inch diameter conical 35-micrometer-mesh tow net. In 1992 and 1993, samples were collected using a 12-inch diameter conical 80-micrometer-mesh tow net. For zooplankton samples collected at Scoggins Creek below Henry Hagg Lake (USGS station number 14202980) and Tualatin River at Dilley (USGS station number 14203500), the net was placed in midchannel for 3 to 5 minutes. Empirical relations between flow and velocity were used to determine the total volume of water filtered. Ideally, 1 cubic meter of water was filtered at each station. At all other zooplankton sample-collection sites, the net was towed along a cross section at an average rate of 0.5 meters per second, but the tow speed was varied somewhat to facilitate vertical integration. Towing distances were premeasured and marked for accuracy. Samples were preserved by using buffered-sugared formalin. Analyses of zooplankton samples were performed by ZP's Taxonomic Services of Keizer, Oregon.

Zooplankton were enumerated by splitting an approximate total subsample size of 400 individuals and counting until 100 individuals of the most abundant species was reached. A minimum of 300 crustaceans were counted if present in a particular sample. If initial sample splits did not achieve the numeric criteria, larger sample splits were used until the criteria were met. Samples were enumerated at 32X magnification. Species identifications were made at higher levels of magnification when necessary. Abundances are reported in number per cubic meter for each species.

Quality Assurance

Quality assurance was incorporated into the sampling plan by using the following techniques: (1) submitting laboratory split surface-water samples and field spikes of surface-water samples to the various laboratories for analysis, (2) submitting reference samples of nutrient standards with known concentrations to laboratories for analysis, (3) submitting replicate and blank samples to the USGS NWQL for ground-water samples, (4) calibrating the Hydrolab multiparameter instru- ments before and after measurements, (5) obtaining calibration reports for the LI-COR quantum sensors from the manufacturer, (6) calibrating the four- parameter continuous field monitor at RM 3.4, (7) submitting replicate samples for biochemical oxygen demand (BOD) and carbonaceous bio- chemical oxygen demand (CBOD) analysis, and (8) performing quality-assurance protocols in the analysis of biological data. Codes used to identify samples in the "Quality-Assurance" data files are listed in table 17.

Laboratory Split Samples

Laboratory split samples of Tualatin River water were collected on a weekly basis. The water samples were collected and poured into a USGS churn splitter. This sample was then subsampled, chilled on ice, and delivered to the USA Water Quality Laboratory, the USA Durham Wastewater Treatment Facility Laboratory, the USA Rock Creek Wastewater Treatment Facility Laboratory, and shipped overnight to the USGS NWQL. These samples were analyzed for nutrients, total solids, dissolved solids, suspended solids, and chloride. The results of these duplicate analyses were compared to assess laboratory accuracy and comparability.

During the late summer of 1992 and the entire summer of 1993, field-spike solutions were submitted to the USA Water Quality Laboratory, the USA Durham Wastewater Treatment Facility Laboratory, the USA Rock Creek Wastewater Treatment Facility Laboratory, and the USGS NWQL. This field spike consisted of a subsample of Tualatin River water from the USGS churn splitter with a known volume and concentration of nutrient standard added. This field spike was used to measure the ability of different laboratories to recover specific constituent concentrations.

Table 17. Codes for quality-assurance data files

Quality-assurance code	Quality-assurance code interpretation	Quality-assurance code definition
AC	Actual concentration	Theoretical concentration of standard solution as determined by USGS District Laboratory in Portland, Oregon. [1]
BL	Blank solution	Blank solution (usually distilled-deionized water) submitted to laboratory for analysis.
FM	Field measurement	Measurements of temperature, dissolved oxygen, specific conductance, and pH made in the field.
FS	Field spike	River water sample spiked with a known volume and concentration of nutrient standard.
HL	High-level solution	Solution of high-level nutrient standard, similar to concentrations observed in some wastewater treatment plant effluent.
LL	Low-level solution	Solution of low level nutrient standard, similar to concentrations observed in the upper reaches of the Tualatin River.
ML	Medium-level solution	Solution of medium-level nutrient standard, similar to concentrations observed in the lower Tualatin River and tributaries.
RP	Replicate sample	Duplicate samples of similar composition used to test laboratory precision.
RW	River water	Water sample from the Tualatin River.
SP	Spike solution	Concentration of nutrient standard added to river water sample.

[1]Specific conductance samples measured in the laboratory (parameter code 90095) are labeled as "AC" but should not be considered as "actual theoretical values."

