Prepared in cooperation with Cascade Water Alliance

Quality of Water in the White River and Lake Tapps, Pierce County, Washington, May–December 2010

Scientific Investigations Report 2012–5022

Cover:

Photograph of Lake Tapps, Washington, with Mount Rainier in the background.
(Photograph taken by Ryan Burge, private citizen, December 31, 2011.)

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By S.S. Embrey, R.J. Wagner, R.L. Huffman, A.M. Vanderpool-Kimura, and
J.R. Foreman

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Scientific Investigations Report 2012–5022

U.S. Department of the Interior
U.S. Geological Survey

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Conversion Factors, Datums, and Abbreviations and Acronyms

Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
Length		
inch (in)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		
square mile (mi ²)	259.0	hectare (ha)
Volume		
acre-foot (acre-ft)	1,233	cubic meter (m ³)
Flow rate		
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second (m ³ /s)

SI to Inch/Pound

Multiply	By	To obtain
Length		
meter (m)	3.281	foot (ft)
Volume		
milliliter (mL)	0.034	ounce, fluid (fl. oz)
liter (L)	0.2642	gallon (gal)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$^{\circ}\text{F}=(1.8\times^{\circ}\text{C})+32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$^{\circ}\text{C}=(^{\circ}\text{F}-32)/1.8$$

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (μS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (μg/L).

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Conversion Factors, Datums, and Abbreviations and Acronyms—Continued

Datums

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27) or to the North American Datum of 1983 (NAD 83).

Abbreviations and Acronyms

Abbreviation or Acronym	Definition
CFU	colony-forming units
CTD	conductivity-temperature-depth
DEET	N,N-diethyl-meta-toluamide
DCP/EDL	data collection platform and electronic data logger
FSU	Field Services Unit
FNU	formazin nephelometric turbidity units
GC/MS	gas chromatography/mass spectrometry
HPLC/MS	high-performance liquid chromatography/mass spectrometry
NIST	National Institute of Standards and Technology
NWIS	National Water Information System
NWQL	USGS National Water Quality Laboratory
NTU	nephelometric turbidity units
NTRU	nephelometric turbidity ratio units
PAR	photosynthetically active radiation
ppb	parts per billion
QC	quality control
RM	river mile
TSI	trophic state index
TSS	total suspended solids
USGS	U.S. Geological Survey
WAWSC	Washington Water Science Center

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By S.S. Embrey, R.J. Wagner, R.L. Huffman, A.M. Vanderpool-Kimura, and J.R. Foreman

Abstract

The White River and Lake Tapps are part of a hydropower system completed in 1911–12. The system begins with a diversion dam on the White River that routes a portion of White River water into the southeastern end of Lake Tapps, which functioned as a storage reservoir for power generation. The stored water passed through the hydroelectric facilities at the northwestern end of the lake and returned to the White River through the powerhouse tailrace. Power generation ceased in January 2004, which altered the hydrology of the system by reducing volumes of water diverted out of the river, stored, and released through the powerhouse. This study conducted from May to December 2010 created a set of baseline data collected under a new flow regime for selected reaches of the White River, the White River Canal (Inflow), Lake Tapps Diversion (Tailrace) at the powerhouse, and Lake Tapps.

Three sites, one on the White River at Headworks, one on the White River at R Street, and one on the Tailrace, were equipped for continuous recording of water-quality data, and three sites (Headworks, White River Canal Inflow, and Tailrace) were sampled for discrete water-quality data. Nine lake sites were measured for physical and water-quality properties and samples were collected for analyses of nutrients, suspended solids, and fecal-coliform bacteria concentrations. Samples from the lake also were analyzed for concentrations of chlorophyll *a* and organic chemicals.

Discrete samples indicated that water from the White River, White River Canal Inflow, and Tailrace sites generally was turbid, warm, chemically dilute, and well-oxygenated. Exceptions occurred at the sites when flow to the White River Canal was suspended or when little or no flow was released from the lake into the Tailrace. The quality of physical properties and concentrations in water measured continuously at the three sites generally was good and met the freshwater criteria designated by Washington State Department of Ecology for recreational and aquatic-life uses,

with several exceptions. The 7-day average of daily maximum temperatures (7–DADMax) was greater than the freshwater aquatic life criterion of 16 degrees Celsius (°C) for core summer salmonid habitat on 6 days at the Headworks site and 37 days at the R-Street site during the study. The 7-DADMax temperatures were greater than the 13°C criterion for spawning, rearing, and incubation on 6 days at the Headworks site and 20 days at the R-Street site. The freshwater aquatic life criterion for dissolved oxygen of 9.5 milligrams per liter (mg/L) for core summer salmonid habitat was not met at the Headworks and R-Street sites for periods during July and August 2010. Exceptions also occurred at the Headworks site for measurements of pH, which were greater than the aquatic life upper limit of 8.5 pH units during July 2010. Aquatic life pH criteria were not met at the Tailrace site during June, July, and August 2010, when pH was greater than 8.5 pH units, and during August 2010 when pH decreased to less than 6.5 pH units.

Lake Tapps water near the surface was relatively clear, warm, and well oxygenated. The clearest water of the nine lake sites was at the Deep site with a median Secchi disk transparency measurement of 6.05 m (meters), which represents a two- to six-fold increase over historical measurements of transparency at this location. Median water temperatures were 18.2–18.9°C and maximums were from 22.9–25.0°C. Median dissolved oxygen concentrations were greater than 8.42 mg/L and minimums generally were not lower than 7.4 mg/L.

By early July 2010, weak thermal stratification developed at most lake sites into at least a warm surface layer overlying a small thermocline. A well-defined hypolimnion developed below the thermocline only at the Deep site. With the development of thermal stratification, hypolimnion water became anoxic at several sites (Deep, Tapps Island, Snag Island, and Lake Outlet). By late September 2010, an anoxic layer about 15 m thick had formed in the hypolimnion of the Deep site. Mixing during autumn overturn in late November re-oxygenated the water column of all the sites with about 10–12 mg/L of dissolved oxygen.

On the basis of pH and specific conductance measurements, Lake Tapps water is pH neutral and chemically dilute. Median pH values for water in the epilimnion and the hypolimnion ranged from 6.84 to 7.64 pH units and maximums did not exceed 7.8 pH units at any site. Median specific conductance was typically less than 70 microsiemens per centimeter at 25°C for the epilimnion and the hypolimnion.

Concentrations of nutrients and chlorophyll *a* in Lake Tapps were low. At most of the sites and in most of the samples from the epilimnion, total phosphorus concentrations were less than the Washington State Department of Ecology phosphorus criterion of 0.01 mg/L for maintaining oligotrophic conditions. Median concentrations of total nitrogen (unfiltered water) ranged from about 0.14 mg/L (Deep, Tapps Island, and Dike 2B sites) to about 0.18 mg/L (Allan Yorke and Lake Inlet sites). Chlorophyll *a* concentrations were low with median concentrations of 2.16 micrograms per liter (mg/L) or less. The majority of chlorophyll *a* concentrations were well below the Oregon Department of Environmental Quality action level of 10 mg/L.

Using the Carlson Trophic-Status Index and average measures of transparency, chlorophyll *a*, and total phosphorus data from this study, Lake Tapps generally fits within the oligotrophic classification, but with a few exceptions. At Allan Yorke, Lake Inlet, and Southeast Arm sites, the chlorophyll *a* and total phosphorus indexes of nearly 40 approach the upper limit of oligotrophic conditions. In addition, average concentrations of total phosphorus at Lake Inlet and Southeast Arm are at Nürnberg's (1996) threshold concentration of 0.01 mg/L, which suggests a slight tendency towards mesotrophic conditions at these two sites during summer July–September.

On the basis of epilimnetic nitrogen to phosphorus concentration ratios of greater than 17, Lake Tapps primary production is phosphorus limited at all but two study sites. At the Lake Inlet and Southeast Arm sites, ratios of 15 and 16, respectively, for the summer period suggest either nitrogen or phosphorus (or both) may limit algal growth.

Water samples collected at the Allan Yorke, Snag Island, and Lake Outlet study sites were screened for the presence of more than 250 organic chemicals. A total of 14 compounds were detected in trace amounts (or determined to be present) at one or more of the 3 sites. The Allan Yorke site had 9 detections, the Snag Island site had 10 detections, and

the Lake Outlet site had 5 detections of compounds mostly belonging to the group of wastewater indicator chemicals. Compounds detected (or with verified presence) at all three sites included the herbicide 2,4-D, the insecticide and mosquito repellent DEET, the herbicide fluridone used for Eurasian watermilfoil eradication, and the herbicide prometon. The largest concentrations of these compounds were in samples from the Allan Yorke site; the lowest concentrations were from the Lake Outlet site.

Introduction

The completion in 1911–12 of a hydroelectric power-generation project in the White River basin (a subbasin of the Puyallup River basin) of Washington ([fig. 1](#)) resulted in hydrologic changes to the river including the formation of Lake Tapps, an off-channel reservoir. A diversion dam constructed on the White River routes a portion of water from the White River into the White River Canal, which delivers the water into Lake Tapps where it was stored for power generation. Dike construction and filling of the reservoir inundated four existing natural lakes and combined them into present-day Lake Tapps (Washington State Department of Ecology, 2010a). Stored water passes through the hydroelectric facilities at the northwestern end of Lake Tapps and returns to the White River through the powerhouse Tailrace at Dieringer. Typical operation of the system involved lowering the lake elevation during autumn and winter, and filling the lake to full elevation in early spring.

Puget Sound Energy ceased generating hydroelectric power in January 2004, which again changed the hydrology of the White River system. Water diversions from the White River continued, but at reduced volumes, for the purpose of maintaining water levels in Lake Tapps. During water years 1982–2003 when hydroelectric power was produced, water diverted from the White River into the White River Canal averaged 890 ft³/s ([fig. 2](#)) and peaked at 2,340 ft³/s on December 17, 2001 (U.S. Geological Survey, 2011a, site 12099000). For the same period, an average of 892 ft³/s was returned to the river through the powerhouse at Dieringer (U.S. Geological Survey, 2011a, site 12101100). Because the stream-gaging equipment on the White River Canal was not designed for the regularly occurring low discharges after

Figure 1. U.S. Geological Survey surface-water and lake-elevation gaging stations in the White River basin, Pierce County, Washington.

Figure 2. Average discharge at White River Canal (Headworks) and Lake Tapps Diversion at Dieringer (Tailrace), Washington, water years 1982–2010.

January 2004, discharge calculations were discontinued. However, water discharged into the Tailrace at Dieringer provides reasonable approximations of discharge in the White River Canal. During the post power-generation period from 2004 to 2010, discharge in the Tailrace averaged 121 ft³/s and ranged from 56 to 350 ft³/s (U.S. Geological Survey, 2011a, site 12101100). Using the assumption that lake outflow is approximately equal to lake inflow, water diverted from the river was reduced from about 890 ft³/s during the power-generation period to about 120 ft³/s during post

power-generation period. With reduced water diversions, average flows in the river downstream of the diversion dam increased from 579 ft³/s during the power-generation period (U.S. Geological Survey, 2011a, site 12100000) to 1,270 ft³/s during the post power-generation period (U.S. Geological Survey, 2011a, site 12099200). The White River Canal inflow to Lake Tapps was further modified in 2007 with the completion of a backflow prevention structure on the Canal downstream of Printz Basin (fig. 3), which now limits the maximum flow into Lake Tapps to about 1,000 ft³/s (Washington State Department of Ecology, 2010a).

Figure 3. Continuous and discrete water-quality study sites on the White River at Headworks (Headworks site), White River at R Street (R-Street site), White River Canal (Inflow site), and Lake Tapps Diversion (Tailrace site), Washington.

During 2008–2010, Cascade Water Alliance, with the Muckleshoot Indian Tribe, the Puyallup Tribe of Indians, and Lake Tapps Community (a collective of nine non-profit Lake Tapps entities) entered into a set of agreements to facilitate the development of Lake Tapps as a new source of municipal water supply while protecting and enhancing fishery resources in the White and Puyallup River basins (Washington State Department of Ecology, 2010a). The White River Management Agreement, the 2009 Lake Tapps Community Agreement, and the 2010 Lake Tapps Area Water Resources Agreement include a flow regime specification that provides for minimum flows in the White River; diversions of water from the White River to Lake Tapps Reservoir; operation and maintenance of the Lake Tapps system; continued maintenance of recreational lake levels; and restoration, protection, and enhancement of fishery resources and habitat in the White River basin. The bimonthly schedules for minimum flows and other permit specifications can be found in Washington State Department of Ecology (Ecology) Report of Examination for Permit Number S2-29920(A) (Washington State Department of Ecology, 2010b). The agreements also provide for development and implementation of a cooperative monitoring program to assess water quality in the White River and in Lake Tapps under a new flow regime.

In December 2009, Cascade Water Alliance became the new owners and managers of Lake Tapps Reservoir and the related Lake Tapps-White River hydroelectric project facilities (Washington State Department of Ecology, 2010a). In September 2010, Ecology granted Cascade Water Alliance a set of municipal water rights for new appropriations and the transfer of an existing right (Washington State Department of Ecology, 2010a).

Ecology conducted a study of Lake Tapps and the White River from July 2004 to June 2005 to document water-quality conditions soon after power generation had ceased and when flow through the lake was reduced (Hallock, 2006). Hallock (2006) reported the lake to be oligotrophic but with some indication of mesotrophy based on concentrations of chlorophyll *a* and determined phosphorus to be the limiting nutrient for primary production. Concentrations of total phosphorus at the lake outlet site were less than concentrations at the lake inlet site indicating the lake functions as a net sink for phosphorus (Hallock, 2006). Pierce County Public Works and Utilities and the Muckleshoot Indian Tribe also collected intermittent data during this 2004–05 time frame (Pierce County Public Works and Utilities, 2007). In summarizing these 2004–05 data, Welch shows Lake Tapps (represented by the main western basin and deepest location)

to be oligotrophic and phosphorus limited (Eugene Welch, University of Washington, professor emeritus, written commun., March 2011). With reduced diversions from the White River and inflows to the lake, Welch also noted transparency depths increased from about 1 m in 1981 to 3.6 m in 2005 and related these greater transparencies to longer water retention times in the lake when inflows into the lake were reduced. The longer retention time allows for more settling of non-algal particles, including particles with adsorbed phosphorus, resulting in clearer water and lower total phosphorus concentration. Because the lake productivity is limited by phosphorus, Welch concluded that the clearer water should not result in larger algae populations, but it might favor greater establishment and growth of macrophytes, particularly Eurasian watermilfoil (Eugene Welch, written commun., March 2011). In 2006 and 2007, another set of water-quality data was collected by the Muckleshoot Indian Tribe (Nancy Rapin, Muckleshoot Indian Tribe, written commun., March 2011). Earlier studies of the White River-Lake Tapps system from about 1974 through 2002 (Bortleson and others, 1976; Sumioka and Dion, 1985; Smith and others, 2000; Bell-McKinnon, 2002; Ebbert, 2002, 2003) were conducted when lake water levels, White River diversions, and releases back into the White River were managed by Puget Sound Energy for power production.

This study was conducted in cooperation with Cascade Water Alliance. The water-quality data from this study establishes a baseline set of data collected under the flow regime in place from May to December 2010 for selected reaches of the White River, White River Canal, Lake Tapps Diversion, and Lake Tapps.

Purpose and Scope

This report presents and summarizes water-quality data collected by the U.S. Geological Survey (USGS) from May to December 2010 from a total of 13 sites—two on the White River (Headworks, R-Street), one on the White River Canal (Inflow), one on the Lake Tapps Diversion (Tailrace), and from nine sites on Lake Tapps. Discrete water samples were collected bimonthly in July and August at the White River at Headworks and White River Canal sites. The Tailrace site was sampled bi-monthly in July and August and monthly in November and December. Discrete water samples were not collected at the R-Street site; only continuous, 15-minute water-quality data were collected. The nine lake sites were sampled bimonthly from July through October and monthly in November and December.

The water-quality data collected for this study consist of concentrations of nutrients, suspended solids, fecal-coliform bacteria, and turbidity in discrete water samples; and 15-minute values of water temperature, specific conductance, dissolved oxygen concentration, pH, and turbidity continuously measured by in-situ water-quality sondes. Water-quality data collected from the lake sites consist of concentrations of nutrients, suspended solids, fecal-coliform bacteria, chlorophyll *a*, and turbidity, and vertical profiles of various water-quality and physical properties through the lake water column. In addition, a one-time sampling of water from three of the lake sites was analyzed for suites of organic chemicals. This report focuses on the water-quality data collected under the conditions of the May–December 2010 flow regime in the White River, White River Canal, Lake Tapps Diversion, and through Lake Tapps.

Description of Study Area

The White River, which is located in Pierce County, Washington, originates from glaciers on Mount Rainier. From Mount Rainier, the river flows to its confluence with the Puyallup River, which subsequently empties into Commencement Bay near the city of Tacoma, Washington ([fig. 1](#)). Because of its glacial origins, the White River transports fine glacial till material that gives the river a whitish color during summer. Lake Tapps also is located in Pierce County about 18 mi east of Tacoma. The City of Bonney Lake lies along the southern end of the lake ([fig. 3](#)).

Downstream of the Mud Mountain Dam, the White River flows generally northwest to river mile (RM) 24.3 where a diversion dam at the hydropower headworks diverts water out of the White River and into the White River Canal. Downstream of the diversion dam, the White River continues to flow northwest to the city of Auburn. Near Auburn, the river turns generally southwest then flows south through the town of Pacific, past the powerhouse at Dieringer, and joins the Puyallup River at the city of Sumner ([fig. 3](#)). The reach of the river between the diversion dam at RM 24.3 and RM 3.6 is referred to as the Diversion Reach. The river is about 75 mi long with a drainage area of 494 mi² (Washington State Department of Ecology, 2010a).

Six anadromous salmonid species use the White River basin for spawning, incubation, rearing, and migration. These species include Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), pink salmon (*O. gorbuscha*), steelhead (*O. mykiss*), and bull trout (*Salvelinus confluentus*) (National Marine Fisheries Service, 1999, 2007; U.S. Fish and Wildlife Service, 1999). The National Marine Fisheries Services (1999, 2007) listed Puget Sound Chinook and steelhead as threatened under the Endangered Species Act in 1999 and 2007, respectively. The U.S. Fish and Wildlife Service (1999) listed Coastal-Puget Sound bull trout as threatened under the Endangered Species Act in 1999. Favorable water-quality conditions for fish occasionally have not been met in the reach of the White River downstream of the diversion dam. Some segments in this reach have been included on Ecology's water quality assessment and 303(d) list for pH, temperature, or fecal-coliform bacteria, and at RM 0.4, the White River is on the 303(d) list for dissolved oxygen concentrations (Washington State Department of Ecology, 2009).

The river water that is routed into the White River Canal at the Headworks diversion dam flows through 8 mi of canals, flumes, fish screens, five settling basins, and pipes (Washington State Department of Ecology, 2010a) into Lake Tapps at the southeastern end ([fig. 3](#)). The lake is about 4.5 mi long and 2.5 mi wide with an area of 2,740 acres (Washington State Department of Ecology, 2010a). The lake has a maximum volume of 67,000 acre-ft, a mean depth of about 25 ft and a maximum depth of about 90 ft (Sumioka and Dion, 1985). The normal water-surface elevation of the lake at full pool is between 541.0 and 542.5 ft with an active storage capacity of 46,700 acre-ft (Washington State Department of Ecology, 2010a). The area around Lake Tapps was originally sparsely populated, but the lake shoreline is now developed with residential homes. There are several public and private parks and boat launch facilities on the lake ([fig. 3](#)), which are heavily used for recreation by residents and visitors. At the northwestern end of Lake Tapps, the stored water passes through the hydroelectric facilities and returns to the White River at RM 3.6 through the ½-mile long Lake Tapps Diversion at Dieringer (Reese, 2010).

For this report, names of stream gaging and sampling sites have been abbreviated or simplified. USGS station identification numbers and details of site locations are shown in [table 1](#).

8 Quality of Water in the White River and Lake Tapps, Pierce County, Washington, May–December 2010

Table 1. Description of study sites on the White River, White River Canal, and Lake Tapps Diversion, Washington, where water-quality and discharge data were collected by the U.S. Geological Survey, May–December 2010.

[**Type of data:** Continuous, water-quality data electronically monitored and recorded at 15-minute intervals. Discrete, water-quality data measured by water-sample collection and analysis at a point in time. —, no data or not applicable]

USGS station No.	USGS station name	Short name	Latitude ° ' "	Longitude ° ' "	River mile	Drainage area	Type of data
12098700	White River at Headworks, above Flume, near Buckley	Headworks	47 10 12	122 00 05	24.3	410	Water-quality monitoring (continuous, discrete)
12099000	White River Canal at Buckley	White River Canal	47 10 19	122 01 13	—	—	Discharge
12099060	White River Canal above Lake Tapps, near Buckley	Inflow	47 11 49	122 08 22	—	—	Water-quality monitoring (discrete)
12099200	White River above Boise Creek, at Buckley	—	47 10 26	122 00 29	—	411	Discharge
12100000	White River at Buckley	—	47 10 28	122 01 09	—	427	Discharge
12100490	White River at R Street, near Auburn	R-Street	47 16 30	122 12 24	7.6	474	Discharge, water-quality monitoring (continuous)
12101000	Lake Tapps near Sumner	—	47 14 28	122 11 26	—	—	Lake elevation
12101100	Lake Tapps Diversion at Dieringer	Tailrace	47 14 18	122 13 37	3.6	—	Discharge, water-quality monitoring (continuous, discrete)

1. The reach of the White River between the diversion dam at RM 23 near Buckley and Lake Tapps Diversion at Dieringer at RM 6 is referred to as Diversion Reach;
2. White River at Headworks above Flume near Buckley is referred to as Headworks;
3. White River at R Street near Auburn is referred to as R-Street;
4. Lake Tapps Diversion at Dieringer is referred to as Tailrace; and
5. White River Canal above Lake Tapps near Buckley is referred to as Inflow.

Discrete water samples for measuring chemical concentrations and physical properties were collected from the Headworks, Tailrace, and Inflow sites. Discrete water samples

were not collected at the R-Street site. Stream-gaging stations for measuring stage and discharge also are located at the R-Street and Tailrace sites ([table 1](#)). Three sites—Headworks, R-Street, and Tailrace—were equipped for recording measures of water-quality data at 15-minute intervals to provide a nearly continuous record of water quality and capture the seasonal, diurnal, and event-driven fluctuations in water quality ([fig. 3](#)).

The nine sampling sites on Lake Tapps were distributed throughout the lake to coincide with or to be near sampling locations of previous investigations and to include a range of physical and nearshore conditions ([fig. 4](#)). The Deep site (map No. L1) in the main part of the western basin is the deepest of the nine study sites at about 27 m. The shallowest site of the study at about 3 m in depth was Southeast Arm (map No. L7) ([table 2](#)).

Table 2. Description of Lake Tapps study sites, Washington, July–December 2010.

[USGS site No: The 01 suffix uniquely identifies data for the epilimnion (E) and the 02 suffix uniquely identifies data for the hypolimnion (H). **Latitudes and longitudes:** In minutes, degrees, seconds. **Comments:** CWA, Cascade Water Alliance; Ecology, Washington State Department of Ecology; #, number. **Abbreviation:** m, meter]

Map No. (see fig. 4)	USGS site No.	Site name abbreviation (locale)	Latitude	Longitude	Approximate depth (m)	Comments
L1	471418122121101 (E) 471418122121102 (H)	Deep (main western basin ¹)	47° 13' 18"	122° 10' 34"	27	CWA site #3, Ecology site #1
L2	471142122094701 (E) 471142122094702 (H)	Allan Yorke ¹ (City of Bonney Lake)	47° 11' 42"	122° 09' 47"	5	CWA site #2
L3	471358122085201 (E) 471358122085202 (H)	Northeast Arm ¹ (east side of Tapps Island)	47° 13' 58"	122° 08' 52"	10	CWA site #5
L4	471405122093301 (E) 471405122093302 (H)	Tapps Island (near Lake Tapps Park)	47° 14' 03"	122° 09' 40"	15	Ecology site #4, and CWA site #4 are farther to the northwest than USGS site #L4.
L5	471324122093901 (E) 471324122093902 (H)	Snag Island (north side of Snag Island)	47° 13' 21"	122° 09' 37"	15	Ecology site #5, near CWA site #8
L6	471223122091201 (E) 471223122091202 (H)	Lake Inlet (near White River Canal Inflow)	47° 12' 24"	122° 09' 12"	5	Ecology site #6
L7	471241122084401 (E) 471241122084402 (H)	Southeast Arm ¹ (east side of Snag Island)	47° 12' 40"	122° 08' 44"	3	CWA site #7
L8	471423122115001 (E) 471423122115002 (H)	Lake Outlet ¹ (northeast Lake Tapps)	47° 14' 23"	122° 11' 51"	10	CWA site #6
L9	471456122110801 (E) 471456122110802 (H)	Dike 2B (north Lake Tapps near Lake Tapps Park)	47° 14' 57"	122° 11' 08"	5	Near CWA site #9

¹Site or locale names from Michael Gagliardo, Cascade Water Alliance, written commun., June 2010.

Methods and Procedures

River Continuous Monitors

Multiparameter water quality sondes, housed in an open-ended 4 in. × 12.5 ft PVC pipe perforated with numerous ½-in. diameter holes, were installed at three sites and fully operational by late May 2010. The sondes were programmed to collect measurements of physical properties (water temperature, specific conductance, pH, and turbidity) and concentrations of dissolved oxygen in ambient water every 15 minutes. The sondes interfaced with a data collection platform and electronic data logger (DCP/EDL) to transmit data hourly using high-data rate satellite telemetry. All sondes were calibrated prior to deployment, as described by Wagner and others (2006) and Gibbs and others (2007), and generally checked for calibration monthly or every 2 months during autumn and winter.

The conductivity sensors were calibrated using a 1-point calibration to a 1,000 µS/cm potassium chloride standard. Linearity response of the sensor was checked monthly, or

before and after sensor replacement, by ensuring a zero reading of the dry sensor in air and measuring several specific conductance standards between 0 and 1,000 µS/cm that included the expected range of specific conductance. The pH sensors were calibrated using a 2-point calibration with temperature adjusted pH 7 and pH 10 buffer solutions. The dissolved oxygen sensors were calibrated in water-saturated air using the percent-saturation method prior to deployment, but subsequent calibrations or calibration checks used air-saturated water at stable temperatures in the USGS Washington Water Science Center (WAWSC) Field Services Unit (FSU) to ensure 100 percent saturation. The turbidity sensors (YSI 6136) were calibrated using a 2- or 3-point calibration with the first point being zero formazin nephelometric turbidity units (FNU) and followed by a 10 or 1,000 FNU turbidity standard. The sensors were calibrated at the FSU prior to deployment and all calibrations or calibration checks were performed using a dedicated sonde guard and dedicated plastic calibration cups and protected from wind and direct sunlight, as described in YSI Inc. (2010). Calibration and reporting procedures for turbidity also are discussed by Anderson (2005).

The water temperature sensors do not require calibration, but the sondes were compared at five temperature points (between 0 and 30°C) with a National Institute of Standards and Technology (NIST) traceable thermistor, as described by Wilde (2006) in the month prior to deployment. During site visits, temperature readings of the installed sonde were compared with another sensor that also had been checked annually at five temperature points and 2-point calibration checks at least twice during the year.

Turbidimeter and Vertical Profiling Instruments for River and Lake Measurements

Prior to use, the HACH 2100P turbidimeters were calibrated with the manufacturer's standards and according to the manufacturer's guidance. Prior to use, the conductivity-temperature-depth (CTD) instrument used for profiling surface-to-bottom water quality conditions at each lake site was sent to the manufacturer (Sea-Bird Electronics, Inc., Bellevue, Washington) for factory calibration and installation of a new pH sensor. Calibration coefficients in the CTD firmware were updated and the calibration records filed in the WAWSC in Tacoma, Washington. The CTD instrument used during this study was a Sea-Bird SBE 19*plus* V2 SEACAT equipped with auxiliary sensors that included a SBE 43 dissolved oxygen sensor, a SBE 18 pH sensor, a QSO2300 Biospherical photosynthetically active radiation (PAR) sensor, and a WETLabs ECO-FLU fluorometer and turbidity sensor.

Field-Trip Preparation, Sample-Collection, and Sample-Handling Protocols

All equipment for sample collection, compositing, filtration, and processing of water for chemical analyses was cleaned in the WAWSC FSU using parts-per-billion (ppb) procedures, as described by Wilde (2004) in the USGS National Field Manual (U.S. Geological Survey, variously dated). In addition, all collection and processing equipment used for fecal-coliform bacteria analyses were autoclaved after cleaning, as described by Myers and others (2007). Autoclave indicator tape was applied to each piece of equipment to identify it as sterile and to distinguish it from other non-sterile equipment. Capsule and disk filters used in the field to filter water samples for chemical analyses were pre-conditioned, and sample bottles for shipping to laboratories rinsed with FSU Type I deionized water treated by reverse osmosis. Petri dishes (plates) of solid medium for culturing fecal-coliform bacteria were prepared 1 day prior to sampling. A sufficient volume of medium was prepared at one time and the plates

needed to process all three river and nine lake sites over 2 days were poured and held in the refrigerator for no longer than 72 hours (U.S. Geological Survey, 2011b). Two people collected, processed, and handled water samples at the sampling sites following ppb protocol, as described by U.S. Geological Survey (2006). Samples for chemical analysis requiring filtration or preservation treatment were processed onsite. All samples were stored in the dark and on ice (in ice chests) for transportation back to the FSU where the samples were stored in refrigerators for further processing or for shipping to laboratories the following day. Samples for the enumeration of fecal-coliform bacteria were filtered and incubated in the FSU within 6 hours of collection, as described by Myers and others (2007).

Prior to each field sampling event, the battery life of the CTD instrument was checked, and batteries changed if needed. The conductivity cell was filled with a 0.1-percent Triton-X-100 solution, using a syringe and clear Tygon® tubing attached to the intake of the CTD instrument. The solution was syringed into the conductivity cell at least 1 hour prior to deployment to thoroughly wet the cell. The pH sensor was calibrated monthly with three pH buffer solutions (pH 4, 7, and 10) following procedures as described by Sea-Bird Electronics, Inc. (2010).

Post-Field Trip Sample Processing and Handling

In the FSU following the day of collection, the sample bottles for chemical analyses were packed in waterproof bags in ice chests and shipped on ice by overnight delivery to the USGS National Water Quality Laboratory (NWQL) in Lakewood, Colorado, and to Test America Laboratory in Arvada, Colorado, which is under contract to the NWQL. Samples for turbidity measurements were removed from the refrigerators and allowed to warm to room temperature. After verifying the calibration of the meter, aliquots of sample water were measured using a HACH 2100P portable turbidimeter. As many as five readings were recorded on the site field sheet. The median value was reported in ratio-corrected nephelometric turbidity units (NTRU), as described by Anderson (2005). Sample water for laboratory determinations of chlorophyll *a* concentration was filtered through glass fiber filters with a 0.7-μm effective pore size, sealed in foil and waterproof bags, and frozen. The frozen filters for all nine lake sites collected over a 2-day period were shipped together on dry ice to the NWQL the same week of sample collection. Plates culturing the fecal coliform bacteria were examined after 22–26 hours for colony growth, and the number of colonies was recorded on the site field sheet.

Post-Field Trip Vertical Profiling Instrument Maintenance and Data Processing

After deployment, the outside of the CTD instrument was rinsed thoroughly in the FSU with tap water to clean off any debris, silt, or mud. The outer sensors (PAR, fluorometer, and pH) were inspected and rinsed thoroughly with tap water followed by deionized water. The pH sensor was then stored in fresh pH 4 buffer solution saturated with potassium chloride. The conductivity cell and the dissolved oxygen sensor plumbing assembly were cleaned with 0.1-percent Triton-X-100 solution using a syringe and tubing attached to the CTD sample intake. The solution was agitated through the plumbing several times to flush the entire plumbing assembly; the flushing was followed by several deionized-water rinses. The CTD instrument was then allowed to dry and stored in a clean dry environment until the next deployment.

Processing of Vertical Profiling Instrument Data Files

The CTD profile data were collected at the maximum resolution of the CTD instrument, four scans of data per second. CTD data files were further processed using Sea-Bird SBE Data Processing[®] software. The primary variables of pressure, temperature, conductivity, dissolved oxygen, and fluorometric values were converted from raw data to engineering values and voltages. After converting the data, the SBE Data Processing software advances temperatures by 0.5 second and dissolved oxygen values by 3 seconds to compensate for transit delays to the pumped sensors and response-time differences. Additional software commands further match response times for temperature, conductivity, and pressure; and remove digital noise from pressure data. The DERIVE command generates variables that are dependent on pressure, temperature, conductivity, or auxiliary sensor data, such as depth, in meters; dissolved oxygen, in milligrams per liter; and specific conductance, in microsiemens per centimeter at 25 degrees Celsius. Data recorded during the up and down casts were then separated and the down-cast data averaged over 0.5-m depths. Data processing details are described in the SBE Data Processing Manual (Sea-Bird Instruments, Inc., 2011).

River, Canal, and Diversion Water Sampling and Onsite Processing

Samples of water were collected from the White River at a bridge at the Headworks site and from the Inflow site at a bridge on 218th Street E using a DH-95 sampler at 5–10 equidistant vertical locations (multiple vertical and non-isokinetic). The Tailrace site was sampled by wading upstream of the weir using a DH-81 sampler, as described by

Wilde (2006). The samples from multiple vertical locations were composited in a plastic or Teflon[®] churn splitter, which is used to split the composited water into various subsamples for preservation or further processing, as described by Wilde and others (2004). Sample bottles for analyses requiring unfiltered water were filled first from the churn and bottles for analyses requiring filtered water were then filled using a peristaltic pump and a 0.45- μ m disposable filter. Field parameters (water temperature, pH, dissolved oxygen, specific conductance, and sometimes turbidity) were measured at the same vertical locations using a multiparameter sonde and median values were reported.

