From:	Frantz, Waikele M.
To:	"Irle, Pat (ECY)"; Charlie McKinney;
cc:	Bitterman, Deborah; Sokolowski, Rosana;
Subject:	Final 2011 Gas Abatement Annual Report
Date:	Thursday, January 12, 2012 1:35:15 PM
Attachments:	FINAL 2011 Gas Abatement Annual Report.pdf - Adobe Acrobat Professional.pdf

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To: Pat Irle, Washington Department of Ecology
Charlie McKinney, Washington Department of Ecology

From: Waikele Hampton, Environmental Permit Coordinator
Public Utility District No. 1 of Chelan County (Chelan PUD)

Re: Rocky Reach Hydroelectric Project No. 2145 and Rock Island Hydroelectric Project No. 943
Final 2011 Gas Abatement Report

Please find attached the Final 2011 Gas Abatement Report for Rocky Reach and Rock Island hydroelectric projects.

If you have any questions, please do not hesitate to contact me.

Thank you,
Waikele Frantz
509-661-4627

ROCKY REACH and ROCK ISLAND HYDROELECTRIC PROJECTS FERC No. 2145 AND 943

2011 GAS ABATEMENTANNUAL REPORT

Prepared by:

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Public Utility District No. 1 of Chelan County
Wenatchee, WA 98801

January 2012

FINAL

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

EXECUTIVE SUMMARY

This Total Dissolved Gas Abatement Annual Report is being submitted to the Washington State Department of Ecology (Ecology) as required by the 401 Water Quality Certification (401 Certification) for the Rocky Reach Hydroelectric Project (Project) and the Gas Abatement Plans (GAPs) for Rocky Reach and Rock Island hydroelectric projects that were approved by Ecology in March 2011.

Chelan County Public Utility District No.1 (Chelan PUD) has prepared this annual report to summarize the results of the operations and activities detailed in the 2011 GAPs. The intent of these actions was to meet TDG requirements, while ensuring the fish passage requirements are met as set forth in the Rocky Reach and Rock Island Habitat Conservation Plans (HCPs). Operations and activities detailed in the 2011 GAPs and reported on in this document include:

- Operations (spill configurations and fish spill plan)
- Fisheries Management (HCP)
- Biological Monitoring
- Involvement in water quality forums
- Physical Monitoring
- Gas abatement methods (operational and structural)

Mean daily flow discharges during the 2011 fish spill season were higher than the 2001-2010 average (about 162% of average at Rocky Reach, and 160% of average at Rock Island) over the entire fish spill season. Due to these above average flows, high levels of involuntary spill occurred at both projects beginning in May and continuing through mid- (Rock Island) and late- (Rocky Reach) July.

During the 2011 fish spill season, Chelan PUD implemented spill programs as guided by the Rocky Reach and Rock Island HCPs. At Rocky Reach, the Juvenile Fish Bypass (JFB) was operated exclusively with no spill for fish during the spring migration (April 1 – June 3) and 9% of the daily average flow was spilled voluntarily for fish, as required by the HCP, during the summer migration (June 4 – August 12). An additional 19.5% was spilled involuntarily during this same time due to high river flows. To meet HCP fish passage requirements at Rock Island, 10% of the daily average flow was spilled voluntarily for fish during the spring migration (April 1 – June 3), while 20% of the daily average flow was spilled voluntarily for during the summer migration (June 9 – August 24). An additional 10.77% and 7.28% were involuntarily spilled during the spring and summer migration, respectively, due to high river flows.

Data analysis showed that water coming into the Rocky Reach forebay from upstream exceeded Washington State water quality criteria of 115% on 73 days. TDG exceeded the modified Washington State water quality TDG criteria on 58 days in the Rocky Reach tailrace (120%), 70 days in the Rock Island forebay (115%), and 62 days in Rock Island tailrace (120%) during this monitoring period. Numeric criteria were exceeded on 76 days (using a method that eliminates the double-counting issue) in the Wanapum forebay (115%). These exceedances of the water quality criteria did not necessarily result in noncompliance, as many occurred during river flows that exceeded 7Q10 or when forebay TDG levels were above the numeric criteria. For instance all exceedances in the Rocky Reach and Rock Island tailraces occurred when flows exceeded 7Q10 or when the forebay exceeded 115%, resulting in 100% compliance at both tailrace FMS. All but one exceedance in the Rock Island forebay occurred when flows exceeded 7Q10 or when the Rocky Reach forebay exceeded 115%, resulting in 98.8% compliance at this FMS. Lastly only 8 of the observed exceedances in the Wanapum forebay occurred during flows below 7Q10 and when the Rock Island forebay was below 115%, resulting in 90% compliance at this FMS.

1. INTRODUCTION

1.1 Project Description

The Columbia River watershed lies east of the Cascade Mountains and west of the Rocky Mountains and encompasses parts of British Columbia, Idaho, Montana, Nevada, Oregon and Washington. Rocky Reach and Rock Island projects are located in mid-Washington State on the mainstem of the Columbia River (Figure 1). The study area involved 59 river miles (RM), from the forebay of Rocky Reach Project (RM 474) downstream to the forebay of Wanapum Project (RM 415). This included the 21 RM between Rocky Reach and Rock Island dams and 38 RM between Rock Island and Wanapum dams.

1.1.1 Rocky Reach

The powerhouse at Rocky Reach Project contains a total of 11 vertical axis-generating units and is situated on the west half of the river parallel to the flow (Figure 2). The spillway at Rocky Reach houses 12 individually opening 170-ton tainter gates arranged on the east half of the river, perpendicular to the river flow. The normal maximum reservoir water surface elevation is 707 ft. with an average tailrace water surface elevation of 618 ft., providing a gross head of 89 ft. The depth of the stilling basin immediately downstream of the project is approximately 40 ft. at average tailwater elevation.

In 2003, Chelan PUD began operation of the Juvenile Fish Bypass (JFB), which continues to be the primary juvenile fish survival tool at Rocky Reach Project. Testing completed during the first year of operation assisted Chelan PUD in determining the guidance efficiency of the JFB and estimate the level of spill necessary to meet the Rocky Reach Habitat Conservation Plan (RRHCP) survival standards. Voluntary spill is used at Rocky Reach to supplement the effectiveness of the JFB, when needed, to reach survival goals of the RRHCP (See Section 2.3 for details). Due to the success of the JFB, Chelan PUD has reduced spill levels used to supplement the JBS for juvenile salmonid passage since 2007. During the migration season for yearling Chinook and steelhead (generally mid-April to early-June), Chelan PUD has not needed to use spill to supplement the JFB. During the subyearling Chinook migration (generally mid-June to mid/late August) a spill level of 9 percent of daily flow (reduced from 15 percent) has been provided.

The 2011 fish spill program at Rocky Reach was managed to maximize fish passage, meet HCP requirements, minimize voluntary spill, and still stay within the terms of the State TDG fish spill water quality criteria. Voluntary spill levels were managed in real time as detailed in the TDG Operational Plan (Appendix A) for the Rocky Reach Project. When Project operators observed instantaneous TDG levels

that exceeded the criteria as set forth in the Plan, spill was reduced to the extent possible and TDG levels monitored.

Figure 1. Location of Rocky Reach and Rock Island Hydroelectric Projects on the Columbia River

Figure 2. Location of forebay and tailrace fixed monitoring stations at Rocky Reach Project.

1.1.2 Rock Island

Rock Island Project consists of two separate powerhouses connected by a spillway. There are a total of 18 generating units; ten vertical axis Kaplan and Nagler turbines in the first powerhouse on the east shore, and eight horizontal axis bulb turbine generators in the second powerhouse on the west side of the river (Figure 3). The spillway is 1,184 ft. long and houses 31 spillgates divided by a center adult fishway. The east spillway contains a total of 14 gates, arranged perpendicularly to the river flow. The west spillway has 17 gates, situated at a slight angle to the river flow. Spillways are either 33 or 55 feet deep and have two or three spillgates stacked in the gate slot. Lifting one or more of these crest gates regulates spill volume. Each gate is 30 feet wide by 11 or 22 feet high. A total of nine gates have been modified or constructed to provide relatively low volume (1,850 or 2,500 cubic feet per second (cfs)) surface spill for fish bypass. The normal maximum reservoir elevation of Rock Island Project is 613 ft. with a tailrace elevation of 572 ft. and a head of 41 ft. Tailrace bathymetry below Rock Island is complex and ranges in elevation from approximately 580 ft. below bays 21-23 to approximately 520 ft. below Bay 1.

Chelan PUD has installed the following three TDG abatement structures at Rock Island:

1. Notched gates
   These gates reduce TDG by reducing the volume of water necessary for voluntary fish passage.

2. Spill deflector in Bay 16
   The main objective for the design of this deflector was to reduce the uptake of TDG per total volume of water and to safely pass downstream migrants during the fish spill season. Studies conducted on the deflector have shown that it can reduce TDG by 2.7%.

3. Three Over/under gates
   Testing of the first gate installed indicated a reduction in TDG uptake by 8.5 - 13.5% points, as compared to the existing notched gate method, and by an additional 2.5 - 4.5 % points as compared to deflectors. Fish passage survival tests performed indicated that overall survival was between 99% and 100%. Because the original Over/Under gate was successful at reducing TDG and maintaining fish survival, Chelan PUD made the decision to have three in place prior to the initiation of the 2007 spill season and these were utilized in 2008 - 2010, and again in 2011.

Figure 3. Location of forebay fixed monitoring station at Rock Island Project.

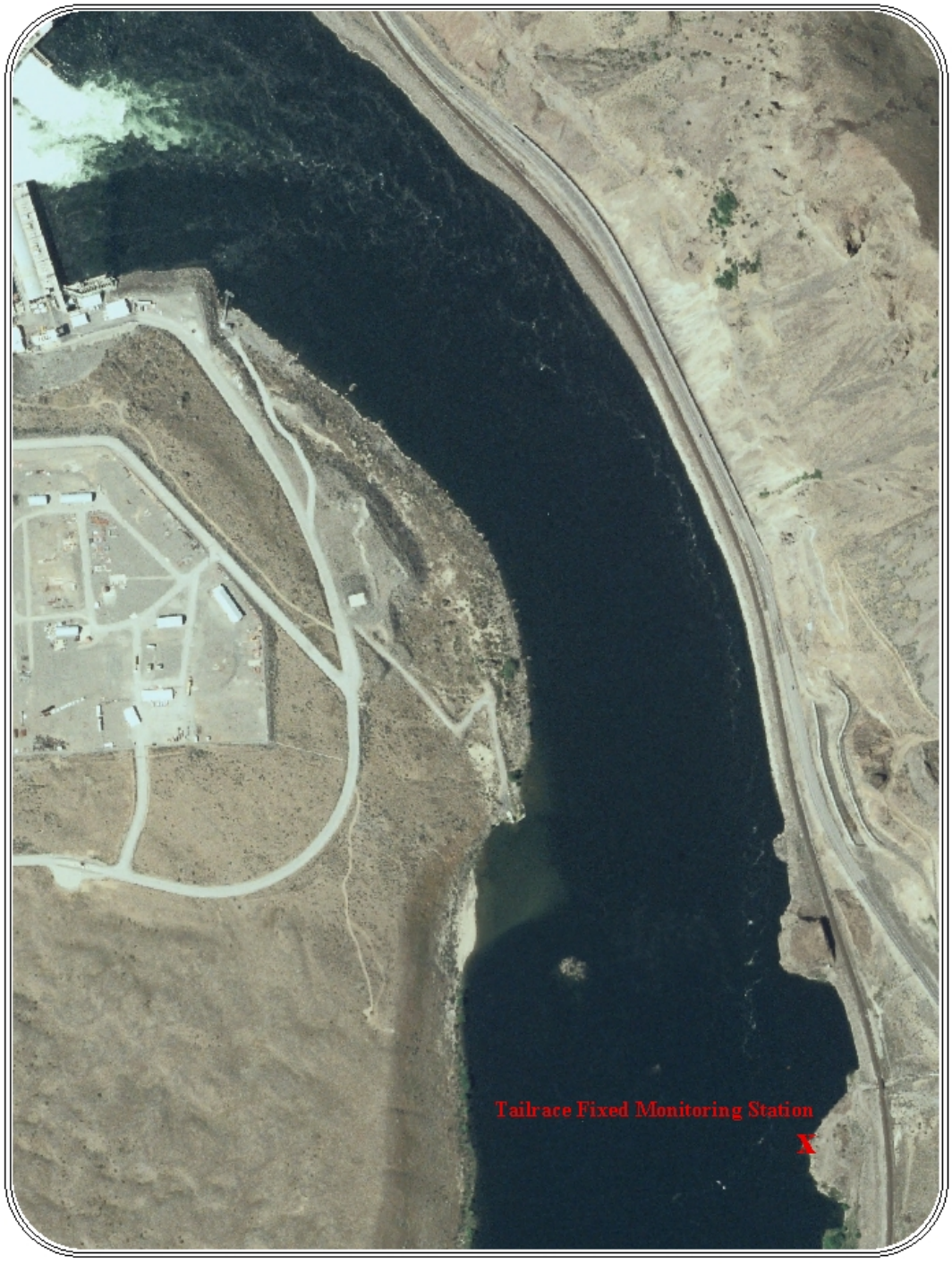

Figure 4. Location of tailrace fixed monitoring station below Rock Island Project.

Operating under a spill regime of 20% of the daily average river flow through 2006, the Rock Island HCP (RIHCP) survival standards for spring plan species have been met at Rock Island and Chelan PUD began testing powerhouse optimization in 2007. This testing has resulted in Chelan PUD reducing spring fish spill at Rock Island from **20% of the daily average flow to just 10%** of the daily average flow. This testing continued into 2011. Summer fish spill at Rock Island remains at 20% of the daily average flow.

The fish spill program at Rock Island was managed to maximize fish passage, meet HCP requirements, minimize voluntary spill, and still stay within the terms of the State TDG fish spill water quality criteria. Voluntary spill levels were managed in real time as detailed in the TDG Operational Plan (Appendix A) for the project. When Project operators observed instantaneous TDG levels that exceeded the criteria as set forth in the Plan, spill was reduced to the extent possible and TDG levels monitored.

1.2 Fixed Monitoring Station (FMS) Locations

At all sampling locations discussed below, TDG measurements were recorded throughout the monitoring season at 15-minute intervals, enabling plant operators to adjust spill volumes to maintain gas levels to reduce the likelihood of exceeding the TDG criteria. These 15-minute intervals were averaged into hourly readings for use in compiling daily and 12-hour averages. All hourly data were forwarded to Chelan PUD headquarters building and then onto the US Army Corps of Engineers Reservoir Control Center and posted at their site on the World Wide Web.

Forebay FMS were located at fixed sites on the upstream face of Rocky Reach and Rock Island projects (Figures 2 and 3, respectively). A dissolved gas probe (Minisonde) developed by Hydrolab, Inc. was lowered down a conduit secured to the upstream face of each project and submerged to a depth of approximately 15 ft.

