CONTINUED MONITORING OF DO, pH, AND TURBIDITY IN THE WELLS FOREBAY AND LOWER OKANOGAN RIVER
(DO, pH and Turbidity Study)

WELLS HYDROELECTRIC PROJECT

FERC NO. 2149

INTERIM REPORT
NOT REQUIRED BY FERC

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The current Wells Hydroelectric Project (Wells Project) license will expire on May 31, 2012. As part of the Wells Project relicensing process, the Public Utility District No. 1 of Douglas County (Douglas PUD) is required to obtain a water quality certificate pursuant to Section 401 of the Clean Water Act. As part of the 401 certification process, the Washington State Department of Ecology (Ecology) must determine whether the Wells Project is in compliance with state water quality standards, including the numeric standards, for dissolved oxygen (DO), pH, and turbidity.

The Aquatic Resource Work Group (Aquatic RWG), which is comprised of interested parties (including Ecology) and Douglas PUD, was formed for the purpose of identifying issues that may require study during the Wells Project relicensing. The Aquatic RWG proposed a study to collect additional DO, pH, and turbidity data from within the Wells Project. The goal of this study was to augment the established sampling regimes for existing monitoring programs and provide additional information related to DO, pH, and turbidity at the Wells Project.

A Quality Assurance Project Plan (QAPP), revised to incorporate review comments from Ecology, identified the organization, schedule, data quality objectives, sampling design, field and laboratory procedures, quality control, and data management and reporting parameters required to implement the DO, pH, and turbidity study proposed by the Aquatic RWG (Parametrix, 2008a).

Three Hydrolab Minisonde5 instruments equipped with DO, pH, and turbidity sensors were installed throughout the lower Okanogan River and began recording data at 30-minute intervals on May 5, 2008. Protective instrument housings were attached to pilings at the Malott Bridge (River Mile [RM] 17.0, above the Project boundary), Monse Bridge (RM 5.0) and Highway 97 Bridge (RM 1.3). Similar instrumentation, operating in the Wells Dam forebay at RM 515.6, began recording DO and pH measurements at 1-hour intervals on May 30, 2008, and a Global Water WQ750 sensor began monitoring turbidity at 5-minute intervals on June 3, 2008. These forebay instruments complete the network of four continuous water quality monitoring locations.

Six Okanogan River instrument servicing events were conducted. Each servicing event involved downloading data, calibrating and performing maintenance on the instruments, performing quality control checks (including Winkler's titrations for dissolved oxygen determination), and replacing batteries. High river flows and woody debris accumulations at times precluded access to some of the instruments in the Okanogan River during two of the six servicing events. Battery failures also caused some data gaps. The Wells Dam forebay MiniSonde was serviced bi-monthly without any data gaps. The WQ750 turbidity sensor's self-cleaning mechanism did not function properly and, even with frequent manual cleaning, the data were judged to be unreliable and were rejected as unusable.

Effects of the Project on DO concentrations in the Okanogan River are not evident as incoming DO concentrations closely resemble those within the inundated portions of the Okanogan River. In general, DO measurements in the Okanogan River remained above 9 to 10 mg/L early in the monitoring season and then after July 1, 2008 started to show excursions below 8.0 mg/L at night as snowmelt runoff receded and water temperatures increased. Minimum daily DO

concentrations upriver from the Project at Malott have been below the 8.0 mg/L criterion from July 1 through August 5 (monitoring period covered by this interim report). In the lower Okanogan River, within Project boundary there has been no pattern of lower DO in the Project compared to upriver at Malott that would suggest Project effects. Minimum daily DO concentrations dropped below 8.0 mg/L at Monse starting in early July. At the Highway 97 Bridge, daily minimum DO readings began to occasionally drop below 8.0 mg/L on July 1, and stayed below 8.0 mg/L to August 5. Wells forebay DO readings also declined as water temperature increased seasonally, but was continuously within compliance with the water quality standard of a minimum daily DO concentration of 8.0 mg/L.

Most excursions from the water quality criteria for pH (6.5 to 8.5) were recorded upriver from the Project area at Malott. On those few occasions when pH exceeded the criteria at Monse or Highway 97, the variation from pH values at Malott was less than 0.5 units. The Okanogan River pH measurements have ranged from 7.23 to 8.70 at Malott Bridge, 7.07 to 8.68 at Monse Bridge and 7.39 to 8.61 at the Highway 97 Bridge. At the Wells Dam forebay the pH has ranged from 7.09 to 8.07, which is within the water quality criteria. There were only three days in early May when excursions above the water quality pH criteria (6.5 to 8.5) were recorded at Monse, comprising less than six percent of the days with pH records. At no time did the pH at Monse exceed pH upriver from the Project at Malott by more than 0.5 units, the criterion for human-caused variation. At Highway 97 there was only one day when pH exceeded the criteria, out of 83 days with pH records, and that daily maximum was only 0.3 units above the Malott pH. One thirteen-day period of daily pH excursions occurred at the Malott Bridge between July 24 and August 5 when diurnal occurrences of higher late afternoon to nighttime pH peaked between 8.58 and 8.70. Because this repeated diurnal excursion occurred above the Wells Project boundary at Malott, these pH excursions were unrelated to Project operations. Since monitoring began in early May, 99.6 percent of recorded pH values in the Project area were within the criteria range of 6.5 to 8.5. When pH at the Highway 97 Bridge or Monse Bridge sampling locations exceeded 8.5, daily maximum values were within 0.26 units of the pH values for water entering the Project (Malott Bridge sampling location).

Turbidity ranged from 0.1 nephelometric turbidity unit (NTU) to 647 NTU at Highway 97, 489 NTU at Monse, and 400 NTU at Malott. Data interpretation was problematic, as the Malott Bridge location instrument failed to collect turbidity data when installed, and was not functional when peak runoff caused maximum turbidity within the Project at the two lower Okanogan River monitoring locations. However, given that high values peaked coincident with annual spring runoff, it is reasonable to attribute those highest values to natural, annual snowmelt and runoff. Due to problems with the self-cleaning mechanism and maintenance of the Wells Dam forebay turbidity sensor, data collected there were judged to be unreliable and were rejected as unusable for the period covered by this interim report.

1.0 INTRODUCTION

1.1 General Description of the Wells Hydroelectric Project

The Wells Hydroelectric Project (Wells Project) is located at river mile (RM) 515.6 on the Columbia River in the State of Washington (Figure 1.1-1). Wells Dam is located approximately 30 river miles downstream from the Chief Joseph Hydroelectric Project, owned and operated by the United States Army Corps of Engineers (COE); and 42 miles upstream from the Rocky Reach Hydroelectric Project owned and operated by Public Utility District No. 1 of Chelan County (Chelan PUD). The nearest town is Pateros, Washington, which is located approximately 8 miles upstream from the Wells Dam.

The Wells Project is the chief generating resource for Public Utility District No. 1 of Douglas County (Douglas PUD). It includes ten generating units with a nameplate rating of 774,300 kW and a peaking capacity of approximately 840,000 kW. The design of the Wells Project is unique in that the generating units, spillways, switchyard, and fish passage facilities were combined into a single structure referred to as the hydrocombine. Fish passage facilities reside on both sides of the hydrocombine, which is 1,130 feet long, 168 feet wide, with a crest elevation of 795 feet in height.

The Wells Reservoir is approximately 30 miles long. The Methow and Okanogan rivers are tributaries of the Columbia River within the Wells Reservoir. The Wells Project boundary extends approximately 1.5 miles up the Methow River and approximately 15.5 miles up the Okanogan River. The surface area of the reservoir is 9,740 acres with a gross storage capacity of 331,200 acre-feet and usable storage of 97,985 acre feet at the normal maximum water surface elevation of 781 above mean sea level (msl) (Figure 1.1-1).

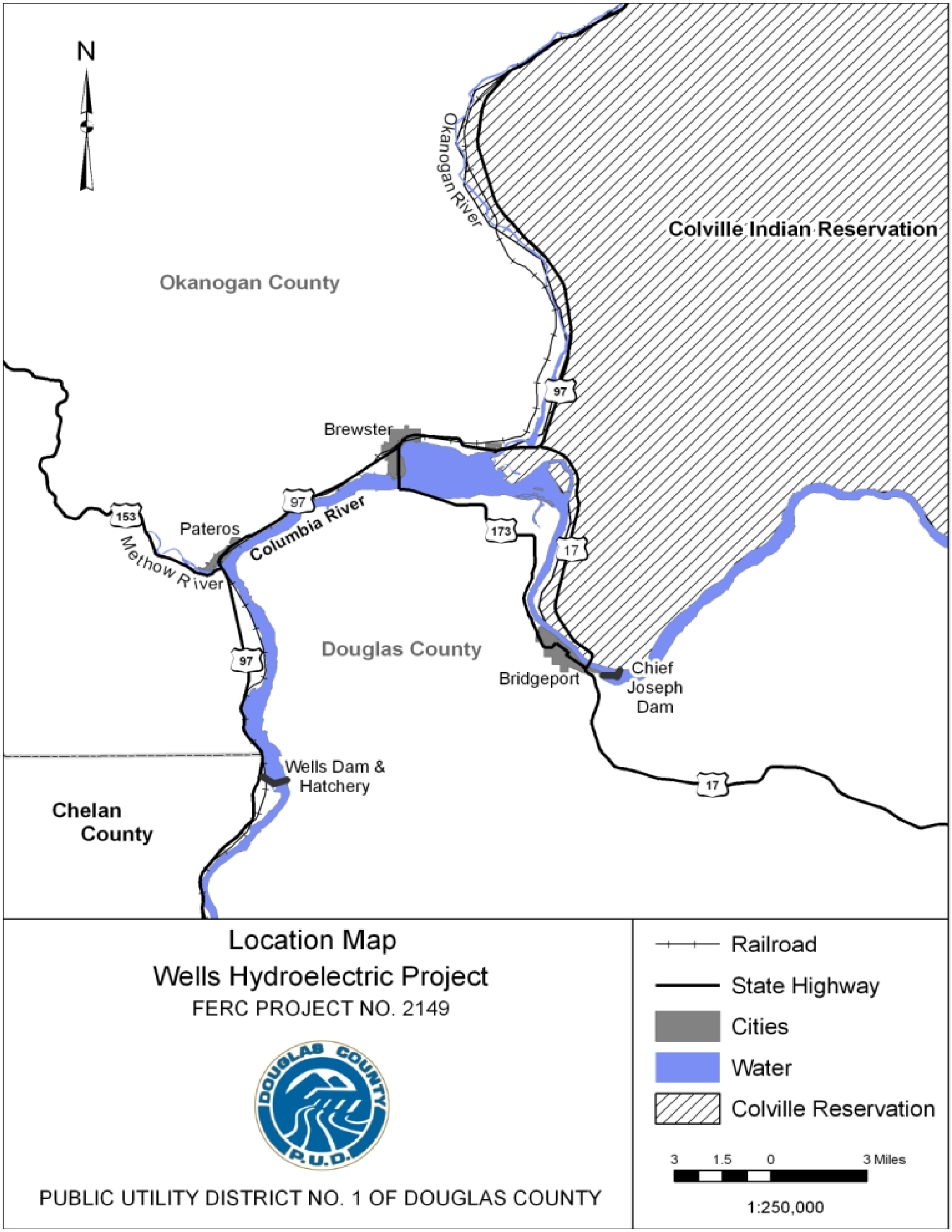

Figure 1.1-1 Location Map of the Wells Project

1.2 Relicensing Process

The current Wells Project license will expire on May 31, 2012. Douglas PUD is using the Integrated Licensing Process (ILP) promulgated by Federal Energy Regulatory Commission (FERC) Order 2002 (18 CFR Part 5). Stakeholders, including representatives from state and federal agencies, tribes, local governments, non-governmental organizations and the general public have participated in the Wells Project ILP, from a very early stage, to identify information needs related to the relicensing of the Wells Project.