Sondes were calibrated onsite at the beginning of each sample day or in the FSU prior to field work. If sondes were calibrated in the FSU, the buffers and standards were used at room temperature, but if sondes were calibrated onsite, the buffers and standards were submerged in a mesh bag in the stream to equilibrate to the stream temperature. The pH sensor was calibrated with a 2-point calibration using pH 7 and pH 10 buffers that were within 5°C of the stream temperature (when calibrated in the field). The conductivity sensor was calibrated with a 1,000 μ S/cm potassium chloride standard, and values of several standards that bracketed the conductance of the sample water were verified. The polarographic dissolved oxygen sensor was calibrated using the water-saturated air calibration method or in an air-saturated water bath at the FSU, whereas the optical dissolved oxygen sensor was calibrated in an air-saturated water bath in the FSU. The barometric pressure and water temperature were used to determine the dissolved oxygen concentration at saturation for calibrating the sensor. All sonde thermistors were checked annually for accuracy against a standard NIST traceable reference thermometer with a five-point temperature check. In addition, all meters are checked at two temperatures, an ice bath and room temperature, at least twice during the year.

Lake Water Sampling and Onsite Processing

Upon anchoring the boat at the sampling sites, the initial activity was to prepare the CTD profiling instrument for deployment. This involved attaching the instrument to a cable on a reel; removing the syringe duct plumbing, pH storage container, and protective caps housing the auxiliary sensors; and switching on the power. Using the reel, the CTD instrument was lowered into the water and submerged to the top of the purge plumbing to allow excess air to escape. The instrument was soaked at the water surface for about 1 minute to allow the sample pump to begin operating and flushing the plumbing. The instrument was then lowered through the water column at a rate of about 1 ft/s and raised at the same rate, if possible, for a complete profile cast ([fig. 5](#)). After the cast, the instrument was recovered onboard, turned off, then the protective caps and pH buffer storage container were placed back onto the appropriate sensors.

Figure 5. Sea-Bird conductance, temperature, depth (CTD) profiling instrument assembly (A) and deployment while monitoring real-time data output (B).

The CTD instrument was attached to a laptop computer during the casts in order to observe real-time data showing total water-column depth and associated field parameters of temperature, dissolved oxygen, specific conductance, pH, turbidity, fluorescence, and PAR with depth. The real-time data, particularly the temperature profile that indicated if the water column was thermally stratified, and the total water-column depth determined the sampling strategy for that site on the day of collection. During the casts of the CTD instrument, Secchi disk and air temperature readings were recorded on field sheets with additional notes concerning weather, boat traffic, water conditions, and other observations ([appendix A](#)).

If the water column at the lake sampling site was thermally stratified, sample water for chemical analyses typically was collected from four points within the epilimnion and hypolimnion, then composited into separate plastic or Teflon® churn splitters. Water for analyses requiring whole water was split from the churn and then the remaining water was passed through a 0.45- μ m pore-size disk filter into bottles for analyses requiring filtered water. If the water column was not thermally stratified, point samples were collected from 1 m below the water surface and from about 0.5 m to 1 m above the lake bottom. Thus, discussions of the quality of water in the epilimnion and hypolimnion in this report can refer to data obtained by point or composite-sampling, or by a combination of both methods.

During the first sampling event of July, samples were collected with a 1.7-L Niskin bottle attached to a weighted rope marked in 0.5-m intervals and positioned at one or more specific depths in the water column depending on stratification. If the Niskin bottle was used for non-stratified point samples, the bottle was filled multiple times at the target depth and emptied into a churn splitter until a sufficient volume was obtained to fill all sample bottles for chemical analyses.

Beginning with the second sampling event in July and continuing through the remainder of the study, sample collection was changed from Niskin bottles to a peristaltic pump with Teflon® or polyethylene tubing to allow more thorough cleaning and to easily collect organic samples using Teflon® materials. With the tubing lines attached to the weighted rope, the sampling-line orifice was lowered to specific depths and water pumped to the surface with the peristaltic pump. If the water column was stratified, the sampling-line orifice was lowered to multiple target depths and pumped into a churn splitter. If the water column was not stratified, the sampling-line orifice was lowered to 1 m below the water surface and to about 0.5–1 m above the lake bottom and pumped directly as whole water into sample bottles or through a 0.45- μ m pore-size disk filter into sample bottles.

Water for analysis of fecal-coliform bacteria was collected approximately 0.5 m below the water surface. An autoclaved sterile DH-81 bottle and cap assembly attached to a DH-81 sampler was lowered to the target depth and allowed to fill.

Samples requiring preservative were acidified with 1 mL of 4.5-normal sulfuric acid. Lot numbers for the preservative and disk filters were recorded on the site field sheet. Sample bottles were sealed in waterproof bags and stored in ice chests for scheduled mid-day pick up by USGS personnel so that samples could be returned to the FSU and the fecal-coliform bacteria samples processed within 6 hours of collection.

Analytical Methods

All river and lake samples were analyzed for concentrations of nutrients, total suspended solids, turbidity, and fecal-coliform bacteria. Lake samples also were analyzed for concentrations of chlorophyll *a*, and samples from three lake sites were analyzed for organic chemicals. The NWQL in Lakewood, Colorado, analyzed the samples for nutrients using NWQL Schedule 1865 ([appendix B](#)). Filtered samples for the analysis of ammonia were analyzed colorimetrically using a salicylate-hypochlorite method described by Fishman (1993). Filtered samples were analyzed for nitrite-plus-nitrate nitrogen by reducing the nitrate to nitrite with copperized cadmium. The resulting nitrite, plus any originally present in the sample, was determined by automated, continuous flow colorimetry (Fishman, 1993). Filtered samples for the analysis of orthophosphate phosphorus used a phosphomolybdate method, as described by Fishman (1993). Total nitrogen and total phosphorus in filtered and unfiltered samples were determined as nitrate and orthophosphate after conversion to those species by alkaline persulfate digestion (Patton and Kryskalla, 2003). Similarly, filtered and unfiltered samples for the analysis of low-level phosphorus were oxidized to be determined as orthophosphate, as described by U.S. Environmental Protection Agency (1993). In this report, unfiltered phosphorus is referred to as total phosphorus. Nitrate and orthophosphate in the persulfate digests were analyzed with a dual-channel photometric, air-segmented continuous flow analyzer, as described by Patton and Kryskalla (2003).

The Allan Yorke, Snag Island, and Lake Outlet study sites were sampled to screen for the presence of organic chemicals. These sites were chosen for potential effects on water quality from population density and management activities with respect to future water uses. Water samples collected from the sites on September 21 and 22 were filtered through a 0.7- μ m glass-fiber filter and submitted to NWQL for analyses of wastewater indicator chemicals, pesticides, human-health pharmaceuticals, and the pesticide fluridone ([appendix C](#)). Pharmaceutical compounds were analyzed using

NWQL Schedule 2080; wastewater indicator compounds were analyzed using Schedule 1433; human-health pharmaceuticals were analyzed using NWQL laboratory code 8144 as an add-on to Schedule 1433; pesticide and pesticide degradation products were analyzed using Schedule 2033; and the pesticide fluridone was analyzed by NWQL laboratory code 8072 as an add-on to Schedule 2033. Samples for analysis of wastewater indicator compounds were extracted by vacuum through polystyrene-divinylbenzene cartridges, eluted, and then analyzed by capillary-column gas chromatography/mass spectrometry (GC/MS), as described by Zaugg and others (2002). Samples for analysis of human-health pharmaceuticals were extracted through polystyrene-divinylbenzene cartridges and analyzed by high-performance liquid chromatography/mass spectrometry (HPLC/MS), as described by Furlong and others (2008). Samples for analysis of pesticides were isolated by solid-phase extraction and analyzed by GC/MS, as described by Zaugg and others (1995), Lindley and others (1996), Sandstrom and others (2001), and Madsen and others (2003). Fluridone was added to the NWQL spiking compound for Schedule 2033 and analyzed using the same methodology and data quality objectives, as described for Schedule 2033. Similarly, 47 additional human-health pharmaceutical compounds were added to the spiking compound for Schedule 1433 and analyzed using the same methodology and data-quality objectives as Schedule 1433. Because the analysis for these additional compounds has not been formally approved by the USGS, the data are not approved for storage in the National Water Information System (NWIS) database.

Test America Laboratory in Arvada, Colorado, under contract with the NWQL, analyzed samples for total suspended solids (TSS). Test America Laboratory analyzes TSS samples by Standard Methods number 2540D (American Public Health Association and others, 1998).

Samples for the analysis of chlorophyll *a* and pheophytin were filtered in the FSU through glass fiber filters at low vacuum, frozen, and shipped to the NWQL overnight on dry ice. Samples were extracted at the NWQL using an ultrasonic microprobe and quantified by fluorescence (NWQL Schedule 1637), as described by Arar and Collins (1997).

Analysis of fecal-coliform bacteria by membrane filtration using a 0.45- μ m filter on fecal-coliform agar culture medium followed the procedures described in Standard Methods number 9222D (American Public Health Association and others, 1998). Each water sample required about five plates for the analysis with the first plate and filter consisting of 50 mL of sterile, phosphate-buffered rinse water (filtration blank). The remaining plates consisted of filtered sample volumes ranging from 3 to 100 mL. The plated filters were cultured in incubators at $44.5 \pm 0.2^\circ\text{C}$. After 24 ± 2 hours of

incubation, the plates were examined for growth of blue colonies. The target colonies were counted (using 10-power magnification, if needed), the numbers recorded on a field sheet, and expressed as a concentration in colony-forming units per 100 mL (CFU/100 mL) of water.

Quality Assurance

All field activities for the collection of water-quality samples and water-quality monitoring follow the general guidelines and procedures described in the USGS WAWSC Quality Assurance Plan, as described by Wagner and others (2007). In addition to the maintenance and calibrations of water-quality instruments and onsite documentation previously discussed, a total of 53 quality-control (QC) samples for analyses of nutrients, total-suspended solids, chlorophyll *a*, turbidity, organic compounds, or fecal-coliform bacteria were prepared at the study sites. Of the QC samples, 13 were from the Headworks, Inflow, and Tailrace sites and 40 from the lake sites over the 6-month study (table 3). The field QC samples included replicates to assess total variability in the data due to collection, handling, and laboratory analytical methods; field blanks to evaluate if any positive bias to constituent concentrations was introduced during collection and handling of equipment and sample water; and a field spike to evaluate positive or negative matrix effects on concentrations of organic chemicals. The proportion of QC sample types to the number of environmental samples collected was about 25 percent.

Field Quality Control Samples

Field-blank samples were subjected to the same conditions and handling as the environmental samples and were prepared onsite with reagent-grade water prior to the collection of environmental sample water. Field blanks for nutrients, chlorophyll *a*, total suspended solids, and turbidity were prepared with water certified for use for inorganic constituents; and field blanks for pesticides, wastewater indicator chemicals, and pharmaceuticals were prepared with organic-free water. Field blanks for fecal-coliform bacteria were prepared with sterile Type I water from the FSU. Typically, the same set of equipment was used for collecting the environmental water. The handling and preparation of equipment for field blank collection and processing followed the guidelines in the National Field Manual (U.S. Geological Survey, 2006).

Table 3. Types and numbers of quality control samples collected at Lake Tapps, White River (Headworks), White River Canal (Inflow), and Lake Tapps Diversion (Tailrace) sites, Washington, July–December 2010.

[Abbreviation: QC, quality-control sample]

Month	Number of field blanks				Number of replicates		
	Nutrients, Total suspended solids, Turbidity	Chlorophyll <i>a</i>	Fecal coliform bacteria	Wastewater indicator chemicals, human-health pharmaceuticals	Nutrients, Total suspended solids, Turbidity	Chlorophyll <i>a</i>	Fecal coliform bacteria
Lake							
July	3	2	0	0	2	1	0
August	3	1	1	0	3	1	0
September	4	1	0	1	1	1	2
October	2	1	1	0	2	1	0
November	1	1	0	0	0	0	0
December	1	0	0	0	2	0	0
QC totals each type	14	6	2	1	10	4	2
Headworks, Inflow, Tailrace							
	Number of field blanks			Number of replicates			
	Nutrients, Total suspended solids, Turbidity	Fecal coliform bacteria		Nutrients, Total suspended solids, Turbidity	Fecal coliform bacteria		
July	1	1		2	0		
August	2	1		1	1		
September	0	0		0	0		
October	0	0		0	0		
November	1	1		1	0		
December	0	0		0	1		
QC totals each type	4	3		4	2		

Summary of quality control samples

Sample type	Numbers for lake	Numbers for river
Blanks	23	7
Replicates	16	6
Organic matrix spike	1	0
Total	40	13

Replicate samples were of two types—split and sequential. Split-replicate samples simply involved collecting enough water to fill the churn and split out two sets of sample bottles for whole water analyses and filter remaining water for two sets of filtered water. Split-replicate samples from churn splitters were prepared at the Headworks, Inflow, and Tailrace sites and at the lake sites when churn splitters were used to composite water from different sampling depths. Sequential-replicate samples were prepared at lake sites when churn splitters were not used, by pumping through the sampling lines and sequentially filling two sets of bottles with whole-water and two sets of bottles with filtered water.

The matrix-spike organic samples were split-replicate samples consisting of multiple 1-L glass bottles filled from the churn splitter and held on ice for transport to the FSU. At the FSU, the raw water was filtered into another set of clean 1-L glass bottles and shipped on ice to the NWQL for organic chemical analyses. The bottle of filtered water to be analyzed for wastewater indicator chemicals was spiked with 0.1 mL of a spike solution containing a mix of target analytes in known concentrations (for Schedule 1433). A second bottle of filtered water for analysis of human-health pharmaceuticals (by Schedule 2080) was shipped on ice to the NWQL and spiked in the laboratory.

Laboratory Quality Control Samples

In addition to quality-assurance procedures used in the field, the NWQL also follows general guidelines and procedures to ensure quality work procedures and results as described by Maloney (2005). The NWQL routinely follows standard operating procedures for the analysis of all constituents; follows accepted procedures for instrument calibration; and utilizes instrument blanks, laboratory replicates, and continuing calibration verification standards to ensure the quality of analyzed data. These internal quality-control procedures are augmented by analysis of samples in several external standard reference programs, such as participation in the USGS Branch of Quality Systems NWQL Blind Blank Program, Inorganic Blind Sample program, and Organic Blind Blank program (U.S. Geological Survey, 2010). Results from these internal quality-control procedures indicated the NWQL data quality to be within acceptable limits during the period of this study.

Analytical Results for Quality Control Samples

Field blanks for the Headworks, Inflow, and Tailrace sites were free of detections of total suspended solids, nitrite, nitrite-plus-nitrate nitrogen, orthophosphate phosphorus, filtered and total phosphorus, unfiltered total nitrogen, and fecal-coliform bacteria ([appendix table D1](#)). Ammonia was detected in all four field-blank samples and filtered total nitrogen was detected in three of the field blanks at low concentrations near the laboratory reporting or method detection levels. Corresponding environmental sample concentrations were all less than the laboratory reporting level and therefore do not exhibit a positive bias ([table 4A](#)). The exception may be for the field-blank and environmental samples collected on August 17, 2010, at the Inflow site in which filtered total-nitrogen and ammonia concentrations were nearly the same ([appendix table D1](#)). Turbidities analyzed in the FSU using a HACH 2100P were consistently about 0.1 NTRU, which do not affect environmental values that were one to two orders of magnitude greater than the field-blank value.

Relative percent differences among 42 pairs of replicate concentrations from the Headworks, Inflow, and Tailrace sites ranged from 0 to 66.7 percent, with more than one-half of the 42 replicate pairs greater than an acceptable limit of less than 5-percent relative difference ([table 4B](#)). The largest difference (66.7 percent) was observed in one pair of filtered nitrite concentrations, followed by 44.2 percent for one pair of filtered total nitrogen concentrations ([appendix table D1](#)). Concentration data reported for all constituents include total variation (errors) accumulated through sampling, processing, and analysis. In addition, random bias, as shown in blank concentrations ([table 4A](#)) increases variation. For example, concentrations of filtered total nitrogen in field blanks ranged from 0.06 to 0.21 mg/L and these random detections are reflected in the 8–44.2 percent relative differences observed between replicate pairs of filtered total nitrogen ([table 4B](#)). Measurement of variability in concentrations that are at or near the limit of detection may result in a large relative percent difference. For example, the pair of nitrite concentrations in samples from the Tailrace site during November 2010 (0.001 and 0.002 mg/L) is reported to three significant digits and the small difference between these concentrations results in a large relative percent difference. Another source of variability in replicates of nutrient analyses can be due to the tendency for nitrogen and phosphorus to adsorb to particles. Some of the variation seen in unfiltered nutrient concentrations may be a reflection of the variation seen in the turbidity and suspended solids replicates ([table 4B](#)).

Table 4. Summary of analytical results for (A) field-blank samples and corresponding environmental water samples and (B) relative percent difference between pairs of samples collected from White River (Headworks), White River Canal (Inflow), and Lake Tapps Diversion (Tailrace) sites, Washington, July–December 2010.

[Abbreviations: mg/L, milligram per liter; NTRU nephelometric turbidity ratio units; e, estimated; <, less than]

A. Field blank samples and corresponding environmental water samples

Constituent	Field blanks			Environmental water sample concentration
	Total number of samples	Number of samples with detections	Sample concentration	
Ammonia nitrogen, filtered (mg/L)	4	4	e0.014	<0.01
			e0.012	e0.013
			e0.012	<0.01
			0.018	0.018
Nitrite plus nitrate nitrogen, filtered (mg/L)	4	1	e0.013	0.028
Total nitrogen, filtered (mg/L)	4	3	0.21	<0.05
			e0.1	0.14
			e0.06	<0.05
Turbidity, NTRU	4	3	0.1	30
			0.1	9.1
			0.1	2.5

B. Relative percent difference between pairs of samples collected from Headworks, Inflow, and Tailrace

Constituent	Number of sample pairs	Number of samples with difference greater than 5 percent	Relative difference (percent)		
			Median	Minimum	Maximum
Ammonia nitrogen, filtered	4	3	9.1	0	37.5
Nitrite plus nitrate nitrogen, filtered	4	2	5.7	0	22.2
Nitrite nitrogen, filtered	4	1	0	0	66.7
Orthophosphate phosphorus, filtered	4	1	0	0	9.5
Phosphorus, filtered	4	1	0	0	13.3
Phosphorus, unfiltered	4	3	9.2	3.5	26.3
Total nitrogen, filtered	4	4	11.6	8.0	44.2
Total nitrogen, unfiltered	4	3	10.1	0	40.0
Total suspended solids	4	3	9.1	0	20.0
Turbidity	4	2	6.2	1.8	20.6
Fecal-coliform bacteria	2	2	26.8	22.2	31.3

Field blanks for Lake Tapps sites were free of detections of nitrite nitrogen, orthophosphate phosphorus, filtered and total phosphorus, filtered total nitrogen, chlorophyll *a* and pheophytin *a*, and fecal-coliform bacteria ([appendix table D2](#)). Nitrite-plus-nitrate nitrogen and unfiltered total nitrogen were each detected in 1 of the 14 field-blank samples. The nitrite-plus-nitrate concentration of 0.01 mg/L detected in the blank sample from Lake Inlet on July 20, 2010, is near the method detection level of 0.008 mg/L. The unfiltered total nitrogen concentration of 0.13 mg/L in the blank sample from Allan Yorke site on August 3, 2010, is the same as the concentration of the environmental sample ([appendix table D2](#)). Extensive flushing of the sampling lines with lake water before the sample collection probably minimized or eliminated potential residual contaminants and any positive bias to water samples. Concentrations of ammonia in 4 of the 14 field-blank samples were present at low concentrations near the method detection

level of 0.01 mg/L and similar to the concentration in the environmental samples. Turbidities analyzed in the FSU using a HACH 2100P showed consistent low-level values for the 14 field-blank samples, ranging from 0.07 to 0.19 NTRU with a median of 0.12 NTRU. This low level likely indicates a background level associated with the reagent waters and instrumentation and not a contamination bias to samples from collection and handling. Turbidity in lake water samples were at least three times greater than field-blank values ([table 5](#)). Three organic compounds—isorhorene, benzophenone, and phenol—were detected in the field-blank sample prepared at the Lake Outlet site in September ([appendix table D3](#)). The detection of these compounds did not alter the sample concentrations because the compounds were reported as less than the laboratory reporting level or reported as measured and detected, but not quantified.

Table 5. Constituent concentrations in field-blank samples with detections at or greater than laboratory method detection or reporting levels, and concentrations in corresponding water samples from Lake Tapps, Washington, July–December 2010.

[See [appendixes](#) for all quality-control analytical results. **Abbreviations:** mg/L, milligram per liter; NTRU nephelometric turbidity ratio units; µg/L, microgram per liter; e, estimated; <, less than; n, less than the laboratory reporting level and greater than the long-term method detection level; M, presence of analyte verified, but not quantified]

Constituent	Field blanks			Lake-water sample concentration
	Total number of samples	Number of samples with detection	Sample concentration	
Ammonia nitrogen, filtered (mg/L)	14	4	0.01	0.011
			0.011	0.012
			e0.014	<0.010
			0.02	0.031
Nitrite plus nitrate nitrogen, filtered (mg/L)	14	1	e0.01	<0.008
Total nitrogen, unfiltered (mg/L)	14	1	0.13	0.13
Turbidity (NTRU)	14	14	0.07	1.2
			0.08	3.2
			0.08	0.7
			0.08	1.8
			0.08	1.6
			0.09	0.8
			0.11	0.6
			0.14	0.7
			0.14	2.5
			0.17	0.7
			0.17	1.5
			0.19	1.1
			0.19	0.6
			0.19	0.6
Isophorone, filtered (µg/L)	1	1	e0.033	M
Phenol, filtered (µg/L)	1	1	n0.14	<0.16
Benzophenone, filtered (µg/L)	1	1	0.046	M

Constituent concentrations in replicate samples from the lake sites generally agreed within acceptable limits of less than 5-percent relative difference, except for fecal-coliform bacteria, filtered and unfiltered total nitrogen, and unfiltered total phosphorus (table 6). The analytical results for the three sample pairs of fecal-coliform bacteria showed the greatest variability with relative differences of 35.1, 66.7, and 93.3 percent. On the basis of medians, the constituents with the next largest variability after the bacteria were unfiltered and filtered total nitrogen with differences of 12.0 and 8.2 percent, respectively (table 6).

Of the compounds in Schedules 2080 and 1433, only prometon and DEET in Schedule 1433 were detected at a level that provided a sufficient background concentration for calculating a matrix-spike recovery. Recoveries for these two

compounds were 95 and 99 percent, respectively. All other recoveries were calculated with background-sample values reported as less than the laboratory reported level and shown as ranges of spike recovery. This range uses zero for the lowest possible concentration and the laboratory reporting level for the highest possible concentration. Recoveries of two compounds for Schedule 2080, sulfamethoxazole and thiabendazole, were less than 60 percent for the high value of the calculated range. In the methods development testing of South Platte River and Boulder Creek water (Furlong and others, 2008), recoveries of these two pharmaceuticals also were low at less than 50 percent. Ten compounds in Schedule 1433 had recoveries at the high end of the calculated ranges that were less than 60 percent (table 7).

Table 6. Summary of relative percent difference among pairs of samples collected from Lake Tapps sites, Washington, July–December 2010.

[All samples filtered unless indicated]

Constituent	Number of sample pairs	Number of samples with difference greater than 5 percent	Relative difference (percent)		
			Median	Minimum	Maximum
Ammonia nitrogen	10	4	1.6	0	27.8
Chlorophyll <i>a</i>	4	0	2.1	0	4.8
Fecal coliform bacteria	3	3	66.7	35.1	93.3
Nitrite plus nitrate nitrogen	10	2	0.0	0	17.4
Nitrite nitrogen	10	2	0.0	0	14.5
Orthophosphate phosphorus	10	3	0.6	0	24.5
Phosphorus	10	3	0.9	0	6.6
Phosphorus, unfiltered	10	5	5.4	0	26.6
Total suspended solids, unfiltered	10	4	0.0	0	40.0
Total nitrogen	8	5	8.2	0.8	40.8
Total nitrogen, unfiltered	10	10	12.0	6.0	59.4
Turbidity, unfiltered	10	3	3.4	0	49.8

Table 7. Wastewater indicator compounds of analytical Schedule 1433 with low recoveries of a fortified matrix spike solution in sample water from the Lake Outlet (fig. 4, map No. L8) site on Lake Tapps, Washington, September 22, 2010.

[Abbreviations: µg/L, microgram per liter; <, less than; e, estimated]

Parameter code	Wastewater indicator compound	Background concentration (µg/L)	Matrix-spike concentration (µg/L)	Recovery range (percent)
62059	3- <i>tert</i> -Butyl-4-hydroxyanisole ¹	<8	e0.092	-475–5.5
34476	Tetrachloroethene ¹	<0.12	e0.32	12–19.2
62073	<i>d</i> -Limonene ¹	<0.08	0.52	26.4–31.2
62076	Indole	<0.08	0.096	6.4–38.4
62068	<i>beta</i> -Sitosterol	<4	e3.8	-2.5–47.5
62061	4- <i>n</i> -Octylphenol ¹	<0.16	e0.1	-28.8–48.1
62063	5-Methyl-1H-benzotriazole	<1.2	1.7	15–51.1
62086	<i>beta</i> -Stigmastanol	<2.6	e1.1	-72.1–52.9
62078	Isopropylbenzene ¹	<0.3	0.23	-16.8–55.3
34288	Tribromomethane ¹	<0.1	0.99	53.5–59.5

¹Compounds with low recovery, high variable recovery, unstable instrument response, or from a technical mixture to be reported with an estimated (e) code from testing during method development.

Environmental and Hydrologic Conditions During the Sample-Collection Period

Weather records by the National Weather Service at SeaTac Airport generally showed below-normal temperatures and above-normal rainfall during the period of study (National Climatic Data Center, 2010). Average departure of air temperatures from normal monthly temperatures were –0.7°F during July; –0.2°F during July and September; and 0.6°F during October. The first sampling event in early July (July 6–8) followed a cooler than normal June with air temperatures averaging 2.4°F below normal, and the last sampling event in early December (December 7–8) followed a cooler than normal November with an average temperature of 2.0°F below normal. Rainfall for July and August was below normal at 0.48 and 0.38 in., respectively. However, September and October rainfall was 3.17 and 2.05 in. above normal, respectively. By the end of October, precipitation was 6.89 in. above normal for the year. The first sampling event in July (July 6–8) followed a wet June, with precipitation totaling

1 in. above normal, and the last sampling event in December (December 7–8) followed a drier than normal November with precipitation nearly 1 in. below the normal of 5.9 in.

July and August samples were collected during generally warm and dry weather. However, weather conditions often varied on a daily basis over the course of sampling. For example, during the first sampling event in early July, air temperatures rose from a high of 64°F on July 6, the first day of sampling, to 86°F on July 8, the third day of sampling. Similarly, on August 3, the weather was cloudy, foggy, and cool, but on the second day of sampling (August 4), the sky was clear with bright sun ([appendix A](#)). The first sampling event in September (September 7–8) occurred during 3 days of substantial rainfall totaling more than 1.6 in., as measured at nearby McMillin Reservoir, a National Oceanic and Atmospheric Administration (2011) National Weather Service site (station 45-5224-03) operated by the city of Tacoma. Wet weather dominated sampling conditions during the remainder of the study from late September through early December, either by raining for a few days prior to, or by raining on the day of collection ([fig. 6](#)).

Figure 6. Daily rainfall amounts from precipitation records at McMillin Reservoir (station 45-5224-03, National Oceanic and Atmospheric Administration, 2011) near Puyallup, Washington, June–December 2010.

Wind and waves occasionally affected sampling conditions at some lake sites. Although wind waves typically were less than about 1 ft high, wakes from boats and personal watercraft at several sites on the sunny and warm days of July and August could have affected the position of the sampling-tube orifice in the water column and Secchi disk measurements ([appendix A](#)).

Beginning in late August 2010, Cascade Water Alliance closed the gates that divert water from the White River into the White River Canal and cleared all water from the Headworks to the twin pipe inlet structure east of Printz Basin. This dewatering process allowed staff to examine and repair structures and facilities in the White River Canal. Because there was no water being diverted at the Headworks and minimal water was being released from Lake Tapps from March through October, sampling at the Headworks, Inflow, and Tailrace sites was discontinued in late August ([fig. 7](#)). In preparation for winter drawdown, water was released from Lake Tapps in November 2010 ([fig. 8](#)), and the Tailrace was sampled two additional times during November and December.

With water diversions from the White River into the White River Canal, filling of Lake Tapps reservoir began in mid-March 2010. By late April, the reservoir was at the target water-surface elevation of about 542 ft. Water-quality sampling occurred with steady water-surface elevation until mid-October when Cascade Water Alliance began releasing water and lowering the lake. By the last sampling of the lake in December, the water level had declined to about 539 ft above NGVD 29.

Figure 7. Lake Tapps Diversion downstream of the Dieringer powerhouse (Tailrace) at no-flow, stagnant condition (A) and at a flow of 100 cubic feet per second (B).

Figure 8. Daily discharge hydrograph for stream-gaging station 12101100, Lake Tapps Diversion at Dieringer (Tailrace), Washington, May–December 2010.

Quality of Water in the White River, White River Canal, Lake Tapps Diversion, and Lake Tapps

This section presents summaries and discussions of the water-quality data collected from sampling and monitoring sites on the White River, White River Canal (Inflow), Lake Tapps Diversion (Tailrace), and Lake Tapps from May to December 2010. Discussion of the water quality of the White River, Inflow, and Tailrace system is presented first followed by descriptions of the quality of water in Lake Tapps. Where appropriate, the data obtained from this study are referenced to standards or criteria established by the State of Washington (2006, 2011) for the protection of aquatic life and recreation designated uses ([table 8](#)).

Quality of Water in the White River (Headworks), White River Canal (Inflow), and Lake Tapps Diversion (Tailrace)—Discrete Samples

Physical Properties

Because the source of the White River is from glaciers on Mount Rainier, the river transports fine glacier material that frequently gives the river a whitish color, especially during summer. The three sites sampled were relatively turbid, with median turbidity of 59 NTRU at the Headworks site, 16 NTRU at the Inflow site, and 6.8 NTRU at the Tailrace site. The turbidity measured from samples collected at all three sites during the study ranged from 2.4 NTRU at the Tailrace site to 340 NTRU at the Headworks site ([table 9](#)).

Table 8. Summary of Washington State freshwater aquatic life and recreation designated uses and criteria.

[Abbreviations: °C, degrees Celsius; mg/L, milligram per liter; mL, milliliter; CFU/100 mL, colony-forming units per 100 milliliters]

A. Aquatic Life Temperature Criteria	
Category	7-day average of daily maximum temperatures
Salmon and trout spawning and incubation ¹	13 °C
Core summer salmonid habitat ²	16 °C
Salmonid spawning, rearing, and migration ³	17.5 °C

B. Aquatic Life Dissolved Oxygen Criteria⁴	
Category	Lowest 1-day minimum
Core summer salmonid habitat ²	9.5 mg/L
Salmonid spawning, rearing, and migration ³	8.0 mg/L

C. Aquatic Life pH Criteria⁴	
Category	Range of pH units
Core summer salmonid habitat ²	6.5 to 8.5, with a human-caused variation of less than 0.2 units.
Salmonid spawning, rearing, and migration ³	6.5 to 8.5, with a human-caused variation of less than 0.5 units.

D. Water Contact Recreation Bacteria Criteria⁴	
Category	Fecal-coliform bacteria single-sample limits
Extraordinary primary contact recreation ⁵	100 CFU/100 mL.
Primary contact recreation ⁶	200 CFU/100 mL.

¹September 15–July 1 for the reach of the White River upstream of latitude 47° 14' 37.68" longitude 122° 14' 31.91" to the diversion dam and excluding the Muckleshoot Indian Reservation (Washington State Department of Ecology, 2006).

²For reaches of the White River from latitude 47° 14' 37.68" longitude 122° 14' 31.91" to Mud Mountain dam (Washington State Department of Ecology, 2011, table 602).

³For reaches of the White River downstream of latitude 47° 14' 37.68" longitude 122° 14' 31.91" (Washington State Department of Ecology, 2011, table 602).

⁴Washington State Department of Ecology (2011).

⁵For Lake Tapps and reaches of the White River above Mud Mountain Dam (Washington State Department of Ecology, 2011, table 602).

⁶For reaches of the White River from the mouth to Mud Mountain Dam (Washington State Department of Ecology, 2011, table 602).

Table 9. Summary statistics of water-quality properties and concentrations of nutrients, total suspended solids, and fecal-coliform bacteria for the study sites on the White River (Headworks), White River Canal (Inflow), and Lake Tapps Diversion (Tailrace), Washington, July–December 2010.

[Site: Headworks, White River at Headworks above Flume near Buckley, Washington, USGS, 12098700. Inflow, White River Canal at 218th Street E, above Lake Tapps near Buckley, Washington, USGS, 12099060. Tailrace, Lake Tapps Diversion at Dieringer, Washington, USGS, 12101100. Number of samples for Headworks, Inflow, and Tailrace sites equals 4, 4, and 6, respectively. **Abbreviations:** mg/L, milligram per liter; $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 °C; °C, degrees Celsius; NTRU, nephelometric turbidity ratio units; mL, milliliter; <, less than]

Site	Statistic	Turbidity (NTRU)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance ($\mu\text{S}/\text{cm}$)	pH (standard units)	Total suspended solids (mg/L)
Headworks	Median	59	11.7	10.7	52	7.6	255
	Range	5.7–340	10.6–14.0	10.3–11.9	50–53	7.4–7.8	22–1,000
Inflow	Median	16	21.0	8.7	70	7.4	89
	Range	5.8–15	16.3–25.4	7.9–9.7	57–70	7.3–7.9	4–190
Tailrace	Median	6.8	12.9	9.5	140	7.4	14.5
	Range	2.4–9.1	7.0–14.3	6.0–12.9	66–145	7.3–7.9	<1.1–27

Site	Statistic	Fecal coliform bacteria (colony-forming units per 100 mL)	Ammonia nitrogen, filtered (mg/L)	Nitrite nitrogen, filtered (mg/L)	Nitrite plus nitrate nitrogen (mg/L)	Total nitrogen, filtered (mg/L)
Headworks	Median	22	0.012	<0.001	0.028	0.12
	Range	<1–47	<0.01–0.016	<0.001–0.001	0.025–0.032	<0.05–0.19
Inflow	Median	24	0.012	<0.001	0.015	0.14
	Range	15–40	<0.01–0.033	<0.001–0.001	0.013–0.029	0.11–0.35
Tailrace	Median	320	0.025	0.001	0.024	0.24
	Range	2–570	<0.01–0.038	<0.001–0.002	<0.008–0.084	<0.05–0.28

Site	Statistic	Total nitrogen, unfiltered (mg/L)	Orthophosphate phosphorus (mg/L)	Phosphorus, filtered (mg/L)	Phosphorus, unfiltered (mg/L)
Headworks	Median	0.06	0.017	0.013	0.382
	Range	<0.05–0.13	0.013–0.019	0.008–0.018	0.028–0.492
Inflow	Median	0.2	0.005	0.005	0.089
	Range	0.18–0.71	0.005–0.01	<0.003–0.007	0.017–0.278
Tailrace	Median	0.31	0.02	0.016	0.068
	Range	0.16–0.56	<0.004–0.032	<0.003–0.029	0.008–0.145

The water temperature of the White River is moderated somewhat by residence time upstream of Mud Mountain Dam and generally becomes progressively warmer at downstream sites. Median water temperatures in samples collected during the study were 11.7°C at the Headworks site, 21.0°C at the Inflow site, and 12.9°C at the Tailrace site. The temperature measured from samples collected at all three sites during the study ranged from a minimum of 7.0°C at the Tailrace site to a maximum of 25.4°C at the Inflow site ([table 9](#)). The warmer temperatures at the Inflow site were due to the reduced flow diverted from the river to the White River Canal during 2010, and the Inflow site was essentially a stagnant pool during the latter half of the year. The median water temperature at the Tailrace site generally was warmer than at the Headworks site because the lake outlet is at a mid-to-lower lake elevation during summer, and the water being drawn from the lake is usually cooler than the surface of the lake but warmer than the river. Because flow from the White River to the White River Canal was suspended in late August to repair the wooden flume, the Headworks and Inflow sites were sampled only four times. However, water was released from Lake Tapps in November and, with flow restored to the Tailrace, the site was sampled once in November and once in December, which explains the minimum temperature during the study at the Tailrace site.