Tailrace monitoring stations were located downstream of both projects. The Rocky Reach monitoring station was located approximately one third of a mile downstream of the spillway on the juvenile fish bypass outfall (Figure 2), as required by the 401 Water Quality Certification (Ecology, April 4, 2006). This location was chosen because it was the most feasible location near the end of the aerated zone, which is the compliance point for the Mid-Columbia TDG TMDL. There is not a bridge or other structure downriver of Rock Island Project to which a monitoring station can be attached. For this reason, Chelan PUD developed a monitoring station about 1.5 miles downriver from the project on the eastern shoreline (Figure 4). Representativeness of the site is summarized in the Total Maximum Daily Load for Total Dissolved Gas in the Mid-Columbia River and Lake Roosevelt Submittal Report (2004):

The representativeness of TDG readings at the tailwater FMS can vary according to spillway and powerhouse operations. Since spill flows tend to hug the east bank, the river is not fully mixed at the tailwater FMS. Operation of the Second Powerhouse will tend to push higher TDG flows into the east bank. However, First Powerhouse flows can have the opposite effect, pushing higher TDG flows towards the middle of the channel so that FMS readings reflect forebay TDG levels carried by powerhouse flows.

Unfortunately, there is no other feasible location for probe deployment at this time.

Either a Hydrolab Minisonde or Datasonde4 was deployed at each tailrace station. The units were submerged approximately 15 ft. below the surface using a 3/8-inch weighted wire cable.

1.3 Regulatory Framework

1.3.1 Washington State Department of Ecology (Ecology) Water Quality Numeric Criteria

The Washington State water quality numeric criteria for TDG (WAC 173-201A-200(1)(f)) address standards for the surface waters of Washington State. Under the water quality standards (WQS), TDG shall not exceed 110 percent at any point of measurement in any state water body. However, the TDG criteria may be adjusted to aid fish passage over hydroelectric dams when consistent with an Ecology-approved gas abatement plan. This plan must be accompanied by fisheries management and physical and biological monitoring plans. The elevated TDG levels are intended to allow increased fish passage without causing more harm to fish populations than caused by turbine fish passage. The following special fish passage exemptions for the Snake and Columbia rivers apply when spilling water at dams is necessary to aid fish passage:

- TDG must not exceed an average of one hundred fifteen percent as measured in the forebays of the next downstream dams and must not exceed an average of one hundred twenty percent as measured in the tailraces of each dam (these averages are measured as an average of the twelve highest consecutive hourly readings in any one day, relative to atmospheric pressure); and
- A maximum TDG one hour average of one hundred twenty-five percent must not be exceeded during spillage for fish passage.

Chelan PUD submitted the required Gas Abatement Plan for each Rocky Reach and Rock Island to Ecology in February 2011 and received approval for both plans in March 2011.

The amount of control that Chelan PUD has over TDG supersaturation in the Columbia River is limited to control of spill at the Rocky Reach and Rock Island projects. In high flow years, river flows regularly exceed the hydroelectric capacity of projects located on the mainstem Columbia, forcing large volumes of water to be spilled throughout the basin. Meekin and Allen (1974) noted that supersaturated waters do not completely equilibrate in transit through the downstream reservoirs. In many years, TDG levels

arriving at the Rocky Reach forebay exceed the 110% TDG criteria and even the 115% fish passage exemption due to spill at upstream projects. When TDG levels arrive at the Rocky Reach forebay exceeding the 115% forebay criterion, the Chelan PUD projects may not be able to meet the TDG criteria for the tailrace or the forebay of the next project.

1.3.2 Daily TDG Compliance Value Calculation

Chelan PUD calculated TDG levels for compliance with the numeric criteria as per an April 2, 2008 memo from Chris Maynard (former Hydropower Coordinator with Ecology), which reads:

> "Beginning during the 2008 spill season, the operators should use the following method to average and report the 12 consecutive hourly highest (12-C high) TDG reading in a day:
>
> *Method*: Use a rolling average to measure 12 consecutive hours. The highest 12 hour average in 24 hours is reported on the calendar day (ending at midnight) of the final measurement.
>
> - The first averaging period of each calendar day begins with the first hourly measurement at 0100 hrs. This hour is averaged with the previous day's last hourly measurements.
> - Each subsequent hourly measure is averaged with the previous 11 hours
> - until there are 24 averages for the day.
> - From the 24 hour averages, the highest average is reported for the calendar day.
> - Round the 12 hour average to nearest whole number."

Using this rolling average method that begins at 0100 hrs 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 criterion exceedance may be indicated on two separate days ("double counting") based on the same group of hours. Consider a spill event beginning at 1300 hrs on a Tuesday and continuing through 0100 hrs on Wednesday. Suppose TDG values during those hours of spill were 125% and 100% for all remaining hours. Under this situation, 12-C High values would be 125% for both days despite daily averages equaling 112% and 101%, respectively. In other words, Wednesday would be deemed to be an exceedance despite having only one hour above the standard (since the 0100 hrs moving average includes the 11 previous hours of high spill occurring on Tuesday).

Because there was no established methodology prior to the 2011 monitoring season to address this issue, Chelan PUD coupled the above rolling average methodology with the following to eliminate "double counting":

1. Calculate a moving average for each hour, including that hour and the previous eleven consecutive hours (which may or may not include the previous calendar day), resulting in a 12-hour moving average, with trailing values, associated with each daily hour.
2. Review the data to determine if there is an exceedance (12-C High > 120%).

3. When it appears an exceedance is a result of the influence of high hourly TDG levels from the previous day, filter the data set to exclude the first twelve 12-hr rolling averages of that day when an exceedance was noted.
4. Tabulate the resulting data set to reflect the maximum value observed on each specific calendar date. In other words, the greatest moving average value (including the previous eleven hours) observed through the last twelve hours of each day should be reported.
5. Count the total number of resulting values that exceed 120%. This should be reported as a number of days and as a proportion of total days observed (e.g., X days above 120% ÷ total number of days measured = XX.X % days of exceedance).

Use of the above methodology allowed for the monitoring of consecutive hours while eliminating "double counting". In the abovementioned example, only one day, not two, would have been reported as an exceedance under this method.

Chelan PUD understands and appreciates the need for consistency throughout the basin in regards to compliance monitoring and reporting and will modify or replace the methodology described above at such time as Ecology provides an approved method.

2. OPERATIONS

2.1 Description of 2010 Fish Spill Season Flow Characteristics

Mean daily discharge during the 2011 fish spill season was compared to the 10-year average of mean daily flows from 2001-2010, as measured at the Rocky Reach Hydroelectric Project (Figure 5) and the Rock Island Hydroelectric Project (Figure 6). Mean daily flow discharges during the 2011 fish spill season were higher than the 2001-2010 average (about 162% of average at Rocky Reach, and 160% of average at Rock Island) over the entire fish spill season. Flow for all months during the spill season were higher than the monthly 10-year average at both projects. The maximum hourly flows observed at Rocky Reach and Rock Island during the spill season were 340 kcfs and 331.3 kcfs, respectively, on June 5. The average monthly flow for all of June exceeded the 7Q10 value at both projects. Of the 153 days during the spill season (April 1 – August 31), there were 42 and 36 instances where the daily average flows exceeded the 7Q10 value at Rocky Reach and Rock Island, respectively.

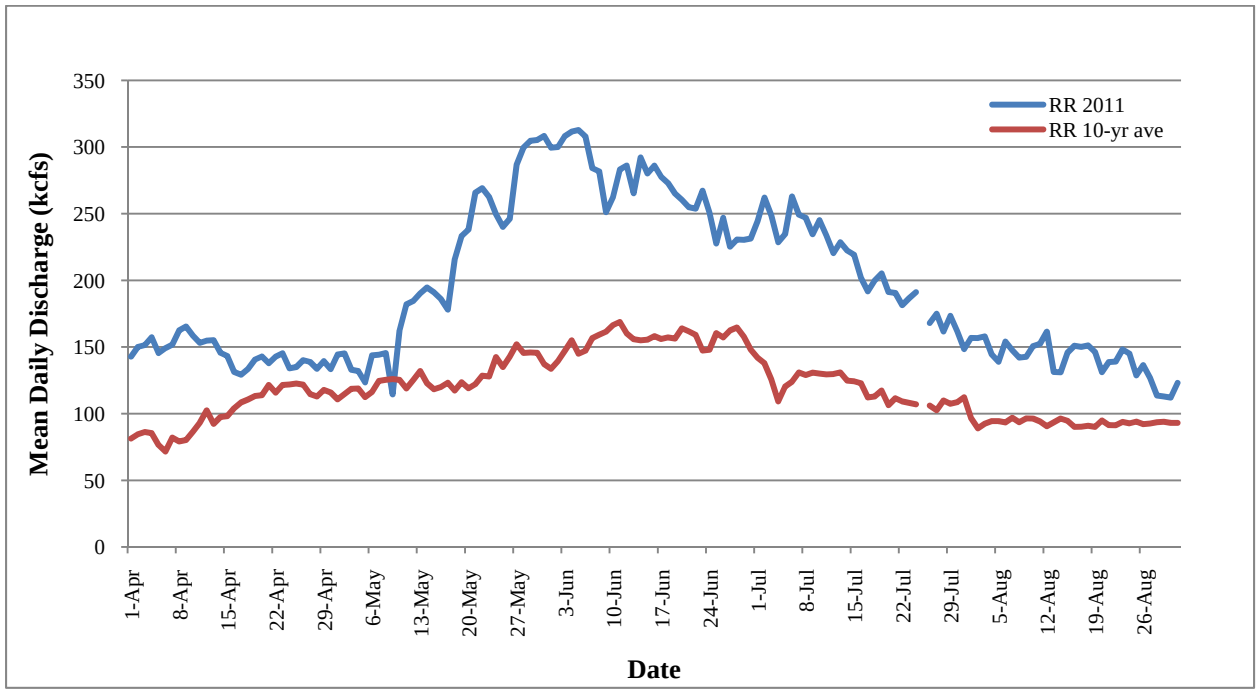

Figure 5. Comparison of 2011 vs previous 10-year average (2001-2010) of mean daily discharge at Rocky Reach Hydroelectric Project.

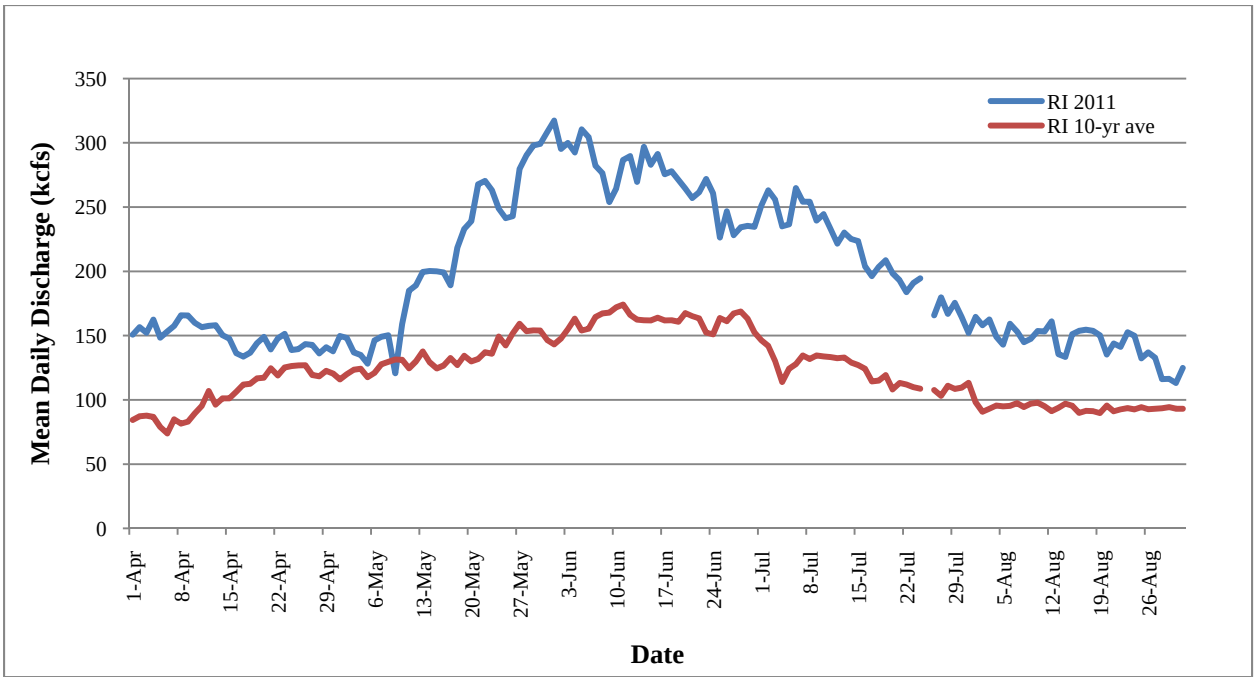

Figure 6. Comparison of 2011 vs previous 10-year average (2001-2010) of mean daily discharge at Rock Island Hydroelectric Project.

2.2 Spill Configurations

The spill levels for fish passage set forth below are subject to real-time modification to meet TDG standards, in accordance with a real-time operational plan. The Project operators are instructed to monitor the tailrace TDG level and reduce spill if TDG levels specified in the TDG Operational Plan (Appendix A) are exceeded. The operators at the Rock Island Hydroelectric Project are also instructed to inform the operators at Rocky Reach when the Rock Island forebay TDG level exceeds 115%. Since implementation of this plan, TDG exceedances in the tailrace of each project have been reduced.

2.2.1 Rocky Reach

The standard spill configuration used at Rocky Reach uses gates 2-8 with a minimum discharge per spill bay of about 4 kcfs. The standard spill configuration was designed to create a crown-shaped pattern of turbulent flow below the spillway with decreasing velocities leading toward the fishway entrances. This spill pattern provides favorable guidance conditions for adult migrant salmon and steelhead. The same pattern is used for juvenile fish passage spill. During spill operations, whether for juvenile fish passage, TDG management, or for other purposes, the gates are operated via a computer automated system that follows the spill pattern. Gates 9-12 are used only in high flow conditions when gates 2-8

cannot pass enough water. The standard spill pattern was deviated from only when needed during high flow and spill events.

Section 5.4(1)(b) of the 401 Water Quality Certification requires Chelan PUD to implement alternative spillway operations, using any of gates 2 through 12, to determine, in consultation with the Rocky Reach Fish Forum (RRFF) and HCP Coordinating Committee, whether TDG levels can be reduced without adverse effects on fish passage. Chelan PUD did not implement this action in 2011, but plans to develop a study plan during the winter of 2011/2012.

2.2.2 Rock Island

The standard spill pattern for fish spill at Rock Island first utilizes the three Over/Under gates (31, 32, 30), then with increased spill, followed by the notched gates (1, 26, 16, 18, 24, 29), and finally the full gates (20, 17, 19, 22, 25 and 21).

The standard spill pattern was deviated from in 2011 at Rock Island in an attempt to maintain TDG compliance during high flow and spill events. This deviation included the closing of notched gates and the addition of gates 6 and 27. Due to the level of incoming gas levels and flows, these changes in spill pattern were not as successful at maintaining gas levels below 120% as they have been in previous years.