Reference Samples

Reference samples of known nutrient concentrations were submitted on a weekly basis to the USA Water Quality Laboratory, the USA Durham Wastewater Treatment Facility Laboratory, the USA Rock Creek Wastewater Treatment Facility Laboratory, and occasionally to the USGS NWQL. Reference solutions were submitted in three concentration levels: (1) a low-level solution, which contained nutrient concentrations similar to those in the upper reaches of the Tualatin River, (2) a medium-level solution, which contained nutrient concentrations similar to those in tributaries and the lower Tualatin River, and (3) a high-level solution, which contained nutrient concentrations similar to those in some wastewater-treatment-plant effluents. A blank solution of distilled-deionized water that was used to prepare the reference solutions was also submitted to the USA Water Quality Laboratory on a weekly basis and on occasion to the USGS NWQL. The blank solution was analyzed to be certain that the distilled-deionized water did not contain detectable nutrient concentrations and was not contaminating nutrient standards with additional concentrations of the target analytes. In addition, the USGS NWQL conducts a blind-sample quality-assurance program to assess laboratory precision. The results from 1991 were reported in Maloney and others (1994). Quality-control practices employed by the USGS NWQL were reported by Pritt and Raese (1992). Results of the blind-sample program are available in the National Water Information System (NWIS) database (Lucey, 1990). These quality-assurance data were used to evaluate sample-collection and processing techniques, water-matrix affects, laboratory accuracy and precision, and the comparability of each laboratory's analytical results.

Quality Assurance of Ground-Water Samples

Ground-water samples were analyzed at the USGS NWQL. Quality assurance of ground-water samples was assessed by submitting replicate samples and blank samples to the USGS NWQL. Replicate samples were collected at a site immediately after the actual sample, and the two were considered to be identical in composition. Replicates are used to assess the consistency of sample-collection and sample-processing tech- niques and analytical precision. Blank solutions consisted of distilled-deionized water that was presumed to contain the target analytes at concen- trations below their detection limits. The distilled- deionized water was pumped through the same sampling apparatus as the ground-water samples. The results of the replicate and blank-solution analyses are listed in the ground-water quality-assurance section of the data files on CD-ROM (table 1).

Calibration of Multiparameter Water-Quality Field Probes

Hydrolab multiparameter water-quality probes were calibrated immediately before and after use, according to the manufacturer's recommendations. Calibration results were recorded in maintenance logbooks for each instrument. Slight linear shifts were applied to temperature, specific conductance, pH, and dissolved oxygen when calibration differences exceeded 0.2 degrees Celsius, 5 percent, 0.2 pH units, and 0.2 milligrams per liter, respectively. USGS techniques for the computation of streamflow records (Kennedy, 1983) were applied to water-quality data to shift, develop, and check field-parameter data from these instruments.

Calibration of Quantum Sensors

The quantum sensors used to measure PAR were calibrated by the manufacturer in April 1991 and March 1992. The manufacturer recommended that the sensors be recalibrated every 2 years. Calibration constants and calibration multipliers were within plus or minus 2 percent for the submersible spherical quantum sensor. Calibration constants and calibration multipliers were within plus or minus 2.2 percent for the quantum sensor placed on the roof of the Durham Wastewater Treatment Facility. The sensors were cleaned regularly during the study period.

Calibration of Four-Parameter Continuous Field Monitor

The four-parameter continuous field monitor installed at RM 3.4 was calibrated on a weekly basis during the low-flow sampling season (May through November) and on a monthly basis during the high-flow periods of the year. Calibration results were recorded in a logbook. When necessary, linear shifts were applied to recorded data according to USGS techniques for the computation of streamflow records (Kennedy, 1983).

Quality Assurance for Biochemical Oxygen Demand Samples

BOD and CBOD samples were analyzed at the USGS District Laboratory in Portland, Oregon. DO meters were calibrated before use, and the calibration was checked after all samples were analyzed. Replicate samples were subsampled from the same churn splitter and presumed to be identical in composition. These replicate samples were used to evaluate sample-processing and laboratory analytical precision. The BOD and CBOD measurements in the surface-water-quality section of the data files (table 1) are an average of the two replicate analyses acquired on that date. The BOD and CBOD measurements in the quality-assurance section of the data files include both of the replicate analyses successively.

Quality Assurance for Biological Samples

Quality assurance for the benthic-macroinvertebrate samples was performed by employing a second biologist to perform random checks on enumerations to confirm identifications.

The microscope used to enumerate phytoplankton samples by Aquatic Analysts of Tigard, Oregon, was calibrated by using a standard concentration of latex spheres provided by the Environmental Protection Agency (EPA). The concentration of these spheres was 12,075 per milliliter. Duplicate preparations of the standard spheres were analyzed; the average result was 11,700 spheres per milliliter (96.9 percent). The computer program used to calculate algal densities was adjusted to compensate for this 3.1 percent error. Slides prepared by Aquatic Analysts from phytoplankton samples were archived and are available for review. In 1993, phytoplankton samples were split and sent to both Aquatic Analysts and to Dr. David Culver's Laboratory at Ohio State University. Dr. Culver's Laboratory used methods of Utermohl (1931).

Quality assurance of zooplankton samples analyzed by ZP's Taxonomic Services of Keizer, Oregon, was performed by recounting between 2 percent and 5 percent of all samples. Taxonomic accuracy was maintained by frequent discussions with other taxonomists and regular reviews of the literature.