The White River generally is well-oxygenated, and the median dissolved oxygen concentration in samples collected during the study was 10.7 mg/L at the Headworks site. The suspension of the diversion of river water into the White River Canal for flume maintenance that resulted in warm water at the Inflow site also resulted in generally low concentrations of dissolved oxygen. The median dissolved oxygen concentration at the Inflow site was 8.7 mg/L and concentrations ranged from 7.9 to 9.7 mg/L. Flow also was reduced from the Lake Tapps Powerhouse in order to make valve repairs and to assist in maintaining the Lake Tapps summer elevation. Because the flow in the Tailrace was reduced to nearly zero from mid-June until early November, the water was less oxygenated and more influenced by metabolic processes from bacteria, algae, and macrophytes growing in the stream. The median dissolved oxygen concentration in samples collected during the study at the Tailrace site was 9.5 mg/L. The dissolved oxygen measured from samples collected at all three sites during the study ranged from a minimum of 6.0 mg/L to a maximum of 12.9 mg/ (both at the Tailrace site, [table 9](#)). The dissolved oxygen concentration of 6.0 mg/L measured on August 17, 2010, is lower than all categories of freshwater Aquatic Life Dissolved Oxygen Criteria established by the Washington State Department of Ecology (2011) ([table 8](#)).

The composition of the water in the White River, based on specific conductance and pH, generally is dilute and near neutrality. Median specific conductance values in samples collected during the study were 52 µS/cm at the Headworks site, 70 µS/cm at the Inflow site, and 140 µS/cm at the Tailrace site. Specific-conductance measurements made at all three sites during the study ranged from 50 µS/cm at Headworks to 145 µS/cm at the Tailrace ([table 9](#)). The pH is a measure of the acidity or basicity of aqueous solutions and is influenced by the dissolved constituents and biological processes occurring in the waterbody. The median pH in samples collected during the study were 7.6 pH units at the Headworks site and 7.4 pH units at the Inflow and Tailrace sites. The pH measurements made at all three sites during the study ranged from 7.3 pH units at the Inflow and Tailrace sites to 7.9 pH units at the Inflow and Tailrace sites ([table 9](#)).

Total Suspended Solids and Bacteria

The USGS traditionally uses measurements of suspended-sediment concentration as the most accurate method to measure suspended material in a sample collected from a stream (American Society for Testing and Materials, 2007). However, because TSS data have been used as a surrogate for suspended-sediment concentrations and because TSS is the appropriate measurement for the lake (non-flowing water), the TSS analysis was selected as a common measure for river and lake samples. The median concentrations of TSS in samples collected during the study were 255 mg/L at the Headworks site, 89 mg/L at the Inflow site, and 14.5 mg/L at the Tailrace site. TSS measured at all three sites during the study ranged in concentration from less than 1.1 mg/L (the minimum reporting level) at Tailrace to 1,000 mg/L at Headworks ([table 9](#)).

The microbial quality of the surface water was measured by analyzing for fecal-coliform bacteria during this study. The fecal-coliform group of bacteria includes bacteria that can indicate contamination from humans, livestock, pets, and wildlife, but also can include bacteria from non-enteric sources (U.S. Environmental Protection Agency, 1986). The median concentrations in samples collected during the study were 22 CFU/100 mL at the Headworks site, 24 CFU/100 mL at the Inflow site, and 320 CFU/100 mL at the Tailrace site. Measurements of fecal-coliform bacteria made at all three sites during the study ranged from less than 1 CFU/100 mL in a sample from Headworks to 570 CFU/100 mL in a sample from Tailrace. The concentrations of fecal-coliform bacteria in samples from Tailrace did not meet the single-sample primary contact recreation criterion of 200 CFU/100 mL for freshwater (Washington State Department of Ecology, 2011) ([table 8](#)) on four occasions out of six ([table 10](#)).

Table 10. Fecal-coliform bacteria in samples from Lake Tapps Diversion at Dieringer (Tailrace), Washington, July–December 2010.

[**Criterion** is the single-sample level for primary contact recreation (Washington State Department of Ecology, 2011). **Abbreviations:** ft³/s, cubic foot per second; CFU/100 mLs, colony-forming units per 100 milliliters; e, estimate]

Date	Time	Streamflow (ft ³ /s)	Fecal-coliform bacteria (CFU/100 mLs)	Criterion (CFU/100 mLs)
07-06-10	0950	e 0.63	570	200
07-20-10	0840	e 0.63	e 430	200
08-03-10	0830	e 1.52	270	200
08-17-10	0900	e 0.88	370	200
11-16-10	1040	109	2	200
12-07-10	1040	107	10	200

Nutrients

Water samples were collected and analyzed for concentrations of the nitrogen species ammonia, nitrite, nitrite-plus-nitrate, and total nitrogen. Samples submitted for analysis of ammonia, nitrite, and nitrite-plus-nitrate nitrogen were filtered, and samples for analysis of total nitrogen were filtered and unfiltered. The concentrations of ammonia generally were quite small ranging from less than 0.01 mg/L at all three sites to a maximum of 0.038 mg/L at the Tailrace site; median concentrations of ammonia were 0.012 mg/L at the Headworks and Inflow sites, and 0.025 mg/L at the Tailrace site ([table 9](#)). Nitrite was rarely detected in concentrations greater than the method detection level of 0.001 mg/L in samples from all three sites during the study. Median concentrations of nitrite-plus-nitrate nitrogen were 0.028 mg/L at Headworks, 0.015 mg/L at Inflow, and 0.024 mg/L at Tailrace. The concentrations of nitrite-plus-nitrate nitrogen at all three sites during the study ranged from less than 0.008 mg/L to 0.084 mg/L (both at Tailrace). The concentrations of filtered total nitrogen at all three sites during the study ranged from less than 0.05 mg/L at Headworks to 0.35 mg/L at Inflow with median concentrations of 0.12 mg/L at Headworks, 0.14 mg/L at Inflow, and 0.24 mg/L at Tailrace. Median concentrations of unfiltered total nitrogen were 0.06 mg/L at Headworks, 0.2 mg/L at Inflow, and 0.31 mg/L at Tailrace. The concentrations of unfiltered total nitrogen at all three sites during the study ranged from less than 0.05 mg/L at Headworks to 0.71 mg/L at Inflow.

Analyses of the phosphorus forms included orthophosphate (also referred to as soluble reactive phosphorus), filtered phosphorus, and unfiltered phosphorus (also referred to as total phosphorus). Median concentrations of orthophosphate were 0.017 mg/L at Headworks, 0.005 mg/L at Inflow, and 0.02 mg/L at Tailrace. Concentrations of orthophosphate in samples from all three sites during the

study ranged from less than 0.004 to 0.032 mg/L (both at Tailrace). Median concentrations of filtered phosphorus were 0.013 mg/L at Headworks, 0.005 mg/L at Inflow, and 0.016 mg/L at Tailrace. Concentrations of filtered phosphorus in samples from all three sites during the study ranged from less than 0.003 to 0.029 mg/L (both at Tailrace). Median concentrations of unfiltered phosphorus were 0.382 mg/L at Headworks, 0.089 mg/L at Inflow, and 0.068 mg/L at Tailrace. Concentrations of unfiltered phosphorus in samples from all three sites during the study ranged from 0.008 mg/L at Tailrace to 0.492 mg/L at Headworks.

Quality of Water in the White River and Lake Tapps Diversion (Tailrace)—Continuous Monitoring

Multiparameter water-quality sondes installed at three sites ([table 1](#)) were fully operational by late May 2010. The White River at R Street (R-Street) is missing several weeks of data during June while the deployment was being optimized for high flows, and during mid-December when the sonde was removed because of debris during high flows. The Headworks site also is missing some record during December when flows were altered at the diversion dam and the sonde was out of water.

Even though the source of the White River is from glaciers on Mount Rainier, the water temperature of the White River is moderated somewhat by residence time upstream of the Mud Mountain Dam. Continuous measurements of water temperature were used to calculate the 7-day average of daily maximum temperatures (7-DADMax) by averaging the maximum for a day with the daily maximum of the 3 days prior and the 3 days after that date ([appendix E](#)). The 7-DADMax at the Headworks site ranged from 2.6°C on November 25, 2010, to 16.5°C on August 14–15, 2010 ([fig. 9](#)).

Figure 9. Seven-day average of daily maximum water temperatures at White River at the Headworks, White River at R Street, and Lake Tapps Diversion at Dieringer (Tailrace), Washington, May–December 2010.

The 7-DADMax at the R-Street site ranged from 2.9°C on November 24, 2010, to 18.9°C on August 14–15, 2010 (fig. 9). The 7-DADMax at the Tailrace site ranged from 6.1°C on December 28, 2010, to 18.1°C on July 9, 2010 (fig. 9).

The White River is well-oxygenated with concentrations of dissolved oxygen at the Headworks site ranging from a minimum of 9.2 mg/L on August 5, 14, and 16, 2010, to a maximum during the study of 14.4 mg/L on December 31, 2010 (fig. 10). Dissolved oxygen at the Tailrace site, however, was affected by reduced flow during the study and concentrations ranged from a minimum of 0.7 mg/L on August 9, 2010, to a maximum during the study of 22.0 mg/L on July 8, 2010 (fig. 11). The concentrations of dissolved oxygen at the R-Street site ranged from a minimum of 9.4 mg/L on August 16–17, 2010, to a maximum of 15.0 mg/L on November 23–24 (U.S. Geological Survey, 2011c).

The continuous measurements of pH at the Headworks site ranged from a low of 6.9 pH units measured on December 13, 2010, to a maximum during the study of 8.6 pH

units measured on July 28, 2010. Measurements of pH at the R-Street site ranged from 6.8 pH units on December 13–15, 2010, to a maximum of 7.4 pH units on July 24, 28, and 30, 2010. Measurements of pH at the Tailrace site ranged from 6.4 pH units on September 28, 2010, to a maximum of 9.4 pH units on September 14, 2010.

Specific conductance generally was low, reflecting the relatively dilute chemical composition of the water. Specific conductance at the Headworks site ranged from a minimum of 39 $\mu\text{S}/\text{cm}$ on December 13, 2010, to a maximum of 84 $\mu\text{S}/\text{cm}$ on October 15–17, 2010. Specific conductance at the R-Street site ranged from a minimum of 45 $\mu\text{S}/\text{cm}$ on July 12, 2010, to a maximum of 87 $\mu\text{S}/\text{cm}$ on October 7, 21–24, and November 26, 2010. Specific conductance at the Tailrace site ranged from a minimum of 53 $\mu\text{S}/\text{cm}$ on December 31, 2010, to a maximum of 2,270 $\mu\text{S}/\text{cm}$ on September 28, 2010. Spikes in specific conductance at the Tailrace on August 31 and September 10, 2010, may be related to storm-water runoff from pipes discharging near the sonde sensors. The maximum

Figure 10. Minimum, maximum, and mean dissolved oxygen concentrations at White River at Headworks, Washington, May–December 2010.

value of 2,270 $\mu\text{S}/\text{cm}$ recorded on August 31 followed a rain event of 0.15 in. over a 24-hour period recorded at the McMillin Reservoir rain gage ([fig. 1](#)). The sources of the runoff and the dissolved materials driving these high conductivity spikes are unknown. When water is released from the lake, specific conductance generally is less than about 70 $\mu\text{S}/\text{cm}$ and similar to the lake water at the Lake Outlet site. The specific conductance values of about 140 $\mu\text{S}/\text{cm}$ occurred during periods of no water releases from the lake and likely reflect the input of subsurface water, which typically carries higher content of dissolved solids than surface water.

The quality of physical properties and concentrations in water measured continuously at the three sites (Headworks, R-Street, and Tailrace) generally was good and met the freshwater criteria designated by the Washington State Department of Ecology (2006, 2011) for recreational uses and aquatic life uses, with several exceptions. The 7-DADMax temperatures exceeded the freshwater aquatic life

criterion of 16°C for core summer salmonid habitat ([table 8](#); Washington State Department of Ecology, 2011) on 6 days at the Headworks site and 37 days at the R-Street site. A higher criterion of 17.5°C for salmonid spawning, rearing, and migration applies to the White River from the mouth to latitude 47° 14' 37.68" longitude 122° 14' 31.91" upstream of RM 3.6 and the Tailrace (Washington State Department of Ecology, 2011), and 7-DADMax temperatures exceeded this criterion on 5 days at the Tailrace site. A lower criterion of 13°C for salmon and trout spawning and incubation applies to reaches of the White River upstream of latitude 47° 14' 37.68" longitude 122° 14' 31.91" to the Diversion Dam (excluding portions within the Muckleshoot Indian Reservation) from September 15 to July 1 (Washington State Department of Ecology, 2006). This lower criterion of 13°C was exceeded by 7-DADMax temperatures on 6 days at the Headworks site and on 20 days at the R-Street site ([fig. 9](#)).

Figure 11. Minimum, maximum, and mean dissolved oxygen at Lake Tapps Diversion at Dieringer (Tailrace), Washington, May–December 2010.

The freshwater aquatic life dissolved oxygen criterion of 9.5 mg/L for core summer salmonid habitat ([table 8](#); Washington State Department of Ecology, 2011) was not met at the Headworks site for several weeks during July and August 2010 ([fig. 10](#)) and at the R-Street site on August 16–17, 2010. The 1-day minimum dissolved oxygen criterion of 8.0 mg/L for salmonid spawning, rearing, and migration occasionally was not met at the Tailrace site in June and frequently was not met during May–November 2010 ([fig. 11](#)). However, the dissolved oxygen criteria require that

measurements should not be taken from shallow stagnant backwater areas, but reduced flow in the Tailrace frequently created such environments.

Exceptions for measurements of pH greater than the freshwater aquatic-life upper limit of 8.5 pH units occurred at the Headworks site during July 2010 ([fig. 12](#)). Aquatic life criteria for pH also were not met at the Tailrace site during June, July, and August 2010, when pH values were greater than 8.5 pH units ([fig. 13](#)) and briefly in August when daily minimum pH values decreased to less than 6.5 pH units.

Figure 12. Minimum, maximum, and median pH at White River at Headworks, Washington, May–December 2010.

Figure 13. Minimum, maximum, and median pH at Lake Tapps Diversion at Dieringer (Tailrace), Washington, May–December 2010.

Quality of Water in Lake Tapps

This section presents field observations noted during the lake sampling events and the results of laboratory analyses for chemical and biological constituents. Field observations recorded during sampling included weather conditions, the extent of human or bird activity near the sampling location, total depth of water at the sampling location, and profiles of physical properties with depth. Results presented include the inorganic and organic chemical analyses performed at the NWQL and Test America Laboratory, and the turbidity and fecal-coliform analyses performed by project staff at the FSU.

Physical Properties and Profiles

In general, the epilimnion (or near surface) water of Lake Tapps was relatively clear as indicated by low median turbidity values of less than about 1.6 NTRU and relatively high median Secchi disk transparencies of 4.9 m or more ([table 11](#)). The clearest water of the nine sites as measured by Secchi disk, was at the Deep site with a median Secchi disk measurement of 6.05 m, and at the Lake Outlet site with a median of 5.80 m. The Secchi disk measurements at the Deep site represent a 2 to 6-fold increase in transparency depths from historical measurements at this location during 1974–1997 (Bortleson and others, 1976; Sumioka and Dion, 1985; Smith and others, 2000). However, at the Allan Yorke, Lake Inlet, and Southeast Arm sites, the water was more turbid and less transparent than the other six sites with median turbidities as high as 3.04 NTRU and median Secchi disk transparencies of 2.61 m or less.

Water of the epilimnion at all sites generally was warm, yet well oxygenated. Median water temperatures were from 18.2 to 18.9°C and maximums ranged from 22.9 to 25.0°C ([table 11](#)). At sites where total water depth was

equal to or greater than 15 m, median water temperatures in the hypolimnion (or near the bottom) ranged from 9.2°C at the Deep site to 10.7°C at Snag Island and 12.0°C at Tapps Island sites ([table 11](#)). At shallow sites (5 m or less) (Allan Yorke, Lake Inlet, Southeast Arm, and Dike 2B), hypolimnion temperatures were similar to those of the epilimnion or only a few tenths of a degree cooler ([table 11](#), [fig. 14](#)). Median dissolved oxygen concentrations in the epilimnion were 8.42 mg/L or greater. Minimum concentrations were not less than 7.4 mg/L except at the Snag Island and Lake Inlet sites with minimums of 6.5 and 6.9 mg/L, respectively ([table 11](#)). At the deep sites (Deep, Tapps Island, and Snag Island), the hypolimnion became anoxic with dissolved oxygen concentrations of less than about 0.1 mg/L ([fig. 15](#)). The hypolimnion of the shallow sites, except at the Lake Inlet site, remained oxygenated during the study with at least 6.3 mg/L dissolved oxygen; at the Lake Inlet site, dissolved oxygen reached a low of 1.4 mg/L.

On the basis of pH and specific conductance measurements, Lake Tapps water is pH neutral and chemically dilute. For the most part, median pH values from the epilimnion and hypolimnion were within a relatively neutral range of 6.84 to 7.64 pH units, and maximum pH values did not exceed 7.8 pH units at any site during the study ([table 11](#), [fig. 16](#)). At most of the sites, median specific conductance for the epilimnion and the hypolimnion was less than 70 $\mu\text{S}/\text{cm}$ ([table 11](#)). These low magnitudes of specific conductance indicate a generally dilute type of water with low concentrations of dissolved solids. The highest specific conductance values and the greatest variability in the measurements were observed in the hypolimnion water of the Deep and Snag Island sites with medians of 73 and 88 $\mu\text{S}/\text{cm}$, respectively, and maximums of 120 and 126 $\mu\text{S}/\text{cm}$, respectively ([fig. 17](#)).

Table 11. Summary statistics of water-quality properties and concentrations of nutrients, total suspended solids, fecal-coliform bacteria, and chlorophyll *a* for nine Lake Tapps study sites, Washington, July–December 2010.

[Statistics calculated with censoring levels set to a common level for each constituent, which entailed using water year 2011 method detection limits to match 2010 laboratory reporting levels and are not rounded to standard USGS significant figures. **Abbreviations:** CFU/100 mL, colony forming units per 100 milliliters; mg/L, milligram per liter; μ S/cm, microsiemens per centimeter at 25°C; °C, degrees Celsius; e, estimated; m, meter; μ g/L, microgram per liter; NTRU, nephelometric turbidity ratio units; ND, no detections greater than method detection level; <, less than; –, no data or not applicable]

Site	Statistic	Turbidity (NTRU)		Secchi transparency depth (m)	Water temperature (°C)		Dissolved oxygen (mg/L)	
		Epilimnion	Hypolimnion	Epilimnion	Epilimnion	Hypolimnion	Epilimnion	Hypolimnion
Deep	Median	0.85	3.86	6.05	18.2	9.2	8.42	0.34
	Mean	1.19	9.03	5.38	16.8	9.1	8.53	2.36
	Range	0.6–2.7	0.9–42	2.09–8.09	6.8–23.8	6.4–11.0	7.4–10.1	0.1–10.4
Allan Yorke	Median	1.68	2.23	2.61	18.4	18.0	8.78	8.48
	Mean	1.94	2.64	2.57	16.8	16.1	9.26	8.41
	Range	1.3–3.6	1.3–5.7	1.62–3.22	4.8–24.2	4.8–22.0	8.2–12.6	6.3–12.6
Northeast Arm	Median	0.94	1.58	4.94	18.8	15.4	8.64	4.52
	Mean	1.20	2.18	4.69	17.2	14.4	8.84	5.37
	Range	0.5–3.3	0.9–4.2	1.62–6.29	6.3–24.0	6.2–18.4	7.8–10.9	0.8–10.9
Tapps Island	Median	1.55	2.07	5.26	18.4	12.0	8.71	0.54
	Mean	1.28	2.11	5.00	16.9	11.7	8.87	3.41
	Range	0.6–1.8	1.2–3.7	3.34–6.94	6.4–23.2	6.3–14.5	7.8–10.9	0.1–10.9
Snag Island	Median	1.17	5.37	4.87	18.3	10.7	8.45	0.19
	Mean	1.76	5.15	4.68	16.8	10.5	8.54	3.05
	Range	0.6–6.0	1.4–9.2	2.69–7.14	6.2–23.5	6.2–12.8	6.5–10.9	0.1–10.9
Lake Inlet	Median	1.67	2.15	2.54	18.9	18.1	8.68	8.11
	Mean	1.82	2.09	2.58	17.4	16.2	8.90	6.78
	Range	1.1–3.1	1.2–3.1	1.82–3.39	5.3–24.9	5.3–21.3	6.9–11.6	1.4–11.6
Southeast Arm	Median	3.04	3.56	1.63	18.5	18.3	8.77	8.34
	Mean	2.68	4.03	1.80	17.1	16.6	9.22	8.66
	Range	1.1–3.9	1.3–11	1.40–2.54	4.6–25.0	4.6–23.6	8.1–12.4	6.6–12.4
Lake Outlet	Median	0.72	1.22	5.80	18.2	14.8	8.72	8.26
	Mean	1.12	1.40	5.67	16.8	14.1	8.81	7.01
	Range	0.5–3.0	0.7–3.2	2.33–8.24	6.8–22.9	6.8–17.6	7.8–9.9	2.8–9.88
Dike 2B	Median	0.70	0.87	4.93	18.4	17.9	8.84	8.89
	Mean	1.21	1.29	4.25	16.8	16.7	8.92	9.06
	Range	0.6–2.9	0.5–2.7	1.91–5.77	6.9–23.0	6.9–22.9	8.0–10.3	8.4–10.3

Table 11. Summary statistics of water-quality properties and concentrations of nutrients, total suspended solids, fecal-coliform bacteria, and chlorophyll *a* for nine Lake Tapps study sites, Washington, July–December 2010.—Continued

[Statistics calculated with censoring levels set to a common level for each constituent, which entailed using water year 2011 method detection limits to match 2010 laboratory reporting levels and are not rounded to standard USGS significant figures. **Abbreviations:** CFU/100 mL, colony forming units per 100 milliliters; mg/L, milligrams per liter; $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25°C; °C, degrees Celsius; e, estimated; m, meters; $\mu\text{g}/\text{L}$, micrograms per liter; NTRU, nephelometric turbidity ratio units; ND, no detections greater than method detection level; <, less than; –, no data or not applicable]

Site	Statistic	pH (standard units)		Specific conductance ($\mu\text{S}/\text{cm}$)		Total suspended solids (mg/L)		Fecal coliform bacteria (CFU/100 mL)
		Epilimnion	Hypolimnion	Epilimnion	Hypolimnion	Epilimnion	Hypolimnion	Epilimnion
Deep	Median	7.60	6.84	67	73	<1.1	e2.40	<1
	Mean	7.54	6.93	66	77	e1.80	5.65	14
	Range	7.3–7.7	6.6–7.4	65–67	67–120	<1.1–3.6	<1.1–30	<1–68
Allan Yorke	Median	7.62	7.63	68	68	e1.80	e3.0	4
	Mean	7.61	7.60	69	68	2.05	e3.0	5
	Range	7.4–7.8	7.4–7.8	68–73	64–73	<1.1–5.2	<1.1–6.0	2–14
Northeast Arm	Median	7.52	7.42	66	69	<1.1	<1.1	<1
	Mean	7.53	7.44	66	69	<1.1	e1.57	1
	Range	7.4–7.7	7.3–7.6	64–67	65–72	<1.1–e2.0	<1.1–6.8	<1–3
Tapps Island	Median	7.58	7.17	66	68	<1.1	e1.80	2
	Mean	7.57	7.20	66	68	<1.1	e1.94	3
	Range	7.4–7.7	6.8–7.5	64–67	66–72	<1.1–e1.6	<1.1–e3.6	<1–12
Snag Island	Median	7.49	6.94	67	88	<1.1	4.0	1
	Mean	7.50	7.06	67	91	<1.1	4.25	2
	Range	7.3–7.6	6.7–7.5	64–69	66–126	<1.1–e1.6	<1.1–7.6	<1–13
Lake Inlet	Median	7.50	7.48	67	68	e2.00	e2.80	1
	Mean	7.52	7.48	67	69	e2.55	e2.83	1
	Range	7.3–7.7	7.3–7.6	66–69	66–77	<1.1–4.0	<1.1–4.4	<1–5
Southeast Arm	Median	7.52	7.50	67	68	e3.60	e3.80	1
	Mean	7.53	7.52	67	68	e3.12	5.09	1
	Range	7.4–7.7	7.4–7.6	65–69	65–71	<1.1–5.2	<1.1–14	<1–4
Lake Outlet	Median	7.52	7.45	66	66	<1.1	<1.1	4
	Mean	7.50	7.44	66	67	<1.1	1.33	10
	Range	7.4–7.6	7.4–7.6	64–68	66–69	<1.1–e2.4	<1.1–3.6	1–54
Dike 2B	Median	7.64	7.64	66	66	<1.1	<1.1	2
	Mean	7.60	7.60	66	66	<1.1	<1.1	5
	Range	7.4–7.8	7.4–7.7	65–67	65–67	<1.1–e1.2	<1.1–e1.2	<1–16

Table 11. Summary statistics of water-quality properties and concentrations of nutrients, total suspended solids, fecal-coliform bacteria, and chlorophyll *a* for nine Lake Tapps study sites, Washington, July–December 2010.—Continued

[Statistics calculated with censoring levels set to a common level for each constituent, which entailed using water year 2011 method detection limits to match 2010 laboratory reporting levels and are not rounded to standard USGS significant figures. **Abbreviations:** CFU/100 mL, colony forming units per 100 milliliters; mg/L, milligram per liter; μ S/cm, microsiemens per centimeter at 25°C; °C, degrees Celsius; e, estimated; m, meters; μ g/L, microgram per liter; NTRU, nephelometric turbidity ratio units; ND, no detections above method detection level; <, less than; –, no data or not applicable]

Site	Statistic	Ammonia nitrogen (mg/L)		Nitrite nitrogen (mg/L)		Nitrite plus nitrate nitrogen (mg/L)	
		Epilimnion	Hypolimnion	Epilimnion	Hypolimnion	Epilimnion	Hypolimnion
Deep	Median	0.008	0.024	ND	<0.001	<0.008	0.073
	Mean	0.011	0.076	–	<0.001	0.01	0.1
	Range	<0.01–0.029	<0.01–0.51	–	<0.001–0.002	<0.008–0.028	<0.008–0.253
Allan Yorke	Median	ND	<0.01	<0.001	0.001	<0.008	<0.008
	Mean	–	0.011	<0.001	<0.001	<0.008	<0.008
	Range	–	<0.01–0.022	<0.001–0.001	<0.001–0.001	<0.008–0.039	<0.008–0.04
Northeast Arm	Median	0.01	0.018	<0.001	<0.001	<0.008	<0.008
	Mean	0.013	0.019	<0.001	0.001	0.009	0.009
	Range	<0.01–0.04	<0.01–0.037	<0.001–0.001	<0.001–0.004	<0.008–0.03	<0.008–0.03
Tapps Island	Median	0.007	0.018	<0.001	<0.001	<0.008	<0.008
	Mean	0.014	0.03	0.001	0.001	<0.008	<0.008
	Range	<0.01–0.019	<0.01–0.1	<0.001–0.001	<0.001–0.002	<0.008–0.029	<0.008–0.031
Snag Island	Median	0.011	0.22	<0.001	0.001	<0.008	<0.008
	Mean	0.017	0.297	0.001	0.001	<0.008	<0.008
	Range	<0.01–0.026	0.02–0.85	<0.001–0.001	<0.001–0.003	<0.008–0.03	<0.008–0.031
Lake Inlet	Median	0.009	0.008	0.001	<0.001	<0.008	<0.008
	Mean	0.009	0.01	0.001	<0.001	<0.008	<0.008
	Range	<0.01–0.012	<.001–0.014	<0.001–0.001	<0.001–0.001	<0.008–0.019	<0.008–0.02
Southeast Arm	Median	<0.01	ND	<0.001	<0.001	<0.008	<0.008
	Mean	0.01	–	0.001	<0.001	<0.008	<0.008
	Range	<0.01–0.014	–	<0.001–0.001	<0.001–0.001	<0.008	<0.008–0.01
Lake Outlet	Median	0.008	0.01	<0.001	<0.001	<0.008	<0.008
	Mean	0.013	0.013	0.001	0.001	<0.008	<0.008
	Range	<0.01–0.0038	<0.01–0.035	<0.001–0.003	<0.001–0.001	<0.008–0.029	<0.008–0.03
Dike 2B	Median	0.005	<0.01	<0.001	<0.001	<0.008	<0.008
	Mean	0.025	0.014	0.001	0.001	<0.008	<0.008
	Range	<0.01–0.046	<0.01–0.035	<0.001–0.002	<.001–0.002	<0.008–0.031	<0.008–0.03

Table 11. Summary statistics of water-quality properties and concentrations of nutrients, total suspended solids, fecal-coliform bacteria, and chlorophyll *a* for nine Lake Tapps study sites, Washington, July–December 2010.—Continued

[Statistics calculated with censoring levels set to a common level for each constituent, which entailed using water year 2011 method detection limits to match 2010 laboratory reporting levels and are not rounded to standard USGS significant figures. **Abbreviations:** CFU/100 mL, colony forming units per 100 milliliters; mg/L, milligram per liter; μ S/cm, microsiemens per centimeter at 25°C; °C, degrees Celsius; e, estimated; m, meters; μ g/L, microgram per liter; NTRU, nephelometric turbidity ratio units; ND, no detections above method detection level; <, less than; –, no data or not applicable]

Site	Statistic	Total nitrogen, filtered (mg/L)		Total nitrogen, unfiltered (mg/L)		Orthophosphate phosphorus, filtered (mg/L)	
		Epilimnion	Hypolimnion	Epilimnion	Hypolimnion	Epilimnion	Hypolimnion
Deep	Median	0.116	0.255	0.14	0.301	<0.004	0.007
	Mean	0.119	0.271	0.142	0.298	0.004	0.008
	Range	0.07–0.19	0.08–0.72	0.1–0.18	0.08–0.77	<0.004–0.005	<0.004–0.054
Allan Yorke	Median	0.125	0.129	0.176	0.167	<0.004	<0.004
	Mean	0.129	0.139	0.178	0.185	<0.004	<0.004
	Range	0.08–0.18	0.1–0.2	0.13–0.26	0.13–0.25	<.0004–0.006	<0.004–0.006
Northeast Arm	Median	0.122	0.134	0.152	0.154	<0.004	<0.004
	Mean	0.119	0.133	0.140	0.157	<0.004	<0.004
	Range	0.07–0.12	0.1–0.15	0.11–0.2	0.12–0.2	<0.004–0.005	<0.004–0.004
Tapps Island	Median	0.120	0.134	0.138	0.165	<0.004	<0.004
	Mean	0.118	0.138	0.133	0.192	0.004	<0.004
	Range	0.09–0.16	0.1–0.2	0.11–0.16	0.15–0.36	<0.004–0.004	<0.004–0.005
Snag Island	Median	0.12	0.366	0.156	0.372	<0.004	0.006
	Mean	0.132	0.479	0.148	0.508	<0.004	0.005
	Range	0.07–0.25	0.14–1.1	0.1–0.17	0.16–1.4	<0.004–0.005	<0.004–0.007
Lake Inlet	Median	0.116	0.11	0.175	0.17	<0.004	<0.004
	Mean	0.122	0.141	0.167	0.178	<0.004	<0.004
	Range	0.09–0.17	0.09–0.26	0.12–0.21	0.12–0.35	<0.004	<0.004–0.004
Southeast Arm	Median	0.124	0.13	0.166	0.181	<0.004	<0.004
	Mean	0.13	0.132	0.168	0.186	<0.004	<0.004
	Range	0.08–0.2	0.1–0.21	0.14–0.2	0.14–0.25	<0.004–0.005	<0.004
Lake Outlet	Median	0.118	0.118	0.150	0.142	<0.004	0.004
	Mean	0.114	0.118	0.157	0.151	0.004	0.004
	Range	0.07–0.14	0.08–0.15	0.11–0.27	0.1–0.2	<0.004–0.005	<0.004–0.005
Dike 2B	Median	0.103	0.115	0.136	0.138	<0.004	<0.004
	Mean	0.102	0.112	0.132	0.191	0.004	0.004
	Range	0.07–0.13	0.09–0.13	0.1–0.18	0.11–0.66	<0.004–0.005	<0.004–0.005

Table 11. Summary statistics of water-quality properties and concentrations of nutrients, total suspended solids, fecal-coliform bacteria, and chlorophyll *a* for nine Lake Tapps study sites, Washington, July–December 2010.—Continued

[Statistics calculated with censoring levels set to a common level for each constituent, which entailed using water year 2011 method detection limits to match 2010 laboratory reporting levels and are not rounded to standard USGS significant figures. **Abbreviations:** CFU/100 mL, colony forming units per 100 milliliters; mg/L, milligram per liter; μ S/cm, microsiemens per centimeter at 25°C; °C, degrees Celsius; e, estimated; m, meters; μ g/L, microgram per liter; NTRU, nephelometric turbidity ratio units; ND, no detections above method detection level; <, less than; –, no data or not applicable]

Site	Statistic	Phosphorus, filtered (mg/L)		Phosphorus, unfiltered (mg/L)		Chlorophyll <i>a</i> , (μ g/L)	Pheophytin <i>a</i> , (μ g/L)
		Epilimnion	Hypolimnion	Epilimnion	Hypolimnion	Epilimnion	Epilimnion
Deep	Median	<0.003	0.003	0.004	0.01	0.74	0.34
	Mean	<0.003	0.005	0.005	0.017	0.81	0.35
	Range	<0.003–0.004	<0.003–0.056	<0.004–0.007	<0.004–0.074	0.4–1.4	0.1–0.5
Allan Yorke	Median	<0.003	<0.003	0.009	0.011	2.06	1.03
	Mean	<0.003	0.003	0.009	0.011	2.92	1.12
	Range	<0.003–0.004	<0.003–0.005	0.007–0.012	0.008–0.015	1.4–10	0.5–2.1
Northeast Arm	Median	<0.003	<0.003	0.004	0.006	0.80	0.34
	Mean	<0.003	<0.003	0.005	0.007	0.76	0.35
	Range	<0.003–0.005	<0.003–0.004	<0.004–0.008	<0.004–0.017	0.4–1.0	0.1–0.6
Tapps Island	Median	<0.003	0.003	0.005	0.009	0.81	0.41
	Mean	<0.003	0.003	0.005	0.011	0.79	0.40
	Range	<0.003	<0.003–0.004	<0.004–0.006	0.004–0.033	0.6–1.1	0.2–0.5
Snag Island	Median	0.003	0.004	0.006	0.013	0.93	0.48
	Mean	<0.003	0.004	0.006	0.014	0.92	0.44
	Range	<0.003–0.003	<0.003–0.008	<0.004–0.008	0.005–0.021	0.5–1.2	0.2–0.7
Lake Inlet	Median	<0.003	<0.003	0.009	0.009	1.83	0.89
	Mean	<0.003	<0.003	0.009	0.01	2.05	0.83
	Range	<0.003–0.005	<0.003–0.004	0.007–0.012	0.006–0.012	0.7–3.9	0.3–1.2
Southeast Arm	Median	<0.003	<0.003	0.011	0.013	2.16	1.20
	Mean	0.003	<0.003	0.011	0.013	2.82	1.12
	Range	<0.003–0.004	<0.003–0.004	0.008–0.013	0.01–0.021	1.1–5.8	0.4–1.6
Lake Outlet	Median	<0.003	<0.003	0.005	0.006	0.80	0.38
	Mean	<0.003	<0.003	0.005	0.009	0.81	0.39
	Range	<0.003–0.005	<0.003–0.006	<0.004–0.008	0.004–0.034	0.6–1.1	0.3–0.5
Dike 2B	Median	<0.003	<0.003	0.005	0.005	0.64	0.33
	Mean	<0.003	<0.003	0.005	0.013	0.69	0.35
	Range	<0.003–0.003	<0.003	<0.004–0.007	<0.004–0.086	0.5–1.0	0.3–0.5

Figure 14. Water temperature measured in the epilimnion (or near the surface) and hypolimnion (or near the bottom) at Lake Tapps study sites, Washington, July–December 2010. Adjacent values are last observations less than 1.5 times the interquartile range beyond the end of the box. Outside values are observations 1.5–3 times the interquartile range. Far out values are observations greater than 3 times the interquartile range.

