SUMMARY OF 2014 ANNUAL FISH-SPILL SEASON AND TOTAL DISSOLVED GAS MONITORING

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for

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Executive Summary

This report summarizes the results of the 2014 fish-spill season and associated total dissolved gas (TDG) and biological monitoring within the Priest Rapids Hydroelectric Project (Project), owned and operated by the Public Utility District No. 2 of Grant County, Washington (Grant PUD).

Mean daily discharges during the 2014 fish-spill season were slightly higher than the 2003 – 2013 average (about 11% higher on average) over the entire fish-spill season (April 1 through August 31).

During the 2014 fish-spill season, the Wanapum Reservoir was drawn down more than 20 feet below its normal minimum operating level while repairs were made to the spillway section of Wanapum Dam (a fracture was discovered in February of 2014 and the reservoir behind Wanapum Dam was lowered to prevent further damage, and has been drawn down since then). Because of the drawdown of the Wanapum Reservoir, which impacted the amount of flow through the WFB, additional tainter gate spill took place at Wanapum Dam to bring fish-spill to approximately 19 kcfs. The additional spillway gates at Wanapum Dam were operated on an as-needed basis to pass involuntary spill, according to spill patterns designed for the optimal fish-passage safety and as approved by the Priest Rapids Coordinating Committee (PRCC). Grant PUD implemented the Priest Rapids Dam spill program as guided by the Biological Opinion and the PRCC, which called for operation of the Priest Rapids Fish Bypass ((PRFB), which was completed/operational in April of 2014), which is designed to safely pass outmigrating smolts, while minimizing TDG uptake. Depending on forebay elevations, the PRFB passes up to 24 kcfs. The spillway at Priest Rapids Dam was operated on an as-needed basis to pass involuntary spill, according to spill patterns designed for the optimal fish-passage safety and as approved by the PRCC.

In accordance with the Washington Department of Ecology's (WDOE's) water quality standards, the fish-spill season for TDG compliance purposes occurred from April 1 through August 31, 2014 (see Washington Administrative Code (WAC) 173-201A-200(1)(f)). In accordance with the Biological Opinion, the fish-spill season began at Wanapum Dam on April 17, 2014 and concluded on August 28, 2014. The fish-spill season began at Priest Rapids Dam on April 18, 2014 and concluded on August 28, 2014. The fish-spill periods were closely matched with the juvenile migration timing, with greater than 99% of the yearling spring outmigrants passing during the spring fish-spill period between April 17 and June 14, 2014 (FPC 2014). The combined spring and summer fish-spill periods from April 17 through August 28 encompassed greater than 99% of the entire 2014 outmigration (FPC 2014) and greater than 92% of the sub-yearling Chinook passed by August 12 (FPC 2014); fish-spill from August 12 through the 28 allowed fish to move downstream through the Wanapum and Priest Rapids developments.

During the 2014 fish-spill season, there were 84 total exceedances of the 115/120 %SAT standard (based on daily average of the 12-highest consecutive hourly readings). There were 44 exceedances of the 1-hour 125 %SAT standard, all occurring at either the Wanapum Dam tailrace (25) or Priest Rapids Dam forebay (19) fixed-site monitoring stations (FSM stations) and all occurring during times of involuntary spill at Wanapum Dam. The Priest Rapids forebay FSM station accounted for the majority of TDG exceedances in 2014 (56 of 84 or 67%), all of which occurred when river flows were in excess of Wanapum Dam's current hydraulic capacity (~158.5 kcfs). When flows were above Wanapum Dam's current hydraulic capacity, involuntary spill was required that contributed to elevated TDG levels, and because of the short distance

between Wanapum and Priest Rapids dams (18 river miles (RM)), TDG levels did not have a chance to dissipate below the 115 %SAT by the time they reached the Priest Rapids Dam forebay FSM station. Furthermore, of the 56 exceedances recorded at the Priest Rapids Dam forebay FSM station, 24 (or 43%) corresponded with incoming TDG levels 115 %SAT or above recorded during the same time period at the Wanapum Dam forebay FSM station. Additionally, there were other factors that were unique during the 2014 fish-spill season that could possibly be attributed towards some of the exceedances of the TDG standards at the compliance points. For instance, during the entire 2014 fish-spill season, the Wanapum Reservoir was drawn down more than 20 feet below its normal minimum operating level for repairs to be made to the spillway sections of Wanapum Dam (a fracture was discovered in February of 2014 and the reservoir behind Wanapum Dam was lowered to prevent further damage, and has been drawn down since then). Because of this incident, some unique factors could have attributed to some of the exceedances of TDG during the 2014 fish-spill season. Included in these factors were: differences in Project operations because of the discrepancy in operating ranges (3-4 ft. during 2014 vs. normal year 10-11 ft.), differences in fish-spill operations, and differences in upstream operations. Appendix D of this report provides comments and/or corrective action descriptions associated with exceedances that occurred during the 2014 fish-spill season.

Grant PUD strives to meet TDG standards, as well achieve juvenile and adult salmonid and steelhead fish passage and survival standards for the Project, all while meeting regional energy loads and demands. Grant PUD attempted to reduce TDG when feasible by implementing operational TDG abatement measures in 2014, including attempting to maximize turbine flows by setting involuntary spill caps and minimum generation requirements (and thus maximizing turbine flows and reducing involuntary spill), participation in regional spill/project operation meetings, implementation of the regional Spill Priority List, and continuing to preemptively spill based on anticipated high flow/low power load time periods. Examples of structural abatement measures include the construction of spillway deflectors at Wanapum Dam (2000), the construction of the WFB (2008), and the PRFB (2014). Grant PUD believes that by implementing these measures over the next four years (as part of the ten-year compliance schedule that began in 2009) it is implementing the most current reasonable and feasible measures to reduce elevated TDG values that occur during the fish-spill season.

Grant PUD will continue to closely monitor TDG levels during the fish-spill season in accordance with its WDOE-approved Quality Assurance Project Plan (QAPP; Hendrick 2009), and will develop its spill programs in accordance with current TDG water quality criteria as set by WDOE, adjusting spill percentages as needed to comply with current TDG standards.

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List of Abbreviations

%SAT	percent saturation
7Q10 flow	highest seven consecutive day average flow with a 10-year recurrence frequency
BPA	Bonneville Power Administration
Biological Opinion	National Marine Fisheries Service's Biological Opinion for the Priest Rapids Hydroelectric Project
Chelan PUD	Public Utility District No. 1 of Chelan County, Washington
Corps	U.S. Army Corps of Engineers
DO	dissolved oxygen
DS	DataSonde
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FPC	Fish Passage Center
FSM station(s)	fixed-site monitoring station(s)
GAP	Gas Abatement Plan
GBT	gas bubble trauma
Grant PUD	Public Utility District No. 2 of Grant County, Washington
kcfs	thousand cubic feet per second
mg/L	milligrams per liter
mm Hg	millimeters of mercury
MS	MiniSonde
MW	megawatt
NIST	National Institute of Standards and Technology
NMFS	National Marine Fisheries Service
NTU	Nephelometric Turbidity Unit
PASCO	Pasco fixed-site monitoring station
PRDF	Priest Rapids forebay
PRDT	Priest Rapids tailrace
PRFB	Priest Rapids Fish Bypass
PRCC	Priest Rapids Coordinating Committee
Project	Priest Rapids Hydroelectric Project
QAPP	quality assurance project plan

QA/QC	quality assurance/quality control
RPA	Reasonable and Prudent Alternative
RM	river mile
TDG	total dissolved gas
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WANF	Wanapum forebay
WANT	Wanapum tailrace
WFB	Wanapum Fish Bypass
WDOE	Washington Department of Ecology
WQC	water quality certification

1.0 Introduction

The Public Utility District No. 2 of Grant County, Washington (Grant PUD) owns and operates the Priest Rapids Hydroelectric Project (Project; Figure 1). The Project is licensed as Project No. 2114[1] by the Federal Energy Regulatory Commission (FERC) and includes Wanapum and Priest Rapids dams. A 401 water quality certification (WQC) for the operation of the Project was issued by the Washington Department of Ecology (WDOE) on April 3, 2007, amended on March 6, 2008, and effective on issuance of the FERC license to operate the Project on April 17, 2008 (FERC 2008). Section 6.4.11(c) of the 401 WQC (WDOE 2007) requires Grant PUD to submit an annual report on fish-spill and total dissolved gas (TDG) monitoring by October 31 annually. The following sections summarize the results of the 2014 fish-spill and TDG monitoring season.

1.1 Priest Rapids Project Description

The Wanapum development consists of a 14,680-acre reservoir and an 8,637-foot-long by 186.5-foot-high dam spanning the Columbia River. The dam consists of left and right embankment sections; left and right concrete gravity dam sections; a left and right fish passage structure, each with an upstream fish ladder; a gated spillway; a downstream fish passage structure (the Wanapum Fish Bypass (WFB)); and a powerhouse containing ten vertical shaft integrated Kaplan turbine/generator sets with a total authorized installed capacity (best gate) of 735 MW (Figure 2).

The Priest Rapids development consists of a 7,725-acre reservoir and a 10,103-foot-long by 179.5-foot-high dam spanning the Columbia River. The dam consists of left and right embankment sections; left and right concrete gravity dam sections; a left and right fish passage structure, each with an upstream fish ladder; a gated spillway; a downstream fish passage structure (the Priest Rapids Fish Bypass (PRFB)) and a powerhouse containing ten vertical shaft integrated Kaplan turbine/generator sets with a total authorized installed capacity (best gate) of 675 MW (Figure 3).

The Wanapum and Priest Rapids dam spillways were initially designed to accommodate flows that exceeded turbine capacity and have more recently been used to spill water for the purpose of supplementing downstream smolt migrations. However, releasing flows over the spillways can also result in elevated TDG, which can be harmful to fish. To address this issue, Grant PUD coordinates its fish-spill program to address fish migrations and comply with current water quality standards for TDG and has implemented downstream bypass measures to safely pass salmonids and/or to reduce or minimize TDG.

[1] 123FERC¶61,049

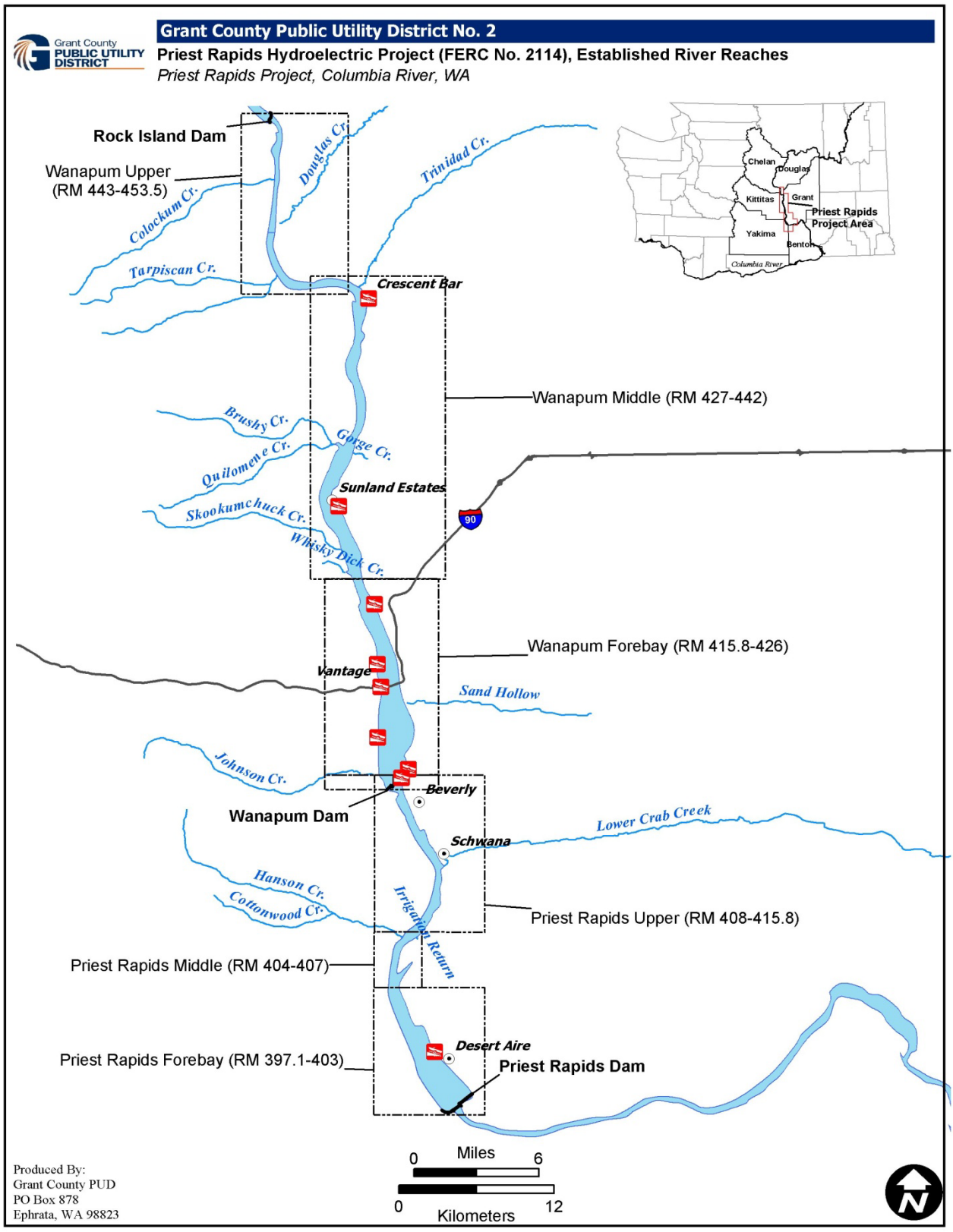

Figure 1 **The Priest Rapids Project and established river reaches presented by river mile (RM), mid-Columbia River, WA.**

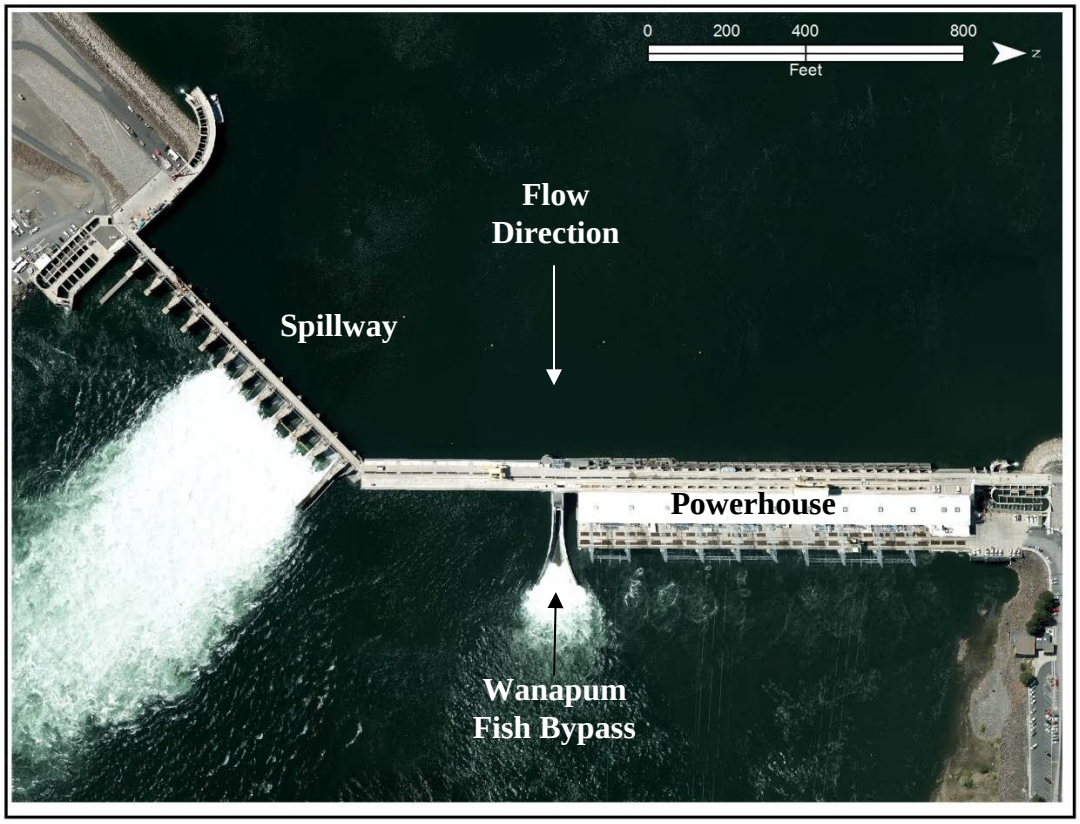

Figure 2 Aerial photograph of Wanapum Dam, mid-Columbia River, WA.