2.3 Fish Spill Program

As part of the HCPs for the Rocky Reach and Rock Island hydroelectric projects, Chelan PUD is required to meet survival standards for fish migrating through the projects. Juvenile dam passage survival is a key component of project survival. Chelan PUD uses a different combination of tools to facilitate fish passage at the Rocky Reach and Rock Island Projects because of each project's unique features. At Rocky Reach, passage is facilitated by the juvenile fish bypass (JFB), which is the primary method to increase juvenile dam passage survival. The efficiency of the JFB has allowed for a reduction in the amount and duration of spill at certain phases of the migration season, thereby reducing TDG levels. At Rock Island, spill is still the preferred method of moving fish past the project, with most of the spill being passed through the modified "notched" spill gates. Results of survival studies conducted at Rock Island have enabled Chelan PUD to reduce voluntary (fish) spill in the spring from 20% of the daily average flow to 10% of the daily average flow. Summer spill at Rock Island remains at 20% of the daily average flow.

The spill regimes implemented by Chelan PUD at each project are dictated by the timing of each species of fish migration. In the spring (generally mid-April to early- June), yearling Chinook, steelhead and

sockeye migrate past the projects, while subyearling Chinook migrate during the summer (generally mid-June to mid/late-August).

2.3.1 Fish Spill Quantities and Duration

Spill scenarios can be divided into two categories: fish spill (voluntary) and non-fish spill (involuntary). Non-fish/involuntary spill scenarios include, but are not limited to:

- Flow in excess of hydraulic capacity
- Plant load rejection spill
- Immediate replacement spill
- Maintenance spill
- Error in communication spill
- Spill past unloaded units

Definitions of these spills can be found in the 2011 Rocky Reach and Rock Island Gas Abatement Plans.

In 2011, spill events at Rocky Reach were involuntary April 1 - June 3 (spring), both voluntary and involuntary June 4 – end of July, and voluntary through August 12 (end of summer fish spill). Of the total volume of water spilled at Rocky Reach April 1 – June 3, 100% was involuntary. Between June 4 and August 12 (summer), 31.4% of the total volume spilled was voluntary, while 68.6% was involuntary. Spill events at Rock Island were voluntary April 17 – May 10, both voluntary and involuntary May 11 – mid-July, and voluntary July 12 – August 24 (end of summer fish spill). Of the total volume of water spilled at Rock Island April 1 – June 3, 48% was voluntary and 52% was involuntary. Between June 4 and August 24, 73.6% of the total volume of water spilled was voluntary, while 26.4% was involuntary at Rock Island. All involuntary spill was a result of high river flows.

Monthly average spills at Rocky Reach ranged from 1.97 to 99.94 thousand cubic feet per second (kcfs) (Table 1) and from 9.92 to 92.06 kcfs at Rock Island (Table 2). Minimum and maximum daily average spills at Rocky Reach varied from 0 to 139.6 kcfs and from 0 to 121.9 kcfs at Rock Island.

Table 1. Average monthly total flow, spill, and percent of total flow spilled for different purposes at Rocky Reach, April 1 - August 31, 2011.

				Spill Purpose					
				Fish Spill			Other		
	Average Flow Kcfs	Average Spill Kcfs	Misc Flow	Spill Kcfs	% of flow	% of Total Spill	Spill Kcfs	% of flow	% of Total Spill
April	144.99	1.97	0.43	0	0	0	1.97	1.40	100
May	207.32	32.03	0.43	0	0	0	32.03	15.50	100
June	269.8	99.94	0.43	21.37	7.9	21.4	78.57	29.1	78.60
July	209.23	50.95	0.43	18.4	8.8	36	32.56	15.6	64.00
August	141	5.91	0.43	4.9	3.5	83	1.01	0.70	17

Table 2. Average monthly total flow, spill, and percent of total flow spilled for different purposes at Rock Island, April 1 - August 31, 2011.

				Spill Purpose					
				Fish Spill			Other		
	Average Flow Kcfs	Average Spill Kcfs	Misc Flow	Spill Kcfs	% of flow	% of Total Spill	Spill Kcfs	% of flow	% of Total Spill
April	148.89	9.92	1.5	6.51	4.4	66	3.41	2.3	34
May	209.21	45.66	1.5	20.25	9.7	44	25.41	12.15	56
June	271.96	92.06	1.5	52.15	19.2	57	39.91	14.70	43
July	212.56	53.83	1.5	42.97	20.1	79	11.16	5.30	21
August	144.54	21.58	1.5	21.18	14.7	98	0.4	0.03	2

The following sections describe in detail the voluntary fish spill quantities and durations at Rocky Reach and Rock Island.

2.3.1.1 Rocky Reach

During the spring of 2011, Chelan PUD operated the juvenile fish bypass system exclusively with no voluntary spill for yearling Chinook, steelhead, and sockeye passage. However, high river flows required operation of the spillway during the late spring at Rocky Reach. Because these spill events were not required for fish passage, they are considered involuntary.

To meet RRHCP survival standards for subyearling (summer) Chinook, Chelan PUD had a target spill level of 9% of daily average river flow at Rocky Reach for a duration covering 95% of their outmigration during the summer of 2011. The summer spill program for subyearling Chinook began on June 4 and ended on August 12. Percent daily river flow spilled during the summer spill season amounted to 28.5%;

however, only 9% was spill for fish, while the remaining 19.5% was involuntary spill due to higher than average flows.

Table 3 below provides a summary of the Juvenile Fish Passage Operations at Rocky Reach in 2011.

Table 3. Summary of juvenile fish passage operations at Rocky Reach, April 1 - August 31, 2011.

Date	Juvenile Fish Passage Program	Quantity	Notes
1-Apr	Juvenile Fish Bypass (JFB) Operation Began		Operated exclusively with no fish spill during the spring (April 1 - June 3)
4-Jun	Summer Spill Initiated	9% of daily average river flow	Spill for sub-yearling (summer) Chinook
12-Aug	End of summer spill		
31-Aug	Juvenile Fish Bypass Operation Ended		

2.3.1.2 Rock Island

Spill through modified gates remains the primary fish passage measure used to meet RIHCP survival standards at Rock Island Project. Spring fish spill of 10% began on April 17 and was continued through June 3. Total spill during the spring fish spill season amounted to 20.77%; however, only 10% was spill for fish, while the remaining 10.77% was involuntary spill due to high river flows.

Rock Island fish spill increased to 20% upon onset of the summer outmigration of subyearling Chinook. Summer spill commenced on June 4 and continued through August 24. Total spill during the summer fish spill season amounted to 27.28%; however, only 20% was spill for fish, while the remaining 7.28% was involuntary spill due to high river flows.

Table 4 below provides a summary of the Juvenile Fish Passage Operations at Rock Island in 2011.

Table 4. Summary of juvenile fish passage operations at Rock Island, April 1 - August 31, 2011.

Date	Juvenile Fish Passage Program	Quantity
1-Apr	Fish Bypass Operation Began	
17-Apr	Spring Spill Initiated	10% daily average river flow
3-Jun	End of Spring Spill	
4-Jun	Start of Summer Spill	20% of daily average river flow
24-Aug	End of Summer Spill	
31-Aug	Fish Bypass Operation Ended	

3. IMPLEMENTATION RESULTS

3.1 Fisheries Management

3.1.1 Fish Bypass Efficiencies

A fish bypass efficiency (the proportion of downstream juvenile migrating fish using the bypass system) study was conducted for yearling Chinook salmon at Rocky Reach in 2010 (Steig et al. 2011) and 2011 as part of the project survival study with no spill at the dam. Bypass efficiency for yearling Chinook was estimated to be 53.57 % in 2010. Preliminary bypass efficiency results for the study conducted in 2011 are not yet available.

3.1.2 Survival Studies

Both the Rocky Reach and Rock Island HCPs include an overall combined project survival goal for adult and juvenile fish of 91%. Until 2011, upstream passage survival for adult fish could not be conclusively measured due to harvest losses and low numbers returning adult fish containing PIT tags. While this conditions still persists for adult steelhead and adult summer Chinook, the District was able for the first time in 2011 to measure conversion rates (passage survival) for adult spring Chinook salmon between Rock Island Dam and Wells Dam for years 2009-2011. This adult passage analysis showed survival of adult spring Chinook at the Rocky Reach project to be 99.90%, with just one PIT tagged fish lost between the dams in the three year period between 2009 and 2011. Together with a four-year average juvenile project survival of 92.37%, the combined passage survival for spring Chinook at the Rocky Reach Project was estimated at 92.28%, surpassing the HCP survival standard of 91%. In the event that combined adult and juvenile survival cannot be measured, the HCPs set even higher standards for achieving juvenile survival alone at each project– 93% juvenile project survival throughout the Project (i.e., 1,000 feet below the tailrace of the upstream dam to 1,000 feet below the tailrace of the project dam) or 95% juvenile dam passage survival (survival through the dam only). Sockeye and steelhead have both achieved the juvenile passage standard of 93%. Juvenile passage survival is a major component of the HCPs, but since the Projects are so distinct, different methods in the HCPs have been and will continue to be used at each dam to meet the survival goals set forth in the HCPs.

3.1.2.1 Rocky Reach

During the spring of 2011 Chelan PUD conducted project survival test using daytime and nighttime releases of tagged juvenile yearling Chinook. The purpose of the study was to estimate Project passage survival for both groups with no project spill. The standard powerhouse operation “Waterview” was in place, with no spill intended during the study. However, high river flows required mandatory spill during the last two weeks of the study.

Preliminary results from the 2011 survival study showed a Project passage survival of 92.94% for combined day and night yearling Chinook releases. Dam passage survival for yearling Chinook smolts arriving at Rocky Reach during day and night was estimated to be 96.55%

No studies were conducted in 2011 on steelhead or sockeye, as HCP survival standards have been achieved for both species at Rocky Reach. No more studies are required until 2021 when a survival verification study will be conducted to ensure project survival is being maintained. Additionally, due to tag technology limitations and uncertainties regarding their life history (outmigration behavior) no survival studies for summer/fall subyearling Chinook have been conducted since 2004.

3.1.2.2 Rock Island

No studies were conducted in 2011 on yearling (spring) Chinook, steelhead, or sockeye, as survival studies for these species are complete at Rock Island under the 10% spill operations, putting all three in HCP Phase III Standards Achieved Status. Additionally, due to tag technology limitations and uncertainties regarding their life history (outmigration behavior), no survival studies for subyearling Chinook have been conducted since 2004.

3.2 Biological Monitoring (GBT)

Gas bubble trauma (GBT) monitoring is not conducted on an annual basis at Rocky Reach Dam. However, as required by Section 5.4(1)(c) of the Rocky Reach 401 Water Quality Certification, Chelan PUD is developing a plan to study GBT below Rocky Reach Dam. Implementation of this study is not expected to occur before 2012.

As part of the Fish Passage Center's Smolt Monitoring Program at Rock Island, yearling and subyearling Chinook salmon and steelhead were examined for evidence of GBT between 21 April and 18 August 2011. Each week a random sample of up to 100 fish composed of both yearling Chinook salmon and steelhead were examined in April and May two days per week. In June, when the subyearling Chinook salmon collection exceeded the yearling Chinook collection, the sample was changed to subyearling Chinook. A random sample of up to 100 subyearling was examined two days per week. Examinations followed FPC standardized procedure as outlined by FPC (2004).

During 2011 monitoring, 3,300 smolts were examined for GBT. Of these, 279, or 8.45%, showed signs of GBT. Elevated signs and levels of GBT can be attributed to higher than normal flows throughout the

system causing involuntary spill and elevating the levels of TDG in the Columbia River from Grand Coulee Dam to Priest Rapids Dam. Table 5 provides the summary results of 2011 GBT monitoring.

Table 5. Summary of Gas Bubble Trauma examinations at Rock Island in 2011.

Species	Number of fish examined	Fish with GBT		Location with GBT			
				Fins		Eyes	
		N	%	N	%	N	%
Chinook yearling	927	18	1.94%	18	1.94%	1	0.11%
Steelhead	1022	230	22.50%	216	21.14%	22	2.15%
Chinook Sub-yearling	1351	31	2.29%	30	2.22%	1	0.07%
Total	3300	279	8.45%	264	8.00%	24	0.73%

3.3 Water Quality Forums

Chelan PUD has actively participated in regional water quality forums with Ecology, WDFW, NMFS, Tribal Agencies, the U.S. Fish and Wildlife Service, the USACE, and other Mid-Columbia PUDs. These meetings, ranging from Transboundary Gas Group to Columbia Basin meetings with USACE, allow for coordination for monitoring, measuring, and evaluating water quality in the Columbia Basin. Chelan PUD will continue its involvement in water quality meetings for further coordination with other regional water quality managers.

Because Chelan PUD staff was unable to attend the Corps's year-end TDG Monitoring and Quality Assurance/Quality Control (QA/QC) meeting, materials were requested and reviewed. Presentations from the various agencies conducting TDG (and other water quality) monitoring within the Columbia River Basin included topics on: monitoring locations, equipment used, data completeness, QA/QC and calibrations. Agencies presenting at this meeting included the USGS, Corps, other mid-Columbia River PUDs, and private consultants.

3.4 Physical Monitoring (TDG)

Chelan PUD conducted TDG monitoring at the four FMS discussed in Section 1.2 from April 1 through August 31, 2011. TDG levels from these four stations were obtained every fifteen minutes and the hourly averages of these readings were recorded in the head-quarters computer. The extensive nature of the hourly data makes presentation of the complete data set in this report impractical. Hourly data can be obtained upon request from Chelan PUD or can be accessed at the following internet site: http://www.nwd-wc.usace.army.mil/report/tdg.htm.

3.4.1 Data evaluation and analyses (QA/QC)

3.4.1.1 Data completeness

A comparison was made to determine what percentage of all possible data (hourly readings at all FMS) was collected throughout the monitoring season (Table 6). Prior to the start of fish spill season, software and hardware upgrades were completed at each FMS to help increase the FMS system reliability. Throughout the 2011 monitoring season (April 1 - August 31), nearly 100% of all possible data were collected at the Rocky Reach forebay and tailrace FMS. At the Rock Island forebay FMS, 98.04% of all possible data was collected, while at the Rock Island tailrace FMS, 97.28% of all possible data was collected (Table 8).

The causes of the data losses in the Rock Island forebay and tailrace have not yet been determined.

Table 6. Overview of total dissolved gas data set during 2011 fish spill season.

Location	Available data collection hours	Number of omitted/ lost hourly readings	Percent data completeness (%)
RRFB	3672	5	99.86
RRTR	3672	7	99.71
RIFB	3672	72	98.04
RITR	3672	100	97.28
Total	14,688	184	98.75

3.4.1.2 Calibration and Maintenance

Chelan PUD entered into a Professional Services Agreement with Columbia Basin Environmental to perform monthly calibrations and equipment maintenance. Quality Assurance/Quality Control measures were accomplished through training in instrument maintenance, operation, and factory prescribed calibration methods. A detailed log was maintained for all work done on the monitoring equipment, including monthly maintenance, calibration, exchange of instruments, and any other pertinent information. Redundant measurements with a mobile instrument to verify the accuracy of the in-situ instruments were conducted during the monthly calibrations. Calibration reports are included as Appendix E.