In August 2005, Douglas PUD initiated a series of Resource Work Group (RWG) meetings with stakeholders regarding the upcoming relicensing of the Wells Project. This voluntary effort was initiated to provide stakeholders with information about the Wells Project, to identify resource issues and to develop preliminary study plans prior to filing the Notice of Intent (NOI) and Pre-Application Document (PAD). The RWGs were formed to discuss issues related to the Wells Project and its operations.

The primary goals of the RWGs were to identify resource issues and potential study needs in advance of Douglas PUD filing the NOI and PAD. Through 35 meetings, each RWG cooperatively developed a list of Issue Statements, Issue Determination Statements and Agreed-Upon Study Plans. An Issue Statement is an agreed-upon definition of a resource issue raised by a stakeholder. An Issue Determination Statement reflects the RWGs' efforts to apply FERC's seven study criteria to mutually determine the applicability of each individual Issue Statement. Agreed-Upon Study Plans are the finished products of the informal RWG process.

Douglas PUD submitted the NOI and PAD to FERC on December 1, 2006. The PAD included the RWGs' 12 Agreed-Upon Study Plans. The filing of these documents initiated the relicensing process for the Wells Project under FERC's regulations governing the ILP.

On May 16, 2007, Douglas PUD submitted a Proposed Study Plan (PSP) Document. The PSP Document consisted of the Applicant's Proposed Study Plans, Responses to Stakeholder Study Requests and a schedule for conducting the Study Plan Meeting. The ILP required Study Plan Meeting was conducted on June 14, 2007. The purpose of the Study Plan Meeting was to provide stakeholders with an opportunity to review and comment on Douglas PUD's PSP Document, to review and answer questions related to stakeholder study requests and to attempt to resolve any outstanding issues with respect to the PSP Document.

On September 14, 2007, Douglas PUD submitted a Revised Study Plan (RSP) Document. The RSP Document consisted of a summary of each of Douglas PUD's RSPs and a response to stakeholder comments on the PSP Document.

On October 11, 2007, FERC issued its Study Plan Determination based on its review of the RSP Document and comments from stakeholders. FERC's Study Plan Determination required Douglas PUD to complete 10 of the 12 studies included in its RSP Document. Douglas PUD has opted to complete all 12 studies to better prepare for the 401 Water Quality Certification process conducted by the Washington State Department of Ecology (Ecology) and to fulfill its commitment to the RWGs who collaboratively developed the 12 Agreed-Upon Study Plans with

Douglas PUD. These study plans have been implemented during the designated ILP study period. The results from the study plans have been developed into 12 Study Reports. Each report is included in Douglas PUD's Initial Study Report (ISR) Document, which is scheduled for filing with FERC on October 15, 2008.

This study was voluntarily conducted by Douglas PUD based upon the agreed-upon study plan filed with FERC in the Revised Study Plan. This interim report provides initial results from the Dissolved Oxygen (DO), pH and Turbidity Study including data collected through August 5, 2008. Additional field sampling is scheduled to take place during August, September and October 2008. The final report containing all of the data collected during 2008 will be completed and available to the public in early 2009.

2.0 GOALS AND OBJECTIVES

The goal of this study is to continue monitoring DO, pH, and turbidity in the Wells Dam forebay and lower Okanogan River, both above and within the Wells Project boundary.

Ecology is the agency responsible for administering the state water quality standards (WQS) and for the issuance of 401 water quality certificates for hydroelectric projects in Washington. The information gathered from this monitoring effort will assist Ecology in determining whether the Project is compliant with the specified numeric criteria for DO, pH and turbidity.

3.0 STUDY AREA

The study area consists of waters within the Wells Project with a particular emphasis on the Wells Dam forebay and the lower Okanogan River from its confluence with the Columbia River up to RM 17.0 (Figure 1.1-1).

4.0 BACKGROUND AND EXISTING INFORMATION

DO levels are a critical variable for aquatic life and affect the chemical dynamics of a water body. DO levels are influenced by a suite of factors including the level of biological activity in the water, turbulence, and temperature (EES Consulting, 2006).

The term pH is used to describe the acidity or hydrogen ion content of a liquid. Factors influencing the pH of a water body include the chemical composition of soils in the watershed, photosynthetic activity, pollutants, and respiration of organisms (EES Consulting, 2006). Levels of pH which are extremely acidic or basic can adversely impact aquatic life and may indicate that other pollutants are present within a watershed.

Turbidity is the measure of the light scattering from suspended particles in water that reduce its transparency. After light enters water, it is absorbed, reflected or refracted by dissolved organic substances, pigmented (phytoplankton) and colored particulates, inorganic particulates, and by the water itself. Transparency also regulates primary productivity and trophic dynamics which ultimately can affect fish populations. There is a direct relationship between turbidity, water transparency and the depth at which macrophytes grow (EES Consulting, 2006).

Factors and activities affecting water quality in the Wells Project include: 1) nonpoint source pollution from agricultural runoff and irrigation return flow, 2) point source pollution from mines, municipal and industrial sources upriver and outside of the Wells Project boundary, 3) depletion of in-stream flows from water diversions and consumptive uses, 4) watershed management in the tributaries and Upper Columbia River above Wells Dam, 5) the operation of large water storage facilities located upriver of Wells Dam on the mainstem Columbia and in the Okanogan watershed, 6) effects related to operations of the Wells Project, and 7) elevated sediment concentrations due to rain and snowmelt runoff.

Under section 303(d) of the Clean Water Act (CWA), states are required to list all water body segments that do not meet the state water quality standards. Within the Wells Project boundary, specific water reaches have been put on the state's 303(d) list in the past for various parameters. However, no river segments within the Project boundary are on Ecology's current 303(d) list for DO, pH or turbidity (Ecology, 2008a).

Douglas PUD and state and federal agencies have implemented water quality monitoring programs to collect information within or adjacent to the Wells Project. The programs collect a variety of biological, chemical, and physical water quality parameters and typically include the three parameters of interest (DO, pH, and turbidity). Unpublished data collected from these monitoring activities have indicated that waters within the Wells Project are generally in compliance with the state standards. During times when Wells Project waters are in exceedance of the stated numeric criteria for these parameters, waters entering the Wells Project are also out of compliance.

4.1 Aquatic Resource Work Group

As part of the relicensing process for the Wells Project, Douglas PUD established an Aquatic RWG which began meeting informally in November, 2005. This voluntary effort was initiated to provide stakeholders with information about the Wells Project, to collaboratively identify potential resource issues related to Project operations and relevant to relicensing, and to develop preliminary study plans to be included in the Wells Pre-Application Document (PAD) (DCPUD, 2006).

Through a series of meetings, the Aquatic RWG cooperatively developed a list of Issue Statements, Issue Determination Statements and Agreed-Upon Study Plans. An Issue Statement is an agreed-upon definition of a resource issue raised by a stakeholder. An Issue Determination Statement reflects the RWG's efforts to review the existing project information and to determine whether an issue met FERC's seven criteria and would be useful in making future relicensing decisions. Agreed-Upon Study Plans are the finished products of the informal RWG process.

The Issue Statement and Issue Determination Statement described below were included in the PAD (section number included) filed with FERC on December 1, 2006:

4.1.1 Issue Statement (PAD Section 6.2.1.7)

Project operations may affect compliance with DO, pH and turbidity standards in the Wells Project.

4.1.2 Issue Determination Statement (PAD Section 6.2.1.7)

The Wells Project may have an effect on compliance with the standards for DO, pH and turbidity. Currently, Douglas PUD has collected water quality data toward the evaluation of meeting the numeric criteria for these parameters. Initial data collected during the 2005 baseline limnological assessment indicates that Douglas PUD is in compliance with the Washington State standard for these parameters. However, additional monitoring is required to make a final determination.

The resource work group agreed that a study during the two-year ILP study period would be necessary. The study was to focus on the collection of DO, pH and turbidity in the Wells Project especially focusing on data collection from the Okanogan River and at Wells Dam.

4.2 Project Nexus

Ecology is responsible for the protection and restoration of the state's waters. Ecology has adopted water quality standards that set limits on pollution in lakes, rivers, and marine waters in order to protect water quality. On July 1, 2003, Ecology completed the first major overhaul of the state's water quality standards in a decade. A significant revision presented in the 2003 water quality standards classifies fresh water by actual use, rather than by class as was done in the 1997 standards. These revisions were adopted in 2003 and are maintained in the current 2006 standards in order to make the standards less complicated to interpret and provide future flexibility as the uses of a water body evolve.

Under the 2006 WQS, the Wells Project includes designated uses for spawning/rearing (aquatic life), primary contact recreation, and all types of water supply and miscellaneous uses (Ecology, 2006). Numeric criteria to support the protection of these designated uses consist of various physical, chemical, and biological parameters, including the water quality indicators that are the subject of this study: dissolved oxygen (DO), pH, and turbidity. The 2006 WQS for DO, pH, and turbidity are presented below in Section 4.4.

The information resulting from continued monitoring of DO, pH, and turbidity will assist the Aquatic RWG in the development of licensing requirements through the 401 water certification process.

4.3 Water Quality Standards

Congress passed the CWA in 1972, and designated EPA as the administering federal agency. This federal law requires that a state's WQS protect the surface waters of the U.S. for beneficial or designated uses, such as recreation, agriculture, domestic and industrial use, and habitat for aquatic life. Any state WQS, or amendments to these standards, do not become effective under the CWA until they have been approved by EPA.

Ecology is responsible for the protection and restoration of the State's waters. Ecology establishes WQS that set limits on pollution in lakes, rivers, and marine waters in order to protect water quality and specified designated and potential uses of such water bodies. These standards are found at WAC 173-201A.

4.3.1 Water Quality Standards for the Project

The Project includes the mainstem Columbia River above Wells Dam, one mile of the mainstem Columbia River below Wells Dam, the Methow River (up to RM 1.5) and the Okanogan River (up to RM 15.5).

Under the 2006 WQS, the Project includes designated uses for spawning/rearing (aquatic life), primary contact recreation, and all types of water supply and miscellaneous uses (Ecology, 2006). Numeric criteria to support the protection of these designated uses consist of various physical, chemical, and biological parameters, including the water quality indicators that are the subject of this study: dissolved oxygen (DO), pH, and turbidity.