Figure 15. Dissolved oxygen concentrations measured in the epilimnion (or near surface) and hypolimnion (or near bottom) at Lake Tapps study sites, Washington, July–December 2010. Adjacent values are last observations less than 1.5 times the interquartile range beyond the end of the box. Outside values are observations 1.5–3 times the interquartile range. Far out values are observations greater than 3 times the interquartile range.

Figure 16. pH measured in the epilimnion (or near the surface) and hypolimnion (or near the bottom) at Lake Tapps study sites, Washington, July–December 2010. Adjacent values are last observation less than 1.5 times the interquartile range beyond the end of the box. Outside values are observations 1.5–3 times the interquartile range. Far out values are observations greater than 3 times the interquartile range.

Figure 17. Specific conductance measured in the epilimnion (or near the surface) and hypolimnion (or near the bottom) at Lake Tapps study sites, Washington, July–December 2010. Adjacent values are last observation less than 1.5 times the interquartile range beyond the end of the box. Outside values are observations 1.5–3 times the interquartile range. Far out values are observations greater than 3 times the interquartile range.

Total Suspended Solids and Fecal-Coliform Bacteria

Concentrations of TSS throughout the lake were low with values typically less than 10 mg/L and several with concentrations less than the laboratory reporting level of 1.1 mg/L. At six of the nine study sites (Deep, Northeast Arm, Tapps Island, Snag Island, Lake inlet, and Southeast Arm), median concentrations in samples from the epilimnion were less than 1.1 mg/L (table 11). The highest median concentrations were observed at the Southeast Arm site with a median of 3.6 mg/L for the epilimnion and 3.8 mg/L for the hypolimnion. At the Deep site, TSS concentrations in the hypolimnion were as high as 30 mg/L depending on sample depth (fig. 18).

Tapps Island, Snag Island, Lake Outlet, and Dike 2B), median concentrations in samples from the epilimnion were less than 1.1 mg/L (table 11). The highest median concentrations were observed at the Southeast Arm site with a median of 3.6 mg/L for the epilimnion and 3.8 mg/L for the hypolimnion. At the Deep site, TSS concentrations in the hypolimnion were as high as 30 mg/L depending on sample depth (fig. 18).

Figure 18. Total suspended solids measured in the epilimnion (or near the surface) and hypolimnion (or near the bottom) at Lake Tapps study sites, Washington, July–December 2010. Adjacent values are last observation less than 1.5 times the interquartile range beyond the end of the box. Outside values are observations 1.5–3 times the interquartile range. Far out values are observations greater than 3 times the interquartile range.

The microbial quality of the lake water at the nine sampling sites is considered excellent for the purposes of this study in that 24 percent of samples had concentrations of less than 1 CFU/100 mL of fecal-coliform bacteria, and of the remaining samples with detections, 60 percent had concentrations of 5 CFU/100 mL or less. In addition, all samples positive for fecal-coliform bacteria had concentrations that would meet the Washington State single sample freshwater criterion for extraordinary primary contact recreation of less than 100 CFU/100 mL (Washington State Department of Ecology, 2011).

Nutrients and Chlorophyll *a*

Concentrations of nutrients in Lake Tapps were low at all sites during the study, and certain forms of nitrogen and phosphorus were often not detected at concentrations greater than the laboratory method detection levels. Median epilimnion concentrations of total nitrogen (unfiltered water) ranged from about 0.14 mg/L at the Deep, Tapps Island, and Dike 2B sites to about 0.18 mg/L at the Allan Yorke and Lake Inlet sites; and median epilimnion concentrations of total phosphorus (unfiltered water) ranged from 0.004 mg/L at the Deep and Northeast Arm sites to 0.011 at the Southeast Arm site ([table 11](#)). Higher concentrations of total nitrogen and total phosphorus were observed for hypolimnion samples than for epilimnion samples. Median hypolimnion concentrations of total nitrogen ranged from about 0.14 mg/L at the Lake Outlet and Dike 2B sites to 0.372 mg/L at Snag Island; and median hypolimnion concentrations of total phosphorus ranged from 0.005 mg/L at Dike 2B to 0.013 mg/L at Snag Island and Southeast Arm.

At most sites and in most samples from the epilimnion, total phosphorus concentrations were less than the Washington State phosphorus criterion of 0.01 mg/L for maintaining oligotrophic conditions (Moore and Hicks, 2004) ([fig. 19](#)). A few samples from the epilimnion at the Allan Yorke and Lake Inlet sites had concentrations greater than 0.01 mg/L, yet they were still well below the Washington State action value of 0.02 mg/L for preserving mesotrophic conditions (Moore and Hicks, 2004). At the Southeast Arm site, all sample concentrations except one exceeded 0.01 mg/L, but none was greater than 0.02 mg/L ([fig. 19](#)).

The State of Washington does not govern nitrogen concentrations with an absolute standard or criterion (Moore and Hicks, 2004). However, during the process of developing

the phosphorus criteria, the consensus was that ratios of total nitrogen-to-total phosphorus greater than 10-to-1 should be maintained to prevent cyanobacteria (blue-green algae) dominance over the algal community (Moore and Hicks, 2004). As an example, the Washington State Department of Ecology nutrient standards committee suggested that for a total phosphorus concentration of 0.02 mg/L to be protective, total nitrogen concentrations would need to be greater than 0.2 mg/L (Moore and Hicks, 2004). Total nitrogen concentrations in samples from the epilimnion of all sites rarely exceeded 0.2 mg/L. However, this is not a concern for this study because epilimnetic total phosphorus concentrations were all less than 0.02 mg/L ([fig. 19](#)).

Concentrations of nitrite-plus-nitrate and orthophosphate in samples from the epilimnion and the hypolimnion were mostly less than laboratory method detection levels of 0.008 and 0.004 mg/L, respectively ([table 11](#)). Except for a few hypolimnion samples, nitrite generally was not present in water samples at concentrations greater than the method detection level of 0.001 mg/L. In the hypolimnion, nitrite was detected in at least one sample at each site at a concentration at or near the detection level of 0.001 mg/L ([table 11](#)). Ammonia was present in at least one sample from the epilimnion and hypolimnion of all sites. Median concentrations of ammonia in the epilimnion ranged from less than 0.01 mg/L at the Southeast Arm site to 0.011 mg/L at the Snag Island site. The highest ammonia concentrations in hypolimnion samples also were from the Snag Island site, with a median of 0.22 mg/L; the second highest ammonia concentrations were from the hypolimnion of the Deep site with a median of 0.024 mg/L.

Chlorophyll *a* concentrations were low with median concentrations of 2.16 µg/L or less for all nine sites and less than 1 µg/L at six of the sites. Dike 2B had the lowest concentration of the nine sites with a median of 0.64 µg/L ([table 11](#)). Chlorophyll *a* concentrations for the lake as a whole were moderately correlated with concentrations of unfiltered total phosphorus (coefficient of 0.61) and unfiltered total nitrogen (coefficient of 0.52). However, chlorophyll *a* concentrations did not correlate (coefficients less than 0.37) with concentrations of ammonia, nitrite-plus-nitrate, orthophosphate, filtered total phosphorus, filtered total nitrogen, and TSS. Washington State has no standard or criterion for chlorophyll *a*, but for comparison, these concentrations are well below the Oregon State action level of 10 µg/L to identify potential nuisance phytoplankton growth in natural lakes that thermally stratify and 15 µg/L in lakes and reservoirs that do not stratify (Oregon State Archives, 2003).

Figure 19. Total phosphorus (A) and total nitrogen (B) measured in unfiltered water samples from the epilimnion (or near the surface) and hypolimnion (or near the bottom) at Lake Tapps study sites, Washington, July–December 2010. Adjacent values are last observation less than 1.5 times the interquartile range beyond the end of the box. Outside values are observations 1.5–3 times the interquartile range. Far out values are observations greater than 3 times the interquartile range.

Variations in Water-Quality Properties and Constituents over Time

Multiple processes that could potentially affect the quality of water observed during the course of this study included volumes of inflow and outflow and the corresponding flow through the main body of the lake; the quality of the inflow water; and the types and intensity of land use, such as shoreline development around the lake. Importantly, data for this study were collected under unique, reduced flow conditions when dewatering of the White River Canal eliminated the primary inflow to the lake and there were no releases of water at the outflow. Other factors include physical characteristics of each site, including water depth, and location on the lake with respect to open water, narrow arms, or sheltered embayments. Weather conditions, such as rain events prior to or during sampling, also could affect measurements of physical properties and concentrations of nutrients and other constituents over time.

Analyses of the data indicate Allan Yorke, Lake Inlet, and Southeast Arm sites shared similar water-quality characteristics during the sample-collection period and these characteristics often differed from the water quality of the other study sites. For example, concentrations of water-quality constituents generally were higher in magnitude and seemed to be more sensitive to environmental conditions, such as rain events, than was observed at many of the other sites. All three sites are located in regions of shallow water, with fully developed, residential shorelines, and in proximity to the White River Canal Inflow. The area around the Southeast Arm site contains a large number of drowned, tree remnants. These three sites also are in a region of the lake that was treated during the last week of August and the week of September 13 for control of Eurasian watermilfoil (Cascade Water Alliance, 2011), which may or may not have had any influence on the observed water-quality data.

Field personnel usually described the near-surface water color at each site at the time of sampling as green. By September, water color at the Allan Yorke and Southeast Arm sites had shifted to yellowish green or brownish green and remained in this condition through December ([appendix A](#)). Personnel also described the water at these sites as somewhat turbid at these particular times.

At the Allan Yorke, Lake Inlet, and Southeast Arm sites, where total water depth is shallow (see [table 2](#)) and Secchi disk transparencies were low, there was little change in Secchi disk values from month to month over the July–December period of sample collection ([fig. 20](#)). At the other six sites, Secchi disk transparencies generally were deepest from early

July until early October, then by late October, transparencies decreased by as much as 50 percent. At Dike 2B, Secchi disk visibility, which often extended to the lake bottom during summer, decreased in late October–December. These reduced transparencies at Dike 2B were partly due to shallower water depths (from 5 to 3 m) with the annual lowering of the lake water surface. The reduced transparencies (and increases in turbidity) at the sites during autumn might have been due in part to detritus from submerged vegetation die-off and to other particulate materials resuspended and circulated within the water column during rainstorms, wind turbulence, and lake turnover.

By early July, depth profiles of water temperatures showed weak, thermal stratification at most of the sites into at least a warm surface layer overlying a thermocline. The water column at the Lake Inlet, Southeast Arm and Dike 2B sites did not thermally stratify during this study ([appendix F](#)). A well-defined hypolimnion developed below the thermocline only at the Deep site. After reaching maximum surface temperatures in mid-August, stratification at the Deep site gradually weakened through mid-November, and by early December, the temperature profile showed constant temperatures from top to bottom indicating the lake had turned over at this location ([fig. 21](#)).

Although the epilimnion at all sites remained oxygenated during the study, with the development of thermal stratification during the summer, hypolimnion dissolved oxygen concentrations decreased to less than about 3 mg/L except at the Southeast Arm and Dike 2B sites ([appendix F](#)), and at the Deep, Tapps Island, Snag Island, and Lake Outlet sites, the water was anoxic at depth with concentrations less than 0.1 mg/L ([appendix F](#)). By late September at the Deep site, an anoxic layer about 15 m thick had formed in the hypolimnion ([fig. 21](#)). Mixing during autumn overturn in late November, however, re-oxygenated the water column of the Deep site and of all the other sites with about 10–12 mg/L of dissolved oxygen ([appendix F](#)).

Gradients in values of specific conductance and pH ([appendix F](#)) from surface to bottom developed during summer at all sites except at the Southeast Arm and Dike 2B sites, which also did not thermally stratify. For the most part, these gradients were weak and did not persist into September. At the Deep, Tapps Island, and Snag Island sites, stratification in specific conductance and pH was well-developed by the first sampling event of early July and remained in place through October. With autumn overturn and mixing, specific conductance and pH values in early December were essentially the same throughout the water column.

Figure 20. Secchi disk transparency depths measured at Lake Tapps study sites, Washington, July–December 2010.

Figure 21. Water temperature and dissolved oxygen concentrations with depth at the Deep site on Lake Tapps, Washington, July–December 2010.

During the first week of September, concentrations of TSS (fig. 22) and orthophosphate (fig. 23) in the epilimnion were elevated at several sites, particularly at Allan Yorke, Lake Inlet, and Southeast Arm. These increases might have been due to rainfall for a few days preceding and during the sampling events. The rainstorm in early September was particularly intense with a 3-day total of more than 1.6 in. of rain recorded at the McMillin Reservoir rain gage (fig. 1). During this early September sampling, concentrations of fecal-coliform bacteria at the Lake Outlet site also increased to 54 CFU/100 mL (fig. 24). Concentrations of nitrite-plus-nitrate and chlorophyll *a* did not respond to these two summer rain events. Summer concentrations of nitrite-plus-nitrate were nearly constant near the method detection level of 0.005 mg/L (fig. 25) and summer chlorophyll *a* concentrations remained relatively constant at about 1 µg/L (fig. 26).

With the onset of autumn, epilimnion concentrations of several constituents generally increased, likely due to lake overturn and mixing of the water column by mid-November. For example, at the Deep site, fecal-coliform bacteria concentrations increased to 57 CFU/100 mL in November and to 68 CFU/100 mL in December and appear to coincide with autumn rain events and lake overturn at this location. Nitrite-plus-nitrate concentrations, which had consistently been at laboratory method detection levels,

increased in November and December at all sites except at the Southeast Arm. Concentrations of chlorophyll *a* also increased during October–December to values as high as 10 µg/L (at Allan Yorke).

On the basis of median values calculated using concentration data from all nine lake sites, total phosphorus and total nitrogen in the epilimnion of the lake varied little from month to month (fig. 27). Although epilimnion concentrations in October–December showed slight increases over summer concentrations, the differences between summer and autumn median values were minimal (less than 0.002 mg/L phosphorus and less than 0.03 mg/L nitrogen). Median concentrations of total phosphorus and total nitrogen in the hypolimnion (not including multi-depth samples from the Deep site) also varied little from month to month (fig. 27). As indicated by notched boxplots with overlapping confidence intervals about the median, summer and autumn concentrations of total phosphorus for the epilimnion and total nitrogen for the hypolimnion were not significantly different (significance level of about 5 percent). Autumn concentrations of total nitrogen for the epilimnion and total phosphorus for the hypolimnion, however, were significantly higher (non-overlapping confidence intervals) than summer concentrations, but the differences are small (fig. 27).

Figure 22. Total suspended solids concentrations by sample date for Lake Tapps study sites, Washington, July–December 2010.

Figure 23. Orthophosphate phosphorus concentrations by sample date for Lake Tapps study sites, Washington, July–December 2010.

Figure 24. Fecal-coliform bacteria concentrations by sample date for Lake Tapps study sites, Washington, July–December 2010.

Figure 25. Nitrite-plus-nitrate nitrogen concentrations by sample date for Lake Tapps study sites, Washington, July–December 2010.

Figure 26. Chlorophyll *a* concentrations by sample date for Lake Tapps study sites, Washington, July–December 2010.

Figure 27. Total-phosphorus and total-nitrogen concentrations in unfiltered water samples from the epilimnion (near surface) and hypolimnion (near bottom) by month and by season, Lake Tapps, Washington, June–December 2010. Adjacent values are last observation less than 1.5 times the interquartile range beyond the end of the box. Outside values are observations 1.5–3 times the interquartile range.

Trophic Status

Assessing the trophic state of a lake is a way of describing the condition of the lake with respect to primary production (plant and algal growth), which among other growth requirements, closely depends on concentrations of the nutrients phosphorus and nitrogen. Lakes with high concentrations of nutrients and abundant plant and algal growth are considered eutrophic. Lakes with low nutrient concentrations and low rates of primary production are called oligotrophic. Mesotrophic lakes have nutrient and productivity levels intermediate to eutrophic and mesotrophic lakes. Eutrophication is a slow, natural aging process for a lake; however, humans can accelerate the eutrophication process by contributing excessive amounts of nutrients to the lake through agriculture, lakeshore disturbance, and other activities (U.S. Environmental Protection Agency, 2009, chap. 5).

Trophic state indexes (Carlson, 1977) and trophic state concentration thresholds (Carlson, 1977; Nürnberg, 1996) use measures of Secchi disk transparency depth, chlorophyll *a*, and total phosphorus to describe a continuum of biological productivity of a lake. The trophic state indexes (TSI) and water-quality measures also are used to group lakes into three basic classes of trophic status. TSIs less than 40 describe the oligotrophic class, 40 to 50 describe the mesotrophic class, and greater than 50 describe the eutrophic class (table 12). Oligotrophic lakes are characterized by clear water (high transparency), low concentrations of chlorophyll *a* and total phosphorus, and low biological productivity. Mesotrophic lakes have characteristics intermediate to oligotrophic lakes

and eutrophic or highly productive lakes. Carlson (1977) recommended using indexes calculated for the summer season for purposes of classification. King County Water and Land Resources also uses average summer values (June–September) to calculate TSIs for lakes in the Major Lakes Monitoring program (King County Water and Land Resources Division, 2011).

Lake Tapps as a whole generally fits within the oligotrophic classification on the basis of the TSI (table 13) and average water-quality measures of transparency, chlorophyll *a*, and total phosphorus (table 14). TSIs based on transparency suggest potential mesotrophic status at Allan Yorke and Lake Inlet sites and eutrophic status at the Southeast Arm site (table 13). However, because non-algal particulate matter and other factors can affect Secchi disk measurements, the TSIs at these sites using transparency might not be the best descriptor of trophic state. Carlson (1977) cautions the use of Secchi disk transparency depths in lakes containing high amounts of non-algal particulate matter and favors the use of the chlorophyll index during summer and the phosphorus index during spring, autumn, and winter. Chlorophyll *a* and total phosphorus TSIs indicate oligotrophic conditions at Allan Yorke, Lake Inlet, and Southeast Arm sites; but the TSIs of nearly 40 approach the upper limit of oligotrophic conditions. In addition, average concentrations of total phosphorus at Lake Inlet and Southeast Arm are at Nürnberg’s (1996) threshold of 0.01 mg/L, which suggests a slight tendency towards mesotrophic conditions at these two sites during summer (table 14).

Table 12. Lake trophic states and classification ranges for trophic state index, with thresholds for Secchi-disk transparency depths and concentrations of chlorophyll *a* and total phosphorus (unfiltered water).

[Based on Carlson (1977) and Nürnberg (1996). **Potential for algal blooms:** Data from the King County Major Lakes Monitoring Program (King County Water and Land Resources Division, 2011). **Abbreviations:** m, meter; µg/L, microgram per liter; mg/L, milligram per liter; <, less than; >, greater than]

Lake trophic state	Carlson trophic state index	Secchi disk transparency (m)	Chlorophyll <i>a</i> (µg/L)	Total phosphorus (mg/L)	Potential for algal blooms
Oligotrophic	<40				Low
Values thresholds (Carlson, 1977)		>4	<2.6	<0.012	
Values thresholds (Nurnberg, 1996)		>4	<3.5	<0.010	
Mesotrophic	40–50				
Values thresholds (Carlson, 1977)		2–4	2.6–6.4	0.012–0.024	
Values thresholds (Nurnberg, 1996)		2–4	3.5–9.0	0.010–0.030	
Eutrophic	>50				High
Values thresholds (Carlson, 1977)		<2	>6.4	>0.024	
Values thresholds (Nurnberg, 1996)		<2	>9.0	>0.030	

Table 13. Summer trophic state indexes for Lake Tapps, Washington, using data collected at nine study sites, July–September 2010.

[Summer is defined for this study as July through September. TSI less than 40 usually considered oligotrophic; 40–50 as mesotrophic and indicated in **bold** type; and greater than 50 as eutrophic and indicated in **bold, italic** type (<http://www.epa.gov/bioiweb1/aquatic/carlson.html>). TSI_s , $60 - (14.41 (\lognormal \text{ average Secchi disk, in meters}))$; TSI_p , $(14.42 (\lognormal \text{ average total phosphorus (unfiltered), in micrograms per liter})) + 4.15$; TSI_c , $(9.81 (\lognormal \text{ average chlorophyll } a, \text{ in micrograms per liter})) + 30.6$. **Abbreviation:** TSI, trophic state index]

Site	Secchi disk transparency (TSI_s)	Total phosphorus (TSI_p)	Chlorophyll <i>a</i> (TSI_c)
Deep	33	24	28
Allan Yorke	46	36	37
Northeast Arm	35	26	27
Tapps Island	34	27	28
Snag Island	35	30	29
Lake Inlet	46	37	34
Southeast Arm	52	38	36
Lake Outlet	33	28	28
Dike 2B	37	28	27

Ratios of nitrogen to phosphorus (N:P) are reflected in the composition of the phytoplankton community of a lake (Wetzel, 2001). Changes in the ratios over the long term might forecast shifts in the phytoplankton community and the prevalence of the cyanobacteria (King County Water and Land Resources Division, 2003). These N:P ratios are often used in lake studies to indicate which major nutrient is most likely to limit primary production by algae. Typically in freshwater, limitation by phosphorus tends to be more common than limitation by nitrogen (Wetzel, 2001). Carroll and Pelletier (1991) in a study of Lake Sawyer in King County used commonly reported boundaries of greater than 17 by weight as indicative of phosphorus limitation and less than 10 by weight as probable nitrogen limitation. Intermediate ratios suggest either nitrogen or phosphorus (or both) can be limiting (Carroll and Pelletier, 1991). On the basis of concentration ratios for epilimnetic water, primary production in Lake Tapps appears to be phosphorus limited as indicated by ratios greater than 17 at all but 2 study sites (table 14). At the Lake Inlet and Southeast Arm sites, ratios of 15 and 16, respectively, for the summer period suggest either nitrogen or phosphorus (or both) may limit algal growth.

Table 14. Average summer Secchi-disk transparency depths and concentrations of chlorophyll *a*, total nitrogen, and total phosphorus in unfiltered water from the epilimnion, and ratios of total nitrogen to total phosphorus at Lake Tapps study sites, Washington, July–September 2010.

[Summer is defined as July through September. Values indicating potentially mesotrophic conditions are indicated in **bold type**. Values indicating potentially eutrophic conditions are indicated in **bold, italic type**. See table 13 for lake trophic state classifications and thresholds for associated parameters by Carlson (1977) and Nürnberg (1996). TN:TP ratios by weight greater than 17 can indicate potential phosphorus limitation; ratios between 10:1 and 17:1 suggest limitation by either nitrogen or phosphorus or co-limitation. **Abbreviations:** m, meter; $\mu\text{g/L}$, microgram per liter; mg/L , milligram per liter; TN, total nitrogen, unfiltered water; TP, total phosphorus, unfiltered water]

Site	Secchi-disk transparency depth (m)	Chlorophyll <i>a</i> ($\mu\text{g/L}$)	Total nitrogen (mg/L)	Total phosphorus (mg/L)	TN:TP ratio ($\text{mg/L nitrogen: mg/L phosphorus}$)
Deep	6.41	0.76	0.13	0.003	32
Allan Yorke	2.64	1.85	0.16	0.009	19
Northeast Arm	5.60	0.71	0.13	0.004	29
Tapps Island	5.98	0.76	0.12	0.005	26
Snag Island	5.49	0.82	0.14	0.006	24
Lake Inlet	2.68	1.46	0.15	0.010	15
Southeast Arm	1.78	1.75	0.16	0.011	16
Lake Outlet	6.39	0.78	0.16	0.005	32
Dike 2B	4.95	0.68	0.12	0.005	25

Organic Chemical Screening

Of the 250 organic chemicals analyzed in water samples from each of the three sites, the great majority were not detected in concentrations greater than laboratory reporting levels ([appendix G](#)). A total of 14 compounds were detected in trace amounts at one or more of the three lake sites ([table 15](#)). In samples from one or more of the three sites, 6 of these 14 compounds were verified to be present, but in concentrations too small to quantify. These compounds included camphor, DEET, benzophenone, isophorone, methyl salicylate, and *tris*-(dichloroisopropyl)-phosphate. These compounds are shown in [table 15](#) and in the NWIS database

with the code of “M”. Although these compounds were not quantified, they are included here in the list of 14 compounds with detections. A sample from the Allan Yorke site had 9 detections and a sample from the Snag Island site had 10 detections of compounds mostly belonging to the group of wastewater indicator chemicals. Compounds detected (or with verified presence) in samples at all three sites included the herbicide 2,4-D, the insecticide and mosquito repellent DEET, the herbicide used for milfoil eradication fluridone, and the herbicide prometon. The largest concentrations of these compounds were in the samples from the Allan Yorke site; the lowest concentrations were from the Lake Outlet site.

Table 15. Organic compounds detected in water samples collected at Allan Yorke (fig. 4, map No. L2), Snag Island (map No. L5), and Lake Outlet (map No. L8) sites on Lake Tapps, Washington, September 21–22, 2010.

[Abbreviations: NWQL, National Water Quality Laboratory; µg/L, microgram per liter; <, less than; M, presence of analyte verified, but not quantified; e, estimated; DEET, N,N-diethyl-meta-toluamide; HHCB, Hexahydrohexamethylcyclopentabenzopyran; UV, ultraviolet]

Chemical (NWQL schedule ¹)	Parameter code	Use ¹	Concentration (µg/L)		
			Site L2	Site L5	Site L8
2,4-D (2060)	39732	Herbicide	0.2	0.17	0.16
Camphor (1433)	62070	Flavor, odorant, ointments	<0.044	M	<0.044
DEET (1433)	62082	Insecticide, mosquito repellent	M	M	M
Desulfinylfipronil (2033)	62170	Degradate	e0.006	<0.012	<0.012
Diuron (2060)	49300	Herbicide	<0.04	e0.01	e0.01
Fluridone (2033 add-on)	65216	Herbicide, Eurasian watermilfoil control	2.09	1.02	0.308
Prometon (2033)	04037	Herbicide	0.01	0.01	0.01
1,7-Dimethylxanthine (2080)	62030	Metabolite of caffeine	<0.1	e0.02	<0.1
Acetaminophen (2080)	62000	Analgesic	<0.12	e0.037	<0.12
Benzophenone (1433)	62067	Additive in perfumes, soaps	M	<0.1	<0.1
HHCB (1433)	62075	Musk fragrance (persistent in groundwater)	0.1	<0.1	<0.1
Isophorone (1433)	34409	Solvent	M	M	<0.1
Methyl salicylate (1433)	62081	Liniment, food, beverage, UV-absorbing lotion	<0.044	M	<0.044
<i>Tris</i> (dichloroisopropyl) phosphate (1433)	62088	Flame retardant	M	<0.2	<0.2

¹See [appendix C](#), Organic Schedules for lists of all compounds by analytical schedule, laboratory reporting levels, and references on the uses listed for the chemicals.

Summary

The White River and Lake Tapps are part of a hydropower system completed in 1911–12. The system begins with a diversion dam on the White River that routes a portion of White River water into the southeastern end of Lake Tapps, which functioned as a storage reservoir for power generation. The stored water passed through the hydroelectric facilities at the northwestern end of the lake and returned to the White River through the powerhouse tailrace. Power generation ceased in January 2004, which altered the hydrology of the system primarily by reduced volumes of diverted water. Inflows into the lake, which previously averaged 890 cubic feet per second (ft³/s) decreased to about 120 ft³/s, and average flows in the White River downstream of the diversion dam (Diversion Reach) increased from 579 to 1,270 ft³/s. This study conducted from May to December 2010 created a set of baseline data collected under a new flow regime for Lake Tapps and selected reaches of the White River; the White River Canal, which delivers water to Lake Tapps; and the Lake Tapps Diversion (Tailrace), which returns water to the White River at Dieringer.

Discrete water samples were collected from the Headworks, White River Canal at 218th Street E (Inflow), and Tailrace sites. Three sites were equipped for continuous recording of water-quality data: the Headworks site near the diversion dam, the Tailrace site, and the R-Street site in the Diversion Reach of the river.

Nine lake-study sites were distributed throughout Lake Tapps to include a range of physical and nearshore conditions. The Deep site in the main part of the western basin is the deepest of the nine sites at about 27 meters (m). The Southeast Arm site was the shallowest at a depth of about 3 m. Water depths at the other sites ranged from about 5 to 15 m. Water samples from the study sites were measured for physical and water-quality properties and analyzed for turbidity, concentrations of nutrients, suspended solids, and fecal-coliform bacteria. Samples from the lake sites also were analyzed for concentrations of chlorophyll *a* and organic chemicals.

The samples indicated that the water at the Headworks, Inflow, and Tailrace sites was generally turbid, warm, chemically dilute, and well-oxygenated. Exceptions occurred at sites when flow to the White River Canal was suspended or when little or no flow was released from Lake Tapps. In these cases, water from the Headworks, Inflow, and Tailrace sites was warmer, and more likely to be affected by the biological processes that influence nutrients, pH, and dissolved oxygen. The quality of physical properties and concentrations in water measured continuously at the Headworks, R-Street, and Tailrace sites generally was good and met the freshwater criteria designated by the Washington State Department of Ecology for recreational uses and aquatic life uses, with several exceptions. The 7-day average of daily maximum temperatures (7-DADMax) was greater than the freshwater aquatic life criterion of 16 degrees Celsius (°C) for core

summer salmonid habitat for 6 days at the Headworks site and 37 days at the R-Street site during the study. In addition, 7-DADMax temperatures were greater than the 13°C criterion for spawning, rearing, and incubation on 6 days at the Headworks site and 20 days at the R-Street site. The freshwater aquatic life criterion for dissolved oxygen of 9.5 mg/L for core summer salmonid habitat was not met at the Headworks and R-Street sites for periods of time in July and August 2010. Exceptions also occurred at the Headworks site for measurements of pH, which were greater than the freshwater aquatic life upper limit of 8.5 pH units during July 2010. Aquatic life pH criteria also were not met at the Tailrace site during June, July, and August 2010, when pH was greater than 8.5 pH units, and during August 2010 when pH decreased to less than 6.5 pH units.

Lake Tapps water near the surface was relatively clear as indicated by low turbidity values (medians generally less than about 1.7 ratio-corrected nephelometric turbidity units) and relatively high Secchi disk depths (medians 4.9 m or more) at most sites. The clearest water of the nine lake sites was at the Deep site with a median Secchi disk measurement of 6.05 m, which is as much as six times the historical (1974–97) transparency depth measurements for this location. At three sites in the southern end of the lake (Allan Yorke, Lake Inlet, and Southeast Arm), the water was more turbid (median turbidities as high as 3.04 ratio-corrected nephelometric turbidity units) and less transparent (median Secchi disk transparencies of 2.61 m or less).

