

WASHINGTON STATE  
DEPARTMENT OF  
E C O L O G Y

# **Puyallup and White Rivers Temperature and Dissolved Oxygen July – November 2004**

---

## **Monitoring Report**

May 2005

Publication No. 05-10-053

 *Printed on Recycled Paper*

# **Puyallup and White Rivers Temperature and Dissolved Oxygen July – November 2004**

---

## **Monitoring Report**

Prepared by:

Gregory Zentner  
Washington State Department of Ecology  
Water Quality Program

May 2005  
Publication Number 05-10-053



*Printed on Recycled Paper*

For additional copies of this document contact:

Department of Ecology  
Publications Distribution Center  
P.O. Box 47600  
Olympia, WA 98504-7600

Telephone: (360) 407-7472

**(Refer to Publication Number 05-10-053)**

This report is available on the Department of Ecology home page on the World Wide Web at <http://www.ecy.wa.gov/biblio/05-10-053.html>

**Headquarters (Lacey) 360-407-6000**  
**If you are speech or hearing impaired, call 711 or 1-800-833-6388 for TTY**



*If you need this information in an alternate format, please contact us at 360-407-6270. If you are a person with a speech or hearing impairment, call 711 or 800-833-6388 for TTY.*



# Table of Contents

List of Figures .....	ii
Abstract .....	iii
Acknowledgements .....	iv
Introduction .....	1
Sampling Location and Methods .....	1
Results .....	3
White River at River Mile 1.8 .....	3
Temperature .....	3
Dissolved Oxygen .....	5
Data Quality .....	7
Puyallup River at River Mile 11.8 .....	8
Temperature .....	8
Dissolved Oxygen .....	10
Data Quality .....	10
Discussion .....	12
White River .....	12
Puyallup River .....	14
Data Quality .....	16
Conclusions .....	17
References .....	17

# List of Figures

Figure 1.	Puyallup River Sampling Stations .....	2
Figure 2.	White River Temperature – Probe and Thermometer Data .....	3
Figure 3.	White River Daily Average Temperature and 7-DADAVG.....	4
Figure 4.	White River Daily Maximum Temperature and 7-DADMAX.....	4
Figure 5.	White River Uncorrected Dissolved Oxygen Data.....	5
Figure 6.	White River Corrected Dissolved Oxygen Data.....	6
Figure 7.	White River Daily Average Dissolved Oxygen.....	6
Figure 8.	White River Daily Minimum Dissolved Oxygen .....	7
Figure 9.	White River Probe, Thermometer and Laboratory Data.....	8
Figure 10.	Puyallup River Temperature – Probe and Thermometer Data.....	9
Figure 11.	Puyallup River Daily Average Temperature and 7-DADAVG .....	9
Figure 12.	Puyallup River Daily Maximum Temperature and 7-DADMAX .....	10
Figure 13.	Puyallup River Probe, Thermometer and Lab DO Data .....	11
Figure 14.	Puyallup River Uncorrected Dissolved Oxygen Data .....	11
Figure 15.	White River Average Daily Flow at Auburn, Summer 2001 and 2004.....	12
Figure 16.	Lake Tapps Tailrace, Average Daily Flow, Summer 2001 and 2004.....	13
Figure 17.	White River, Maximum Air and Water Temperature, Summer 2004 .....	13
Figure 18.	Flow and Dissolved Oxygen, White River @ RM 1.8, 2001 .....	15
Figure 19.	Puyallup River, Fall Average Daily Flow.....	16

# Abstract

The Washington State Department of Ecology monitored temperature and dissolved oxygen (DO) at two locations on the Puyallup River in the summer and fall of 2004. The monitoring stations are located on the two major tributaries, the upper Puyallup River and the White River, one to two miles upstream of their confluence.

The White River exceeded the state's temperature standard (18°C) on 24 days between July 26 and August 31 and met the standard thereafter. The upper Puyallup River did not exceed the temperature standard, but we did not commence monitoring there until late September, when high water temperatures are uncommon. High summer air temperatures, watershed conditions, and water diversions (although greatly reduced relative to historic diversions) all probably contributed to high water temperatures in the White River.

Both rivers met the water quality standard for dissolved oxygen (8 mg/L) during their respective study periods, based upon a reasonable interpretation of probe and laboratory data. However, probe-measured dissolved oxygen data quality is poor and did not meet the project data quality objectives.

# Acknowledgements

We thank the following people for their assistance during the study:

- The Riverwalk Homeowners Association and Mr. Frank Shigio.
- Bill Ward, Ecology Environmental Assessment Program
- Kim McKee, Ecology Southwest Regional Office
- Char Naylor, Puyallup Tribe of Indians
- Nancy Rapin, Muckleshoot Indian Tribe

# Introduction

The Washington State Department of Ecology (Ecology) monitored temperature and dissolved oxygen (DO) at two locations on the Puyallup River in the summer and fall of 2004. The monitoring stations are located on the two major tributaries, the upper Puyallup River and the White River, one to two miles upstream of their confluence (Figure 1).<sup>1</sup>

Ecology's monitoring is an outgrowth of the Puyallup River Total Maximum Daily Load (TMDL) study, under which Ecology agreed to expand its water quality monitoring in the basin, using continuous instrumentation and partial stakeholder funding. The purpose of the monitoring program is "to assess spatial and temporal changes in water quality, determine if designated uses are supported by existing in-stream water quality, and provide site-specific water-quality information in support of Ecology's water quality based permitting of dischargers."

The primary goal of the 2004 monitoring was to gather continuous dissolved oxygen and temperature data on the White River downstream of Lake Tapps (RM 1.8) during later summer and early fall critical conditions. In 2001, the United States Geological Survey (USGS) measured dissolved oxygen levels near 8 mg/L in this reach of the river, when flows were dominated by releases from Lake Tapps. In 2004, Puget Sound Energy (PSE) halted diversions for power generation and we wanted to see if DO remained low under the new operating regime.

A second goal of the 2004 monitoring was to gather similar data on Puyallup River water quality above the confluence with the White. We were able to begin monitoring on the Puyallup River in mid-September when a second Solinst probe became available at the end of another Ecology study.

As with 2003 monitoring, a third goal of this season's monitoring was to evaluate use of the Solinst, Inc. Model 3001 LTDO Levelogger® (the probe) over multi-week deployments. Unlike most instruments for dissolved oxygen measurement, the Solinst probe does not require field calibration. Potentially, these instruments can reduce the field labor associated with continuous monitoring by a factor of four – from twice-weekly calibration to biweekly quality control sampling.

## Sampling Location and Methods

The White River sampling location is near the Fryar Avenue/142nd Avenue Bridge in Sumner (River Mile 1.8). We deployed the first probe on July 26 and ended monitoring with that probe on September 16. We deployed a second probe (available with the end of another Ecology study) on September 16 and ended monitoring when we retrieved that probe on October 27.<sup>2</sup> We

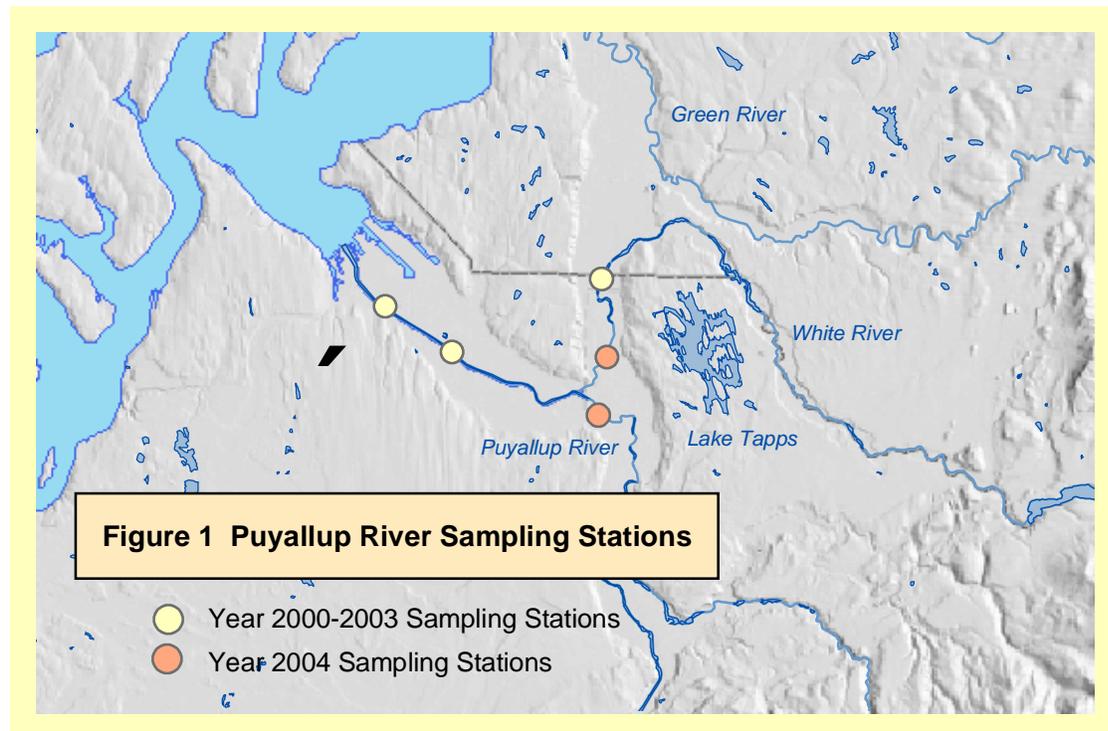
---

<sup>1</sup> In this report, the upper Puyallup River is the river above its confluence with the White River; the lower Puyallup River is the reach below the confluence.