4.3.1.1 Dissolved Oxygen

Dissolved Oxygen criteria are measured in milligrams per liter (mg/L). Based upon criteria developed by Ecology, DO concentrations shall not be under the 1-day minimum of 8.0 mg/L, this being defined as the lowest DO reached on any given day.

When a waterbody's DO is lower than the 8.0 mg/L criteria (or within 0.2 mg/L of the criteria) and that condition is due to natural conditions, then human actions considered cumulatively may not cause the DO of that water body to decrease more than 0.2 mg/L.

Concentrations of DO are not to fall below 8.0 mg/L at a probability frequency of more than once every ten years on average.

DO measurements should be taken to represent the dominant aquatic habitat of the monitoring site. This typically means samples should:

> (A) be taken from well mixed portions of rivers and streams.
>
> (B) not be taken from shallow stagnant backwater areas, within isolated thermal refuges, at the surface, or at the water's edge.

4.3.1.2 pH

The pH of a water body is defined as the negative logarithm of the hydrogen ion concentration. Under the WQS, pH measurements shall be in the range of 6.5 to 8.5, with a human-caused variation within the above range of less than 0.5 units.

4.3.1.3 Turbidity

Turbidity is measured in nephelometric turbidity units (NTUs). Turbidity shall not exceed 5 NTU over background when the background is 50 NTU or less; or a 10% increase in turbidity when the background turbidity is more than 50 NTU.

4.4 Douglas PUD Monitoring Activities

In August, 2005, Douglas PUD began monitoring DO and pH in the Wells Dam forebay during the season when the probability of low DO levels was highest. The results of this monitoring effort indicated that DO levels were not below 8.0 mg/L and pH levels were not outside of the specified range of 6.5 to 8.5, which are the state water quality numeric criteria (Ecology, 2006). In response to requests made by Ecology, Douglas PUD has continued implementing seasonal monitoring for these parameters at hourly intervals at the Wells Dam forebay. Monitoring at the forebay in 2008 began on May 30. The monitoring is performed using a Hydrolab Minisonde deployed at depths that have ranged from 5.08 to 7.76 meters through the 2008 monitoring period.

At Wells Dam, Secchi disk readings are also taken to measure water transparency, which is inversely correlated to turbidity. Sampling occurs daily during the adult fish passage assessment period of May 1 to November 15. Measurements are recorded in feet of visibility and reliable information adhering to a standard protocol has been collected since 1998. During the monitoring period, Secchi disk readings ranged from 2 feet during spring run-off to 16 feet by late summer.

In 2005, Douglas PUD contracted with EES Consulting to conduct a comprehensive limnological investigation of Wells Project waters (EES Consulting, 2006). The year-long study was conducted at nine sites (seven sites in the Columbia River and one site in both the Methow and Okanogan rivers) in order to characterize water quality and seasonal trends in the Wells Project. Water quality sampling was scheduled seasonally with one sample event scheduled for each season. Spring sampling was conducted in May, fall monitoring was conducted in October, and winter sampling occurred in February (2006). Summer sampling was conducted more frequently when water quality exceedances were more likely and temporal changes more dynamic (July, August and September). Results of the study found DO levels at 1m depth in Wells Project waters increased from upriver to downriver at the sites sampled; the average difference (May through October) was 1.07 mg/L. All surface water measurements had DO values greater than 8.0 mg/L and pH for Wells Project waters generally varied between 7.5 and 8.25, which is slightly above neutral. There were no measured exceedances of the water quality criteria for pH. Turbidity in the Wells Reservoir showed relatively little seasonal variation with an annual average of 0.98 NTUs. Longitudinal variation in turbidity was also minimal. Low turbidity in the reservoir was attributed partially to the large upriver storage reservoir capacity that allows fines to settle out. Turbidity in the Okanogan River was consistently higher than in the Wells Reservoir. Turbidity in the Methow River was higher than in the Wells Reservoir in May (due to sediment load) and in August due to phytoplankton growth. The only turbidity reading over 5 NTUs was in the Methow River during May (EES Consulting, 2006).

4.5 Ecology Monitoring Activities

Ecology has conducted monthly water quality monitoring at locations on the Okanogan River near Malott (station 49A070) upriver of the Wells Project boundary at approximately RM 17 and on the Methow River near Pateros (station 48A070) upriver of the Wells Project boundary at approximately RM 5. Both stations are considered "long-term" stations by Ecology and provide the most reliable information for the quality of water entering the Wells Reservoir from tributary inflow. It is important to note that data collected from these stations are representative of water quality conditions upstream of the Wells Project boundary. Data are typically collected as grab samples on a monthly basis. A variety of water quality parameters including DO, pH, and turbidity information as well as site compliance are available at http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html. Table 4.5-1 provides the range of values for the parameters of interest observed at the Okanogan River long-term monitoring station since 2001 (Ecology, 2008b).

Table 4.5-1. The range of DO, pH and turbidity values observed from monthly grab samples collected upriver of the Wells Project on the Okanogan (RM 17). Data from Ecology long-term monitoring stations 2001-2007.

	DO (mg/L)	pH	Turbidity (NTU)
2001	7.32 to 13.87	7.87 to 8.45	0.8 to 5.5
2002	8.80 to 13.63	7.83 to 8.39	1.0 to 19
2003	8.32 to 13.30	7.81 to 8.35	0.8 to 22
2004	8.16 to 14.08	7.48 to 8.55	0.9 to 75
2005	7.24 to 14.11	7.85 to 8.44	0.8 to 7.8
2006	7.89 to 13.53	8.09 to 8.58	<0.5 to 26
2007	7.43 to 13.13	7.94 to 8.45	1.6 to 85

4.6 United States Geological Survey (USGS) Monitoring Activities

The USGS monitors surface water quality in cooperation with local and state governments and with other federal agencies. Monitoring programs consist of collection, analysis and data archiving and dissemination of data and information describing the quality of surface water resources. Similar to Ecology, the USGS has monitoring stations on both the Okanogan (12447200) and Methow (122449950) rivers near Malott and Pateros, respectively. However, the data collected at the Malott station since 1994 has been limited to stage, discharge and water temperature; therefore the USGS is a very limited source of water quality data for the Okanogan River. USGS data can be accessed via the Internet at: http://nwis.waterdata.usgs.gov/wa/nwis/qwdata.

5.0 METHODOLOGY

A Quality Assurance Project Plan (QAPP), revised to incorporate review comments from Ecology, identified the organization, schedule, data quality objectives, sampling design, monitoring locations, field procedures, quality control, and data management and reporting associated with implementing the DO, pH, and turbidity study proposed by the RWG (Parametrix, 2008a).

5.1 Monitoring Locations

In order to collect information that is informative of the effects of Wells Project operations on the water quality parameters of interest and whether these parameters are in compliance with the Washington State water quality standards, monitoring instruments were installed in the following locations:

- Okanogan River above the Project boundary at Malott (RM 17.0);
- Okanogan River near Monse (RM 5.0);
- Okanogan River upriver of the confluence with the Columbia River (RM 1.3);
- Wells Dam forebay (RM 516).

The Okanogan River monitoring instruments are installed on pilings with bridge locations shown on Figures 5.1-1 and 5.2-1.

Figure 5.1-1 Water quality monitoring instrument housing mounted on the downriver side of a Monse Bridge piling.

5.2 Study Design

At each of the three stations located in the lower Okanogan River and at the station in the Wells Dam forebay, dissolved oxygen, pH, and turbidity are measured continuously using Hydrolab Minisonde5 instrumentation. Instruments are calibrated prior to each field visit according to the manufacturer's specifications. Winkler titrations are performed during each field event to ensure the dissolved oxygen probes are functioning properly, and the probes are re-calibrated if the result of the Winkler titration and probe reading differ by more than 0.2 mg/L.

The following sampling and analysis components were designed to address the water quality monitoring objectives:

- Multiprobe water quality instruments capable of continuous monitoring of DO, pH, and turbidity were installed at the three Okanogan River locations to supplement the existing Wells Dam forebay monitoring station. The instruments are deployed in locked housings mounted to bridge pilings near midstream at each Okanogan River location.
- Parametrix and Douglas PUD conducted a reconnaissance of each site in April 2008 to determine the best available location for deploying monitoring instruments, take measurements and determine the hardware needed for constructing and mounting the instrument housings.
- Housings were designed and constructed to protect continuous monitoring instrumentation at the three new locations identified above, and installed to allow the monitoring probes to be approximately 1 meter below the water surface during low flows.
- The instrument housings and multi-probe meters were installed and began recording measurements on May 5 and 6, 2008. The instruments were calibrated and programmed to record DO, pH, and turbidity at 30-minute intervals. They will continue to record measurements through October 30, 2008.
- The Wells Dam forebay multi-probe meter began recording DO and pH at one-hour intervals on May 30, 2008, and a turbidity sensor began recording at 5-minute intervals on June 3, 2008.
- Monitoring instruments were retrieved, calibrated, and maintained, and data downloaded every 2 to 4 weeks, depending on battery life and river conditions effecting accessibility and safety.
- Data are downloaded to a meter and transferred to a personal computer in the field. Backup copies of the data were recorded on a CD or flash drive while still in the field.
- A separate quality assurance/quality control (QA/QC) instrument was calibrated before each downloading event and used for comparisons to the fixed instrument readings. Winkler titrations were performed to verify the accuracy of the DO sensor readings.

Figure 5.2-1 Locations of bridges with water quality monitoring instrumentation on the lower Okanogan River.

5.3 Data Quality Objectives

Because the Okanogan and Columbia rivers are generally well-mixed riverine environments, the field-located sites are expected to be representative of water quality conditions in the monitored reaches. The same type of instruments and monitoring crew were used to collect data at each Okanogan River site; therefore, the data are expected to be comparable between monitoring locations.

The primary instrument for measurement of in situ DO, pH, and turbidity was the Hydrolab Minisonde5 equipped with DO, pH, and turbidity sensors. Sensors are susceptible to fouling by debris, sediment, and growth of organisms (algae, etc.) during continuous deployment. Therefore, luminescent dissolved oxygen (LDO) and self-cleaning turbidity sensors were employed because they are resistant to fouling or configured to retard fouling. The LDO sensor is not affected by fouling or other debris, unless the growth is an organism that locally consumes or produces oxygen, such as algae growing directly on the sensor cap. The self-cleaning turbidity sensor offers a wiper mechanism to reduce the effects of fouling.

The primary QA/QC instrument was a Hydrolab® Datasonde4a coupled with a Surveyor4a (SVR4a) display and recording unit (Figure 5.3-1). This unit was also equipped with DO, pH, and turbidity sensors as well as conductivity and temperature sensors. The Datasonde4a was used in the field to verify the accuracy of the continuously deployed Minisonde5 sensors. The SVR4a display and recording unit was used to download data from the Minisondes during data retrieval events.