Water of the epilimnion (or near the surface) at all sites generally was warm yet well oxygenated. Median water temperatures were about 18.2–18.9°C and maximums were from 22.9–25.0°C. Median dissolved oxygen concentrations in the epilimnion were greater than 8.42 milligrams per liter (mg/L) and minimums generally were not less than 7.4 mg/L.

By early July 2010, weak thermal stratification developed at most sites into at least a warm surface layer overlying a small thermocline. Lake Inlet, Southeast Arm, and Dike 2B sites did not thermally stratify during this study. A well-defined hypolimnion developed below the thermocline only at the Deep site. With the development of thermal stratification, hypolimnion water became anoxic at several sites (Deep, Tapps Island, Snag Island, and Lake Outlet). By late September 2010 at the Deep site, an anoxic layer about 15 m thick had formed in the hypolimnion. Mixing during autumn overturn in late November 2010 re-oxygenated the water column of all sites with about 10–12 mg/L of dissolved oxygen.

On the basis of pH and specific conductance measurements, Lake Tapps water is pH neutral and chemically dilute. Median pH values for water in the epilimnion and hypolimnion ranged from 6.84 to 7.64 pH units and maximums did not exceed 7.8 pH units at any site. Median specific conductance typically was less than 70 microsiemens per centimeter at 25°C for the epilimnion and the hypolimnion.

Concentrations of total suspended solids throughout the lake were low with values typically less than 10 mg/L. Median concentrations in samples from the epilimnion were less than the laboratory reporting level of 1.1 mg/L at six of nine study sites. Median concentrations were highest at the Southeast Arm site with 3.6 mg/L for the epilimnion and 3.8 mg/L for the hypolimnion. At the Deep site, total suspended solids concentrations in the hypolimnion were as high as 30 mg/L depending on sample depth.

The microbial quality of the lake water at the nine sampling sites is considered excellent for the purposes of this study in that 24 percent of samples were negative for fecal-coliform bacteria. Of the samples with detections, 60 percent had concentrations of 5 colony-forming units, or less, per 100 milliliters. All samples positive for fecal-coliform bacteria during the study had concentrations that would meet the Washington State Department of Ecology single-sample freshwater criterion for extraordinary primary contact recreation of less than 100 colony-forming units per 100 milliliters (CFU/100 mL).

Nutrient concentrations in Lake Tapps were low and certain forms of nitrogen and phosphorus were often not detected at concentrations greater than the laboratory method detection levels. Median concentrations of total nitrogen (unfiltered water) ranged from about 0.14 mg/L (Deep, Tapps Island, and Dike 2B) to about 0.18 mg/L (Allan Yorke and Lake Inlet). Median concentrations of total phosphorus (unfiltered water) in the epilimnion ranged from 0.004 mg/L (Deep and Northeast Arm) to 0.011 mg/L (Southeast Arm).

At most of the sites and in most of the samples from the epilimnion, total phosphorus concentrations were less than the Washington State Department of Ecology phosphorus criterion of 0.01 mg/L for maintaining oligotrophic conditions. A few samples from the epilimnion at Allan Yorke and Lake Inlet had concentrations greater than the criterion, yet they were still well below the Washington State Department of Ecology action value of 0.02 mg/L for preserving mesotrophic conditions. At the Southeast Arm site, all sample concentrations except one exceeded 0.01 mg/L, but none was greater than 0.02 mg/L.

Chlorophyll *a* concentrations were low with median concentrations of 2.16 micrograms per liter (mg/L) or less. The Dike 2B site had the lowest concentration of the nine sites with a median of 0.64 mg/L. All concentrations but one were well below the Oregon Department of Environmental Quality action level of 10 mg/L to identify potential nuisance phytoplankton growth in natural lakes that thermally stratify and 15 mg/L in lakes and reservoirs that do not stratify.

Rainfall, particularly an intense rainstorm in early September with more than 1.6 inches of rain over 3 days, may have resulted in temporary increases in epilimnion

concentrations of total suspended solids, orthophosphate phosphorus, and fecal-coliform bacteria at several sites. Conversely, concentrations of nitrite-plus-nitrate nitrogen and chlorophyll *a* did not respond to the summer rain events and remained nearly constant near laboratory method detection levels.

With the onset of autumn, epilimnion concentrations of several constituents, including nitrite-plus-nitrate nitrogen and chlorophyll *a* generally increased. At the Deep site, November concentration of fecal-coliform bacteria of 57 CFU/100 mL and December concentration of 68 CFU/100 mL appeared to coincide with autumn rain events and lake overturn. Nitrite-plus-nitrate nitrogen concentrations increased in November and December at all sites except at the Southeast Arm site. Concentrations of chlorophyll *a* also increased during October–December with one value as high as 10 mg/L (Allan Yorke).

Using the Carlson Trophic-Status Index and average measures of transparency, chlorophyll *a*, and total phosphorus data from this study, Lake Tapps generally fits within the oligotrophic classification, but with a few circumstances bordering on mesotrophy. Although chlorophyll *a* and total phosphorus TSIs indicate oligotrophic conditions at the Allan Yorke, Lake Inlet, and Southeast Arm sites, the TSIs of nearly 40 approach the upper limit of oligotrophic conditions. In addition, average concentrations of total phosphorus at Lake Inlet and Southeast Arm are at Nürnberg's (1996) threshold concentration of 0.01 mg/L, which suggests a very slight tendency towards mesotrophic conditions at these two sites during summer.

Primary production in Lake Tapps as a whole appears to be phosphorus-limited as indicated by ratios of nitrogen-to-phosphorus concentrations of greater than 17. At the Lake Inlet and Southeast Arm sites, however, ratios of 15 and 16, respectively, suggest either nitrogen or phosphorus (or both) may limit algal growth.

Water samples collected at three sites (Allan Yorke, Snag Island, Lake Outlet) were screened for the presence of more than 250 organic chemicals with the great majority not detected at concentrations greater than laboratory reporting levels. A total of 14 compounds were detected in trace amounts (or determined to be present) at one or more of the three sites. The Allan Yorke site had 9 detections and the Snag Island site had 10 detections of compounds mostly belonging to the group of wastewater indicator chemicals. Compounds detected (or with verified presence) at all three sites included the herbicide 2,4-D, the insecticide and mosquito repellent DEET, the herbicide used for milfoil eradication fluridone, and the herbicide prometon. The largest concentrations of these compounds were in the samples from the Allan Yorke site; the lowest concentrations were from the Lake Outlet site.

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Appendix A. Field Notes and Observations Recorded during Sampling of the Nine Sites on Lake Tapps, Washington, July–December 2010

[Map numbers are shown in [figure 4](#). Abbreviations: m, meter; <, less than]

Date	Time	Notes and observations	Sampling depths (m)	
			Eplimnion	Hypolimnion
Deep (map No. L1)				
July 6	1550	Niskin bottle sampler. About 3 days since last rain. Clear sky, warm, light breeze, 1–2 foot waves, numerous boats and personal watercraft. Water color green.	1, 2, 3, 4	12, 13, 15, 17, 19, 21, 22, 24
July 20	1200	Pumped sample. About 2 weeks since last rain. Cloudy, cool, light breeze, water calm. No boats, personal watercraft. Water color green.	1, 3, 5, 6	12, 13, 15, 17, 19, 21, 23, 25
August 3	1100	Pumped sample. About 4 weeks since last rain. Cloudy, fog, cool, light breeze, water calm. No boats, personal watercraft. Water color green.	1, 3, 5, 6	12, 13, 15, 17, 19, 21, 23, 25
August 17	1100	Pumped sample. About 10 days since last rain. Partly cloudy, filtered sun, warm, light breeze, water calm. No boats, personal watercraft.	0.5, 1, 2, 3	14, 15, 16, 18, 19, 20, 22, 24
September 7	1040	Pumped sample. Less than ½ day since last rain. Cloudy, cool, light breeze, water calm. No boats, personal watercraft. Water color green. Slight odor at 24.5 m.	1, 3, 5, 8	13, 14, 17, 18, 20, 21, 23, 24.5
September 21	1020	Pumped sample. Less than 1 day since last rain. Partly cloudy, bright sun, cool, light breeze, water calm. No boats, personal watercraft. Water color green. Moderate odor and color at 24 m.	1, 3, 6, 9	17, 18, 19, 20, 21, 22, 23, 24
October 12	1030	Pumped sample. About 1 day since last rains (amounting to about 1 inch at SeaTac Airport). Partly cloudy, filtered sun, warm, winds calm, water calm. No boats, personal watercraft. Surface ripples interfering with Secchi readings. Water color green. Small clusters of foam on surface. Moderate odor at 24 m.	1, 3, 7, 10.5	16, 17, 18, 19, 20, 21, 22, 24
October 27	1020	Pumped sample. Less than 1 day since last rains (amounting to about 2 inches over 3 days at SeaTac Airport). Clear sky, cool, light breeze, water calm. No boats, personal watercraft. Water color green.	1, 4, 8, 11	16, 17, 18, 19, 20, 21, 22, 24
November 16	1000	Pumped sample. About 1 day since last rains. Cloudy, cold, windy, 1–2 foot waves. No boats, personal watercraft. Surface ripples and waves made Secchi difficult to read. Water color green.	1, 5, 10, 15	16, 17, 18, 19, 20, 21, 22, 23
December 7	1000	Pumped sample. A few hours since last rain. Cloudy, cold, winds calm, water calm. Water color green.	1	2.5, 4.5, 7.5, 10.5, 13.5, 16.5, 19.5, 22.5

Appendix A. Field notes and observations recorded during sampling of the nine sites on Lake Tapps, Washington, July–December 2010.—Continued[Map numbers are shown in [figure 4](#). **Abbreviations:** m, meter; <, less than]

Date	Time	Notes and observations	Sampling depths (m)	
			Eplimnion	Hypolimnion
Allan Yorke (map No. L2)				
July 6	1340	Niskin bottle sampler. About 3 days since last rain. Clear sky, warm, light breeze, water calm. Some boats and personal watercraft. Water color green.	0.5, 1	4
July 20	1000	Pumped sample. About 2 weeks since last rain. Cloudy, fog, cool, light breeze, water calm. No boats, personal watercraft. Water color green.	0.5, 1, 2, 3	4
August 3	0950	Pumped sample. About 4 weeks since last rain. Cloudy, mist, fog, cool, light breeze, water calm. No boats, personal watercraft. Water color green.	0.5, 1, 2, 3	4
August 17	0940	Pumped sample. About 10 days since last rain. Clear sky, filtered sun, warm, light breeze, water calm. No boats, personal watercraft. Water color green. 23 Canada geese landed near boat.	0.5, 1, 2, 3	4
September 7	0930	Pumped sample. Less than ½ day since last rain. Cloudy, cool, winds calm, water calm. No boats, personal watercraft. Water color yellowish green; turbid (algae bloom?).	1	3.5
September 21	0910	Pumped sample. Less than 1 day since last rain. Clear sky, bright sun, cool, winds calm, water calm. No boats, personal watercraft. Water color yellowish green (algae bloom?).	1	4
October 12	0920	Pumped sample. About 1 day since last rains (amounting to about 1 inch at SeaTac Airport). Partly cloudy, bright sun, cool, winds calm, water calm. No boats, personal watercraft. Water color yellowish green to brownish. Small clusters of foam on surface.	1	3.5
October 26	0920	Pumped sample. Raining (moderate intensity). About 2 inches over 3 days at SeaTac Airport. Cloudy, cold, light breeze, <1 foot waves. No boats, personal watercraft. Water color grayish green.	1	3.5
November 16	0850	Pumped sample. About 1 day since last rains. Cloudy, cold, windy, 1–2 foot waves. No boats, personal watercraft. Water color brownish green.	1	3.5
December 7	0920	Pumped sample. A few hours since last rain. Cloudy, cold, light breeze, water calm with occasional ripples. Water color brown.	1	3

Appendix A. Field notes and observations recorded during sampling of the nine sites on Lake Tapps, Washington, July–December 2010.—Continued

[Map numbers are shown in [figure 4](#). **Abbreviations:** m, meter; <, less than]

Date	Time	Notes and observations	Sampling depths (m)	
			Eplimnion	Hypolimnion
Northeast Arm (map No. L3)				
July 7	1540	Niskin bottle sampler. About 4 days since last rain. Clear sky, bright sun, hot, light breeze, 1–2 foot waves. Boats and personal watercraft wake made Secchi difficult to read. Water color light green.	1, 2, 3, 4	9
July 21	1500	Pumped sample. About 2 weeks since last rain. Clear sky, bright sun, warm, light breeze, <1 foot waves. Ripples and waves made Secchi difficult to read. Water color light green.	1, 3, 5, 6	9
August 4	1450	Pumped sample. About 4 weeks since last rain. Clear sky, bright sun, hot, light breeze, <1 foot waves. Waves made Secchi reading difficult. Water color light green.	1, 3, 5, 6	9
August 18	1420	Pumped sample. About 11 days since last rain. Clear sky, bright sun, warm, light breeze, <1 foot waves. No boats, personal watercraft. Ripples on surface during Secchi reading. Water color light green.	0.5, 1, 2, 3	9
September 8	1410	Pumped sample. About ½ day since rain. Cloudy, cool, light breeze, water calm. No boats, personal watercraft.	1, 3, 5, 8.5	9
September 22	1450	Pumped sample. About 2 days since last rain. Cloudy, warm, light breeze, water calm. No boats, personal watercraft.	1	9
October 12	1400	Pumped sample. About 1 day since last rains (amounting to about 1 inch at SeaTac Airport). Clear sky, bright sun, warm, light breeze, water calm. No boats, personal watercraft. Water color green. No foam or debris on surface.	1	9
October 27	1220	Pumped sample. Less than 1 day since last rains (amounting to about 2 inches over 3 days at SeaTac Airport). Clear sky, bright sun, cool, light breeze, <1 foot waves. No boats, personal watercraft. Water color grayish green.	1	9
November 17	1340	Pumped sample. Raining (heavy intensity). Cloudy, cold, light breeze, water calm. No boats, personal watercraft. Water color green.	1	8
December 8	1120	Pumped sample. A few hours since last rain. Partly cloudy, cold, light breeze, <1 foot waves. Water color green.	1	8

Appendix A. Field notes and observations recorded during sampling of the nine sites on Lake Tapps, Washington, July–December 2010.—Continued[Map numbers are shown in [figure 4](#). **Abbreviations:** m, meter; <, less than]

Date	Time	Notes and observations	Sampling depths (m)	
			Eplimnion	Hypolimnion
Tapps Island (map No. L4)				
July 8	0920	Niskin bottle sampler. About 5 days since last rain. Clear sky, bright sun, cool, winds calm, water calm.	1, 3, 5, 6	10.5, 11.5, 12.5, 13.5
July 21	1200	Pumped sample. About 2 weeks since last rain. Clear sky, bright sun, warm, light breeze, <1 foot waves. Quiet, no boats. No defined hypolimnion; steady thermocline from about 6m to bottom.	1, 3, 5, 6	12
August 4	1200	Pumped sample. About 4 weeks since last rain. Clear sky, bright sun, hot, light breeze, <1 foot wave.	1, 3, 5, 6	14
August 18	1130	Pumped sample. About 11 days since last rain. Cloudy, cool, light breeze, <1 foot waves. Large ski boat, personal watercraft circling sample site. Little shade for ideal Secchi reading. Water color grayis.	1, 2, 3, 4	12.5
September 8	1120	Pumped sample. About ½ day since rain. Cloudy, cool, light breeze, <1 foot waves. One boat, fishing nearby. Secchi reading not recorded. Water color green.	1, 4, 7, 10	12
September 22	1200	Pumped sample. About 2 days since last rain. Partly cloudy, cool, winds calm, water calm. No boats, personal watercraft. Odor noticed at 14 m.	1, 3, 7, 10	14
October 13	1140	Pumped sample. About 2 days since last rains (amounting to about 1 inch at SeaTac Airport). Partly cloudy, cold, winds calm, water calm. No boats, personal watercraft. Water color green.	1, 4, 8, 12.5	13.5
October 27	0900	Pumped sample. A few hours since last rains (and about 2 inches over 3 days at SeaTac Airport). Partly cloudy, cool, winds calm, water calm. No boats, personal watercraft. Water color green.	1	13
November 17	1010	Pumped sample. Raining earlier in day. Cloudy, cold, windy, <1 foot waves. No boats, personal watercraft. Water color green. Anchor hung up on submerged snag; had to cut line.	1	12.5
December 8	1200	Pumped sample. A few hours since last rain. Clear sky, cold, light breeze, <1 foot waves. No boats, personal watercraft. Water color green. Samples filtered in mobile lab back at marina.	1	11.5

Appendix A. Field notes and observations recorded during sampling of the nine sites on Lake Tapps, Washington, July–December 2010.—Continued

[Map numbers are shown in [figure 4](#). **Abbreviations:** m, meter; <, less than]

Date	Time	Notes and observations	Sampling depths (m)	
			Eplimnion	Hypolimnion
Snagg Island (map No. L5)				
July 7	1400	Niskin bottle sampler. About 4 days since last rain. Clear sky, bright sun, light breeze, <1 foot waves. Wakes from boats and personal watercraft. Water color light green.	1, 3, 4, 5	12.5
July 21	1320	Pumped sample. About 2 weeks since last rain. Clear sky, bright sun, warm, winds calm, waves calm. One boat pulling air tube. No shade for ideal Secchi reading. Water color light green.	1, 3, 4, 5	11, 12, 13
August 4	1350	Pumped sample. About 4 weeks since last rain. Clear sky, bright sun, hot, light breeze, water calm. Occasional boats and wakes. Water color light green.	1, 3, 5, 6	11, 12, 13
August 18	1300	Pumped sample. About 11 days since last rain. Partly cloudy, filtered sun, warm, light breeze, water calm. No boats, personal watercraft. Little shade and surface ripples for ideal Secchi reading. Water color light green. Tried to sample at 14 m, but large wakes caused sampler to hit lake bed and draw up anaerobic, odiferous sediments.	1, 2, 3, 4	12, 13
September 8	1300	Pumped sample. About ½ day since rain. Cloudy, cool, light breeze, <1 foot waves. One boat, fishing nearby. Ripples and reflection made for non-ideal Secchi readings. Water color green. Slight odor at 13 m.	1, 3, 5, 8.5	12, 13
September 22	1350	Pumped sample. About 2 days since last rain. Partly cloudy, filtered sun, warm, light breeze, water calm. No boats, personal watercraft. Water color yellowish green. At 13.5 m, noticeable odor (organic decay?) and gray color.	1, 3, 6, 9	13, 13.5
October 13	1300	Pumped sample. About 2 days since last rains (amounting to about 1 inch at SeaTac Airport). Clear sky, warm, light breeze, water calm. No boats, personal watercraft. Water color green. At 13 m, noticeable odor (organic decay?) and grayish color.	1, 4, 7, 10.5	13
October 27	1250	Pumped sample. < 1 day since last rains (amounting to about 2 inches over 3 days at SeaTac Airport). Clear sky, cool, light breeze, <1 foot waves. No boats, personal watercraft. 1 gull and 8 Western Grebes. Water color green.	1	13
November 17	1250	Pumped sample. Raining (heavy intensity). Cloudy, cold, windy, <1 foot waves. No boats, personal watercraft. Waves and rain ripples made Secchi difficult to read. Water color green.	1	12
December 8	1050	Pumped sample. A few hours since last rain. Clear sky, bright sun, cold, light breeze, <1 foot waves. No boats, personal watercraft. Water color green.	1	11.5

Appendix A. Field notes and observations recorded during sampling of the nine sites on Lake Tapps, Washington, July–December 2010.—Continued[Map numbers are shown in [figure 4](#). **Abbreviations:** m, meter; <, less than]

Date	Time	Notes and observations	Sampling depths (m)	
			Eplimnion	Hypolimnion
Lake Inlet (map No. L6)				
July 8	1300	Niskin bottle sampler. About 5 days since last rain. Clear sky, bright sun, hot. Wakes from boats and personal watercraft made Secchi difficult to read.	1	4.5, 5
July 20	1500	Pumped sample. About 2 weeks since last rain. Partly cloudy, filtered sun, warm, winds calm, waves calm. Water color light green.	1, 2, 3, 4	4.5, 5
August 3	1420	Pumped sample. About 4 weeks since last rain. Mostly clear sky, bright sun, hot, light breeze, water calm. Few boats. Water color light green.	1, 2, 3, 4	5
August 17	1420	Pumped sample. About 10 days since last rain. Clear sky, bright sun, very warm, light breeze, < 1 foot waves. Occasional boats causing 1–2 foot wakes. Water color light green.	1	5
September 7	1430	Pumped sample. About ½ day since rain. Cloudy, warm, light breeze, water calm. No boats, personal watercraft. Some ripples during Secchi reading. Water slightly turbid (algae?).	1	4.5
September 21	1320	Pumped sample. About 1 day since last rain. Partly cloudy, bright sun, cool, light breeze, < 1 foot waves. No boats, personal watercraft. Water color green.	1	4
October 12	1330	Pumped sample. About 1 day since last rains (amounting to about 1 inch at SeaTac Airport). Clear sky, bright sun, warm, light breeze, < 1 foot waves. No boats, personal watercraft. Water color green.	1	4.5
October 26	1030	Pumped sample. Raining (moderate intensity). About 2 inches over 3 days at SeaTac Airport. Cloudy, cold, windy, < 1 foot waves. Western Grebes nearby. No boats, personal watercraft. Water color grayish green.	1	4.5
November 16	1240	Pumped sample. About 1 day since last rains. Cloudy, cold, windy, < 1 foot waves. No boats, personal watercraft. Surface ripples and wind made Secchi difficult to read. Water color green.	1	4
December 7	1220	Pumped sample. A few hours since last rain. Cloudy, cold, light breeze, < 1 foot waves. Water color green.	1	3.5

Appendix A. Field notes and observations recorded during sampling of the nine sites on Lake Tapps, Washington, July–December 2010.—Continued

[Map numbers are shown in [figure 4](#). **Abbreviations:** m, meter; <, less than]

Date	Time	Notes and observations	Sampling depths (m)	
			Eplimnion	Hypolimnion
Southeast Arm (map No. L7)				
July 20	1630	Pumped sample. About 2 weeks since last rain. Partly cloudy, warm.	1	3
August 3	1320	Pumped sample. About 4 weeks since last rain. Cloudy, filtered sun, warm, light breeze, water calm. No boats. Water color light green.	1	3
August 17	1330	Pumped sample. About 10 days since last rain. Clear sky, some light clouds, bright sun, warm, winds calm, water calm. Occasional boats and wakes. No shade for ideal Secchi reading. Rooted aquatic macrophytes (milfoil?). Water color light green.	1	3
September 7	1340	Pumped sample. About ½ day since rain. Cloudy, warm, winds calm, water calm. Water color green and slightly turbid (algae?).	1	2.5
September 21	1250	Pumped sample. About 1 day since last rain. Partly cloudy, light breeze, water calm. No boats, personal watercraft. Water color yellowish green and turbid.	1	2.5
October 12	1250	Pumped sample. About 1 day since last rains (amounting to about 1 inch at SeaTac Airport). Clear sky, bright sun, warm, winds calm, water calm. No boats, personal watercraft. Water color green and turbid. Clusters of foam on surface.	1	2.5
October 26	1110	Pumped sample. Raining (moderate intensity). About 2 inches over 3 days at SeaTac Airport. Cloudy, fog, cold, windy, < 1 foot waves. No boats, personal watercraft. Water color grayish to brownish green.	1	2
November 16	1210	Pumped sample. About 1 day since last rains. Cloudy, cold, windy, 1–2 foot waves. No boats, personal watercraft.	1	2
December 7	1140	Pumped sample. A few hours since last rain. Cloudy, cold, light breeze, < 1 foot waves. Water color brown.	1	1.5

Appendix A. Field notes and observations recorded during sampling of the nine sites on Lake Tapps, Washington, July–December 2010.—Continued[Map numbers are shown in [figure 4](#). **Abbreviations:** m, meter; <, less than]

Date	Time	Notes and observations	Sampling depths (m)	
			Eplimnion	Hypolimnion
Lake Outflow (map No. L8)				
July 21	0940	Pumped sample. About 2 weeks since last rain. Cloudy, fog, cool, light breeze, waves calm. No boats.	1, 3, 5, 6	8
August 4	1010	Pumped sample. About 4 weeks since last rain. Partly cloudy, filtered sun, cool, light breeze, water calm. No boats. Water color light green.	1, 3, 4, 5	9.5
August 18	0930	Pumped sample. About 11 days since last rain. Cloudy, filtered sun, cool, light breeze, < 1 foot waves. No boats, personal watercraft. Water color light green.	1, 2, 3, 4	8
September 8	0930	Pumped sample. Raining (medium intensity); intermittent rain began about 0100. Cloudy, cool, light breeze, water calm. Water color green. Ripples and reflection made for non-ideal Secchi readings. No boats, personal watercraft.	1, 3, 5, 8.5	9
September 22	0940	Pumped sample. About 2 days since last rain. Partly cloudy, cool, light breeze, water calm. Water color green.	1, 3, 6, 8	9
October 13	0950	Pumped sample. About 2 days since last rains (amounting to about 1 inch at SeaTac Airport). Clear sky, fog, cold, winds calm, water calm. No boats, personal watercraft. Water color green.	1	8.5
October 26	1340	Pumped sample. Raining (moderate intensity). About 2 inches over 3 days at SeaTac Airport. Cloudy, cold, light breeze, water calm but very windy out in main lake. No boats, personal watercraft. Water color grayish green.	1	9
November 17	1120	Pumped sample. Raining a few hours earlier in the day. Cloudy, cold, light breeze, water calm. No boats, personal watercraft. Water color green. Held boat in position with engine; anchor lost at previous site.	1	7.5
December 8	0830	Pumped sample. Raining (light intensity). Cloudy, cold, winds calm, water calm. No boats, personal watercraft. Water color green. Samples filtered in mobile lab back at marina.	1	7

Appendix A. Field notes and observations recorded during sampling of the nine sites on Lake Tapps, Washington, July–December 2010.—Continued

[Map numbers are shown in [figure 4](#). **Abbreviations:** m, meter; <, less than]

Date	Time	Notes and observations	Sampling depths (m)	
			Eplimnion	Hypolimnion
Dike 2B (map No. L9)				
July 21	1050	Pumped sample. About 2 weeks since last rain. Partly cloudy, filtered sun, cool, light breeze, waves calm. One boat, fishing. Can see Secchi at depth (3.2 m). Touched lake bed when setting sampler at 3.5 m. Water color light green.	1	2.5
August 4	1110	Pumped sample. About 4 weeks since last rain. Partly cloudy, filtered sun, warm, light breeze, water calm. No boats. Secchi obscured by rooted vegetation (milfoil?). Water color light green.	1	4
August 18	1020	Pumped sample. About 11 days since last rain. Cloudy, filtered sun, cool, winds calm, water calm. No boats, personal watercraft. 2 mallards near boat. Can see Secchi at depth (5.4 m). Water color light green.	1	4
September 8	1020	Pumped sample. Raining (medium intensity); intermittent rain began about 0100. Cloudy, cool, light breeze, water calm. Water color green. Secchi visible at depth. No boats, personal watercraft.	1	4
September 22	1050	Pumped sample. About 2 days since last rain. Partly cloudy, bright sun, cool, water calm. No boats, personal watercraft. Secchi visible at depth.	1	4.5
October 13	1040	Pumped sample. About 2 days since last rains (amounting to about 1 inch at SeaTac Airport). Clear sky, fog, cold, winds calm, water calm. One boat, fishing. A few mallards. Secchi visible at depth (about 5 m). Water color green.	1	4
October 26	1250	Pumped sample. Raining (light intensity). About 2 inches over 3 days at SeaTac Airport. Cloudy, cold, windy, < 1 foot waves. No boats, personal watercraft. Secchi visible at depth. Water color grayish green. Wind pushing boat off sampling mark for hypolimnion sample.	1	2
November 17	0930	Pumped sample. Raining (light intensity). Cloudy, cold, windy, < 1 foot waves. Water color green.	1	2.5
December 8	0920	Pumped sample. Raining (medium intensity). Cloudy, cold, light breeze, water calm. No boats, personal watercraft. Rain and ripples made Secchi difficult to read. Water color green. Samples filtered in mobile lab back at marina.	1	2.5

Appendix B. Parameter Codes, Analytical Methods, and Reporting Levels for Analytes in National Water Quality Laboratory Schedule 1865 (Nutrients) and Schedule 1637 (Chlorophyll *a* and Pheophytin *a*)

[CAS Registry Number® is a registered trademark of the American Chemical Society. CAS recommends the verification of the CAS Registry Numbers through CAS Client ServicesSM. **Abbreviations:** NWIS, National Water Information System; CAS, Chemical Abstract Services; ltmdl, long-term method detection level; mdl, method detection level; mg/L, milligram per liter; µg/L, microgram per liter; mrl, minimum reporting level; NH₃, ammonia; NO₂, nitrite; NO₃, nitrate]

Schedule 1865, Nutrients

Parameter name	NWIS parameter code	CAS Registry Number®	Analytical method	Reporting level (mg/L)	Reporting level type
Nitrogen, ammonia, filtered	00608	7664-41-7	I-2525-89	0.010	ltmdl
Nitrogen, nitrite, filtered	00613	14797-65-0	I-2540-90	.001	mdl
Nitrogen, nitrite plus nitrate, filtered	00631	—	I-2546091	.008	ltmdl
Phosphorus, filtered	00666	7723-14-0	EPA 365.1	.003	ltmdl
Phosphorus, unfiltered	00665	7723-14-0	EPA 365.1	.004	ltmdl
Phosphorus, phosphate, ortho, filtered	00671	14265-44-2	I-2601-90	.004	ltmdl
Total nitrogen (NH ₃ +NO ₂ +NO ₃ +Organic), filtered	62854	17778-88-0	I-2650-03	.05	ltmdl
Total nitrogen (NH ₃ +NO ₂ +NO ₃ +Organic), unfiltered	62855	17778-88-0	I-4650-03	.05	ltmdl

Schedule 1637, Chlorophyll

Parameter name	NWIS Parameter code	CAS Registry Number®	Reporting level (µg/L)	Reporting level type
Chlorophyll <i>a</i> , phytoplankton	70953	479-61-8	0.1	mrl
Pheophytin <i>a</i> , phytoplankton	62360	603-17-8	.1	mrl

Appendix C. Parameter Codes and Reporting Levels for Organic-Compound Analytes in National Water Quality Laboratory Schedule 2033 (Moderate-Use Pesticides), Schedule 2060 (Polar Pesticides), Schedule 1433 (Wastewater Indicators), Schedule 2080 (Human-Health Pharmaceuticals), and Lab Code 8144 (Human-Health Pharmaceuticals)

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Schedule 2033, Pesticides						
Parameter name	NWIS Parameter code	CAS Registry Number®	Reporting level (µg/L)	Reporting level type	Alternative or common name ^{1,2,3}	Use ^{1,2,3} Class ^{1,2,3}
1-Naphthol	49295	90-15-3	0.036	lrl2	1-Naphthol	Deg -
2,6-Diethylaniline	82660	579-66-8	.0060	lrl2	-	Metabolite
2-Chloro-2,6-diethylacetanilide	61618	6967-29-9	.010	lrl2	2-Chloro-2',6'_alide	Deg -
2-Chloro-4-isopropylamino-6-amino-s- triazine {CIAT}	04040	6190-65-4	.006	lrl2	-	Deg -
2-Ethyl-6-methylaniline	61620	24549-06-2	.010	lrl2	2-Ethyl-6-meth_iline	Deg -
3,4-Dichloroaniline	61625	95-76-1	.0042	lrl2	3,4-Dichloroaniline	Deg -
3,5-Dichloroaniline	61627	626-43-7	.0040	lrl2	3,5-Dichloroaniline	Deg -
4-Chloro-2-methylphenol	61633	1570-64-5	.0046	lrl2	4-Chloro-2-met_henol	Deg -
Acetochlor	49260	34256-82-1	.010	lrl2	-	Chloroacetanilide
Alachlor	46342	15972-60-8	.008	lrl2	Lasso	H Chloroacetanilide
alpha-Endosulfan	34362	959-98-8	.006	lrl2	alpha-Endosulfan	I Organochlorine
Atrazine	39632	1912-24-9	.008	lrl2	-	H Triazine
Azinphos-methyl	82686	86-50-0	.12	lrl2	Guthion	I Organophosphate
Azinphos-methyl-oxon	61635	961-22-8	.042	lrl2	Azinphos-methyl-oxon	Deg -
Benfluralin	82673	1861-40-1	.014	lrl2	Benefin	H Dinitroaniline
Carbaryl	82680	63-25-2	.06	lrl2	Sevin	I Carbamate
Carbofuran	82674	1563-66-2	.060	lrl2	Furadan	I Carbamate
Chlorpyrifos	38933	2921-88-2	.0036	lrl2	-	I Organophosphate
Chlorpyrifos, oxygen analog	61636	5598-15-2	.06	lrl2	Chlorpyrifos, analog	Deg -
cis-Permethrin	82687	61949-76-6	.010	lrl2	-	I Pyrethroid
cis-Propiconazole	79846	60207-90-1	.008	lrl2	cis-Propiconazole	F Triazole
Cyanazine	04041	21725-46-2	.022	lrl2	-	H Triazine
Cyfluthrin	61585	68359-37-5	.016	lrl2	Cyfluthrin	I Pyrethroid
Cypermethrin	61586	52315-07-8	.020	lrl2	Cypermethrin	I Pyrethroid
DCPA	82682	1861-32-1	.0076	lrl2	Chlorthal-dimethyl	H Organochlorine

Appendix C. Parameter codes and reporting levels for organic-compound analytes in National Water Quality Laboratory schedule 2033 (moderate-use pesticides), schedule 2060 (polar pesticides), schedule 1433 (wastewater indicators), schedule 2080 (human-health pharmaceuticals), and lab code 8144 (human-health pharmaceuticals).—Continued