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SUPPLEMENTAL DATA TABLES

Table 18. Tualatin River invertebrate sampling: May 1992, river mile 4.3 to river mile 11.6

[LB, left bank of river, facing downstream; RB, right bank of river, facing downstream; C, center of river; SU, Surber sampler; SC, scraping from submerged log or limb; EC, Ekman dredge sampler]

Taxonomic classification	River mile 4.3				River Mile 5.4			River mile 9.4		River mile 10		River mile 11.6	
	C	RB	RB	LB	LB	C	LB	LB	C	C	RB	RB	C
	SC	EC	SU	EC	EC	SC	SC	SU	SU	SC	EC	EC	SC
	Area sampled in square meters												
	0.058	0.023	0.093	0.023	0.023	0.015	0.054	0.093	0.093	0.017	0.023	0.023	0.021
CLASS													
.......ORDER	Number of Specimens												
..............FAMILY													
.....................Genus													
TURBELLARIA													
.......TRICLADIDA	1					1							
OLIGOCHAETA	67	44	27	38	8	20	24	68	166	27	33	12	22
CRUSTACEA													
.......COPEPODA													
..............CYCLOPODIDAE			2						1				
.......AMPHIPODA													
..............GAMMARIDAE	3		4					11	13				
.....................Gammarus													
.......DECAPODA													
..............CAMBARIDAE	1							1					
.....................Pacifastacus													
INSECTA													
..............EPHEMEROPTERA													
..............BAETIDAE									4				
.....................Baetis													
.......NEUROPTERA													
..............SISYRIDAE							16						
.....................Climacia													
.......TRICHOPTERA													
..............POLYCENTROPODIDAE			1										
.....................Polycentropus													
.......COLEOPTERA													
..............PSYTISCIDAE	1												
.......DIPTERA													
..............CERATOPOGONIDAE	1		1					1					
..............TABANIDAE	2						12						
..............SIMULIDAE										1			
..............CHIRONOMIDAE	54		26	12	20	40	60	154	107	67	10	8	34
GASTROPODA													
.......PULMONATA													
..............LYMNAEIDAE				1					153				
.....................Stagnicola													
.....................Fossaria					1								
.......CTENOBRANCHIATA													
..............VIVIPARIDAE									102				
..............PLEUROCERIDAE	1												
.....................Leptoxis													

Table 19. Tualatin River invertebrate sampling: May 1992, river mile 16.3 to river mile 63.9

[LB, left bank of river, facing downstream; RB, right bank of river, facing downstream; C, center of river; SU, Surber sampler; SC, scraping from submerged log or limb; EC, Ekman dredge sampler]

Taxonomic classification	River mile 16.3				River mile 26.9				River mile 44.4			56.1	River mile 63.9	
	C EC	LB EC	C SC	C SC	RB EC	LB EC	C SC	C EC	C SC	RB EC	C SU	C SC	LB SU	C SU
	Area sampled in square meters													
	0.023	0.023	0.027	0.014	0.023	0.023	0.014	0.079	0.026	0.023	0.093	0.018	0.093	0.093
CLASS ....ORDER ....FAMILY ....Genus	Number of Specimens													
OLIGOCHAETA	26	14	57	90	51	40	12	32	10	40	4	52	10	4
ARACHNOIDEA														
.......HYDRACARINA								1						4
INSECTA														
..............PLECOPTERA														
..............PERLODIDAE											4			
.....................Isoperla														
..............CHLOROPERLIDAE											4			4
..............NEMOURIDAE											8		5	
.....................Zapada														
.......EPHEMEROPTERA														
..............BAETIDAE			1					2			28		78	12
.....................Baetis														
..............SIPHLONURIDAE											4		1	
.....................Ameletus														
..............LEPTOPHLEBIIDAE											16			
..............TRIORYTHIDAE													5	
..............HEPTAGENIIDAE													16	8
.....................Epeorus														
..............EPHEMERIDAE													2	
.....................Serratella														
.......TRICHOPTERA														
..............HYDROPSYCHIDAE											3			
.....................Arctopsyche														
.......COLEOPTERA														
..............ELMIDAE													18	8
.....................Optioserrus														
.......ODONATA														1
.......DIPTERA														
..............CERATOPOGONIDAE		1			2			18						
..............SIMULIDAE													31	
..............CHIRONOMIDAE	28		27	20	22	12	36	27	22		12	88	100	32
..............TIPULIDAE													3	
..............ANTHOMYIIDAE													1	
GASTROPODA														
.......PULMONATA														
..............LYMNAEIDAE											3			
.....................Stagnicola														

Table 20. Tualatin River invertebrate sampling: November 1992, river mile 4.3 to river mile 10.0

[LB, left bank of river, facing downstream; RB, right bank of river, facing downstream; C, center of river; SU, Surber sampler; SC, scraping from submerged log or limb; EC, Ekman dredge sampler]