Figure 5.3-1 Downloading data from a Hydrolab MiniSonde5, located within its protective casing, using a Surveyor4a, at the Highway 97 Bridge.

Accuracy objectives for water quality field measurements are presented in Table 5.3-1.

The monitoring data completeness goal was 90 percent.

Table 5.3-1 Measurement quality objectives for dissolved oxygen, conductivity, pH, turbidity, temperature, and depth.

Parameter	Method	Duplicate Samples Relative Standard Deviation (RSD)	Method Reporting Limit and/or Resolution
Dissolved Oxygen[1]	Hydrolab® Datasonde 5	5% RSD	0.01 mg/L
Dissolved Oxygen[2]	Winkler Titration	+/- 0.1 mg/L	0.01 mg/L
Specific Conductivity[3]	Hydrolab® Datasonde 5	+/- 0.5%	0.01 µS/cm
pH[3]	Hydrolab® Datasonde 5	0.05 s.u.[4]	± 0.01 s.u.
Turbidity[5]	Hydrolab® Datasonde 5	+/- 1% (0 to 100 NTU[6]) +/- 3% (100 to 400 NTU)	0.1 NTU (0-400 NTU)
Water Temperature[3]	Hydrolab® Datasonde 5	+/- 0.1° C	0.01° C
Depth[3,7]	Hydrolab® Datasonde 5	± 0.05 meters	0.01 meters

[1] Luminescent Dissolved Oxygen Sensor
[2] As units of measurement, not RSD or percentages
[3] As percentage of reading, not RSD
[4] Standard Units
[5] Self-cleaning Turbidity Sensor
[6] NTU = Nephelometric Turbidity Unit
[7] Non-vented 0 -100 meter Depth Sensor

5.4 Quality Control Procedures

All sondes and the SVR4a were performance-tested and evaluated (PT&E) by the manufacture before the initial deployment for continuous monitoring. Required factory calibrations and maintenance, as well as necessary repairs, take place during the PT&E event. Should a sonde or the SVR4a be damaged during deployment and monitoring, a replacement loaner will be obtained from the manufacturer while the damaged unit is being repaired.

The sensors of each Minisonde were calibrated before deployment and in the field during instrument servicing/data retrieval events. The QA/QC Datasonde was calibrated before each data retrieval event and used for comparisons to the fixed instruments readings. The Datasonde was also re-calibrated on return from the field. This post-event calibration verifies that the Datasonde was functioning correctly and that the accuracy of the sensors has not deteriorated. Winkler titrations are performed to verify the accuracy of the QA/QC instrument DO sensor readings and, in the field, at each monitoring location to verify Minisonde DO sensor readings.

A calibration log was maintained to document the dates and times of sonde calibration, and any calibration problems and corrective actions taken (e.g., replacing electrolyte solution in the pH probe). This log was kept with the filling and calibration solutions and spare parts that were taken to the field. The calibration log will be retained in the project files.

Datasonde maintenance and replacement of filling solutions occur before each data retrieval event, as necessary. Minisonde maintenance and replacement of filling solutions occured in the field, as necessary, during data retrieval mobilizations. Calibration standards and buffers were replaced based on manufacturers' recommendations.

6.0 RESULTS

Monitoring results from the four study sites are tabulated in Appendices A through D.

6.1 Monitoring Instrument Performance

Hydrolab Minisonde5 instruments equipped with DO, pH, and turbidity sensors were installed at lower Okanogan River locations in protective housings and activated on May 5, 2008. Through the 2008 monitoring period the deployment depth ranged from 3.0 to 5.9 meters at Highway 97, 1.0 to 3.2 meters at Monse, and 1.5 to 5.1 meters at Malott. There were six instrument servicing events through August 5, each event including downloading data, calibrating and performing maintenance on the instruments, performing quality control checks including Winkler's titrations for dissolved oxygen determination, and replacing batteries. A similar instrument deployed in the Wells Dam forebay was serviced bi-monthly.

High river flows and woody debris accumulations limited access to some instruments and battery failures resulted in several periods when the instruments were not recording data from one or more sensors. Efforts to access the instruments at Malott and Monse on May 28 and June 10 were unsuccessful due to high flow and a log jam on the Malott Bridge piling where the instrument was mounted (Figure 6.1-1). Because the instruments could not be serviced the batteries ran out of power on May 29 at Monse and May 30 at Malott. These two instruments were accessed on June 19 and placed back in operation with new batteries. Eleven days of

Figure 6.1-1 High river flow and woody debris preventing safe access to the Malott Bridge monitoring instrument.

monitoring in July were missed at Highway 97 due to faulty batteries that expired well before their typical battery life. Three weeks at Monse and one additional week at Malott were also missed in July due to battery failures. No further access issues are anticipated and data collection will continue until the instruments are retrieved in late October 2008.

Douglas PUD staff reported problems with the self-cleaning mechanism on the Global Water WQ750 turbidity sensor deployed in the Wells Dam forebay. Although there were frequent manual cleanings of the sensor window, problems with instrument fouling persisted. Data collected by this instrument were judged to be unreliable and they were rejected as unusable during the time period covered by this interim report.

6.2 Dissolved Oxygen Results

Lower Okanogan River minimum daily DO concentrations of at least 9 to 10 mg/L were recorded early in the monitoring season. Starting in early July, DO concentrations measured in the lower Okanogan River (above and within Project boundary) dropped to below the 8.0 mg/L water quality criterion as snowmelt runoff receded and water temperatures warmed (Figure 6.2-1). During the period when DO concentrations were below 8.0 mg/L, the lowest DO recorded was upriver of the Project. At the Wells forebay, DO concentrations steadily dropped after early June, reaching a low of 9.01 mg/L on August 1. At this site, DO concentrations consistently remained well above the 8.0 mg/L minimum numeric water quality criterion.

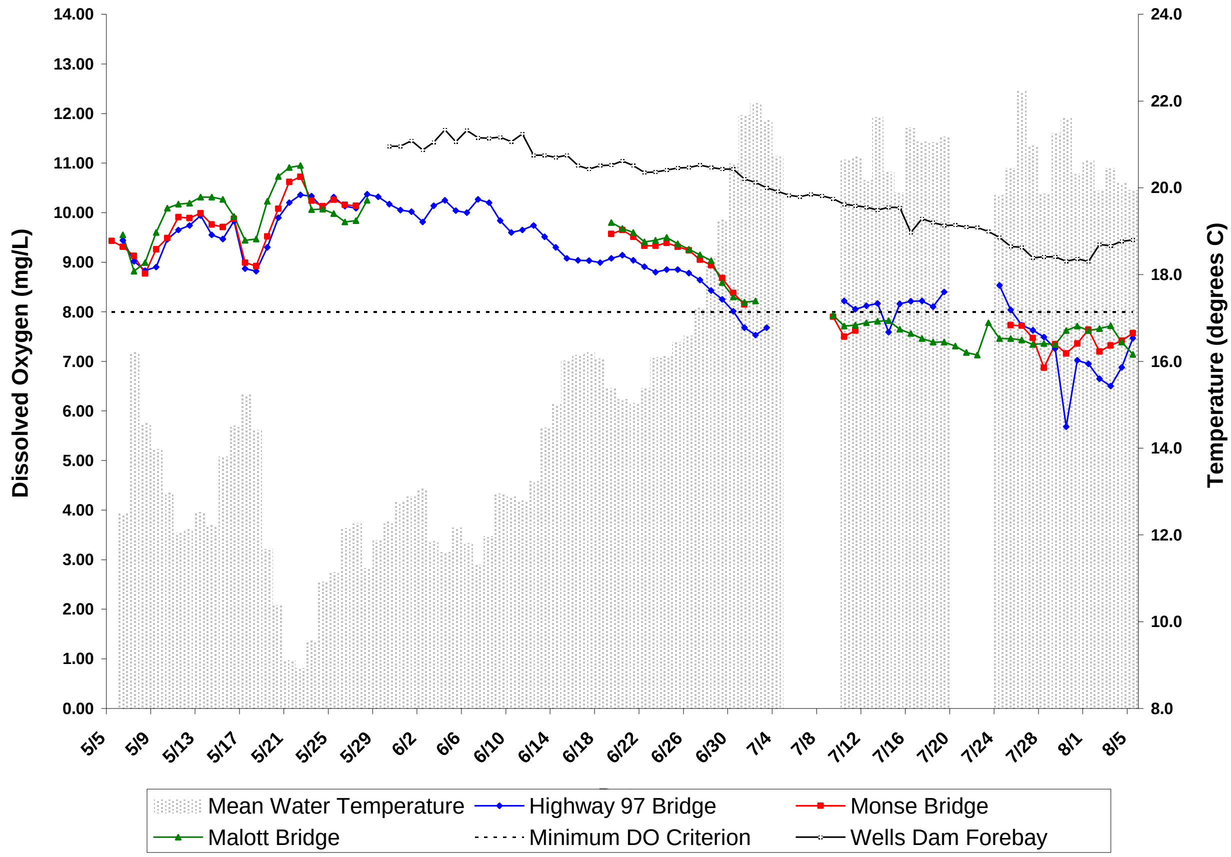

Figure 6.2-1 Daily minimum DO concentrations.

Minimum daily DO concentrations were measured below 8.0 mg/L at Malott and Monse from early July with the lowest measurement of 7.13 mg/L on July 22 at Malott and 6.87 mg/L recorded on July 28 at Monse (Figures 6.2-2 and 6.2-3). Though less pronounced than at Highway 97, there were also much larger daily fluctuations in DO concentrations at Malott and Monse beginning in mid to late July, as illustrated by greater differences between daily minima and maxima. Consistently following a diurnal pattern during this period, DO concentrations at Malott reached their daily peak in the evening followed by daily minima in the morning hours. These observations are consistent with the diurnal respiration cycle of the aquatic vegetation. This diurnal pattern was much less pronounced and consistent at Monse compared to Malott.