<sup>2</sup> This probe stopped taking dissolved oxygen measurements on October 21 so we report data only until that date.

deployed the probes in an anchored, locked housing made of PVC pipe that extended from the shore into the river.

The upper Puyallup River sampling location is located west of Highway 162 at River Mile 11.6. This location was advantageous from a security standpoint, but we were restricted to deploying the probe from a cement block on the river bed. We deployed the probe – used earlier on the White River - on September 28 and ended monitoring on November 5.



**Figure 1. Puyallup River Sampling Stations**

Both probes recorded temperature and dissolved oxygen data at 30 minute intervals. We inspected the probes and retrieved data on one- and two-week intervals. Each time we retrieved a probe, we:

- Inspected the probe and housing for sediment build-up, rinsed both with river water and cleaned the probe membrane.
- Downloaded probe data.
- Obtained water samples for the laboratory dissolved oxygen analysis.

We stored water samples in a covered container and drove the samples to Ecology's Operations Center in Lacey for analysis on the day of sampling, following Standard Methods 4500-0 C (Winkler method). The project Quality Assurance Project Plan (Ecology, 2003) includes additional detail on sampling and quality assurance.

# Results

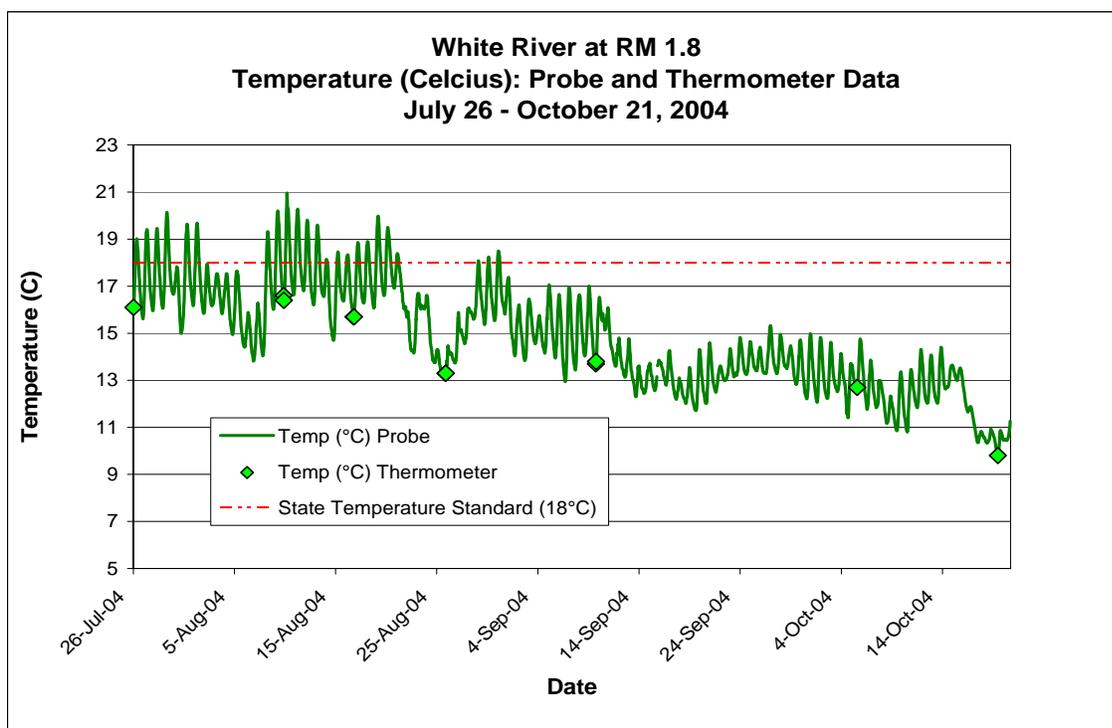
## White River at River Mile 1.8

### Temperature

Temperatures on the White River were highest in late July and mid-August and decreased thereafter through the end of summer and the beginning of fall (Figure 2).

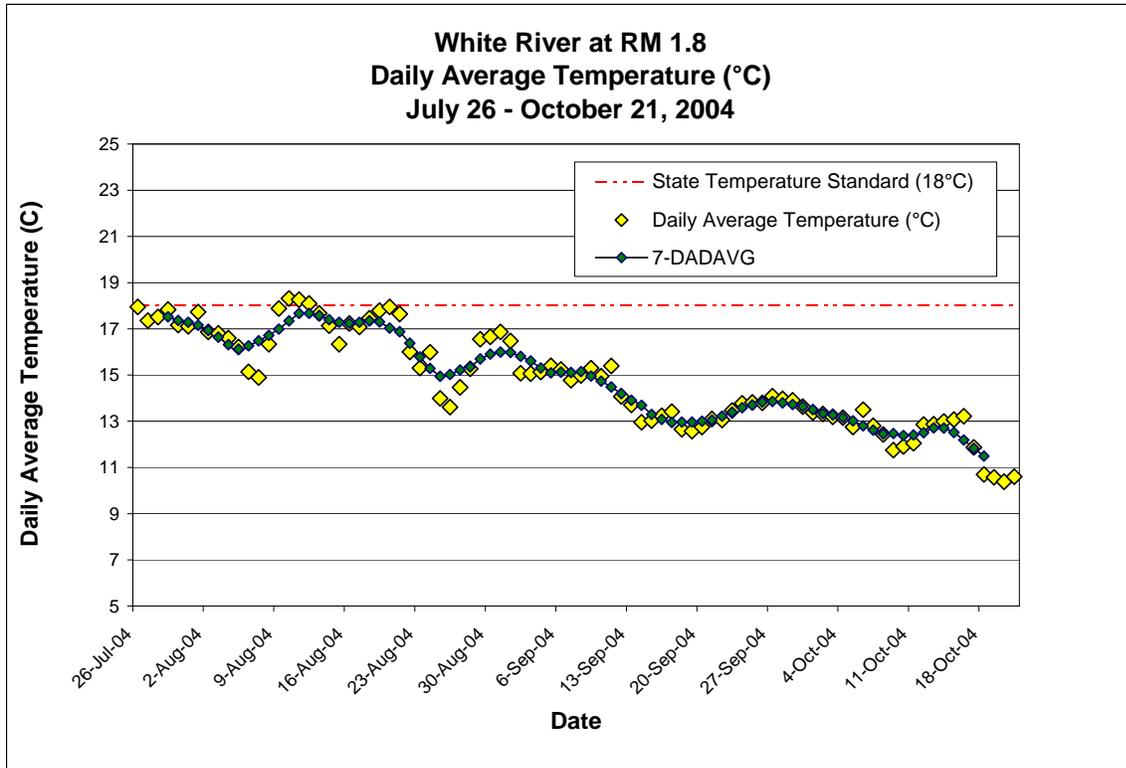
*Average* daily temperatures on the White River varied between 18.3°C in August and 10.4°C in October (Figure 3). The seven-day average of the daily average temperature (7-DADAVG) stayed above 16 °C between July 29 and August 22, and was at or below 16°C thereafter.

*Maximum* daily temperatures varied between 21°C in August and 10.9°C in October (Figure 4). Temperatures exceeded the 18°C state standard on 24 days between July 26 and August 31. The seven-day average of the daily maximum temperature (7-DADMAX) was above the proposed state standard of 17.5 °C between July 29 and August 22.<sup>3</sup>