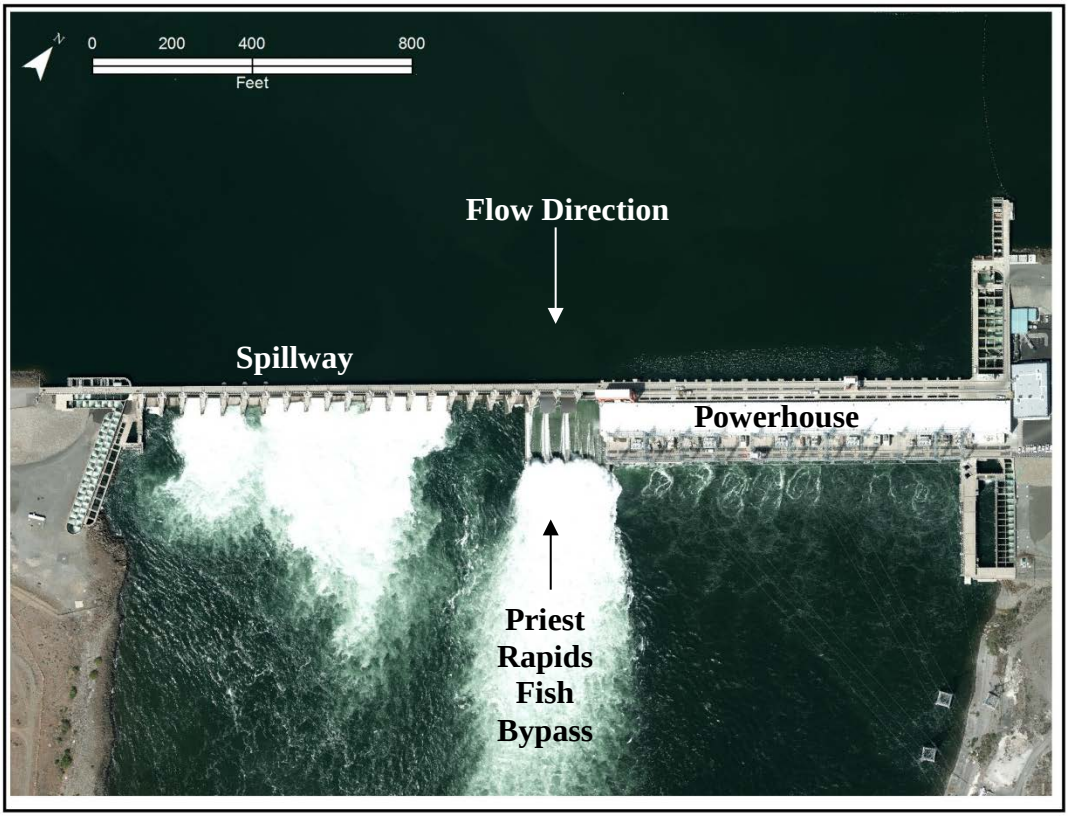

Figure 3 Aerial photograph of Priest Rapids Dam, mid-Columbia River, WA.

1.1.1 Fixed Site Water Quality Monitoring Stations

Grant PUD currently operates and maintains four fixed-site water quality monitoring stations (FSM stations) that record water depth (m), barometric pressure (millimeters of mercury (mm/hg)), TDG (mm/hg), temperature (°C), dissolved oxygen (DO; milligrams per liter (mg/L)), pH (units), and turbidity (Nephelometric Turbidity Unit (NTU)). Barometric pressure, TDG, and temperature are monitored on an hourly basis throughout the year, while depth, DO, pH, and turbidity grab-samples are collected every two to three weeks throughout the year in accordance with Grant PUD's WDOE-approved Quality Assurance Project Plan (QAPP; Hendrick 2009). Grant PUD's FSM stations are located midway across the river channel in the forebay and tailrace of each dam. The Public Utility District No. 1 of Chelan County (Chelan PUD) also operates and monitors a FSM station located in the Rock Island Dam tailrace, approximately 38 river miles (RMs) upstream of Wanapum Dam, during the fish-spill season. This allows Grant PUD to monitor upstream river conditions during the fish-spill season. The Pasco FSM station located at RM 329 and owned/operated by the U.S. Army Corps of Engineers (Corps), serves as the next downstream forebay TDG compliance point for Priest Rapids Dam. This location was chosen to measure mixed river gas conditions before dilution or concentration with the waters of the Snake River. This site allows Grant PUD to monitor downstream river conditions during the fish-spill season.

Each Grant PUD FSM station is equipped with a Hydrolab® Corporation DataSonde (DS) 5X, DS 5, DS4A, or MiniSonde (MS) 5 or MS4A multi-probe enclosed in a submerged conduit. Multi-probes are connected to an automated system that allows Grant PUD to monitor barometric pressure, TDG, and water temperature on an hourly basis. A National Institute of Standards and Technology (NIST) certified barometer located at each FSM station provides the barometric pressure readings necessary to correct the partial pressure readings taken by the multi-probe.

For a complete description of the FSM stations see the QAPP (Hendrick 2009).

1.2 Regulatory Framework

Washington state water quality standards are established by the WDOE for TDG during the non-fish and fish-spill seasons (see Washington Administrative Code (WAC) 173-201A-200(1)(f)). The current standard for TDG (in percent saturation (%SAT)) during the non-fish spill season (September 1 through March 31) is 110 %SAT for any hourly measurement. The current standard for TDG (in %SAT) during the fish-spill season (April 1 through August 31) is 115 %SAT in the forebay and 120 %SAT in the tailrace, based on the average of the twelve highest consecutive hourly readings in a twenty-four hour period. A one-hour, 125 %SAT maximum standard for TDG also applies throughout the Project.

1.2.1 7Q10 Flows

Section 5.0(b) of the 401 WQC (WDOE 2007) and WAC 173-201A-200(f)(i) provides that the TDG water quality standard for both Wanapum and Priest Rapids dams shall be waived if flows exceed the "7Q10 flood flow", which is the highest-seven consecutive day average flow with a ten-year recurrence frequency. The 7Q10 flood flow is calculated to be 264 kcfs for Wanapum and Priest Rapids dams.

1.2.2 Daily Total Dissolved Gas Compliance Value Calculation Method

Prior to 2008, the method used to calculate the daily TDG compliance value during the fish-spill season were based on the average of the twelve highest hourly values in a twenty-four hour period, starting at 0100 hours and ending at 2359 hours. This method was based on WDOE's 1997 water

quality standards (WDOE 1997). In WDOE's 2006 revision to the water quality standards (which were not approved by the Environmental Protection Agency (EPA), and thus not effective, until 2008; WDOE 2008a) the method for calculating the TDG compliance value were changed. The new method provided that the TDG compliance value be determined by calculating the average of the twelve highest ***consecutive*** hourly values in a twenty-four hour period. Prior to the 2008 fish-spill season, there were discussion amongst the Columbia and Snake River dam operators on how to properly implement the "rolling average" method, especially as it related to what time the rolling average began. There were concerns related to the addition of the previous day's last eleven hours to the compliance value calculation on the next day.

On April 2, 2008 WDOE requested, via letter, that all Columbia and Snake River dam operators use a rolling average method for calculating the twelve highest consecutive hourly TDG readings in a twenty-four hour period, beginning at 0100 hours, based on WDOE's 2006 revised water quality standards (WDOE 2008b). Using a rolling average method that begins at 0100 hours results in counting the hours 1400 through 2359 twice: in the average calculations on the day they occur ***and*** on the next reporting day. As a result, a TDG water quality standard exceedance may be indicated on two separate days based on the same group of hours. On April 15, 2008 Grant PUD sent a letter to WDOE that expressed and provided an example of its concern regarding the rolling average method (Grant PUD 2008). Grant PUD also expressed its intention to monitor these "double-counting" problems and reported any instances in which the same block of hours create an exceedance on two different days in its annual report during two separate phone conversations with Mr. Chris Maynard and Ms. Marcie Mangold of WDOE on March 31, 2008.

Appendix A of this report provides an example of how the "rolling average" method created a TDG exceedance on two separate days based on the same grouping of hourly values during the 2014 fish-spill season, and Grant PUD's method for accounting for those occurrences. Additionally, Appendix A provides a table detailing all "double-counting" instances for the 2014 fish-spill season.

2.0 Data Evaluation and Analyses

Data collection, quality assurance/quality controls (QA/QC), and analyses of TDG values were conducted in accordance with the QAPP for the FSM stations (Hendrick 2009). For this report, hourly TDG data recorded during the 2014 fish-spill season were analyzed for apparent exceedances of current water quality standards.

All of the TDG sensors used during the 2014 fish-spill season were calibrated and maintained in accordance with the methods and schedules described in the QAPP (Hendrick 2009). TDG sensors that did not pass calibration tests were sent back to the manufacture for repair and/or replaced prior to deployment. Suspect or erroneous TDG values were omitted from the analysis, but are included, as well as explanation for omission, in Appendix B of this report.

The data QA/QC issues during the 2014 fish-spill season were related to TDG membrane failures at the Wanapum Dam tailrace FSM station. Overall data loss for Grant PUD's operated FSM stations during the 2014 fish-spill season was 247 hourly readings (1.7% of the total available data collection hours), which was well within the 90% data completeness/quality objective as specified in the QAPP (Hendrick 2009).

Table 1 below displays the number of TDG values that were omitted from the dataset due to QA/QC issues during the 2014 fish-spill season. Appendix B provides detailed information related to data that was omitted due to QA/QC issues.

Table 1 Overview of total dissolved gas data set during 2014 fish-spill season.

Location	Available data collection hours	Number of omitted/lost hourly readings[1]	Percent data loss (%)
WANF	3672	0	0.0
WANT	3672	247	6.7
PRDF	3672	0	0.0
PRDT	3672	0	0.0
Total	14688	247	1.7

Note: WANF = Wanapum forebay, WANT = Wanapum tailrace, PRDF = Priest Rapids forebay, PRDT = Priest Rapids tailrace.
[1]See Appendix B for dates, times, and circumstances relating to omitted/lost data.

3.0 Results

The following sections describe the 2014 fish-spill season flow characteristics compared to the previous ten-year average, the 2014 fish-spill season programs, the fish migration timing compared to fish-spill season durations, and the 2014 biological TDG monitoring results.

3.1 Description of 2014 Fish-Spill Season Flow Characteristics

Mean daily discharge during the 2014 fish-spill season were compared to the ten-year average of mean daily flows from 2003 to 2013 (Figure 4) as measured at the U.S. Geological Survey (USGS) stream flow gage #12472800 located 2.6 RMs downstream of Priest Rapids Dam (USGS 2014). In general, 2014 mean daily discharges were slightly higher than the 2003–2013 average (~11% higher on average) during the fish-spill season (April 1 through August 31).

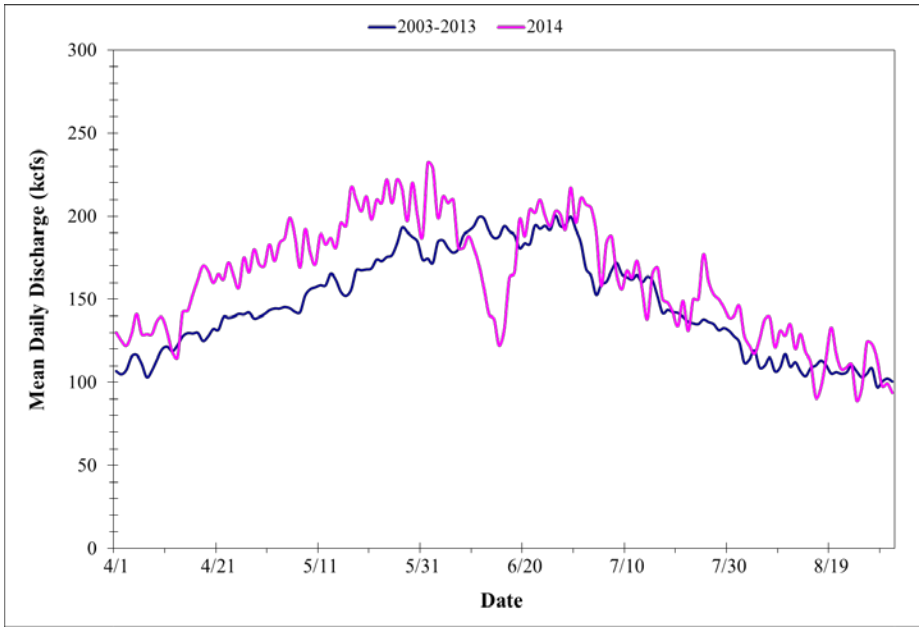

Figure 4 Comparison of 2014 vs. previous ten-year average of mean daily discharge values as measured at the USGS streamflow gage #12472800 located below Priest Rapids Dam, mid-Columbia River, WA.

3.2 Fish-Spill Programs

On February 1, 2008 the National Marine Fisheries Service (NMFS) issued a Biological Opinion (Biological Opinion) for the Project. The Biological Opinion includes terms and conditions related to Grant PUD's fish-spill program, and those terms and conditions are incorporated in the FERC license for operation of the Project (FERC 2008). Reasonable and Prudent Alternative (RPA) 1, and associated terms and conditions of the Biological Opinion (NMFS 2008) require Grant PUD to initiate its fish-spill programs before 2.5% of the spring migration period has passed, as documented by the smolt index counts at Rock Island Dam. The spring fish-spill program can conclude when 97.5% of the spring migration period is complete, or on June 15, whichever occurs first. The summer fish-spill program begins immediately after the end of the spring fish-spill season, as guided by the Priest Rapids Coordinating Committee (PRCC) and the fishway prescription set forth in the Priest Rapids Project Salmon and Steelhead Settlement Agreement (Grant PUD 2006), and continues until 95% of summer outmigrating smolts have passed. Grant PUD also provides limited spill (typically around 2 kcfs) for adult fallback until November 15, annually.

