US Army Corps of Engineers®
Portland District

WATER QUALITY REPORT

THE DALLES DAM, LAKE CELILO
COLUMBIA RIVER BASIN
COLUMBIA RIVER, OREGON AND WASHINGTON

The Dalles Dam, Lake Celilo

Water Quality Report
September 2020

EXECUTIVE SUMMARY

The Dalles Lock and Dam was authorized by Section 201 of the River and Harbor/Flood Control Acts of 1950. The dam was originally authorized for the purposes of navigation and hydropower. Fish and wildlife conservation, recreation, water quality, and irrigation were added as project purposes following the original authorization. The Dalles Lock and Dam is located at River Mile (RM) 192 of the lower Columbia River (Figure 1-1). It lies at the upstream end of Lake Bonneville.

Lake Celilo is the 24-mile long reservoir, with a surface area of approximately 9,400 acres, on the Columbia River between The Dalles Dam and John Day Dam (RM 215.6). Lake Celilo provides slackwater navigation at a minimum depth of 15 feet in the main channel. The normal forebay operating range is 155 to 160 feet above mean sea level. During tribal fishing seasons, the forebay is operated within a 1.5-foot range to accommodate tribal treaty fishing on the Columbia River.

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ACRONYMS

Acronym	Description
μg/L	Micrograms Per Liter
μS/cm	Microsiemens Per Centimeter
$CaCO_3$	Calcium Carbonate
CHL	Chlorophyll A
Corps	U.S. Army Corps of Engineers
DART	Data Access in Real Time
Detects	Detections
DO	Dissolved Oxygen
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
HUC	Hydrologic Unit Code
JHAW	John Day Tailwater Monitoring Station
KM	Kaplan-Meier
max	Maximum
med	Median
mg/L	Milligrams Per Liter
min	Minimum
mmHg	Millimeters of Mercury
MPN/100 mL	Most Probable Number Per 100 Milliliters
mV	Millivolts
ND	Non-Detection
ng/L	Nanograms Per Liter
NTU	Nephelometric Turbidity Unit
Obs	Observations
ODEQ	Oregon Department of Environmental Quality
ORP	Oxidation-Reduction Potential
PCB	Polychlorinated Biphenyl
Q1	First Quartile
Q3	Third Quartile
RM	River Mile
SD	Secchi Disk Depth
TCDD	Tetrachlorodibenzo-P-Dioxin
TDA	The Dalles Dam Forebay Monitoring Station
TDDO	The Dalles Dam Tailwater Monitoring Station
TDG	Total Dissolved Gas
TEQ	Toxic Equivalent
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSI	Trophic State Index
USGS	U.S. Geological Survey

SECTION 1 - INTRODUCTION

1.1 STUDY AREA

The Columbia River Basin is one of the world's great river basins in terms of its land area and river volume, as well as its environmental and cultural significance (U.S. Environmental Protection Agency [EPA] 2009). The basin drains about 259,000 square miles across seven U.S. states and British Columbia, Canada. Of that total, about 219,400 square miles, or 85 percent of the Pacific Northwest region, are in the United States; the remaining 39,500 square miles are in Canada (Pacific Northwest River Basins Commission 1979). The basin's rivers and streams carry the fourth largest volume of runoff in North America. The Columbia River begins at Columbia Lake in the Canadian Rockies and travels 1,243 miles over 14 dams to reach the Pacific Ocean 100 miles downstream from Portland, Oregon. The river's final 300 miles from the border between Washington and Oregon. The Snake River is the largest tributary to the Columbia River, with a drainage area of 108,500 square miles, or 49 percent of the U.S. portion of the watershed. There are more than 370 major dams on tributaries of the Columbia River Basin (Bonneville Power Administration [Bonneville], U.S. Army Corps of Engineers [Corps], and Bureau of Reclamation 2001). With its many major federal and nonfederal hydropower dams, the river is one of the most intensive hydroelectric developments in the world. About 65 percent (approximately 33,000 megawatts) of the Pacific Northwest's generating capacity comes from hydroelectric dams. Under normal precipitation, the dams produce about three-quarters (16,200 average megawatts) of the region's electricity. Some of the other major uses of the multi-purpose dams on the Columbia and Snake Rivers include flood control, commercial navigation, irrigation, and recreation (Northwest Power and Conservation Council 2000).

The Dalles Lock and Dam was authorized by Section 201 of the River and Harbor/Flood Control Acts of 1950. The dam was originally authorized for the purposes of navigation and hydropower. Fish and wildlife conservation, recreation, water quality, and irrigation were added as project purposes following the original authorization. The Dalles Lock and Dam is located at River Mile (RM) 192 of the lower Columbia River (Figure 1-1). It lies at the upstream end of Lake Bonneville.

Figure 1-1. Location Map for The Dalles Dam

Construction of The Dalles Dam began in 1952 and was completed in 1960. The dam is a run-of-river dam, and is 185 feet high and 2,640 feet long. The project consists of navigation lock, spillway, powerhouse, fish passage facilities, and a non-overflow section. The powerhouse is 2,089 feet long and contains 22 generating units. The spillway is 1,467 feet long and contains 23 spillbays; the maximum spillway capacity is 2,290,000 cubic feet per second (cfs).

Lake Celilo is the 24-mile long reservoir, with a surface area of approximately 9,400 acres, on the Columbia River between The Dalles Dam and John Day Dam (RM 215.6). Lake Celilo provides slackwater navigation at a minimum depth of 15 feet in the main channel. The normal forebay operating range is 155 to 160 feet above mean sea level. During tribal fishing seasons, the forebay is operated within a 1.5-foot range to accommodate tribal treaty fishing on the Columbia River.

1.2 PREVIOUS STUDIES

The Oregon Department of Environmental Quality (ODEQ) is responsible for keeping Oregon’s waters safe and healthy for many uses, such as drinking water, recreation, and agriculture, and fish habitats. To monitor the water quality status, ODEQ regularly collects water samples at over 130 sites on more than 50 rivers and streams across the state. The Water Quality Monitoring Program provides critical information for understanding how well water quality goals are being met and for identifying emerging water quality concerns, planning wastewater and industrial permit limits, assessing compliance with environmental regulations, developing effective watershed pollution reduction strategies, and understanding trends in water quality statewide. ODEQ's Water Monitoring Program meets these needs by planning and coordinating environmental data collection efforts, collecting representative and valid data, managing environmental data to ensure availability, and analyzing and interpreting water quality-related data to produce reports that identify water quality conditions and any threats to water quality. Further information about ODEQ's Water Quality Monitoring Program and associated data and reports can be accessed online (ODEQ 2017a).

The Corps monitors the water quality of reservoir releases at the projects throughout the Columbia River Basin to manage fish pass spill operations at the fish passage projects in the lower Snake and lower Columbia Rivers, as well as to manage system wide water quality. Corps completes water quality monitoring of total dissolved gas (TDG) and temperature at the 12 Corps dams in the Columbia River Basin (Bonneville, The Dalles, John Day, McNary, Chief Joseph, Ice Harbor, Lower Monumental, Little Goose, Lower Granite, Dworshak, Libby, and Albeni Falls dams). Corps prepares annual reports to address responsibilities related to the ODEQ TDG modification, the Washington State Department of Ecology (Ecology) TDG criteria adjustment, and the 2002 and 2003 TDG total maximum daily loads (TMDLs) for the lower Columbia and lower Snake Rivers (e.g., Corps 2016b). TDG and temperature are monitored throughout the Columbia River Basin via 43 fixed monitoring stations. Corps operates 25 of these stations: Portland District operates 8 stations on the lower Columbia River from John Day Dam to Camas-Washougal; the Seattle District is responsible for 2 monitoring stations in the Upper Columbia River Basin (at Chief Joseph Dam); and the Walla Walla District is responsible for 15 monitoring stations in the lower Snake and Clearwater River basins, and at McNary Dam on the Columbia River. Chemical runoff data from dam turbine, generation machinery, and from the dam deck is not available.

The University of Washington (UW), through their Columbia River Data Access in Real Time (DART) webpage, provides an interactive data resource designed for research and management purposes relating to the Columbia Basin salmon populations and river environment. Columbia River DART focuses on the Columbia Basin Dams and fish passage. Detailed information is brought in daily from federal, state, and tribal databases to provide a comprehensive information tool. Daily and historic information dating back to 1878 is available online.

1.3 WATER QUALITY DATA USED FOR THIS ANALYSIS

Available data for parameters within the last 10 years was used. Recent water quality data used for the analysis of existing conditions originates from the following sources:

- ODEQ water quality monitoring stations (listed in Section 2.2). Vertical profiles of specific conductivity, dissolved oxygen (DO), oxidation-reduction potential, pH, temperature, and turbidity were collected, along with single analyses of other constituents. This data was obtained through instructions provided on the ODEQ webpage (ODEQ 2017a).

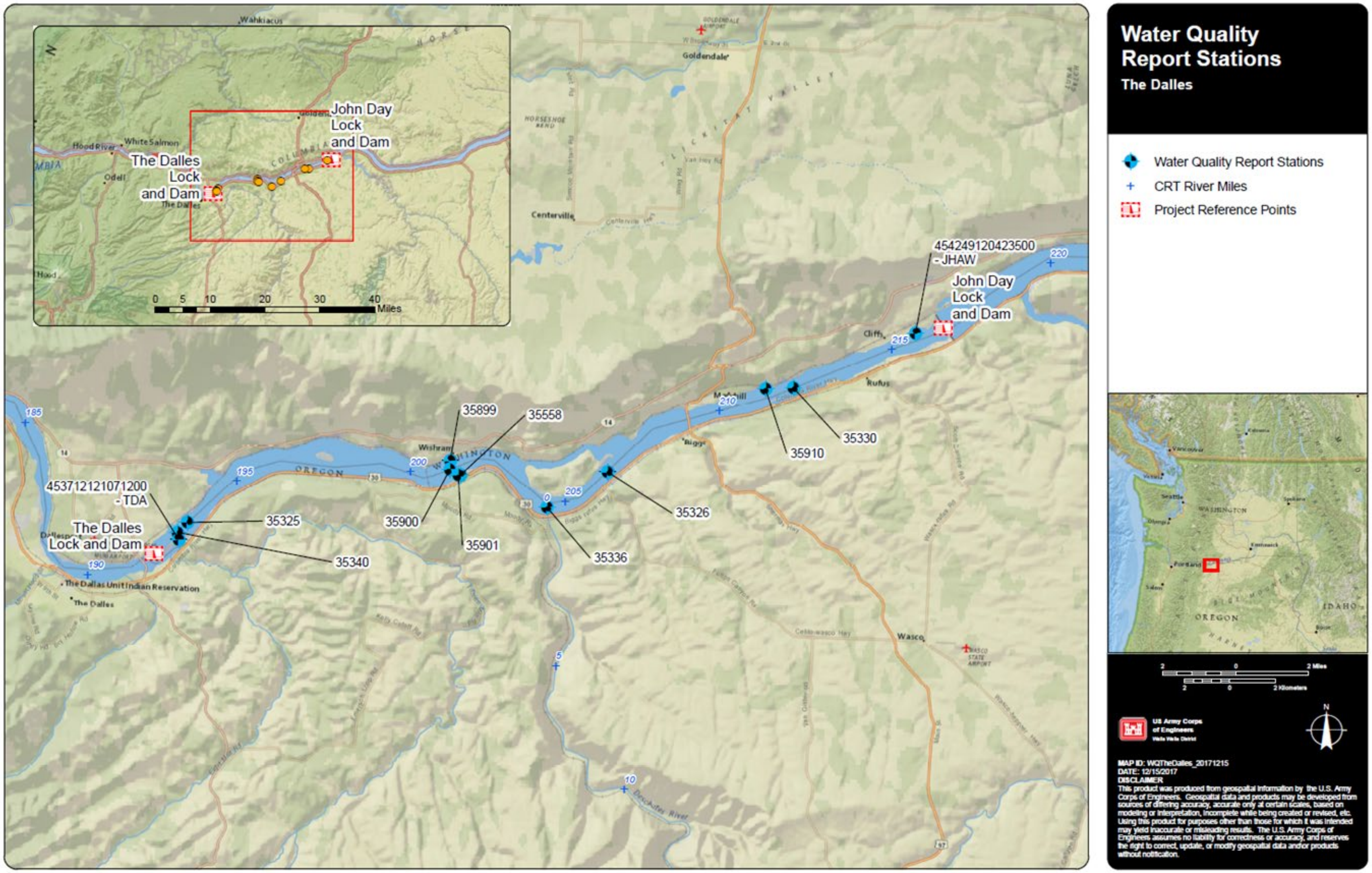
- Corps/U.S. Geological Survey [USGS] TDG/temperature monitoring stations JHAW (John Day Tailwater; RM 214.7; USGS station number 454249120423500), TDA (The Dalles Dam forebay; RM 192.6; USGS station number 453712121071200), and TDDO (The Dalles Tailwater; RM 189.1; USGS station number 14105700).
- Secchi depth measurements of the Dalles forebay from 2008 – 2009 were available via the UW Columbia River DART webpage (Columbia River DART, 2018).

ODEQ and Corps monitoring station locations are shown in Figure 1-2. The station names corresponding to the station numbers are given in Table 1-1.

Table 1-1. Sampling and Monitoring Locations Used for this Analysis

Entity	Station ID	Station Description
ODEQ	35325	Columbia R at Lake Celilo Channel Marker 1 St Mi 193.1
ODEQ	35326	Columbia R at East end of Miller Is. St Mi 206
ODEQ	35330	Columbia R at Rufus 0.5 Mi US of Channel Marker 41 St Mi 212
ODEQ	35336	Columbia R at Miller Is (S Channel) 0.2 Mi US Channel Marker 4
ODEQ	35340	Columbia R US of The Dalles Locks Channel Marker 1 St Mi 193.2
ODEQ	35558	Columbia River Shoreline at Celilo Park
ODEQ	35899	Columbia River at Celilo Park Transect North Bank
ODEQ	35900	Columbia River at Celilo Park Transect Center Channel
ODEQ	35901	Columbia River at Celilo Park Transect South Bank
ODEQ	35910	Columbia River Shoreline at The Wall by Maryhill (WA)
Corps	454249120423500 - JHAW	Columbia River, right bank, near Cliffs, Washington (John Day tailwater)
Corps	453712121071200 - TDA	Columbia River at The Dalles Dam forebay, Washington
Corps	14105700 – TDDO	The Dalles Tailwater

Figure 1-2. Locations of Sampling/Monitoring Stations–The Dalles Dam and Lake Celilo



SECTION 2 - WATER QUALITY

2.1 GENERAL DESCRIPTION

The Dalles reach is defined as the stretch of the Columbia River beginning immediately downstream of The Dalles Dam at RM 192 upstream to John Day Dam at RM 216. The most notable tributary in The Dalles reach is the Deschutes River (Oregon). There are other smaller tributaries that flow into this reach from both the Oregon and Washington borders.