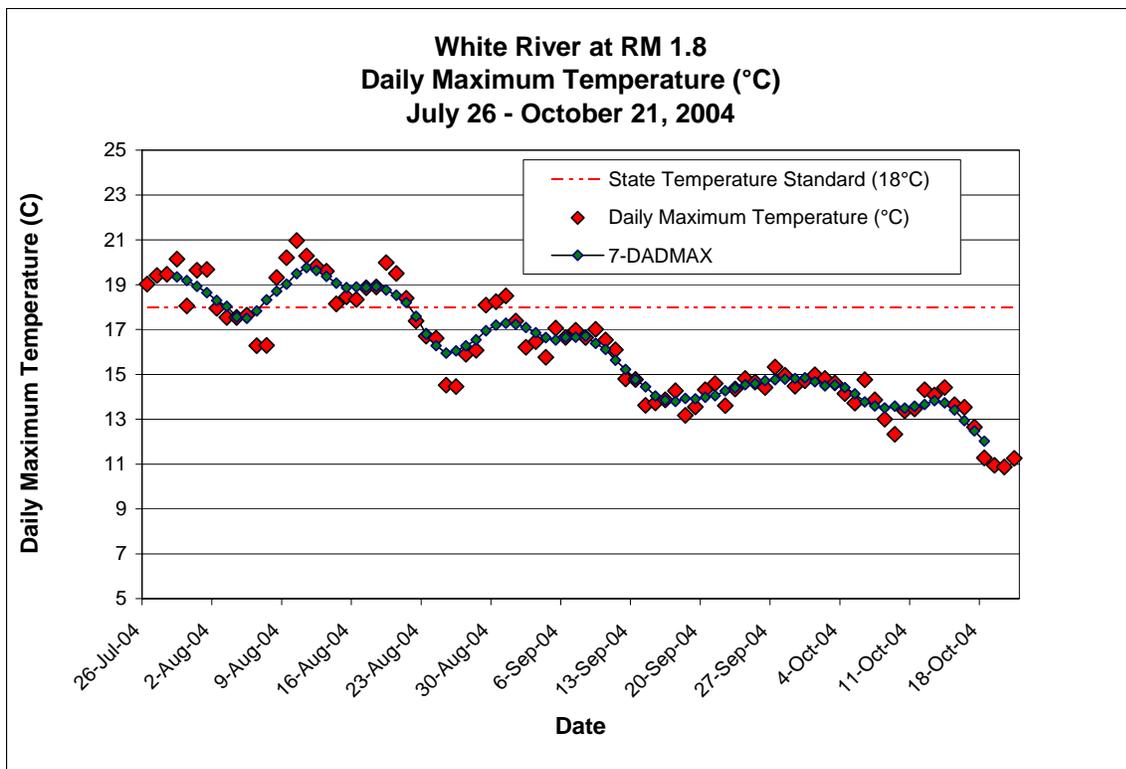


**Figure 2. White River Temperature – Probe and Thermometer Data**

<sup>3</sup> Ecology has proposed changing its temperature standards, from instantaneous maximum values (e.g., 18°C for Class A waters) to seven-day averages. EPA is reviewing the proposed changes.



**Figure 3. White River Daily Average Temperature and 7-DADAVG**



**Figure 4. White River Daily Maximum Temperature and 7-DADMAX**

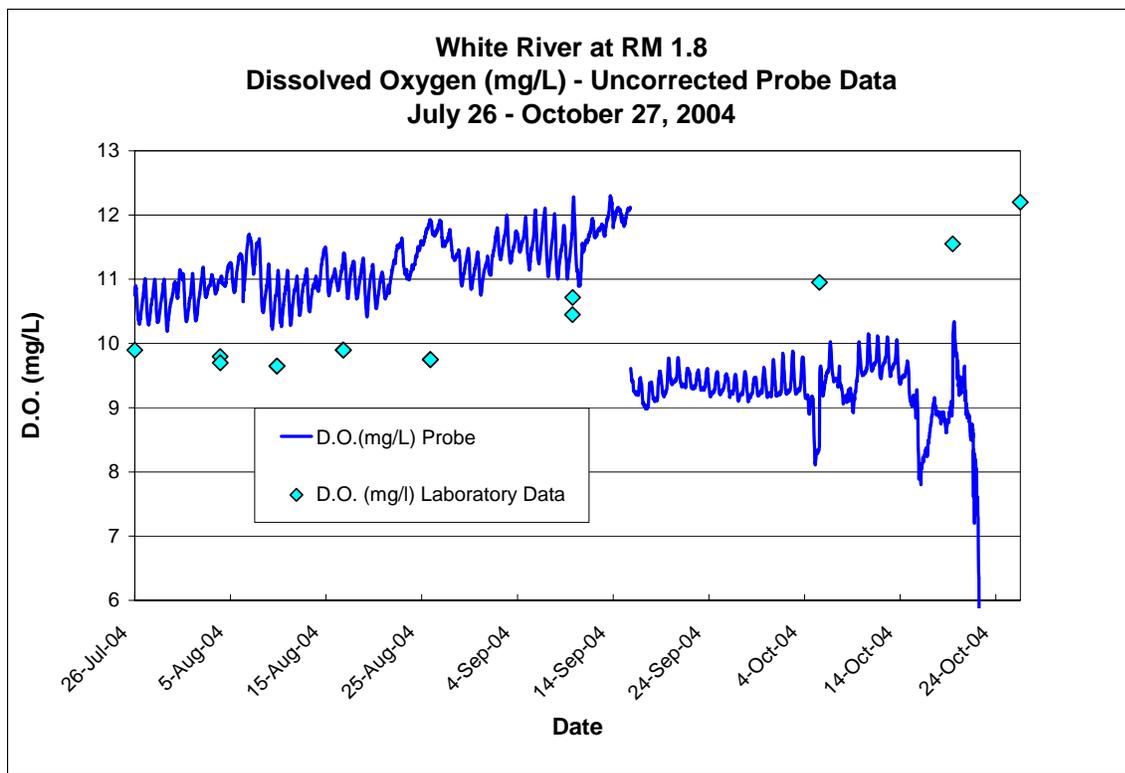
## Dissolved Oxygen

The two probes that we used measured substantially different dissolved oxygen levels, compared to each other and compared to the laboratory data (Figure 5).

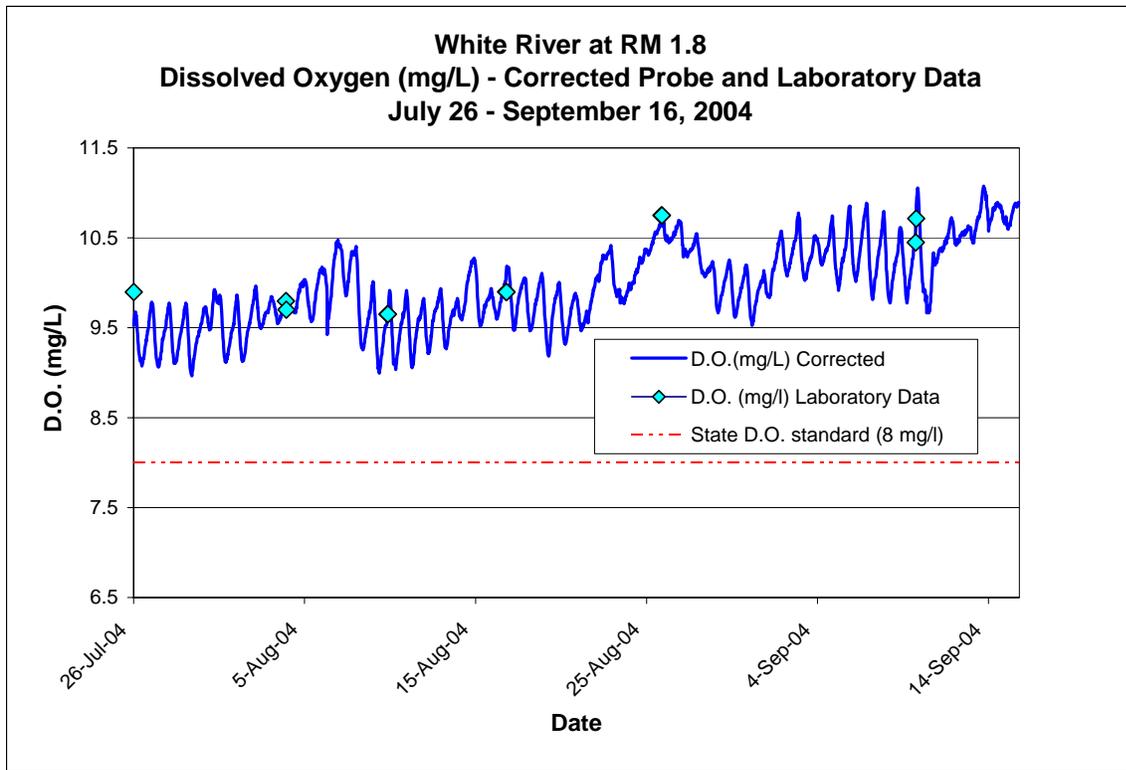
The first probe (July 26-September 16) measured dissolved oxygen that was consistently *higher* (1.2-1.4 mg/L) than the laboratory data, but it did track the laboratory data trend (rising dissolved oxygen as temperatures fell with the onset of fall). We corrected this data by subtracting the average of the difference between the laboratory and probe measured values (1.23 mg/L) (Figures 6-8).

The second probe (September 16 – October 21) measured dissolved oxygen that was consistently *lower* than the laboratory data, and it *did not* track the laboratory data trend. We did not correct this data and are not presenting it here.