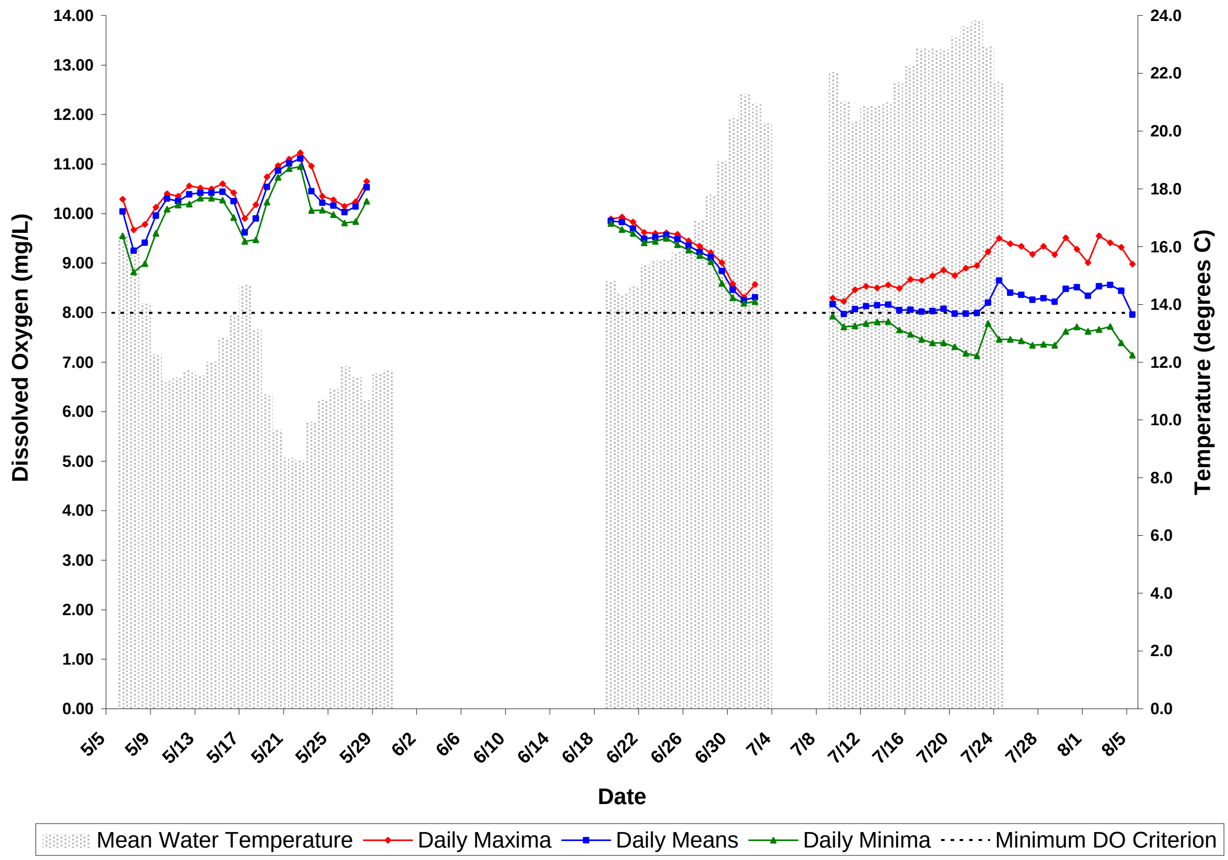

Figure 6.2-2 **Daily minimum, mean and maximum DO measurements at Malott Bridge, with daily mean temperatures.**

Figure 6.2-3 Daily minimum, mean and maximum DO measurements at Monse Bridge, with daily mean temperatures.

At Highway 97 the daily minimum DO readings began to occasionally drop below 8.0 mg/L on July 1, and remained below 8.0 mg/L since July 26 (Figure 6.2-4). Between May 5 and 8, there was at least a 2.0 mg/L difference between daily minima and maxima, followed by a period through July 3 when the daily DO fluctuation was generally no more than 0.5 mg/L. By July 10 substantial differences between daily minima and maxima, at times more than 3.0 mg/L, resumed and continued through the most recent data downloading event.

Relatively minor differences between daily minimum and maximum DO were observed at the Wells Dam forebay (Figure 6.2-5). DO concentrations at this monitoring site generally declined through the summer as the river warmed. DO measurements at the Wells Dam forebay remained above 9.0 mg/L (and above the 8.0 mg/L minimum water quality criterion) throughout the 2008 monitoring period.

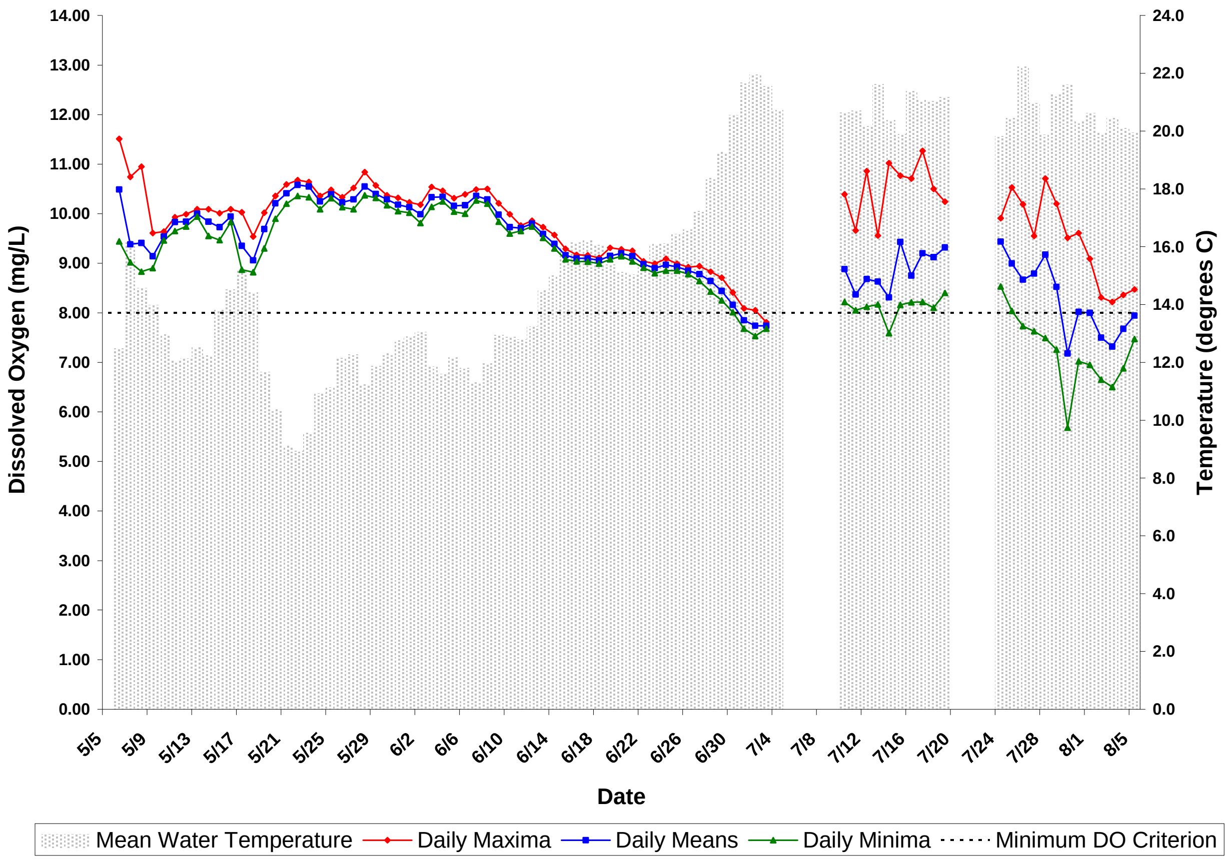

Figure 6.2-4 Daily minimum, mean and maximum DO measurements at the Highway 97 Bridge, with daily mean temperatures.

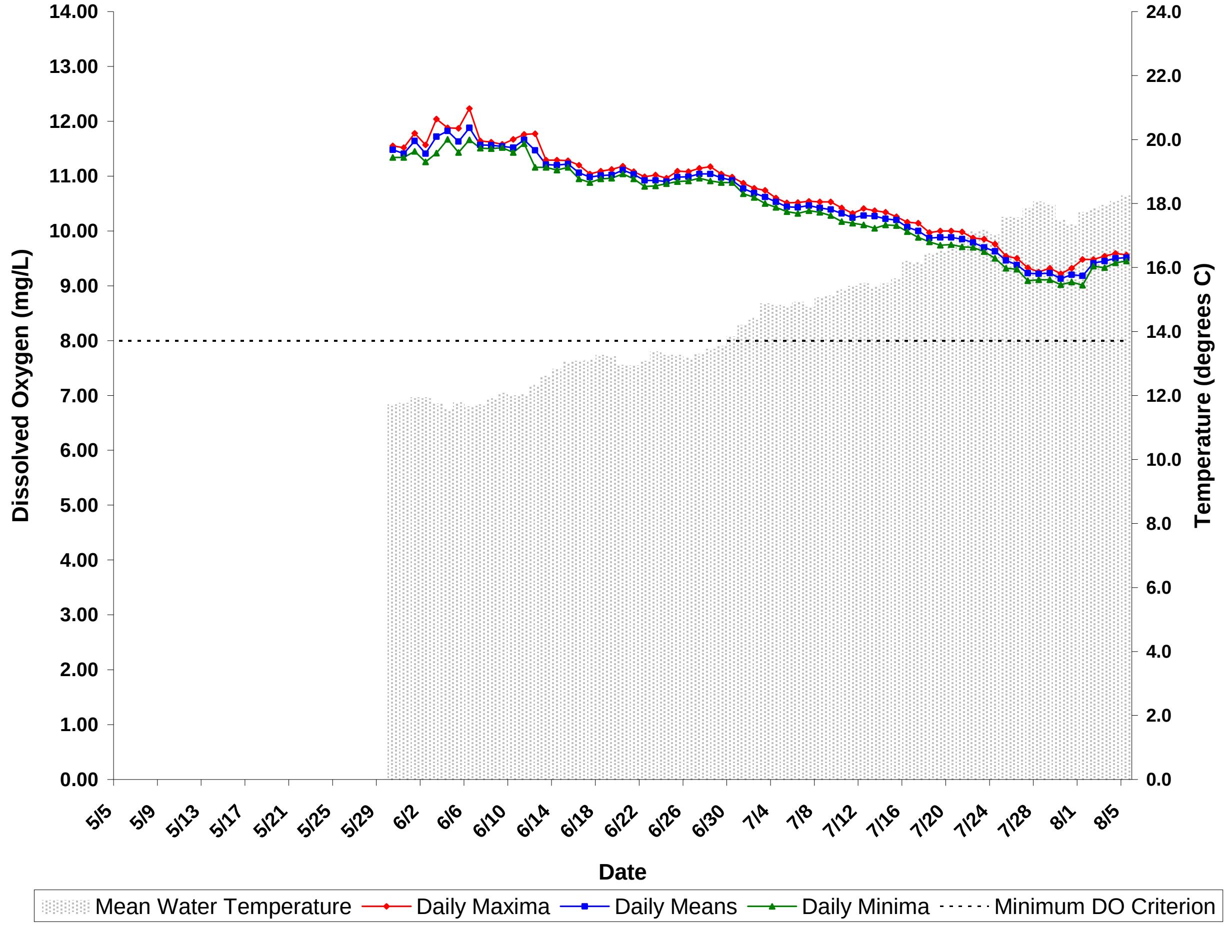

Figure 6.2-5 **Daily minimum, mean and maximum DO measurements at the Wells Dam forebay, with daily mean temperatures.**

6.3 pH Results

Okanogan River pH was neutral to slightly alkaline during 2008 monitoring. The pH measurements ranged from 7.23 to 8.70 at Malott Bridge, 7.07 to 8.68 at Monse Bridge, and 7.39 to 8.61 units at the Highway 97 Bridge. There were only a few excursions of pH outside the 6.5 to 8.5 range of water quality criteria: pH reached 8.56 on May 6 at Malott Bridge, pH reached 8.58 on May 5 and 8.68 on May 6 at Monse Bridge, and pH reached 8.61 at Highway 97 on the evening of July 17 (Figures 6.3-1 to 6.3-4). The only extensive period of pH excursions occurred at the Malott Bridge between July 24 and August 5 when diurnal occurrences of higher late afternoon to nighttime pH reached as high as 8.70. At no time has pH approached the 6.5 minimum criterion.