In The Dalles reach, the Columbia River sits at an approximate elevation of 162 feet above mean sea level (USGS 2018). The geological formations through which the Columbia River passes in The Dalles reach are primarily igneous, basalt formations that were deposited during the middle and lower Miocene (between 11.5 and 23 million years ago) (Huntting et al. 1961; Walker and MacLeod 1991).

This portion of the lower Columbia River is notable for its commercial navigation and recreational activities, including fishing. There are also significant tribal treaty-reserved fisheries that occur during many months of the year on the Columbia River between McNary and Bonneville Dams. These tribally regulated fisheries use many different fishing methods, including drift and set nets or fishing from platforms that are built on the banks of the river. The U.S. Supreme Court and lower Federal courts have upheld Columbia River tribal fishing rights on multiple occasions. Extensive tribal fisheries also occur in tributaries to the Columbia and elsewhere on the mainstem Columbia River where salmon and steelhead (Oncorhynchus mykiss) are present. Additionally, a portion of the upland on both banks of the Columbia River is designated as a National Scenic Area. Interstate 84 in Oregon and Highway 14 in Washington parallel the Columbia River throughout this segment of river.

Regional climate information for the Northwest Climate Region (Washington, Oregon, and Idaho) was obtained from the National Oceanic and Atmospheric Administration National Centers for Environmental Information Climate at a Glance webpage (2018). The average monthly air temperature in the Northwest Climate Region for the last 30 years (1987 to 2018) is shown in Figure 2-1. The average annual temperature for the last 30 years is shown in Figure 2-2. Within the last 30 years, the average annual temperature was above the mean temperature from 1901 to 2017 in all but 3 years. Based on air temperature data from 1895 through 2017, average annual temperatures in the Northwest Climate Region are increasing at a rate of 0.2 degrees Fahrenheit (0.11 degrees Celsius) per decade. The average monthly precipitation in the Northwest Climate Region for the last 30 years (1987 to 2018) is shown in Figure 2-3. The average annual precipitation for the last 30 years is shown in Figure 2-4. Based on precipitation data from 1895 to 2017, average annual precipitation in the Northwest Climate Region is increasing at a rate of 0.11 inches per decade.

Figure 2-1. Average Monthly Temperatures in the Northwest Climate Region from 1987 through 2018

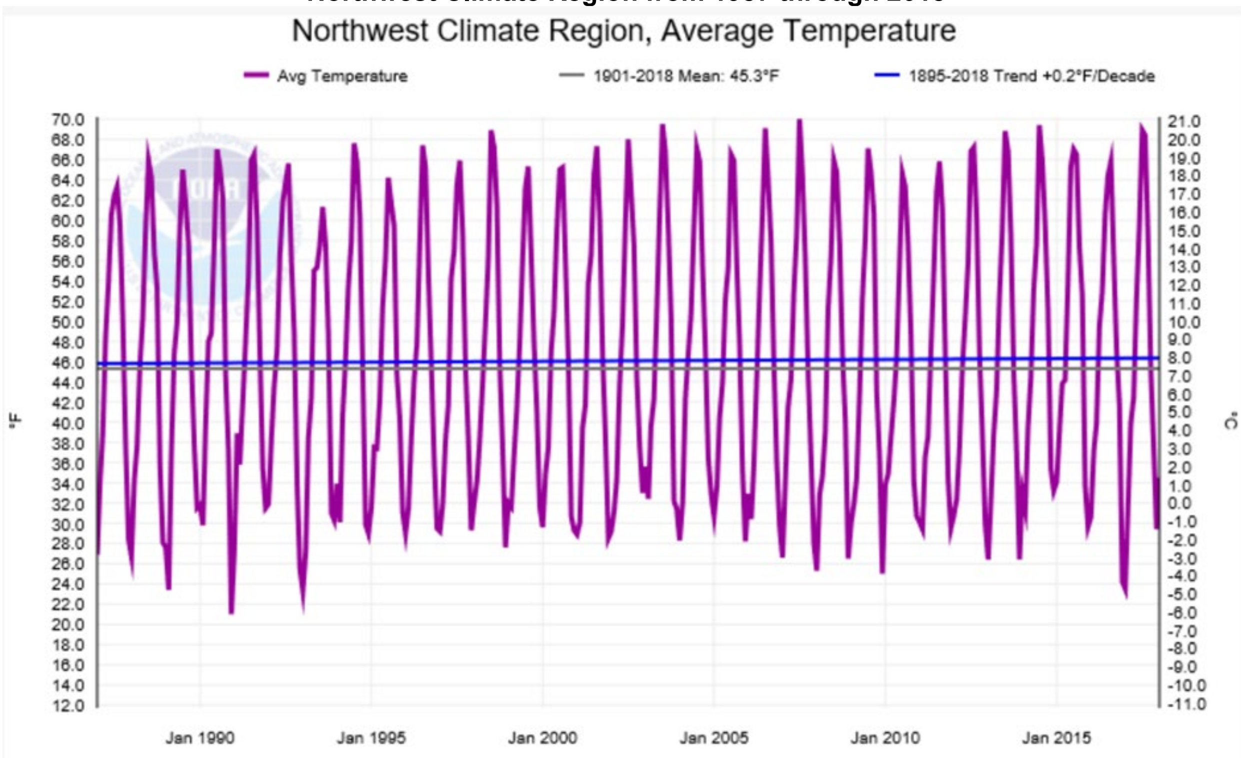


Figure 2-2. Average Annual Temperatures in the Northwest Climate Region from 1987 to 2018

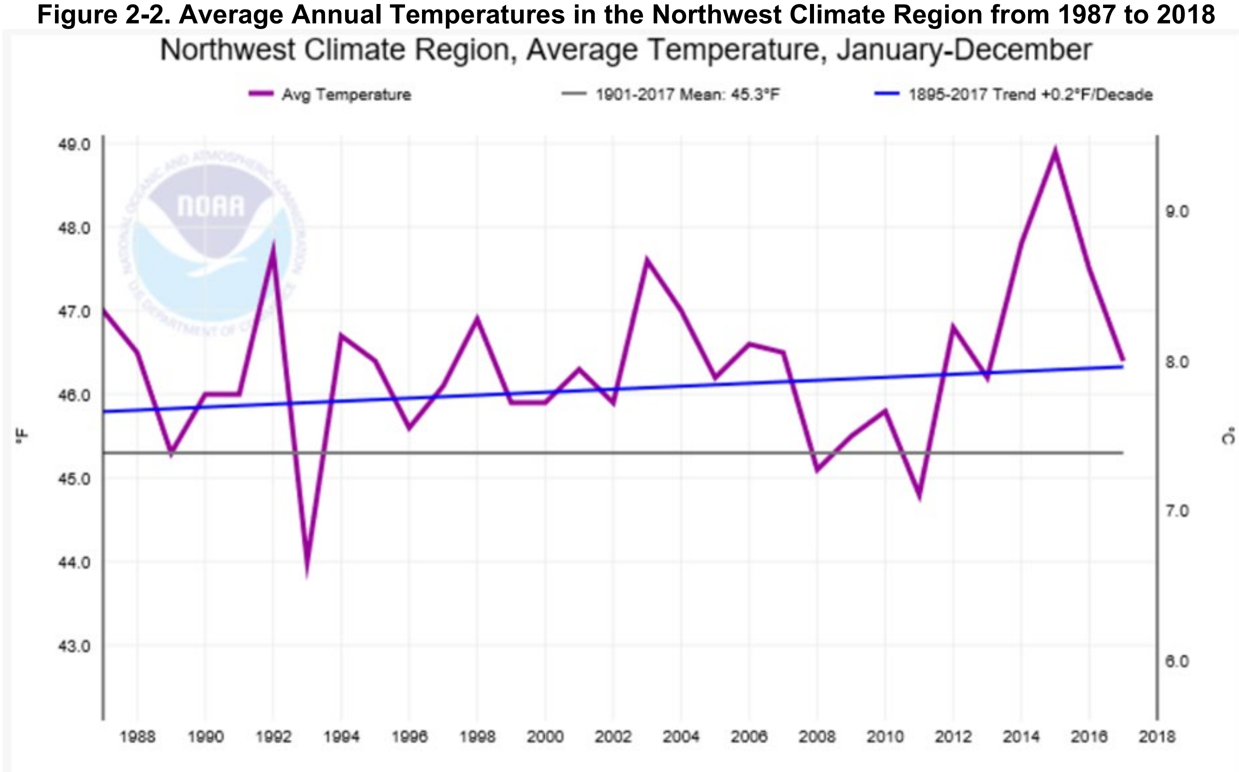


Figure 2-3. Average Monthly Precipitation in the Northwest Climate Region from 1987 to 2018

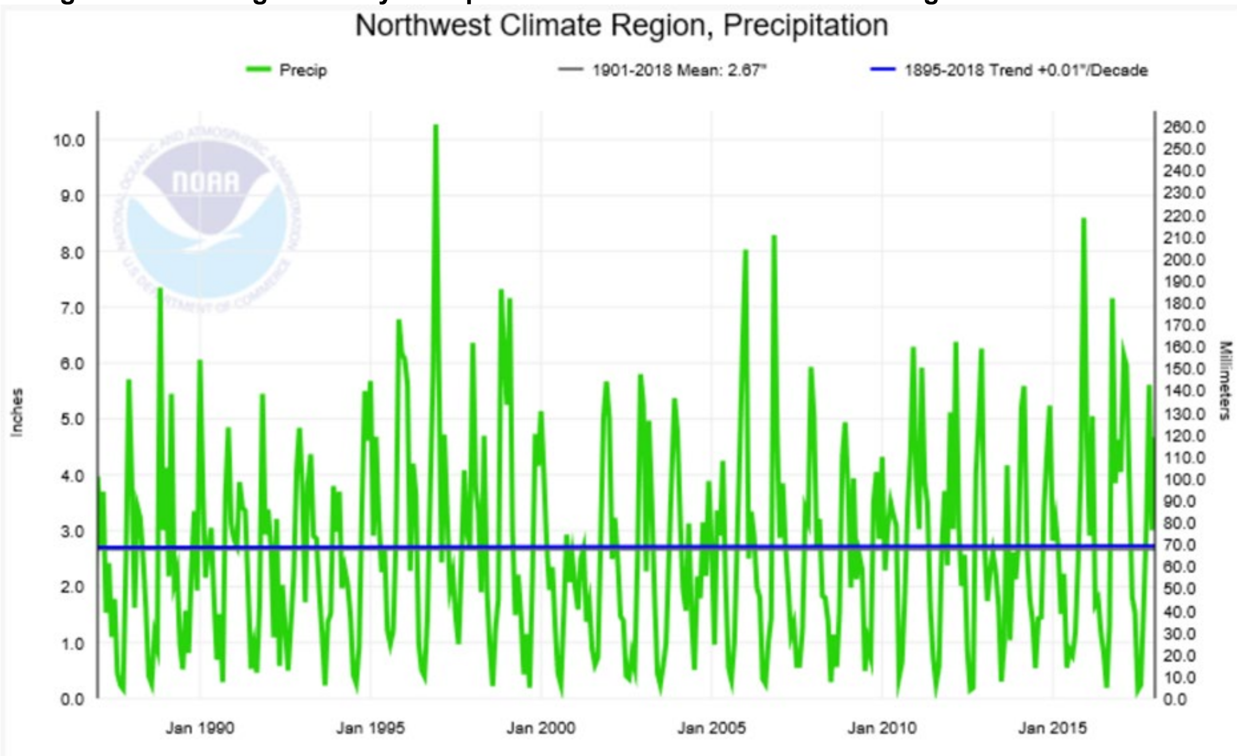
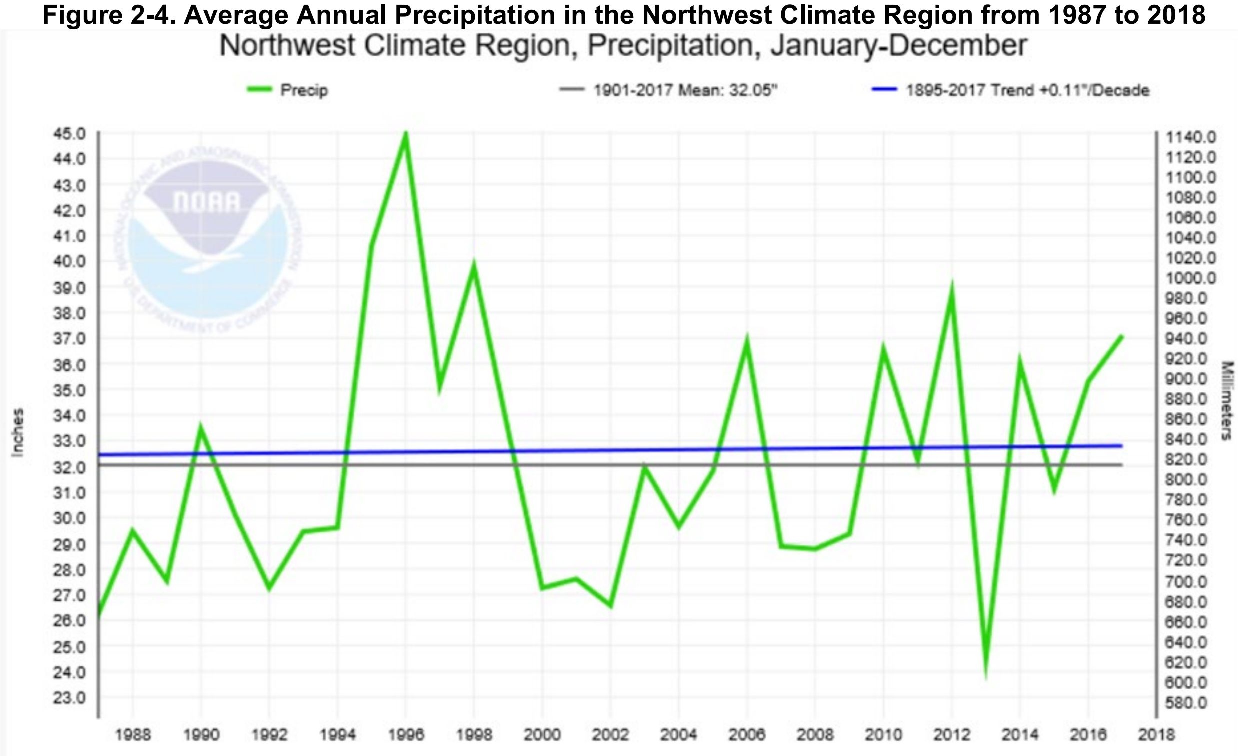


Figure 2-4. Average Annual Precipitation in the Northwest Climate Region from 1987 to 2018



River conditions associated with flow greater than the 7Q10 flow are exempt from state water quality standards since it is impossible for dam operators to abate TDG saturation of these natural origin flows (7Q10 flow is the average peak annual flows for seven consecutive days that has a recurrence interval of 10 years, and at these flows, the ODEQ and Ecology TDG criteria do not apply). The 7Q10 flow rate identifies the upper flow limit for which state TDG standards are applicable and therefore represents the “worst case” for TDG generation (Corps 2016a). The Dalles 7Q10 flow criteria for 2000 to 2016 was 461,000 cfs and was updated for 2017 and the future to be 448,000 cfs. There were 29 exceedances of the 7Q10 flow criteria in 2011, but there have not been any exceedances in other years since 2008 (Corps 2008 to 2016b).