3.2.1 Wanapum Dam

During the 2014 fish-spill season, the Wanapum Reservoir was drawn down more than 20 feet below its normal minimum operating level while repairs were being made to the spillway section of Wanapum Dam (a fracture was discovered in February of 2014 and the reservoir behind Wanapum Dam was lowered to prevent further damage, and has been drawn down since then). Because of the drawdown of the Wanapum Reservoir, which impacted the amount of flow through the WFB, additional tainter gate spill took place at Wanapum Dam to bring fish-spill to approximately 19 kcfs. The additional spillway gates at Wanapum Dam were operated on an as-needed basis to pass involuntary spill (46% of the time for the entire 2014 fish-spill season, see Section 3.5.3), according to spill patterns designed for the optimal fish-passage safety and as approved by the PRCC. See Table 2 below for more details on fish-spill.

3.2.2 Priest Rapids Dam

During the 2014 fish-spill season, Grant PUD implemented the Priest Rapids Dam spill program as guided by the Biological Opinion and the PRCC, which called for operation of the PRFB (completed/operational in April of 2014), designed to safely pass outmigrating smolts, while minimizing TDG uptake. Depending on forebay elevations, the PRFB passes up to 24 kcfs. The spillway at Priest Rapids Dam was operated on an as-needed basis to pass involuntary spill (37% of the time for the entire 2014 fish-spill season), according to spill patterns designed for the optimal fish-passage safety and as approved by the PRCC.

3.3 Fish-Spill Quantities and Duration

Spring fish-spill began at Wanapum Dam on April 17, 2014 at 1400 hours and ended June 14, 2014 at 2359 hours, while spring fish-spill began at Priest Rapids Dam on April 18, 2014 at 1400 hours and ended June 14, 2014 at 2359 hours. Summer fish-spill began on June 15, 2014 at 0000 hours in accordance with the Priest Rapids Project Salmon and Steelhead Agreement (Grant PUD 2006), immediately following the end of the spring fish-spill season and continued through 1000 hours on August 28, 2014 at Wanapum Dam and 1300 hours on August 28, 2014 at Priest Rapids Dam (see Appendix C).

Table 2 provides a summary of the 2014 fish-spill for Wanapum and Priest Rapids dams. A considerable amount of adjustments in the fish-spill program were warranted at Wanapum Dam to adjust to the low forebay levels from the drawdown.

Table 2 Summary of 2014 fish-spill operations at Wanapum and Priest Rapids dams, Priest Rapids Project, mid-Columbia River, WA.

Wanapum Dam			
Date	**Spill Program**	**Quantity[1]**	**Purpose**
April 17, 2014	***Spring Spill Initiated***		
April 17-June 14	WFB, TG-7&8 open 1ft., TG-9 thru 12 open 2ft. (Open 24 Hours/Day)	Up to 19 kcfs	RPA 1 and terms and conditions of the Biological Opinion and as guided/approved by the PRCC. Adjusted based on the drawn down conditions of Wanapum Reservoir
June 15, 2014	***End of Spring Spill/ Summer Spill Initiated***		
June 15-Aug 28	WFB, TG-7&8 open 1ft., TG-9 thru 12 open 2ft. (Open 24 Hours/Day)	Up to 19 kcfs	Priest Rapids Project Salmon and Steelhead Settlement Agreement and as guided/approved by the PRCC. Adjusted based on the drawn down conditions of Wanapum Reservoir
August 22, 2014	***End of Summer Spill***		
[1]Actual quantity spilled is dependent on forebay and tailwater elevations.			

Priest Rapids Dam			
Date	**Spill Program**	**Quantity[1]**	**Purpose**
April 18, 2014	***Spring Spill Initiated***		
April 18-June 14	PRFB (Open 24 Hours/Day)	Up to 24 kcfs	RPA 1 and terms and conditions of the Biological Opinion and as guided/approved by the PRCC
June 15, 2014	***End of Spring Spill/ Summer Spill Initiated***		
June 15-Aug 28	PRFB (Open 24 Hours/Day)	Up to 24 kcfs	Priest Rapids Project Salmon and Steelhead Settlement Agreement and as guided/approved by the PRCC
August 28, 2014	***End of Summer Spill***		
[1]Actual quantity spilled is dependent on forebay and tailwater elevations.			

3.3.1 Involuntary Spill

At Wanapum Dam, involuntary spill occurred 65% of the time during the spring fish-spill season, 27% of the time during the summer fish-spill season, and 46% of the time over the entire fish-spill season. At Priest Rapids Dam, involuntary spill occurred 51% of the time during the spring fish-spill season, 23% of the time during the summer fish-spill season, and 37% of the time over the entire fish-spill season. These percentages are based on the total number of hourly spill values greater than the designated fish-spill values vs. the total number of available hours during the fish-spill season (from April 1 through August 31). For a more detailed description of 2014 fish-spill season duration, methods, and adjustments see Appendix C.

3.4 Biological Evaluations

The following sections provide a summary of fish passage timing results as they relate to the 2014 fish-spill season at Wanapum and Priest Rapids dams, a description of the fish passage studies conducted in 2014, and results from gas bubble trauma (GBT) monitoring.

3.4.1 Fish Passage Efficiencies

The fish-spill periods at the Project were very closely matched with the juvenile migration timing (as documented by smolt index counts at Rock Island Dam (FPC 2014)). Figure 5 illustrates that approximately 99% of the yearling spring outmigrants passed during the spring fish-spill period between April 17 and June 14 (FPC 2014). Figure 6 shows that the combined spring and summer fish-spill periods from April 17 through August 23 encompassed greater than 99% of the entire 2014 outmigration (FPC 2014), while Figure 7 shows that greater 92% of the sub-yearling Chinook passed by August 12 (FPC 2014); spill from August 12–28 allowed the remaining percentages of outmigrant fish to move downstream through the Wanapum and Priest Rapids developments.

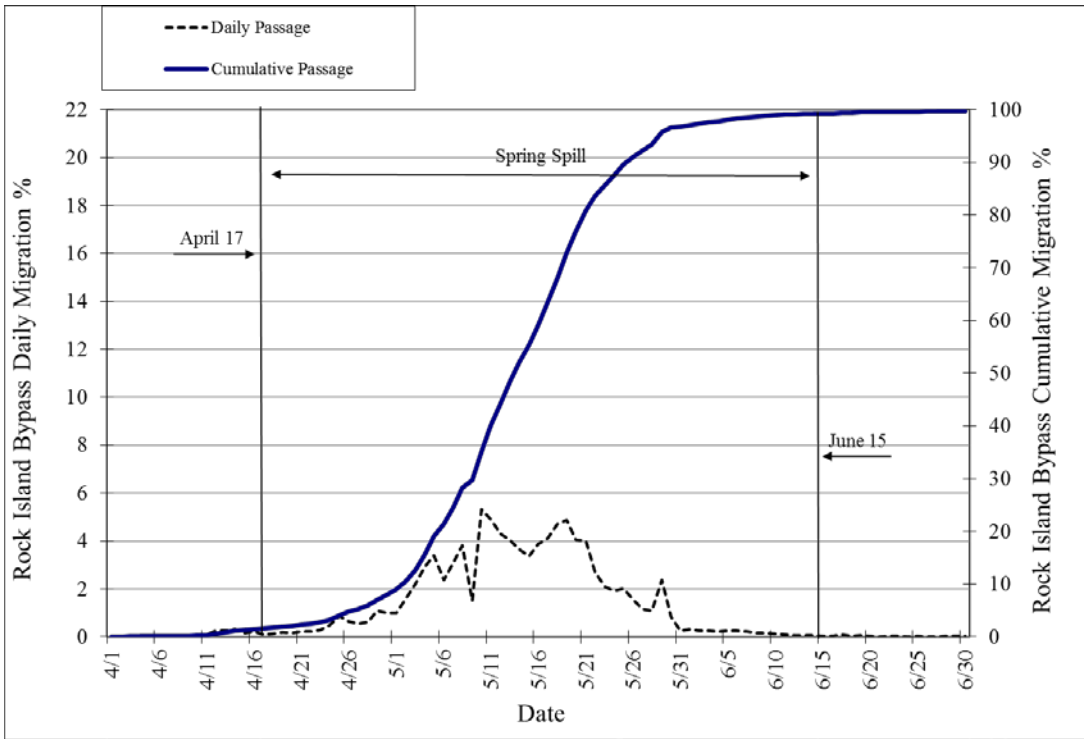

Figure 5 **Fish-spill and migration timing for yearling Chinook and steelhead, spring 2014. Priest Rapids Project, mid-Columbia River, WA. Rock Island Bypass Index data courtesy of the Fish Passage Center (2014).**

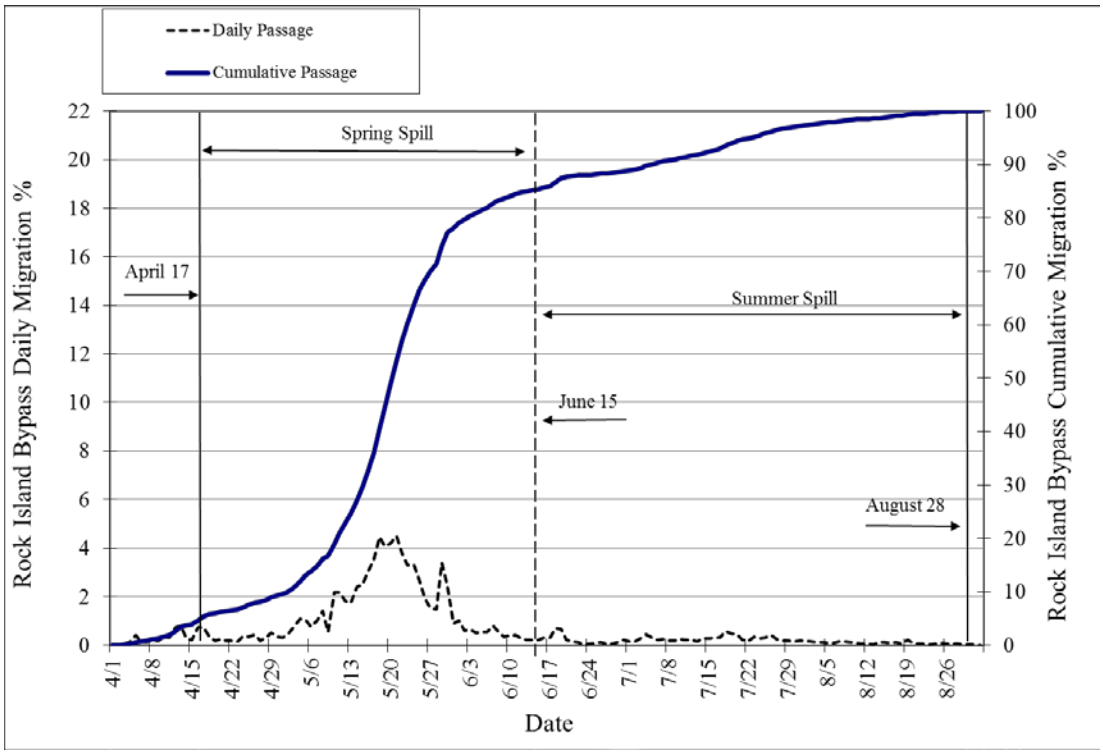

Figure 6 **Fish-spill and migration timing for all species, 2014. Priest Rapids Project, mid-Columbia River, WA. Rock Island Bypass Index data courtesy of the Fish Passage Center (2014).**

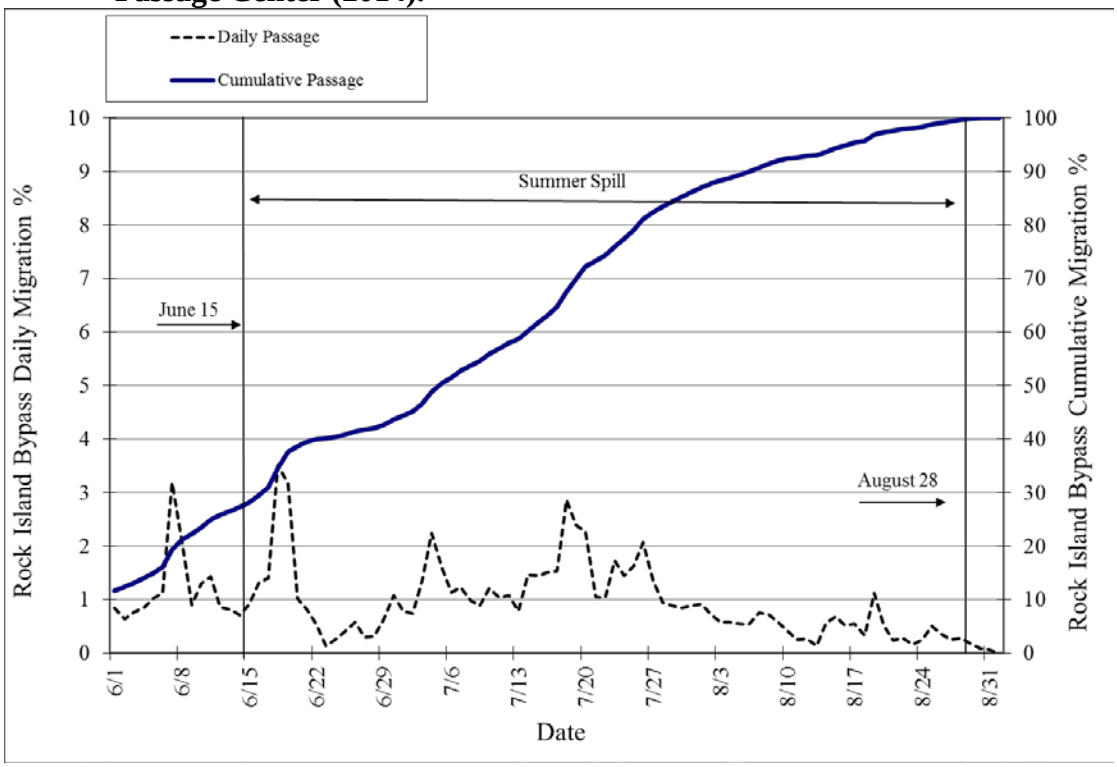

Figure 7 **Fish spill and migration timing for sub-yearling Chinook, summer 2014. Priest Rapids Project, mid-Columbia River, WA. Rock Island Bypass Index data courtesy of the Fish Passage Center (2014).**

3.4.2 Survival and Behavior Evaluation Studies

In 2014, as part of emergency Endangered Species Act (ESA) consultation with NOAA Fisheries and in consultation and coordination with the PRCC, Grant PUD continued forward with a multi-species survival and behavior evaluation (juvenile steelhead and yearling Chinook) in the Wanapum Reservoir and at Wanapum Dam to determine route specific survival (turbine, WFB and spillway) and fish passage efficiency (FPE) in relationship to each passage routeYearling Chinook were released in the Rock Island Dam tailrace during the month of May with multi-day releases. It was found that 65.0% of the tagged yearling Chinook passed Wanapum Dam via the powerhouse passage. Powerhouse survival for yearling Chinook was 98.2%. Fish Passage Efficiency and survival for yearling Chinook passing through the WFB was 7.5% and 96.3% survival, respectively. Spillway passage (6 gates in use to aid in non-turbine passage) FPE was 27.5%, with an observed survival of 97.0%. Total estimated survival for yearling Chinook passing Wanapum Dam was 98.8%, while estimated survival through the Wanapum Reservoir was 95.2%.