3.4.2 Fish Spill Season TDG Monitoring Results

Hourly TDG data from Rocky Reach and Rock Island projects was averaged and the daily averages are presented in Appendix D. The summary values (mean, min, max) for all hourly TDG measurements taken from each FMS during the 2011 fish spill season are presented in Table 7 below.

Table 7. Average TDG levels (based on the 12-highest consecutive hours) in forebay and tailrace of Rocky Reach and Rock Island and forebay of Wanapum, April 1 – August 31, 2011.

Location	Mean	Minimum	Maximum
Rocky Reach Forebay	117.3	105.9	134.6
Rocky Reach Tailrace	116.7	105.1	135.3
Rock Island Forebay	116.1	104.9	131.4
Rock Island Tailrace	118.8	106.1	134.5
Wanapum Forebay	116.4	105.4	132.0

Figures 7 and 8 show the volume of spill and average of the 12 highest consecutive hourly readings from each 24-hr period during the fish spill season from each fixed monitoring station.

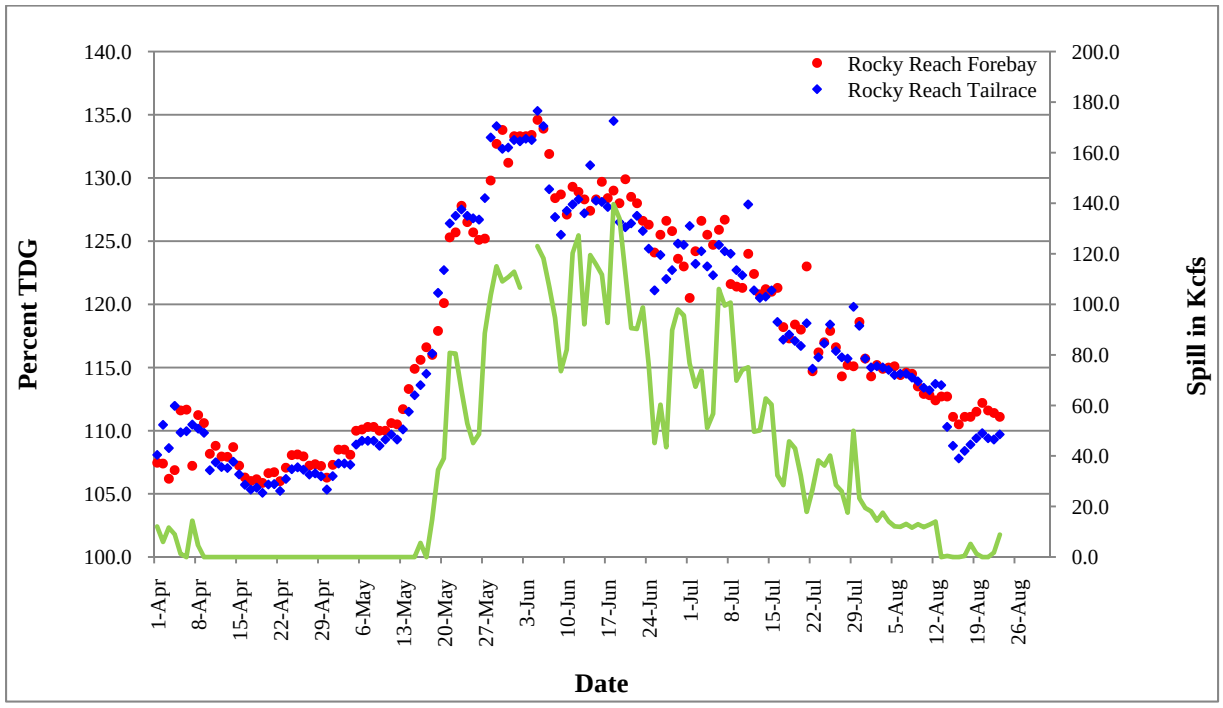

Figure 7. Spill volume and daily average TDG (based on the 12 highest consecutive hours) in the forebay and tailrace of Rocky Reach Dam during the 2011 fish spill season.

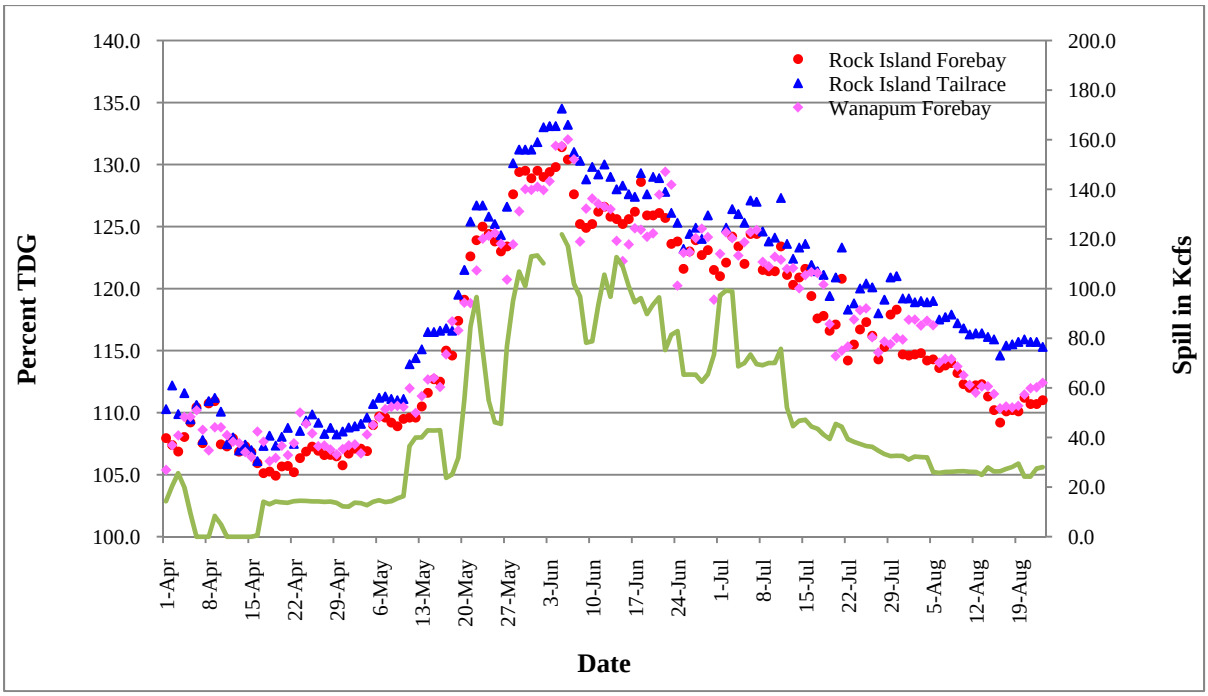

Figure 8. Spill volume and daily average TDG (based on the 12 highest consecutive hours) in the forebay and tailrace of Rock Island Dam and Wanapum forebay during the 2011 fish spill season.

Regression analysis was used to evaluate the relationship between the change in TDG levels from forebay to tailrace and the total volume spilled at both Rocky Reach and Rock Island projects. This analysis was not conducted for days of no spill (voluntary or involuntary). These results were examined to identify any correlation between project operations and spill related TDG fluctuations from the forebay to the tailrace.

3.4.2.1 Rocky Reach

The following TDG data represent the season as a whole, April 1 – August 31, regardless if there was spill (voluntary or involuntary) or not. The regression analysis includes only those days when spill occurred. ***Data presented in the following are based on the daily average of the 12 highest consecutive hours.***

From April 1 to August 31, 2011, TDG levels in the Rocky Reach forebay averaged 117.3% and ranged from 105.9% to 134.1%. TDG levels in the tailrace averaged 116.7% and ranged from 105.1% to 135.3%. The average (based on the 12 highest consecutive hours) change in percent TDG from the forebay to the tailrace was an increase of 0.6%, ranging from a decrease of 4.6% to an increase of 5.7%. A summary of this data can be found in Tables 7 and 8.

Regression analysis showed a weak relationship between the total volume spilled to percent change in TDG (r^2=.0041, Figure 9). This compares well to previous years, with the exception of 2007, when the relationship was strong. Total volume of spilled to change in percent TDG for the season as a whole (April 1 – August 31) is also represented in Figure 10 below.

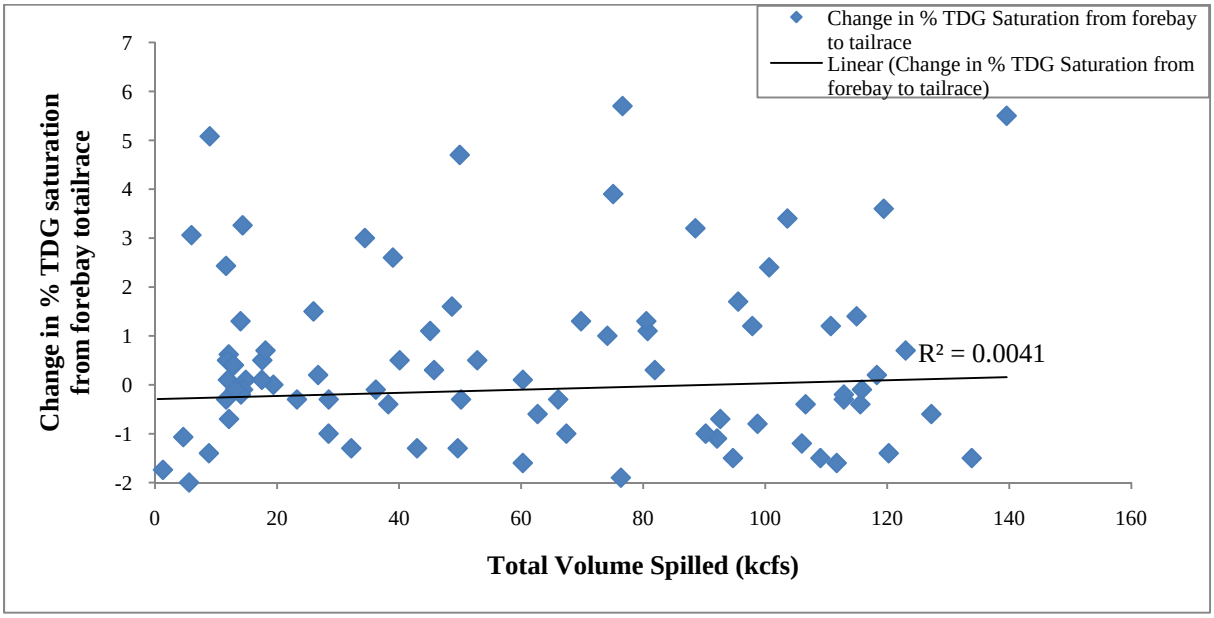

Figure 9. Total volume spilled to change in percent TDG saturation from forebay to tailrace at Rocky Reach Project, June 4 - August 12, 2011.

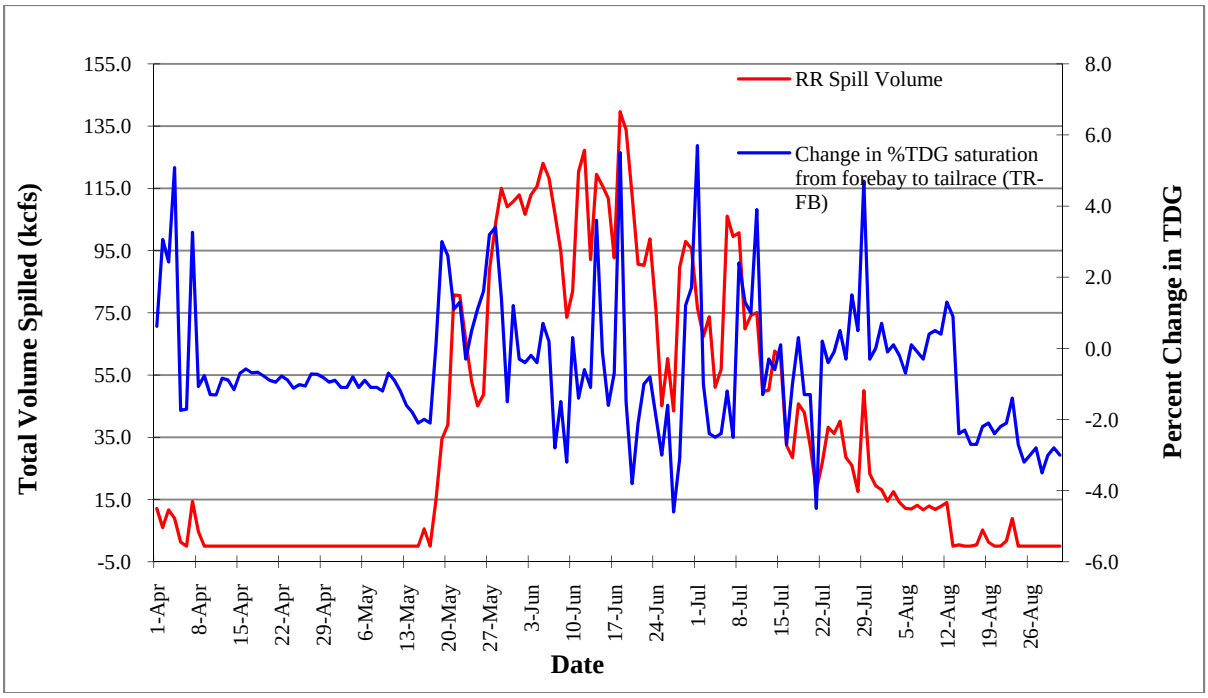

Figure 10. Total volume spilled to change in percent TDG saturation from forebay to tailrace at Rocky Reach Project, April 1 - Aug 31, 2011.

3.4.2.2 Rock Island

The following TDG data represent the season as a whole, April 1 – August 31, regardless if there was spill (voluntary or involuntary) or not. The regression analysis includes only those days when spill occurred. ***Data presented in the following are based on the daily average of the 12 highest consecutive hours.***

From April 1 to August 31, 2011, TDG levels in the Rock Island forebay averaged 116.1% and ranged from 104.9% to 131.4%. TDG levels in the tailrace averaged 118.8% and ranged from 106.1% to 134.58%. The average (based on the 12 highest consecutive hours) change in percent TDG from the forebay to the tailrace was an increase of 2.8%, ranging from no change to an increase 5.7%. A summary of this data can be found in Tables 7 and 8.

Regression analysis showed a weak relationship between the total volume spilled to percent change in TDG (r^2=.0121, Figure 11). This compares well to previous years, with the exception of 2007 when the relationship was strong. Total volume of spilled to change in percent TDG for the season as a whole (April 1 – August 31) is also represented in Figure 12 below.