The most recent Washington and Oregon state water quality classifications for Lake Celilo are shown in Table 2-1 and Table 2-2, respectively (Ecology, 2017; ODEQ, 2017b). Category 5 listings are those that are on the Clean Water Act 303(d) list; Category 4A listings are those that have an approved TMDL that is actively being implemented. In Lake Celilo, temperature, mercury, and polychlorinated biphenyls (PCBs) are on the 303(d) list. Dioxin (2,3,7,8-TCDD) and TDG have TMDLs in at least some portion of this reach. ODEQ’s 303(d) list does not distinguish the media (i.e., water, tissue, sediment) that serves as the basis for the water quality evaluation. Based on characteristics of the substances, it is assumed that the mercury, PCB, and dioxin 303(d) listings are based on tissue or sediment rather than water.

Table 2-1. 2017 Washington State Water Quality Classifications and 303(d) Listings

Assessment Unit ID; Brief Description	Listing ID	Category	Medium	Parameter
170701050103_01_01; Downstream of John Day Dam to just downstream of Miller Island	5892	5	Water	Temperature
170701050103_01_01	5895	4A	Water	Total dissolved gas

Table 2-2. 2017 Oregon State Water Quality Classifications and 303(d) Listings

USGS Hydrologic Unit Codes	Record ID	River Miles	Category	Parameter
17070101; 17070105; 17080001; 17080003; 17080006; 17090012	13288	0 to 303.9	5	Temperature
17070101; 17070105; 17080001; 17080003; 17080006; 17090012	21819	0 to 303.9	3B	Phosphate phosphorus
17070101; 17070105; 17080001; 17080003; 17080006; 17090012	20002	0 to 303.9	3	Barium
17070101; 17070105; 17080001; 17080003; 17080006; 17090012	20006	0 to 303.9	3	Chloride
17070101; 17070105; 17080001; 17080003; 17080006; 17090012	20007	0 to 303.9	3	Chlorophyll a
17070101; 17070105; 17080001; 17080003; 17080006; 17090012	20008	0 to 303.9	3	Chlorophyll a
17070101; 17070105; 17080001; 17080003; 17080006; 17090012	20026	0 to 303.9	3	Nitrates
17070101; 17070105; 17080001; 17080003; 17080006; 17090012	20035	0 to 303.9	3	Thallium
17070101; 17070105; 17080001; 17080003; 17080006; 17090012	19999	0 to 303.9	2	Ammonia
17070101; 17070105; 17080001; 17080003; 17080006; 17090012	25982	0 to 303.9	2	Chromium

USGS Hydrologic Unit Codes	Record ID	River Miles	Category	Parameter
17070101; 17070105; 17080001; 17080003; 17080006; 17090012	20010	0 to 303.9	2	Copper
17070101; 17070105; 17080001; 17080003; 17080006; 17090012	21103	0 to 303.9	2	DO
17070101; 17070105; 17080001; 17080003; 17080006; 17090012	20025	0 to 303.9	2	Nickel
17070101; 17070105; 17080001; 17080003; 17080006; 17090012	20032	0 to 303.9	2	Selenium
17070101; 17070105; 17080001; 17080003; 17080006; 17090012	20036	0 to 303.9	2	Zinc
17070101; 17070105; 17080001; 17080003; 17090012	19998	34.5 to 303.9	2	Alkalinity
17070101; 17070105; 17080001	20024	137.1 to 303.9	2	Manganese
17070101; 17070105	26018	142 to 287.1	5	Mercury
17070101; 17070105	9284	142 to 287.1	5	PCBs
17070101; 17070105	25983	142 to 303.9	3	Arsenic
17070101; 17070105	25986	142 to 303.9	3	Cadmium
17070101; 17070105	20020	142 to 303.9	3	Iron
17070101; 17070105	25985	142 to 303.9	3	Lead
17070101; 17070105	25984	142 to 303.9	3	Silver
17070101; 17070105	26027	142 to 303.9	2	pH
17070101; 17070105	41	188.6 to 213.7	4A	Dioxin (2,3,7,8-TCDD)
17070101; 17070105	42	188.6 to 213.7	4A	Dioxin (2,3,7,8-TCDD)
17070101; 17070105	25	188.6 to 213.7	4A	Total dissolved gas
17070101; 17070105	26025	188.6 to 303.9	3	pH
17070101	44	213.7 to 287.1	4A	Dioxin (2,3,7,8-TCDD)
17070101	43	213.7 to 287.1	4A	Dioxin (2,3,7,8-TCDD)
17070101	26	213.7 to 287.1	4A	Total dissolved gas

2.2 EXISTING WATER QUALITY CONDITIONS

A set of physical, chemical, and biological water quality parameters were collected by ODEQ during a 14-day period from August to September 2009 at 5 locations along this reach. Table 2-3 identifies these monitoring stations. Depth profiles of physical parameters from these ODEQ stations are summarized in Table 2-4. The other physical, chemical, and biological parameters obtained during the surface water-sampling event (depth 0.2 meters) were analyzed together because the parameter values, for the most part, were similar. The summary of this data is presented in Table 2-5. There were 5 other stations with ODEQ data within the last 10 years (Table 2-6). Each of these stations had four or fewer observations for specific conductivity, temperature, pH, DO, and E. coli bacteria from August to October 2008; Table 2-7 summarizes that data. Because only one comprehensive dataset for water quality, other than temperature and total dissolved gas was available, the complete data is dated. Because of the low frequency of recent sampling events, the observations and inferences regarding this data is of limited utility as far as characterizing spatial and temporal trends in water quality.

Table 2-3. ODEQ Monitoring Stations with Data from August to September 2009

Station	Station Description
35325	Columbia R at Lake Celilo Channel Marker 1 St Mi 193.1
35326	Columbia R at East end of Miller Is. St Mi 206
35330	Columbia R at Rufus 0.5 Mi US of Channel Marker 41 St Mi 212
35336	Columbia R at Miller Is (S Channel) 0.2 Mi US Channel Marker 4
35340	Columbia R US of The Dalles Locks Channel Marker 1 St Mi 193.2

Table 2-4. Depth Profiles for ODEQ Monitoring Stations with Data from August to September 2009

Station Number	Station ID	River Mile	Profile Date	Sample Depth (m)	Specific Conductivity (µS/cm @ 25°C)	DO (% Saturation)	DO (mg/L)	ORP (mV)	pH	Temp (°C)	Turbidity (NTU)
35330	Columbia R at Rufus 0.5 Mi US of Channel Marker 41 St Mi 212	212	9/9/2009	0.2	152	97	8.6	217	8	21.2	1
35330	Columbia R at Rufus 0.5 Mi US of Channel Marker 41 St Mi 212	212	9/9/2009	1	152	97	8.5	219	8	21.2	1
35330	Columbia R at Rufus 0.5 Mi US of Channel Marker 41 St Mi 212	212	9/9/2009	4.5	152	97	8.5	220	8	21.2	1
35330	Columbia R at Rufus 0.5 Mi US of Channel Marker 41 St Mi 212	212	9/9/2009	6	152	97	8.5	221	8	21.2	1
35326	Columbia R at East end of Miller Is. St Mi 206	206	9/9/2009	0.2	152	99	8.6	187	8	21.3	1
35326	Columbia R at East end of Miller Is. St Mi 206	206	9/9/2009	1	152	98	8.6	205	8	21.2	1
35326	Columbia R at East end of Miller Is. St Mi 206	206	9/9/2009	3	152	95	8.4	209	7.9	21.1	1
35326	Columbia R at East end of Miller Is. St Mi 206	206	9/9/2009	4.5	152	95	8.3	211	7.9	21.1	1
35326	Columbia R at East end of Miller Is. St Mi 206	206	9/9/2009	6	152	95	8.3	212	7.9	21.1	1
35336	Columbia R at Miller Is (S Channel) 0.2 Mi US Channel Marker 4	~205	9/9/2009	0.2	152	98	8.6	207	8	21.4	1
35336	Columbia R at Miller Is (S Channel) 0.2 Mi US Channel Marker 4	~205	9/9/2009	1	152	98	8.6	210	8	21.4	1
35336	Columbia R at Miller Is (S Channel) 0.2 Mi US Channel Marker 4	~205	9/9/2009	2.5	152	97	8.5	212	8	21.3	1
35336	Columbia R at Miller Is (S Channel) 0.2 Mi US Channel Marker 4	~205	9/9/2009	5	152	97	8.5	213	8	21.2	1
35336	Columbia R at Miller Is (S Channel) 0.2 Mi US Channel Marker 4	~205	9/9/2009	7	152	95	8.4	215	7.9	21.1	1
35340	Columbia R US of The Dalles Locks Channel Marker 1 St Mi 193.2	193.2	8/27/2009	0.2	151	105	9.2	106	7.9	21.5	2
35340	Columbia R US of The Dalles Locks Channel Marker 1 St Mi 193.2	193.2	8/27/2009	4	151	105	9.2	121	8	21.5	NA
35340	Columbia R US of The Dalles Locks Channel Marker 1 St Mi 193.2	193.2	8/27/2009	8	151	105	9.1	131	8	21.4	NA
35325	Columbia R at Lake Celilo Channel Marker 1 St Mi 193.1	193.1	8/27/2009	0.2	150	105	9.3	138	8.1	22.1	2
35325	Columbia R at Lake Celilo Channel Marker 1 St Mi 193.1	193.1	8/27/2009	3	151	105	9.2	146	8.1	21.5	NA
35325	Columbia R at Lake Celilo Channel Marker 1 St Mi 193.1	193.1	8/27/2009	6	151	105	9.1	151	8.1	21.4	NA

Notes: µS/cm = microsiemens per centimeter; mg/L = milligrams per liter; NTU = Nephelometric Turbidity Unit; mV = millivolts; Nephelometric Turbidity Unit.

Table 2-5. Data Summary for ODEQ Monitoring Stations with Data from August to September 2009

Type	Parameter	Start Date	End Date	# of Obs	# of Detects	% of NDs	Min ND Value	Max ND Value	KM Mean	Min[1/]	Max[1/]	Mean[1/]	Med[1/]	Q1	Q3
Physical	Specific Conductivity (µS/cm @ 25° C)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	151.4	150	152	151.4	152	151	152
Physical	DO (% Saturation)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	100.8	97	105	100.8	99	98	105
Physical	DO(mg/L)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	8.86	8.6	9.3	8.86	8.6	8.6	9.2
Physical	Oxidation-reduction potential (mV)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	171	106	217	171	187	138	207
Physical	pH	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	8	7.9	8.1	8	8	8	8
Physical	Temperature (°C)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	21.5	21.2	22.1	21.5	21.4	21.3	21.5
Physical	Turbidity (NTU)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	1.4	1	2	1.4	1	1	2
Chemical	Calcium (mg/L)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	17.38	17.3	17.5	17.38	17.4	17.3	17.4
Chemical	Magnesium (mg/L)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	4.886	4.84	4.94	4.886	4.88	4.85	4.92
Chemical	Sulfate (mg/L)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	10.7	9.5	11.1	10.7	11.1	10.7	11.1
Chemical	Alkalinity as calcium carbonate (mg/L)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	60.4	60	61	60.4	60	60	61
Chemical	Hardness as $CaCO_3$ (mg/L)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	63.5	63.2	63.7	63.5	63.5	63.4	63.7
Chemical	Antimony, total recoverable (µg/L)	8/27/2009	9/9/2009	5	0	100.00%	2	2	N/A	N/A	N/A	N/A	N/A	2	2
Chemical	Arsenic, total recoverable (µg/L)	8/27/2009	9/9/2009	5	0	100.00%	2	2	N/A	N/A	N/A	N/A	N/A	2	2
Chemical	Barium, total recoverable (µg/L)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	28.24	27.8	28.8	28.24	28.1	27.8	28.7
Chemical	Beryllium, total recoverable (µg/L)	8/27/2009	9/9/2009	5	0	100.00%	0.3	0.3	N/A	N/A	N/A	N/A	N/A	0.3	0.3
Chemical	Cadmium, total recoverable (µg/L)	8/27/2009	9/9/2009	5	0	100.00%	0.3	0.3	N/A	N/A	N/A	N/A	N/A	0.3	0.3
Chemical	Chromium, total recoverable (µg/L)	8/27/2009	9/9/2009	5	0	100.00%	1	1	N/A	N/A	N/A	N/A	N/A	1	1
Chemical	Cobalt, total recoverable (µg/L)	8/27/2009	9/9/2009	5	0	100.00%	0.2	0.2	N/A	N/A	N/A	N/A	N/A	0.2	0.2
Chemical	Copper, total recoverable (µg/L)	8/27/2009	9/9/2009	5	0	100.00%	1.5	1.5	N/A	N/A	N/A	N/A	N/A	1.5	1.5