Taxonomic classification	River mile 4.3				River mile 5.4			River mile 9.4				River mile 10.0	
	LB SU	LB SC	RB SC	RB EC	LB SU	LB SC	RB SC	RB EC	LB SU	C SU	C SU	RB SC	LB EC
	Area sampled in square meters												
	0.093	0.01	0.048	0.023	0.093	0.016	0.024	0.023	0.093	0.093	0.093	0.032	0.023
CLASS ....ORDER ....FAMILY ....Genus													
	Number of Specimens												
TURBELLARIA													
.......TRILADIDA		1											
OLIGOCHAETA	40	29	12	16	20	4	5	24	152	64	52	4	40
CRUSTACEA													
.......COPEPODA		1											
..............CYCLOPOIDA					8								
.......AMPHIPODA													
..............GAMMARIDAE	44	1			12				52	44	76		
.....................Gammarus													
ARACHNOIDEA													
.......HYDRACARINA			4										
INSECTA													
.......MEGALOPTERA													
..............SIALIDAE			4	12									
.......TRICHOPTERA													
..............POLYCENTROPODIAE													
.....................Polycentropus	4	3											
.......DIPTERA													
..............CERATOPOGONIDAE					4								
..............EMPIDIDAE			12										
..............CHIRONOMIDAE	112	53	60	32	80	92	9	32	28			80	4
GASTROPODA													
.......PULMONATA													
..............LYMNAEIDAE	4							12		24	70		
.......CTENOBRANCHIA													
..............VIVIPARIDAE								56			46		
PELECYPODA													4

APPENDIXES

APPENDIX 1— DATA PRESENTATION

Data presented from this cooperative U.S. Geological Survey (USGS) and Unified Sewerage Agency (USA) study include header information explaining the format of the data files, followed by an example of the data as it appears in the data files. The data on CD-ROM only (table 1) include surface-water-quality data, ground-water-quality data, discharge data, biological data, CBOD data, solar insolation data, calculated light-extinction coefficients, data from the four-parameter continuous field monitor at RM 3.4, meteorological data from the Tualatin Valley Irrigation District (TVID) Agrimet Weather Station in Verboort, Oregon, and quality-assurance data from laboratories that performed analyses for this study.

Header Files and Information

Header files are provided to facilitate data retrieval from the CD-ROM. Each data file is located in a subject-specific subdirectory. The data files have an accompanying header file that explains how the data are arranged. Each data file has a unique column arrangement that explains what is contained within each field. At the end of each header file is an example of a line or two of data as it appears on the CD-ROM. A "." is used as a placeholder when a field is blank, except for the remark-code field (see table 1.1 for list of remark codes). On the CD-ROM, the remark-code field is always the last column (if there is a remark-code field in that particular data file) and a placeholder is not needed. For a cumulative list of all codes used on the CD-ROM, see table 1.2.

Table 1.1. Remark codes used in data files

Remark Code	Code Definition
E	Estimated value
M	Presence of constituent verified but not quantified
U	Constituent specifically analyzed for but not detected
<	Actual value is known to be less than shown
>	Actual value is known to be greater than shown

Header Information for Surface-Water-Quality Data Files

The data files that contain surface-water-quality data for the Tualatin River Basin are located in the subdirectory "qwdata." The data file that contains water-quality data from the main-stem Tualatin River stations is called "mainstem.dat." The header information for the main-stem Tualatin River water-quality data is in a file called "mainstem.hdr." The data file that contains water-quality data from tributaries of the Tualatin River is called "tribs.dat." The header information for that data file is in a file called "tribs.hdr." Water-quality data from the wastewater-treatment plants is in a file called "wwtp.dat." The header information for the wastewater-treatment-plant water-quality data is in a file called "wwtp.hdr." The surface-water-quality data files are arranged as follows:

USA station identification number............................columns 1–7;
USGS station identification number..........................columns 9–23;
Collecting agency..column 25; G = USGS; A = USA and all other agencies;

Table 1.2. Cumulative alphabetical listing of codes in data files

Code	Type Code	Code Interpretation	Defined in table number
A	Collecting Agency	Unified Sewerage Agency and all others except U.S. Geological Survey	15
aa	Analyzing Agency	Aquatic Analysts Laboratory	15
AC	Quality Assurance	Actual Concentration	17
BL	Quality Assurance	Blank	17
CW	Sample Type	In-Channel Well	7
DC	Sample Type	Discrete Composite	7
DH	Analyzing Agency	Durham Wastewater Treatment Facility	15
DM	Sample Type	Domestic Well	7
DS	Sample Type	Depth Specific	7
E	Remark	Estimated value	1.1
ED	Sample Type	Equal-Discharge Increment	7
EW	Sample Type	Equal-Width Increment	7
FC	Sample Type	Flow Composite	7
FM	Quality Assurance	Field Measurement	17
FM	Sample Type	Field Measurement	7
FS	Quality Assurance	Field Spike	17
G	Collecting Agency	U.S. Geological Survey	15
GS	Sample Type	Grab Sample	7
HB	Analyzing Agency	Hillsboro Wastewater Treatment Facility	15
HL	Quality Assurance	High-Level Reference Solution	17
HY	Sample Type	Hypolimnetic Sample	7
IC	Sample Type	Integrated Composite	7
IS	Sample Type	Integrated Sample	7
IT	Sample Type	Integrated Composite over top ten feet	7
J	Analyzing Agency	Joint Water Commission	15
J	Collecting Agency	Joint Water Commission	15
LL	Quality Assurance	Low-Level Reference Solution	17
M	Remark	Presence of constituent verified but not quantified	1.1
ML	Quality Assurance	Medium Level Reference Solution	17
NL	Analyzing Agency	USGS National Water Quality Laboratory	15
O	Collecting Agency	Oregon Water Resources Department	15
os	Analyzing Agency	Dr. David Culver's Laboratory at Ohio State University	15
PD	Analyzing Agency	USGS Portland Oregon District Laboratory	15
RC	Analyzing Agency	Rock Creek Wastewater Treatment Facility	15
RP	Quality Assurance	Replicate Sample	17
RP	Sample Type	Replicate Sample	7
RW	Quality Assurance	River Water	17
SP	Quality Assurance	Spike Solution	17
T	Collecting Agency	Tualatin Valley Irrigation District	15
U	Remark	Constituent specifically analyzed for but not detected	1.1
WQ	Analyzing Agency	Unified Sewerage Agency Water Quality Laboratory	15
<	Remark	Actual value is known to be less than shown	1.1
>	Remark	Actual value is known to be greater than shown	1.1