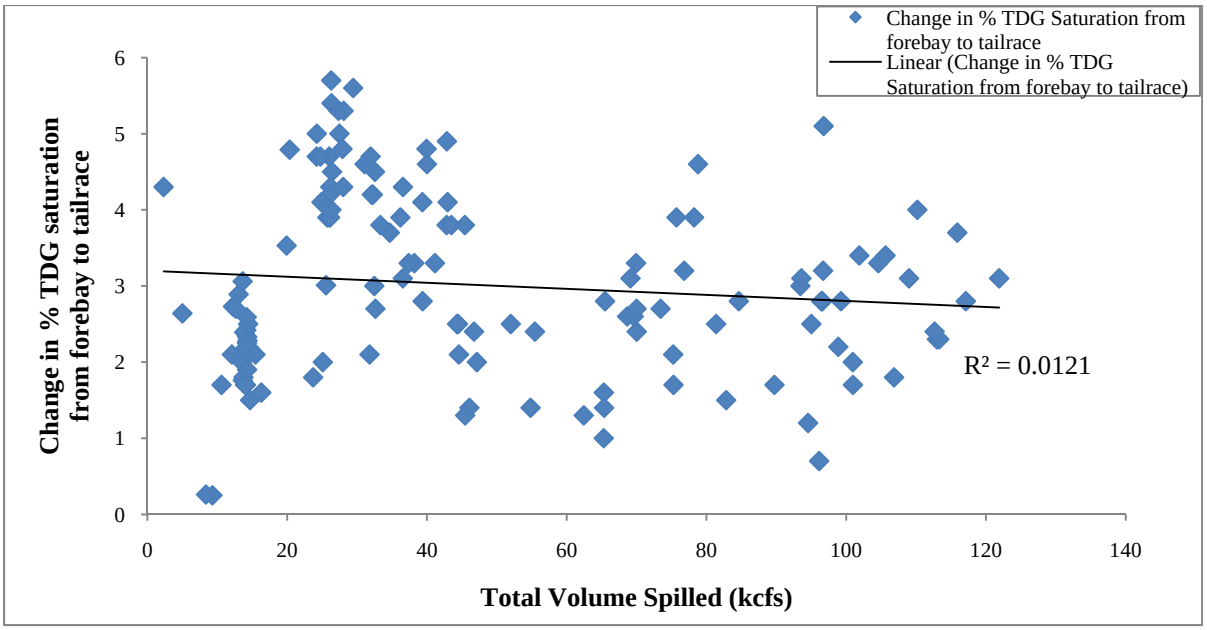

Figure 11. Total volume spilled to percent change in TDG from forebay to tailrace at Rock Island Project, April 17 - August 24, 2011.

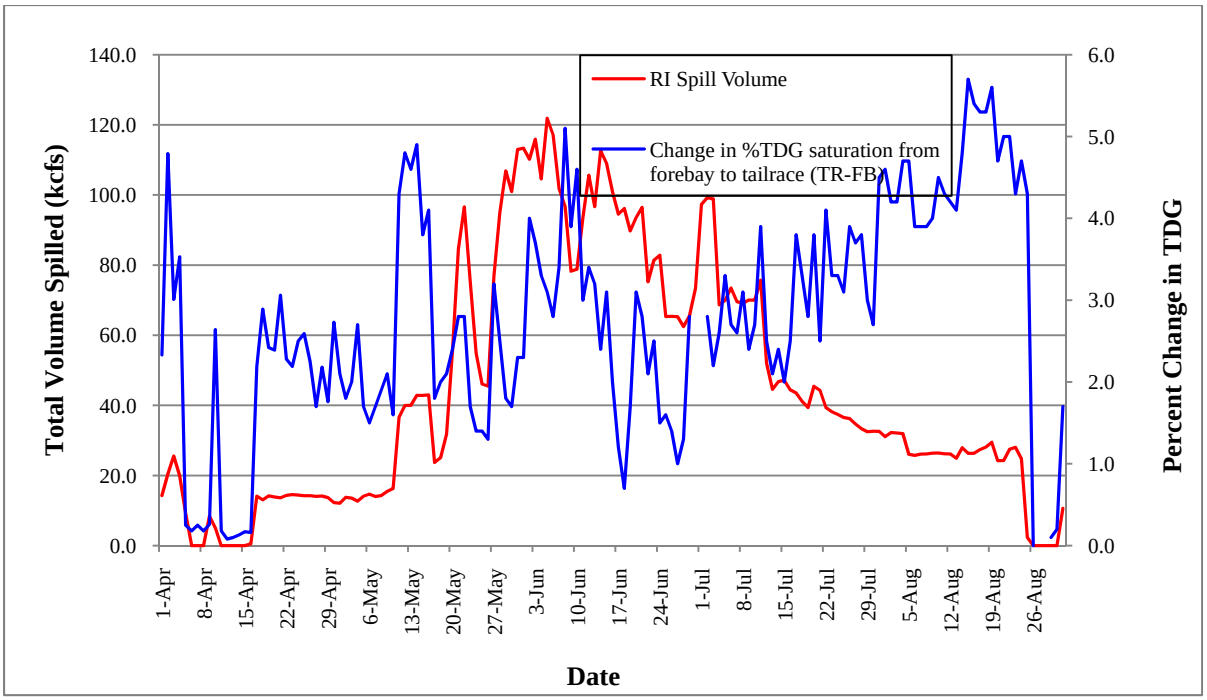

Figure 12. Total volume spilled to percent change in TDG from forebay to tailrace at Rock Island Project, April 1 - Aug 31, 2011.

Table 8 below provides a summary of total flow spilled, percent river flow spilled, and change in TDG from forebay to tailrace at Rocky Reach and Rock Island dams during the 2011 spill season.

Table 8. Rocky Reach and Rock Island projects: Average of total volume spilled (voluntary and involuntary), percent total river flow spilled, and change in percent TDG from forebay to tailrace, April 1 – August 31, 2011.

	Rocky Reach			**Rock Island**		
	Average Volume Spilled (Kcfs)	Percent Total River Flow Spilled	Change in Percent TDG	Average Volume Spilled (Kcfs)	Percent Total River Flow Spilled	Change in Percent TDG
April	1.97	1.15	0.3	9.94	6.84	1.7
May	32.10	11.60	-0.1	45.70	19.60	2.5
June	100.00	36.90	-0.8	92.10	33.70	2.7
July	50.90	23.30	-0.1	53.70	24.60	3.0
August	5.89	3.95	-1.4	21.57	14.43	4.0
Average*	38.00	15.30	-0.6	44.50	19.80	2.8
(Range)	(0-139.6)	(0-51.7)	(-4.6-5.7)	(0-121.9)	(0-39.2)	(0-5.7)

***Averages and ranges shown here are of all daily 12-highest consecutive hours, not averages or ranges of the monthly averages.**

3.4.2.3 Wanapum Forebay

From April 1 to August 31, 2011, TDG levels in the Wanapum forebay averaged 116.4% and ranged from 105.4% to 132.0%.

3.4.3 Discussion of Exceedances

At both Rocky Reach and Rock Island dams, there are three compliance criteria for the 2011 fish passage waiver that must be met in association with operation of the projects.: 1) average TDG in the tailrace cannot exceed 125% for one hour or 2) 120% for 12 continuous hours (12C-High), and 3) TDG in the next downstream forebay cannot exceed 115% 12C-High. These compliance criteria are waived when flows exceed the seven-day, 10-year frequency flood (7Q10) (252 kcfs at Rocky Reach and 264 kcfs at Rock Island) or when incoming water is exceeds 115% TDG 12C-High in the project's forebay.

Data analysis showed that water coming into the Rocky Reach forebay from upstream exceeded Washington State water quality criteria on 73 days (47.7% of the total number of days observed). TDG exceeded the modified Washington State TDG fish spill water quality criteria on 58 days (37.9% of the total number of days observed) in the Rocky Reach tailrace, 70 days (46.3% of the total number of days observed) in the Rock Island forebay, and 62 days (41.6% of the total numbers of days observed) in the Rock Island tailrace during this monitoring period. Numeric criteria were exceeded on 76 days (49.7% of

the total number of days observed) (using the revised method that eliminates the double-counting issue) in the Wanapum forebay (Grant County PUD). These exceedances of the water quality criteria did not necessarily result in noncompliance, as many occurred during river flows that exceeded 7Q10 or when forebay TDG levels were above the numeric criteria.

When the average of the 12 highest consecutive hourly discharge values in a 24-hour period exceeded the 7Q10 for the project or when the upstream forebay TDG exceeded 115%, TDG values for that 24-hour period were omitted from the data set used for determination of compliance. In addition, when the hourly flow value at the relevant dam was greater than the 7Q10 flow or when the hourly forebay TDG exceeded 115%, the hourly TDG value for that hour was omitted from the data set used for determination of compliance.

Noncompliance at each FMS is further detailed in the following sections and Table 9 below.

3.4.3.1 Rocky Reach

Tailrace 125% Standard

Total hours of TDG data collected during the 2011 fish spill season in the Rocky Reach tailrace equaled 3,665. Of these 3,665 hours; however, 1,679 hours were omitted from the data set due to flows in exceedance of the 7Q10 flow or hourly forebay levels exceeding 115%. Of the remaining 1,986 hours when flows were below the 7Q10 flow and hourly forebay TDG <115%, hourly tailrace TDG levels exceeded 125% **for 0 hours**.

Compliance with this standard was 100%.

Tailrace 120% Standard

TDG data was collected on 153 days during the 2011 fish spill season in the Rocky Reach tailrace. However, of those 153 days 73 were omitted from the data set used for determination of compliance due to flows exceeding the 7Q10 flows or upstream forebay 12C-High TDG exceeding 115% .Of the remaining 80 days when flows were below the 7Q10 flow and the upstream forebay 12C-High TDG was below 115%, the tailrace 12C-High TDG exceeded 120% on **0 days**.

Compliance with this standard was 100%.

Downstream (Rock Island) Forebay 115% Standard

TDG data was collected on 153 days during the 2011 fish spill season in the Rock Island forebay. However, of those 153 days 73 were omitted from the data set used for determination of compliance due to flows exceeding the 7Q10 flows or upstream forebay 12C-High TDG exceeding 115% . Of the remaining 80 days when flows were below the 7Q10 flow and the upstream forebay 12C-High TDG was below 115%, the Rock Island forebay 12C-High TDG exceeded 115% on **one day**, July 29.

Compliance with this standard was 98.8%

At Rocky Reach average compliance for all three TDG standards was 99.6% during the 2011 fish passage season. This is exceptionally high compliance, given the significantly higher than average flows and incoming TDG levels experienced at the project.

3.4.3.2 Rock Island

Tailrace 125% Standard

Total hours of TDG data collected during the 2011 fish spill season in the Rock Island tailrace equaled 3,572. Of these 3,572 hours; however, 1,577 hours were omitted from the data set due to flows in exceedance of the 7Q10 flow or hourly forebay TDG levels exceeding 115%. Of the remaining 1,996 hours when flows were below the 7Q10 flow and hourly forebay TDG <115%, hourly tailrace TDG levels exceeded 125% for **0 hours.**

Compliance with this standard was 100%.

Tailrace 120% Standard

TDG data was collected on 153 days during the 2011 fish spill season in the Rock Island tailrace. However, of those 153 days 70 were omitted from the data set used for determination of compliance due to flows exceeding the 7Q10 flows or upstream forebay 12C-High TDG exceeding 115% .Of the remaining 83 days when flows were below the 7Q10 flow and the upstream forebay 12C-High TDG was below 115%, the tailrace 12C-High TDG exceeded 120% **on 0 days**.

Compliance with this standard was 100%.

Downstream (Wanapum) Forebay 115% Standard

TDG data was collected on 153 days during the 2011 fish spill season in the Wanapum forebay. However, of those 153 days 70 were omitted from the data set used for determination of compliance due to flows exceeding the 7Q10 flows or upstream forebay 12C-High TDG exceeding 115% .Of the remaining 83 days when flows were below the 7Q10 flow and the upstream forebay 12C-High TDG was below 115%, the Wanapum forebay 12C-High TDG exceeded 115% on 8 days.

Compliance with this standard was 90%.

At Rock Island average compliance for all three TDG standards was 96.7% during the 2011 fish passage season. Like Rocky Reach, this is exceptionally high compliance, given the significantly higher than average flows and incoming TDG levels experienced at the project.

Table 9. Number of 2011 fish spill season TDG noncompliance* exceedances, Rocky Reach tailrace, Rock Island forebay and tailrace, and Wanapum forebay.

Location	Number of Exceedances (based on 12C-High Criteria)**	Total # of Days Sampled	% Days > Standard	Number of 1-hr Maximum (>125%)	Total # of Hours Sampled	% Hours >125% standard
RRTR	0	80	0	0	1986	0
RIFB	1	80	1.2			
RITR	0	83	0	0	1995	0
WANFB	8	83	10			
Total	9	326	2.8		3981	0

*A noncompliance exceedance is one that occurred while flows were below 7Q10 and the forebay was <115%

**>115% in forebay (FB) and >120% in tailrace (TR)

3.4.4 Non-Fish Spill TDG Monitoring Results

As per WAC 173-201A-200(1)(f), total dissolved gas shall not exceed 110 percent of saturation at any point of sample collection (during the non-fish spill season).

Chelan PUD has chosen to leave the monitoring equipment in place during the non-fish spill season so as to be able to monitor TDG levels year round; however, this was not implemented until September 2011.

Except for three hours on September 1 in the Rock Island tailrace when TDG was 112%, hourly TDG levels at all sites (Rocky Reach tailrace, Rock Island forebay, Rock Island tailrace, and Wanapum forebay) were below 110%, for a resulting overall compliance from September 1 to December 31 of 99.97%. Chelan PUD has no measured TDG data for non-fish spill seasons prior to this time

3.4.5 Corrective Actions

Actions taken to maintain/regain compliance with the TDG standards included:

- Implementation of the TDG Operational Plan.
- Chelan PUD adjusted spill, as possible, at both projects; and adjusted gate configurations at Rock Island to reduce TDG, when possible. These actions were consistent with the Operational Plans for TDG.
- Chelan PUD executed a TDG Emergency Operations Agreement between Chelan PUD, Pacificorp, and ALCOA to further mitigate TDG at Rocky Reach. This agreement allowed Chelan to set a higher minimum generation limit for the project which reduced the need for spill. Central saw the execution of this Agreement as being helpful in allocating the generation and spill among the Mid-C projects to reduce TDG. The requirement to sustain high levels of generation contributed to negative energy prices due to over generation which resulted in monetary losses to the Mid-C PUD's and power purchasers.
- Attempted to maximize turbine flows by setting minimum generation requirements, which included establishing a common methodology for setting minimum generation requirements specific to Rocky Reach and Rock Island dams 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 2011, 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.
- Participation in regional spill/project operation meetings. As the high flow conditions became apparent, the non-federal Mid-Columbia project operators organized two separate meetings (February 17, 2011, and March 17, 2011). The purpose of these meetings was to discuss alternative actions to mitigate the expected high TDG values that were anticipated to accompany the high flow conditions. These meetings 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 US Army Corps of Engineers (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.
- 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 Priest Rapids or Wanapum dam 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.

- Utilizing Rock Island's unique water passage capabilities. Several of the units at the Rock Island project can pass flow through the turbines without producing power (sluicing)*. Water exiting the turbines is discharged below the tailwater surface thus, not contributing to the production of TDG. In addition two of the project's spill gates also discharge below the tailwater surface. Water passed by either of these methods is classified as spilled energy. In certain conditions, these capabilities offer a better alternative than traditional spill placement for the management of system TDG. Prior to using this spill alternative, energy accounting system calculations needed to be changed to properly allocate energy spilled at Rock Island to those of the Mid-C collective that were responsible for spilling the energy. On 1/27/2011, the energy accounting system was changed to recognize unloaded turbine spill at Rock Island in the same manner as the other four non-federal projects.