Juvenile steelhead were also released into the Rock Island Dam tailrace during the drawdown phase of Wanapum Reservoir. FPE for juvenile steelhead passing through the powerhouse was 44.8%, with an observed estimated survival rate of 94.1%. At the WFB, juvenile steelhead survival was estimated at 100%. Estimated survival through the Wanapum spillway was 99.4% for juvenile steelhead. Total estimated survival for juvenile steelhead passing through Wanapum Dam was 97.8%, while survival through the Wanapum Reservoir was 92.4%.

Grant PUD with approval of NOAA Fisheries and the PRCC also conducted a survival evaluation within the Priest Rapids Reservoir (under normal operations) and survival and behavior evaluations associated with the Priest Rapids Bypass.

For yearling Chinook the FPE/survival percentage for the PRFB was 38.1% and 99.8%, respectively. Spillway FPE was 26.9% with an observed survival of 98.0%. The FPE for the powerhouse was 34.9%. For juvenile steelhead the FPE at the PRFB was 47.2% with an observed survival estimate of 99.6%. Spillway FPE and survival was 27.0% and 97.0%, respectively. Meanwhile powerhouse FPE and survival was 30.9% and 93.8%, respectively.

3.4.3 Gas Bubble Trauma Monitoring

Grant PUD conducted GBT monitoring during the 2014 fish-spill season using the Smolt Gas Bubble Trauma Examination Protocol, developed by the Fish Passage Center (FPC; FPC 2009). This protocol has been used extensively throughout the Columbia and Snake River basins to standardize GBT examination practice by participating agencies within the Pacific Northwest. The principal objective was to administer smolt GBT examinations and record the presence of observed GBT-related tissue damage on salmonid smolt as a function of species, as they passed through the collection facilities at either Priest Rapids or Wanapum dams.

During the 2014 fish-spill season, 3,174 smolts were examined for GBT, with 5 exhibiting signs of GBT, or approximately 0.16% of the total smolts sampled. According to the FPC (FPC 2009), a rank is assigned based upon the percent area of the fin or eye covered with bubbles. A rank 0 is assigned if no bubbles occur; rank 1 is assigned if 1-5% of the fin or eye is covered with bubbles; rank 2 is assigned for 6-25% area covered; rank 3 for 25-50% area covered; and rank 4 for >50% area covered. Three of the smolts that had symptoms of GBT during the 2014 season were Chinook and received a rank of one, while one was a Chinook with a rank of 2. Lastly, one

Steelhead with a rank of 1 was recorded. Table 3 below provides the summary results of GBT monitoring during the 2014 fish-spill season recorded at either Priest Rapids or Wanapum dam.

Table 3 Gas bubble trauma monitoring results from either Priest Rapids or Wanapum dam in 2014. Priest Rapids Project, mid-Columbia River, WA.

		Number of fish with GBT Signs				
Species	Number of fish sampled	Rank 1	Rank 2	Rank 3	Rank 4	Total
Chinook	2,741	3	1	0	0	4
Steelhead	433	1	0	0	0	1
Total	***3,174***	***4***	***1***	0	0	***5***

3.5 Total Dissolved Gas Monitoring

The following sections discuss the results of TDG monitoring from the 2014 fish-spill season within the Project and at the Pasco compliance point location. Specific sections include TDG averages with associated figures for each FSM station/compliance point location, a breakdown of all TDG exceedances and possible explanations for those exceedances, and the connection between elevated TDG levels and involuntary spill during the 2014 fish-spill season.

Summary values for all hourly TDG measurements taken from each FSM station during the 2014 fish-spill season are presented in Table 4 below.

Table 4 Summary of hourly total dissolved gas measurements from each fixed-site monitor station (FSM station) during the 2014 fish-spill season. Priest Rapids Project, mid-Columbia River, WA.

Location	Data Interval	Mean	Standard Deviation	Minimum	Maximum
WANF	04/1 – 08/31	111.7	3.6	100.8	122.6
WANT	04/1 – 08/31	114.1	4.5	101.9	126.5
PRDF	04/1 – 08/31	112.4	4.5	99.5	127.4
PRDT	04/1 – 08/31	114.0	3.8	101.8	123.9
PASCO	04/1 – 08/31	110.3	3.1	99.6	119.4

Notes:
All values represent %SAT.
WANF = Wanapum forebay, WANT = Wanapum tailrace, PRDF = Priest Rapids forebay, PRDT = Priest Rapids tailrace, PASCO = Pasco Fixed-Site Monitoring Station located upstream of McNary Dam (next downstream forebay), operated by the US Army Corps of Engineers.

3.5.1 Total Dissolved Gas Averages during the Fish-Spill Season

Figure 8 through Figure 12 display the average of the 12-highest consecutive hourly readings from each 24-hour period during the fish-spill season from each FSM station, except for days when there was no data available due to sensor membrane failure (see Sections 1.2.1 and 2.0). The average of the 12-highest consecutive hourly TDG readings from each day during the spring and summer fish-spill seasons from each FSM station, including explanation of possible causes of TDG exceedances and corrective actions taken to reduce elevated TDG levels are presented in Appendix D of this report.

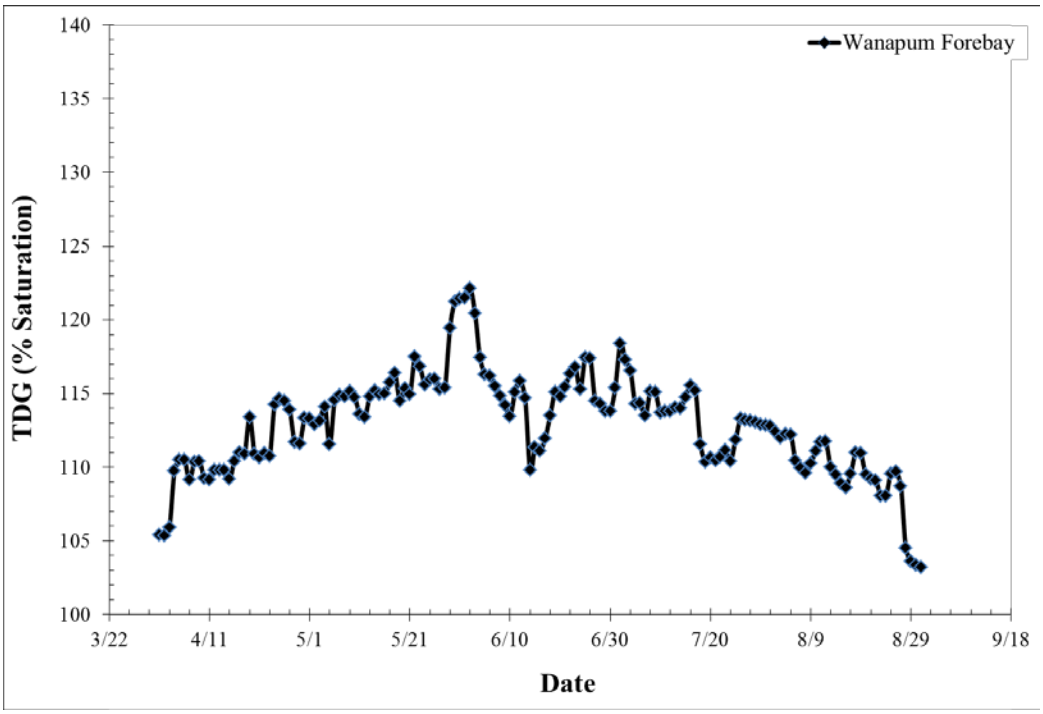

Figure 8 **Total dissolved gas measurements (average of the 12-highest consecutive hourly TDG readings in a 24-hour period) from the 2014 fish-spill season recorded at the Wanapum Dam forebay FSM station. Priest Rapids Project, mid-Columbia River, WA.**

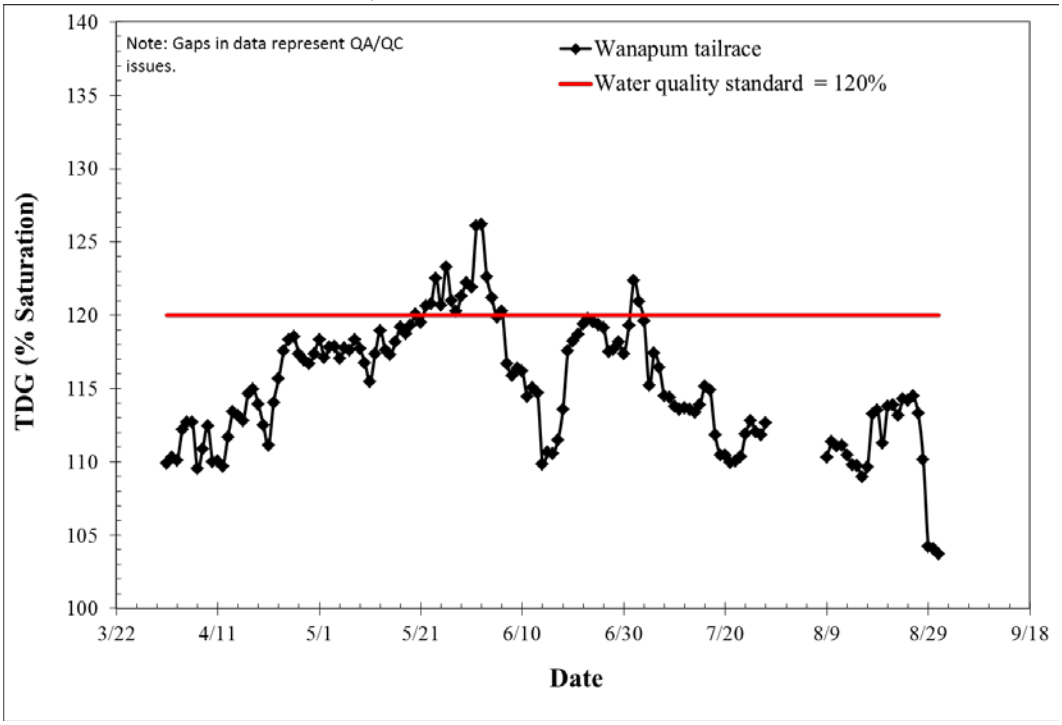

Figure 9 **Total dissolved gas measurements (average of the 12-highest consecutive hourly TDG readings in a 24-hour period) from the 2014 fish-spill season recorded at the Wanapum Dam tailrace FSM station. Priest Rapids Project, mid-Columbia River, WA.**

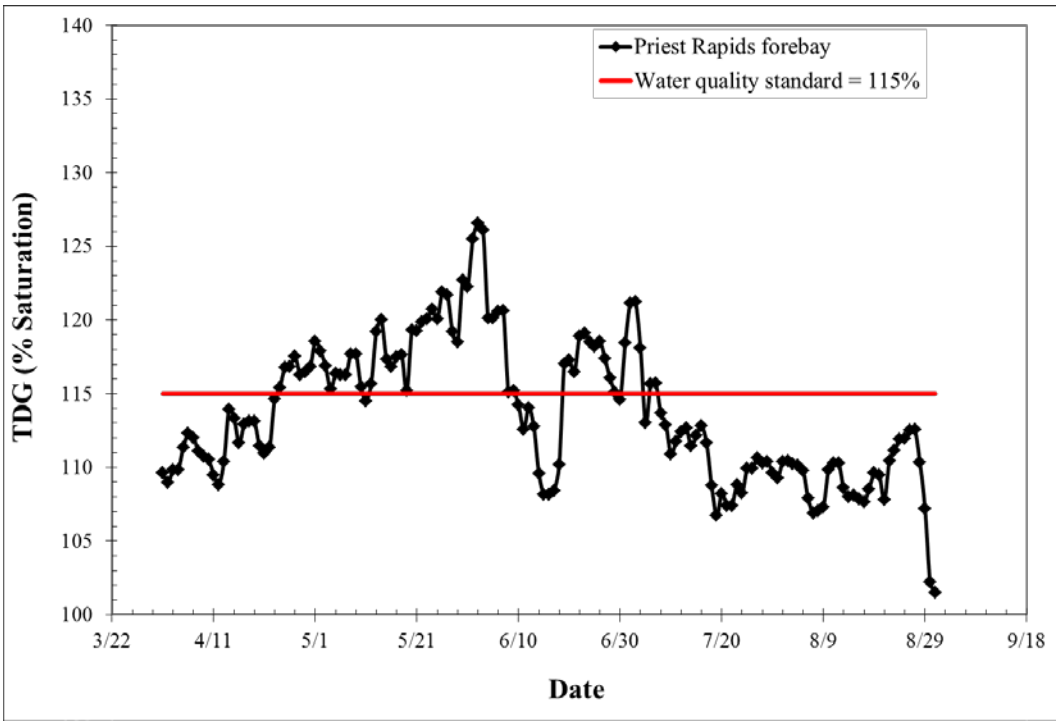

Figure 10 **Total dissolved gas measurements (average of the 12-highest consecutive hourly TDG readings in a 24-hour period) from the 2014 fish-spill season recorded at the Priest Rapids Dam forebay FSM station. Priest Rapids Project, mid-Columbia River, WA.**

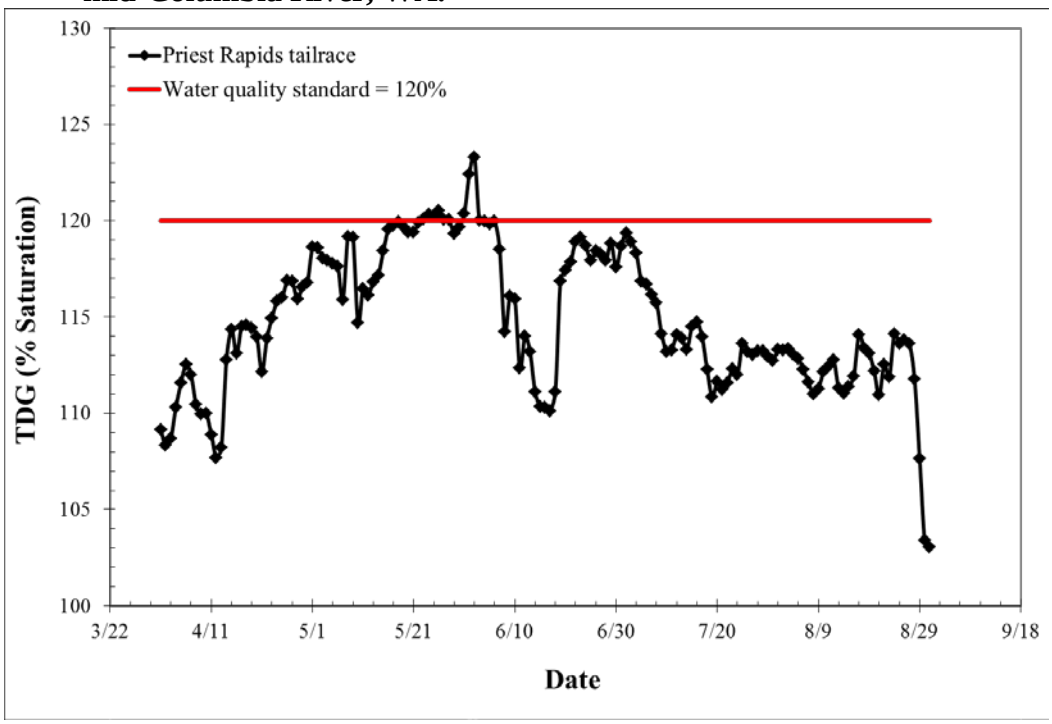

Figure 11 **Total dissolved gas measurements (average of the 12-highest consecutive hourly TDG readings in a 24-hour period) from the 2014 fish-spill season recorded at the Priest Rapids Dam tailrace FSM station. Priest Rapids Project, mid-Columbia River, WA.**