Analyzing agency .... columns 28–29; NL= USGS National Water Quality Laboratory; WQ= USA Water Quality Laboratory; FM = field measurement; DH = USA Durham Wastewater Treatment Facility; PD = USGS Portland District Laboratory; RC = USA Rock Creek Wastewater Treatment Facility; HB = USA Hillsboro Wastewater Treatment Facility; FG = USA Forest Grove Wastewater Treatment Facility, (see table 15 for additional analyzing agency information);
Sample Type .... columns 31–32; GS = grab sample; IS = integrated sample; DS = depth specific; IC = integrated composite; FC = flow composite; DC = 24 hr composite discrete; IT = integrated composite from top 10 feet of water column; EW = equal-width increments; ED = equal-discharge increments (see table 7 for additional sample-collection-method information);
Date .... columns 34–43; mm/dd/yyyy;
Time .... columns 45–49; hh:mm;
WATSTORE code .... columns 51–55 (see table 8);
Value .... columns 57–64;
Depth (feet .... columns 66–69;
Remark codes .... column 71 (see table 1.1 for interpretation of remark codes).

Below is an example of a line of data as it appears in the data files:

3701715 14202300 A FM IS 05/23/1991 10:05 61 68.200 3.0 E

Header Information for Ground-Water-Quality Data File

The data file that contains ground-water-quality data for the Tualatin River Basin is located in the subdirectory “qwdata.” The data file that contains ground-water data is called “grdwtr.dat.” The header information is in a file called “grdwtr.hdr.” The data file “grdwtr.dat” is arranged as follows:

Station identification number .... columns 1–15;
Analyzing agency .... columns 17–18; NL = USGS National Water Quality Laboratory; FM = field measurement (see table 15 for additional analyzing agency information);
Well type .... columns 20–21; CW = in-channel well; DM = domestic well (see table 7 for additional sample-collection method information);
Date .... columns 23–32; mm/dd/yyyy;
Time .... columns 34–38; hh:mm;
WATSTORE code .... columns 40–44 (see table 10);
Value .... columns 46–53;
Remark codes .... column 55 (see table 1.1 for interpretation of remark codes).

Below is an example of a line of data as it appears in the data file:

453129122561401 NL DM 10/12/1990 12:05 1106 10.000 <

Header Information for Streamflow Data File

The data file that contains discharge data for the Tualatin River Basin is located the subdirectory “flow.” The file that contains streamflow discharge data is called “flow.dat.” The header information is in a file called “flow.hdr.” The data file “flow.dat” is arranged as follows:

USA station identification .... columns 1–7;
USGS station identification .... columns 9–16;
Collecting agency .... column 18; G = USGS; O = Oregon Water Resources Department; T = Tualatin Valley Irrigation District;
Analyzing agency .... columns 21–22; PD = USGS Portland District Laboratory; O = Oregon Water Resources Department; J = Joint Water Commission (see table 15);
Date .... columns 24–33; mm/dd/yyyy;
Value (daily mean value measured in cubic feet per second) .... columns 35–38;
Remark codes .... column 40 (see table 1.1 for interpretation of remark codes).

Below is a line of data as it appears in the data file:

3805048 14202980 G PD 01/22/1991 290

Header Information for Wastewater-Treatment-Plant Discharge Data File

The data file that contains discharge data for the wastewater-treatment plants is located in the subdirectory "flow." Discharge data from the USA wastewater-treatment plants are in a file called "wwtpflow.dat." The header information is in a file called "wwtpflow.hdr." The data file "wwtpflow.dat" is arranged as follows:

USA station identification number............................columns 1–7;
USGS station identification number..........................columns 9–23;
Date..columns 25–34; mm/dd/yyyy;
Value (mean daily value measured
in cubic feet per second)...columns 36–39

Below is a line of data as it appears in the data files:

2370014 453040123052000 05/03/1992 6.0

Header Information for Oswego Canal Gage-Height Data File

The data file that contains gage-height data for the Tualatin River at the Oswego Canal is located in the subdirectory "flow." The file that contains these gage-height data (station number "14206990") is called "14206990.dat." The header information is in a file called "14206990.hdr." The data file "14206990.dat" is arranged as follows:

USA station identification...columns 1–7;
USGS station identification.......................................columns 9–16;
Collecting agency...column 18; G = USGS; O = Oregon Water Resources Department; T = Tualatin Valley Irrigation District;
Analyzing agency...columns 21–22; PD = USGS Portland District Laboratory; O = Oregon Water Resources Department; J = Joint Water Commission (see table 15);
Date..columns 24–33; mm/dd/yyyy;
Value (gage height in feet)......................................columns 35–38 (to convert gage height to elevation above mean sea level add 100.20 feet in 1991 and 1992, for 1993 add 100.22 feet);
Remark codes...column 40 (see table 1.1 for interpretation of remark codes).