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Schedule 2033, Pesticides—Continued							
Parameter name	NWIS Parameter code	CAS Registry Number®	Reporting level (µg/L)	Reporting level type	Alternative or common name ^{1,2,3}	Use ^{1,2,3}	Class ^{1,2,3}
Desulfinylfipronil	62170	-	0.012	lrl2	-	Deg	-
Desulfinylfipronil amide	62169	-	.029	lrl2	-	Deg	-
Diazinon	39572	333-41-5	.0060	lrl2	-	I	Organophosphate
Diazinon, oxygen analog	61638	962-58-3	.010	lrl2	-	Deg	-
Dichlorvos	38775	62-73-7	.04	lrl2	Dichlorvos	Fum	Organophosphate
Dicrotophos	38454	141-66-2	.08	lrl2	Dicrotophos	I	Organophosphate
Dieldrin	39381	60-57-1	.008	lrl2	-	I	Organochlorine
Dimethoate	82662	60-51-5	.006	lrl2	Dimethoate	I	Organothiophosphate
Disulfoton	82677	298-04-4	.040	lrl2	-	I	Organophosphate
Disulfoton sulfone	61640	2497-06-5	.014	lrl2	Disulfoton sulfone	Deg	-
Endosulfan sulfate	61590	1031-07-8	.016	lrl2	Endosulfan sulfate	Deg	-
s-ethyl dipropylthiocarbamate (EPTC)	82668	759-94-4	.0056	lrl2	Eptam	H	Carbamate
Ethion	82346	563-12-2	.008	lrl2	Ethion	I	Organothiophosphate
Ethion monoxon	61644	17356-42-2	.021	lrl2	Ethion monoxon	Deg	-
Ethoprophos	82672	13194-48-4	.016	lrl2	Mocap	I	Organophosphate
Fenamiphos	61591	22224-92-6	.030	lrl2	Fenamiphos	N	Organothiophosphate
Fenamiphos sulfone	61645	31972-44-8	.054	lrl2	Fenamiphos sulfone	Deg	-
Fenamiphos sulfoxide	61646	31972-43-7	.08	lrl2	Fenamiphos sulfoxide	Deg	-
Fipronil	62166	120068-37-3	.018	lrl2	-	I	Pyrazole
Fipronil sulfide	62167	120067-83-6	.012	lrl2	-	Deg	-
Fipronil sulfone	62168	120068-36-2	.024	lrl2	-	Deg	-
Fluridone (Schedule 2033 add-on)	65216	59756-60-4	.026	lrl2	-	H	-
Fonofos	04095	944-22-9	.0048	lrl2	Dyfonate	I	Organophosphate
Hexazinone	04025	51235-04-2	.008	lrl2	Hexazinone	H	Triazine
Iprodione	61593	36734-19-7	.014	lrl2	Iprodione	F	Amide
Isofenphos	61594	25311-71-1	.006	lrl2	Isofenphos	I	Organothiophosphate
<i>lambda</i> -Cyhalothrin	61595	91465-08-6	.010	lrl2	Cyhalothrin	I	Pyrethroid
Malaaxon	61652	1634-78-2	.022	lrl2	Malaaxon	Deg	-
Malathion	39532	121-75-5	.016	lrl2	-	I	Organophosphate
Metalaxyl	61596	57837-19-1	.014	lrl2	Metalaxyl	F	Amino acid derivative
Methidathion	61598	950-37-8	.012	lrl2	Methidathion	I	Organothiophosphate

Appendix C. Parameter codes and reporting levels for organic-compound analytes in National Water Quality Laboratory schedule 2033 (moderate-use pesticides), schedule 2060 (polar pesticides), schedule 1433 (wastewater indicators), schedule 2080 (human-health pharmaceuticals), and lab code 8144 (human-health pharmaceuticals).—Continued

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Schedule 2033, Pesticides—Continued							
Parameter name	NWIS Parameter code	CAS Registry Number®	Reporting level (µg/L)	Reporting level type	Alternative or common name ^{1,2,3}	Use ^{1,2,3}	Class ^{12,3}
Metolachlor	39415	51218-45-2	0.020	lrl2	Dual	H	Amide
Metribuzin	82630	21087-64-9	.012	lrl2	Lexone; Sencor	H	Triazine
Molinate	82671	2212-67-1	.0040	lrl2	Ordram	H	Carbamate
Myclobutanil	61599	88671-89-0	.010	lrl2	Myclobutanil	F	Triazole
Oxyfluorfen	61600	42874-03-3	.006	lrl2	Oxyfluorfen	H	Diphenyl ether
Paraoxon-methyl	61664	950-35-6	.014	lrl2	Paraoxon-methyl	Deg	-
Parathion-methyl	82667	298-00-0	.008	lrl2	Penncap-M	I	Organophosphate
Pendimethalin	82683	40487-42-1	.012	lrl2	-	H	Dinitroaniline
Phorate	82664	298-02-2	.020	lrl2	Thimet	I	Organochlorine
Phorate oxygen analog	61666	2600-69-3	.027	lrl2	Phorate oxon	Deg	-
Phosmet	61601	732-11-6	.014	lrl2	Phosmet	I	Organothiophosphate
Phosmet oxon	61668	3735-33-9	.051	lrl2	Phosmet oxon	Deg	-
Prometon	04037	1610-18-0	.012	lrl2	-	H	Triazine
Prometryn	04036	7287-19-6	.006	lrl2	Prometryn	H	Triazine
Propanil	82679	709-98-8	.010	lrl2	Stampede	H	Amide
Propargite	82685	2312-35-8	.020	lrl2	Omite; alkyl sulfite	I	Miscellaneous
Propyzamide	82676	23950-58-5	.0036	lrl2	Kerb; Pronamide	H	Amide
Simazine	04035	122-34-9	.006	lrl2	Aquazine; Princep	H	Triazine
Tebuthiuron	82670	34014-18-1	.028	lrl2	Spike	H	Urea
Tefluthrin	61606	79538-32-2	.010	lrl2	Tefluthrin	I	Pyrethroid
Terbufos	82675	13071-79-9	.018	lrl2	Counter	I	Organophosphate
Terbufos oxygen analog sulfone	61674	56070-15-6	.045	lrl2	-	Deg	-
Terbutylazine	04022	5915-41-3	.0060	lrl2	Terbutylazine	H	Triazine
Thiobencarb	82681	28249-77-6	.016	lrl2	Bolero	H	Carbamate
trans-Propiconazole	79847	60207-90-1	.010	lrl2	trans-Propiconazole	F	Triazole
Tribufos	61610	78-48-8	.018	lrl2	Tribufos	Def	Organothiophosphate
Trifluralin	82661	1582-09-8	.018	lrl2	Treflan	H	Dinitroaniline

Appendix C. Parameter codes and reporting levels for organic-compound analytes in National Water Quality Laboratory schedule 2033 (moderate-use pesticides), schedule 2060 (polar pesticides), schedule 1433 (wastewater indicators), schedule 2080 (human-health pharmaceuticals), and lab code 8144 (human-health pharmaceuticals).—Continued

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Schedule 2060, Pesticides						
Parameter name	NWIS Parameter code	CAS Registry Number®	Reporting level (µg/L)	Reporting level type	Alternative or common name ⁴	Use ⁴ Class ⁴
2,4-D	39732	94-75-7	0.06	lrl2	Weedone-2,4-DP	H Chlorophenoxy acid
2,4-D methyl ester	50470	1928-38-7	.2	lrl2	2,4-Dichlorophenoxyacetic methyl ester	H Chlorophenoxy acid
2,4-DB	38746	94-82-6	.02	lrl2	4-(2,4-dichlorophenoxy) butanoic acid	H Chlorophenoxy acid
2-Chloro-4-isopropylamino-6-amino-s- triazine {CIAT}	04040	6190-65-4	.06	lrl2	—	H-Deg Triazine
2-Chloro-6-ethylamino-4-amino-s-triazine {CEAT}	04038	1007-28-9	.06	lrl2	—	H-Deg Triazine
2-Hydroxy-4-isopropylamino-6- ethylamino-s-triazine {OIET}	50355	2163-68-0	.06	lrl2	4-(ethylamino)-6-[(1- methylethyl)amino]-1,3,5- Triazin-2(1H)-one	H-Deg Triazine
3(4-Chlorophenyl)-1-methyl urea	61692	5352-88-5	.06	lrl2	N'-(4-chlorophenyl)-N- methylurea	H-Deg Phenylurea
3-Hydroxycarbofuran	49308	16655-82-6	.04	lrl2	2,3-dihydro-2,2-dimethyl- 3,7-Benzofurandiol, 7-(methylcarbamate)	I-Deg Carbamate
Acifluorfen	49315	50594-66-6	.04	lrl2	Tackle; Blazer	H Diphenyl ether
Aldicarb	49312	116-06-3	.12	lrl2	Temik	I Carbamate
Aldicarb sulfone	49313	1646-88-4	.08	lrl2	Aldoxycarb	I-Deg Carbamate
Aldicarb sulfoxide	49314	1646-87-3	.06	lrl2	Temik Sulfoxide	I-Deg Carbamate
Atrazine	39632	1912-24-9	.04	lrl2	Atrex; Atritol	H Triazine
Bendiocarb	50299	22781-23-3	.04	lrl2	Ficam	I Carbamate
Benomyl	50300	17804-35-2	.06	lrl2	Benlate	F Benzimidazole
Bensulfuron-methyl	61693	83055-99-6	.06	lrl2	Londax	H Sulfonylurea
Bentazon	38711	25057-89-0	.06	lrl2	Adagio; Galaxy; Storm	H Benzothiadiazole
Bromacil	04029	314-40-9	.06	lrl2	Bromax; Hyvar; Uragon	H Uracil
Bromoxynil	49311	1689-84-5	.12	lrl2	Bromanil; Bucril; Torch	H Benzonitrile
Caffeine	50305	58-08-2	.08	lrl2	1,3,7-Trimethylxanthine	H Carbamate
Carbaryl	49310	63-25-2	.04	lrl2	Sevin	H Carbamate
Carbofuran	49309	1563-66-2	.04	lrl2	Crisfuran; Furadan	H Carbamate
Chloramben, methyl ester	61188	7286-84-2	.10	lrl2	Amiben, methyl ester	H Chlorophenoxy acid
Chlorimuron-ethyl	50306	90982-32-4	.08	lrl2	Classic	H Sulfonylurea

Appendix C. Parameter codes and reporting levels for organic-compound analytes in National Water Quality Laboratory schedule 2033 (moderate-use pesticides), schedule 2060 (polar pesticides), schedule 1433 (wastewater indicators), schedule 2080 (human-health pharmaceuticals), and lab code 8144 (human-health pharmaceuticals).—Continued

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Schedule 2060, Pesticides—Continued							
Parameter name	NWIS Parameter code	CAS Registry Number®	Reporting level (µg/L)	Reporting level type	Alternative or common name ⁴	Use ⁴	Class ⁴
Clopyralid	49305	1702-17-6	0.06	lrl2	Stinger; Lontrel	H	Pyridine
Cycloate	04031	1134-23-2	.04	lrl2	Ro-Neet; Marathon	H	Thiocarbamate
DCPA monoacid	49304	887-54-7	.04	lrl2	Monomethyl tetrachloroterephthalate	H-Deg	Chlorophenoxy acid
Dicamba	38442	1918-00-9	.04	lrl2	Banval; Marksman; Clarity	H	Benzoic acid
Dichlorprop	49302	120-36-5	.04	lrl2	2,4-DP; Weedone DP	H	Chlorophenoxy acid
Dinoseb	49301	88-85-7	.04	lrl2	DNPB; Caldon; Dynamite	H	Dinitrophenol
Diphenamid	04033	957-51-7	.04	lrl2	Dymid; Enide; Rideon; Dyfen	H	Acetamide
Diuron	49300	330-54-1	.04	lrl2	DCMU; Diurex; Aguron	H	Phenylurea
Fenuron	49297	101-42-8	.06	lrl2	Beet-Klean	H	Phenylurea
Flumetsulam	61694	98967-40-9	.06	lrl2	DE 498; XRD 498	H	Sulfonamide
Flumeturon	38811	2164-17-2	.04	lrl2	Cortoran; Lanex; Cottonex	H	Phenylurea
Imazaquin	50356	81335-37-7	.06	lrl2	Image 1.5LC; Scepter 1.5L	H	Imidazolinone
Imazethapyr	50407	81335-77-5	.06	lrl2	Pursuit; Pursuit DG	H	Imidazolinone
Imidacloprid	61695	138261-41-3	.06	lrl2	Admire; Gaucho; Merit	I	Chloro-Nicotinyl
Linuron	38478	330-55-2	.04	lrl2	Lorox; Afalon; Linurex; Linex	H	Phenylurea
MCPA	38482	94-74-6	.04	lrl2	Bordermaster; Metaxon	H	Chlorophenoxy acid
MCPB	38487	94-81-5	.2	lrl2	Tropotox; Can-Trol; PDQ	H	Chlorophenoxy acid
Metalaxyl	50359	57837-19-1	.04	lrl2	Apron; Subdue; Ridomil	F	Acylalanine
Methiocarb	38501	2032-65-7	.04	lrl2	Mercaptodimethur; Draza; Mesurol	I	Carbamate
Methomyl	49296	16752-77-5	.12	lrl2	Nudrin; Lannate; Lanox	I	Carbamate
Metsulfuron methyl	61697	74223-64-6	.14	lrl2	Escort; Gropper; Ally	H	Sulfonyleurea
Neburon	49294	555-37-3	.02	lrl2	Granurex; Herbalt; Kloben	H	Phenylurea
Nicosulfuron	50364	111991-09-4	.10	lrl2	Accent; Accent DF	H	Sulfonyleurea
Norflurazon	49293	27314-13-2	.04	lrl2	Zorial; Evital; Solicam; Telok	H	Pyridyloxyacetic acid
Oryzalin	49292	19044-88-3	.04	lrl2	Ryzelan; Surflan; Dirimal	H	Dinitroaniline
Oxamyl	38866	23135-22-0	.12	lrl2	Vydate; Thioxamyl	I	Carbamate

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Schedule 2060, Pesticides—Continued						
Parameter name	NWIS Parameter code	CAS Registry Number®	Reporting level (µg/L)	Reporting level type	Alternative or common name ⁴	Use ⁴ Class ⁴
Picloram	49291	1918-02-1	0.12	lrl2	Tordon; Amdon; Grazon	H Pyridine
Propham	49236	122-42-9	.04	lrl2	IPC; Chem-Hoe; Premalox	H Carbamate
Propiconazole	50471	60207-90-1	.04	lrl2	Tilt; Orbit; Banner: Proconazole; Wocosin	F Triazole
Propoxur	38538	114-26-1	.06	lrl2	Baygon; PHC; Suncide; Unden	I Carbamate
Siduron	38548	1982-49-6	.04	lrl2	Tupersan; Trey	H Phthalimide
Sulfometuron-methyl	50337	74222-97-2	.06	lrl2	Oust; DPX-T5648	H Sulfonylurea
Tebuthiuron	82670	34014-18-1	.06	lrl2	Graslan; Spike; Perflan	H Thiadiazole
Terbacil	04032	5902-51-2	.04	lrl2	Sinbar; DPX-D732; Geonter	H Uracil
Triclopyr	49235	55335-06-3	.08	lrl2	Garlon; Curtail; Redeem; Remedy	H Pyridyloxyacetic acid

Appendix C. Parameter codes and reporting levels for organic-compound analytes in National Water Quality Laboratory schedule 2033 (moderate-use pesticides), schedule 2060 (polar pesticides), schedule 1433 (wastewater indicators), schedule 2080 (human-health pharmaceuticals), and lab code 8144 (human-health pharmaceuticals).—Continued

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Schedule 1433, Wastewater indicators					Possible compound uses or sources ⁵	
Parameter name	NWIS Parameter code	CAS Registry Number®	Reporting level (µg/L)	Reporting level type		
1,4-Dichlorobenzene	34572	106-46-7	0.040	Irl2	Moth repellant, fumigant, deodorant	
1-Methylnaphthalene	62054	90-12-0	.022	Irl2	2-5% of gasoline, diesel fuel, or crude oil	
2,6-Dimethylnaphthalene	62055	581-42-0	.06	Irl2	Present in diesel/kerosene (trace in gasoline)	
2-Methylnaphthalene	62056	91-57-6	.036	Irl2	2-5% of gasoline, diesel fuel, or crude oil	
3- <i>beta</i> -Coprostanol	62057	360-68-9	1.8	Irl2	Carnivore fecal indicator	
3-Methyl-1(H)-indole (Skatole)	62058	83-34-1	.036	Irl2	Fragrance, stench in feces and coal tar	
3- <i>tert</i> -Butyl-4-hydroxy anisole (BHA)	62059	25013-16-5	.6	Irl2	Antioxidant, general preservative	
4-Cumylphenol	62060	599-64-4	.060	Irl2	Nonionic detergent metabolite	
4- <i>n</i> -Octylphenol	62061	1806-26-4	.06	Irl2	Nonionic detergent metabolite	
4-Nonylphenol diethoxylate, (sum of all isomers) aka NP2EO	62083	—	5.0	Irl2	Nonionic detergent metabolite	
4- <i>tert</i> -Octylphenol	62062	140-66-9	.14	Irl2	Nonionic detergent metabolite	
4- <i>tert</i> -Octylphenol diethoxylate, aka OP2EO	61705	—	1	Irl2	Nonionic detergent metabolite	
4- <i>tert</i> -Octylphenol monoethoxylate, aka OP1EO	61706	—	1	Irl2	Nonionic detergent metabolite	
5-Methyl-1H-benzotriazole	62063	136-85-6	1.2	Irl2	Antioxidant in antifreeze and deicers	
Acetophenone	62064	98-86-2	.4	Irl2	Fragrance in detergent and tobacco, flavor in beverages	
Acetyl hexamethyl tetrahydronaphthalene (AHTN)	62065	21145-77-7	.028	Irl2	Musk fragrance (widespread usage) persistent in ground water	
Anthracene	34221	120-12-7	.01	Irl2	Wood preservative, component of tar, diesel, or crude oil, CP	
Anthraquinone	62066	84-65-1	.16	Irl2	Manuf dye/textiles, seed treatment, bird repellant	
Benzofalpyrene	34248	50-32-8	.018	Irl2	Regulated PAH, used in cancer research, CP	
Benzophenone	62067	119-61-9	.08	Irl2	Fixative for perfumes and soaps	
<i>beta</i> -Sitosterol	62068	83-46-5	4	Irl2	Plant sterol	
<i>beta</i> -Stigmastanol	62086	19466-47-8	2.6	Irl2	Plant sterol	
Bromacil	04029	314-40-9	.36	Irl2	H (GUP), >80% noncrop usage on grass/brush	
Bromoform	34288	75-25-2	.10	Irl2	WW ozonation byproduct, military/explosives	
Caffeine	50305	58-08-2	.06	Irl2	Beverages, diuretic, very mobile/biodegradable	
Camphor	62070	76-22-2	.044	Irl2	Flavor, odorant, ointments	
Carbaryl	82680	63-25-2	.16	Irl2	I, crop and garden uses, low persistence	
Carbazole	62071	86-74-8	0.03	Irl2	I, Manuf dyes, explosives, and lubricants	

Appendix C. Parameter codes and reporting levels for organic-compound analytes in National Water Quality Laboratory schedule 2033 (moderate-use pesticides), schedule 2060 (polar pesticides), schedule 1433 (wastewater indicators), schedule 2080 (human-health pharmaceuticals), and lab code 8144 (human-health pharmaceuticals).—Continued

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Schedule 1433, Wastewater indicators—Continued

Parameter name	NWIS Parameter code	CAS Registry Number®	Reporting level (µg/L)	Reporting level type	Possible compound uses or sources ⁵
Chlorpyrifos	38933	2921-88-2	.16	IrI2	I, domestic pest and termite control (domestic use restricted as of 2001)
Cholesterol	62072	57-88-5	2.0	IrI2	Often a fecal indicator, also a plant sterol
Cotinine	62005	486-56-6	.8	IrI2	Primary nicotine metabolite
Diazinon	39572	333-41-5	.16	IrI2	I, > 40% nonagricultural usage, ants, flies
<i>d</i> -Limonene	62073	5989-27-5	.08	IrI2	F, antimicrobial, antiviral, fragrance in aerosols
Fluoranthene	34377	206-44-0	.024	IrI2	Component of coal tar and asphalt (only traces in gasoline or diesel fuel), CP
Hexahydrohexamethylcyclopentabenzopyran (HHCB)	62075	1222-05-5	.052	IrI2	Musk fragrance (widespread usage) persistent in ground water
Indole	62076	120-72-9	.08	IrI2	Pesticide inert ingredient, fragrance in coffee
Isoborneol	62077	124-76-5	.08	IrI2	Fragrance in perfumery, in disinfectants
Isophorone	34409	78-59-1	.032	IrI2	Solvent for lacquer, plastic, oil, silicon, resin
Isopropylbenzene	62078	98-82-8	.30	IrI2	Manuf phenol/acetone, fuels and paint thinner
Isoquinoline	62079	119-65-3	.046	IrI2	Flavors and fragrances
Menthol	62080	89-78-1	.32	IrI2	Cigarettes, cough drops, liniment, mouthwash
Metalaxyl	50359	57837-19-1	.12	IrI2	H, F (GUP), mildew, blight, pathogens, golf/turf
Methyl salicylate	62081	119-36-8	.044	IrI2	Liniment, food, beverage, UV-absorbing lotion
Metolachlor	39415	51218-45-2	.028	IrI2	H (GUP), indicator of agricultural drainage
N,N-diethyl-meta-toluidide (DEET)	62082	134-62-3	.06	IrI2	I, urban uses, mosquito repellent
Naphthalene	34443	91-20-3	.040	IrI2	Fumigant, moth repellent, major component (about 10%) of gasoline
<i>para</i> -Nonylphenol (total) (branched)	62085	84852-15-3	2	IrI2	Nonionic detergent metabolite
<i>p</i> -Cresol	62084	106-44-5	.08	IrI2	Wood preservative
Phenanthrene	34462	85-01-8	.016	IrI2	Manuf explosives, component of tar, diesel fuel, or crude oil, CP
Phenol	34466	108-95-2	.16	IrI2	Disinfectant, manuf several products, leachate
Prometon	04037	1610-18-0	.12	IrI2	H (noncrop only), applied prior to blacktop
Pyrene	34470	129-00-0	.042	IrI2	Component of coal tar and asphalt (only traces in gasoline or diesel fuel), CP
Tetrachloroethylene	34476	127-18-4	.12	IrI2	Solvent, degreaser, veterinary anthelmintic
Tributyl phosphate	62089	126-73-8	.16	IrI2	Antifoaming agent, flame retardant
Triclosan	62090	3380-34-5	.20	IrI2	Disinfectant, antimicrobial (concern for acquired microbial resistance)

Appendix C. Parameter codes and reporting levels for organic-compound analytes in National Water Quality Laboratory schedule 2033 (moderate-use pesticides), schedule 2060 (polar pesticides), schedule 1433 (wastewater indicators), schedule 2080 (human-health pharmaceuticals), and lab code 8144 (human-health pharmaceuticals).—Continued

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Schedule 1433, Wastewater indicators—Continued

Parameter name	NWIS Parameter code	CAS Registry Number®	Reporting level (µg/L)	Reporting level type	Possible compound uses or sources ⁵
Triethyl citrate (ethyl citrate)	62091	77-93-0	0.16	Ir12	Cosmetics, pharmaceuticals
Triphenyl phosphate	62092	115-86-6	.12	Ir12	Plasticizer, resin, wax, finish, roofing paper, flame retardant
Tris(2-butoxyethyl)phosphate	62093	78-51-3	.8	Ir12	Flame retardant
Tris(2-chloroethyl)phosphate	62087	115-96-8	.10	Ir12	Plasticizer, flame retardant
Tris(dichloroisopropyl)phosphate	62088	13674-87-8	.16	Ir12	Flame retardant

Appendix C. Parameter codes and reporting levels for organic-compound analytes in National Water Quality Laboratory schedule 2033 (moderate-use pesticides), schedule 2060 (polar pesticides), schedule 1433 (wastewater indicators), schedule 2080 (human-health pharmaceuticals), and lab code 8144 (human-health pharmaceuticals).—Continued

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Schedule 2080, Pharmaceuticals						
Parameter name	NWIS Parameter code	CAS Registry Number®	Reporting level (µg/L)	Reporting level type	Alternate or common name ⁶	Use ⁶
1,7-Dimethylxanthine (<i>p</i> -Xanthine)	62030	611-59-6	0.10	Ir12	Paraxanthine (metabolite of caffeine)	Precursor is a stimulant
Acetaminophen	62000	103-90-2	.12	Ir12	Tylenol	Analgesic
Albuterol (Salbutamol)	62020	18559-94-9	.08	Ir12	Salbutamol, Proventil	Bronchodilator
Caffeine	50305	58-08-2	.06	Ir12	Caffeine; Guaranine; methyltheobromide; Methyltheobromine; No-Doz	Stimulant
Carbamazepine	62793	298-46-4	.06	Ir12	Epitol; Tegretol; Tegretol; Teril	Antiepileptic
Codeine	62003	76-57-3	.046	Ir12	Actacode; Calcidrine; Methylmorphine; N-methyl norcodeine; Robitussin AC; Tussar-2; Tussi-organidin	Opiate agonist
Cotinine	62005	486-56-6	.038	Ir12	1-Methyl-5-(3-pyridinyl)-2- pyrrolidinone (nicotine metabolite)	Precursor is a naturally occurring alkaloid stimulant
Dehydronifedipine	62004	67035-22-7	.08	Ir12	Metabolite of nifedipine (Procardia)	Precursor is an antiangial
Diltiazem	62008	42399-41-7	.02	Ir12	Dilzem, Tiazac, Cardizem, Cartia XT	Antihypertensive
Diphenhydramine	62796	147-24-0	.058	Ir12	Banophen, Benadryl, Diphen Af, Genahist, Sleep-eze	Antipruritic
Sulfamethoxazole	62021	723-46-6	.091	Ir12	Bactrim; Fectrim; Gantrim; Septrim; Septin; Sulfotrim; Trisulfam; Urobak	Antibiotic
Thiabendazole	62801	148-79-8	.06	Ir12	Bioguard; bovizole; equizole; lombristop; Mintezol; nemapan; omnizole; thiaben	Anthelmintic, fungicide
Trimethoprim	62023	738-70-5	.034	Ir12	Abaprim; Chemotrim; Idotrim; Lidaprim; Methoprim; Monotrim; Primosept; Ratiopharm; Trimpep; Uretrim; Wellcoprim	Antibiotic
Warfarin	62024	81-81-2	.08	Ir12	Coumadin; Dethnel; Panwarfin; Rodex; Sofarin; Vampirinip; Zoocoumarin	Anticoagulant, rodenticide

Appendix C. Parameter codes and reporting levels for organic-compound analytes in National Water Quality Laboratory schedule 2033 (moderate-use pesticides), schedule 2060 (polar pesticides), schedule 1433 (wastewater indicators), schedule 2080 (human-health pharmaceuticals), and lab code 8144 (human-health pharmaceuticals).—Continued

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Lab Code 8144, Human-health pharmaceuticals					
Parameter name	NWIS Parameter code	CAS Registry Number®	Reporting level (µg/L)	Reporting level type	Use ^{7,8,10}
2-ethyl-2-phenylmalonamide	67804	7206-76-0	0.1	irl2	Primidone metabolite
Acetaminophen	62000	103-90-2	.64	irl2	Analgesic
Amitriptyline	67962	50-48-6	.16	irl2	Antidepressant
Antipyrine	67805	60-80-0	.32	irl2	—
Butalbital	63768	77-26-9	.16	irl2	Barbiturate
Carbamazepine	62793	298-46-4	.16	irl2	Anti-convulsant
Carisoprodol	65180	78-44-4	.16	irl2	Muscle relaxant
Celecoxib	67806	169590-42-5	.64	irl2	Anti-inflammatory
Chirald	67960	38345-66-3	.16	irl2	Opiate metabolite
3,5-Xylenol, 4-chloro-	66574	88-04-0	.08	irl2	Antimicrobial
Chlorpheniramine	63769	132-22-9	.08	irl2	Antihistamine
Citalopram	67807	59729-33-8	.08	irl2	Antidepressant
Codeine	62003	76-57-3	.32	irl2	Opiate agonist; analgesic
Dextromethorphan	67809	125-71-3	.16	irl2	Antitussive
Diazepam (valium)	63770	439-14-5	.16	irl2	Sedative
Dihydrocodeine	67810	125-28-0	.16	irl2	Narcotic
Diltiazem	62008	42399-41-7	.04	irl2	Antihypertensive
Diphenhydramine	62796	147-24-0	.08	irl2	Antihistamine
Efavirenz	67811	154598-52-4	.32	irl2	Anti-HIV
Fluconazole	67812	86386-73-4	.16	irl2	Antifungal
Fluoxetine ⁹	62011	54910-89-3	.64	irl2	Antidepressant
Griseofulvin	67813	126-07-8	.32	irl2	Antibacterial
Hydrocodone	63771	125-29-1	.32	irl2	Narcotic
Ibuprofen ⁹	62014	15687-27-1	.64	irl2	Anti-inflammatory
Iminostilbene	67815	256-96-2	.08	irl2	Anticonvulsant
Lidocaine	67816	137-58-6	.08	irl2	Anesthetic
Meperidine	67818	57-42-1	.08	irl2	Narcotic
Meprobamate	67819	57-53-4	.32	irl2	Sedative
Metaxalone	63772	1665-48-1	.08	irl2	Muscle relaxant
Methadone	63774	76-99-3	.08	irl2	Narcotic
Methocarbamol ⁹	65183	532-03-6	.64	irl2	Muscle relaxant

Appendix C. Parameter codes and reporting levels for organic-compound analytes in National Water Quality Laboratory schedule 2033 (moderate-use pesticides), schedule 2060 (polar pesticides), schedule 1433 (wastewater indicators), schedule 2080 (human-health pharmaceuticals), and lab code 8144 (human-health pharmaceuticals).—Continued

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Lab Code 8144, Human-health pharmaceuticals—Continued					
Parameter name	Parameter code	CAS Registry Number®	Reporting level (µg/L)	Reporting level type	Use ^{7,8,10}
Methylphenidate	67820	113-45-1	0.08	irl2	Sedative
Norpropoxyphene	67821	3376-94-1	.32	irl2	Opiate metabolite
Oxcarbazepine	67822	28721-07-5	.32	irl2	Anticonvulsant
Oxycodone	63775	76-42-6	.32	irl2	Narcotic
Pentobarbital	67823	76-74-4	.16	irl2	Sedative
Pentoxifylline	67824	1677687	.32	irl2	Vasodilator
Phendimetrazine	63776	634-03-7	.04	irl2	Stimulant, appetite suppressant
Phenobarbital	67319	50-06-6	.16	irl2	Sedative
Phenytion	67825	57-41-0	.16	irl2	Anticonvulsant
Piperonyl butoxide	67826	51-03-6	.08	irl2	Synergist
Primidone	67827	125-33-7	.32	irl2	Anticonvulsant
Propofol	67828	2078-54-8	.04	irl2	Sedative
Temazepam	67830	846-50-4	.32	irl2	Sedative
Ticlopidine	67831	55142-85-3	.08	irl2	Fibrinolytic
Tramadol	67832	27203-92-5	.04	irl2	Narcotic
Venlafaxine	67833	93413-69-5	.04	irl2	Antidepressant
Verapamil	67834	52-53-9	.08	irl2	Vasodilator

¹ Zaugg and others, 1995.

² Sandstrom and others, 2001.

³ Madsen and others, 2003.

⁴ Furlong and others, 2001.

⁵ Zaugg and others, 2002 (rev. 2007).

⁶ Furlong and others, 2008.

⁷ Furlong and others, 2008.

⁸ http://toxics.usgs.gov/regional/emc/compound_list.xls.

⁹ No values are reported in appendix G because of matrix interference.

¹⁰ Written commun., Steve Zaugg, U.S. Geological Survey, National Water Quality Laboratory, 2012.

Appendix D. Analytical Results for Quality-Control Samples Collected at White River at Headworks, White River Canal, Lake Tapps Diversion, and Lake Tapps, Washington Study Sites, July–December 2010

Appendix D1. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from the White River at Headworks, White River Canal (Inflow), and Lake Tapps Diversion (Tailrace), July–December 2010.