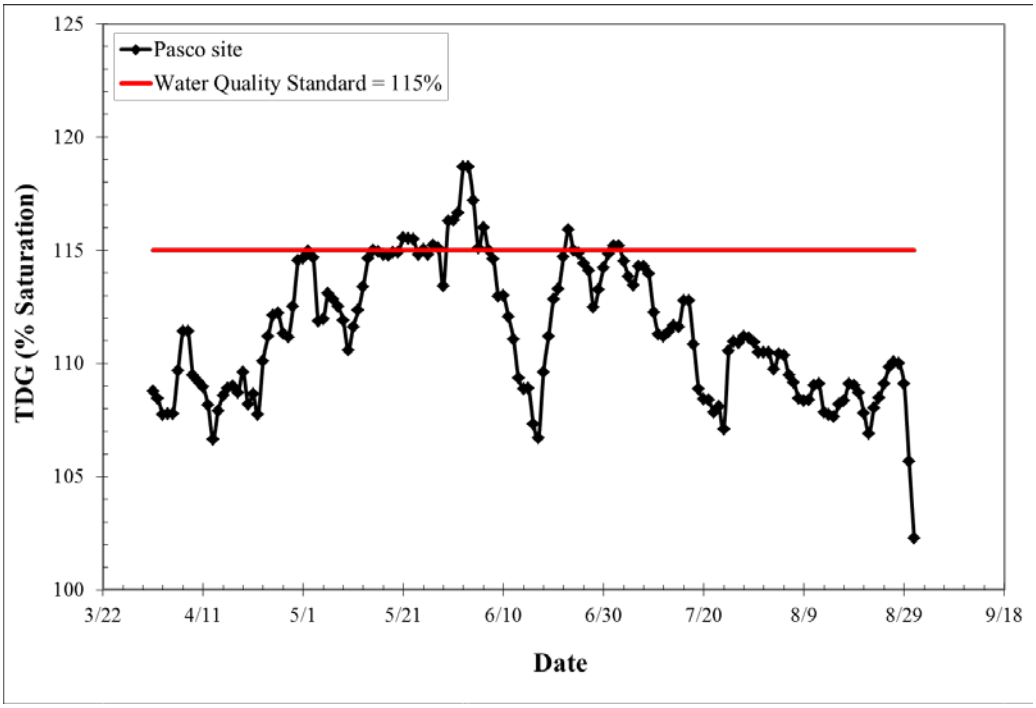

Figure 12 Total dissolved gas measurements (average of the 12-highest consecutive hourly TDG readings in a 24-hour period) from the 2014 fish-spill season recorded at the McNary forebay (Pasco site), mid-Columbia River, WA.

3.5.2 Total Dissolved Gas Exceedances

Table 5 displays the total number of times TDG levels exceeded the current water quality standards during the 2014 fish-spill season as measured at each of Grant PUD's FSM stations along with the Pasco compliance point (owned/operated by the Corps). The total number of exceedances also reflects the omission of exceedances caused by the previous day's hourly values, if those same hourly values also created a 12-hour average TDG value above standards for the previous day (see Section 1.2.2 and Appendix A for explanation of how the WDOE 12-high consecutive calculation method and associated "double-counting" issues were addressed in 2014). Appendix B within this report presents all omitted data with explanations of why they were omitted.

During the 2014 fish-spill season, there was a total of 84 exceedances of the 115/120 %SAT standard (based on daily average of the 12-highest consecutive hourly readings). There were 44 exceedances of the 1-hour 125 %SAT standard, all occurred at either the Wanapum Dam tailrace (25) or Priest Rapids Dam forebay (19) fixed-site monitoring stations (FSM stations).

Table 5 Number of 2014 fish-spill season total dissolved gas exceedances. Priest Rapids Project, mid-Columbia River, WA.

	Number of 115 %SAT/120 %SAT exceedances					Number of 125 %SAT exceedances		
Location[1]	Spring Spill	Summer Spill	Total	Total # of days[2]	% above standard	Total	Total # of hrs[2]	% above standard
WANT	13	2	15	142	11%	25	3,425	0.7%
PRDF	40	16	56	153	37%	19	3,672	0.5%
PRDT	3	0	3	153	2%	0	3,672	0%
PASCO	9	1	10	153	7%	0	3,672	0%
Total	65	19	84	601	14%	44	14,441	0.3%

[1]WANT = Wanapum tailrace, PRDF = Priest Rapids forebay, PRDT = Priest Rapids tailrace, PASCO = Pasco Fixed Site Monitor located upstream of McNary Dam (next downstream forebay), operated by the US Army Corps of Engineers.
[2]Based on total number of available days/hrs minus days/hrs omitted due to TDG membrane failures or other QA/QC issues.

The Priest Rapids forebay FSM station accounted for the majority of TDG exceedances in 2014 (56 of 84 or 67%), all of which are attributed to river flow in excess of Wanapum Dam's current hydraulic capacity (~158.5 kcfs). When flows were above Wanapum Dam's hydraulic capacity, involuntary spill was required that contributed to elevated TDG levels, and because of the short distance between Wanapum and Priest Rapids dams (18 river miles (RM)), TDG levels did not have a chance to dissipate below the 115 %SAT by the time they reached the Priest Rapids Dam forebay FSM station. Additionally, of the 56 exceedances recorded at the Priest Rapids Dam forebay FSM station, 24 (43%) corresponded with incoming TDG levels 115 %SAT or above recorded during the same time period at the Wanapum Dam forebay FSM station (Figure 13).

Furthermore, other factors during the 2014 fish-spill season can be attributed towards some of the exceedances of TDG standards at the compliance points. During the 2014 fish-spill season, the Wanapum Reservoir was drawn down more than 20 feet below its normal minimum operating level for repairs to be made to the spillway sections of Wanapum Dam (a fracture was discovered in February of 2014 and the reservoir behind Wanapum Dam was lowered to prevent further damage, and has been drawn down since then). Because of this occurrence, some unique factors attributed to some of the exceedances of TDG during the 2014 fish-spill season. Included in these factors were differences in Project operations because of the variance in operating ranges (3-4 ft. during 2014 vs. normal year 10-11 ft.), differences in fish-spill operations (see Table 2 above), and differences in upstream operations at Rock Island Dam because of the decrease in average river flows from the impacts of the Wanapum drawdown operations. As river flows decreased, tailwater elevations decreased in the Rock Island Reservoir, which caused the head on the generation units of powerhouse 2 at Rock Island Dam to increase and exceed 51.5 ft., which is the upper limit of the safe normal operating head for the powerhouse 2 units. Consequently, Rock Island was forced to cease generation of these powerhouse 2 units and utilize spill to pass total river flow, thus increasing the amount of spill and consequently, the TDG levels in the Rock Island tailrace.

Appendix D of this report provides comments and/or corrective action descriptions associated with exceedances that occurred during the 2014 fish-spill season.

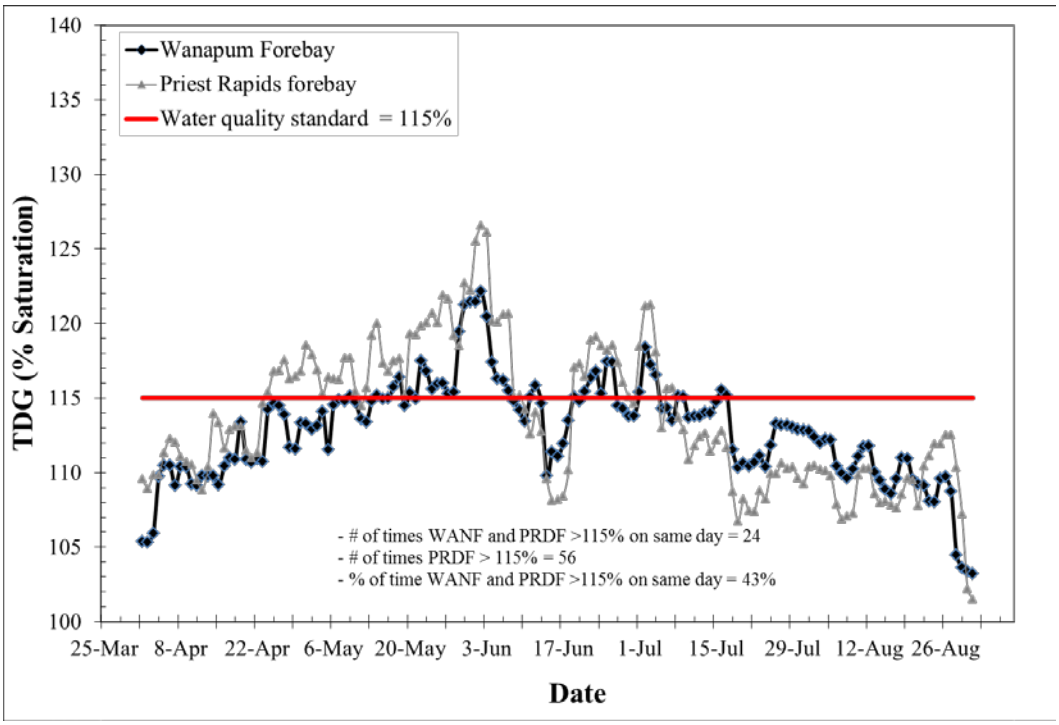

Figure 13 Total dissolved gas measurements (average of the 12-highest consecutive hourly TDG readings in 24-hour period) from the 2014 fish-spill season recorded at the Wanapum Dam forebay FSM station and the Priest Rapids Dam forebay FSM station. Priest Rapids Project, mid-Columbia River, WA.

3.5.3 Total Dissolved Gas and Involuntary Spill

Figure 14 and Figure 15, and Table 6 show that mean daily flow values recorded at Wanapum Dam exceeded the 2014 fish-spill season Wanapum Dam Powerhouse capacity of 139.5 kcfs 67% of the time over the entire fish-spill season. In addition, mean daily flow values recorded at Wanapum Dam were in excess of the current Wanapum Dam Powerhouse capacity plus voluntary (fish-spill) amounts (~158.5 kcfs) 46% of the time during the entire fish-spill season. As a result of these flows, increased involuntary spill was required for part of the fish-spill season, and all of the TDG exceedances occurred during periods of involuntary spill.

Table 6 Amount of time mean daily flow values exceeded Wanapum Dam's powerhouse capacity and/or powerhouse capacity plus fish-spill amounts. Priest Rapids Project, mid-Columbia River, WA.

Season (total # of days)	Number of days >139.5[1]	Percent of days >139.5	Number of days >158.5[2]	Percent of days >158.5
Spring Spill (75)	64	85%	49	65%
Summer Spill (78)	39	50%	21	27%
Entire Season (153)	103	67%	70	46%

Notes:
[1]The 2014 powerhouse capacity at Wanapum Dam was limited to 139.5 kcfs during the fish-spill season.
[2]Fish-spill amounts at Wanapum Dam during the 2014 fish-spill season were up to 19 kcfs, therefore powerhouse capacity plus fish-spill amounts were equal to ~158.5 kcfs.

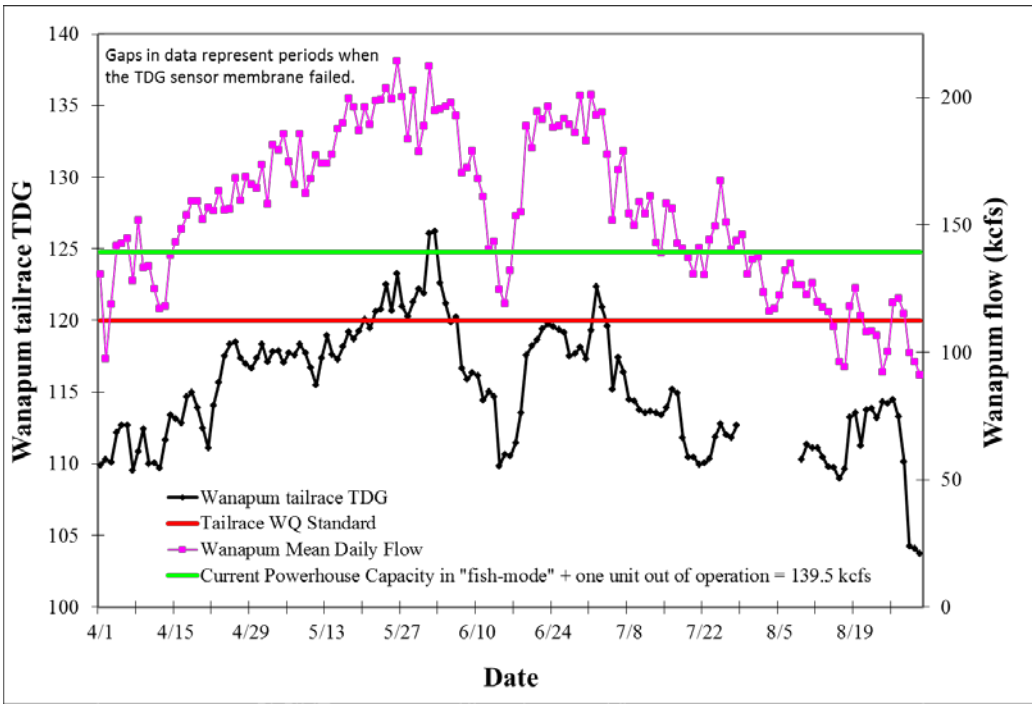

Figure 14 **Total dissolved gas measurements (average of the 12-highest consecutive hourly TDG readings in a 24-hour period) from the 2014 fish-spill season recorded at the Wanapum Dam tailrace FSM station vs. Wanapum Dam mean daily flow values. Priest Rapids Project, mid-Columbia River, WA.**