Below is a line of data as it appears in the data file:

3701068 14206990 O PD 01/01/1991 1.90

Header Information for Phytoplankton Data File

The data file that contains phytoplankton data for samples collected in the Tualatin River Basin is located in the subdirectory "biodata." The data file that contains phytoplankton data is called "algal.dat." The header information is in a file called "algal.hdr." The file "algal.dat" is arranged as follows:

USA station identification number............................columns 1–7;
USGS station identification number..........................columns 9–23;
Date..columns 25–34; MM/DD/YYYY;
Species code (unique to Aquatic Analysts
Laboratory)..columns 36–39;
Genus...columns 41–54;
Species...columns 56–67;
Abundance (numbers/milliliter)................................columns 69–76;

Below are two examples of data as they appear in the data file:

3701054 14207050 05/09/1991 NZXX Nitzschia sp. 16.107
3701116 14206785 05/09/1991 ACLC Achnanthes lanceolata 8.054

Header Information for Zooplankton Data File

The data file that contains zooplankton data for samples collected in the Tualatin River Basin is located in the subdirectory "biodata." The file that contains zooplankton data is called "zooplank.dat." The header information is in a file called "zooplank.hdr." The file "zooplank.dat" is arranged as follows:

USA station identification number.............................. columns 1–7;
USGS station identification number........................... columns 9–23;
Date... columns 25–34; MM/DD/YYYY;
Species code .... columns 36–40;
Genus... columns 42–55;
Species.. columns 57–65;
Abundance (number/cubic meter)............................. columns 67–74;

Below are two examples of data as they appear in the data file:

3805048 14202980 06/27/1991 603.0 Craspedacusta sowerbyi 61.4
3805048 14202980 06/27/1991 611.0 Oligochaeta species 20.5

Header Information for Carbonaceous Biochemical Oxygen Demand (CBOD) Data File

The data files that contain CBOD data for the Tualatin River Basin are located in the subdirectory "qwdata." The file that contains the CBOD data is called "cbod.dat." The header information is in a file called "cbod.hdr." The data file "cbod.dat" is arranged as follows:

USA station identification number.............................. columns 1–7;
USGS station identification number........................... columns 9–23;
Collecting agency.. columns 25; G = USGS; A = USA and all other agencies;
Analyzing agency... columns 28–29; PD = USGS Portland District Laboratory;
Sample type... columns 31–32; IC = integrated composite; IS = integrated Sample; EW = equal width;
Date sample was collected... columns 34–43; mm/dd/yyyy;
Time sample was collected .... columns 45–49; hh:mm;
Elapsed days .... columns 51–54;
Value (milligrams per liter) .... columns 56–61.

Below are two lines of data as they appear in the data file:

3701391 14206440 G PD EW 12/04/1991 11:00 0.00 0.000
3701391 14206440 G PD EW 12/04/1991 11:00 2.00 0.350

Header Information for USA Wastewater-Treatment-Plant Carbonaceous Biochemical Oxygen Demand (CBOD) Data File

The data file that contains CBOD data for the USA wastewater-treatment plants is located in the subdirectory "qwdata." The file that contains the CBOD data from the USA wastewater-treatment-plant samples is called "cbodwwtp.dat." These samples were analyzed at the USGS Portland District Laboratory. The header information is in a file called "cbodwwtp.hdr." The data file "cbodwwtp.dat" is arranged as follows:

USA station identification number.............................. columns 1–7;
USGS station identification number........................... columns 9–23;
Collecting agency.. columns 25; G = USGS; A = USA and all other agencies;
Analyzing agency... columns 28–29; PD = USGS Portland District Laboratory;
Sample type... columns 31–32; DC = discrete composite;
Date analysis began (samples were a 24-hour composite from the previous day)............................. columns 34–43; mm/dd/yyyy;
Elapsed days .... columns 45–48;
Value (milligrams per liter) .... .columns 50–55.

Below are two lines of data as they appear in the data file:

2370014 453040123052000 A PD DC 01/08/1992 0.00 0.000
2370014 453040123052000 A PD DC 01/08/1992 1.00 1.637

Header Information for Continuous Quantum Sensor Data File

The data file that contains continuous quantum sensor data collected during this study is located in the subdirectory "cont_dat." The data file that contains the continuous quantum sensor data is called "light.dat." The header information is in a file called "light.hdr." The data file "light.dat" is arranged as follows:

Date.. columns 1–10; mm/dd/yyyy;
Time .... columns 12–16; hh:mm (these data include time changes from Pacific Daylight Time to Pacific Standard Time, which occurred from 1:00 a.m. to 2:00 a.m. on 10/25/1992 and 1:00 a.m. to 2:00 a.m. on 10/31/1993, data from 1991 are all Pacific Daylight Time); Value (an average of 60 instantaneous measurements taken at 1-minute intervals over the previous hour, measured in microeinsteins per square
meter per second ($\mu E/[m^2 s]$) .... columns 18–21;
Remark codes.. column 23 (see table 1.1 for interpretation of remark codes).