[**Abbreviations:** nm, nanometer; e, estimated; <, less than; –, no value; all values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels; NTRU, nephelometric turbidity ratio units]

STAID	Station number	12098700—White River at Headworks				
		20100706		20100720		
DATES	Date	1230	1231	1348	1340	
TIMES	Sample Time					
NWIS Parameter code	Parameter name	Sample concentration	Replicate concentration	Relative percent difference	Blank concentration	Sample concentration
P63676	Turbidity, water, unfiltered, broad band light source (400–680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	5.7	5.6	0.9	0.1	30
P00530	Suspended solids, water, unfiltered, milligrams per liter	22	18	10.0	<1.1	110
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	e .013	e0.019	18.8	e .014	<.010
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	.025	.025	0	e .013	.028
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	<.001	<.001	0	<.001	<.001
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	.013	.013	0	<.004	.017
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	.008	.008	0	<.003	.012
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	.028	.029	1.8	<.004	.347
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	.18	.16	5.9	.21	<.05
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	<.05	<.05	0.0	<.05	.07
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	<1	–	–	–	5

Appendix D1. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from the White River at Headworks, White River Canal (Inflow), and Lake Tapps Diversion (Tailrace), July–December 2010.—Continued

[**Abbreviations:** nm, nanometer; e, estimated; <, less than; –, no value; all values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels; NTRU, nephelometric turbidity ratio units]

STAID	Station number	12098700—White River Canal (Inflow)				
		20100720			20100817	
DATES	Date	1130	1131		1428	1420
TIMES	Sample Time					
Parameter code	Parameter name	Sample concentration	Replicate concentration	Relative percent difference	Blank concentration	Sample concentration
P63676	Turbidity, water, unfiltered, broad band light source (400-680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	23	25	4.2	0	5.8
P00530	Suspended solids, water, unfiltered, milligrams per liter	160	160	0	<1.1	4
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	<.010	e .011	4.8	e .012	e .013
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	.029	.03	1.7	<.008	e.013
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	<.001	<.001	0	<.001	<.001
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	.01	.011	4.8	<.004	e .005
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	.007	.008	6.7	<.003	<.003
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	.145	.189	13.2	<.004	.017
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	.3	.47	22.1	e .10	.14
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	.18	.27	0	<.05	.22
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	40	—	—	—	21

Appendix D1. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from the White River at Headworks, White River Canal (Inflow), and Lake Tapps Diversion (Tailrace), July–December 2010.—Continued

[**Abbreviations:** nm, nanometer; e, estimated; <, less than; –, no value; all values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels; NTRU, nephelometric turbidity ratio units]

STAID	Station number	12101100—Lake Tapps Diversion (Tailrace)			
		20100706		20100803	
DATES	Date	0958	0950	0838	0830
TIMES	Sample Time				
Parameter code	Parameter name	Blank concentration	Sample concentration	Blank concentration	Sample concentration
P63676	Turbidity, water, unfiltered, broad band light source (400-680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	–	–	0.1	9.1
P00530	Suspended solids, water, unfiltered, milligrams per liter	–	–	<1.1	18
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	–	–	e .012	<0.010
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	–	–	<.008	.018
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	–	–	<.001	e .002
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	–	–	<.004	.018
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	–	–	<.003	.015
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	–	–	<.004	.057
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	–	–	e .06	<.05
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	–	–	<.05	.23
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	<1	570	<1	270

Appendix D1. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from the White River at Headworks, White River Canal (Inflow), and Lake Tapps Diversion (Tailrace), July–December 2010.—Continued

[**Abbreviations:** nm, nanometer; e, estimated; <, less than; –, no value; all values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels; NTRU, nephelometric turbidity ratio units]

STAID	Station number	12101100—Lake Tapps Diversion (Tailrace)		
		20100817		
DATES	Date			
TIMES	Sample Time	1040	1041	
Parameter code	Parameter name	Sample concentration	Replicate concentration	Relative percent difference
P63676	Turbidity, water, unfiltered, broad band light source (400–680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	5.9	4.8	10.3
P00530	Suspended solids, water, unfiltered, milligrams per liter	11	10	4.8
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	.022	.024	4.8
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	<.008	e.010	11.1
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	<.001	<.001	0
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	.021	.021	0
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	.017	.017	0
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	.079	.074	3.3
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	.28	.25	5.7
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	.38	.33	0
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	370	270	–

Appendix D1. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from the White River at Headworks, White River Canal (Inflow), and Lake Tapps Diversion (Tailrace), July–December 2010.—Continued

[**Abbreviations:** nm, nanometer; e, estimated; <, less than; –, no value; all values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels; NTRU, nephelometric turbidity ratio units]

STAID	Station number	12101100—Lake Tapps Diversion (Tailrace)				
		20101116				
DATES	Date					
TIMES	Sample Time	1040	1041		1048	1040
Parameter code	Parameter name	Sample concentration	Replicate concentration	Relative percent difference	Blank concentration	Sample concentration
P63676	Turbidity, water, unfiltered, broad band light source (400-680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	2.5	2.4	2.0	0.1	2.5
P00530	Suspended solids, water, unfiltered, milligrams per liter	<1.1	e 1.2	4.3	<1.1	<1.1
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	.018	.018	4.8	.018	.018
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	.024	.026	11.1	<.008	.024
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	.002	.001	0	<.001	.002
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	<.004	<.004	0	<.004	<.004
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	<.003	<.003	0	<.003	<.003
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	.008	.009	5.9	<.004	.008
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	.12	.13	4.0	<.05	.12
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	.16	.17	0.0	<.05	.16
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	2	–	–	<1	2

Appendix D1. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from the White River at Headworks, White River Canal (Inflow), and Lake Tapps Diversion (Tailrace), July–December 2010.—Continued

[**Abbreviations:** nm, nanometer; e, estimated; <, less than; –, no value; all values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels; NTRU, nephelometric turbidity ratio units]

STAID	Station number	12101100—Lake Tapps Diversion (Tailrace)		
		20101207		
DATES	Date			
TIMES	Sample Time	1040	1041	
Parameter code	Parameter name	Sample concentration	Replicate concentration	Relative percent difference
P63676	Turbidity, water, unfiltered, broad band light source (400–680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	2.4	–	–
P00530	Suspended solids, water, unfiltered, milligrams per liter	<1.1	–	–
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	0.027	–	–
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	.035	–	–
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	.001	–	–
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	.005	–	–
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	<.003	–	–
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	.011	–	–
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	.2	–	–
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	.17	–	–
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	10	8	11.1

Appendix D2. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from Lake Tapps study sites, July–December 2010.

[All values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels **Abbreviations:** nm, nanometer; <, less than; e, estimated; µg/L, microgram per liter; –, no quality-control sample; NTRU, nephelometric turbidity ratio units]

STAID	Station number	471142122094701					
SNAME	Station name	EPILIMNION-Allan Yorke (map No. L2)					
DATES	Date	20100803		20100907		20100921	
TIMES	Sample start time	0958	0950	0930	0931	0910	0911
Parameter code	Parameter name	Blank concentration	Sample concentration	Sample concentration	Replicate concentration	Sample concentration	Replicate concentration
P63676	Turbidity, water, unfiltered, broad band light source (400–680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	0.2	1.5	3.6	–	1.8	–
P00530	Suspended solids, water, unfiltered, milligrams per liter	<1.1	e 2.4	5.2	–	e 1.6	–
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	e.014	<.010	<.010	–	<.010	–
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	<.008	<.008	<.008	–	<.008	–
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	<.001	<.001	<.001	–	<.001	–
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	<.004	<.004	e.004	–	<.004	–
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	<.003	e.003	<.003	–	e.003	–
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	<.004	.008	.012	–	.009	–
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	<.05	e.08	.11	–	.12	–
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	.13	.13	.17	–	.13	–
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	<1	3	2	–	11	4
P70953	Chlorophyll <i>a</i> , phytoplankton, chromatographic-fluorometric method, µg/L	<.01	e 2.1	e 2.1	e 2.1	e 2.2	–
P62360	Pheophytin <i>a</i> , phytoplankton, µg/L	<.01	e 1.1	e 1.3	e 1.2	e 1.0	–

Appendix D2. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from Lake Tapps study sites, July–December 2010.—Continued

[All values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels **Abbreviations:** nm, nanometer; <, less than; e, estimated; µg/L, microgram per liter; –, no quality-control sample; NTRU, nephelometric turbidity ratio units]

STAID	Station number	471223122091201			
		EPILIMNION-Lake Inlet (map No. L6)			
SNAME	Station name	20100720		20101207	
		1508	1500	1228	1220
DATES	Date				
TIMES	Sample start time				
Parameter code	Parameter name	Blank concentration	Sample concentration	Blank concentration	Sample concentration
P63676	Turbidity, water, unfiltered, broad band light source (400–680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	0.1	1.2	0.2	1.1
P00530	Suspended solids, water, unfiltered, milligrams per liter	e 1.2	e 3.2	<1.1	<1.1
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	<.010	<0.010	.011	0.012
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	e .010	<.008	<.008	.019
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	<.001	<.001	<.001	.001
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	<.004	<.004	<.004	<.004
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	<.003	<.003	<.003	<.003
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	<.004	e .008	<.004	.008
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	<.05	.11	<.05	.17
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	<.05	.14	<.05	.18
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	<1	e 1	–	e 1
P70953	Chlorophyll a, phytoplankton, chromatographic-fluorometric method, µg/L	<.01	e 1.5	–	e 3.5
P62360	Pheophytin a, phytoplankton, µg/L	<.01	e .7	–	e .9

Appendix D2. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from Lake Tapps study sites, July–December 2010.—Continued

[All values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels **Abbreviations:** nm, nanometer; <, less than; e, estimated; µg/L, microgram per liter; –, no quality-control sample; NTRU, nephelometric turbidity ratio units]

STAID	Station number	471241122084401			
		EPILIMNION-Southeast Arm (map No. L7)			
SNAME	Station name	20100921		20101026	
DATES	Date				
TIMES	Sample start time	1258	1250	1118	1110
Parameter code	Parameter name	Blank concentration	Sample concentration	Blank concentration	Sample concentration
P63676	Turbidity, water, unfiltered, broad band light source (400–680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	0.1	3.2	–	3.9
P00530	Suspended solids, water, unfiltered, milligrams per liter	< 1.1	e 3.6	–	4
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	< .010	< .010	–	< .010
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	< .008	< .008	–	< .008
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	< .001	< .001	–	< .001
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	< .004	< .004	–	< .004
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	< .003	e .003	–	< .003
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	< .004	.011	–	.013
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	< .05	.11	–	.12
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	< .05	.16	–	.18
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	–	< 1	< 1	< 1
P70953	Chlorophyll <i>a</i> , phytoplankton, chromatographic-fluorometric method, µg/L	–	e 2.0	–	e 4.5
P62360	Pheophytin <i>a</i> , phytoplankton, µg/L	–	e .9	–	e 1.3

Appendix D2. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from Lake Tapps study sites, July–December 2010.—Continued

[All values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels **Abbreviations:** nm, nanometer; <, less than; e, estimated; µg/L, microgram per liter; –, no quality-control sample; NTRU, nephelometric turbidity ratio units]

STAID	Station number	471324122093901				471324122093902	
		EPILIMNION-Snag Island (map No. L5)				HYPOLIMNION-Snag Island (L5)	
DATES	Date	20100707		20101013		20101013	
TIMES	Sample start time	1408	1400	1300	1301	1310	1311
Parameter code	Parameter name	Blank concentration	Sample concentration	Sample concentration	Replicate concentration	Sample concentration	Replicate concentration
P63676	Turbidity, water, unfiltered, broad band light source (400–680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	0.2	0.7	2.7	2.3	7.6	7.5
P00530	Suspended solids, water, unfiltered, milligrams per liter	<1.1	e1.2	e1.6	e1.2	7.2	8
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	<.010	<.010	.026	.025	.849	.846
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	<.008	<.008	<.008	<.008	<.008	<.008
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	<.001	<.001	<.001	<.001	.003	.003
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	<.004	<.004	<.004	<.004	.006	.007
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	<.003	<.003	<.003	<.003	.006	.006
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	<.004	e.006	.007	.007	.021	.021
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	<.05	.1	.12	.13	1.1	1.01
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	<.05	.13	.16	.14	1.4	1.2
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	–	<1	2	–	–	–
P70953	Chlorophyll <i>a</i> , phytoplankton, chromatographic-fluorometric method, µg/L	<.01	e.6	e1.0	e1.0	–	–
P62360	Pheophytin <i>a</i> , phytoplankton, µg/L	<.01	e.3	e.6	e.6	–	–

Appendix D2. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from Lake Tapps study sites, July–December 2010.—Continued

[All values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels **Abbreviations:** nm, nanometer; <, less than; e, estimated; µg/L, microgram per liter; —, no quality-control sample; NTRU, nephelometric turbidity ratio units]

STAID	Station number	471358122085201	
SNAME	Station name	EPILIMNION-Northeast Arm (map No. L3)	
DATES	Date	20100922	
TIMES	Sample start time	1458	1450
Parameter code	Parameter name	Blank concentration	Sample concentration
P63676	Turbidity, water, unfiltered, broad band light source (400–680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	0.1	0.7
P00530	Suspended solids, water, unfiltered, milligrams per liter	<1.1	<1.1
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	<.010	<.010
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	<.008	<.008
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	<.001	<.001
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	<.004	<.004
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	<.003	<.003
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	<.004	<.004
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	<.05	.11
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	<.05	.12
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	—	2
P70953	Chlorophyll <i>a</i> , phytoplankton, chromatographic-fluorometric method, µg/L	—	e.7
P62360	Pheophytin <i>a</i> , phytoplankton, µg/L	—	e.2

Appendix D2. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from Lake Tapps study sites, July–December 2010.—Continued

[All values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels **Abbreviations:** nm, nanometer; <, less than; e, estimated; µg/L, microgram per liter; –, no quality-control sample; NTRU, nephelometric turbidity ratio units]

STAID	Station number	471405122093301					
		EPILIMNION-Tapps Island (map No. L4)					
SNAME	Station name	20100804		20100908		20101027	
		1200	1201	1128	1120	0908	0900
DATES	Date						
TIMES	Sample start time						
Parameter code	Parameter name	Sample concentration	Replicate concentration	Blank concentration	Sample concentration	Blank concentration	Sample concentration
P63676	Turbidity, water, unfiltered, broad band light source (400–680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	0.7	0.7	0.1	1.8	0.1	1.6
P00530	Suspended solids, water, unfiltered, milligrams per liter	<1.1	<1.1	<1.1	<1.1	<1.1	e 1.6
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	<.010	<.010	<.010	<.010	<.010	<.010
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	<.008	<.008	<.008	<.008	<.008	<.008
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	<.001	<.001	<.001	<.001	<.001	<.001
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	<.004	<.004	<.004	e.004	<.004	<.004
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	<.003	e.003	<.003	<.003	<.003	<.003
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	e.005	e.004	<.004	e.005	<.004	.005
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	e.09	e.07	<.05	.12	<.05	.12
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	.12	0.11	<.05	.14	<.05	.14
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	<1	–	–	12	–	5
P70953	Chlorophyll <i>a</i> , phytoplankton, chromatographic-fluorometric method, µg/L	e 1.1	e 1.0	–	e.7	–	e 1.0
P62360	Pheophytin <i>a</i> , phytoplankton, µg/L	e.3	e.3	–	e.5	–	e.5

Appendix D2. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from Lake Tapps study sites, July–December 2010.—Continued

[All values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels **Abbreviations:** nm, nanometer; <, less than; e, estimated; µg/L, microgram per liter; –, no quality-control sample; NTRU, nephelometric turbidity ratio units]

STAID	Station number	471405122093302		471418122121101			
SNAME	Station name	HYPOLIMNION-Tapps Island (map No. L4)		EPILIMNION-Deep (map No. L1)			
DATES	Date	20100804		20100817		20100907	
TIMES	Sample start time	1210	1211	1100	1101	1048	1040
Parameter code	Parameter name	Sample concentration	Replicate concentration	Sample concentration	Replicate concentration	Blank concentration	Sample concentration
P63676	Turbidity, water, unfiltered, broad band light source (400–680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	2.4	4	0.6	0.7	0.1	0.8
P00530	Suspended solids, water, unfiltered, milligrams per liter	e 2.0	e 2.0	<1.1	<1.1	<1.1	e 3.2
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	.034	.031	e .011	e .011	<.010	<.010
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	<.008	<.008	<.008	<.008	<.008	<.008
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	<.001	<.001	<.001	<.001	<.001	<.001
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	<.004	<.004	e .004	e .005	<.004	e .005
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	e .004	e .005	<.003	<.003	<.003	<.003
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	.014	.015	<.004	<.004	<.004	e .004
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	.14	.13	.12	.12	<.05	.12
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	.17	.2	.14	.13	<.05	.15
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	–	–	<1	–	–	1
P70953	Chlorophyll <i>a</i> , phytoplankton, chromatographic-fluorometric method, µg/L	–	–	e .4	–	<.01	e 1.2
P62360	Pheophytin <i>a</i> , phytoplankton, µg/L	–	–	e .1	–	<.01	e .5

Appendix D2. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from Lake Tapps study sites, July–December 2010.—Continued

[All values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels **Abbreviations:** nm, nanometer; <, less than; e, estimated; µg/L, microgram per liter; –, no quality-control sample; NTRU, nephelometric turbidity ratio units]

STAID	Station number	471423122115001					
		EPILIMNION-Lake Outlet (map No. L8)					
		20100707		20100721		20100804	
		1000	1001	0940	0941	1018	1010
Parameter code	Parameter name	Sample concentration	Replicate concentration	Sample concentration	Replicate concentration	Blank concentration	Sample concentration
P63676	Turbidity, water, unfiltered, broad band light source (400–680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	0.9	0.9	0.6	–	0.2	0.6
P00530	Suspended solids, water, unfiltered, milligrams per liter	e.2.4	e 1.6	<1.1	–	<1.1	<1.1
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	<.010	<.010	<.010	–	<.010	<.010
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	<.008	e.008	<.008	–	<.008	<.008
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	<.001	<.001	<.001	–	<.001	<.001
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	<.004	<.004	e.004	–	<.004	<.004
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	e.005	e.004	<.003	–	<.003	e.005
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	.009	.01	<.004	–	<.004	e.005
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	e.09	.11	.12	–	<.05	e.07
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	.27	.15	.15	–	<.05	.15
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	2	4	7	–	–	3
P70953	Chlorophyll <i>a</i> , phytoplankton, chromatographic-fluorometric method, µg/L	e.8	–	e.9	e.9	–	e 1.0
P62360	Pheophytin <i>a</i> , phytoplankton, µg/L	e.4	–	e.4	e.4	–	e.5

Appendix D2. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from Lake Tapps study sites, July–December 2010.—Continued

[All values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels **Abbreviations:** nm, nanometer; <, less than; e, estimated; µg/L, microgram per liter; –, no quality-control sample; NTRU, nephelometric turbidity ratio units]

STAID	Station number	471423122115001					
SNAME	Station name	EPIILMNION-Lake Outlet (map No. L8)					
DATES	Date	20100908		20101013		20101208	
TIMES	Sample start time	0930	0931	0958	0950	0830	0831
Parameter code	Parameter name	Sample concentration	Replicate concentration	Blank concentration	Sample concentration	Sample concentration	Replicate concentration
P63676	Turbidity, water, unfiltered, broad band light source (400–680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	0.7	–	0.1	0.6	2.3	2.4
P00530	Suspended solids, water, unfiltered, milligrams per liter	<1.1	–	<1.1	<1.1	<1.1	<1.1
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	.023	–	.01	.011	.038	.05
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	<.008	–	<.008	<.008	.029	.035
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	<.001	–	<.001	<.001	.001	.001
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	e.005	–	<.004	<.004	.004	.004
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	<.003	–	<.003	<.003	<.003	<.003
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	e.004	–	<.004	<.004	.006	.008
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	.14	–	<.05	–	–	–
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	.15	–	<.05	.12	.16	.2
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	54	77	–	1	15	–
P70953	Chlorophyll <i>a</i> , phytoplankton, chromatographic-fluorometric method, µg/L	e.7	–	<.01	e.6	e 1.1	–
P62360	Pheophytin <i>a</i> , phytoplankton, µg/L	e.4	–	<.01	e.3	e.5	–

Appendix D2. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from Lake Tapps study sites, July–December 2010.—Continued

[All values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels **Abbreviations:** nm, nanometer; <, less than; e, estimated; µg/L, microgram per liter; —, no quality-control sample; NTRU, nephelometric turbidity ratio units]

STAID	Station number	471423122115002			
		HYPOLIMNION-Lake Outlet (map No. L8)			
DATES	Date	20100707		20101208	
TIMES	Sample start time	1010	1011	0840	0841
Parameter Code	Parameter name	Sample concentration	Replicate concentration	Sample concentration	Replicate concentration
P63676	Turbidity, water, unfiltered, broad band light source (400–680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	1.1	1.2	2.4	2.5
P00530	Suspended solids, water, unfiltered, milligrams per liter	e 3.6	e 2.4	< 1.1	< 1.1
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	< .010	< .010	.035	.044
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	< .008	< .008	.03	.036
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	< .001	< .001	.001	.001
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	e .004	e .004	.004	.004
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	e .003	e .003	< .003	< .003
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	.011	.01	.006	.007
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	.12	e .08	—	—
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	.2	.15	.16	.18
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	—	—	—	—
P70953	Chlorophyll <i>a</i> , phytoplankton, chromatographic-fluorometric method, µg/L	—	—	—	—
P62360	Pheophytin <i>a</i> , phytoplankton, µg/L	—	—	—	—

Appendix D2. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from Lake Tapps study sites, July–December 2010.—Continued

[All values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels **Abbreviations:** nm, nanometer; <, less than; e, estimated; µg/L, microgram per liter; –, no quality-control sample; NTRU, nephelometric turbidity ratio units]

ST AID	Station number	471456122110801				471456122110801	
		EPILIMNION-Dike 2B (map No. L9)				EPILIMNION-Dike 2B (L9)	
SNAME	Station name	20100721		20100818		20101117	
		1058	1050	1028	1020	0938	0930
DATES	Date	Blank concen- tration	Sample concen- tration	Blank concen- tration	Sample concen- tration	Blank concen- tration	Sample concen- tration
TIMES	Sample start time						
Parameter code	Parameter name	Blank concen- tration	Sample concen- tration	Blank concen- tration	Sample concen- tration	Blank concen- tration	Sample concen- tration
P63676	Turbidity, water, unfiltered, broad band light source (400-680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	0.1	0.7	0.2	0.6	0.1	2.5
P00530	Suspended solids, water, unfiltered, milligrams per liter	<1.1	e 1.2	<1.1	<1.1	<1.1	<1.1
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	<.010	<.010	<.010	<.010	.02	0.031
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	<.008	<.008	<.008	<.008	<.008	.015
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	<.001	<.001	<.001	<.001	<.001	.002
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	<.004	e.005	<.004	e.004	<.004	<.004
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	<.003	e .003	<.003	<.003	<.003	<.003
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	<.004	e.005	<.004	e.005	<.004	<.004
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	<.05	.11	<.05	.11	–	–
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	<.05	.14	<.05	.14	<.05	–
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	–	<1	–	15	–	1
P70953	Chlorophyll <i>a</i> , phytoplankton, chromatographic-fluorometric method, µg/L	–	e 1.0	–	e.6	<.1	e.7
P62360	Pheophytin <i>a</i> , phytoplankton, µg/L	–	e.5	–	e.3	<.1	e.3

Appendix D2. Concentrations of constituents in field blank samples and replicate samples along with the corresponding environmental concentrations from Lake Tapps study sites, July–December 2010.—Continued

[All values except turbidity and fecal-coliform bacteria referenced to laboratory long-term method detection levels **Abbreviations:** nm, nanometer; <, less than; e, estimated; µg/L, microgram per liter; —, no quality-control sample; NTRU, nephelometric turbidity ratio units]

STAID	Station number	471456122110802	
		HYPOLIMNION-Dike 2B (map No. L9)	
SNAME	Station name	20100922	
DATES	Date		
TIMES	Sample start time	1100	1101
Parameter code	Parameter name	Sample concentration	Replicate concentration
P63676	Turbidity, water, unfiltered, broad band light source (400–680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	0.7	0.7
P00530	Suspended solids, water, unfiltered, milligrams per liter	<1.1	<1.1
P00608	Ammonia, water, filtered, milligrams per liter as nitrogen	<.010	<.010
P00631	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen	<.008	<.008
P00613	Nitrite, water, filtered, milligrams per liter as nitrogen	<.001	<.001
P00671	Orthophosphate, water, filtered, milligrams per liter as phosphorus	<.004	<.004
P00666	Phosphorus, water, filtered, milligrams per liter as phosphorus	<.003	<.003
P00665	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	e .004	e .004
P62854	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter	.11	.1
P62855	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	.11	.1
P31616	Fecal-coliform bacteria, M-FC MF (0.45 micrometer) method, water, colony-forming units per 100 milliliters	—	—
P70953	Chlorophyll <i>a</i> , phytoplankton, chromatographic-fluorometric method, µg/L	—	—
P62360	Pheophytin <i>a</i> , phytoplankton, µg/L	—	—

Appendix D3. Concentrations of organic compounds in field blank samples and matrix-spike samples along with the corresponding environmental concentrations from the Lake Outlet site (map No. L8) on Lake Tapps, September 22, 2010.

[All measurements in micrograms per liter (µg/L). **Abbreviations:** e, estimated; <, less than; –, no quality-control sample]

STAID	Station number	471423122115001			
SNAME	Station name	EPILIMNION			
DATES	Date	20100922			
TIMES	Sample start time	0948	0940	0942	0943
Parameter code	Parameter name	Blank concentration	Sample concentration	Matrix spike concentration, schedule 2080	Matrix spike concentration, schedule 1433
P62030	1,7-Dimethylxanthine, water, filtered, recoverable	<0.10	<0.10	e0.220	
P62000	Acetaminophen, water, filtered, recoverable	<.12	<.12	.244	–
P62020	Albuterol, water, filtered, recoverable	<.08	<.08	.220	–
P50305	Caffeine, water, filtered, recoverable	<.06	<.08	.362	–
P62793	Carbamazepine, water, filtered, recoverable	<.06	<.16	.186	–
P62003	Codeine, water, filtered, recoverable	<.046	<.32	.246	–
P62005	Cotinine, water, filtered, recoverable	<.038	<.038	.189	–
P62004	Dehydronifedipine, water, filtered, recoverable	<.08	<.08	.278	–
P62008	Diltiazem, water, filtered, recoverable	<.06	<.04	e.221	–
P62796	Diphenhydramine, water, filtered, recoverable	<.036	<.08	.193	–
P62021	Sulfamethoxazole, water, filtered, recoverable	<.16	<.16	e.048	–
P62801	Thiabendazole, water, filtered, recoverable	<.06	<.06	.148	–
P62023	Trimethoprim, water, filtered, recoverable	<.034	<.034	.222	–
P62024	Warfarin, water, filtered, recoverable	<.08	<.08	e.204	–
P34572	1,4-Dichlorobenzene, water, filtered, recoverable	<.040	<.040	–	0.52
P62054	1-Methylnaphthalene, water, filtered, recoverable	<.022	<.022	–	.29
P62055	2,6-Dimethylnaphthalene, water, filtered, recoverable	<.06	<.06	–	.26
P62056	2-Methylnaphthalene, water, filtered, recoverable	<.036	<.036	–	.27
P62057	3- <i>beta</i> -Coprostanol, water, filtered, recoverable	<1.8	<1.8	–	e2.00
P62058	3-Methyl-1H-indole, water, filtered, recoverable	<.036	<.036	–	.34
P62059	3- <i>tert</i> -Butyl-4-hydroxyanisole, water, filtered, recoverable		<8	–	e.092
P62060	4-Cumylphenol, water, filtered, recoverable	<.06	<.06	–	.35
P62061	4- <i>n</i> -Octylphenol, water, filtered, recoverable	<.16	<.16	–	e.100
P62085	4-Nonylphenol (sum of all isomers), water, filtered, recoverable	<2	<2	–	e2.00
P62083	4-Nonylphenol diethoxylate (sum of all isomers), water, filtered, recoverable	<5.0	<5.0	–	e4.50
P61705	4- <i>tert</i> -Octylphenol diethoxylate, water, filtered, recoverable	<1.0	<1.0	–	e.370
P61706	4- <i>tert</i> -Octylphenol monoethoxylate, water, filtered, recoverable	<1.0	<1.0	–	e1.10
P62062	4- <i>tert</i> -Octylphenol, water, filtered, recoverable	<.14	<.14	–	e.150
P62063	5-Methyl-1H-benzotriazole, water, filtered, recoverable	<1.2	<1.2	–	1.7
P62066	9,10-Anthraquinone, water, filtered, recoverable	<.16	<.16	–	e.420
P62064	Acetophenone, water, filtered, recoverable	<.4	<.4	–	.9
P62065	Acetyl hexamethyl tetrahydro naphthalene, water, filtered, recoverable	<.028	<.028	–	.39
P34221	Anthracene, water, filtered, recoverable	<.028	<.028	–	.17
P34248	Benzo[a]pyrene, water, filtered, recoverable	<.050	<.050	–	.16
P62067	Benzophenone, water, filtered, recoverable	.046	<.08	–	.88
P62068	<i>beta</i> -Sitosterol, water, filtered, recoverable	<4	<4	–	e3.80
P62086	<i>beta</i> -Stigmastanol, water, filtered, recoverable	<2.6	<2.6	–	e1.10
P04029	Bromacil, water, filtered, recoverable	<.36	<.06	–	1.6
P62070	Camphor, water, filtered, recoverable	<.044	<.044	–	.8

Appendix D3. Concentrations of organic compounds in field blank samples and matrix-spike samples along with the corresponding environmental concentrations from the Lake Outlet site (map No. L8) on Lake Tapps, September 22, 2010.—Continued

[All measurements in micrograms per liter (µg/L). **Abbreviations:** e, estimated; <, less than; –, no quality-control sample]

STAID	Station number	471423122115001			
		EPILIMNION			
DATES	Date	20100922			
TIMES	Sample start time	0948	0940	0942	0943
Parameter code	Parameter name	Blank concentration	Sample concentration	Matrix spike concentration, schedule 2080	Matrix spike concentration, schedule 1433
P82680	Carbaryl, water, filtered (0.7 micron glass fiber filter), recoverable	<0.38	< 0.06	–	e 0.550
P62071	Carbazole, water, filtered, recoverable	<.030	<.030	–	.22
P38933	Chlorpyrifos, water, filtered, recoverable	<.16	<.010	–	2.8
P62072	Cholesterol, water, filtered, recoverable	<2	<2	–	e 2.00
P62082	DEET, water, filtered, recoverable	<.06	e .008	–	.42
P39572	Diazinon, water, filtered, recoverable	<.16	<.005	–	1.9
P62073	<i>d</i> -Limonene, water, filtered, recoverable	<.08	<.08	–	.52
P34377	Fluoranthene, water, filtered, recoverable	<.024	<.024	–	.2
P62075	Hexahydrohexamethyl cyclopentabenzopyran, water, filtered, recoverable	<.052	<.052	–	.38
P62076	Indole, water, filtered, recoverable	<.08	<.08	–	.096
P62077	Isoborneol, water, filtered, recoverable	<.18	<.18	–	.76
P34409	Isophorone, water, filtered, recoverable	e .033	<.08	–	.37
P62078	Isopropylbenzene, water, filtered, recoverable	<.30	<.30	–	.23
P62079	Isoquinoline, water, filtered, recoverable	<.046	<.20	–	<.046
P62080	Menthol, water, filtered, recoverable	<.32	<.32	–	3.1
P50359	Metaxyl, water, filtered, recoverable	<.12	<.04	–	1.6
P62081	Methyl salicylate, water, filtered, recoverable	<.044	<.044	–	.83
P39415	Metolachlor, water, filtered, recoverable	<.08	<.014	–	.38
P34443	Naphthalene, water, filtered, recoverable	<.040	<.040	–	.16
P62084	<i>p</i> -Cresol, water, filtered, recoverable	<.08	<.40	–	.71
P34462	Phenanthrene, water, filtered, recoverable	<.032	<.032	–	.18
P34466	Phenol, water, filtered, recoverable	.14	<.16	–	.81
P04037	Prometon, water, filtered, recoverable	<.12	.013	–	e 1.60
P34470	Pyrene, water, filtered, recoverable	<.042	<.042	–	.2
P34476	Tetrachloroethene, water, filtered, recoverable	<.12	<.12	–	e .320
P34288	Tribromomethane, water, filtered, recoverable	<.10	<.10	–	.99
P62089	Tributyl phosphate, water, filtered, recoverable	<.16	<.16	–	.36
P62090	Triclosan, water, filtered, recoverable	<.20	<.20	–	2.8
P62091	Triethyl citrate, water, filtered, recoverable	<.38	<.38	–	.4
P62092	Triphenyl phosphate, water, filtered, recoverable	<.12	<.12	–	.78
P62093	Tris(2-butoxyethyl) phosphate, water, filtered, recoverable	<.8	<.8	–	e 6.30
P62087	Tris(2-chloroethyl) phosphate, water, filtered, recoverable	<.10	<.10	–	1.5
P62088	Tris(dichloroisopropyl) phosphate, water, filtered, recoverable	<.16	<.16	–	3.4

Appendix E. Seven-Day Average of Daily Maximum Temperatures on the White River at Headworks, White River at R Street, and Lake Tapps Diversion (Tailrace), Washington, May–December 2010

[7-day average of daily maximum temperatures, degrees Celsius. **Abbreviations:** –, not available or not applicable]

Dates	Headworks	R-Street	Tailrace	Dates	Headworks	R-Street	Tailrace
May				July—Continued			
30	–	10.1	–	15	14.7	15.1	16.8
31	9.3	10.1	–	16	14.5	14.9	16.6
June				17	14.8	15.0	16.5
1	9.4	10.3	13.7	18	15.0	15.3	16.2
2	9.9	10.7	13.6	19	15.0	15.1	16.0
3	10.2	11.0	13.5	20	15.1	15.2	15.8
4	10.2	11.0	13.2	21	15.3	15.7	15.9
5	10.4	11.2	12.9	22	15.5	16.2	16.0
6	10.5	11.3	12.8	23	15.7	16.6	16.2
7	10.5	11.4	12.7	24	15.9	17.1	16.3
8	10.7	11.5	12.7	25	16.0	17.1	16.3
9	10.9	–	12.7	26	16.0	17.2	16.2
10	11.1	–	12.8	27	16.1	17.3	16.0
11	11.3	–	12.7	28	15.9	16.9	15.8
12	11.2	–	12.7	29	15.8	16.7	15.5
13	11.0	–	12.7	30	15.7	16.3	15.2
14	10.8	–	12.8	31	15.7	16.1	15.0
15	11.0	–	13.3	August			
16	10.7	–	13.5	1	15.7	16.4	15.0
17	10.2	–	13.4	2	15.8	16.7	15.3
18	10.2	–	13.7	3	15.9	16.7	15.5
19	10.6	–	14.5	4	15.9	16.8	15.8
20	11.3	–	15.2	5	15.7	16.6	15.6
21	12.0	–	15.8	6	15.6	16.5	15.5
22	12.2	–	16.0	7	15.4	16.4	15.4
23	12.6	–	16.5	8	15.3	16.3	15.4
24	13.3	–	17.1	9	15.3	16.2	15.3
25	13.6	–	17.1	10	15.3	16.6	15.3
26	13.5	–	16.7	11	15.5	17.1	15.2
27	13.2	–	16.5	12	15.9	17.8	15.6
28	13.0	13.3	16.1	13	16.2	18.4	16.0
29	12.6	13.0	15.9	14	16.5	18.9	16.4
30	12.3	12.9	15.6	15	16.5	18.9	16.5
July				16	16.3	18.7	16.4
1	11.8	12.6	15.4	17	16.1	18.4	16.1
2	11.5	12.4	15.5	18	15.7	17.9	16.0
3	11.8	12.7	15.9	19	15.1	17.2	15.6
4	12.3	13.3	16.2	20	14.8	16.7	15.2
5	12.8	13.9	16.6	21	14.7	16.6	14.9
6	13.6	14.6	17.0	22	14.7	16.8	14.7
7	14.2	15.1	17.4	23	14.8	16.7	14.7
8	14.9	15.7	17.9	24	14.5	16.5	14.6
9	15.5	16.2	18.1	25	14.4	16.3	14.4
10	15.2	15.9	17.9	26	14.3	16.2	14.2
11	15.1	15.7	17.8	27	14.2	16.0	14.2
12	15.0	15.7	17.7	28	13.7	15.3	14.4
13	14.9	15.5	17.5	29	13.3	14.7	14.5
14	14.8	15.3	17.2	30	13.2	14.6	14.6
				31	13.4	14.9	14.9

Appendix E. Seven-day average of daily maximum temperatures on the White River at Headworks, White River at R Street, and Lake Tapps Diversion (Tailrace), Washington, May–December 2010.—Continued[7-day average of daily maximum temperatures, degrees Celsius. **Abbreviations:** –, not available or not applicable]

Dates	Headworks	R-Street	Tailrace	Dates	Headworks	R-Street	Tailrace
September				October—Continued			
1	13.6	15.0	15.1	17	8.7	9.9	10.7
2	13.6	15.2	15.2	18	8.6	9.8	10.5
3	13.3	14.8	15.5	19	8.6	9.9	10.5
4	13.3	15.0	15.4	20	8.8	10.1	10.7
5	13.1	14.9	15.3	21	9.0	10.3	11.0
6	12.7	14.5	15.1	22	9.0	10.3	11.3
7	12.2	13.9	15.0	23	8.8	10.1	11.4
8	12.1	13.8	14.8	24	8.6	9.8	11.5
9	12.1	13.8	14.8	25	8.4	9.6	11.6
10	12.5	14.3	14.6	26	8.3	9.3	11.6
11	12.7	14.5	14.4	27	8.0	9.0	11.3
12	12.9	14.7	14.2	28	7.9	8.9	11.1
13	13.1	14.9	14.4	29	8.0	8.9	11.1
14	13.2	15.1	14.6	30	8.1	9.0	11.4
15	13.3	15.1	15.0	31	8.2	9.1	11.7
16	13.4	15.0	15.4	November			
17	12.9	14.5	15.6	1	8.3	9.2	11.9
18	12.6	14.1	15.6	2	8.2	9.1	12.2
19	12.3	13.9	15.6	3	8.4	9.3	12.5
20	12.1	13.5	15.3	4	8.5	9.3	12.8
21	12.0	13.3	14.8	5	8.3	9.2	12.8
22	11.9	13.2	14.2	6	8.0	8.8	12.7
23	11.9	13.3	13.8	7	7.7	8.6	12.6
24	12.1	13.7	13.6	8	7.3	8.2	12.5
25	12.3	13.9	13.6	9	7.0	8.0	12.3
26	12.4	14.0	13.5	10	6.7	7.6	12.1
27	12.7	14.4	13.4	11	6.6	7.5	11.9
28	12.8	14.5	13.4	12	6.7	7.6	11.8
29	12.9	14.5	13.4	13	6.9	7.9	11.7
30	12.8	14.3	13.2	14	7.0	7.9	11.6
October				15	6.9	7.8	11.5
1	12.5	13.9	13.0	16	6.8	7.6	11.3
2	12.2	13.6	12.7	17	6.6	7.4	11.2
3	11.9	13.3	12.5	18	6.1	6.9	11.0
4	11.5	12.9	12.3	19	5.3	6.1	10.7
5	11.4	12.9	12.2	20	4.3	5.0	10.4
6	11.2	12.7	12.5	21	3.4	4.0	10.0
7	11.1	12.5	12.9	22	3.0	3.5	9.6
8	10.9	12.3	13.1	23	2.8	3.3	9.2
9	10.6	11.9	13.2	24	2.7	2.9	8.8
10	10.4	11.7	13.2	25	2.6	3.4	8.5
11	10.3	11.6	13.3	26	2.7	3.3	8.2
12	10.0	11.2	13.1	27	3.1	3.8	8.0
13	9.5	10.7	12.6	28	3.7	4.5	7.9
14	9.0	10.2	11.9	29	4.1	4.8	7.8
15	8.7	10.0	11.3	30	4.2	5.0	7.8
16	8.7	9.9	10.9				

Appendix E. Seven-day average of daily maximum temperatures on the White River at Headworks, White River at R Street, and Lake Tapps Diversion (Tailrace), Washington, May–December 2010.—Continued

[7-day average of daily maximum temperatures, degrees Celsius. **Abbreviations:** —, not available or not applicable]

Dates	Headworks	R-Street	Tailrace	Dates	Headworks	R-Street	Tailrace
December				December—Continued			
1	4.0	4.9	7.7	17	—	5.0	7.1
2	4.1	4.9	7.6	18	—	4.7	6.9
3	4.3	5.0	7.5	19	—	4.6	6.7
4	—	5.2	7.5	20	—	4.5	6.6
5	—	5.4	7.4	21	—	4.6	6.4
6	—	5.5	7.3	22	—	4.9	6.3
7	—	5.5	7.3	23	—	5.2	6.3
8	—	5.8	7.2	24	—	5.3	6.3
9	—	6.1	7.2	25	—	5.4	6.3
10	—	6.4	7.3	26	4.9	5.4	6.2
11	5.6	6.5	7.4	27	4.6	5.1	6.2
12	5.6	6.4	7.4	28	4.0	4.5	6.1
13	—	6.3	7.4	29	—	—	—
14	—	6.2	7.4	30	—	—	—
15	—	5.9	7.4	31	—	—	—
16	—	5.4	7.2				

Appendix F. Vertical Profiles of Water-Quality Properties with Depth for Selected Sampling Dates at Nine Sites on Lake Tapps, Washington.