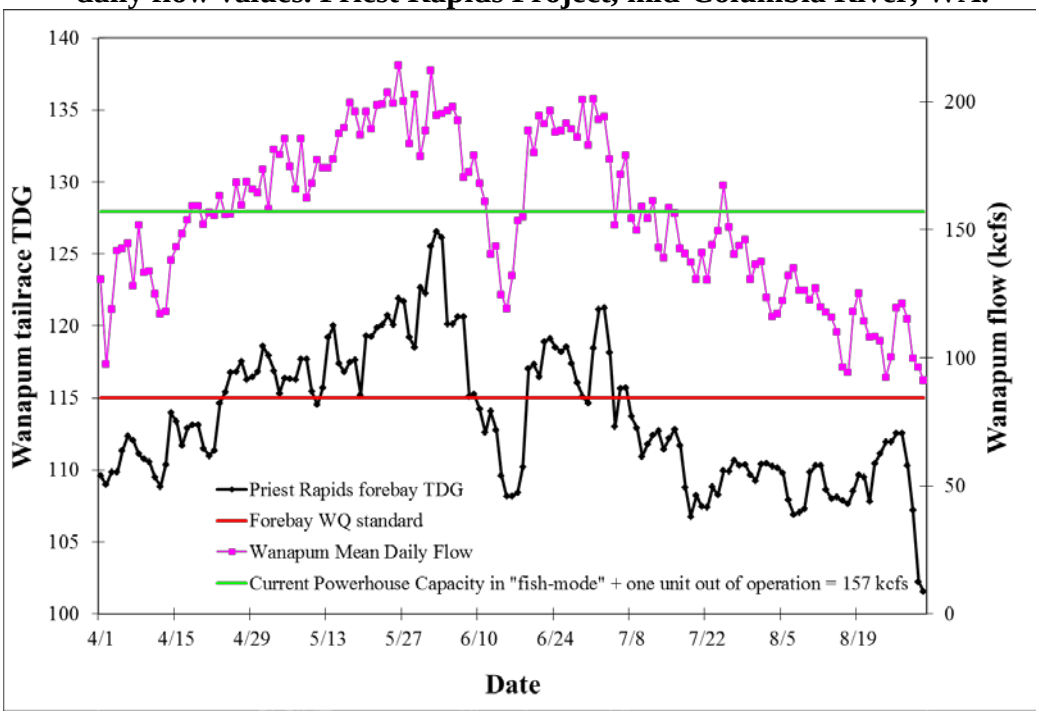

Figure 15 **Total dissolved gas measurements (average of the 12-highest consecutive hourly TDG readings in a 24-hour period) from the 2014 fish-spill season recorded at the Priest Rapids Dam forebay FSM station vs. Wanapum Dam mean daily flow values. Priest Rapids Project, mid-Columbia River, WA.**

Because all of the TDG exceedances during the 2014 fish-spill season occurred when mean daily flows from Wanapum Dam exceeded powerhouse capacities, modifications to the fish-spill program were not a feasible TDG reduction option. Note that Grant PUD is also limited to how "full" it can run its powerhouse due to regional and federal constraints, and thus in general the combination of both Wanapum and Priest Rapids dams are limited to 85% of their full capacity (Section 4.1 provides additional detail). When possible, Grant PUD attempted to maximize powerhouse discharge (up to the aforementioned 85% capacity) and minimize involuntary spill, and Section 4.1 below provides a summary of the TDG abatement measures taken during the 2014 fish-spill season.

The dates of each TDG exceedance and the corrective measures taken to reduce the elevated values are shown in Appendix D.

4.0 Total Dissolved Gas Abatement Measures

The following sections describe some of the TDG abatement measures that Grant PUD undertook during the 2014 fish-spill season, as well as those it intends to take in the future as part of its WDOE-approved Gas Abatement Plan (GAP; Keeler 2013a).

4.1 Total Dissolved Gas Abatement Measures in 2014

During the 2014 fish-spill season, Grant PUD continued to implement TDG abatement measures per its GAP (Keeler 2014), including the following:

Operational measures that were implemented, when feasible, to minimize involuntary spill and the TDG impacts associated with involuntary spill included:

- Attempting to maximize turbine flows by setting minimum generation requirements, this included establishing a common methodology for setting minimum generation requirements specific to Wanapum and Priest Rapids dam for the management of TDG. Each dam's minimum generation requirements were then allocated to power purchasers that receive a percentage of the projects' output. Mandating a high level of turbine usage during periods of high flow was, at times during 2014, an effective means of limiting involuntary spill and TDG impacts; however, during periods of very high-sustained flows, there was not adequate turbine capacity to sufficiently limit spill.

  It is important to note that while attempting to maximize powerhouse flows, there are other regional constraints and considerations, as well as federal requirements that limit Grant PUD's ability to maximize powerhouse flows to 100% of its capacity. These constraints, considerations, and requirements include, but are not limited to:

  1. Variable market conditions, which can change rapidly and impact Grant PUD's ability to sell energy that will maximize powerhouse discharge.
  2. Variable incoming flow estimates (which is used, in part, to guide energy sales), which can change rapidly based on upstream project operational decisions and can impact Grant PUD's ability to maximize powerhouse discharge. For example if a given incoming flow estimate provided by upstream operators is changed, operators of projects below must attempt to account for the additional water that was not anticipated and based on the variable market conditions described above, can limit Grant PUD's ability to maximize powerhouse discharge.

3. Regional renewable energy portfolio standards and federal tax incentives have stimulated investment in variable energy resources. The Pacific Northwest has the highest wind production capacity in the country, which tends to peak during the spring runoff (e.g. higher flow) and lower energy demand periods, which can lead to limited markets for hydroelectric energy, forcing negative pricing and/or involuntary spill.
4. Requirements for Grant PUD to maintain "operating reserves", which requires that Grant PUD hold up to 7% of its powerhouse capacity in reserve to respond to changes to system load and Northwest Power Pool reserve sharing group obligations.

Thus, in general both Wanapum and Priest Rapids dams are limited to 85% of their capacity based on the abovementioned regional constraints/considerations and federal requirements. Grant PUD attempted to operate its dams up to this capacity in order maximize powerhouse discharge and limit involuntary in order to help mitigate elevated TDG levels.

- Participation in regional spill/project operation meeting on February 27, 2014. The purpose of this meeting was to discuss alternative actions to mitigate the expected high TDG values that were anticipated to accompany the high flow conditions. This meeting brought together representatives from Natural Resources, Marketing, and Operations from Chelan, Douglas, and Grant PUDs, as well as representatives from Bonneville Power Association (BPA) and the Corps. Discussions included topics such as:
    - Each project's operational limitations, competing regulations, fish studies, and/or other natural resources requirements (e.g. Hanford Reach fall Chinook flow protection requirements).
    - The possibility of shifting generation away from those projects that produce relatively low levels of TDG to those that have the propensity to produce higher TDG levels (e.g. reevaluation of the regional Spill Priority List).
    - Each project's planned maintenance schedules and how it may limit ability to spill water through spillways and/or pass water through turbine units.
- Grant PUD Natural Resources Department participation in Grant PUD operational and power management scheduling meetings, which allowed Grant PUD staff with expertise in TDG management to provide input to operational planning decisions (e.g. request for turbine outages, power and river flow forecasting and subsequent operational strategy decisions, etc.).
- Implementation of the Spill Priority List which included, for example, having the Mid-Columbia Project (i.e. Grant, Chelan, and Douglas PUDs) operators working to coordinate spill to reduce the overall TDG on the entire Columbia River system. The Columbia River Basin Projects Spill Priority List provided guidance to federal river operators when there was insufficient generation request available to pass the needed amount of water through the Federal Columbia River Power System. A mechanism through hourly coordination was used to shift load from the non-federal projects to the federal projects (by mutual agreement) to reduce the amount of spill (and TDG levels) that would otherwise occur at the federal projects using the Spill Priority List. Although this measure may not have

resulted in direct decreases in TDG at Grant PUD's projects (and in some cases it may have increased TDG within Grant PUD's Project if spill was shifted to Wanapum or Priest Rapids dams in order to reduce spill at another project within the system), it was meant to help mitigate high TDG levels throughout the entire Columbia River system.

- Preemptive spill was used as feasible to coordinate spill sought to manage both the spill rate and the forebay elevation for better TDG management. For example, the spill rate could be stabilized if a project's storage was used to absorb flow fluctuations from upstream projects. Generally, a target operation of one foot from the allowed maximum at each project was used. When flows spike high, the storage could be used to lower the need for spill; when flows drop, the storage quantities could be reestablished by maintaining spill rates. Allowing a greater amount of storage to absorb variations can be an effective method in stabilizing spill flows but it can also provide adequate time for adjusting spill to meet survival study objectives and TDG requirements.

4.2 Future Total Dissolved Gas Abatement Measures

Per requirements contained in the 401 WQC, Grant PUD's GAP will be updated annually to reflect any changes in implementation schedules, new or improved technologies, or new TDG abatement measures. The 2014 draft GAP provides a summary of the proposed operational and structural abatement measures that Grant PUD plans to implement for the 2014 fish-spill season (Keeler 2013b). Operational abatement measures include minimizing involuntary spill by scheduling maintenance operations based on predicted flows and continuing to participate in the Hourly Coordination Agreement, which uses Automatic Control Logic to maintain preset reservoir levels at the mid-Columbia River dams in order to meet load requirements and prevent involuntary spill. In addition, Grant PUD plans to consult with WDOE on non-routine operational changes that may affect TDG, as well as manage fish-spill programs to meet TDG water quality standards through coordination with the PRCC. Grant PUD will also continue to conduct biological monitoring for GBT during the fish-spill season. Finally, Grant PUD plans to continue implementation of the TDG abatement measures described in Section 4.1 above that were conducted in 2014, including attempting to maximize turbine flows by setting minimum generation requirements, participation in regional spill/project operation meetings, implementation of the regional Spill Priority, and continuing to preemptively spill based on anticipated high flow/low power load time periods.

Structural abatement measures include the operation of the WFB, which is designed to safely pass outmigrating smolts while minimizing TDG uptake. The PRFB, which is designed to increase fish-passage while maintaining or reducing TDG levels at Priest Rapids Dam, is scheduled to be completed in 2014 (construction began in September of 2011). The installation of the advanced hydropower turbines at Wanapum is complete, with the final unit completed in September of 2013. As required under Sections 6.4.4(b) and 6.4.9 of the Project's 401 WQC (WDOE 2007), as well as Section II of the individual 401 WQC (WDOE 2004) for the advanced turbine installation project, Grant PUD conducted a field study to evaluate TDG levels with all ten of the advanced turbines operating to determine the effect, if any, the advanced turbines have on TDG below Wanapum Dam. Data for this evaluation was collected in early October (of 2013). Results from these evaluations are presented in Keeler 2014a and were submitted to the WDOE/PRCC and the FERC on December 13, 2013 and February 20, 2014, respectively.

TDG compliance monitoring will continue at Grant PUD's FSM stations. TDG and water temperature data will be collected on an hourly basis throughout the year and will be reported to

Grant PUD's water quality web-site (http://www.grantpud.org/environment/water-quality/monitoring-data). An annual report to WDOE will summarize Grant PUD's TDG monitoring and fish-spill season results.

5.0 Conclusions

During the 2014 fish-spill season, all TDG exceedances occurred when flow volumes were greater than the current hydraulic capacity at Wanapum Dam (see Figure 15, and Table 7), which resulted in involuntary spill. Grant PUD implemented abatement measures intended to help moderate high TDG levels (see Section 4.1), including attempting to maximize powerhouse flows (up to its capacity that is available after accounting for regional and federal constraints) and reduce involuntary spill by selling power at reduced costs, participating in regional efforts to reduce TDG at each mid-Columbia River dam, and closely monitoring TDG and incoming flows.

As described in Section 4.0 and in the 2014 GAP (Keeler 2014), continuing and upcoming TDG abatement measures will be implemented by Grant PUD over the next four years (as part of the ten-year compliance schedule that began in 2008) to mitigate for elevated TDG values that may occur during the fish-spill season. Examples of structural abatement measures include installation of spillway deflectors at Wanapum Dam, construction/use of the WFB, construction/use of the PRFB, and installation of advanced hydropower turbines at Wanapum Dam.

Grant PUD will continue to closely monitor TDG levels during the fish-spill season in accordance with the QAPP (Hendrick 2009), and will develop its spill programs in accordance with current TDG water quality criteria as set by WDOE, adjusting spill percentages as needed to comply with current TDG standards.

Literature Cited

Federal Energy Regulatory Commission (FERC). 2008. Order Issuing New License for Public Utility District No. 2 of Grant County, 123 FERC ¶ 61,049, Washington D.C.

Fish Passage Center (FPC). 2009. Gas Bubble Trauma Monitoring Program Protocol for Juvenile Salmonids. April 2009. http://www.fpc.org/smolt/gasbubbletrauma.html. Accessed March 2010.

FPC. 2013. Columbia River Data Access in Real Time (DART) Smolt Index Report. http://www.cbr.washington.edu/dart/pass.html. Accessed September 2012.

Hendrick, R. 2009. Quality Assurance Project Plan for Monitoring Selected Water Quality Parameters within the Priest Rapids Hydroelectric Project. Prepared for Public Utility District No. 2 of Grant County, Washington. January, 2009. http://www.gcpud.org/resources/resLandWater/waterQuality.htm

Jacobs, IIHR Hydroscience & Engineering, and Oakwood Consulting Inc. 2003. Fish Passage Alternatives Study for the Priest Rapids Project: Final Report January 31, 2003. Report prepared for Public Utility District No. 2 of Grant County, Washington.

Juul, Steve. 2013. Personal Communication. Email from Steve Juul (Corps) to Carson Keeler (Grant PUD) stating reasons for suspect TDG data in the Pasco site database and which data they (the Corps) consider to be unreliable. Dated October 29, 2013.

Keeler, C. 2012a. Final Total Dissolved Gas Abatement Plan for the Priest Rapids Hydroelectric Project. Prepared for Public Utility District No. 2 of Grant County, Washington. January 2012.

Keeler C. 2012b. Wanapum Dam Advanced Turbine Total Dissolved Gas Evaluation – Final Study Plan. Prepared for the Public Utility District No. 2 of Grant County, Washington. September 2012.

Keeler, C. 2014. Final Total Dissolved Gas Abatement Plan for the Priest Rapids Hydroelectric Project. Prepared for the Public Utility District No. 2 of Grant County, Washington. February 2014.

Keeler C. 2014a. Evaluation of Total Dissolved Gas Related to the Operation of Advanced Turbines at Wanapum Dam. Public Utility District No. 2 of Grant County, Ephrata, WA. February 2014.

National Marine Fisheries Service (NMFS). 2008. Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Consultation for the Priest Rapids Hydroelectric Project, FERC Project No. 2114.

Public Utility District No. 2 of Grant County, (Grant PUD). 2006. Priest Rapids Project Salmon and Steelhead Settlement Agreement, FERC Project No. 2114. February 10, 2006.

Public Utility District No. 2 of Grant County, Washington (Grant PUD). 2008. Letter to Washington State Department of Ecology; RE: Method for calculating total dissolved gas compliance value using highest 12 consecutive hour averages in any one day. Sent to Mr. James Bellatty on April 15, 2008.

Sullivan, L. S. and seven co-authors. 2008. Analysis of Juvenile Chinook, Steelhead, and Sockeye Salmon Behavior Using Acoustic Tags at Wanapum and Priest Rapids Dams, 2008. Prepared by HTI, Inc. Seattle, WA. Prepared for Public Utility District No. 2 of Grant County, Washington.

Timko, M.A. and six co-authors. 2007. Analysis of Juvenile Chinook, Steelhead and Sockeye Salmon Behavior Using Acoustic Tags at Wanapum and Priest Rapids Dams, 2007. Prepared by HTI, Inc. Seattle, WA. Prepared for Public Utility District No. 2 of Grant County, Washington.