Type	Parameter	Start Date	End Date	# of Obs	# of Detects	% of NDs	Min ND Value	Max ND Value	KM Mean	Min[1/]	Max[1/]	Mean[1/]	Med[1/]	Q1	Q3
Chemical	Lead, total recoverable (µg/L)	8/27/2009	9/9/2009	5	0	100.00%	0.2	0.2	N/A	N/A	N/A	N/A	N/A	0.2	0.2
Chemical	Molybdenum, total recoverable (µg/L)	8/27/2009	9/9/2009	5	0	100.00%	3	3	N/A	N/A	N/A	N/A	N/A	3	3
Chemical	Nickel, total recoverable (µg/L)	8/27/2009	9/9/2009	5	0	100.00%	1	1	N/A	N/A	N/A	N/A	N/A	1	1
Chemical	Selenium, total recoverable (µg/L)	8/27/2009	9/9/2009	5	0	100.00%	2	2	N/A	N/A	N/A	N/A	N/A	2	2
Chemical	Silver, total recoverable (µg/L)	8/27/2009	9/9/2009	5	0	100.00%	0.1	0.1	N/A	N/A	N/A	N/A	N/A	0.1	0.1
Chemical	Thallium, total recoverable (µg/L)	8/27/2009	9/9/2009	5	0	100.00%	0.1	0.1	N/A	N/A	N/A	N/A	N/A	0.1	0.1
Chemical	Uranium, total recoverable (µg/L)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	0.726	0.72	0.73	0.726	0.73	0.72	0.73
Chemical	Vanadium, total recoverable (µg/L)	8/27/2009	9/9/2009	5	0	100.00%	4	4	N/A	N/A	N/A	N/A	N/A	4	4
Chemical	Zinc, total recoverable (µg/L)	8/27/2009	9/9/2009	5	0	100.00%	3	3	N/A	N/A	N/A	N/A	N/A	3	3
Chemical	Mercury, dissolved (ng/L)	8/27/2009	9/9/2009	5	0	100.00%	0.5	0.5	N/A	N/A	N/A	N/A	N/A	0.5	0.5
Chemical	Mercury, total recoverable (ng/L)	8/27/2009	9/9/2009	5	4	20.00%	0.5	0.5	0.645	0.545	0.8	0.682	0.69	0.545	0.727
Chemical	Methyl mercury, dissolved (ng/L)	8/27/2009	9/9/2009	5	0	100.00%	0.051	0.051	N/A	N/A	N/A	N/A	N/A	0.051	0.051
Chemical	Methyl mercury, total (ng/L)	8/27/2009	9/9/2009	5	0	100.00%	0.049	0.049	N/A	N/A	N/A	N/A	N/A	0.049	0.049
Chemical	Total suspended solids (mg/L)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	2	2	2	2	2	2	2
Chemical	Secchi disk depth (m)	8/27/2009	9/9/2009	4	4	0.00%	N/A	N/A	2.975	2.8	3.3	2.975	2.9	2.8	3.075
Chemical	Nitrate/nitrite as N (mg/L)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	0.0807	0.065	0.1	0.081	0.069	0.068	0.099
Chemical	Ammonia as N (mg/L)	8/27/2009	9/9/2009	5	0	100.00%	0.02	0.02	N/A	N/A	N/A	N/A	N/A	0.02	0.02
Chemical	Total phosphorus (mg/L)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	0.022	0.02	0.03	0.022	0.02	0.02	0.02
Chemical	Orthophosphate as P (mg/L)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	0.0102	0.009	0.01	0.01	0.01	0.009	0.011
Chemical	Total organic carbon (mg/L)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	2	2	2	2	2	2	2
Chemical	Dissolved organic carbon (mg/L)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	2	2	2	2	2	2	2
Biological	Chlorophyll a (µg/L)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	1.42	0.7	2.4	1.42	1.2	1.1	1.7
Biological	Pheophytin a (µg/L)	8/27/2009	9/9/2009	5	5	0.00%	N/A	N/A	0.94	0.7	1.1	0.94	0.9	0.9	1.1
Biological	E. Coli (MPN/100 mL)	8/27/2009	9/9/2009	5	3	40.00%	1	1	1.4	1	2	1.667	2	1	2

Notes: Obs = observations; Detects = detections; ND = non-detection; Min = minimum; Max = maximum; KM = Kaplan-Meier; Med = median; Q1 = first quartile; Q3 = third quartile.
µg/L = micrograms per liter; $CaCO_3$ = calcium carbonate; MPN/100 mL = most probable number per 100 milliliters; ng/L = nanograms per liter.
1/ These summary statistics are based on only the detected values.

Table 2-6. ODEQ Monitoring Stations with Data from August to October 2008

Station	Station Description
35558	Columbia River Shoreline at Celilo Park
35899	Columbia River at Celilo Park Transect North Bank
35900	Columbia River at Celilo Park Transect Center Channel
35901	Columbia River at Celilo Park Transect South Bank
35910	Columbia River Shoreline at The Wall by Maryhill (WA)

Table 2-7. Data Summary for ODEQ Monitoring Stations with Data from August to October 2008

Location	Parameter	Start Date	End Date	# of Obs	# of Detects	% of NDs	Min ND Value	Max ND Value	KM Mean	Min[1/]	Max[1/]	Mean[1/]	Med[1/]
35558 - Columbia River Shoreline at Celilo Park	Specific Conductivity (µS/cm @ 25°C)	8/6/2008	10/2/2008	4	4	0.00%	N/A	N/A	131	118	145	131	130
35558 - Columbia River Shoreline at Celilo Park	pH	8/6/2008	10/2/2008	2	2	0.00%	N/A	N/A	8.42	8.24	8.59	8.42	8.42
35558 - Columbia River Shoreline at Celilo Park	Temperature (°C)	8/6/2008	10/2/2008	4	4	0.00%	N/A	N/A	20.62	18.88	21.6	20.62	21
35558 - Columbia River Shoreline at Celilo Park	Dissolved oxygen (mg/L)	8/6/2008	10/2/2008	2	2	0.00%	N/A	N/A	8.49	7.55	9.42	8.49	8.49
35558 - Columbia River Shoreline at Celilo Park	E. Coli (MPN/100 mL)	8/25/2008	8/25/2008	1	1	0.00%	N/A	N/A	1	1	1	1	1
35899 - Columbia River at Celilo Park Transect North Bank	Specific Conductivity (µS/cm @ 25°C)	9/10/2008	9/10/2008	1	1	0.00%	N/A	N/A	141	141	141	141	141
35899 - Columbia River at Celilo Park Transect North Bank	pH	9/10/2008	9/10/2008	1	1	0.00%	N/A	N/A	7.7	7.7	7.7	7.7	7.7

Location	Parameter	Start Date	End Date	# of Obs	# of Detects	% of NDs	Min ND Value	Max ND Value	KM Mean	Min[1/]	Max[1/]	Mean[1/]	Med[1/]
35899 - Columbia River at Celilo Park Transect North Bank	Temperature (°C)	9/10/2008	9/10/2008	1	1	0.00%	N/A	N/A	20.19	20.19	20.19	20.19	20.19
35900 - Columbia River at Celilo Park Transect Center Channel	Specific Conductivity (µS/cm @ 25°C)	9/10/2008	9/10/2008	1	1	0.00%	N/A	N/A	141	141	141	141	141
35900 - Columbia River at Celilo Park Transect Center Channel	pH	9/10/2008	9/10/2008	1	1	0.00%	N/A	N/A	7.59	7.59	7.59	7.59	7.59
35900 - Columbia River at Celilo Park Transect Center Channel	Temperature (°C)	9/10/2008	9/10/2008	1	1	0.00%	N/A	N/A	20.11	20.11	20.11	20.11	20.11
35901 - Columbia River at Celilo Park Transect South Bank	Conductivity (µS/cm @ 25°C)	9/10/2008	9/10/2008	1	1	0.00%	N/A	N/A	138	138	138	138	138
35901 - Columbia River at Celilo Park Transect South Bank	pH	9/10/2008	9/10/2008	1	1	0.00%	N/A	N/A	7.85	7.85	7.85	7.85	7.85
35901 - Columbia River at Celilo Park Transect South Bank	Temperature (°C)	9/10/2008	9/10/2008	1	1	0.00%	N/A	N/A	20.18	20.18	20.18	20.18	20.18
35901 - Columbia River at Celilo Park Transect South Bank	E. Coli (MPN/100 mL)	9/10/2008	9/10/2008	1	1	0.00%	N/A	N/A	1	1	1	1	1
35910 - Columbia River Shoreline at The Wall by Maryhill (WA)	Specific Conductivity (µS/cm @ 25°C)	8/14/2008	8/15/2008	2	2	0.00%	N/A	N/A	132.1	130	134.1	132.1	132.1
35910 - Columbia River Shoreline at The Wall by Maryhill (WA)	Temperature (°C)	8/14/2008	8/15/2008	2	2	0.00%	N/A	N/A	21.9	21.8	22	21.9	21.9

Note: 1/ These summary statistics are based on only the detected values.

Daily average water temperature and hourly TDG data from Corps/USGS temperature/TDG monitoring stations JHAW (John Day Tailwater), TDA (The Dalles Dam forebay), and TDDO (The Dalles Tailwater) for the last 10 years is also available. The temperature data from these two stations is briefly summarized in Table 2-8 and Table 2-9. Hourly temperature data at different depths was also available from station TDA from June to October of 2012. TDG exceedances are briefly discussed as summarized in TDG Reports from 2007 through 2016 (Corps 2007 to 2016b).

Table 2-8. Annual Summary of Maximum Daily Water Temperature Data from Corps Station JHAW from 2007 to 2016 (°C)

Year	Min	Max	Average	Median
2007	2.3	22.0	12.3	12.5
2008	1.7	21.9	11.9	11.9
2009	2.4	23.4	12.0	11.5
2010	4.0	22.4	12.4	12.4
2011	2.9	21.5	11.7	11.9
2012	2.5	22.1	12.1	12.7
2013	2.9	22.7	12.5	12.6
2014	1.8	22.8	12.6	12.9
2015	4.2	23.4	13.6	13.8
2016	3.6	22.8	13.2	13.8

Table 2-9. Annual Summary of Maximum Daily Water Temperature Data from Corps Station TDA from 2007 to 2016 (°C)

Year	Min	Max	Average	Median
2007	7.3	22.1	16.6	17.5
2008	6.4	22.2	15.0	14.9
2009	4.9	23.3	15.7	16.9
2010	6.6	22.6	15.4	15.3
2011	6.6	21.6	15.0	15.0
2012	5.3	21.9	14.7	15.1
2013	6.7	22.7	16.4	17.1
2014	5.4	22.8	15.6	16.2
2015	7.7	23.5	17.3	19.7
2016	7.0	22.7	16.6	17.7

2.2.1 Physical

2.2.1.1 *Temperature*

The temperature-related characteristics of water have a large effect on water quality and the ecology of lakes. As lake water warms in the spring and summer it becomes less dense and floats on top of colder water. In the absence of sufficient energy (i.e., wind or high inflows) to mix the water and equilibrate the temperature, a lake will thermally stratify and form two separate temperature layers. Thermal stratification produces a warm water upper layer, called the epilimnion, and a cold water bottom layer, called the hypolimnion. The transition zone between these two layers is called the metalimnion or thermocline, and it is marked by rapid changes in water temperatures from top to bottom. Typical direct thermal stratification is apparent when the temperature in this transition zone decrease at least 1 degree Celsius for every 1-meter increase in depth. Because of the temperature difference in a stratified lake, there is little mixing of water between the epilimnion and hypolimnion until the lake de-stratifies in the fall and winter resulting in a uniform temperature throughout the water column.

Elevated temperatures affect multiple life history stages in anadromous fish including migration, gametogenesis, gamete viability, egg incubation, timing of emergence, predator exposure, growth, migration and maturation, and ultimate survival of individuals and overall population productivity. For example, adult fallback over and through dam turbines and screen bypass systems after they have migrated through fish ladders can be substantial and could be caused by warm water temperatures in the fish ladders or at other places within the project boundaries (Wagner and Hillison 1991). Additionally, warm water temperatures in reservoirs cause severe temperature stresses, including a higher risk of disease and increased susceptibility to parasites, e.g., the *Neascus* spp. (aka "blackspot") infection. The comibation of infestation by the parasite and exposure to high temperatures leads to more fish die-offs. Higher stream temperatures have also been shown to increase sensitivity of subyearling Chinook salmon (Oncorhynchus tshawytscha) in the Columbia River Basin to pesticides (EPA 2014).

Additionally, the run timing of steelhead and Chinook salmon overlap with the period of high summer temperatures in the Lower Columbia (Palmer, 2017). Accordingly, steelhead and fall Chinook are the species that most often encounter warm Columbia River temperatures, and are the species that use cold water refuges to escape the warm Columbia River temperatures. In the Lower Columbia River, these cold water refuges are primarily where cooler tributary rivers flow into the Columbia River. Protecting and restoring cold water refuges is likely to be important for the recovery of salmon and steelhead populations in the Columbia River Basin. The importance of protecting and restoring these cold water refuges may take on more significance due to climate change, which is expected to increase the water temperatures in both the tributaries and the Columbia River.

The Washington state water temperature criteria is a 68°F (20°C) daily maximum. The Oregon state water temperature criterion is a 68°F (20°C) 7-day moving average of daily maximum.

Depth profiles obtained by ODEQ in September 2009 (Table 2-4) suggest that there is weak or no thermal stratification. Temperatures during the 2009 ODEQ sampling event (Table 2-5) ranged from 20.7 to 22.9°C and averaged 22.03°C. In none of the profiles was there a 1°C decrease per meter in depth. However, water temperatures are high in September and begin to decline as air temperatures decline. Thus, it is possible that a thermocline might develop, which might provide some cool water refugia for adults. This is important because many steelhead reject the mainstem river during August and seek cool water in tributaries to the mainstem, which impacts their ultimate migration and spawning areas (High, Peery, and Bennett 2006). Nine observations from five sampling locations during the August to October 2008 ODEQ sampling events (Table 2-7) had temperature values ranging from 18.88 to 22°C; vertical measurements taken on the same day in other locations in the reservoir resulted in similar temperature values, suggesting weak or no stratification in the reservoir during this period.

From January 2007 through May 2017, maximum daily temperatures from Corps monitoring station JHAW (John Day Dam tailwater; RM 214.7) exceeded the Washington state daily maximum criteria on 627 days (Figure 2-5); on average, about 63 days per year when ignoring the 2017 calendar year when summer temperatures were not yet reported. Over the same period, maximum daily temperatures from Corps monitoring station TDA (The Dalles Dam forebay; RM 192.6) exceeded the Washington state daily maximum criteria on 594 days (Figure 2-6); on average, about 59 days per year. Station TDA does not have data from late summer/early fall through late winter/early spring. Also, maximum daily temperatures from Corps monitoring station TDDO (The Dalles Tailwater; RM 189.1) exceeded the Washington state daily maximum criteria on 625 days (Figure 2-7); on average, about 63 days per year. Summaries of maximum daily temperatures are provided for stations JHAW, TDA, and TDDO in Table 2-8, Table 2-9, and Table 2-10, respectively. Water temperatures at The Dalles tailwater location TDDO generally do not appear substantially different from those at John Day tailwater location JHAW. Hourly temperature data at different depths (from 1 to 80 meters) from station TDA from June to October 2012 is shown in Figure 2-8; at no time was there more than a 1°C decrease per meter of depth, indicating weak or no stratification in the reservoir during this period.