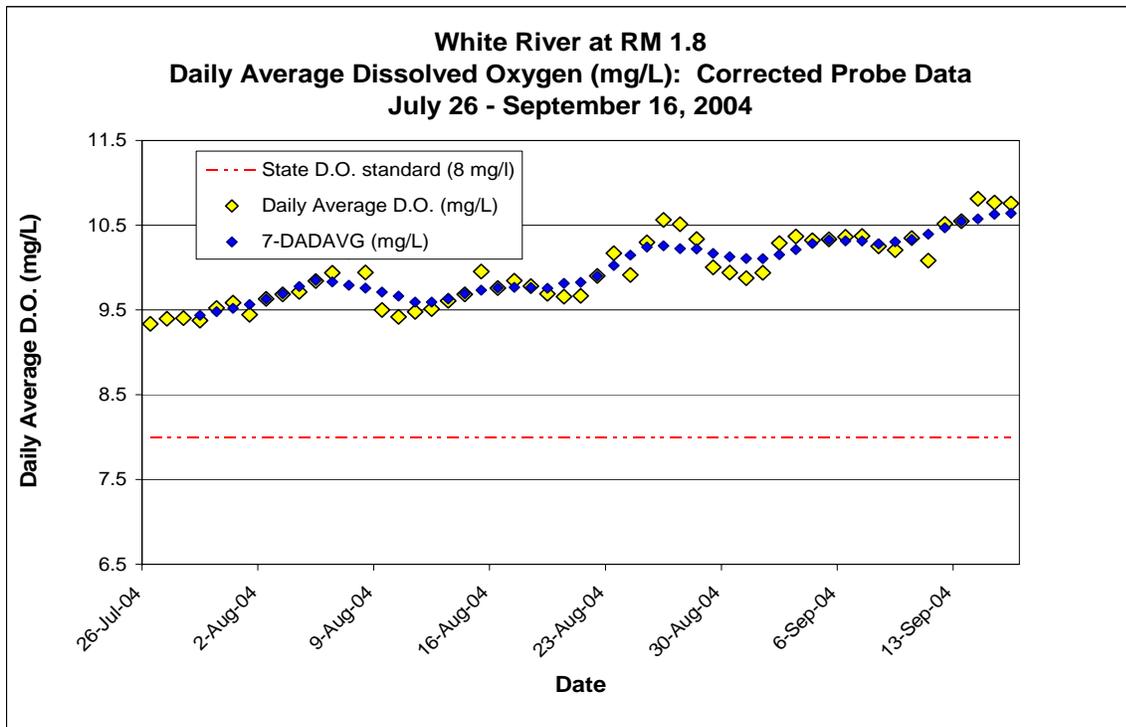
From July 26 to September 16, dissolved oxygen rose steadily as water temperatures fell (Figure 6). Based upon corrected probe data, *average* daily DO varied between 9.3 mg/L in July to 10.8 mg/L in October (Figure 7). *Minimum* daily DO varied between 9.0 mg/L and 10.6 mg/L (Figure 8). Dissolved oxygen levels did not fall below the state standard, 8.0 mg/L.



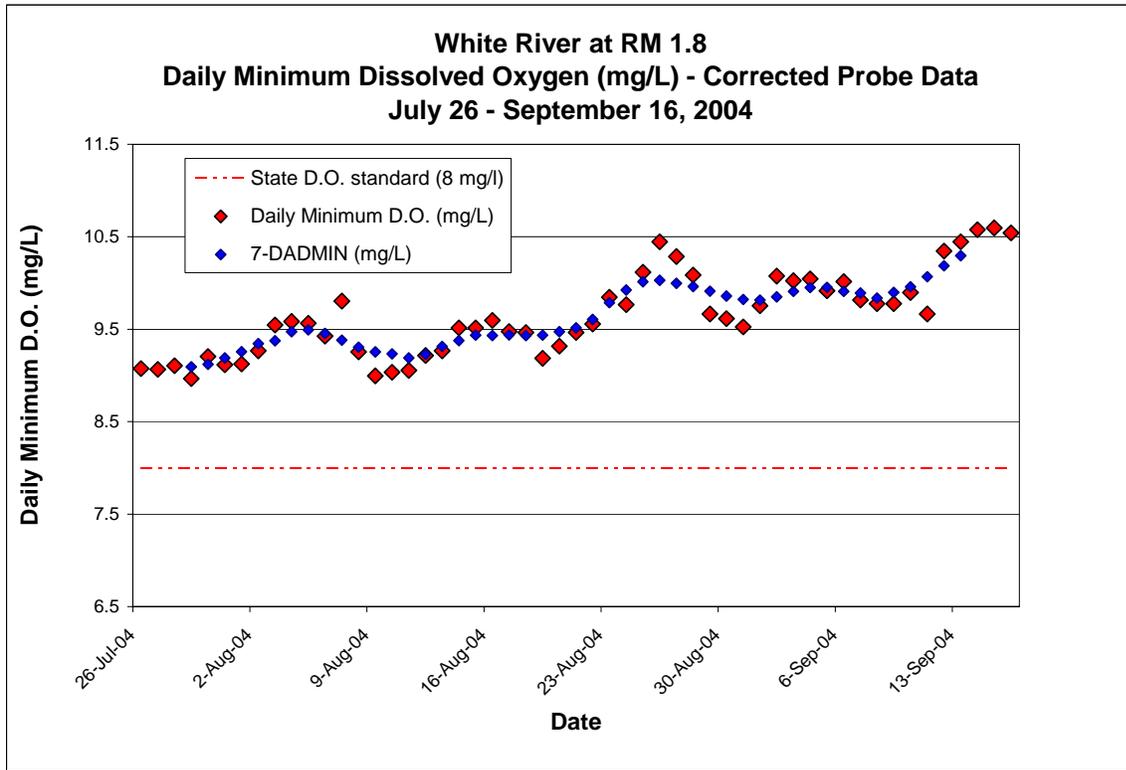
**Figure 5. White River Uncorrected Dissolved Oxygen Data**



**Figure 6. White River Corrected Dissolved Oxygen Data**



**Figure 7. White River Daily Average Dissolved Oxygen**



**Figure 8. White River Daily Minimum Dissolved Oxygen**

### Data Quality

Probe-measured temperatures were within the manufacture’s specification (0.2°C) as determined by comparing probe measurements to thermometer measurements (Figure 9).

Dissolved oxygen measurements were not within the manufacturer’s specification (0.2 mg/L) or this study’s data quality objective (0.5 mg/L). The first probe consistently measured DO that was 1.2 – 1.4 mg/L above laboratory data. We corrected that data by subtracting 1.23 mg/L (the average difference) from the probe-measured value.

The second probe measured DO 1.8–2.6 mg/L below laboratory data. Additionally, measurements did not track the seasonal rise in DO that we measured in the laboratory, and the daily data range does not compare well with the first probe. For these reasons, we did not correct the data and are not using it. A battery check near the end of the sampling season showed that voltage was 80 percent of fully charged.

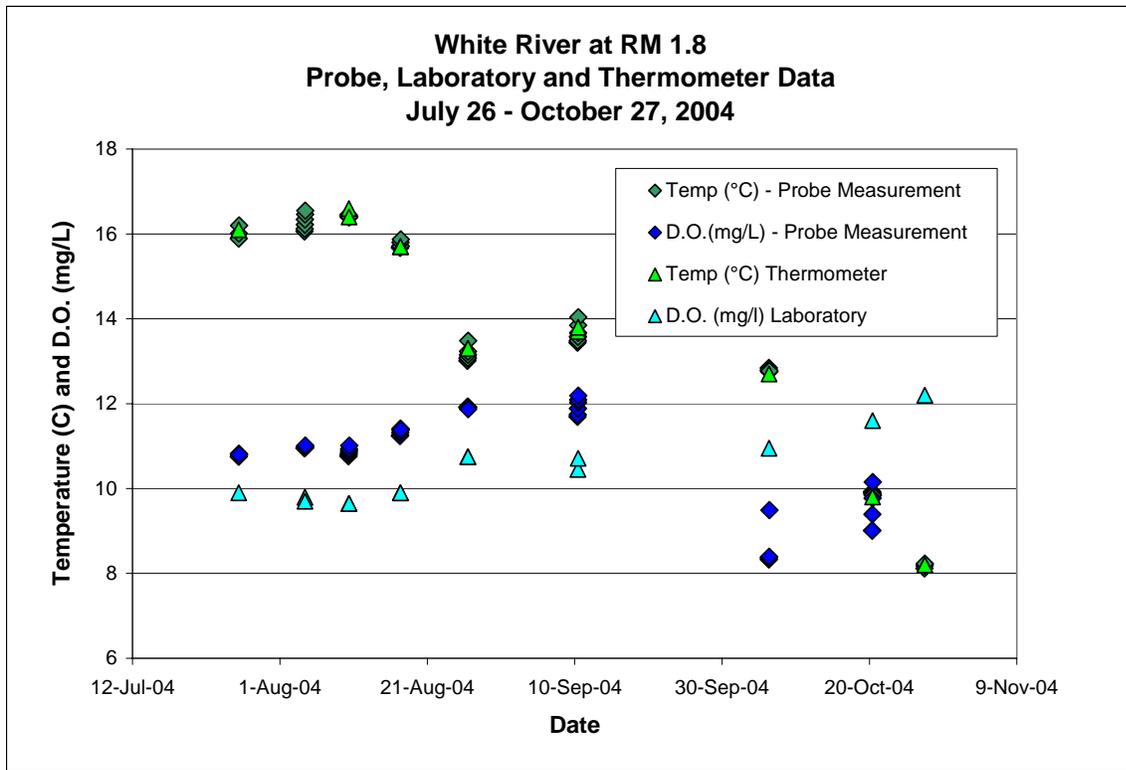
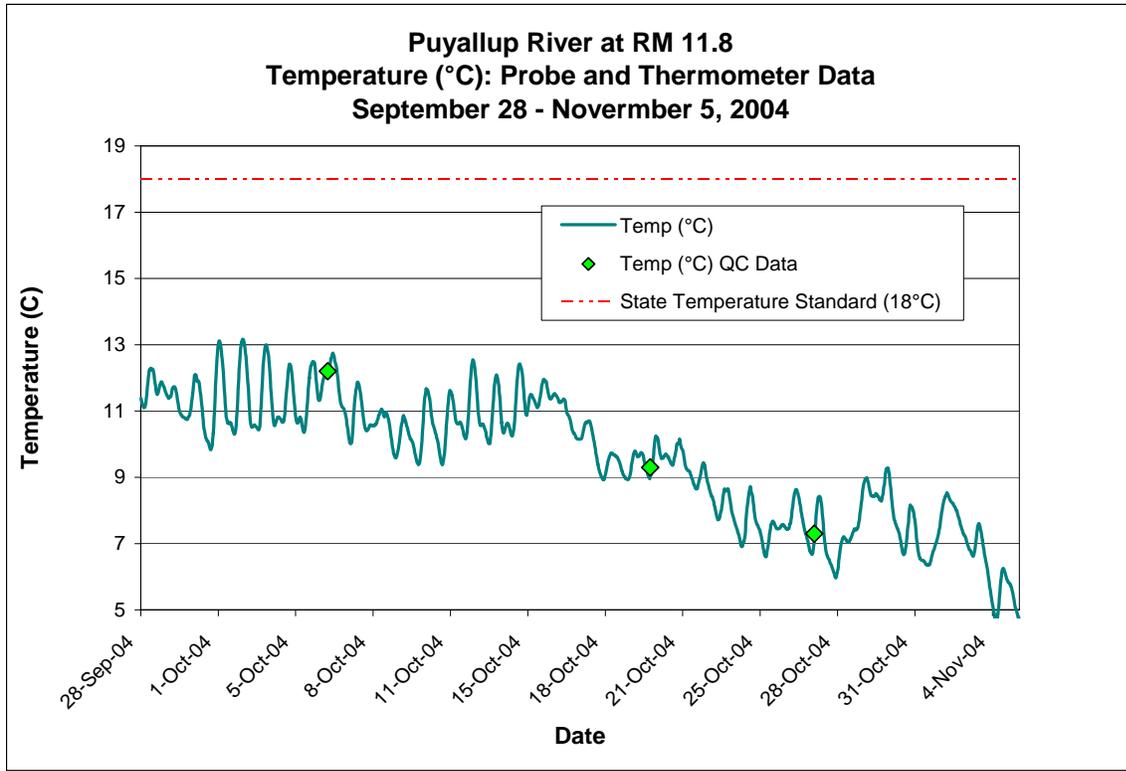