Timko, M.A.and ten co-authors. 2009. Behavior and survival analysis of steelhead and sockeye through the Priest Rapids Hydroelectric Project in 2009. Final report by Blue Leaf Environmental, Ellensburg, WA. Prepared for Public Utility District No. 2 of Grant County, Washington.

Timko, M.A. and ten co-authors. 2010. Behavior and survival analysis of steelhead and sockeye through the Priest Rapids Hydroelectric Project in 2010. Final report by Blue Leaf Environmental, Ellensburg, WA. Prepared for the Public Utility District No. 2 of Grant County, Washington.

U.S. Geological Survey (USGS). 2014. Streamflow data collected at gage #12472800: Columbia River Below Priest Rapids Dam, WA. http://waterdata.usgs.gov/wa/nwis/uv?station= 12472800. Accessed September 2011.

Washington Department of Ecology (WDOE). 1997. Water quality standards for surface waters of the state of Washington. Chapter 173-201, AWAC. Olympia, WA.

WDOE. 2004. Water Quality Certification for the installation of new turbines at Wanapum Dam. Order No. 1026 dated March 2004.

WDOE. 2007. Water Quality Certification for the Priest Rapids Hydroelectric Project. Order No. 4219 dated April 2007, amended March 6, 2008 (Order 5419). http://www.ecy.wa.gov/programs/wq/ferc/existingcerts.html#G.

WDOE. 2008a. Water quality standards for surface waters of the state of Washington. Chapter 173-201A, AWAC. Olympia, WA.

WDOE. 2008b. Letter to Columbia and Snake River Dam Operators; RE: Method for averaging 12 consecutive daily average high TDG readings in any one day. Sent by Mr. Chris Maynard on April 2, 2008.

Appendix A
Total dissolved gas compliance value calculation method

Table A-1, below, presents an example of when the Washington Department of Ecology (WDOE) TDG compliance value calculation method, which includes the last eleven hourly values from the previous day, created a double-counting instance during the 2014 fish-spill season.

On May 19, 2014, the WDOE compliance method would have created two TDG exceedances based on the same group of hours recorded at the Priest Rapids Dam forebay fixed-site monitoring station (FSM station). The red highlighted hours below indicate those which would have been counted on both days, which would have created the value of 117.6 percent saturation (%SAT) on May 18 ***and*** 117.1 %SAT on May 19 (yellow highlights), even though there was no hourly value above 115%SAT on May 19. To correct this issue during the 2014 fish-spill season, Grant PUD documented double-counting events. In the example below, the compliance value on May 19 of 117.1 %SAT was replaced by the average of the highest 12 consecutive hourly values that did NOT include the previous days last eleven hourly values (which already created a TDG exceedance on May 18). This resulted in a TDG compliance value on May 19, 2014 of 115.2 %SAT (green highlight).

In total, during the 2014 fish-spill season, there were 12 occurrences of the double-counting instances that lead to an apparent exceedance of TDG standards (see Table A-2). Grant PUD will continue to use this method for tracking and accounting for double-counting issues in future fish-spill seasons.

Table A-1 Example of double counting using "rolling average" method.

Date	Hour	Hourly TDG Value	Average of 12 previous hours	Highest 12-hr consecutive average for each day
5/18/2014	1500	117.4	116.5	
5/18/2014	1600	117.7	116.5	
5/18/2014	1700	117.7	116.6	
5/18/2014	1800	117.5	116.7	
5/18/2014	1900	117.5	116.9	
5/18/2014	2000	117.1	117.0	
5/18/2014	2100	117.1	117.1	
5/18/2014	2200	117.0	117.1	
5/18/2014	2300	116.7	117.2	
5/18/2014	2359	116.7	117.2	**117.6**
5/19/2014	0100	116.1	117.1	**117.1**
5/19/2014	0200	116.1	117.0	
5/19/2014	0300	115.9	116.9	
5/19/2014	0400	115.8	116.7	
5/19/2014	0500	115.5	116.6	
5/19/2014	0600	115.3	116.4	
5/19/2014	0700	115.2	116.2	
5/19/2014	0800	114.8	116.0	
5/19/2014	0900	114.5	115.8	
5/19/2014	1000	114.4	115.6	
5/19/2014	1100	114.3	115.4	
5/19/2014	1200	114.3	115.2	**115.2**
5/19/2014	1300	114.4	115.0	
5/19/2014	1400	114.7	114.9	
5/19/2014	1500	114.8	114.8	
5/19/2014	1600	114.9	114.8	
5/19/2014	1700	115.2	114.7	
5/19/2014	1800	115.4	114.8	
5/19/2014	1900	116.1	114.8	
5/19/2014	2000	116.2	114.9	
5/19/2014	2100	115.2	115.0	
5/19/2014	2200	114.6	115.0	
5/19/2014	2300	115.0	115.1	
5/19/2014	2359	115.2	115.2	

Table A-2 Exceedance events created by hourly values from the previous day (double counting instances).

Date	Location[1]	12-high with previous day values[2]	12-high without previous day values[3]
5/4/2014	PRDF	116.2	115.3
5/19/2014	PRDF	117.1	115.2
6/3/2014	PRDT	122.9	120.0
6/5/2014	PASCO	115.7	115.1
6/7/2014	PASCO	115.9	115.0
6/24/2014	WANF	116.4	115.3
6/24/2014	PASCO	115.9	115.0
6/29/2014	PRDF	116.0	115.1
7/4/2014	WANT	121.1	119.6
7/5/2014	WANF	116.1	114.3
7/5/2014	PRDF	117.8	113.0
7/8/2014	PRDF	116.4	113.7

Notes:
[1]WANF = Wanapum forebay, WANT = Wanapum tailrace, PRDF = Priest Rapids forebay, PRDT = Priest Rapids tailrace, PASCO = Pasco Fixed Site Monitor located upstream of McNary Dam (next downstream forebay), operated by the US Army Corps of Engineers.
[2]value is based on 12-high calculation with last 11 hrs of previous day included.
[3]value is based on 12-high calculation without previous days last 11 hrs.

Appendix B
Data omitted from the 2014 fixed-site monitoring total dissolved gas dataset because of QA/QC issues (Table B-1)

Table B-1 Hourly data points/sections omitted from the fixed site monitoring total dissolved monitoring dataset

Location	Date(s)	hr(s)	Problem/reason for omission	Comments/action taken to correct problem
WANT	7/29-8/8	1100-0800	Faulty TDG membrane	Replaced with new probe
WANT	8/26	0200-1000	Faulty TDG membrane	Replaced with new probe
Note: WANT = Wanapum tailrace				

Appendix C
2014 Fish-Spill Season Memoranda

Grant County
PUBLIC UTILITY DISTRICT
Innovation & Excellence...Yesterday, Today and Tomorrow

MEMORANDUM April 16, 2014

TO: Dispatch
Wanapum Dam Control Room
Priest Rapids Dam Control Room
Planning and Scheduling

VIA: Tom Dresser, Fish, Wildlife, and Water Quality Manager

FROM: Curt Dotson, Fisheries Program Supervisor – Anadromous Fish Passage & Operations Branch

Purpose: Start of 2014 Spring Fish Spill

Background: On April 17, 2008 FERC issued a new 44 year license to the Public Utility District No. 2 of Grant County (Grant PUD) for the operation of the Priest Rapids Project (Project No. 2114-116). Incorporated into this license are the fishway prescriptions set forth in the Biological Opinion that National Marine Fisheries Service (NOAA Fisheries) issued to Grant PUD on February 1, 2008.

Under Section 2.9.6 (Terms and Conditions) of the Biological Opinion, Action 1.5 states that the primary juvenile salmonid passage at Wanapum Dam will be 20 kcfs spill through the Wanapum Future Unit Fish Bypass (WFB) and that spill will commence before more than 2.5 percent of the spring migration have passed. Action 1.8, under that same Section, states that the Wanapum turbines will be operated in "fish mode" for 95 percent of the juvenile spring migration, and that turbine operation in "fish mode" will commence before 2.5 percent of the spring migrants have passed.

For juvenile fish passage at Priest Rapids Dam, Section 2.9.6, Action 1.13 states that the primary juvenile salmonid passage will be tainter gate spill of 61 percent of average daily total river flow, or total dissolved gas (TDG) limits, whichever is less. This spill will also commence before 2.5 percent of the spring migrants have passed Priest Rapids Dam. Action 1.16 states that the Priest Rapids turbines will be operated in "fish mode" for 95 percent of the juvenile spring migration, and that turbine operation in "fish mode" will also commence before 2.5 percent of the spring migrants have passed the dam. Action 1.12 of Section 2.9.6 allows Grant PUD to evaluate alternative top-spill concepts for juvenile fish passage at Priest Rapids Dam, which was the basis for the construction of the Priest Rapids Fish Bypass.

Discussion: The Rock Island Dam smolt index numbers indicate that the spring out-migration has begun. Based on the Biological Opinion, spring fish-spill at Wanapum and Priest Rapids dams will commence as indicated below and continue until further notice.

Fish Spill at Wanapum and Priest Rapids Dams:

Hydro Project	Start Date	Start Time	Spill Rate	Duration
Wanapum Dam	April 17, 2013	1400 hrs.	WFB, TG-7thru 12	24 hours/day
Priest Rapids Dam	April 18, 2013	1400 hrs.	PR Fish Bypass (Bays 20-22)	24 hours/day

Due to the drawdown of the Wanapum Reservoir, which impacted the amount of flow through the WFB, additional tainter gate spill will take place at Wanapum Dam to bring "fish-spill" to approximately 20 kcfs. Wanapum Dam should follow the spill pattern titled, "2014 Wanapum Dam Spill Pattern during Fish Spill". In the case of any inadvertent spill (excess of powerhouse capacity), that spill shall be discharged through the spillbay(s) as indicated in the "2014 Wanapum Dam Inadvertent Spill Pattern during Fish Spill" spread sheet.

Priest Rapids Dam should follow the spill pattern titled "2014 Spill Pattern during Fish Spill". In case of any inadvertent spill, please follow the inadvertent spill pattern give in the "2014 Priest Rapids Dam Inadvertent Spill Pattern during Fish Spill".

Operation of the Wanapum and Priest Rapids turbines in "fish mode" will commence at the same date and time that "fish spill" starts for each associated dam. For a listing of unit priority of turbine operations, please refer to the "First On / Last Off" List that was sent to each of the associated control rooms.

The Fish Spill Representatives will monitor TDG levels and make spill changes to ensure TDG levels remain within Washington Department of Ecology's water standards.

Please give Curt Dotson a call (509-750-1999) if you have any questions.

Grant County
PUBLIC UTILITY DISTRICT
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MEMORANDUM June 13, 2014

TO: Dispatch
Wanapum Dam Control Room
Priest Rapids Dam Control Room
Planning and Scheduling

VIA: Tom Dresser, Fish, Wildlife, and Water Quality Manager

FROM: Curt Dotson, Fisheries Program Supervisor

Purpose: Start of 2014 Summer Fish Spill

Background: On April 17, 2008 FERC issued a new 44 year license to the Public Utility District No. 2 of Grant County (Grant PUD) for the operation of the Priest Rapids Project (Project No. 2114-116). Incorporated into this license are the fishway prescriptions set forth in the Priest Rapids Salmon and Steelhead Settlement Agreement (SSA) that Grant PUD entered into with Governmental and Tribal (Fishery) Parties on February 10, 2006. This document addresses summer fish spill (Section 9.3) by establishing spill levels that are intended to pass 95% of the summer juvenile migrants (fall and summer Chinook). This calls for 49% summer spill at Wanapum Dam and 39% summer spill at Priest Rapids Dam. The summer migration season begins when summer/fall Chinook smolts are present in the river or June 15th, whichever occurs first. The Priest Rapids Salmon and Steelhead Settlement Agreement also provided the latitude for Grant PUD, in consultation with the PRCC, to implement operational measures for the Project to protect that portion of the run that passes the Project in order to improve downstream passage survival at the Project and contribute to achieving the overall no net impact (NNI) objective for summer/fall Chinook in the program area.

Action 9 & 18 of the SSA states that the Wanapum and Priest Rapids turbines will be operated in "fish mode" for the juvenile migration. Action 13 allows Grant PUD to evaluate alternative top-spill concepts for juvenile fish passage at Priest Rapids Dam.

Discussion: At Wanapum Dam, Spring Fish Spill will continue until 2359 hr. of June 14th, 2014 at which time Summer Fish Spill will begin. The 2014 Summer Fish Spill program for Wanapum Dam will be the same as the 2014 Wanapum Spring Fish Spill

program – operation of the Wanapum Fish Bypass (WFB) and tainter gates (TG) 7 thru 12.

At Priest Rapids Dam, Spring Fish Spill will continue until 2359 hr. of June 14th, 2014 at which time Summer Fish Spill will begin. The 2014 Summer Fish Spill program for Priest Rapids Dam will be the same as the 2014 Priest Rapids Spring Fish Spill program – operation of the Priest Rapids Fish Bypass (TG 20-22).

- Fish Spill at Wanapum and Priest Rapids Dams:

Hydro Project	Start Date	Start Time	Spill Rate	Duration
Wanapum Dam	June 14, 2014	2359 hrs.	WFB & TG 7-12	24 hours/day
Priest Rapids Dam	June 14, 2014	2359 hrs.	PRFB (TG 20-22)	24 hours/day

Wanapum Dam should follow the spill pattern titled, "2014 Wanapum Dam Spill Gate Operations for Inadvertent Spill during Fish Spill" if inadvertent spill is needed.

Priest Rapids Dam should follow the spill pattern titled "Inadvertent Spill Pattern 2014 Priest Rapids Dam", if inadvertent spill is needed.

Operation of the Wanapum and Priest Rapids turbines in "fish mode" will commence at the same date and time that summer "fish spill" starts for each associated dam.

The Fish Spill Representatives will monitor TDG levels and make spill changes to ensure TDG levels remain within Washington Department of Ecology's water standards.

Please give Curt Dotson a call (509-750-1999) if you have any questions.

Grant County
PUBLIC UTILITY DISTRICT
Innovation & Excellence...Yesterday, Today and Tomorrow

MEMORANDUM

August 28, 2014
(Version 2.0)

TO: Grant Dispatch
Wanapum Dam Control Room
Priest Rapids Dam Control Room

VIA: Tom Dresser, Fish, Wildlife, and Water Quality Manager

FROM: Curt Dotson, Fisheries Program Supervisor

Purpose: 2014 Summer Fish Spill - Ending

Discussion: The 2014 Summer Fish Spill Program began at Wanapum and Priest Rapids dams on June 14 (at 2359 hr), immediately following the end of spring fish spill. The 2014 Summer Fish Spill program for Wanapum Dam was the same as the 2014 Wanapum Spring Fish Spill program – operation of the Wanapum Fish Bypass (WFB), with the addition of spill thru TG-7-12 (to bring total fish-spill flow to 20 kcfs – due to lowered Wanapum reservoir). The 2014 Summer Fish Spill program for Priest Rapids Dam was the same as the 2014 Priest Rapids Spring Fish Spill program – operation of Priest Rapids Fish Bypass (bays 22, 21, & 20) 24/7.

The Priest Rapids Project Salmon and Steelhead Settlement Agreement states that '*....summer spill ends after 95% of the summer and fall Chinook juvenile migrants have passed Wanapum and Priest Rapids dams.*'

Summer fish-spill at Wanapum Dam will end on August 28, 2014 at 1000 hr. and at Priest Rapids Dam on August 28, 2014 at 1300 hr.