Appendix F1. Representative summer and fall depth profiles of limnological characteristics at the Deep site (map No. L1) on Lake Tapps, Washington.

Appendix F2. Representative summer and fall depth profiles of limnological characteristics at Allan Yorke site (map No. L2) on Lake Tapps, Washington.

Appendix F3. Representative summer and fall depth profiles of limnological characteristics at Northeast Arm site (map No. L3) on Lake Tapps, Washington.

Appendix F4. Representative summer and fall depth profiles of limnological characteristics at Tapps Island site (map No. L4) on Lake Tapps, Washington.

Appendix F5. Representative summer and fall depth profiles of limnological characteristics at Snag Island site (map No. L5) on Lake Tapps, Washington.

Appendix F6. Representative summer and fall depth profiles of limnological characteristics at Lake Inlet site (map No. L6) on Lake Tapps, Washington.

Appendix F7. Representative summer and fall depth profiles of limnological characteristics at Southeast Arm site (map No. L7) on Lake Tapps, Washington.

Appendix F8. Representative summer and fall depth profiles of limnological characteristics at Lake Outlet site (map No. L8) on Lake Tapps, Washington.

Appendix F9. Representative summer and fall depth profiles of limnological characteristics at Dike 2B site (map No. L9) on Lake Tapps, Washington.

Appendix G. Pesticides, Wastewater Indicator Chemicals, and Human-Health Pharmaceuticals in Samples from Allan Yorke (map No. L2), Snag Island (map No. L5), and Lake Outlet (map No. L8) Study Sites on Lake Tapps, Washington, September 2010

[See [Appendix C](#) for full names of chemical compounds and other details. Remark codes used in this table: <, less than; E, estimated; M, presence verified, but not quantified; ug/L, micrograms per liter; %, percent]

Station number	Station name	Date	Time	Depth to bot. from surface at samp locatn, meters (82903)	Depth to bottom of sampling intrval, meters (82048)	Depth to top of sampling intrval, meters (82047)	Sam-pling depth, meters (00098)					
471142122094701	EPILIMNION-LAKE TAPPS NR BONNEY LAKE, WA SITE 2	09-21-10	0910	4.70	--	--	1.0					
471324122093901	EPILIMNION-LAKE TAPPS NR SUMNER, WA SITE 5	09-22-10	1350	14.6	9.0	1.0	--					
471423122115001	EPILIMNION-LAKE TAPPS NR SUMNER, WA SITE 8	09-22-10	0940	10.0	8.0	1.0	--					
Station number	Date	2,4,5-T HCH-d6, surrog, water, fltrd, percent recovery (99958)	alpha-HCH-d6, surrog, Sch2003 wat flt percent recovery (99995)	Barban, surrog, Sched. 2060/ 9060, wat flt % recvy (90640)	Caffe-ine-13C, surrog, 2033 & 8033, wat flt percent recovery (99959)	Caffe-ine-13C, sur Sch 2033 & 8033, surrog, wat flt % recvy (99584)	Carba-maze-pine-d10, 8033, wat flt % recvy (90797)	DecaF-biphenl sur Sch 2033 & 8033, wat flt % recvy (99585)	Diazi-non-d10, surrog, Sch2003 wat flt percent recovery (99994)	Ethyl nico-tinate-d4, surrog, wat flt % recvy (99571)	Fluor-anthene-d10, sur Sch 20/8033 wat flt % recvy (99586)	1,4-Di-chloro-benzene, water, fltrd, ug/L (34572)
471142122094701	09-21-10	82.5	95.8	75.0	85.7	80.7	78.3	48.2	111	92.2	76.6	<.040
471324122093901	09-22-10	84.8	94.4	91.4	89.7	80.8	74.4	39.6	112	92.2	72.3	<.040
471423122115001	09-22-10	75.8	96.0	86.8	87.9	83.7	74.8	47.2	116	92.8	78.3	<.040
Station number	Date	1-Naph-thol, water, fltrd, 0.7u GF (49295)	2,4-D methyl ester, water, fltrd, ug/L (50470)	2,4-DB, water, fltrd, 0.7u GF (39732)	2,6-Di-ethyl-aniline, water, fltrd, 0.7u GF (38746)	2Chloro-2',6'-diethyl acet-anilide, water, fltrd, ug/L (61618)	CIAT, water, fltrd, ug/L (04040)	CEAT, water, fltrd, ug/L (04038)	2-Ethyl-6-methyl-aniline, water, fltrd, ug/L (61620)	OIET, water, fltrd, ug/L (50355)	3,4-Di-chloro-aniline, water, fltrd, ug/L (61625)	
471142122094701	09-21-10	<.036	<.200	.20	<.02	<.006	<.010	<.014	<.06	<.010	<.060	<.004
471324122093901	09-22-10	<.036	<.200	.17	<.02	<.006	<.010	<.014	<.06	<.010	<.060	<.004
471423122115001	09-22-10	<.036	<.200	.16	<.02	<.006	<.010	<.014	<.06	<.010	<.060	<.004
Station number	Date	3,5-Di-chloro-aniline, water, fltrd, ug/L (61627)	3-Hydroxy carbo-furan, wat flt 0.7u GF (49308)	4-Chloro-2-methyl-phenol, wat flt 0.7u GF (61633)	Aceto-chlor, water, fltrd, ug/L (49260)	Aci-fluor-fen, water, fltrd, 0.7u GF (49315)	Ala-chlor, water, fltrd, ug/L (46342)	Aldi-carb sulfone, fltrd, ug/L (49313)	Aldi-carb sulf-oxide, wat flt 0.7u GF (49314)	Aldi-carb, water, fltrd, ug/L (49312)	alpha-Endo-sulfan, water, fltrd, ug/L (34362)	Atra-zine, water, fltrd, ug/L (39632)
471142122094701	09-21-10	<.003	<.040	<.003	<.010	<.040	<.008	<.08	<.060	<.12	<.006	<.007
471324122093901	09-22-10	<.003	<.040	<.003	<.010	<.040	<.008	<.08	<.060	<.12	<.006	<.007
471423122115001	09-22-10	<.003	<.040	<.003	<.010	<.040	<.008	<.08	<.060	<.12	<.006	<.010
Station number	Date	Azin-phos-methyl oxon, water, fltrd, ug/L (61635)	Azin-phos-methyl, water, fltrd, 0.7u GF (82686)	Bendio-carb, water, fltrd, ug/L (50299)	Ben-flur-alin, water, fltrd, ug/L (82673)	Benomyl, water, fltrd, ug/L (50300)	Bensul-furon, methyl, fltrd, ug/L (61693)	Ben-tazon, water, fltrd, 0.7u GF (38711)	Broma-cil, water, fltrd, ug/L (04029)	Brom-oxynil, water, fltrd, 0.7u GF (49311)	Camphor, water, fltrd, ug/L (62070)	Car-baryl, water, fltrd, 0.7u GF (49310)
471142122094701	09-21-10	<.04	<.120	<.04	<.014	<.060	<.06	<.06	<.06	<.12	<.044	<.04
471324122093901	09-22-10	<.04	<.120	<.04	<.014	<.060	<.06	<.06	<.06	<.12	M	<.04
471423122115001	09-22-10	<.04	<.120	<.04	<.014	<.060	<.06	<.06	<.06	<.12	<.044	<.04
Station number	Date	Car-baryl, water, fltrd, 0.7u GF (82680)	Carba-zole, water, fltrd, ug/L (62071)	Carbo-furan, water, fltrd, 0.7u GF (49309)	Carbo-furan, water, fltrd, ug/L (82674)	Chlor-amben methyl ester, water, fltrd, ug/L (61188)	Chlori-muron-ethyl, water, fltrd, ug/L (50306)	Chlor-pyrifos oxon, water, fltrd, ug/L (61636)	Chlor-pyrifos, water, fltrd, ug/L (38933)	cis-Per-methrin, water, fltrd, 0.7u GF (82687)	cis-Propi-cona-zole, water, fltrd, ug/L (79846)	Clopyr-alid, water, fltrd, 0.7u GF (49305)
471142122094701	09-21-10	<.060	<.030	<.040	<.060	<.10	<.080	<.05	<.010	<.014	<.006	<.06
471324122093901	09-22-10	<.060	<.030	<.040	<.060	<.10	<.080	<.05	<.010	<.014	<.006	<.06
471423122115001	09-22-10	<.060	<.030	<.040	<.060	<.10	<.080	<.05	<.010	<.014	<.006	<.06

Appendix G. Pesticides, Wastewater Indicator Chemicals, and Pharmaceuticals in Samples from Allan Yorke (map No. L2), Snag Island (map No. L5), and Lake Outlet (map no. L8) Study Sites on Lake Tapps, Washington, September 2010

[See [Appendix C](#) for full names of chemical compounds and other details. Remark codes used in this table: <, less than; E, estimated; M, presence verified, but not quantified; ug/L, micrograms per liter; %, percent]

Station number	Date	Cyana- zine, water, fltrd, ug/L (04041)	Cyclo- ate, water, fltrd, ug/L (04031)	Cyflu- thrin, water, fltrd, ug/L (61585)	Cyper- methrin water, fltrd, ug/L (61586)	DCPA mono- acid, water, fltrd 0.7u GF ug/L (49304)	DCPA, water, fltrd 0.7u GF ug/L (82682)	DEET, water, fltrd, ug/L (62082)	Desulf- inyl- fipro- nil amide, wat flt ug/L (62169)	Desulf- inyl- fipro- nil, water, fltrd, ug/L (62170)	Diazi- non, water, fltrd, ug/L (39572)	Dicamba water, fltrd 0.7u GF ug/L (38442)
471142122094701	09-21-10	<.022	<.04	<.016	<.020	<.04	<.008	M	<.029	E.006	<.005	<.04
471324122093901	09-22-10	<.022	<.04	<.016	<.020	<.04	<.008	M	<.029	<.012	<.005	<.04
471423122115001	09-22-10	<.022	<.04	<.016	<.020	<.04	<.008	M	<.029	<.012	<.005	<.04
Station number	Date	Di- chlor- prop, water, fltrd 0.7u GF ug/L (49302)	Di- chlor- vos, water, fltrd, ug/L (38775)	Dicro- tophos, water, fltrd, ug/L (38454)	Diel- drin, water, fltrd, ug/L (39381)	Dimeth- oate, water, fltrd 0.7u GF ug/L (82662)	Dinoseb water, fltrd 0.7u GF ug/L (49301)	Diphen- amid, water, fltrd, ug/L (04033)	Disulf- oton sulfone, water, fltrd, ug/L (61640)	Disul- foton, water, fltrd 0.7u GF ug/L (82677)	Diuron, water, fltrd 0.7u GF ug/L (49300)	Endo- sulfan sulfate water, fltrd, ug/L (61590)
471142122094701	09-21-10	<.04	<.02	<.08	<.009	<.006	<.04	<.04	<.01	<.04	<.04	<.014
471324122093901	09-22-10	<.04	<.02	<.08	<.009	<.006	<.04	<.04	<.01	<.04	E.01	<.014
471423122115001	09-22-10	<.04	<.02	<.08	<.009	<.006	<.04	<.04	<.01	<.04	E.01	<.014
Station number	Date	EPTC, water, fltrd 0.7u GF ug/L (82668)	Ethion monoxon water, fltrd, ug/L (61644)	Ethion, water, fltrd, ug/L (82346)	Etho- prop, water, fltrd 0.7u GF ug/L (82672)	Fenami- phos sulfone water, fltrd, ug/L (61645)	Fenami- phos oxide, water, fltrd, ug/L (61646)	Fenami- phos water, fltrd, ug/L (61591)	Fenuron water, fltrd 0.7u GF ug/L (49297)	Fipro- nil sulfide water, fltrd, ug/L (62167)	Fipro- nil sulfone water, fltrd, ug/L (62168)	Fipro- nil, water, fltrd, ug/L (62166)
471142122094701	09-21-10	<.002	<.02	<.008	<.016	<.053	<.08	<.03	<.06	<.013	<.024	<.018
471324122093901	09-22-10	<.002	<.02	<.008	<.016	<.053	<.08	<.03	<.06	<.013	<.024	<.018
471423122115001	09-22-10	<.002	<.02	<.008	<.016	<.053	<.08	<.03	<.06	<.013	<.024	<.018
Station number	Date	Flumet- sulam, water, fltrd, ug/L (61694)	Fluo- meturon water, fltrd 0.7u GF ug/L (38811)	Fluri- done, wat flt ug/L (65216)	Fonofos water, fltrd, ug/L (04095)	Hexa- zinone, water, fltrd, ug/L (04025)	Imaza- quin, water, fltrd, ug/L (50356)	Imaze- thapyr, water, fltrd, ug/L (50407)	Imida- clopid, water, fltrd, ug/L (61695)	Ipro- dione, water, fltrd, ug/L (61593)	Isofen- phos, water, fltrd, ug/L (61594)	lambda- Cyhalo- thrin, water, fltrd, ug/L (61595)
471142122094701	09-21-10	<.06	<.04	2.09	<.004	<.008	<.06	<.06	<.060	<.014	<.006	<.010
471324122093901	09-22-10	<.06	<.04	1.02	<.004	<.008	<.06	<.06	<.060	<.014	<.006	<.010
471423122115001	09-22-10	<.06	<.04	.308	<.004	<.008	<.06	<.06	<.060	<.014	<.006	<.010
Station number	Date	Linuron water, fltrd 0.7u GF ug/L (38478)	Mala- oxon, water, fltrd, ug/L (61652)	Mala- thion, water, fltrd, ug/L (39532)	MCPA, water, fltrd 0.7u GF ug/L (38482)	MCPB, water, fltrd 0.7u GF ug/L (38487)	Meta- laxyl, water, fltrd, ug/L (50359)	Meta- laxyl, water, fltrd, ug/L (61596)	Methid- athion, water, fltrd, ug/L (61598)	Methio- carb, water, fltrd 0.7u GF ug/L (38501)	Meth- omyl, water, fltrd 0.7u GF ug/L (49296)	Methyl para- oxon, water, fltrd, ug/L (61664)
471142122094701	09-21-10	<.04	<.080	<.016	<.04	<.20	<.04	<.007	<.006	<.040	<.120	<.01
471324122093901	09-22-10	<.04	<.080	<.016	<.04	<.20	<.04	<.007	<.006	<.040	<.120	<.01
471423122115001	09-22-10	<.04	<.080	<.016	<.04	<.20	<.04	<.007	<.006	<.040	<.120	<.01
Station number	Date	Methyl para- thion, water, fltrd 0.7u GF ug/L (82667)	Metola- chlor, water, fltrd, ug/L (39415)	Metri- buzin, water, fltrd, ug/L (82630)	Metsul- furon- methyl, water, fltrd, ug/L (61697)	Moli- nate, water, fltrd 0.7u GF ug/L (82671)	Myclo- butanil water, fltrd, ug/L (61599)	N-(4- Chloro- phenyl) -N'- methyl- urea, water, fltrd, ug/L (61692)	Neburon water, fltrd 0.7u GF ug/L (49294)	Nico- sul- furon, water, fltrd, ug/L (50364)	Norflur azon, water, fltrd 0.7u GF ug/L (49293)	Ory- zalin, water, fltrd 0.7u GF ug/L (49292)
471142122094701	09-21-10	<.008	<.014	<.012	<.14	<.003	<.010	<.06	<.02	<.10	<.04	<.04
471324122093901	09-22-10	<.008	<.014	<.012	<.14	<.003	<.010	<.06	<.02	<.10	<.04	<.04
471423122115001	09-22-10	<.008	<.014	<.012	<.14	<.003	<.010	<.06	<.02	<.10	<.04	<.04

Appendix G. Pesticides, Wastewater Indicator Chemicals, and Pharmaceuticals in Samples from Allan Yorke (map No. L2), Snag Island (map No. L5), and Lake Outlet (map No. L8) Study Sites on Lake Tapps, Washington, September 2010

[See [Appendix C](#) for full names of chemical compounds and other details. Remark codes used in this table: <, less than; E, estimated; M, presence verified, but not quantified; ug/L, micrograms per liter; %, percent]

Station number	Date	Oxamyl, water, fltrd, ug/L (38866)	Oxy-fluor-fen, water, fltrd, ug/L (61600)	p-Cresol, water, fltrd, ug/L (62084)	Pendi-meth-alin, water, fltrd, ug/L (82683)	Phorate oxon, water, fltrd, ug/L (61666)	Phorate water, fltrd, ug/L (82664)	Phosmet oxon, water, fltrd, ug/L (61668)	Phosmet water, fltrd, ug/L (61601)	Pic-loram, water, fltrd, ug/L (49291)	Piper-onyl but-oxide, water, fltrd, ug/L (67826)	Prome- ton, water, fltrd, ug/L (04037)
471142122094701	09-21-10	<.12	<.010	<.40	<.012	<.03	<.020	<.05	<.034	<.12	<.1	.009
471324122093901	09-22-10	<.12	<.010	<.08	<.012	<.03	<.020	<.05	<.034	<.12	<.1	.013
471423122115001	09-22-10	<.12	<.010	<.40	<.012	<.03	<.020	<.05	<.034	<.12	<.1	.013
Station number	Date	Prome- tryn, water, fltrd, ug/L (04036)	Pro-panil, water, fltrd, ug/L (82679)	Propar-gite, water, fltrd, ug/L (82685)	Propham, water, fltrd, ug/L (49236)	Propi- cona- zole, water, fltrd, ug/L (50471)	Pro- poxur, water, fltrd, ug/L (38538)	Propy- zamide, water, fltrd, ug/L (82676)	Siduron, water, fltrd, ug/L (38548)	Sima- zine, water, fltrd, ug/L (04035)	Sulfo- met- ruron, methyl, water, fltrd, ug/L (50337)	Tebu- thiuron, water, fltrd, ug/L (82670)
471142122094701	09-21-10	<.006	<.010	<.02	<.040	<.04	<.060	<.004	<.04	<.006	<.060	<.03
471324122093901	09-22-10	<.006	<.010	<.02	<.040	<.04	<.060	<.004	<.04	<.006	<.060	<.03
471423122115001	09-22-10	<.006	<.010	<.02	<.040	<.04	<.060	<.004	<.04	<.006	<.060	<.03
Station number	Date	Teflu- thrin, water, fltrd, ug/L (61606)	Terba- cil, water, fltrd, ug/L (04032)	Ter- bufos oxon sulfone, water, fltrd, ug/L (61674)	Terbu- fos, water, fltrd, ug/L (82675)	Ter- buthyl- azine, water, fltrd, ug/L (04022)	Thiaben- dazole, water, fltrd, ug/L (62801)	Thio- bencarb, water, fltrd, ug/L (82681)	trans- Propi- cona- zole, water, fltrd, ug/L (79847)	Tribu- phos, water, fltrd, ug/L (61610)	Tri- clopyr, water, fltrd, ug/L (49235)	Tri- flur- alin, water, fltrd, ug/L (82661)
471142122094701	09-21-10	<.010	<.040	<.04	<.02	<.01	<.060	<.016	<.02	<.018	<.08	<.018
471324122093901	09-22-10	<.010	<.040	<.04	<.02	<.01	<.060	<.016	<.02	<.018	<.08	<.018
471423122115001	09-22-10	<.010	<.040	<.04	<.02	<.01	<.060	<.016	<.02	<.018	<.08	<.018
Station number	Date	1,7-Di- methyl- Xan- thine, water, fltrd, ug/L (62030)	1- Methyl- naphth- alene, water, fltrd, ug/L (62054)	2,6-Di- methyl- naphth- alene, water, fltrd, ug/L (62055)	2-Ethyl- 2- phenyl- malon- amide, wat flt ug/L (67804)	2- Methyl- naphth- alene, water, fltrd, ug/L (62056)	3-beta- Copros- tanol, water, fltrd, ug/L (62057)	3- Methyl- 1H- indole, water, fltrd, ug/L (62058)	3-tert- Butyl- 4-hy- droxy- anisole, wat flt ug/L (62059)	4- Cumyl- phenol, water, fltrd, ug/L (62060)	4-n- Octyl- phenol, fltrd, ug/L (62061)	4- Nonyl- phenol, all isomers, wat flt ug/L (62085)
471142122094701	09-21-10	<.100	<.022	<.1	<.1	<.036	<.2	<.036	<.8	<.06	<.16	<.2
471324122093901	09-22-10	E.020	<.022	<.1	<.1	<.036	<.2	<.036	<.8	<.06	<.16	<.2
471423122115001	09-22-10	<.100	<.022	<.1	<.1	<.036	<.2	<.036	<.8	<.06	<.16	<.2
Station number	Date	4-Nonyl- phenol di- ethox- ylate, wat flt ug/L (62083)	4t-Octyl- phenol di- ethox- ylate, wat flt ug/L (61705)	4t-Octyl- phenol mono- ethox- ylate, wat flt ug/L (61706)	4-tert- Octyl- phenol, water, fltrd, ug/L (62062)	5-Meth- yl-1H- benzo- tri- azole, wat flt ug/L (62063)	9,10- Anthra- quinone, water, fltrd, ug/L (62066)	Acet- amino- phen, water, fltrd, ug/L (62000)	Aceto- phenone, water, fltrd, ug/L (62064)	AHTN, water, fltrd, ug/L (62065)	Albut- erol, water, fltrd, ug/L (62020)	Amitri- ptylene, water, fltrd, ug/L (67962)
471142122094701	09-21-10	<.5	<.1	<.1	<.14	<.1	<.2	<.120	<.4	<.028	<.080	<.16
471324122093901	09-22-10	<.5	<.1	<.1	<.14	<.1	<.2	E.037	<.4	<.028	<.080	<.16
471423122115001	09-22-10	<.5	<.1	<.1	<.14	<.1	<.2	<.120	<.4	<.028	<.080	<.16
Station number	Date	Anthra- cene, water, fltrd, ug/L (34221)	Anti- pyrene, water, fltrd, ug/L (67805)	Benzo- [a]- pyrene, water, fltrd, ug/L (34248)	Benzo- phenone, water, fltrd, ug/L (62067)	beta- Sitos- terol, water, fltrd, ug/L (62068)	beta- Stigmas- tanol, water, fltrd, ug/L (62086)	Butal- bital, water, fltrd, ug/L (63768)	Caf- feine, water, fltrd, ug/L (50305)	Carbam- azepine, water, fltrd, ug/L (62793)	Cariso- prodol, water, fltrd, ug/L (65180)	Cele- coxib, water, fltrd, ug/L (67806)
471142122094701	09-21-10	<.028	<.3	<.1	M	<.4	<.3	<.2	<.080	<.2	<.2	<.6
471324122093901	09-22-10	<.028	<.3	<.1	<.1	<.4	<.3	<.2	<.080	<.2	<.2	<.6
471423122115001	09-22-10	<.028	<.3	<.1	<.1	<.4	<.3	<.2	<.080	<.2	<.2	<.6

Appendix G. Pesticides, Wastewater Indicator Chemicals, and Pharmaceuticals in Samples from Allan Yorke (map No. L2), Snag Island (map No. L5), and Lake Outlet (map No. L8) Study Sites on Lake Tapps, Washington, September 2010

[See [Appendix C](#) for full names of chemical compounds and other details. Remark codes used in this table: <, less than; E, estimated; M, presence verified, but not quantified; ug/L, micrograms per liter; %, percent]

Station number	Date	Chloral- water, fltrd, ug/L (67960)	Chloro- xylenol water, fltrd, ug/L (66574)	Chlor- phenir- amine, water, fltrd, ug/L (63769)	Choles- terol, water, fltrd, ug/L (62072)	Citalo- pram, water, fltrd, ug/L (67807)	Codeine water, fltrd, ug/L (62003)	Cot- inine, water, fltrd, ug/L (62005)	De- hydro- nife- dipine, water, fltrd, ug/L (62004)	Dextro- meth- orphan, water, fltrd, ug/L (67809)	Diaz- epam, water, fltrd, ug/L (63770)	Di- hydro- codeine water, fltrd, ug/L (67810)
471142122094701	09-21-10	<.16	<.1	<.08	<2	<.1	<.3	<.038	<.080	<.2	<.16	<.2
471324122093901	09-22-10	<.16	<.1	<.08	<2	<.1	<.3	<.038	<.080	<.2	<.16	<.2
471423122115001	09-22-10	<.16	<.1	<.08	<2	<.1	<.3	<.038	<.080	<.2	<.16	<.2
Station number	Date	Diltia- zem, water, fltrd, ug/L (62008)	Diphen- hydra- mine, water, fltrd, ug/L (62796)	D-Limo- nene, water, fltrd, ug/L (62073)	Efa- virenz, water, fltrd, ug/L (67811)	Flucon- azole, water, fltrd, ug/L (67812)	Fluor- anthene water, fltrd, ug/L (34377)	Griseo- fulvin, water, fltrd, ug/L (67813)	HHCB, water, fltrd, ug/L (62075)	Hydro- codone, water, fltrd, ug/L (63771)	Imino- stil- bene, water, fltrd, ug/L (67815)	Indole, water, fltrd, ug/L (62076)
471142122094701	09-21-10	<.04	<.1	<.1	<.3	<.2	<.024	<.3	.1	<.3	<.1	<.1
471324122093901	09-22-10	<.04	<.1	<.1	<.3	<.2	<.024	<.3	<.1	<.3	<.1	<.1
471423122115001	09-22-10	<.04	<.1	<.1	<.3	<.2	<.024	<.3	<.1	<.3	<.1	<.1
Station number	Date	Isobor- neol, water, fltrd, ug/L (62077)	Iso- phorone water, fltrd, ug/L (34409)	Iso- propyl- benzene water, fltrd, ug/L (62078)	Iso- quin- oline, water, fltrd, ug/L (62079)	Lido- caine, water, fltrd, ug/L (67816)	Menthol water, fltrd, ug/L (62080)	Meper- idine, water, fltrd, ug/L (67818)	Mepro- bamate, water, fltrd, ug/L (67819)	Metax- alone, water, fltrd, ug/L (63772)	Meth- adone, water, fltrd, ug/L (63774)	Methyl salicy- late, water, fltrd, ug/L (62081)
471142122094701	09-21-10	<.2	M	<.3	<.2	<.1	<.3	<.1	<.3	<.08	<.1	<.044
471324122093901	09-22-10	<.2	M	<.3	<.046	<.1	<.3	<.1	<.3	<.08	<.1	M
471423122115001	09-22-10	<.2	<.1	<.3	<.2	<.1	<.3	<.1	<.3	<.08	<.1	<.044
Station number	Date	Methyl- phen- idate, water, fltrd, ug/L (67820)	Naphth- alene, water, fltrd, ug/L (34443)	Norpro- oxy- phene, water, fltrd, ug/L (67821)	Ox- carbaz- epine, water, fltrd, ug/L (67822)	Oxy- codone, water, fltrd, ug/L (63775)	Pento- bar- bital, water, fltrd, ug/L (67823)	Pentox- ifyl- line, water, fltrd, ug/L (67824)	Phenan- threne, water, fltrd, ug/L (34462)	Phendi- metra- zine, water, fltrd, ug/L (63776)	Pheno- bar- bital, water, fltrd, ug/L (67319)	Phenol, water, fltrd, ug/L (34466)
471142122094701	09-21-10	--	<.040	<.3	--	<.3	<.2	<.3	<.032	--	<.2	<.2
471324122093901	09-22-10	<.1	<.040	<.3	<.3	<.3	<.2	<.3	<.032	<.04	<.2	<.2
471423122115001	09-22-10	--	<.040	<.3	--	<.3	<.2	<.3	<.032	--	<.2	<.2
Station number	Date	Pheny- toin, water, fltrd, ug/L (67825)	Prim- idone, water, fltrd, ug/L (67827)	Propo- fol, water, fltrd, ug/L (67828)	Pyrene, water, fltrd, ug/L (34470)	Sulfa- methox- azole, water, fltrd, ug/L (62021)	Temaz- epam, water, fltrd, ug/L (67830)	Tetra- chloro- ethene, water, fltrd, ug/L (34476)	Ticlo- pidine, water, fltrd, ug/L (67831)	Trama- dol, water, fltrd, ug/L (67832)	Tri- bromo- methane water, fltrd, ug/L (34288)	Tri- butyl phos- phate, water, fltrd, ug/L (62089)
471142122094701	09-21-10	<.2	<.3	<.04	<.042	<.160	<.3	<.1	<.1	<.04	<.1	<.2
471324122093901	09-22-10	<.2	<.3	<.04	<.042	<.160	--	<.1	<.1	<.04	<.1	<.2
471423122115001	09-22-10	<.2	<.3	<.04	<.042	<.160	<.3	<.1	<.1	<.04	<.1	<.2
Station number	Date	Triclo- san, water, fltrd, ug/L (62090)	Tri- ethyl citrate water, fltrd, ug/L (62091)	Tri- meth- oprim, water, fltrd, ug/L (62023)	Tri- phenyl phos- phate, water, fltrd, ug/L (62092)	Tris(2- butoxy- ethyl) phos- phate, wat flt ug/L (62093)	Tris(2- chloro- ethyl) phos- phate, wat flt ug/L (62087)	Tris(di- chloro- i-Pr) phos- phate, wat flt ug/L (62088)	Venla- faxine, water, fltrd, ug/L (67833)	Vera- pamil, water, fltrd, ug/L (67834)	Warfar- in, water, fltrd, ug/L (62024)	
471142122094701	09-21-10	<.20	<.4	<.034	<.1	<.8	<.1	M	<.04	<.1	<.080	
471324122093901	09-22-10	<.20	<.4	<.034	<.1	<.8	<.1	<.2	<.04	<.1	<.080	
471423122115001	09-22-10	<.20	<.4	<.034	<.1	<.8	<.1	<.2	<.04	<.1	<.080	

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