Figure 9. White River Probe, Thermometer and Laboratory Data

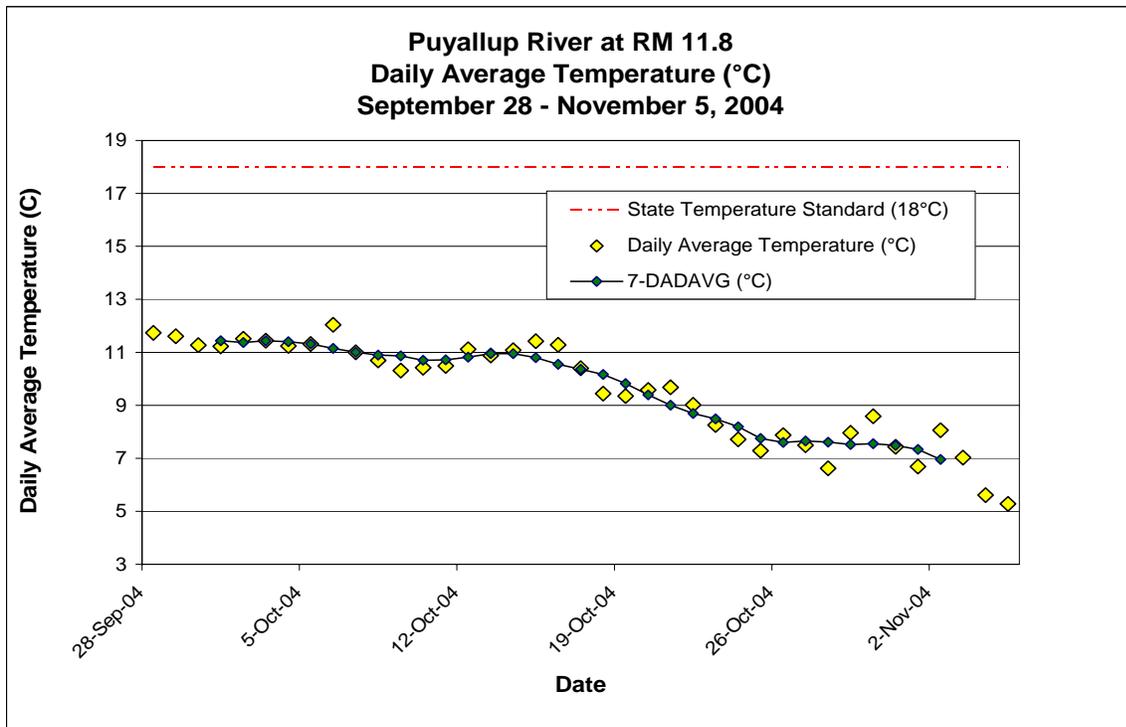
## Puyallup River at River Mile 11.8

### Temperature

Temperatures in the Puyallup River were steady during the last week of September and the first week of October and declined thereafter (Figure 10). *Average* daily temperatures ranged between 12°C in October to 5°C in November (Figure 11). The seven-day average of the daily *average* temperature (7-DADAVG) ranged from 11.4°C to 7°C (Figure 11). *Maximum* daily temperatures varied from 13.2°C to 5.8°C and were below the state standard, 18°C (Figure 12). The seven-day average of the daily *maximum* temperature (7-DADMAX) remained below the proposed state standard, 17.5°C. There were no violations of the water quality standard during this period.