Figure 2-5. Maximum Daily Temperature (°C) at Corps Station JHAW from Jan 1, 2007, to May 31, 2017

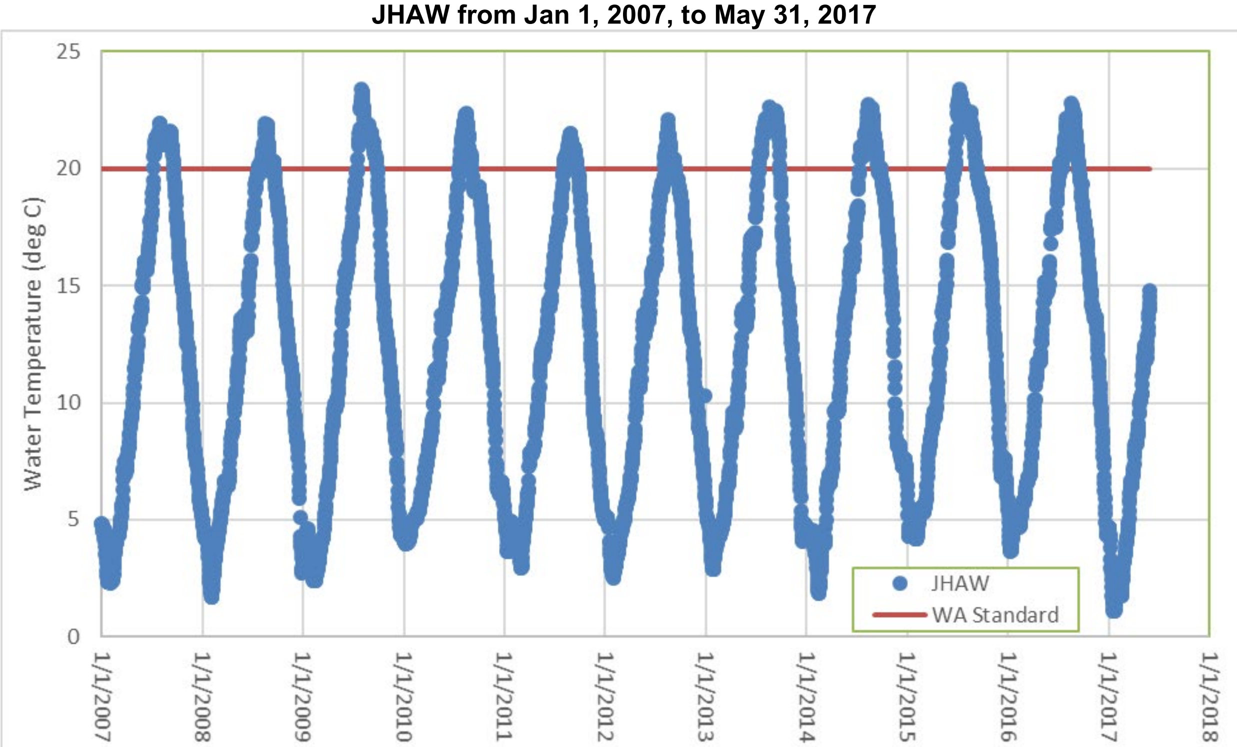


Figure 2-6. Maximum Daily Temperature (°C) at Corps Station TDA from Jan 1, 2007, to May 31, 2017

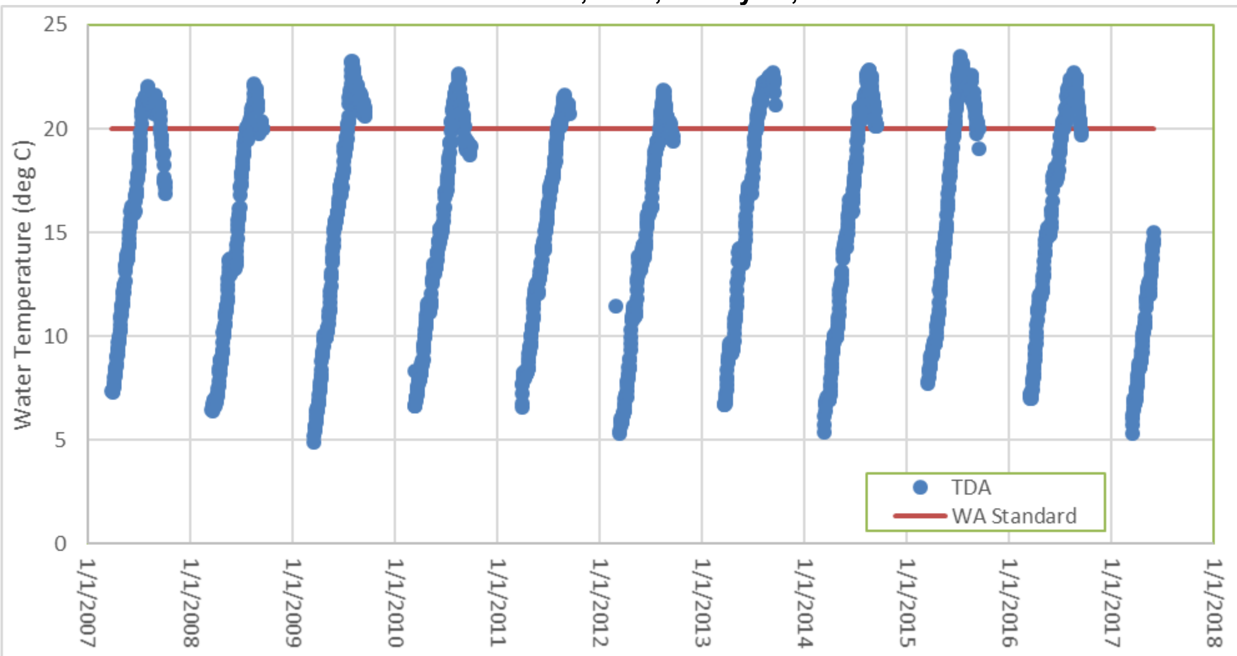


Figure 2-7. Maximum Daily Temperature (°C) at Corps Station TDDO from Jan 1, 2007, to May 31, 2017

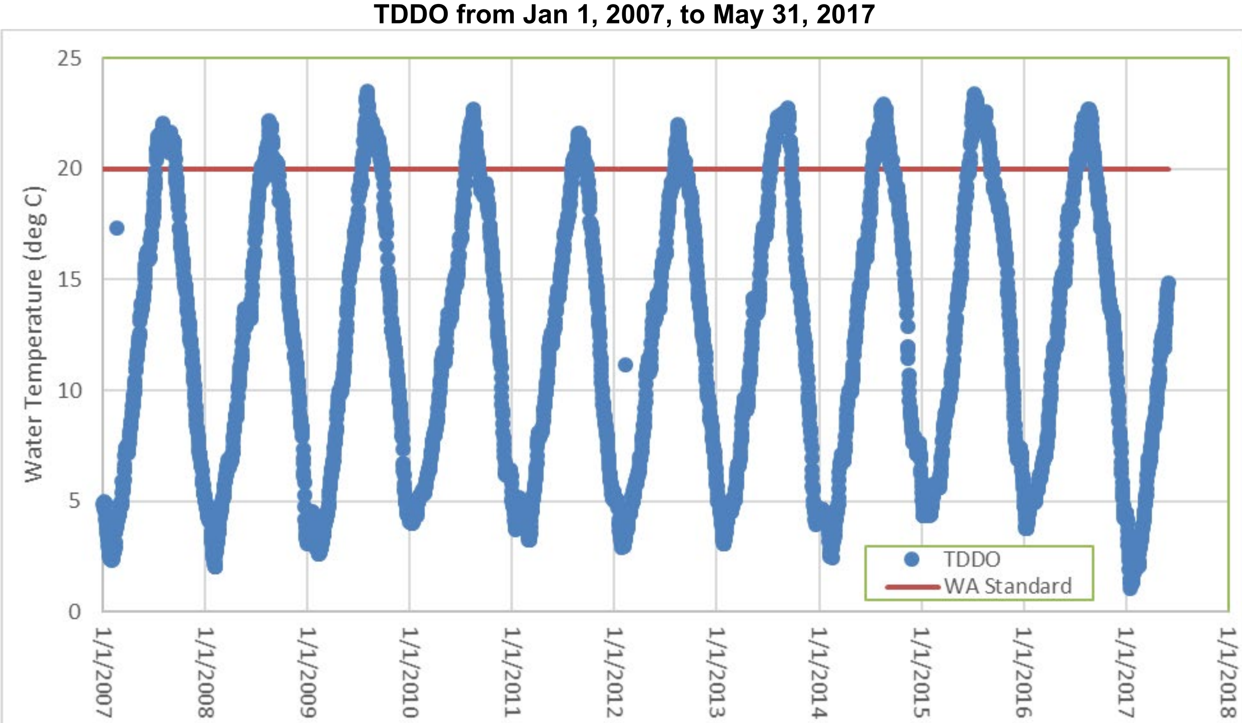
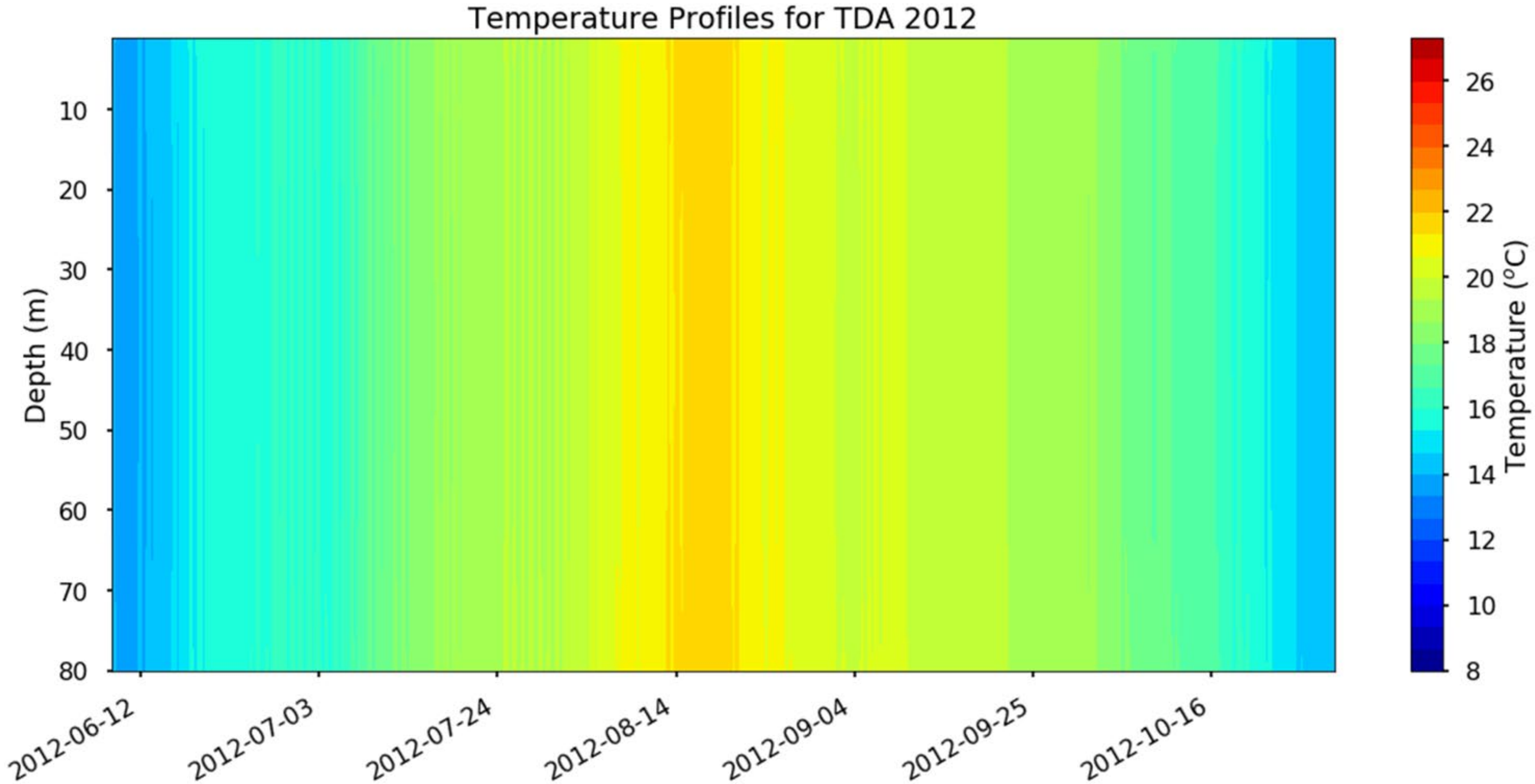


Table 2-10. Annual Summary of Maximum Daily Water Temperature Data from Corps Station TDDO from 2007 to 2016 (°C)

Year	Minimum	Maximum	Average	Median
2007	2.4	22.1	12.4	12.4
2008	2.0	22.2	12.0	12.2
2009	2.6	23.5	12.1	11.6
2010	4.0	22.7	12.5	12.6
2011	3.2	21.6	11.8	11.9
2012	2.9	22.0	12.1	12.5
2013	3.1	22.7	12.6	12.7
2014	2.4	22.9	12.7	12.9
2015	4.3	23.4	13.6	14.0
2016	3.8	22.7	13.3	13.8

Figure 2-8. Temperature (°C) at Corps Station TDA at Different Depths (meters) in 2012



2.2.1.2 *Barometric Pressure*

Barometric pressure, also known as the air pressure, is the weight of the overlying air pressing down on the earth. Barometric pressure has important effects on water chemistry and weather conditions. It affects the amount of gas, such as oxygen, than can dissolve in water. More gas can dissolve in water under higher air pressure than when under lower air pressure. One atmosphere of pressure is equal to 760 millimeters of mercury (mmHg). Barometric pressure is the used in the calculation of the total dissolved gas percent saturation.

Barometric pressure was not reported in data sources used for this analysis.

2.2.1.3 *Total Dissolved Gas*

TDG is a measure of air dissolved into water. TDG is usually discussed in terms of %TDG, which is the percent of total dissolved gas saturation in the water body. The %TDG is calculated by dividing the TDG pressure by the barometric pressure times 100. When fish and other aquatic species are exposed to elevated TDG, the excess gas can build up in their bloodstream and tissues, causing a condition called gas bubble trauma, with symptoms ranging from minor injuries to death depending on the TDG concentration. When water plunges into a pool, it takes air bubbles with it. The high pressure causes the bubbles to dissolve into the water, and the water becomes supersaturated with gases, primarily nitrogen. High spill levels at the dams can increase TDG in the water below the dam because as water flows over the spillway, air becomes trapped by the spill flow. As a result, most of the time, the water that flows over the spillway increases in TDG levels in proportion to increase in flow. However, certain dams, including the Dalles Dam, have flow deflectors that are capable of removing TDG from the water, resulting in lower TDG levels with increased spill. Generally, the background TDG levels go through the project turbines unchanged. TDG generation at a dam is a function of many factors such as structural configurations, spill operations, operational policies, state TDG standards, spill priority list order, spill patterns, total river flow rate, background TDG properties, powerhouse capacity, water temperature, and wind. This comprehensive set of factors result in different TDG production estimates at each dam. Applicable TDG water quality standards are discussed in Appendix 2. The number of TDG instances at Stations JHAW (John Day Tailwater) and TDA (The Dalles Forebay) exceeding water quality standards from 2007 through 2016 are summarized in Table 2-11. The John Day Tailwater averages 17 TDG exceedances per year, while The Dalles Forebay only averages 12 exceedances per year. Hourly TDG percent saturations for stations JHAW and TDA are shown in Figure 2-9 and Figure 2-10.