Wells Dam forebay pH was also neutral to slightly alkaline during 2008 monitoring, ranging from 7.09 to 8.07 (Figure 6.3-5). All measurements were within the 6.5 to 8.5 range of water quality criteria.

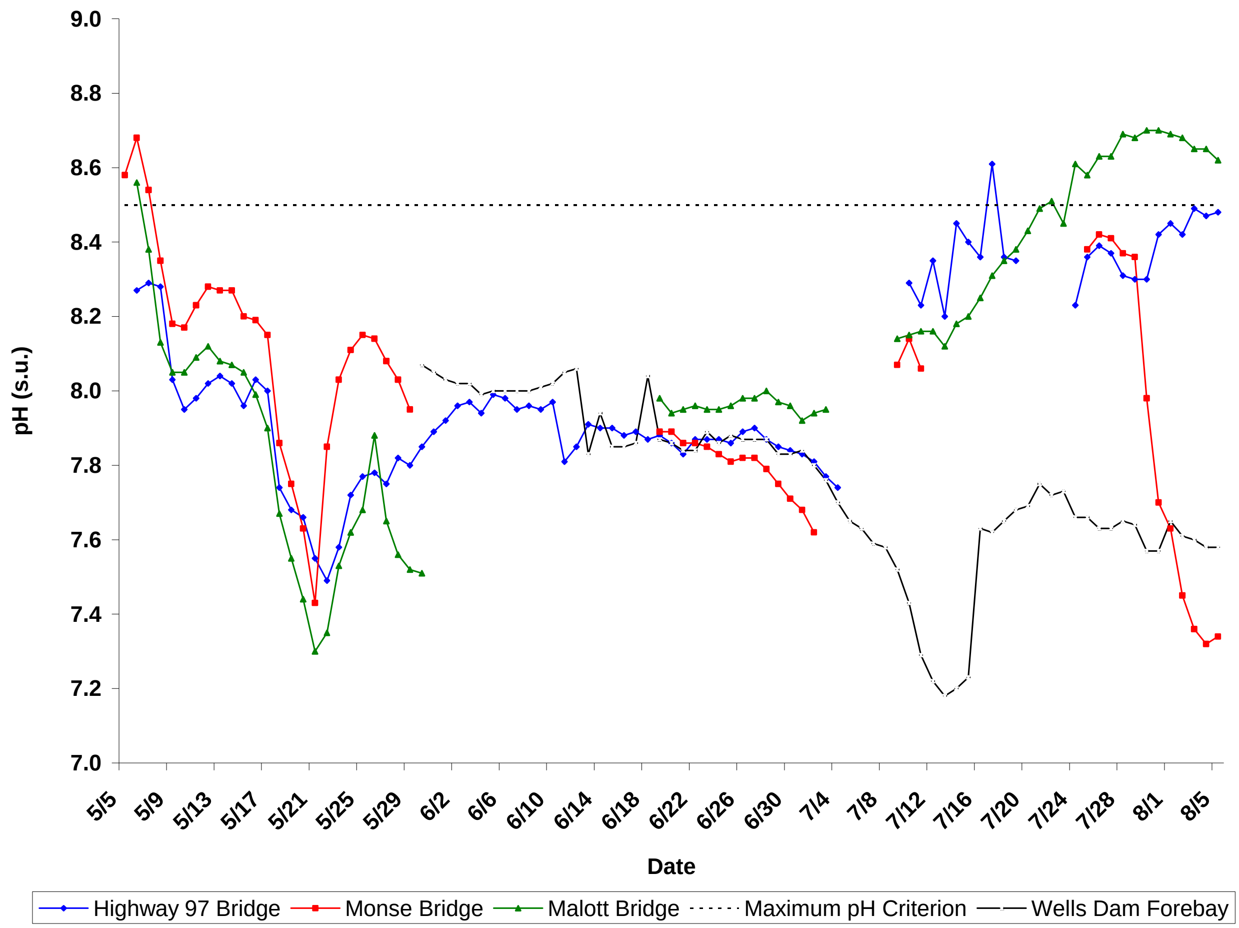

Figure 6.3-1 Daily maximum pH concentrations in the lower Okanogan River.

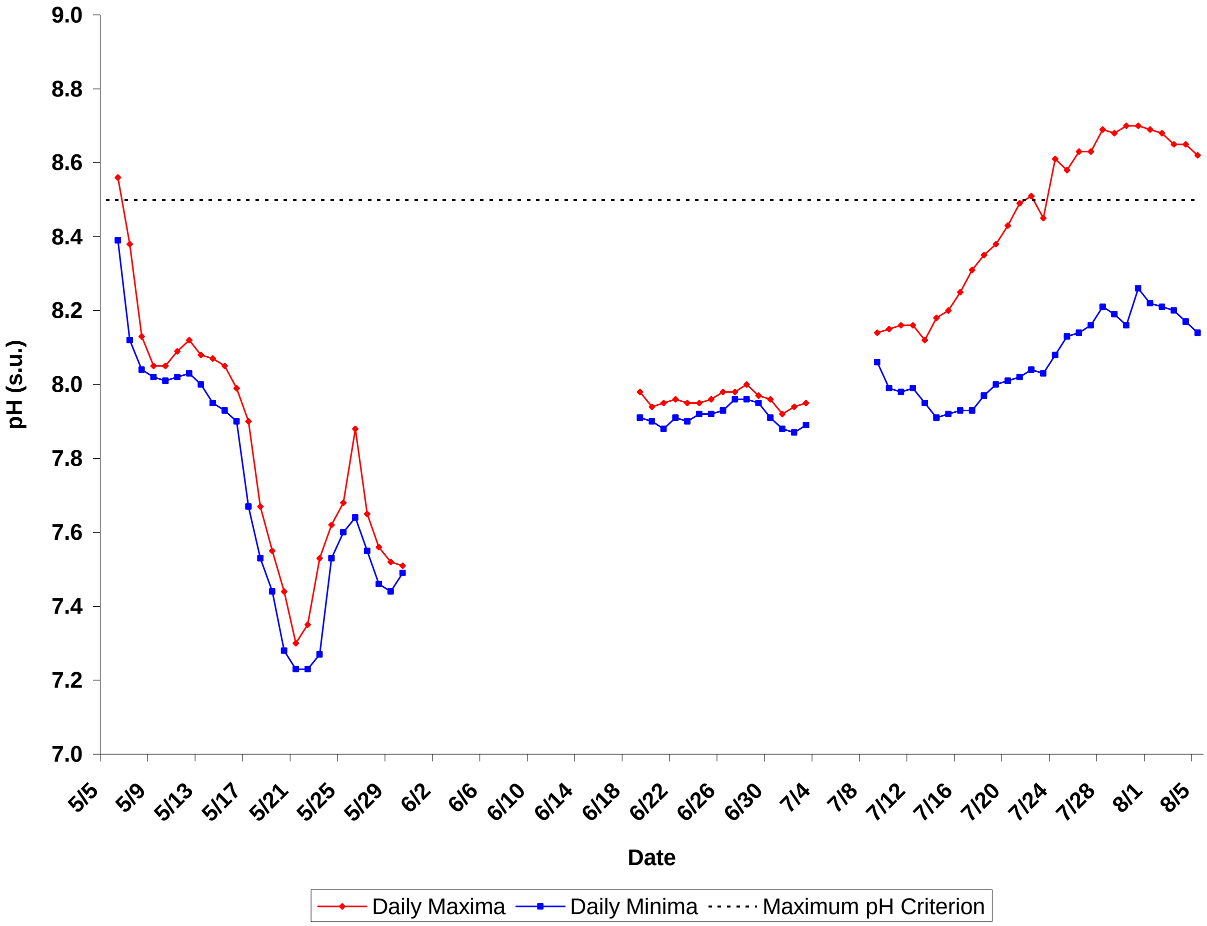

Figure 6.3-2 Daily minimum and maximum pH measurements at Malott Bridge.

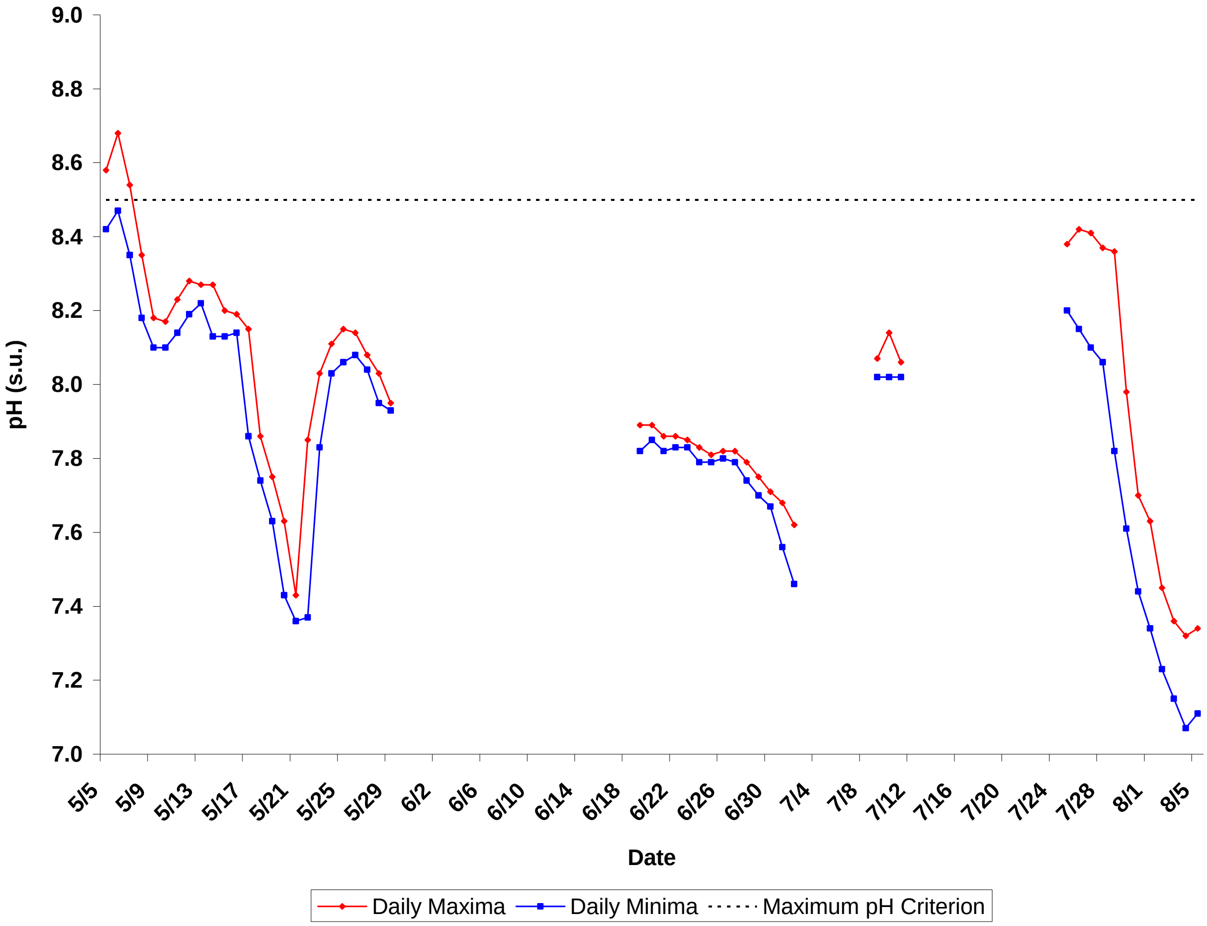

Figure 6.3-3 Daily minimum and maximum pH measurements at Monse Bridge.