**Figure 10. Puyallup River Temperature – Probe and Thermometer Data**



**Figure 11. Puyallup River Daily Average Temperature and 7-DADAVG**

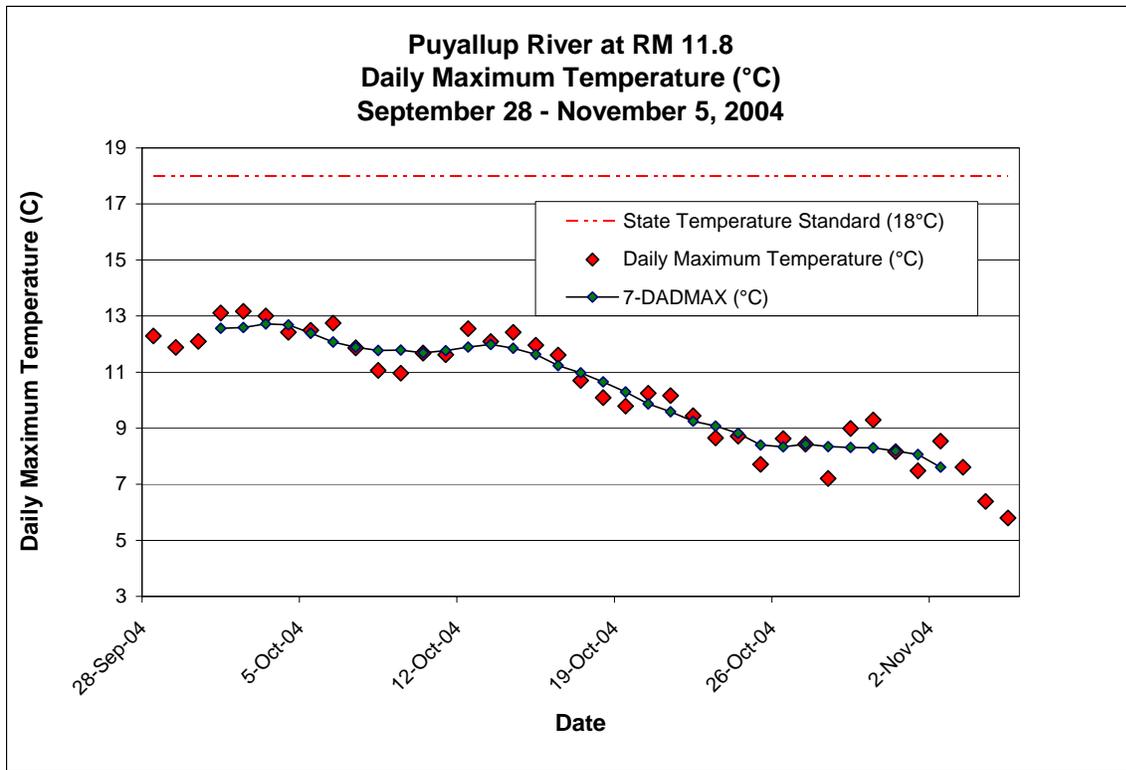


Figure 12. Puyallup River Daily Maximum Temperature and 7-DADMAX

### Dissolved Oxygen

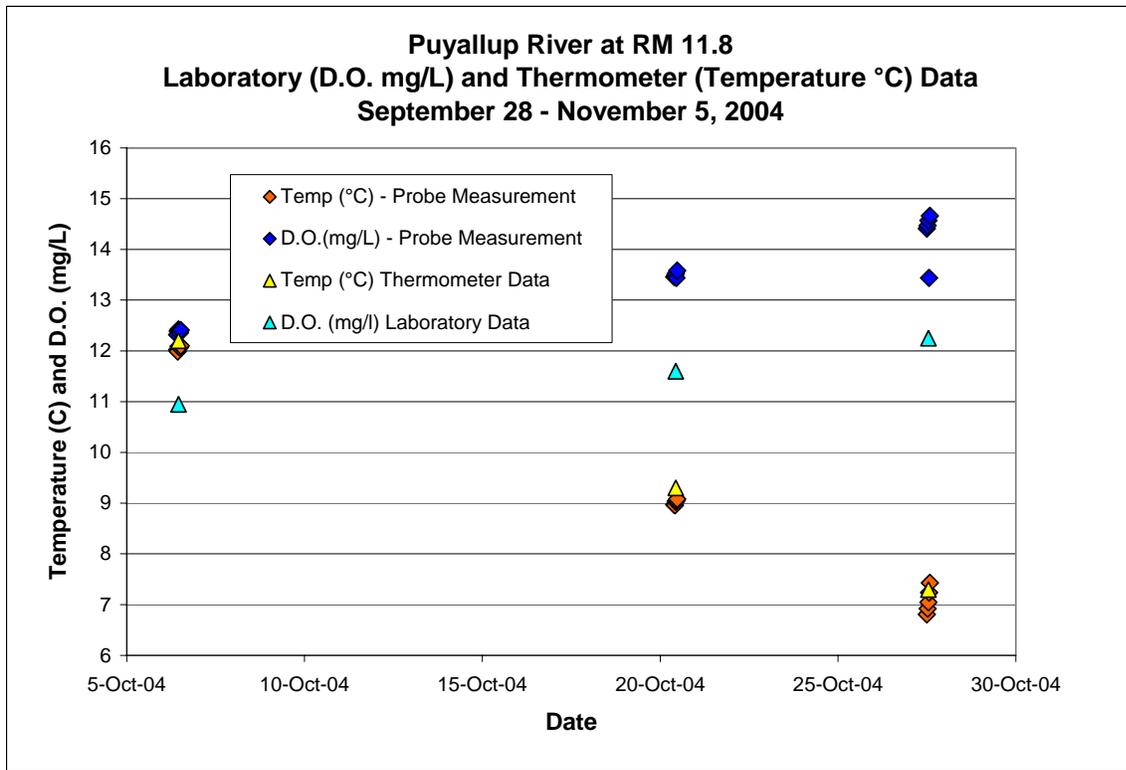
Laboratory data values show dissolved oxygen at or above 11 mg/L in this reach (Figure 13). In 2003, we noted that dissolved oxygen levels vary over a range of about 1 mg/L during a 24-hour period in this part of the river. As a result, minimum dissolved oxygen levels were most likely above 10 mg/L in 2004. We discuss probe measurements in the data quality section (page 9).

### Data Quality

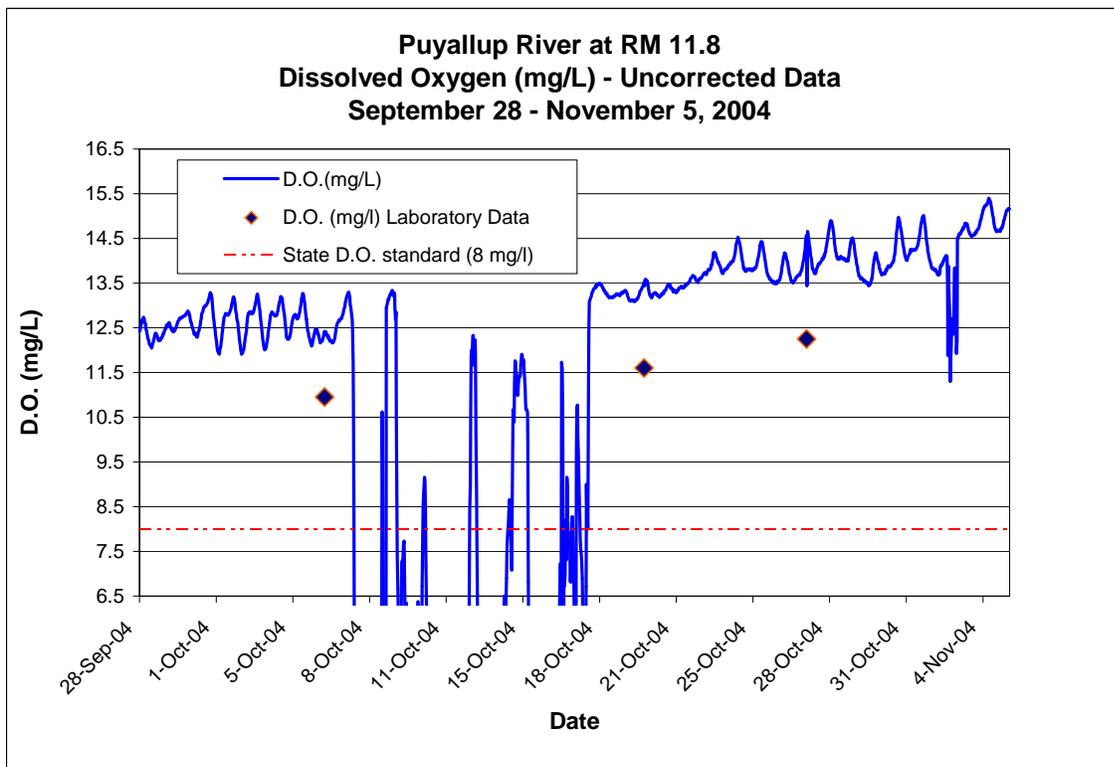
The probe-measured temperature data are within the manufacturer’s specification, 0.2°C. However, probe-measured dissolved oxygen data are not within the manufacturer’s specification (0.2 mg/L) or this study’s data quality objective (0.5 mg/L) (Figure 13).

Problems with probe-measured DO was likely the result of sediment fouling as evidenced by a) sediment build-up in the housing between inspections, b) periods of time in the second and third weeks of October when probe-measured dissolved oxygen fell to zero, c) a change in the DO signature after the period when values fell to zero, and d) an increase in the difference between the probe data and the laboratory DO data, from 1.5 mg/L to 2.3 mg/L (Figure 14).<sup>4</sup> As a result, we are not presenting or using corrected probe DO data.

<sup>4</sup> Although water column turbidity was low, there was apparently movement of material along the bed.



**Figure 13. Puyallup River Probe, Thermometer and Lab DO Data**



**Figure 14. Puyallup River Uncorrected Dissolved Oxygen Data**

# Discussion

## White River

Temperature in the White River exceeded the state standard (18°C) during late summer. These violations occurred even though flow in the Muckleshoot Indian Tribe Reservation reach (upstream of the tailrace) was relatively high compared to years when Puget Sound Energy was diverting water out of the reach for power generation (Figure 15 and Figure 16). Higher flows in the reach in 2004, relative to 2001, and lower tailrace flows, should result in lower river temperatures downstream of the tail race if meteorological conditions are similar.

However, summer air temperatures were apparently much higher in 2004 than in 2001. National Oceanographic and Atmospheric Administration's (NOAA), National Climate Data Center (NCDC) reports that summer temperatures in Washington State in 2004 were "much above normal...one of the 11 warmest periods on record." For 2001, the NCDC reports that summer temperatures were "near normal." High summer air temperatures in 2004 likely contributed to high summer water temperatures; water temperature tracks air temperature closely (Figure 17).