For adult fall-back, the ice/trash sluiceway at Wanapum would normally be opened and remain open to pass water 24/7, but due to the lowered elevation of the Wanapum Reservoir, the ice/trash sluiceway gate is out of the water not available for use. For the 2014 adult fall-back spill, the WAN Fish Bypass will be opened and operated 24/7, until further notice. For adult fall-back operations at Priest Rapids Dam, the ice/trash sluice gate at bay 22 will be opened to the full-open position and pass water 24/7 until further notice. Operation of the Wanapum and Priest Rapids turbines have been in "fish mode" for the duration of the summer fish spill season, and upon reaching the respected date and time for each dam's "end of summer fish-spill", those turbines may return to standard turbine operations.

Conclusion: Based upon agreed criteria and in-season information, Grant PUD believes that the goal of assuring fish spill through 95% of the summer juvenile salmon out-migration through the Priest Rapids Project has been achieved. Therefore, Grant PUD will end summer fish-spill at 1000 hr. on August 28, 2014 at Wanapum Dam and at 1300 hr. on August 28, 2014 at Priest Rapids Dam (Table 1).

Table 1. Fish Spill at Wanapum and Priest Rapids Dams.

Hydro Project	Start Date	Start Time	Spill Rate	Duration
Wanapum Dam	August 28, 2014	1000 hr.	WAN Fish Bypass	24 hours/day.
Priest Rapids Dam	August 28, 2014	1300 hr.	Sluice gate open	24 hours/day

The Wanapum Dam Fish Bypass and the Priest Rapids Dam sluice gate will remain fully opened until November 15, 2014 to provide a fall-back route for adult salmonids.

Please call Curt Dotson if you have any questions (509-750-1999).

Appendix D
Daily averages of the 12-highest hourly total dissolved gas readings during the 2014 fish-spill season

Date	WANF	WANT	PRDF	PRDT	Pasco	Comments/Corrective Action Taken
1-Apr	105.4	109.9	109.6	109.1	108.8	
2-Apr	105.3	110.3	108.9	108.3	108.5	
3-Apr	105.9	110.1	109.8	108.7	107.7	
4-Apr	109.7	112.2	109.8	110.3	107.8	
5-Apr	110.5	112.7	111.3	111.6	107.8	
6-Apr	110.5	112.7	112.3	112.5	109.7	
7-Apr	109.1	109.5	112.0	112.0	111.4	
8-Apr	110.4	110.9	111.1	110.4	111.4	
9-Apr	110.4	112.5	110.7	109.9	109.5	
10-Apr	109.2	110.0	110.5	110.0	109.2	
11-Apr	109.2	110.1	109.5	108.9	109.0	
12-Apr	109.8	109.7	108.8	107.7	108.1	
13-Apr	109.8	111.7	110.4	108.2	106.7	
14-Apr	109.8	113.4	114.0	112.8	107.9	
15-Apr	109.2	113.2	113.3	114.4	108.6	
16-Apr	110.4	112.8	111.6	113.1	108.9	
17-Apr	111.0	114.7	112.9	114.5	109.0	
18-Apr	110.9	115.0	113.1	114.6	108.7	
19-Apr	113.4	113.9	113.1	114.4	109.6	
20-Apr	110.9	112.5	111.5	114.0	108.2	
21-Apr	110.7	111.1	111.0	112.2	108.6	
22-Apr	111.0	114.0	111.3	113.9	107.7	
23-Apr	110.7	115.7	114.6	114.9	110.1	
24-Apr	114.3	117.5	115.4	115.8	111.2	
25-Apr	114.6	118.3	**116.8**	116.0	112.1	Higher than average flows in the Upper/Mid-Columbia system (Grand Coulee Dam flood control preparation); powerhouse flows were increased so that powerhouse was operating at 85+% capacity. Limited amount of de-gassing occurring between WANT and PRDF. Reduced hydraulic capacity at Wanapum Dam plus increase in involuntary spill.
26-Apr	114.5	118.5	**116.8**	116.9	112.2	
27-Apr	113.9	117.4	**117.5**	116.8	111.3	
28-Apr	111.7	117.0	**116.3**	115.9	111.2	
29-Apr	111.6	116.7	**116.5**	116.5	112.5	
30-Apr	113.3	117.4	**116.8**	116.8	114.5	
1-May	113.3	118.3	**118.6**	118.6	114.7	

Date	WANF	WANT	PRDF	PRDT	Pasco	Comments/Corrective Action Taken
2-May	112.9	117.1	**117.9**	118.6	115.0	Same as above.
3-May	113.1	117.8	**116.9**	118.1	114.7	
4-May	114.1	117.9	115.3	118.0	111.9	
5-May	111.5	117.1	**116.4**	117.8	112.0	Same as above
6-May	114.6	117.7	**116.3**	117.6	113.1	
7-May	114.9	117.6	**116.3**	115.9	112.8	
8-May	114.8	118.3	**117.7**	119.2	112.5	
9-May	115.2	117.7	**117.7**	119.1	111.9	
10-May	114.7	116.7	115.5	114.7	110.6	
11-May	113.6	115.5	114.5	116.5	111.6	
12-May	113.4	117.4	**115.7**	116.1	112.3	Same as above.
13-May	114.8	118.9	**119.2**	116.8	113.4	
14-May	115.2	117.6	**120.0**	117.2	114.6	
15-May	115.0	117.3	**117.4**	118.4	115.0	
16-May	115.0	118.2	**116.8**	119.6	114.9	
17-May	**115.7**	119.2	**117.5**	119.7	114.8	These exceedances were associated with higher incoming TDG values (115+%SAT) at the WANF and little to no de-gassing through the system.
18-May	**116.4**	118.7	**117.6**	119.9	114.8	
19-May	114.5	119.3	115.2	119.7	114.9	
20-May	115.3	120.1	**119.3**	119.4	114.9	Powerhouse operating at 85+% capacity; spill caps being met; little to no de-gassing between WANT and PRDF.
21-May	114.9	119.5	**119.3**	119.4	**115.5**	
22-May	**117.5**	**120.6**	**119.9**	119.9	**115.5**	Generation was re-dispatched per BPA's request from the upper Mid-Columbia projects to the lower projects (per agreement between the BPA and the Mid-C's). This required additional spill from both Wells and Rocky Reach increasing the amount of incoming TDG into the system. Powerhouse operating at 85+ % capacity, very little de-gassing throughout system.
23-May	**116.8**	**120.8**	**120.1**	120.1	115.5	
24-May	**115.6**	**122.5**	**120.7**	120.3	114.8	
25-May	**115.9**	**120.7**	**120.1**	120.2	115.0	
26-May	**116.0**	**123.3**	**121.9**	**120.5**	114.8	
27-May	115.3	**121.0**	**121.7**	120.0	115.2	
28-May	115.4	120.3	**119.2**	120.0	115.1	
29-May	**119.4**	**121.3**	**118.5**	119.3	113.4	A fire by Rock Island Dam and two substations (McKenzie and Valhalla) severely limited generation and transmission capabilities on the Upper Columbia. Because of the restrictions, Rock Island Dam had a hydraulic capacity of 65 kcfs, resulting in 130+ kcfs of spill and Wells and Rock Reach had to remove 250 MWs of generation from each dam due to the transmission constraints associated with the loss.
30-May	**121.3**	**122.2**	**122.7**	119.7	**116.3**	
31-May	**121.4**	**121.9**	**122.3**	120.4	**116.3**	
1-Jun	**121.5**	**126.1**	**125.5**	**122.4**	**116.7**	
2-Jun	**122.2**	**126.2**	**126.6**	**123.3**	**118.7**	
3-Jun	**120.4**	**122.6**	**126.1**	120.0	**118.7**	
4-Jun	**117.4**	**121.2**	**120.1**	120.0	**117.2**	

Date	WANF	WANT	PRDF	PRDT	Pasco	Comments/Corrective Action Taken
5-Jun	**116.3**	119.8	**120.1**	119.8	115.1	
6-Jun	**116.2**	120.2	**120.6**	120.0	**116.0**	Same comments as above.
7-Jun	**115.5**	116.7	**120.6**	118.5	115.0	
8-Jun	114.8	115.9	115.1	114.2	114.6	
9-Jun	114.2	116.4	115.2	116.1	113.0	
10-Jun	113.4	116.2	114.2	115.9	113.0	
11-Jun	115.1	114.4	112.6	112.3	112.1	
12-Jun	**115.9**	115.0	114.1	114.0	111.1	
13-Jun	114.7	114.7	112.8	113.2	109.3	
14-Jun	109.8	109.8	109.6	111.1	108.9	
15-Jun	111.4	110.7	108.1	110.4	108.9	
16-Jun	111.1	110.5	108.2	110.3	107.3	
17-Jun	111.9	111.5	108.4	110.1	106.7	
18-Jun	113.5	113.6	110.2	111.1	109.6	
19-Jun	115.1	117.6	**117.0**	116.8	111.2	Powerhouse operating at 85+% capacity; spill caps being met; little to no de-gassing between WANT and PRDF.
20-Jun	114.8	118.2	**117.3**	117.4	112.8	
21-Jun	115.5	118.7	**116.5**	117.9	113.3	
22-Jun	**116.4**	119.4	**118.9**	118.9	114.7	During this time period, there was a capacity reduction at Rocky Reach Dam due to a transmission outage, causing additional spill and higher incoming TDG levels. Hydraulic capacity at Rock Island was limited because of the drawn down operation impacts from Wanapum Reservoir decreasing the safe amount of water that could go through powerhouse number 2, thus increasing the spill operations at Rock Island. Powerhouse operated at 85+ % capacity, very little de-gassing throughout system.
23-Jun	**116.8**	119.8	**119.1**	119.1	**115.9**	
24-Jun	115.3	119.5	**118.5**	118.7	115.0	
25-Jun	**117.5**	119.3	**118.2**	117.9	114.9	
26-Jun	**117.4**	119.1	**118.6**	118.4	114.4	
27-Jun	114.5	117.5	**117.4**	118.3	114.1	
28-Jun	114.3	117.7	**116.0**	117.9	112.5	
29-Jun	113.8	118.2	115.1	118.8	113.3	
30-Jun	113.8	117.3	114.6	117.6	114.2	
1-Jul	115.4	119.3	**118.4**	118.7	114.8	
2-Jul	**118.4**	**122.4**	**121.2**	119.4	115.2	
3-Jul	**117.3**	**120.9**	**121.3**	118.9	115.2	
4-Jul	**116.5**	119.6	**118.1**	118.3	114.5	
5-Jul	114.3	115.2	113.0	116.9	113.8	
6-Jul	114.3	117.4	**115.7**	116.7	113.5	
7-Jul	113.5	116.4	**115.7**	116.2	114.3	

Date	WANF	WANT	PRDF	PRDT	Pasco	Comments/Corrective Action Taken
8-Jul	115.1	114.5	113.7	115.7	114.3	
9-Jul	115.1	114.4	112.9	114.1	114.0	
10-Jul	113.7	113.8	110.9	113.2	112.3	
11-Jul	113.8	113.6	111.8	113.3	111.3	
12-Jul	113.8	113.7	112.4	114.1	111.2	
13-Jul	114.0	113.6	112.7	113.9	111.4	
14-Jul	114.0	113.4	111.4	113.3	111.7	
15-Jul	114.8	113.9	112.2	114.5	111.6	
16-Jul	115.6	115.2	112.8	114.7	112.8	
17-Jul	115.2	114.9	111.7	114.0	112.8	
18-Jul	111.5	111.8	108.7	112.3	110.9	
19-Jul	110.4	110.5	106.7	110.8	108.9	
20-Jul	110.6	110.5	108.2	111.6	108.4	
21-Jul	110.4	109.9	107.4	111.2	108.4	
22-Jul	110.7	110.1	107.4	111.6	107.9	
23-Jul	111.1	110.3	108.8	112.3	108.1	
24-Jul	110.4	111.9	108.2	112.0	107.1	
25-Jul	111.9	112.8	109.9	113.6	110.6	
26-Jul	113.3	112.0	109.9	113.2	111.0	
27-Jul	113.2	111.8	110.7	113.0	110.9	
28-Jul	113.2	112.7	110.3	113.2	111.2	
29-Jul	113.1	n/d	110.4	113.2	111.1	
30-Jul	112.9	n/d	109.6	113.0	110.9	
31-Jul	112.8	n/d	109.2	112.7	110.5	
1-Aug	112.8	n/d	110.4	113.3	110.5	
2-Aug	112.4	n/d	110.5	113.3	110.5	
3-Aug	112.0	n/d	110.2	113.4	109.7	
4-Aug	112.2	n/d	110.1	113.1	110.4	
5-Aug	112.2	n/d	109.8	112.9	110.4	
6-Aug	110.4	n/d	107.9	112.3	109.5	
7-Aug	109.9	n/d	106.9	111.6	109.1	
8-Aug	109.6	n/d	107.1	111.0	108.4	
9-Aug	110.2	110.3	107.3	111.3	108.3	
10-Aug	111.1	111.3	109.8	112.2	108.4	
11-Aug	111.7	111.1	110.3	112.4	109.0	

Date	WANF	WANT	PRDF	PRDT	Pasco	Comments/Corrective Action Taken
12-Aug	111.8	111.1	110.3	112.8	109.1	
13-Aug	110.0	110.4	108.6	111.3	107.9	
14-Aug	109.5	109.8	108.0	111.0	107.7	
15-Aug	108.9	109.7	108.1	111.4	107.6	
16-Aug	108.6	108.9	107.8	111.9	108.2	
17-Aug	109.6	109.6	107.6	114.1	108.3	
18-Aug	111.0	113.2	108.5	113.4	109.1	
19-Aug	110.9	113.5	109.6	113.1	109.0	
20-Aug	109.5	111.3	109.5	112.2	108.7	
21-Aug	109.2	113.8	107.8	110.9	107.8	
22-Aug	109.1	113.9	110.4	112.5	106.9	
23-Aug	108.1	113.2	111.1	111.9	108.0	
24-Aug	108.0	114.3	111.9	114.1	108.5	
25-Aug	109.6	114.2	111.9	113.6	109.1	
26-Aug	109.7	114.5	112.5	113.8	109.8	
27-Aug	108.7	113.3	112.5	113.6	110.1	
28-Aug	104.5	110.1	110.3	111.8	110.0	
29-Aug	103.6	104.2	107.2	107.7	109.1	
30-Aug	103.3	104.1	102.2	103.4	105.7	
31-Aug	103.2	103.7	101.5	103.1	102.3	

Notes:

1. WAND = Wanapum Dam; WANF = Wanapum forebay; WANT = Wanapum tailrace; PRD = Priest Rapids Dam; PRDF = Priest Rapids forebay; PRDT = Priest Rapids tailrace; Pasco = Pasco Fixed Site Monitor located upstream of McNary Dam (next downstream forebay), operated by the US Army Corps of Engineers; n/d. = No data; see Appendix B for an explanation of why data was omitted.
2. Orange highlighted values represent values that are above current water quality standards.
3. Both Wanapum and Priest Rapids dams are, in general, limited to 85% powerhouse capacity due to regional and federal constrains, which were described in Section 3.5.3 and 4.1 of the report.