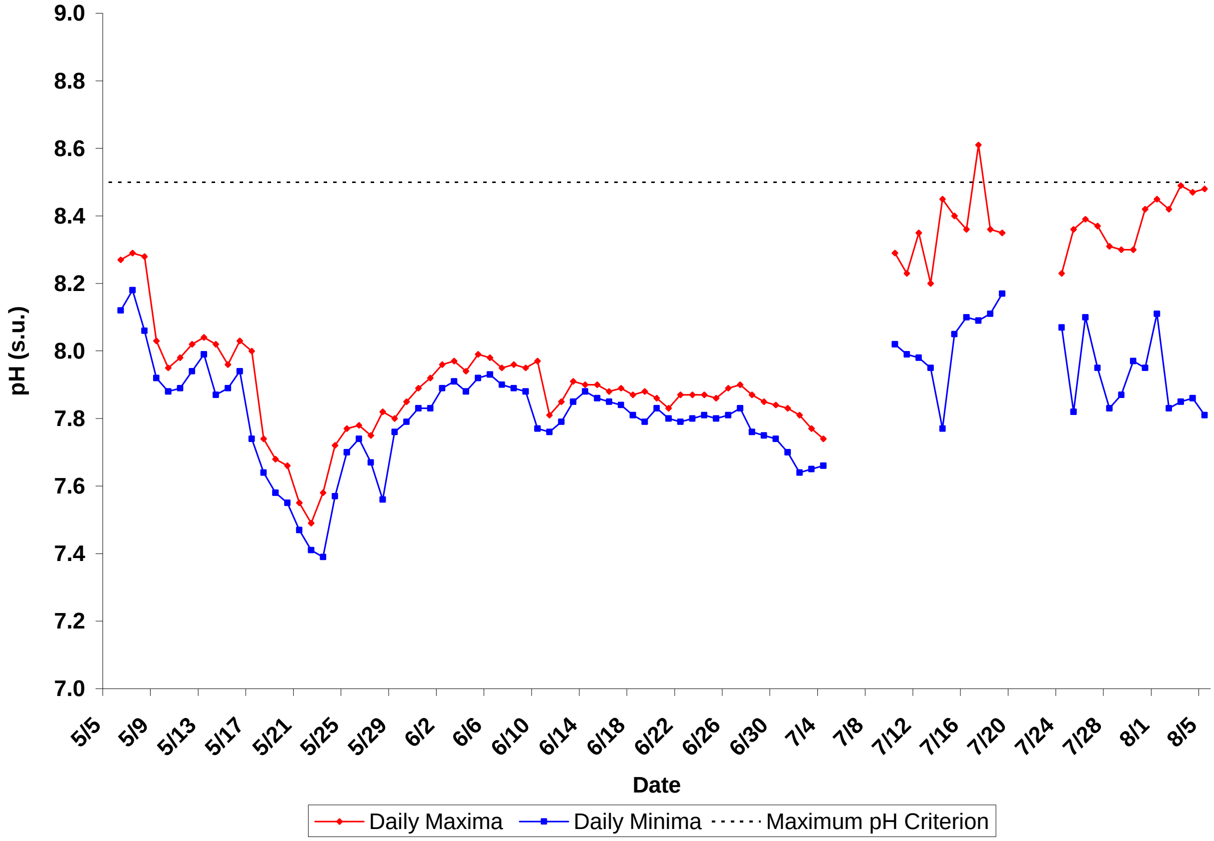

Figure 6.3-4 Daily minimum and maximum pH measurements at Highway 97 Bridge.

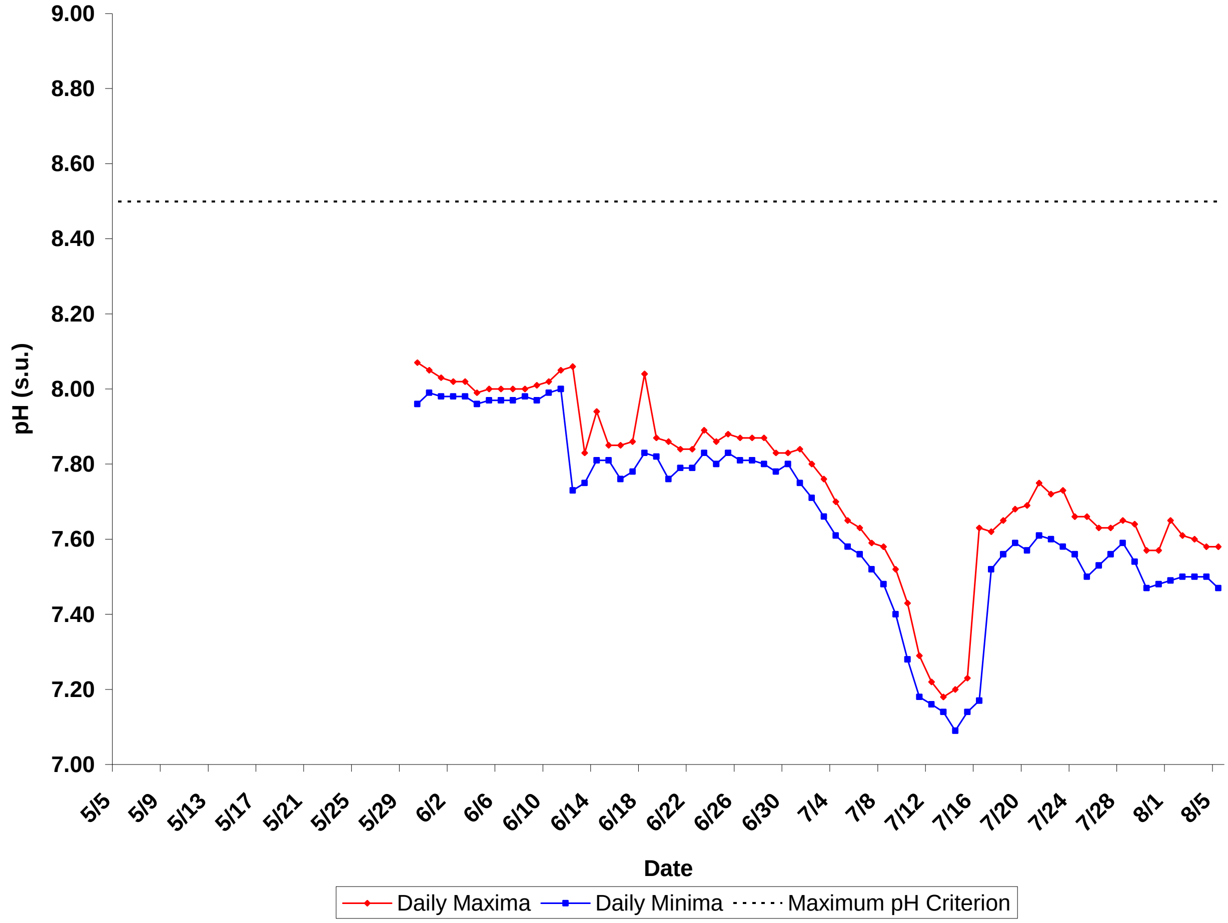

Figure 6.3-5 **Daily minimum and maximum pH measurements at the Wells Dam forebay.**

6.4 Turbidity Results

Lower Okanogan River turbidity increased sharply with the snowmelt runoff peak beginning on May 18, reaching peaks of 350 NTU on May 28 at Monse and 650 NTU on May 19 at Highway 97 (Figure 6.4-1). Unfortunately, the turbidity sensor at Malott did not trigger properly when installed in early May and was inaccessible to the data monitoring crew for over a month due to flooding and a log jam on the Malott Bridge. As a result, no data were recorded at this site upriver from the Wells Project boundary to define incoming turbidity levels. Therefore, comparisons to background turbidity during the most critical time periods were limited. When the turbidity sensor was operational at Malott, there were no times when maximum daily turbidity at Highway 97 exceeded the maximum at Malott. Between June 24 and July 1, turbidity at Monse exceeded turbidity at Malott by more than 5 NTU. Turbidity at Highway 97 (65 NTU) also exceeded turbidity at Malott (27 NTU) by more than 5 NTU on June 3, one of two days during the monitoring period that Ecology collected water quality grab samples at Malott.

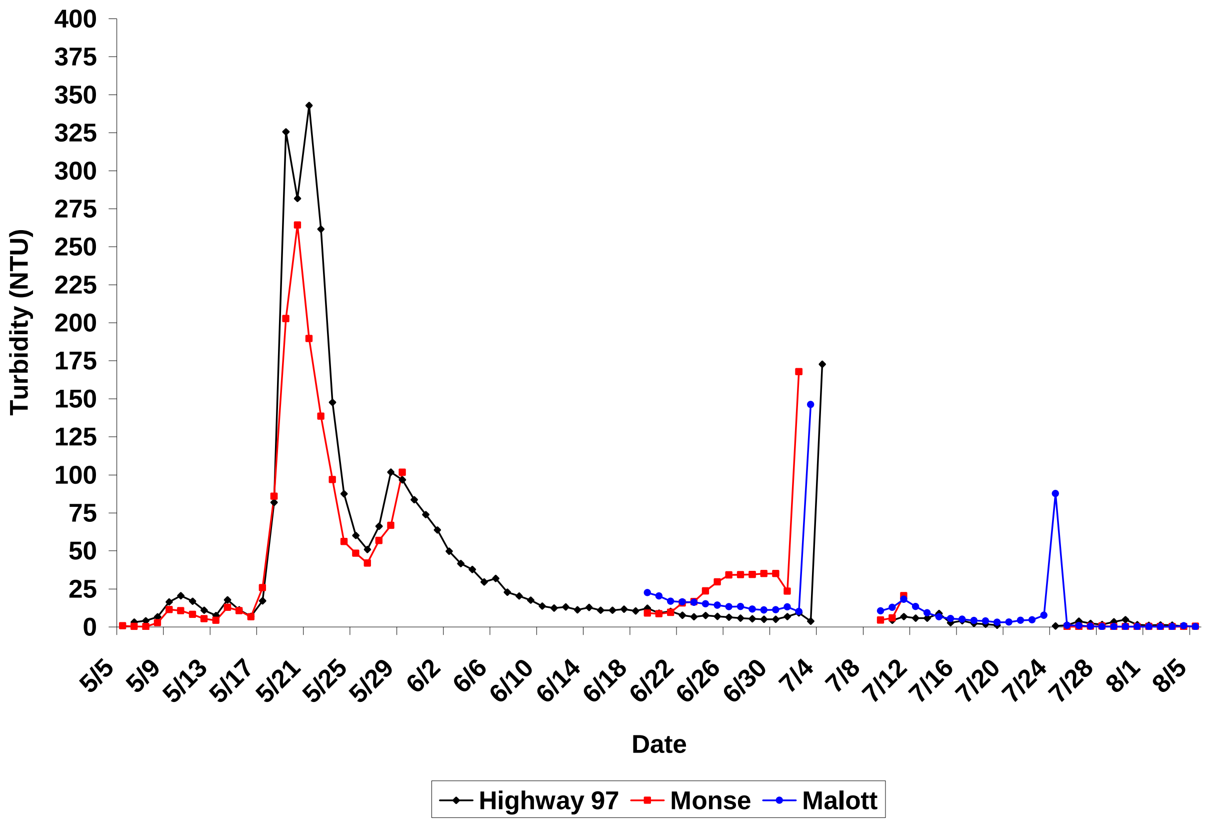

Figure 6.4-1 Daily maximum turbidity measurements (NTU) in the lower Okanogan River.