  *It needs to be noted that although the "sluicing" operation at Rock Island was successful at mitigating TDG to some extent, it is not known at this time if it will possible to implement this operation in the future due to wear and tear on equipment.

- Preemptive spill can be used to coordinate spill sought to manage both the spill rate and the forebay elevation for better TDG management. 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 could be 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. TOTAL DISSOLVED GAS ABATEMENT MEASURES IMPLEMENTED IN 2011

4.1 Operational

Due to the success of the juvenile fish bypass system at Rocky Reach and survival studies at both projects, Chelan PUD has been able to reduce spill at both Rocky Reach and Rock Island for at least a portion of the spill season, thereby reducing the generation of total dissolved gas in the project waters.

4.1.1 Rocky Reach

Results of survival studies have allowed Chelan PUD to greatly reduce spill for fish at Rocky Reach Dam. The JFB is now operated exclusively, ***with no spill***, for spring migrants; and spill during the

summer migration has been reduced to 9% of the daily average flow. Spill levels from 2003 to 2011 are shown in Table 10 below. The JBS continues to be the most efficient non-turbine route for fish passage at the Rocky Reach Project and does not require spill for its operation.

The goal of the Rocky Reach Total Dissolved Gas Abatement Plan (GAP) approved by Ecology in April of 2011 is to implement measures to achieve compliance with the Washington state water quality standards for TDG in the Columbia River at the Project while continuing to meet the fish passage and survival standards set forth in the Rocky Reach HCP and Fish Management Plan. To meet this goal, Chelan PUD implemented the following operational measures:

1. Minimized voluntary spill – no fish (voluntary) spill planned for the spring migration, 9% of the daily average river flow for the summer migration
2. During fish passage, managed voluntary spill levels in real time in an effort to continue meeting TDG numeric criteria, using the TDG Operational Plan (Appendix B).
3. Minimized spill, to the extent practicable, by scheduling maintenance based on predicted flows.
4. Avoided spill, to the extent practicable, by continuing to participate in the Hourly Coordination Agreement, to the extent it reduces TDG.
5. Maximized powerhouse discharge as appropriate up to 212 kcfs.

Table 10. Rocky Reach fish spill comparison, 2003-2011.

Year	Season	Spill Start Date	Spill Stop Date	Days of Spill	*Spill Level
2003	Spring	20-Apr	29-May	40	15% / 25%
2003	Summer	30-May	14-Aug	77	15%
Total				**117**	
2004	Spring	6-May	6-Jun	31.5	0% / 24%
2004	Summer	7-Jun	21-Aug	70	9%
Total				**101.5**	
2005	Spring	10-May	9-Jun	18.5	0% / 24% **
2005	Summer	10-Jun	15-Aug	67	9%
Total				**85.5**	
2006	Spring	2-May	1-Jun	19.0	0% / 24% **
2006	Summer	2-Jun	11-Aug	71	9%
Total				**90**	
2007	Spring	No Spill	No Spill	0	0%
2007	Summer	2-Jun	21-Aug	81	9%
Total				**81**	
2008	Spring	No Spill	No-Spill	0	0%
2008	Summer	8-Jun	31-Aug	81	9%
Total				**81**	
2009	Spring	No Spill	No Spill	**0**	0%
2009	Summer	10-Jun	31-Aug	78	9%
Total				**78**	
2010	Spring	No Spill	No Spill	**0**	0%
2010	Summer	9-Jun	20-Aug	**73**	9%
Total				**73**	
2011	Spring	No Spill	No Spill	**0**	0%
2011	Summer	4-Jun	12-Aug	**70**	9%
Total					

* Percentage of daily average river flow at Rocky Reach. Two values in this column represents two different spill levels during the season (first value is the spill level for yearling Chinook and steelhead, second value is the spill level for sockeye.)
** 24 days of on/off spill test for sockeye

4.1.2 Rock Island

After meeting the HCP juvenile survival standards for all spring migrating species under a 20% spring spill regime in 2006, Chelan PUD has implemented a spill reduction study resulting in spring (voluntary) fish spill being reduced to 10% of the daily average river flow. Spill levels from 2003 to 2011 are shown in Table 11 below.

Table 11. Rock Island fish spill comparison, 2003-2011.

Year	Season	Spill Start Date	Spill Stop Date	Days of Spill	*Spill Level
2003	Spring	17-Apr	31-May	45	20%
2003	Summer	1-Jun	16-Aug	77	20%
Total				**122**	
2004	Spring	17-Apr	8-Jun	53	20%
2004	Summer	9-Jun	4-Aug	57	20%
Total				**110**	
2005	Spring	17-Apr	9-Jun	54	20%
2005	Summer	10-Jun	9-Aug	61	20%
Total				**115**	
2006	Spring	17-Apr	13-Jun	58	20%
2006	Summer	14-Jun	11-Aug	59	20%
Total				**117**	
2007	Spring	17-Apr	1-Jun	46	10%
2007	Summer	2-Jun	21-Aug	81	20%
Total				**127**	
2008	Spring	17-Apr	7-Jun	52	10%
2008	Summer	8-Jun	16-Aug	70	20%
Total				**122**	
2009	Spring	17-Apr	9-Jun	54	10%
2009	Summer	10-Jun	17-Aug	69	20%
Total				**123**	
2010	Spring	17-Apr	8-Jun	53	10%
2010	Summer	9-Jun	20-Aug	73	20%
Total				**126**	
2011	Spring	17-Apr	3-Jun	48	10%
2011	Summer	4-Jun	24-Aug	82	20%
Total				**130**	

* Percentage of daily average river flow at Rock Island

The goal of the Rock Island Total Dissolved Gas Abatement Plan (GAP) approved by Ecology in April of 2011 is to implement measures to achieve compliance with the Washington state water quality standards for TDG in the Columbia River at the Project while continuing to meet the fish passage and survival standards set forth in the Rock Island HCP and Fish Management Plan. To meet this goal, Chelan PUD implemented the following operational measures:

1. Minimized voluntary spill – due to the success thus far of the HCP survival studies, Chelan PUD has been able to reduce spring fish (voluntary) spill from 20% to 10% of the daily average river flow.
2. During fish passage, managed voluntary spill levels in real time in an effort to continue meeting TDG numeric criteria, using the TDG Operational Plan (Appendix B).
3. Minimized spill, to the extent practicable, by scheduling maintenance based on predicted flows.
4. Avoided spill, to the extent practicable, by continuing to participate in the Hourly Coordination Agreement, to the extent it reduces TDG.

4.2 Structural

No structural modifications were made or utilized at Rocky Reach Dam in 2011.

At Rock Island Dam, Chelan PUD utilized the notched gates, the spill deflector, and the Over/Under spill gates during 2011 fish spill operations. Before additional Over/Under gates are constructed, or other structural changes are made, Chelan PUD will operate under the existing structural configuration over the course of the next several years (to include the remainder of Phase I survival testing) to determine the impact on TDG abatement resulting from the three existing Over/Under gates.

5. CONCLUSIONS

In 2011 large volumes of spill at upstream projects (including Grand Coulee) resulted in a high frequency of flows with TDG levels out-of-compliance (>115%) entering the Rocky Reach and Rock Island projects. Additionally, there were numerous days when flows at both projects exceeded the 7Q10 flood flow (252 kcfs at Rocky Reach and 262 kcfs at Rock Island). During the 2011 fish spill season, 95% of all TDG exceedances occurred when either flow volumes were greater than the 7Q10 flows or incoming TDG levels exceeded standards. The flows exceeding 7Q10 values resulted in increased involuntary spill at both projects, as well as the rest of the Mid-C. Chelan PUD undertook all reasonable and feasible abatement measures to moderate high TDG levels (see Section 3.4.4), including attempting to maximize powerhouse flows and reduce involuntary spill by selling power at reduces costs, participating in regional efforts to reduce TDG at each mid-Columbia River dam, and closely monitoring TDG and incoming flows.

Chelan PUD will continue to closely monitor TDG levels during the fish spill season in accordance with Ecology approved GAPs, the Rocky Reach 401 Water Quality Certification, and the Rocky Reach QAPP.

LITERATURE CITED

Pickett, P., H. Rueda, and M. Herold. *Total Maximum Daily Load for Total Dissolved Gas in the Mid-Columbia River and Lake Roosevelt.* Washington State Department of Ecology, Olympia,WA, and U.S. Environmental Protection Agency, Portland, OR. June 2004.

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Steig, T.W., K.K. Kumagai, B.J. Rowdon, c.P. Mott and C. Tunnicliffe. 2011. Route Specific passage and juvenile Chinook and steelhead salmon using acoustic tag methodologies at Rocky Reach and Rock Island Dams in 2010. Final report for Chelan County Public Utility District No. 1, Wenatchee, WA., by Hydroacoustic Technology, Inc, Seattle WA.

APPENDIX A

TDG Operational Plans
Rocky Reach and Rock Island

2011 Rocky Reach Operational Plan

for Total Dissolved Gas During Fish Spill Season

April 1 – August 31

(All spill between these dates is subject to the actions contained in this plan.)
(Applies only when not spilling for headwater control)

Protocol

1. If tailrace TDG average is greater than ***120% for the 6-hour average***
   - reduce spill by 3 kcfs
   - monitor for 1 hour
   - if the 6-hr average TDG >120%, reduce spill by another 2 kcfs
   - monitor for 1 hour
   - continue reducing spill by 2 kcfs until 6-hr average TDG is less than 120% for one full hour
   - **if after reducing spill to control TDG levels, TDG drops below 118% for one full hour, increase spill by 2 kcfs and monitor ****

2. If tailrace TDG is greater than ***125% for 1 hr***
   - follow protocol outlined above, but instead, use **one-hour TDG levels of 125%** as the metric
   - continue until TDG is less than 125% for 1 hr and until the 6-hr average TDG <120%

If you receive a call from RI advising that the RI forebay is out of compliance (greater than 115%) and the RR forebay is 115% or less, reduce spill by 3 kcfs. Two hours after reducing spill, call RI to determine what the RI forebay gas levels are. If still above 115%, reduce spill another 2 kcfs. If after reducing spill for this reason, the Rock Island forebay drops to less than 113%, Rock Island will call again and advise. At this point, increase back to the hourly spill volume target by increasing spill in the reverse order it was decreased. For example, if to bring the RI forebay back into compliance, it was necessary to reduce spill by a total of 5 kcfs, begin by increasing spill by 2 kcfs, wait two hours, and call RI to determine what the forebay TDG levels are. If TDG is still below 115%, increase spill by 3 kcfs (back to the target volume in this case). This will allow for a ramping effect, rather than an open/shut effect which could bump the Rock Island forebay TDG levels back out of compliance (>115%).

**** Note**: It will not be necessary to monitor for one full hour after increasing spill if it appears that TDG is approaching the upper threshold, rather, the procedure will repeat upon reaching the threshold. It is anticipated that in time, the operators will "get a feel" for how much change in TDG will occur as a result of opening or closing gates and it will be possible to hold the TDG around 118% or 119% or so. Once the operators have this down, instead of closing a gate entirely, it may only be necessary to close partially, and visa versa for the opening process.

2011 Rock Island Operational Plan

for Total Dissolved Gas During Fish Spill Season

(Applies only when not spilling for headwater control)

Protocol

1. If tailrace TDG average is greater than ***120% for the 6-hour average***
   - monitor for 2 hours, re-check 6-hour average
   - if TDG >120% for 6-hr average, shift spill from gate 17 to 27
   - monitor for 2 hours, re-check 6-hour average
   - if TDG >120% for 6-hr average, open gate 17 and close 2 notched gates (closure order is listed below)
   - monitor for 2 hrs; re-check 6-hour average
   - if TDG >120% for 6-hr average, close two more notched gates
   - **if after closing gates to control TDG levels, the TDG 1-hr average drops below 118%, re-open notched gates in the reverse order of closure****

2. If tailrace TDG is greater than ***125% for 1 hr***
   - follow protocol outlined above, but instead, use **one-hour TDG levels of 125%** as the metric
   - continue until TDG is less than 125% for 1 hr and until the 6-hr average TDG <120%

3. If forebay TDG exceeds 115% for greater than one hour, call Rocky Reach and advise that the RI forebay is out of compliance. Rocky Reach will then reduce spill, but only if the RR forebay TDG is 115% or less. Once RI forebay TDG levels reduce to 113% call RR again so that they may return to previous spill operations.

4. Order of notched gate closure: **29, 24, 18, 16**

5. If it becomes necessary to implement any further actions to attain TDG compliance, please contact Steve Hemstrom and Waikele Hampton immediately so they can determine the next steps to take.

**** Note**: It will not be necessary to monitor for one full hour after re-opening if it appears that TDG is approaching the upper threshold again, rather, the procedure will repeat upon reaching the threshold. It is anticipated that in time, the operators will "get a feel" for how much change in TDG will occur as a result of opening or closing gates and it will be possible to hold the TDG around 118% or 119% or so. Once the operators have this down, instead of closing a gate entirely, it may only be necessary to close partially, and visa versa for the opening process.

APPENDIX B

2011
Total Dissolved Gas Abatement Plan
Rocky Reach Hydroelectric Project

http://www.chelanpud.org/departments/licensingCompliance/rr_implementation/ResourceDocuments/36518.pdf

APPENDIX C

2011
Total Dissolved Gas Abatement Plan
Rock Island Hydroelectric Project

http://filenet.domain1.chelan/Workplace/getContent?objectStoreName=library_1&vsId=%7B5A0C6928-CC1B-422A-A015-CC4D76B5D595%7D&objectType=document&id=%7BE0F93EB7-C55F-4EA3-BD0F-579068A6D5CA%7D

APPENDIX D

**Dissolved Gas Levels at Rocky Reach,
Rock Island, and Wanapum Projects, 2011**

April 2011. Numbers in bold exceed the water quality criteria.

All TDG values are rounded to the nearest whole number, as specified in the April 2, 2008 memo from Chris Maynard.

Red highlight indicates a TDG level above the water quality criteria (115/120) that occurred when flows were below the 7Q10 flows (does not take into account incoming TDG level in upstream forebay).