Table 2-11. Number of Total Dissolved Gas Instances Exceeding Water Quality Standards from 2007 to 2016

Year	John Day Tailwater	The Dalles Forebay
2007	3	8
2008	17	17
2009	7	11
2010	0	0
2011	18	24
2012	35	41
2013	0	9
2014	19	11
2015	71	0
2016	0	2
Average	17	12

Figure 2-9. Total Dissolved Gas (% Saturation) at Corps Station JHAW

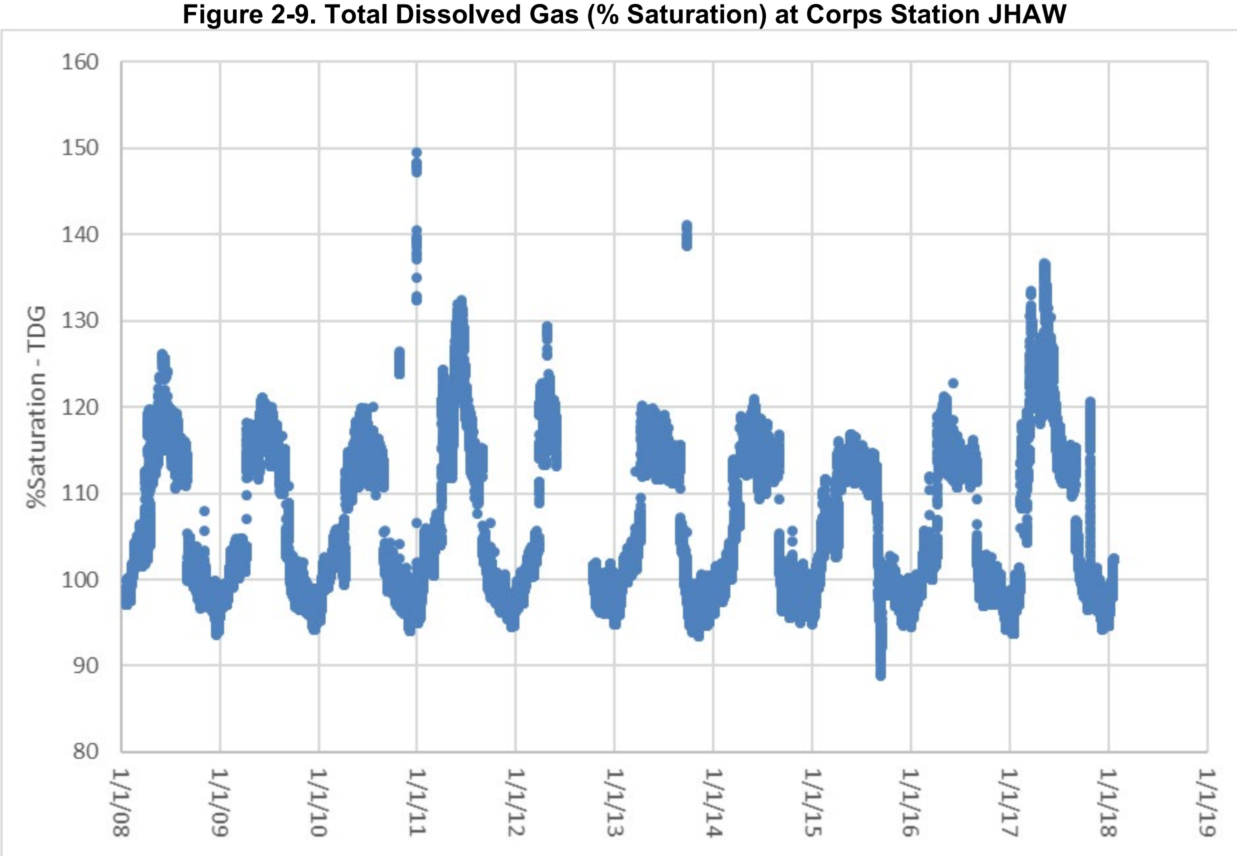
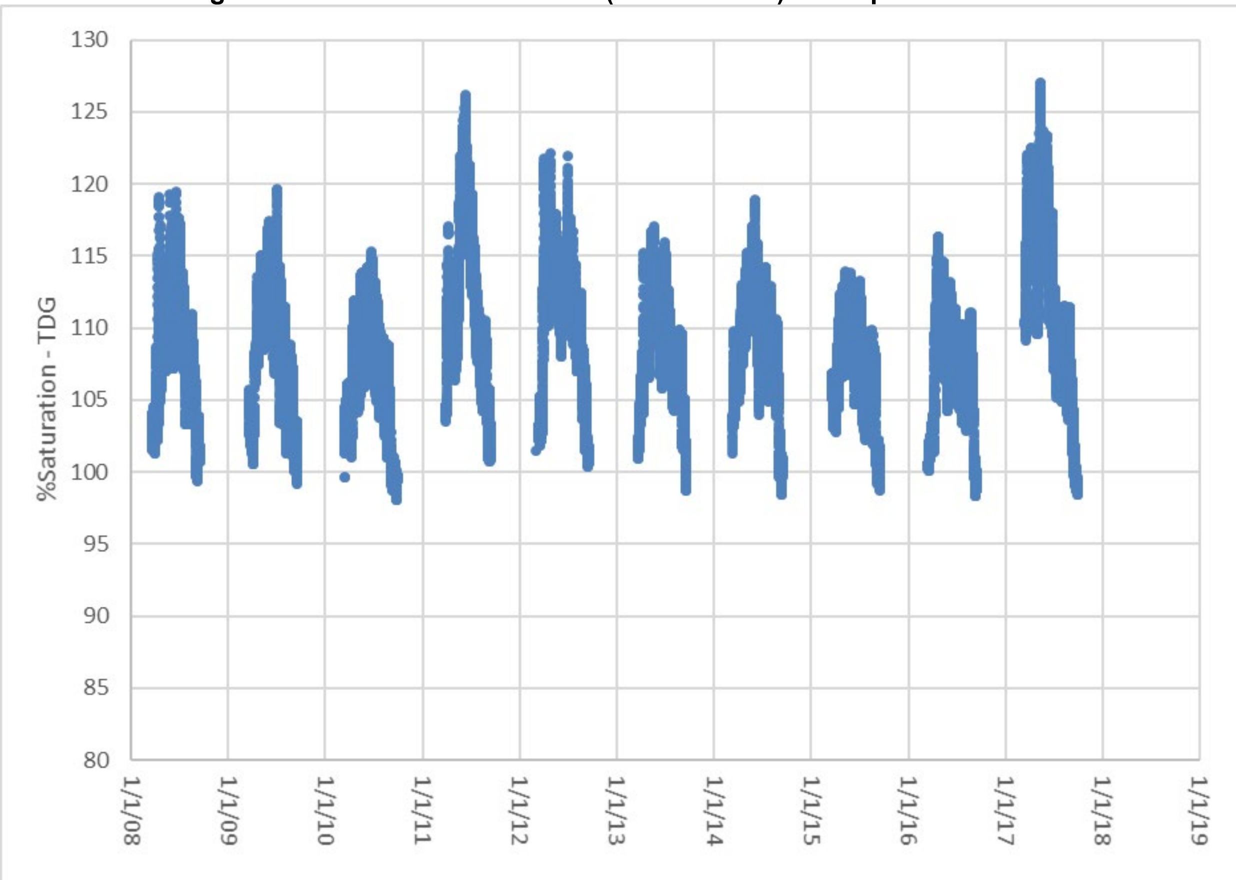


Figure 2-10. Total Dissolved Gas (% Saturation) at Corps Station TDA



2.2.1.4 *Dissolved Oxygen*

DO is the amount of oxygen dissolved in water. Higher forms of aquatic life require oxygen for survival, and the DO determination is used widely in evaluations of the biochemistry of streams and lakes. This oxygen comes from sources such as the atmosphere, aeration, and photosynthesis. The DO concentration may be depleted by processes that consume dissolved, suspended, or precipitated organic matter. Due to photosynthesis, DO typically follows a diurnal pattern rising and falling during daytime and nighttime processes. Photosynthesizing biota can also produce DO values above equilibrium concentrations. In general, aquatic life depends on DO concentrations greater than 5.0 milligrams per liter (mg/L).

Depth profiles from the August to September 2009 ODEQ dataset (Table 2-4) suggest that DO does not vary much with depth. DO concentrations during the 2009 ODEQ sampling event (Table 2-5) ranged from 8.6 to 9.3 mg/L, and averaged 8.9 mg/L. Two observations from sampling location 35558 during the 2008 ODEQ sampling events (Table 2-7) had DO concentrations of 7.55 to 9.42 mg/L and averaged 8.49 mg/L.

2.2.1.5 *pH*

pH is used to indicate the acidity of water and is based on a scale of 0 to 14. Values of less than 7 means the water is acidic or has a higher concentration of hydrogen ions. A reading of higher than 7 means the water is basic or alkaline and has a higher ability to neutralize acids. During photosynthesis, plants use the energy from the sun to convert carbon dioxide (CO_2) to oxygen and sugar, causing an uptake of hydrogen and increase in the pH of the water. The process of respiration and carbon dioxide production releases hydrogen ions, leading to lower pH. Because photosynthesis happens during daylight hours, pH levels may fluctuate from day to night, as well as throughout the seasons and with depth.

A reduction in pH, or acidification, has a negative effect on the reproduction of many aquatic organisms, such as mollusks, zooplankton and fish species. Aquatic species have different tolerances for life in low pH conditions, and although conditions may not lead to death for an individual, it may mean reduced ability in reproduction or growth.

Depth profiles from the September 2009 ODEQ dataset (Table 2-4) suggest that pH does not vary much with depth; this observation must be qualified, however, because these depth profiles were only available during one relatively short period. pH during the 2009 ODEQ sampling event (Table 2-5) ranged from 7.9 to 8.1, and averaged 8.0. This suggests that pH does not vary much within the reservoir at a given time. Five observations from four sampling locations during the 2008 ODEQ sampling events (Table 2-7) had pH values ranging from 7.59 to 8.59.

2.2.1.6 *Specific Conductivity*

Specific conductivity is a measurement of a solution’s ability to conduct electricity and is often used as an indicator of the amount of dissolved ions present since specific conductivity increases with an increase in dissolved ions.

Depth profiles from the September 2009 ODEQ dataset (Table 2-4) suggest that conductivity does not vary much with depth. Specific conductivity during the 2009 ODEQ sampling event (Table 2-5) ranged from 150 to 152 μS/cm, which suggests little variability in specific conductivity along this reach. Nine observations from five sampling locations during the 2008 ODEQ sampling events (Table 2-7) had specific conductivity values ranging from 118 to 145 μS/cm, which suggests some temporal variability; measurements taken on the same day resulted in similar specific conductivity values.

2.2.1.7 *Water Transparency*

Water transparency was measured in Lake Celilo using a Secchi disk, which is an 8-inch disk with alternating black and white quadrants. The depth at which the disk can no longer be seen in the water is called the Secchi disk depth. This depth is a relative measure of water transparency that can be used to look at changes in water clarity over time and between sampling stations. Water clarity is an important parameter when determining the trophic status of a lake because the amount of algae suspended in the water column (phytoplankton) directly impacts transparency. Other factors that can affect transparency include turbidity from suspended matter, soil particles, and natural water color.

Secchi disk depth measured at five locations in this reach during the 2009 ODEQ sampling event (Table 2-5) ranged from 2.8 to 3.3 meters and averaged 3.0 meters.

Secchi disk depth in The Dalles forebay is also reported on the University of Washington Columbia River Data Access in Real Time (DART) webpage (Columbia River DART 2018). Though Secchi disk depth is described on the page as turbidity, it is measured with a Secchi disk. Daily Secchi disk depth measurements for The Dalles forebay from 2008 and 2009 are shown in Figure 2-11 and Figure 2-12 (Secchi disk depth is not reported after 2009).

Figure 2-11. Secchi Disk Depth (in feet) in The Dalles Forebay in 2008

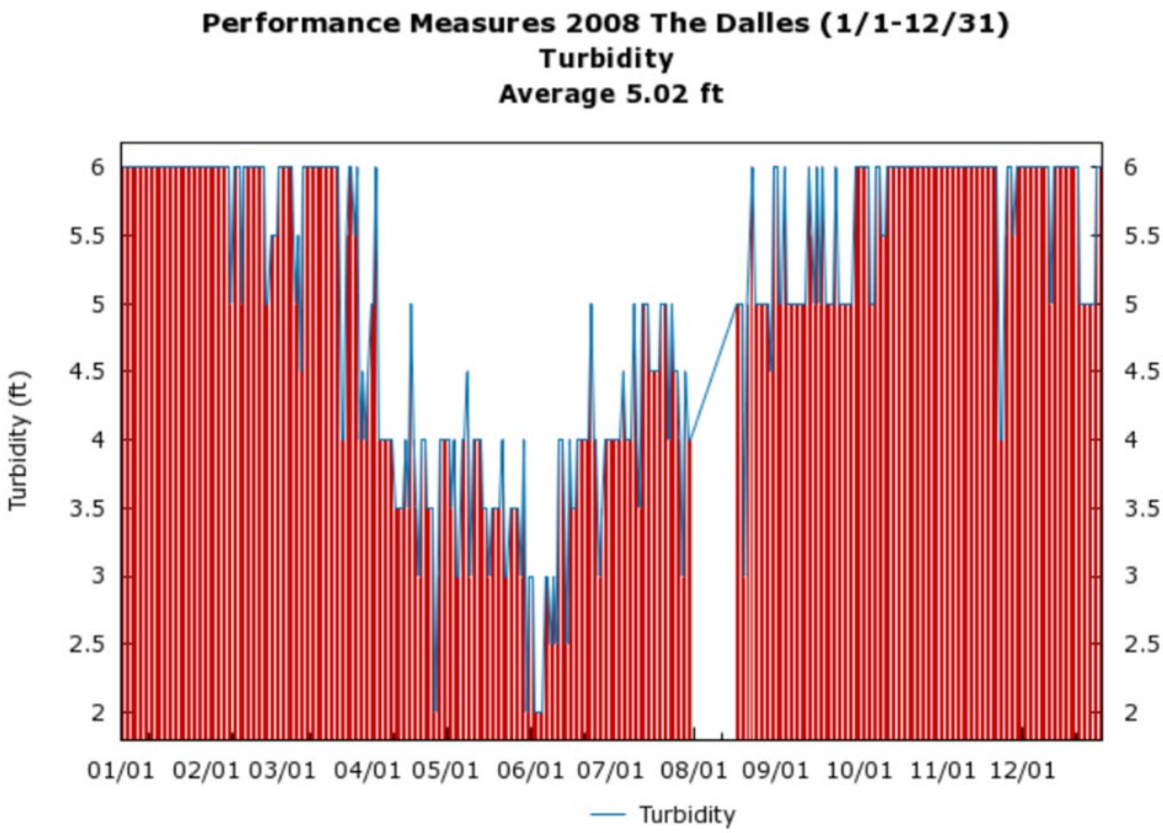
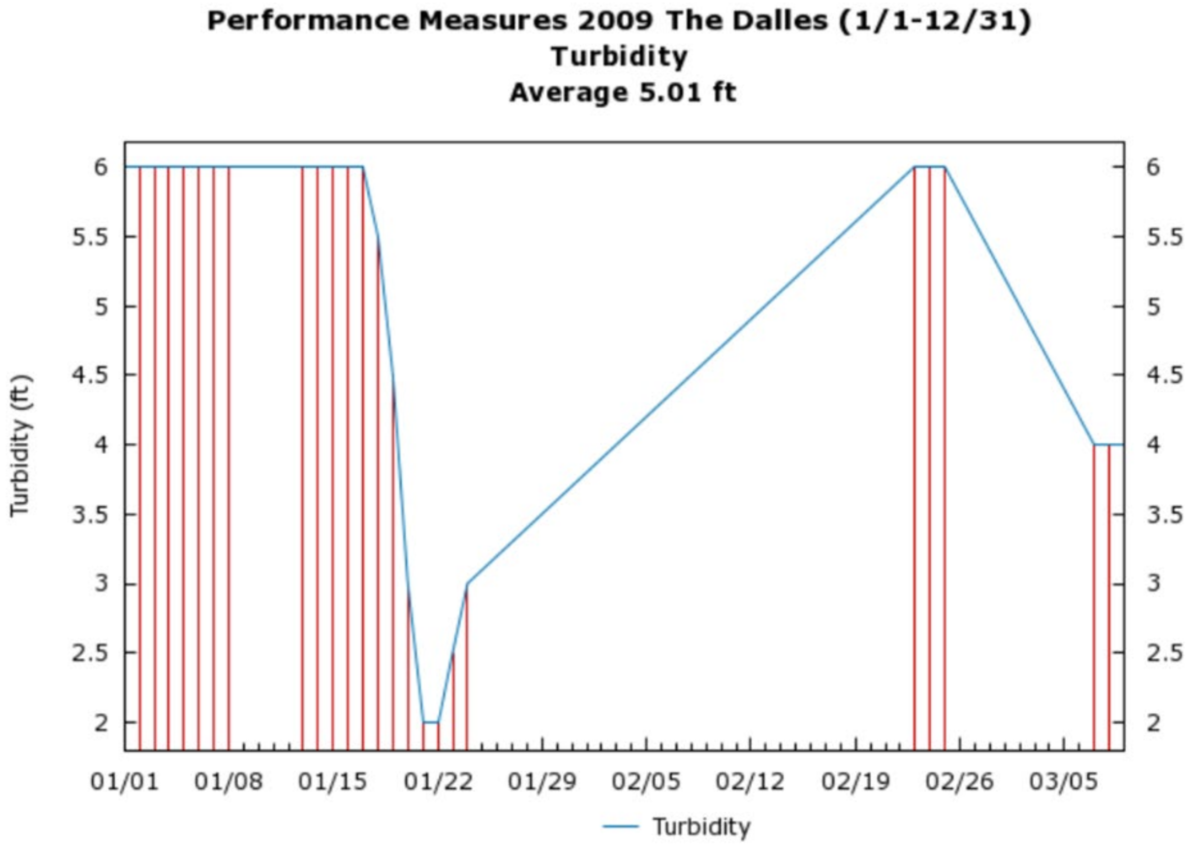