Below is a line of data as it appears in the data file:

05/20/1991 17:00 613

Header Information for Light-Extinction-Coefficient Data File

The data file that contains light-extinction coefficients calculated for sites in the lower Tualatin River is located in the subdirectory "biodata." The file that contains calculated light-extinction coefficients is called "lightext.dat." The header information is in a file called "lightext.hdr." The file "lightext.dat" is arranged as follows:

USA station identification number.............................. columns 1–7;
USGS station identification number .... columns 9–23;
Date.. columns 25–34; MM/DD/YYYY;
Extinction coefficients .... columns 36–39 (1/meter);

Below is an example of two lines line of data as they appear in the data file:

3701271 14206690 07/05/1991 1.68
3701054 14207050 07/08/1991 2.13

Header Information for Four-Parameter Continuous Field Monitor Data File

The file that contains field measurements from the four-parameter continuous field monitor is located in the subdirectory "cont_dat." The data file that contains field measurements from the four-parameter continuous field monitor is called "qwmonitr.dat." The header information is in a file called "qwmonitr.hdr." The file "qwmonitr.dat" is arranged as follows:

Date.. columns 1–10; mm/dd/yyyy;
Time .... columns 12–16: hh:mm;
Water temperature (degrees Celsius) .... columns 18–21;
Specific conductance (microsiemens per
centimeter at 25 degrees Celsius) .... columns 23–27;
Dissolved oxygen (milligrams per liter) .... columns 29–32;
pH... columns 34–37;

Below is an example of a line of data as it appears in the data file:

05/08/1991 10:00 13.4 164.8 7.9 7.2

Header Information for Meteorological Data File

The file that contains meteorological data for this study period (1991–93) is located in the subdirectory "cont_dat." The file that contains TVID meteorological data for this study is called "meteoro.dat." The header information is in a file called "meteoro.hdr." The data file "meteoro.dat" is arranged as follows:

Date.. columns 1–10; mm/dd/yyyy;
Maximum temperature (degrees Fahrenheit) .... columns 12–14;
Minimum temperature (degrees Fahrenheit) .... columns 16–18;
Dewpoint (degrees Fahrenheit) .... columns 20–22;

Windspeed (miles per hour) .... columns 24–26;
Wind direction (compass degrees, where
zero degrees represents true north) .... columns 28–30 and
Precipitation (inches) .... columns 32–35.

Below is an example line of meteorological data as it appears in the data files:

10/25/1991 50 42 46 61 164 0.55

Header Information for Surface-Water Quality-Assurance Data File

The file that contains surface-water quality-assurance data located in the subdirectory "qadata." The data file that contains surface-water quality-assurance data is called "swqa.dat." The header information for "swqa.dat" is in a file called "swqa.hd." The data file "swqa.dat" is arranged as follows:

Solution type .... columns 1–2; RW = river water; BL= blank; SP = spike; FS = field spike; AC = actual concentration; LL = low level; ML = medium level; HL = high level; RP = replicate (see table 17 for quality-assurance code definitions);
Date .... columns 4–13; mm/dd/yyyy;
Analyzing agency .... columns 15–16; WQ= USA Water Quality Laboratory; DH = USA Durham Wastewater Treatment Plant; RC = USA Rock Creek Wastewater Treatment Plant; HB = USA Hillsboro Wastewater Treatment Plant; FG = USA Forest Grove Wastewater Treatment Plant; PD = USGS Portland District Laboratory; NL = USGS National Water Quality Laboratory; FM = field measurement (see table 15 for analyzing agency codes);
WATSTORE code .... columns 18–22 (see table 8);
Value .... columns 24–31;
Remark codes .... columns 33 (see table 1.1 for interpretation of remark codes).

Below is an example of a line of data from the surface-water quality-assurance data file:

RW 05/07/1991 NL 665 0.100

Header Information for Ground-Water Quality-Assurance Data File

The data file that contains ground-water quality-assurance data for the Tualatin River Basin Study is located in the subdirectory "qadata." The file that contains ground-water quality-assurance data is called "gwqa.dat." The header information is contained in a file called "gwqa.hdr." The data file "gwqa.dat" is arranged as follows:

Station identification number .... columns 1–15;
Analyzing agency .... columns 17–18; NL = USGS National Water Quality Laboratory; FM = field measurement;
Well type .... columns 20–21; CW = in-channel well; DM = domestic well; BL = blank; RP = replicate;
Date .... columns 23–32; mm/dd/yyyy;
Time .... columns 34–38; hh:mm;
WATSTORE code .... columns 40–44 (see table 10);
Value .... columns 46–53 and
Remark code .... column 55 (see table 1.1 for interpretation of remark codes).