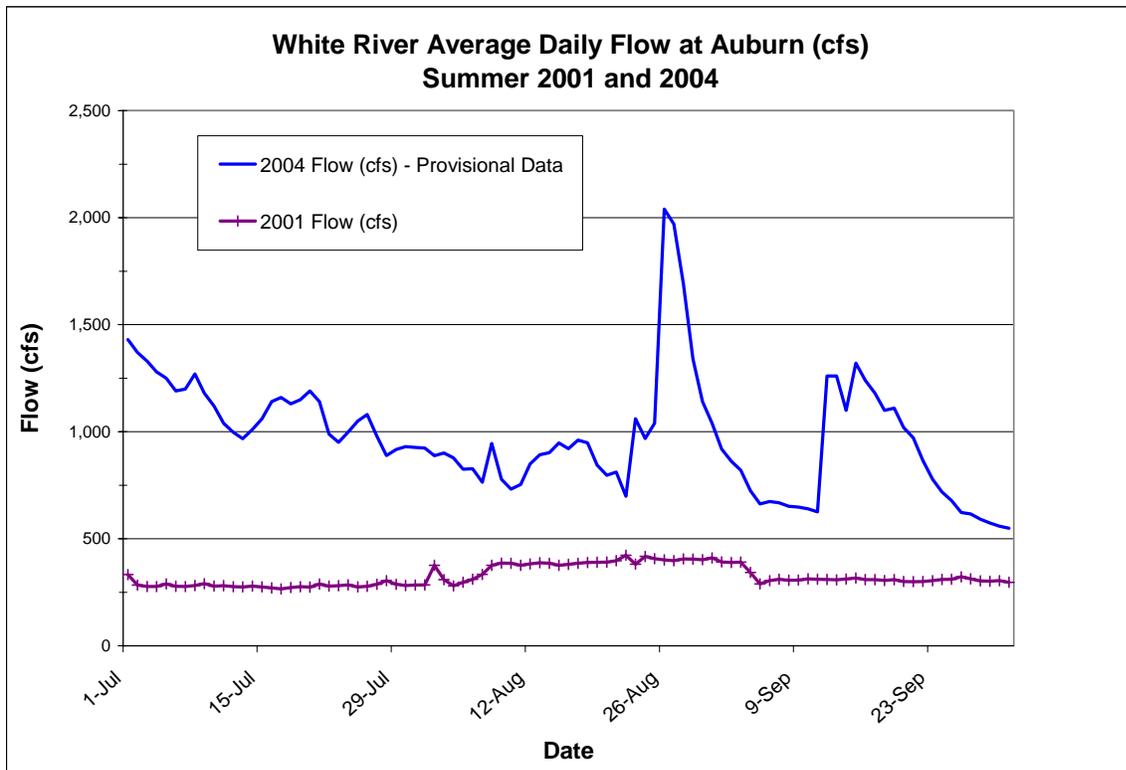
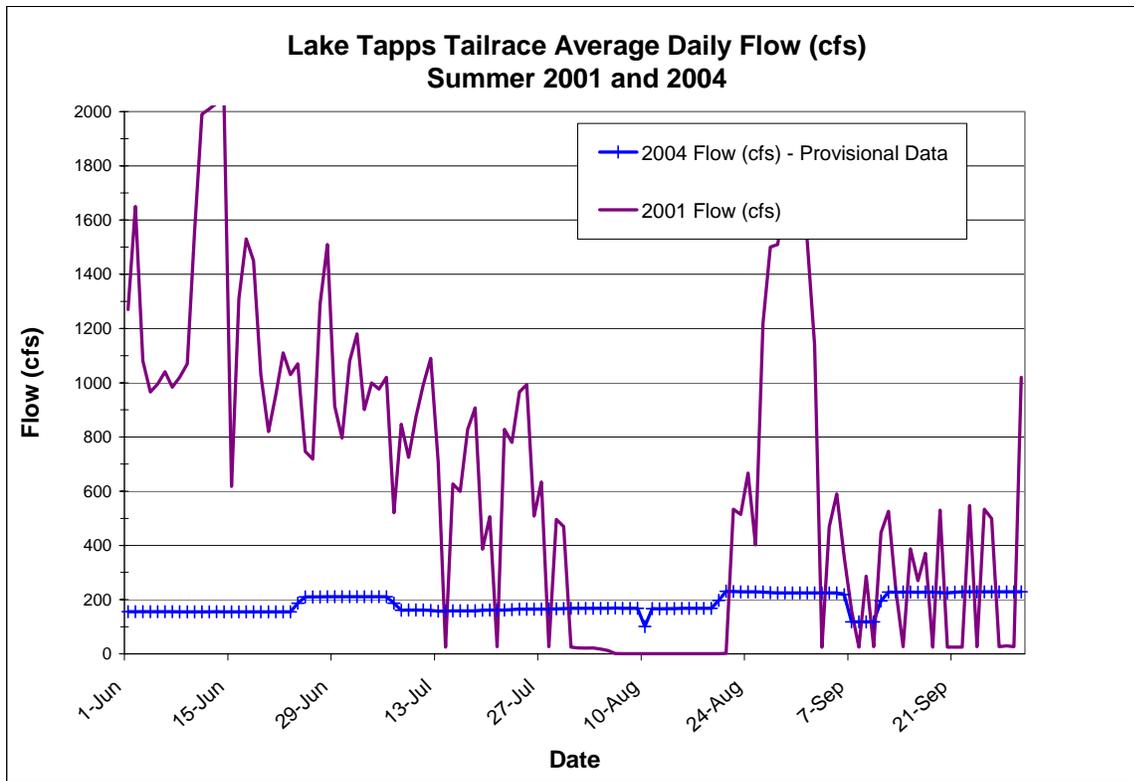
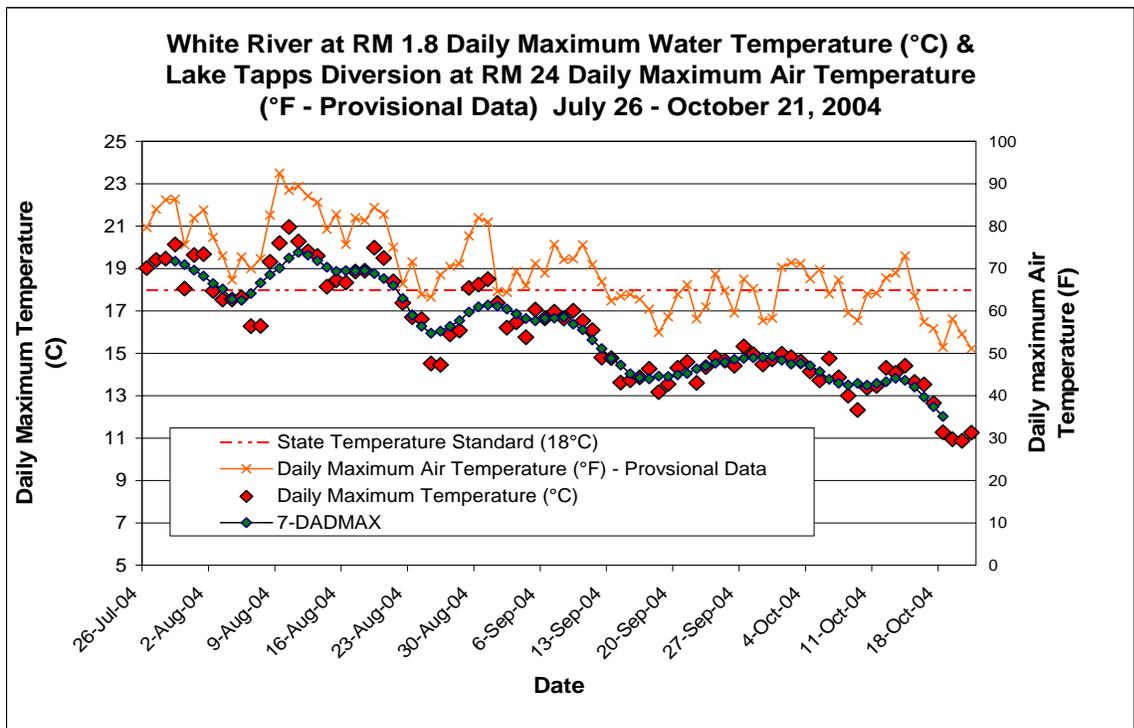


Figure 15. White River Average Daily Flow at Auburn, Summer 2001 and 2004



**Figure 16. Lake Tapps Tailrace, Average Daily Flow, Summer 2001 and 2004**



**Figure 17. White River, Maximum Air and Water Temperature, Summer 2004**

Watershed conditions and diversions probably also contributed to high water temperatures. On August 17, Ecology's Environmental Assessment Program staff measured a temperature of 16.3°C on the White River at R street in the mid-morning. One hour earlier, staff measured a temperature of 11.4°C on the Puyallup River above the confluence. The stations are only a few miles apart and air temperature probably does not vary greatly between the two sites, or not enough to account for this difference in water temperature.

The difference in water temperatures probably cannot be attributed solely to diversions. On the day of the measurements, flow in the Puyallup River was roughly 1230 cubic feet per second (cfs), 960 cfs in the White, and 260 cfs in the diversion canal (provisional data). The difference in flow between the two rivers is probably not enough to account for the temperature difference. Upstream watershed conditions are probably also influencing temperatures on the White River.

The lowest daily minimum dissolved oxygen levels were in the 9.0 – 9.5 mg/L range and occurred between the end of July and mid-August (Figure 8). In contrast, in 2001 between late August and mid-September, minimum dissolved oxygen levels were generally in the 8.5 to 9.0 m/L range, with some readings between 8 and 8.5 mg/L in early August (Figure 18).

The 2001/2004 data comparison shows 0.5 mg/L change in dissolved oxygen below the tail race during hydropower operations. This change is similar to the change noted by the USGS in 2002. During most of August 2002, there were no hydropower releases, and flow and water quality conditions in the White River at RM 1.8 below the tailrace were similar to July 2004 conditions: flow near 1000 cfs, minimum DO levels near 9.0 mg/L. At the end of August 2002, PSE resumed hydro-electric facility releases, and minimum DO levels dropped to the 8.5-9 mg/L range, similar to conditions in 2001.

## **Puyallup River**

Temperature and dissolved oxygen levels in the Puyallup River were well within state standards. Daily maximum water temperatures were generally below 13°C and dissolved oxygen was at or above 11 mg/L, based upon laboratory measurements. Fall river flows were generally above 1000 cfs (Figure 19) and air temperatures had cooled with the onset of fall. Both factors helped keep DO levels up and temperatures down.