Figure 2-12. Secchi Disk Depth (in feet) in The Dalles Forebay in 2009



2.2.2 Chemical

2.2.2.1 *Turbidity*

Turbidity is a measure of the cloudiness of water and can provide an estimate of total suspended solids and sediments in water such as clay, silt, organic matter, and plankton. Turbidity levels of greater than 10 NTU may lead to stress of aquatic life while turbidity levels of greater than 100 NTU are unsafe levels for most aquatic life. However, a certain degree of turbidity is a key water quality parameter affecting juvenile salmon, as it decreases their visibility to piscivorous predators.. The presence of the dam and reservoir decreases turbidity. Junge and Oakley (1966) reported that salmon productivity decreased in the river as a result of dam and reservoir construction. Turbidity and suspended solids are measures of sediment transport, an important geophysical function of rivers that provides diversity in hydraulic geometry and key nutrients to ecological systems (Vannote et al. 1980; Williams et al. 1996).

Depth profiles from the September 2009 ODEQ dataset (Table 2-4) suggest that turbidity does not vary much with depth and did not exceed 2 NTU (Table 2-5).

2.2.2.2 *Suspended Solids*

Suspended solids are small solid particles that remain in suspension in water as a colloid or due to the motion of the water. These solids include anything drifting or floating in the water, from sediment, silt, and sand to plankton and algae. Suspended particles can come from soil erosion, runoff, discharges, stirred bottom sediments, or algal blooms. While it is possible for streams to have naturally high levels of suspended solids, clear water is usually considered an indicator of healthy water. Stream water with a total suspended solids concentration less than an average of 50 mg/L over a 28-day period is considered healthy for fish communities. A sudden increase in suspended solids (or turbidity) in a previously clear body of water may be cause for concern. Excessive suspended sediment can impair water quality for aquatic and human life, impede navigation, and increase flooding risks.

Suspended solids during the 2009 ODEQ sampling event (Table 2-5) was 2 mg/L at all 5 sampling locations, which suggests little variability in suspended solids along this reach.

2.2.2.3 *Major Cations (Ca, Mg, Na, K) and Anions (SO_4, Cl)*

The chemical composition of the major ions of many freshwater lakes is largely derived from the weathering of soils and rocks in the drainage basin, atmospheric precipitation, and evaporation (Wetzel 1975). The ion balance of most freshwaters are dominated by the major cations calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K), and the major anions carbonate (CO_3), bicarbonate (HCO_3), sulfate (SO_4), and chloride (Cl). Other elements, such as phosphorus and nitrogen, are important biologically but are typically only a minor part of the overall chemical composition of freshwater ecosystems.

Calcium concentrations during the 2009 ODEQ sampling event (Table 2-5) ranged from 17.3 to 17.5 mg/L and averaged 17.38 mg/L. Magnesium concentrations (Table 2-5) ranged from 4.84 to 4.94 mg/L and averaged 4.89 mg/L. Sulfate concentrations (Table 2-5) ranged from 9.5 to 11.1 mg/L and averaged 10.7 mg/L. Minimal variation was observed in calcium, magnesium, and sulfate concentrations between sampling stations.

Sodium, potassium, and chloride were not reported in data sources used for this analysis.

2.2.2.4 *Alkalinity and Hardness*

Alkalinity is a measure of the buffering capacity of the water to changes in pH. In many freshwater ecosystems, alkalinity is a function of the concentration of bicarbonates, carbonates, and hydroxides (Wetzel 1975). Hardness is a measure of the amount of calcium and magnesium salts in water that are often combined with either bicarbonate or carbonate, or with anions such as sulfate or chloride (Wetzel 1975). Harder waters have greater concentrations of calcium and magnesium salts. In freshwater, hardness can be important in determining the toxicity of many metals, such as cadmium, chromium, copper, lead, and zinc. Toxicity decreases with an increase in hardness. Therefore, hardness measurements are sometimes used to calculate water quality criteria for various metals.

Alkalinity during the 2009 ODEQ sampling event (Table 2-5) ranged from 60 to 61 mg/L as $CaCO_3$, and averaged 60.4 mg/L as $CaCO_3$, suggesting little variability in alkalinity along this reach during the brief sampling period. Hardness during the 2009 ODEQ sampling event (Table 2-5) ranged from 63.2 to 63.7 mg/L as $CaCO_3$, and averaged 63.5 mg/L as $CaCO_3$, also suggesting little variability in hardness along this reach during the brief sampling period.

2.2.2.5 *Nitrogen*

Nitrogen, like phosphorus, is essential for the growth and production of algae in fresh waters. In freshwater ecosystems, nitrogen exists in many forms including dissolved molecular nitrogen, organic nitrogen, nitrite, nitrate, and ammonia. Sources of nitrogen to freshwaters are varied and include atmospheric inputs via precipitation, nitrogen fixation in the water and sediments, and via surface and groundwater inputs. Losses of nitrogen in the freshwater ecosystem include outflow from the system, reduction of nitrate to nitrogen via denitrification and the subsequent release of nitrogen from the water to the atmosphere, and sedimentation of inorganic and organic forms of nitrogen (Wetzel 1975). The most common forms of nitrogen used by freshwater plants for growth are the dissolved forms that include ammonia-nitrogen and nitrate-nitrogen.

Three forms of nitrogen are typically measured, total nitrogen, nitrate + nitrite (NO_3 + NO_2-N), and ammonia (NH_4^+-N + NH_3-N). The dissolved inorganic forms of nitrogen, ammonia and nitrate + nitrite are all readily available for plant growth. Total nitrogen includes all inorganic plus organic forms of nitrogen, while nitrate + nitrite represents total oxidized nitrogen, with nitrite being an intermediate state between ammonia and nitrate. Nitrate is an essential plant nutrient, while nitrite can be a plant nutrient but is generally rapidly oxidized to ammonia in oxygenated waters. Ammonia nitrogen is an essential plant nutrient that is often used before nitrate. Ammonia is formed in the natural environment through the fixation of nitrogen gas, excretion by animals, and the decomposition of plants and animals. In the aquatic environment, ammonia is produced and excreted by fish. Ammonia is reported as the combined ionized (NH_4^+-N - ammonium) and unionized (NH_3-N - ammonia) forms of ammonia.

The data used to assess nitrogen impacts is about 10 years old. Because of the low frequency of recent sampling events, the observations and inferences regarding this data may be of limited utility; the lack of recent data could be problematic with respect to evaluating the project impacts on anadromous fish, critical habitat, and productivity.

<u>Total Nitrogen</u>

Total nitrogen was not reported in data sources used for this analysis.

2.2.2.6 *Nitrate + Nitrite*

Nitrate plus nitrite concentrations during the 2009 ODEQ sampling event (Table 2-5) ranged from 0.0649 to 0.102 mg/L as nitrogen, and averaged 0.0807 mg/L as nitrogen.

2.2.2.7 *Ammonia*

Ammonia was not detected during the 2009 ODEQ sampling event (Table 2-5).

2.2.2.8 *Phosphorus*

Phosphorus, along with nitrogen, is a major nutrient required for the growth and productivity of aquatic plants. The vast majority of water quality problems in lakes are associated with an overabundance of these nutrients resulting in excessive aquatic plant growth, causing nuisance algae blooms and resulting decay. The decay of large amounts of algae can reduce oxygen concentrations to levels that are difficult to maintain many organisms. In freshwater ecosystems, phosphorus is generally the nutrient with the smallest supply to demand ratio for aquatic plant growth. Consequently, phosphorus is often the nutrient that limits productivity in freshwater ecosystems. Increased phosphorus and nitrogen inputs to freshwater ecosystems from human activities can be attributed to numerous sources including the discharge of detergents, runoff containing fertilizers, seepage from failing septic systems, urban runoff, and sewage discharges (Hem 1985). Phosphorus concentrations in Lake Celilo were reported as total phosphorus and soluble reactive phosphorus.

The data used to assess phosphorus impacts is about 10 years old. Because of the low frequency of recent sampling events, the observations and inferences regarding this data may be of limited utility; the lack of recent data could be problematic with respect to evaluating the project impacts on anadromous fish critical habitat and productivity.

Total Phosphorus

Total phosphorus represents all phosphorus in solution, both dissolved and particulate, including all organically combined phosphorus and all phosphate. Total phosphorus concentrations during the 2009 ODEQ sampling event (Table 2-5) ranged from 0.02 to 0.03 mg/L and averaged 0.022 mg/L.

Soluable Reactive Phosphorus

Soluble reactive phosphorus represents the dissolved form of phosphorus that is readily available for aquatic plant uptake. Orthophosphate (which is the inorganic fraction of soluble reactive phosphorus) was detected in all samples during the 2009 ODEQ sampling event (Table 2-5) with concentrations that ranged from 0.009 to 0.012 mg/L and averaged 0.0102 mg/L. The differences in total phosphorus and orthophosphate concentrations suggest that, while orthophosphate can make up a substantial portion of the total phosphorus, other phosphorus species are also present.

2.2.2.9 *Trace Metals*

Of the many trace metals evaluated in the 2009 ODEQ dataset (summarized in Table 2-5), only mercury, barium, and uranium were detected. Accumulation of trace metals (including methyl mercury) in reservoirs can be a serious water quality issue. Because of the low frequency of recent sampling events, the observations and inferences regarding this data is of limited utility.

Mercury

Organomercuric compounds were widely used as biocides for treatment of seed grain and in various other applications until these uses were banned in the 1960s. A major source of mercury pollution in surface water prior to 1970 was the production of chlorine and sodium hydroxide (mercury was used in the electrolysis cells [Wershaw 1970]); the amount of mercury escaping to the environment through this source has decreased greatly since 1970. The release of mercury to the atmosphere in smelting and fossil fuel combustion have raised the general background level of mercury in the environment substantially above its pre-industrial status (Hem 1985). Based on available data, atmospheric deposition appears to be the major pathway for mercury loading to the Columbia River Basin (EPA 2009). Mercury air deposition includes both emissions from industrial facilities within and near the basin and fallout from the pool of global mercury that has been transported from sources as far away as Asia and Europe. As of 2009, local and regional sources included a cement plant in Durkee, Oregon; several gold mines in northern Nevada; an elemental phosphorous plan in Soda Springs, Idaho; and four coal-fired power plants within or near the boundaries of the basin. Wastewater treatment plants, industrial discharges, and stormwater runoff make up a smaller but not insignificant portion of the mercury loading to the Columbia River Basin.

Elemental mercury is a liquid at normal Earth-surface temperatures, but it is also somewhat volatile at these temperatures. The stable form in most natural water systems is the free metal, Hg(aq) or aqueous mercury. The amount that would be present in water open to the atmosphere is likely to be much lower owing to its tendency to escape as vapor. Mercury may form chloride or hydroxide complexes depending on pH and total chloride concentration. Organic complexes such as methyl mercury and other similar forms can be produced by methane-generating bacteria in contact with metallic mercury in lake or stream sediment (Wood, Kennedy, and Rosen 1968). In this form, the element appears to be concentrated in successive biological species along aquatic food chains so that fish that live in mildly contaminated environments may contain too much mercury to be used safely for food. Concentrations of mercury in filtered natural river water generally are very small, rarely exceeding a few tenths of a microgram per liter. The amount of dissolved mercury that may occur in the form of organic complexes is uncertain, although it appears from available thermodynamic data that the concentrations of mercury occurring in solution even in water that is known to be polluted are below the solubility limits for the common inorganic forms (Hem 1970).

Due to moderate levels of mercury in fish, the Oregon Health Authority (OHA) recommends a limit of one meal per week of resident fish from the Ruckel Creek (1 mile upstream of Bonneville Dam to McNary Dam) (OHA 2017). Dissolved mercury and total and dissolved methyl mercury were not detected in the 2009 ODEQ sampling effort (summarized in Table 2-5). Total recoverable mercury was detected in 80 percent of the samples during that time, ranging from 0.545 to 0.802 ng/L and averaging 0.645 ng/L (Kaplan-Meier mean). The detections of total mercury and lack of detections for dissolved mercury indicate that the majority of mercury burden is associated with suspended particulates.

Barium

Barium is an alkaline earth metal. A likely control over the concentration of barium in natural water is the solubility of barite (BaSO4), which is a fairly common mineral (Hem 1985). The solubility product for barite is near 10^{-10}, so at sulfate concentrations near 10 mg/L, the corresponding equilibrium concentration of barium would be 0.14 mg/L (or 140 µg/L). Typically, high barium concentrations are associated with low sulfate concentrations (Hem 1985). Another factor that seems likely to influence the concentration of barium in natural water is adsorption to metal oxides or hydroxides. Durum and Haffty (1963) reported a median concentration of 0.045 mg/L in the larger rivers of North America.