Below are a few lines of data as they appear in the data file:

452421122523101 NL CW 09/08/1993 9:40 671 1.100
452421122523101 NL RP 09/08/1993 9:45 608 0.910
452421122523101 NL RP 09/08/1993 9:45 613 0.010 <

Header Information for Phytoplankton Quality-Assurance Data File

The data file that contains phytoplankton quality-assurance data for the Tualatin River Basin Study is located in the subdirectory "qadata." The data file that contains quality-assurance data for phytoplankton samples analyzed at Aquatic Analysts Lab in Tigard, Oregon, and at Dr. David Culver's Laboratory at Ohio State University is called "algalqa.dat." The header information is in a file called "algalqa.hdr." The data file "algalqa.dat" is arranged as follows:

USA station identification number .... columns 1–7;

USGS station identification number........................... columns 9–23;
Date.. columns 25–34; MM/DD/YYYY
Analyzing agency .... columns 36–37; aa = Aquatic Analyst Laboratory and os = Dr. David Culver's Laboratory at Ohio State University
Genus .... columns 39–46;
Species.. columns 50–57
Abundance (numbers per milliliter) .... columns 61–68;

Below are examples of two lines of data as they appear in the data files:

3701054 14207050 09/02/1993 aa Tetraedr minimum 83.519

3701054 14207050 09/02/1993 os Chalmydo sp 135.724

Header Information for Biochemical Oxygen Demand (BOD) Quality-Assurance Data File

The data file that contains BOD quality-assurance data for the Tualatin River Basin Study is located in the subdirectory "qadata." The data file that contains replicate quality-assurance data for BOD samples analyzed at the USGS Portland District Laboratory is in a file called "bodrepl.dat." The header information is in a file called "bodrepl.hdr." The data file "bodrepl.dat" is arranged as follows:

USA station identification number............................ columns 1–7;
USGS station identification number.......................... columns 9–23;
Collecting agencies.. columns 25; G = USGS; A = USA and all other;
Analyzing agency .... columns 28–29; PD = USGS Portland District Laboratory;
Sample type .... columns 31–32; IC = integrated composite; IT = integrated composite over top 10 feet; RP = replicate sample;
Date.. columns 34–43; mm/dd/yyyy;
Time .... columns 45–49; hh:mm;
WATSTORE code .... columns 51–55 (see table 8);
Value (milligrams per liter) .... columns 57–64;
Depth (feet)... columns 66–69 and
Remark codes... column 71 (see table 1.1 for interpretation of remark codes).

Below is an example of two lines of data as they appear in the data file:

3701612 14203500 G PD IC 08/22/1991 8:00 310 0.300 .

3701612 14203500 G PD RP 08/22/1991 8:00 310 0.300 .

Header Information for Carbonaceous Biochemical Oxygen Demand (CBOD) Quality-Assurance Data File

The data file that contains CBOD quality-assurance data for the Tualatin River Basin Study is located in the subdirectory "qadata." The data file that contains the replicate quality-assurance data for CBOD samples called "cbodrepl.dat." Header information is located in a file called "cbodrepl.hdr." The data file "cbodrepl.dat" is arranged as follows:

USA station identification number............................ columns 1–7;
USGS station identification number.......................... columns 9–23;
Collecting agency... columns 25; G = USGS; A = USA and all others;
Analyzing agency .... columns 28–29; PD = USGS Portland District Laboratory;
Sample type .... column 31–32; IC = integrated composite; IS = integrated sample; RP = replicate sample (see table 7);
Date sample was collected .... columns 34–43; mm/dd/yyyy;
Time sample was collected .... columns 45–49; hh:mm;
Elapsed days .... columns 51–54;
Value (milligrams per liter) .... columns 56–61.

Below is an example of two lines of data as they appear in the data file:

3810015 14204530 A PD IS 12/04/1991 10:50 30.0 1.100

3815021 14206200 A PD IS 12/04/1991 9:29 0.00 0.000

APPENDIX 2—USGS AND USA STATION NUMBERING SYSTEMS

USGS station-identification numbers are unique numbers that apply to a specific station. The number is assigned when a station is first established and is retained for that station only. There are two systems used by the USGS to assign identification numbers for surface-water stations. The "downstream order" system is used for regularly monitored surface-water stations; this system is based on basin designations according to the Hydrologic Unit Map for Oregon prepared in cooperation with the U.S. Water Resources Council (1974). The "latitude-longitude" system is used for surface-water stations and ground-water stations where only occasional or miscellaneous measurements are made. The "latitude-longitude" system assigns a site identification number designated by using latitude-longitude coordinates, to the nearest second.

USA location codes are established for surface-water sites using a unique seven-digit number. The first four digits are USA codes that define the river or creek. The last three digits are the location of the station in river miles (times 10) to the nearest tenth (USGS and USA river miles do not always coincide). For example, station number "3701165" is assigned to the Tualatin River at Elsner Road, near Sherwood. The digits "3701" define this site as a surface-water site on the main-stem Tualatin River, and the digits "165" identify the site location as RM 16.5 (USA river miles). The location codes for tributary sites are similar. Station number "3840012", for example, is for Fanno Creek at Durham Road. The digits "3840" define the site as a surface-water site on Fanno Creek, and the digits "012" identify the site location as RM 1.2 (USA river miles). River miles for the tributaries are measured upstream from the mouth of the creek.