	Rocky Reach Forebay			Rocky Reach Tailrace			Rock Island Forebay			Rock Island Tailrace			Wan FB	Average Daily Spill		Total Flow		% Flow Spilled		Reason for Spill (in % of total spill) Rocky Reach		Rock Island	
2011	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	RR	RI	RR	RI	RR	RI	Fish	Other	Fish	Other
1-Apr	107	106	108	108	108	111	108	106	109	110	108	114	105	12.1	14.3	140.7	149.5	7.6	9.3	0	10	0	100
2-Apr	107	107	108	110	109	113	107	107	108	112	110	113	107	6.0	20.4	147.2	155.7	4.0	13.5	0	100	0	100
3-Apr	106	105	105	109	107	114	107	104	106	110	108	111	108	11.6	25.6	150.1	155.4	6.5	15.9	0	100	0	100
4-Apr	107	106	107	112	110	114	108	107	109	112	110	113	110	9.0	19.9	153.6	164.4	5.1	11.9	0	100	0	100
5-Apr	112	110	112	110	109	111	109	107	111	109	109	111	110	1.3	9.3	146.1	150.5	0.8	6.5	0	100	0	100
6-Apr	112	108	111	110	108	110	110	109	111	111	109	111	110	0.0	0.0	147.8	153.5	0.0	0.0	0	0	0	0
7-Apr	107	106	107	110	109	116	108	106	110	108	107	110	109	14.4	0.0	155.4	155.9	8.3	0.0	0	100	0	0
8-Apr	111	110	112	110	110	112	111	109	112	111	109	112	107	4.6	0.0	162.7	170.1	2.3	0.0	0	100	0	0
9-Apr	111	108	110	110	108	109	111	108	110	111	109	112	109	0.0	8.4	165.8	165.3	0.0	5.3	0	0	0	100
10-Apr	108	107	109	107	106	107	107	105	107	110	106	111	109	0.0	5.0	158.0	161.2	0.0	3.9	0	0	0	100
11-Apr	109	107	109	108	107	108	107	107	107	107	107	108	108	0.0	0.0	152.5	157.9	0.0	0.0	0	0	0	0
12-Apr	108	108	108	107	107	107	108	107	108	108	107	109	108	0.0	0.0	154.7	157.6	0.0	0.0	0	0	0	0
13-Apr	108	108	109	107	107	108	107	107	108	107	107	108	108	0.0	0.0	153.9	162.3	0.0	0.0	0	0	0	0
14-Apr	109	109	109	108	107	108	107	107	109	107	108	109	107	0.0	0.0	143.0	151.6	0.0	0.0	0	0	0	0
15-Apr	107	107	107	107	106	107	107	106	108	107	107	108	106	0.0	0.0	142.7	148.4	0.0	0.0	0	0	0	0
16-Apr	106	106	107	106	106	106	106	106	106	106	106	106	108	0.0	0.5	130.8	138.6	0.0	0.3	0	0	100	0
17-Apr	106	106	106	105	105	106	105	105	105	107	108	110	108	0.0	14.1	128.8	135.4	0.0	10.6	0	0	100	0
18-Apr	106	106	106	105	105	105	105	105	105	108	107	109	106	0.0	13.1	130.2	138.1	0.0	9.5	0	0	100	0
19-Apr	106	105	106	105	105	105	105	105	105	107	107	108	106	0.0	14.2	139.2	144.4	0.0	9.9	0	0	100	0
20-Apr	107	106	107	106	105	106	106	105	106	108	107	109	107	0.0	13.9	140.8	150.0	0.0	9.3	0	0	100	0
21-Apr	107	106	107	106	105	106	106	105	106	109	107	110	107	0.0	13.6	137.0	139.8	0.0	10.0	0	0	100	0
22-Apr	106	105	106	105	105	105	105	105	105	107	107	108	108	0.0	14.3	141.6	149.1	0.0	9.8	0	0	100	0
23-Apr	107	106	107	106	106	106	106	106	107	109	108	110	110	0.0	14.5	144.6	152.2	0.0	9.6	0	0	100	0
24-Apr	108	108	108	107	106	107	107	106	107	109	109	110	109	0.0	14.4	133.1	141.0	0.0	10.4	0	0	100	0
25-Apr	108	108	108	107	107	107	107	107	107	110	109	110	108	0.0	14.2	133.3	139.5	0.0	10.4	0	0	100	0
26-Apr	108	107	108	107	106	107	107	106	107	109	108	109	107	0.0	14.3	140.6	144.9	0.0	9.9	0	0	100	0
27-Apr	107	107	108	107	106	107	107	106	107	108	108	109	107	0.0	14.1	134.7	143.1	0.0	10.0	0	0	100	0
28-Apr	107	107	107	107	106	107	107	106	107	109	108	109	107	0.0	14.1	132.1	138.3	0.0	10.5	0	0	100	0
29-Apr	107	106	107	106	106	106	106	105	106	108	107	108	107	0.0	13.7	138.6	143.0	0.0	9.7	0	0	100	0
30-Apr	106	106	107	105	105	106	106	105	106	108	107	109	107	0.0	12.3	131.9	140.6	0.0	8.9	0	0	100	0

May 2011. Numbers in bold exceed the water quality criteria.

All TDG values are rounded to the nearest whole number, as specified in the April 2, 2008 memo from Chris Maynard.

Red highlight indicates a TDG level above the water quality criteria (115/120) that occurred when flows were below the 7Q10 flows (does not take into account incoming TDG level in upstream forebay).

	Rocky Reach Forebay			Rocky Reach Tailrace			Rock Island Forebay			Rock Island Tailrace			Wan FB	Average Daily Spill		Total Flow		% Flow Spilled		Reason for Spill (in % of total spill) Rocky Reach		Rock Island	
2011	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	RR	RI	RR	RI	RR	RI	Fish	Other	Fish	Other
1-May	107	107	108	106	106	107	107	106	107	109	108	109	107	0.0	12.1	143.4	151.1	0.0	8.0	0	0	100	0
2-May	109	108	109	107	107	108	107	107	107	109	109	109	107	0.0	13.8	142.1	148.1	0.0	9.4	0	0	100	0
3-May	109	108	108	107	107	107	107	107	107	109	109	110	107	0.0	13.5	130.0	138.8	0.0	9.8	0	0	100	0
4-May	108	108	109	107	107	108	107	106	108	110	109	111	108	0.0	12.7	129.7	137.1	0.0	9.4	0	0	100	0
5-May	110	110	110	109	109	109	109	108	109	111	110	112	109	0.0	14.1	121.9	127.9	0.0	11.2	0	0	100	0
6-May	110	110	110	109	109	109	110	109	110	111	111	112	110	0.0	14.7	140.9	147.5	0.0	10.2	0	0	100	0
7-May	110	110	111	109	109	109	110	109	110	111	111	111	110	0.0	14.0	143.9	149.9	0.0	9.4	0	0	100	0
8-May	110	110	110	109	109	109	109	109	109	111	111	111	110	0.0	14.3	141.9	152.2	0.0	9.5	0	0	100	0
9-May	110	109	110	109	108	109	109	108	109	111	110	112	111	0.0	15.5	114.9	119.6	0.0	13.6	0	0	100	0
10-May	110	110	110	109	109	110	110	109	110	111	111	112	110	0.0	16.3	163.6	164.9	0.0	10.5	0	0	100	0
11-May	111	110	111	110	109	110	110	109	110	114	114	115	112	0.0	36.6	179.6	186.0	0.0	19.8	0	0	54	46
12-May	111	109	110	109	108	109	110	108	109	114	113	114	110	0.0	40.0	182.8	190.4	0.0	21.0	0	0	48	52
13-May	112	111	113	110	109	111	111	109	111	115	114	115	111	0.0	40.0	194.3	200.4	0.0	20.0	0	0	48	52
14-May	113	113	114	112	111	112	112	111	112	117	116	117	113	0.0	42.9	194.6	200.1	0.0	21.5	0	0	45	55
15-May	115	115	115	113	113	113	113	113	113	117	116	117	113	0.0	42.8	189.6	199.9	0.0	21.5	0	0	47	53
16-May	**116**	115	**116**	114	113	114	113	112	113	117	116	117	112	5.6	43.0	185.1	197.8	2.8	21.9	0	100	52	48
17-May	**117**	116	**117**	115	114	115	115	114	115	117	116	117	115	0.0	23.7	177.2	189.7	0.0	12.4	0	0	100	0
18-May	**116**	116	**117**	116	116	117	115	114	115	117	116	117	**117**	14.9	25.1	215.6	219.0	6.9	11.5	0	100	81	19
19-May	**118**	117	**118**	**121**	120	121	**117**	116	**118**	120	118	120	**117**	34.4	31.8	233.9	234.0	14.7	13.6	0	100	72	28
20-May	**120**	120	**120**	**123**	122	124	**119**	118	**120**	**122**	121	123	**119**	39.0	55.5	237.3	239.2	16.1	23.2	0	100	42	58
21-May	**125**	123	**127**	**126**	126	**127**	**123**	122	**123**	**125**	124	**126**	**119**	80.7	84.6	264.6	268.1	30.6	31.6	0	100	30	70
22-May	**126**	125	**126**	**127**	127	**127**	**124**	124	**124**	**127**	126	**127**	**121**	80.5	96.6	269.8	271.1	29.9	35.6	0	100	24	76
23-May	**128**	127	**128**	**128**	127	**128**	**125**	124	**126**	**127**	126	**127**	**124**	66.1	75.3	262.1	262.7	25.0	28.4	0	100	30	70
24-May	**127**	126	**128**	**127**	127	**128**	**124**	124	**125**	**126**	125	**127**	**124**	52.8	54.8	248.3	247.9	21.2	22.1	0	100	41	59
25-May	**126**	125	**127**	**127**	127	**127**	**124**	123	**124**	**125**	125	125	**124**	45.1	46.1	241.9	240.0	18.6	19.2	0	100	47	53
26-May	**125**	123	**125**	**127**	126	**126**	**123**	122	**122**	**124**	123	124	**124**	48.7	45.5	247.9	243.4	19.4	18.6	0	100	45	55
27-May	**125**	123	**127**	**128**	127	**129**	**123**	122	**124**	**127**	126	**128**	**121**	88.6	76.8	286.0	280.0	30.9	27.4	0	100	31	69
28-May	**130**	128	**130**	**133**	131	**134**	**128**	126	**129**	**130**	129	**131**	**124**	103.6	95.0	300.5	291.4	33.8	32.2	0	100	33	67
29-May	**133**	132	**133**	**134**	133	**134**	**129**	129	**130**	**131**	131	**131**	**126**	115.0	106.9	303.9	297.4	37.8	35.9	0	100	26	74
30-May	**134**	133	**135**	**132**	132	**133**	**130**	129	**130**	**131**	131	**131**	**128**	109.1	101.0	304.7	299.3	35.8	33.7	0	100	30	70
31-May	**131**	131	**133**	**132**	131	**134**	**129**	129	**129**	**131**	131	**132**	**128**	110.8	113.0	308.9	308.9	35.8	36.5	0	100	27	73

June 2011. Number in bold exceed the water quality criteria.

All TDG values are rounded to the nearest whole number, as specified in the April 2, 2008 memo from Chris Maynard.

Red highlight indicates a TDG level above the water quality criteria (115/120) that occurred when flows were below the 7Q10 flows (does not take into account incoming TDG level in upstream forebay).

	Rocky Reach Forebay			Rocky Reach Tailrace			Rock Island Forebay			Rock Island Tailrace			Wan FB	Average Daily Spill		Total Flow		% Flow Spilled		Reason for Spill (in % of total spill) Rocky Reach		Rock Island	
2011	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	RR	RI	RR	RI	RR	RI	Fish	Other	Fish	Other
1-Jun	**133**	132	**134**	**133**	132	**134**	**130**	129	**130**	**132**	131	**132**	**128**	113	113	300	317	38	36	0	100	27	73
2-Jun	**133**	133	**134**	**133**	132	**134**	**129**	129	**129**	**133**	132	**133**	**128**	107	110	299	295	36	37	0	100	27	73
3-Jun	**133**	132	**133**	**133**	132	**134**	**129**	129	**130**	**133**	133	**133**	**129**	113	116	307	300	37	39	0	100	25	75
4-Jun	**133**	132	**134**	**133**	132	**134**	**130**	129	**130**	**133**	132	**133**	**132**	116	105	297	293	39	36	23	77	57	43
5-Jun	**135**	134	**135**	**135**	134	**136**	**131**	131	**132**	**135**	134	**135**	**132**	123	122	309	311	40	39	21	79	50	50
6-Jun	**134**	134	**135**	**134**	133	**135**	**130**	130	**131**	**133**	133	**134**	**132**	118	117	308	304	38	38	23	77	46	54
7-Jun	**132**	132	**133**	**129**	129	**131**	**128**	127	**128**	**131**	131	**132**	**130**	107	102	282	283	38	36	24	76	58	42
8-Jun	**128**	128	**130**	**127**	126	**128**	**125**	125	**127**	**130**	130	**131**	**124**	95	97	281	275	34	35	26	74	60	40
9-Jun	**129**	128	**130**	**126**	125	**128**	**125**	125	**125**	**129**	129	**129**	**126**	74	78	248	254	29	30	32	68	71	29
10-Jun	**127**	127	**130**	**127**	127	**128**	**125**	125	**126**	**130**	129	**130**	**127**	82	79	262	264	31	30	29	71	69	31
11-Jun	**129**	128	**131**	**128**	128	**129**	**126**	125	**127**	**129**	129	**130**	**127**	120	93	285	286	42	33	30	70	60	40
12-Jun	**129**	128	**130**	**128**	128	**129**	**127**	126	**127**	**130**	130	**130**	**127**	127	106	286	290	45	36	30	70	55	45
13-Jun	**128**	128	**129**	**127**	127	**128**	**126**	125	**126**	**129**	128	**130**	**126**	92	97	265	271	35	36	27	73	60	40
14-Jun	**127**	126	**129**	**131**	130	**132**	**126**	125	**126**	**128**	128	**129**	**124**	119	113	291	295	41	38	21	79	52	48
15-Jun	**128**	128	**129**	**128**	128	**130**	**125**	125	**126**	**128**	128	**129**	**122**	116	109	280	282	40	39	22	78	54	46
16-Jun	**130**	129	**130**	**128**	128	**129**	**126**	125	**126**	**128**	127	**128**	**124**	112	101	285	291	39	35	23	77	58	42
17-Jun	**128**	128	**129**	**128**	127	**128**	**126**	126	**127**	**127**	127	**128**	**125**	93	95	277	276	34	34	29	71	62	38
18-Jun	**129**	129	**129**	**135**	133	**137**	**129**	127	**130**	**129**	128	**130**	**125**	140	96	270	280	52	34	18	82	58	42
19-Jun	**128**	128	**128**	**127**	126	**131**	**126**	126	**127**	**128**	127	**128**	**124**	134	90	264	270	51	33	18	82	64	36
20-Jun	**130**	128	**131**	**126**	126	**127**	**126**	125	**126**	**129**	128	**129**	**124**	113	94	259	264	44	36	22	78	61	39
21-Jun	**129**	128	**130**	**126**	126	**127**	**126**	125	**127**	**129**	129	**129**	**128**	91	96	255	257	36	38	25	75	55	45
22-Jun	**128**	128	**129**	**127**	127	**127**	**126**	125	**126**	**128**	127	**129**	**129**	90	75	255	263	35	29	24	76	66	34
23-Jun	**127**	125	**128**	**126**	126	**128**	**124**	123	**124**	**126**	126	**127**	**128**	99	81	266	274	37	30	23	77	64	36
24-Jun	**126**	126	**127**	**124**	124	**125**	**124**	123	**124**	**125**	125	**127**	**120**	76	83	249	259	30	32	29	71	63	37
25-Jun	**124**	123	**126**	**121**	121	121	**122**	121	**123**	**123**	123	124	**123**	45	65	228	227	20	29	46	54	75	25
26-Jun	**126**	124	**127**	**124**	123	124	**123**	122	**123**	**124**	123	125	**123**	60	65	246	246	25	27	36	64	78	22
27-Jun	**127**	125	**128**	**122**	122	123	**124**	123	**124**	**125**	124	125	**124**	43	65	225	226	19	29	47	53	73	27
28-Jun	**126**	124	**128**	**123**	122	124	**123**	121	**123**	**124**	123	125	**125**	90	62	229	234	39	27	22	78	75	25
29-Jun	**124**	123	**128**	**125**	124	**126**	**123**	122	**124**	**126**	125	**127**	**124**	98	65	230	234	42	28	21	79	73	27
30-Jun	**123**	120	**124**	**125**	124	125	**122**	120	**122**		127	**128**	**119**	96	73	231	237	42	31	21	79	64	36

July 2011. Number in bold exceed the water quality criteria.