In the September 2009 ODEQ dataset (summarized in Table 2-5), barium concentrations were rather consistent across the reach, ranging from 27.8 to 28.8 µg/L and averaging 28.24 µg/L. These barium concentrations are below both the median concentration in larger North American rivers (Durum and Haffty 1963). Additionally, these barium concentrations are lower than what would be expected with sulfate concentrations near 10 mg/L (Hem 1985), which is what was observed in the ODEQ dataset.

Uranium

Natural uranium is composed of several isotopes, of which uranium-238 is predominant. Stability and solubility diagrams show that reduced species (where the oxidation state is U^{4+}) are only slightly soluble, but that more highly oxidized forms (such as the uranyl ion, UO_2^{2+}) and the anionic species present at high pH are more soluble (Hem 1985). Uranium complexes with carbonate and sulfate may influence the behavior of dissolved uranium. The chemical properties of the U^{6+} state favor the wide dispersion of uranium in the oxidized portion of the Earth's crust. Uranium is present in concentrations between 0.1 and 10 picograms per liter (pg/L) in most natural water. Concentrations greater than 1 mg/L can occur in water associated with uranium-ore deposits (Hem 1985).

In the September 2009 ODEQ dataset (summarized in Table 2-5), uranium concentrations ranged from 0.72 to 0.73 µg/L and averaged 0.726 µg/L. These concentrations far exceed what is typically observed in natural water.

2.2.2.10 *Organic Carbon*

Total organic carbon is the amount of carbon found in an organic compound and is often used as a non-specific indicator of water quality. Total organic carbon in waters comes from decaying natural organic matter and synthetic sources. Humic acid, fulvic acid, amines, and urea are examples of natural organic matter. Some detergents, pesticides, fertilizers, herbicides, industrial chemicals, and chlorinated organics are examples of synthetic sources. Dissolved organic carbon is the organic carbon remaining in a sample after filtering the sample, which removes the particulate organic carbon fraction.

Total organic carbon during the 2009 ODEQ sampling event (Table 2-5) measured 2 mg/L at all 5 locations in the reach. Dissolved organic carbon during the 2009 ODEQ sampling event (Table 2-5) also measured 2 mg/L at all 5 locations in the reach. The similarity is the total and dissolved organic carbon concentrations indicates that the majority of organic carbon is present in the dissolved fraction. Additionally, there does not appear to be much variability in total and dissolved organic carbon along this reach.

Polychlorinated Biphenyls

PCBs are a family of man-made organic chemicals that were domestically produced from 1929 until 1979 when their manufacture was banned. Due to their non-flammability, chemical stability, high boiling point, and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications including:

- Electrical, heat transfer, and hydraulic equipment (e.g., transformers and capacitors, fluorescent light ballasts, cable insulation, thermal insulation)
- Plasticizers in paints, plastics and rubber products
- Pigments, dyes, and carbonless copy paper

PCBs have been demonstrated to cause a variety of adverse health effects, including cancer and a number of serious non-cancer health effects (e.g., effects on the immune system, reproductive system, nervous system, and endocrine system). PCBs can still be released into the environment today from poorly maintained hazardous waste sites, illegal dumping of PCB waste, leaks or releases from electrical transformers containing PCBs, disposal of PCB-containing consumer products into landfills not designed to handle hazardous waste, etc. PCBs in the Columbia River tend to be associated with industrial locations where spills or historic handling practices were more likely to occur. Examples of known PCB disposal sites include Bradford Island at Bonneville Dam and the Alcoa Smelter in Vancouver, Washington. In addition, historically, many pieces of electrical equipment used to generate power at dams in the Columbia River Basin used cooling and insulating oil that contained PCBs. Once in the environment, PCBs do not readily break down. PCBs are not very water-soluble and tend to adhere to organic matter and sediment particles and, therefore, have a high potential to be transported when sediment is transported. PCBs tend to concentrate in the fatty tissue of fish and other animals and can be passed from mother to young. As a result, people who ingest fish may be exposed to PCBs that have bioaccumulated in the fish they are ingesting.

PCB levels have triggered fish and shellfish advisories in the lower Columbia River (EPA 2009).

PCBs were not reported in data sources used for this analysis.

Dioxins

Dioxins are a group of highly toxic persistent organic pollutants that can cause cancer, reproductive and developmental problems, damage to the immune system, and can interfere with hormones. Dioxins are formed in the manufacture of chlorinated organic compounds (such as some herbicides), the combustion of domestic and industrial wastes, the production of chlorine-bleached wood pulp, and the burning of fuels (like wood, coal, or oil). The most studied and most toxic of all dioxins is 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). The concern over dioxin levels in the Columbia River is related to 2,3,7,8-TCDD in effluents and treatment plant sludges at chlorine-bleaching pulp mills, as well as in fish tissue below these mills (EPA 1991).

Dioxins were not reported in data sources used for this analysis.

2.2.3 Biological

2.2.3.1 *Chlorophyll a*

Chlorophyll a is the primary photosynthetic pigment in all photosynthetic organisms requiring oxygen and is found in all freshwater phytoplankton species. This photosynthetic pigment is essential for oxygenic photosynthesis because of its role as the primary electron donor in the electron transport chain. Although there are several different forms of chlorophyll present in plants, chlorophyll a is the dominant form and is generally considered an indicator of algal biomass in freshwater ecosystems (Wetzel 1975). Thus, measurements of chlorophyll a in a water body can provide in indirect estimate of the amount of algal biomass. It should be noted, however, that there are circumstances where chlorophyll a does not make a good estimate (Cullen 1982).

Chlorophyll a concentrations during the 2009 ODEQ sampling event (Table 2-5) ranged from 0.7 to 2.4 µg/L, and averaged 1.42 µg/L.

2.2.3.2 *Pheophytin a*

Pheophytin a is photosynthetic pigment in green plants that is closely related to chlorophyll a. Pheophytin a is a decomposition product of chlorophyll a; biochemically, a pheophytin a molecule is a chlorophyll a molecule that lacks the central Mg^{2+} ion. Pheophytin a serves as the first electron carrier intermediate in the electron transfer pathway of oxygenic photosynthesis. Thus, like chlorophyll a, pheophytin a can be an indicator of algal biomass. The relationship of chlorophyll a and pheophytin a can be evaluated relative to water quality, but that is not assessed here.

Pheophytin a concentrations from five locations during the 2009 ODEQ sampling event (Table 2-5) ranged from 0.7 to 1.1 µg/L and averaged 0.94 µg/L.

2.2.3.3 *Fecal Coliform and E. Coli Bacteria*

Total coliform bacteria are commonly found in the environment and are generally harmless. Fecal coliform bacteria are a sub-group of total coliform bacteria that appear in great quantities in the intestines and feces of people and animals. The presence of fecal coliform in a water sample often indicates recent fecal contamination, meaning that there is a greater risk that pathogens are present than if only total coliform bacteria is detected. Escherichia coli (E. coli) is a sub-group of fecal coliform bacteria. Most E. coli bacteria are harmless and are found in great quantities in the intestines of people and warm-blooded animals. Some strains, however, can cause illness. The presence of E. coli in a water sample usually indicates recent fecal contamination, meaning there is a greater risk that pathogens are present. Coliform data is reported in MPN/100 mL. The MPN is the number of organisms that are most likely to have produced laboratory results in a particular test. The MPN method is used to quantify the concentration of the viable microorganisms in a sample and involves subdividing the original sample by orders of magnitude and assessing the presence or absence in the multiple subdivisions.

Fecal coliform bacteria was not reported in data sources used for this analysis.

E. coli was detected in 60 percent of samples during the 2009 ODEQ sampling event (Table 2-5), ranging from 1 to 2 MPN/100 mL and averaging 1.4 MPN/100 mL. E. coli bacteria did not exceed the Oregon freshwater recreation criteria (406 E. coli organisms per 100 mL; single sample; OAR 340-041-0009[1][a]) in any sample.

2.2.4 Trophic State Classification

The biological productivity, or trophic state, can be classified into three general categories: oligotrophic (low productivity), mesotrophic (moderate productivity), and eutrophic (high productivity). Lakes with low nutrient concentrations and low rates of algal productivity are classified as oligotrophic. Lakes with high nutrient concentrations and high rates of algal productivity are classified as eutrophic. Mesotrophic lakes have nutrient concentrations and algal productivity between those of eutrophic and oligotrophic lakes. The water quality parameters most often used to assess the trophic state of a lake are total phosphorus, chlorophyll a, and transparency. A useful way to group lakes by trophic state is with the trophic state index (TSI), which is based on linear regression relationships developed for total phosphorus, chlorophyll a, and transparency in lakes (Carlson 1977). TSIs were computed using equations developed by Carlson, which classify a lake as oligotrophic with a TSI value less than 40, as mesotrophic with a TSI value between 40 and 50, and as eutrophic with a TSI value greater than 50. Carlson recommends using summer TSI values to classify lakes.

The TSI was calculated for each sample in the August to September 2009 ODEQ dataset where total phosphorus, chlorophyll a, and Secchi disk depth data was available. The TSI is summarized in Table 2-12 and by river mile in Figure 2-13. The TSI classification over the reach is largely dependent on the factor used to calculate it. TSI values based on chlorophyll a concentrations suggest oligotrophic conditions, while

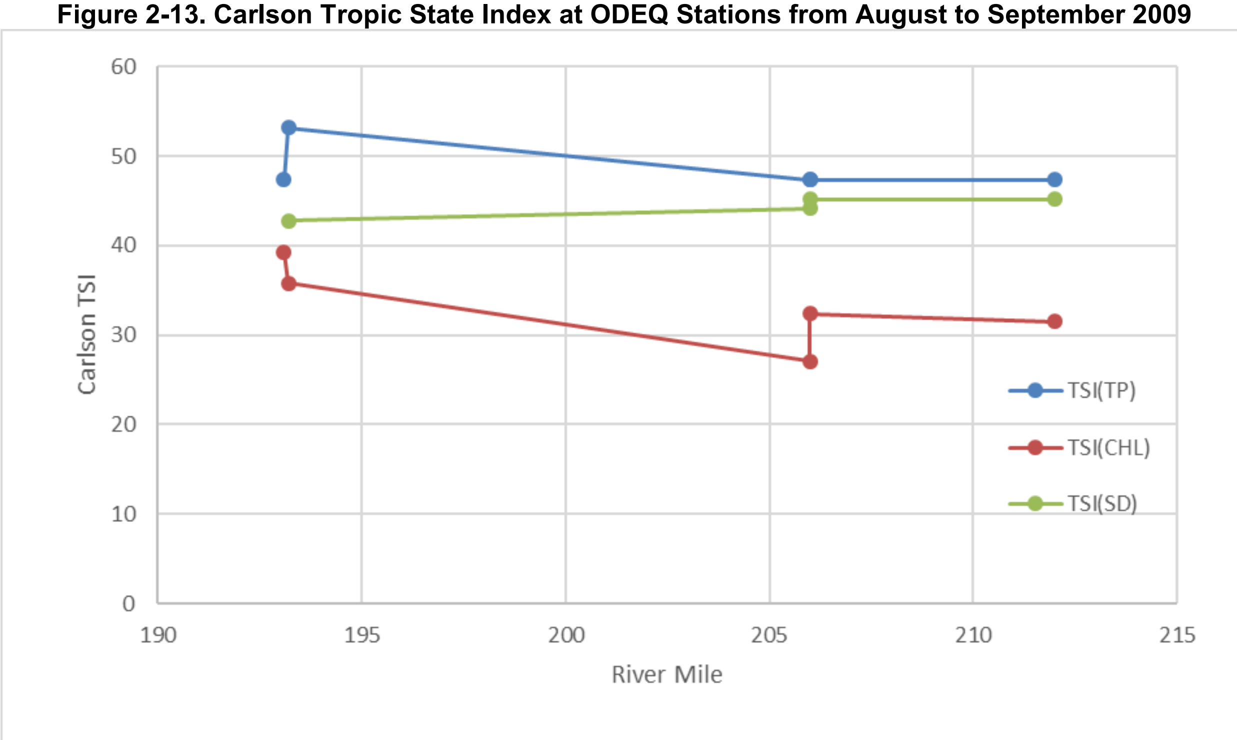
TSI values based on Secchi disk depth and total phosphorus generally suggest mesotrophic conditions. TSI values do not appear to vary much with location in reservoir.

Table 2-12. Summary of Carlson Tropic State Indices at ODEQ Stations from August to September 2009

Statistic	TSI (TP)	TSI (CHL)	TSI (SD)	Classification
Min	47.35	27.10	42.80	Oligotrophic <30-40 to Mesotrophic 40-50
Max	53.20	39.19	45.16	Oligotrophic <30-40 to Eutrophic 50-70
Mean	48.52	33.20	44.32	Oligotrophic <30-40 to Mesotrophic 40-50
Median	47.35	32.39	44.67	Oligotrophic <30-40 to Mesotrophic 40-50
Standard Deviation	2.61	4.56	1.12	

Notes: CHL = chlorophyll a; SD = Secchi disk depth; TP = total phosphorus.

Figure 2-13. Carlson Tropic State Index at ODEQ Stations from August to September 2009



SECTION 3 - SUMMARY

Recent data from several ODEQ stations and three Corps TDG/temperature monitoring stations was available in Lake Celilo for this analysis. Most available ODEQ data was taken in the mid- to late summer, and there are no stations with observations from other seasons. These observations may not hold under different conditions. No monitoring locations were found in the study area that could provide recent long-term assessments of a wide range of water quality parameters; most monitoring locations were limited by lack of sustained sampling efforts in multiple seasons or by the number and kind of observed parameters. The ODEQ data is about 10 years old while the Corps stations are limited in the number of measured parameters (temperature and TDG).

Based on the information used for this analysis, spatial variation was small across the reservoir. Vertical profiles within the water column generally indicated uniformity from surface to bottom; that is, there is weak to no stratification. It is hypothesized that variation within the reservoir would be largely temporal, but there was not enough information available within the last 10 years to support that theory. The following additional observations of the data were made:

- In Lake Celilo, temperature, mercury, and PCBs are the water-based parameters on the 303(d) list. Lake Celilo has TMDLs for dioxins and TDG.
- For most parameters, there does not appear to be much variability within the reservoir during a short period.
- Water temperature does not significantly change within The Dalles Reservoir or as a result of dam operations (downstream of John Day Dam to downstream of The Dalles Dam).
- The highest TDG values occur during the summer when more water is passed through the spillways.
- Carlson TSI calculations suggest that the river is generally oligotrophic to mesotrophic within the reach during the mid to late summer.
- Barium, uranium, and mercury are the only trace metals detected in the river water. The uranium concentrations far exceed what is typically expected in natural waters. The majority of the mercury burden is present in the particulate fraction.

SECTION 4 - REFERENCES

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