As discussed in greater detail in Section 7.1, instrument performance and maintenance issues with the turbidity sensor at the Wells Dam forebay led to the data collected at that site to be judged unreliable and rejected as unusable. Therefore, no turbidity results are reported for that location during the 2008 study season.

6.5 Quality Assurance Results

For side-by-side comparisons with the primary monitoring instruments, a newly calibrated Datasonde was deployed at the same depth to record water quality measurements at two-minute intervals for 10 minutes at the beginning of each servicing event. Comparisons with each primary instrument were used to determine which parameters required re-calibration based on the criteria for duplicate samples stated in the QAPP. The primary instrument was then brought on-board for data downloading, cleaning, inspection, servicing, battery changes, re-calibration, and re-setting the time and depth. After being re-deployed, a second 10-minute period of side-by-side measurements were implemented to verify calibrations, and Winkler titrations were performed to check the accuracy of dissolved oxygen measurements.

A second phase of quality assurance and data reduction was performed after the data were downloaded and converted to spreadsheets. The first step in this phase was to remove information from the file that was not part of the data set and to delete water quality readings that were recorded when the instrument was being deployed and retrieved. The results were then reviewed to qualify results that appeared to have been influenced by low battery charge. Finally, the data were inspected to look for any anomalous values, such as a one-time spike or dip in readings. Qualified anomalous values were retained in the data appendix but were not used in the summaries and graphical presentations of results. The results of data quality reviews for each monitoring parameter are summarized below.

6.5.1 Dissolved Oxygen Quality Assurance Results

Duplicate readings between the Datasonde and the primary instruments met data quality objectives for DO when both were calibrated under equal barometric pressure conditions. Winkler titrations generally confirmed DO measurements within 0.1 mg/L. Winkler titrations could not be completed during the first instrument servicing event because of the interference of high turbidity in the samples. Some very low DO readings from periods when the battery power was depleted were qualified as unusable. No other anomalous DO readings were identified or qualified.

6.5.2 pH Quality Assurance Results

Duplicate pH readings between the Datasonde and primary instruments were generally within 0.1 standard units. The pH electrode does not demand as much power as the other probes and did not seem to be affected by battery depletion. The only pH readings that appeared anomalous were from a five-day period in late July and early August at Monse when the pH dropped approximately one full pH unit. Because the pH at Malott and Highway 97 remained steady or increased slightly over this period, the drop in pH at Monse could not be explained and those data were qualified as questionable.

6.5.3 Turbidity Quality Assurance Results

Duplicate readings between the Datasonde and the primary instruments did exceed the criterion for turbidity by ± 1-2 % during the first two servicing events. The problem was successfully solved by a change in the calibration and verification turbidity standards. After that, duplicate readings between the Datasonde and the primary instruments generally met data quality objectives for turbidity.

A few data points at each lower Okanogan River station were qualified as unusable when the turbidity reading spiked up for only one half-hour reading, possibly due to particle interference or temporary fouling of the probe. A few hours of anomalous data from the Highway 97 site were similarly qualified, likely due to battery depletion. Finally, instrument readings that rounded to 0.0 NTU were manually adjusted to 0.1 following manufacturer recommendations for calibration. Turbidity results are reported according to the rounding conventions specified in Standard Methods for the Examination of Water and Wastewater, 20th Edition (APHA, 1998).

As discussed in Section 6.1, all turbidity results for the Wells Dam forebay location were judged to be unreliable and rejected as unusable. Douglas PUD staff maintaining the instrument reported that the self-cleaning mechanism was not functioning properly and frequent manual cleaning did not successfully prevent fouling of the instrument.

7.0 DISCUSSION

7.1 Dissolved Oxygen

Effects of the Project on DO concentrations in the Okanogan River were not evident, and DO at the Wells forebay remained above the 8.0 mg/L minimum criterion throughout the study season. DO concentrations first dropped below the 8.0 mg/L minimum water quality criterion during the first week of July at Malott (upriver from the Project area), Monse and the Highway 97 Bridge. Minimum daily DO measurements first dropped below 8.0 mg/L at Malott and Monse starting in early July, while the minimum daily DO at the Highway 97 Bridge fluctuated above and below the criterion during this same time period.

There were a few days when the lowest DO measured at one or more downstream location was below the Malott DO by at least 0.2 mg/L. However, the results have not shown any consistent pattern of decreasing DO downstream within the Project, and DO at the Wells Dam forebay has remained above the criterion of 8 mg/L throughout the entire monitoring period.

Of the 14 days when DO at Highway 97 was below 8.0 mg/L:

- The Highway 97 minimum daily DO was at least 0.2 mg/L below the upriver background minimum daily DO measured at Malott for nine of those days;
- the Highway 97 minimum daily DO was not 0.2 mg/L below the minimum daily DO at Malott for one of those days; and
- minimum daily DO was lower at Malott for four of those days .

There were six days when it is unknown whether Highway 97 DO was below 8.0 mg/L due to battery failure; however, there are sufficient data points to determine that there was no consistent pattern of decreasing DO at Highway 97 compared to Malott.

Of the 15 days when DO at Monse was below 8.0 mg/L:

- The Monse minimum daily DO was at least 0.2 mg/L below the minimum daily DO at Malott for six of those days;
- the Monse minimum daily DO was not 0.2 mg/L below the minimum daily DO at Malott for 5 of those days; and
- minimum daily DO was lower at Malott on four of those days.

Although there were 21 days when it is unknown whether Monse DO was below 8.0 mg/L due to battery failure, results for the other days do not indicate any consistent pattern of decreasing DO at Monse compared to Malott.

The increased differences between DO minima and maxima beginning in mid to late July and the distinct diurnal pattern observed at Malott were most likely attributable to similar trends in water temperature. With solar heating and higher temperatures in the late afternoon and evening the dissolved oxygen content of the water is less than in the morning when the water is cooler. At Highway 97 the strong diurnal pattern in DO concentrations was more evident during low flow periods when direct solar heating has a greater influence on the daytime warming of a smaller water volume.

7.2 pH

All pH readings met the water quality standards. Because the majority of higher pH readings in the Okanogan River were recorded above the Wells Project boundary at Malott (i.e., the upriver background for this Project), reservoir operations do not appear to have been a contributing factor to the few occurrences of pH above the 8.5 maximum criterion during this monitoring period. At no time when pH exceeded the 8.5 maximum criterion did the daily maximum pH at a downstream monitoring location exceed the pH at Malott by more than 0.5 units; therefore, the 0.5 standard for human-caused increases in pH was not exceeded. All pH measurements at the Wells forebay were within the 6.5 to 8.5 water quality criteria.

Similar to the trend observed with DO measurements, the differences between daily minima and maxima pH measurements were much greater in mid-July through early August, particularly at the Malott and Highway 97 Bridge sites. Also similar to the DO trend, the pH readings during this time exhibited a strong and consistent diurnal pattern with the highest pH in late afternoon to nighttime, likely associated with water temperatures.

7.3 Turbidity

Although there are limited data available upriver from the Project boundary to enable comparisons to background on the lower Okanogan River, there were at least several days when turbidity at Monse or Highway 97 exceeded background by more than 5 NTU. However, it is not clear what effect, if any, the Project may have had on turbidity. The lower Okanogan River banks are well vegetated and no evidence of shoreline erosion contributing to turbidity was observed during this study. There also has been no evidence of mid-summer high turbidity that might be attributed to phytoplankton productivity. Sediment samples collected during the Assessment of DDT and PCBs in Fish Tissue and Sediment (Parametrix, 2008b) contained increasing amounts of silt and clay at downriver sampling locations compared to upriver locations. Near the Monse Bridge boat launch there was 37.9 percent silt and 2.5 percent clay, compared to zero percent silt and clay upriver near the Wakefield Bridge and the mouth of Chiliwist Creek.

8.0 STUDY VARIANCE

This study was not required by FERC as part of the October 11, 2007 Study Plan Determination. This study was voluntarily conducted by Douglas PUD at the request of Ecology in support of the 401 water quality certification for the Wells Project.

Variances associated with the voluntarily conducted study for DO, pH, and Turbidity included the following:

- The upper sampling station location was changed from the Project boundary (RM 15.5) to the Malott Bridge (RM 17.0). No suitable structure could be found at RM 15.5 and as a result, the instrument housing was installed on the Malott Bridge located at RM 17.0. This change in location should have no effect on the results of this study.
- The Study Plan specified that DO monitoring will occur between mid-July and mid-September when the probability of exceedances is highest. In order to access the river prior to the peak of the spring hydrograph, the monitoring equipment was deployed earlier than required in the study plan. Equipment was deployed on May 5 and 6 at the Okanogan River locations and May 30 at the Wells forebay. The equipment is also expected to continue collecting data through October 30 which is over a month longer than required by the study plan.
- The study plan required that data be collected on an hourly basis. Due to battery failure and instrument inaccessibility during high flow and debris load periods, several significant gaps in the hourly database now exist. Data gaps occurred from May 6 to June 18 at the Malott Bridge, from July 3 to July 9 and July 11 to 24 at the Monse Bridge and from July 19 to 24 at the Highway 97 Bridge.
- All turbidity results for the Wells Dam forebay location were judged to be unreliable and rejected as unusable. Douglas PUD staff maintaining the instrument reported that the self-cleaning mechanism was not functioning properly and frequent manual cleaning did not successfully prevent fouling of the instrument.

9.0 REFERENCES

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