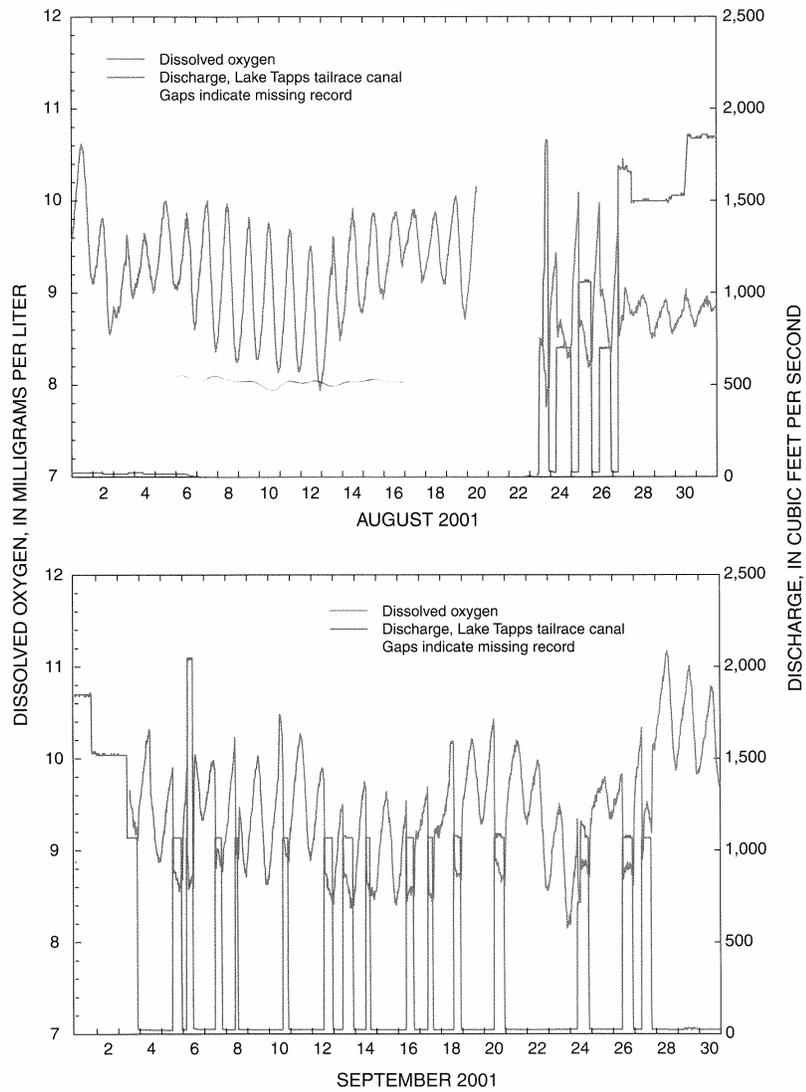


Figure 10. Concentrations of dissolved oxygen in the White River at river mile 1.8 and discharge in the Lake Tapps tailrace canal, August and September 2001.

16 Dissolved Oxygen in the Lower Puyallup and White Rivers, Washington, August and September 2000 and 2001

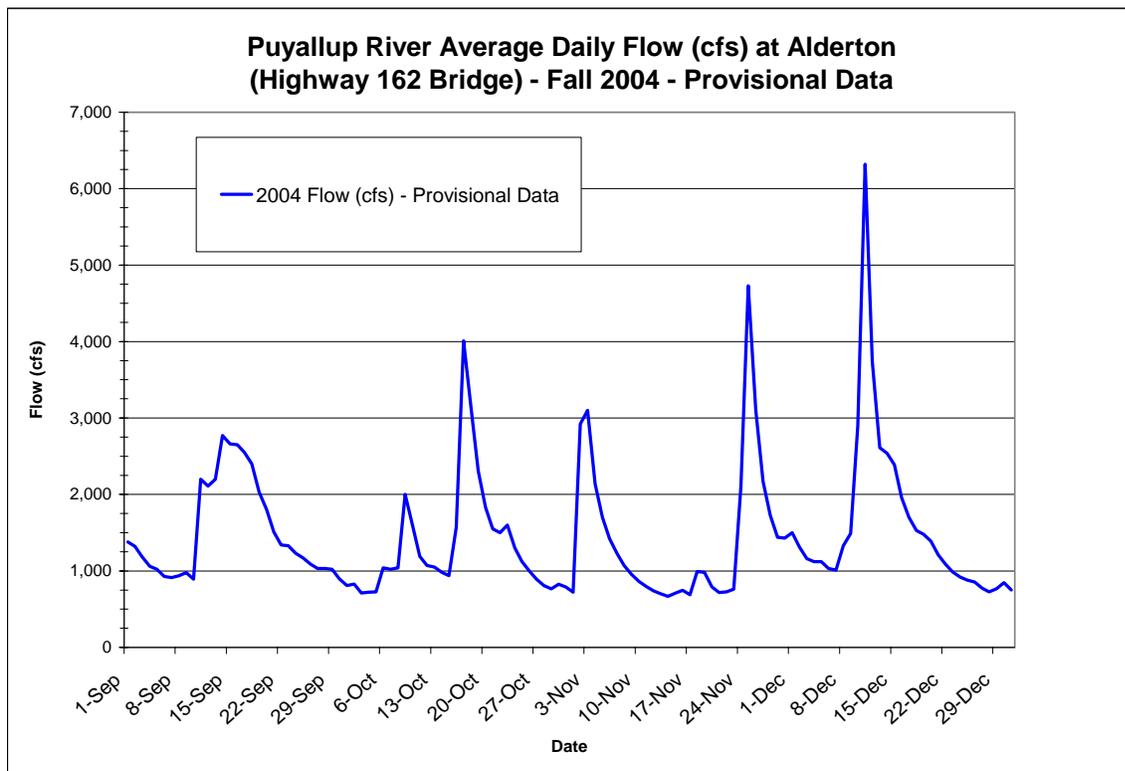
**Figure 18. Flow and Dissolved Oxygen, White River @ RM 1.8, 2001**

## Data Quality

The Solinst Model 3001 LTDO Leveloggers ® performed within the manufacture’s specification for temperature (0.2°C) but not dissolved oxygen (0.2 mg/L). In general, the probe dissolved oxygen data quality is poor – there is a difference of 1 mg/L or more between probe values and laboratory values.

The failure to perform within specifications is unfortunate. However, the manufacture’s specification represents a higher degree of accuracy than is commonly found in the Hydrolab DataSondes® used previously.

Using DataSondes® in 2001 and 2002, the USGS considered probe data that was within 0.3 mg/L to be excellent, and good probe data was within 0.5 mg/L of laboratory data (this study’s data quality objective). Additionally, the USGS serviced the DataSondes® as often as twice a week. “Drift,” the movement of probe measurements away from calibrated values, is common with the DataSondes, requiring frequent re-calibration. In contrast, on the White River with the probe deployed from shore, we were able to deploy for two- to four-week periods in 2003 and 2004 without apparent drift. Solinst, Inc. calibrates each instrument annually. The labor savings associated with the Solinst membrane technology continues to make this an attractive option; other manufacturers are now offering similar instruments.



**Figure 19. Puyallup River, Fall Average Daily Flow**

# Conclusions

The laboratory data and the probe data together allow us to make reasonable estimates about minimum DO levels in the lower reaches of the White and upper Puyallup Rivers. On the White, minimum DO levels were in the range of 9 – 9.5 mg/L, 1–1.5 mg/L above the standard. These levels are about 0.5 mg/L above levels measured in 2001 and 2002 during hydropower operations. On the Puyallup, later in the fall season, minimum DO levels were near or above 11 mg/L, 3 mg/L above the standard.

In general, the data suggest that in 2004 DO levels met standards on both rivers. On the White however, temperature did not meet the standard over a period of about three weeks. Uncharacteristically warm summer weather, watershed conditions, and water diversions all probably contributed to high water temperatures.

## References

Ebert, James. 2002. *Concentrations of Dissolved Oxygen in the Lower Puyallup and White Rivers, Washington, August and September 2000 and 2001*. US Geological Survey Water-Resources Investigations Report 02-4146.

Ebert, James. 2003. *Water Temperature, Specific Conductance, pH and Dissolved Oxygen Concentrations in the Lower White River and the Puyallup River Estuary, Washington, August - October 2002*. US Geological Survey Water-Resources Investigations Report 03-4177.

National Oceanographic and Atmospheric Administration, National Climate Data Center.  
<http://www.ncdc.noaa.gov/oa/climate/research/2004/ann/ann04.html>

Washington State Department of Ecology. 2003. *Temperature and Dissolved Oxygen Monitoring in the Puyallup River at Sumner. Quality Assurance Project Plan*.

Washington State Department of Ecology. 2003. *Temperature and Dissolved Oxygen in the Puyallup River, July to October 2003*.

Washington State Department of Ecology. 2004. *River and Stream Water Quality Data*.  
<http://www.ecy.wa.gov/programs/eap/index.html>