All TDG values are rounded to the nearest whole number, as specified in the April 2, 2008 memo from Chris Maynard.

Red highlight indicates a TDG level above the water quality criteria (115/120) that occurred when flows were below the 7Q10 flows (does not take into account incoming TDG level in upstream forebay).

	Rocky Reach Forebay			Rocky Reach Tailrace			Rock Island Forebay			Rock Island Tailrace			Wan FB	Average Daily Spill		Total Flow		% Flow Spilled		Reason for Spill (in % of total spill) Rocky Reach		Rock Island	
2011	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	RR	RI	RR	RI	RR	RI	Fish	Other	Fish	Other
1-Jul	**121**	119	**123**	**126**	124	**130**	**121**	120	**123**		122	123	**123**	77	97	241	251	32	39	26	74	49	51
2-Jul	**124**	122	**127**	**123**	122	124	**122**	121	**122**	**125**	124	125	**125**	67	99	262	264	26	38	31	69	48	52
3-Jul	**127**	126	**127**	**124**	123	125	**124**	124	**125**	**126**	126	**127**	**124**	74	99	246	255	30	39	27	73	48	52
4-Jul	**126**	125	**126**	**123**	122	124	**123**	122	**124**	**126**	125	**127**	**123**	51	69	230	235	22	29	40	60	68	32
5-Jul	**125**	124	**125**	**122**	122	124	**122**	122	**122**	**125**	125	**127**	**124**	57	70	235	237	24	30	38	62	69	31
6-Jul	**126**	125	**127**	**125**	124	**126**	**124**	124	**125**	**127**	127	**128**	**125**	106	73	262	264	41	28	19	81	64	36
7-Jul	**127**	125	**128**	**124**	124	125	**124**	123	**126**	**127**	126	**128**	**125**	100	70	249	254	40	27	21	79	71	29
8-Jul	**122**	122	**123**	**124**	124	125	**122**	121	**122**	**125**	124	**126**	**122**	101	69	247	254	41	27	21	79	74	26
9-Jul	**121**	121	**122**	**123**	122	124	**121**	121	**122**	**124**	124	124	**122**	70	70	234	239	30	29	26	74	66	34
10-Jul	**121**	121	**122**	**122**	121	123	**121**	120	**122**	**124**	123	124	**123**	74	70	245	245	30	29	27	73	65	35
11-Jul	**124**	123	**125**	**128**	122	124	**123**	122	**124**	**127**	125	**128**	**122**	75	76	232	233	33	32	29	71	67	33
12-Jul	**122**	122	**123**	**121**	121	122	**121**	120	**122**	**124**	123	124	**122**	50	52	219	224	23	23	39	61	95	5
13-Jul	**121**	121	**121**	**121**	120	121	**120**	120	**121**	**122**	122	123	**122**	50	45	229	232	22	19	38	62	97	3
14-Jul	**121**	121	**121**	**121**	120	122	**121**	120	**122**	**123**	123	124	**120**	63	47	221	225	28	21	31	69	100	0
15-Jul	**121**	121	**122**	**121**	120	122	**122**	120	**123**	**124**	123	124	**121**	60	47	217	226	27	21	32	68	100	0
16-Jul	**121**	120	**123**	119	118	119	**119**	119	**120**	**122**	121	122	**121**	32	44	200	206	16	22	61	39	100	0
17-Jul	**118**	118	**119**	117	117	118	**118**	117	**118**	**121**	120	122	**121**	28	44	192	197	15	22	68	32	100	0
18-Jul	**117**	117	**118**	118	117	118	**118**	117	**118**	**121**	120	122	**120**	46	41	199	205	23	20	39	61	100	0
19-Jul	**118**	117	**119**	117	117	118	**117**	116	**117**	119	119	120	**117**	43	39	206	210	21	19	41	59	100	0
20-Jul	**118**	117	**119**	117	116	118	**117**	116	**118**	**121**	120	122	115	32	45	191	199	16	23	55	45	91	9
21-Jul	**123**	121	**125**	119	117	119	**121**	119	**122**	**123**	122	124	115	18	44	189	193	9	23	99	1	92	8
22-Jul	115	114	115	115	115	116	114	114	**116**	118	118	120	115	27	39	180	186	15	21	64	36	100	0
23-Jul	**116**	115	**117**	116	116	117	**116**	115	**116**	119	118	119	**118**	38	38	184	189	21	20	44	56	100	0
24-Jul	**117**	117	**119**	117	117	118	**117**	116	**117**	120	119	120	**118**	36	37	189	198	19	19	45	55	100	0
25-Jul	**118**	118	**119**	118	117	119	**117**	117	**118**	120	120	121	**118**	40	37	175	181	22	20	39	61	100	0
26-Jul	**117**	116	**117**	116	116	118	**116**	116	**118**	120	119	121	**116**	28	36	162	164	17	22	57	43	100	0
27-Jul	114	114	115	116	115	116	114	114	115	118	118	119	115	26	35	173	182	15	19	58	42	100	0
28-Jul	115	115	115	116	115	116	115	114	**116**	119	118	120	**116**	18	33	160	166	11	20	86	14	100	0
29-Jul	115	115	115	120	118	121	**118**	116	**119**	**121**	119	122	**116**	50	32	173	175	28	19	29	71	100	0
30-Jul	**119**	117	**120**	118	117	120	**118**	116	**120**	**121**	119	122	**116**	23	33	160	166	15	20	63	37	100	0
31-Jul	**116**	115	**116**	116	115	117	115	115	**117**	119	119	120	**116**	19	33	150	152	13	21	76	24	100	0

August 2011. Numbers in bold exceed the water quality criteria.

All TDG values are rounded to the nearest whole number, as specified in the April 2, 2008 memo from Chris Maynard.

*Less than 24 hrs of valid data

Red highlight indicates a TDG level above the water quality criteria (115/120) that occurred when flows were <7Q10 flows and upstream forebay TDG <=115.

	Rocky Reach Forebay			Rocky Reach Tailrace			Rock Island Forebay			Rock Island Tailrace			Wan FB	Average Daily Spill		Total Flow		% Flow Spilled		Reason for Spill (in % of total spill) Rocky Reach		Rock Island	
2011	12 ave	24 hr	High	12 hr	24 hr	High	12 hr	24 hr	High	12 hr	24 hr	High	12 hr	RR	RI	RR	RI	RR	RI	Fish	Other	Fish	Other
1-Aug	114	114	115	115	115	117	115	114	115	119	118	119	**117**	18.1	31.1	153.8	164.9	11.8	19.2	73	27	100	0
2-Aug	115	115	115	115	114	115	115	114	**116**	119	118	120	**118**	14.5	32.3	154.9	160.7	9.3	20.2	100	0	100	0
3-Aug	115	114	115	115	114	116	115	113	115	119	118	119	**117**	17.5	32.1	156.6	163.6	11.5	19.6	82	18	100	0
4-Aug	115	114	**116**	115	114	116	114	113	115	119	118	119	**117**	14.1	32.0	142.6	149.0	9.9	21.6	100	0	100	0
5-Aug	115	114	115	114	114	115	114	113	114	119	117	119	**117**	12.1	26.0	138.2	142.9	8.7	18.3	100	0	100	0
6-Aug	114	114	114	115	114	115	114	113	114	118	117	118	114	12.0	25.7	153.2	160.8	7.9	16.1	100	0	100	0
7-Aug	115	114	115	115	114	115	114	113	115	118	117	119	114	13.1	26.1	146.8	152.3	8.8	17.2	90	10	100	0
8-Aug	115	113	114	114	113	114	114	113	114	118	117	118	114	11.7	26.2	140.5	146.5	8.3	17.8	100	0	100	0
9-Aug	114	113	113	114	113	114	113	112	113	117	116	117	114	12.9	26.3	142.6	146.3	9.2	18.0	91	9	100	0
10-Aug	113	112	113	113	113	114	112	112	112	117	116	117	113	11.8	26.4	149.1	155.0	7.9	17.1	100	0	100	0
11-Aug	113	112	113	113	113	113	112	112	112	116	116	117	112	12.8	26.2	151.9	155.0	8.5	16.9	98	2	100	0
12-Aug	112	112	113	114	113	114	112	112	113	116	116	117	112	14.0	26.1	160.2	161.4	8.9	16.1	82	18	100	0
13-Aug	113	112	113	114	110	112	112	111	112	116	116	116	112	0.0	24.9	129.3	135.2	0.0	18.7	0	0	100	0
14-Aug	113	111	112	110	109	110	111	110	111	116	116	116	112	0.4	27.9	130.8	132.3	0.3	21.0	0	100	100	0
15-Aug	111	110	111	109	108	109	110	109	109	116	114	115	112	0.0	26.3	144.2	150.0	0.0	17.7	0	0	100	0
16-Aug	111	110	111	108	107	108	109	109	110	115	114	115	110	0.0	26.3	151.3	155.1	0.0	17.0	0	0	100	0
17-Aug	111	111	111	108	108	109	110	109	111	115	114	116	110	0.4	27.4	148.4	154.7	0.3	17.7	0	100	100	0
18-Aug	111	110	111	109	108	110	110	109	111	116	115	116	110	5.2	28.1	150.6	155.7	3.4	17.9	0	100	100	0
19-Aug	112	111	112	109	109	110	110	110	111	116	115	116	111	1.3	29.5	145.3	149.6	0.8	19.7	0	100	100	0
20-Aug	112	112	113	110	109	110	111	110	112	116	115	116	111	0.0	24.2	131.8	135.9	0.0	18.1	0	0	100	0
21-Aug	112	111	112	109	109	110	111	111	111	116	115	116	112	0.0	24.2	138.5	144.8	0.0	16.8	0	0	100	0
22-Aug	111	111	111	109	109	109	111	110	110	116	115	117	112	1.7	27.5	138.7	141.8	1.1	19.4	0	100	99	1
23-Aug	111	110	111	110	109	112	111	110	113	115	115	117	112	8.8	28.0	148.3	152.3	6.0	18.6	0	100	100	0
24-Aug	111	110	111	108	108	109	111	110	112	115	114	116	113	0.0	24.8	143.1	150.7	0.0	16.5	0	0	100	0
25-Aug	111	110	111	108	107	108	111	109	110	115	110	113	113	0.0	2.3	126.9	131.9	0.0	2.6	0	0	0	100
26-Aug	110	110	111	107	107	108	109*	109	109	109*	109	109	113	0.0	0.0	136.5	138.2	0.0	0.0	0	0	0	0
27-Aug	110	110	110	107	106	107							113	0.0	0.0	124.4	131.3	0.0	0.0	0	0	0	0
28-Aug	110	110	110	107	106	107							111	0.0	0.0	113.1	115.8	0.0	0.0	0	0	0	0
29-Aug	110	109	110	107	106	107	109*	108	109	109*	109	109	111	0.0	0.0	109.8	114.4	0.0	0.0	0	0	0	0
30-Aug	109	108	108	106	105	105	108	107	108	109	107	108	107	0.0	0.0	111.0	114.0	0.0	0.0	0	0	0	0
31-Aug	108	107	108	105	104	105	107	106	107	109	108	112	106	0.0	10.6	122.2	124.2	0.0	7.3	0	0	0	100

APPENDIX E

Monthly Calibration Logs

Site	InstrID	Date	Time	BP mmHg	Temperature (°C)			TDG Pressure (mmHg)				Deviation from STD TDG %Saturation			
				STD	STD	Probe	Diff	100%	113%	126%	139%	100%	113%	126%	139%
RIGW	37606	03/28/11	10:55	748.7	4.50	4.5	0.0	748	848	948	1049	0.1	0.1	0.1	0.0
RIGW	32546	04/25/11	14:40	709.8	12.00	11.9	0.1	710	810	910	1010	0.0	0.0	0.0	0.0
RIGW	32546	05/25/11	13:05	741.1	10.50	10.3	0.2	741	841	941	1041	0.0	0.0	0.0	0.0
RIGW	32546	06/30/11	15:10	746.9	14.30	14.2	0.1	747	847	947	1047	0.0	0.0	0.0	0.0
RIGW	32546	07/27/11	12:15	746.3	17.10	17.0	0.1	747	847	947	1047	-0.1	-0.1	-0.1	-0.1
RIGW	32546	08/24/11	10:20	745.1	19.10	19.0	0.1	745	845	945	1045	0.0	0.0	0.0	0.0
RIGW	32548	09/28/11	14:15	754.7	18.70	18.5	0.2	755	854	954	1055	0.0	0.1	0.1	0.0
RIS	60047	03/28/11	13:30	747.2	5.00	5.1	-0.1	745	844	942	1041	0.3	0.4	0.7	0.8
RIS	37606	04/26/11	12:30	745.9	8.00	7.9	0.1	746	845	945	1045	0.0	0.1	0.1	0.1
RIS	37606	05/25/11	14:10	740.3				741	841	941	1041	-0.1	-0.1	-0.1	-0.1
RIS	37606	06/30/11	13:40	745.4	14.80	14.6	0.2	745	844	944	1045	0.1	0.2	0.2	0.1
RIS	37606	07/27/11	13:30	744.8	17.20	17.1	0.1	744	844	944	1044	0.1	0.1	0.1	0.1
RIS	37606	08/24/11	11:40	743.2	18.80	18.6	0.2	743	843	943	1043	0.0	0.0	0.0	0.0
RIS	37606	09/28/11	13:25	754.0	18.80	18.5	0.3	754	854	954	1055	0.0	0.0	0.0	-0.1
RRDW	38865	03/28/11	11:00	748.8	4.60	4.5	0.1	748	848	948	1048	0.1	0.1	0.1	0.1
RRDW	38865	04/26/11	9:45	744.4	7.40	7.3	0.1	744	844	944	1045	0.1	0.1	0.1	-0.1
RRDW	38865	05/25/11	13:15	739.3	10.60	10.5	0.1	739	839	939	1039	0.0	0.0	0.0	0.0
RRDW	38865	06/30/11	12:05	744.3	14.50	14.3	0.2	744	844	944	1044	0.0	0.0	0.0	0.0
RRDW	38865	07/27/11	14:30	743.5	17.00	16.8	0.2	743	843	943	1043	0.1	0.1	0.1	0.1
RRDW	38865	08/24/11	13:30	741.3	19.00	19.0	0.0	741	840	940	1041	0.0	0.2	0.2	0.0
RRDW	38865	09/28/11	11:50	754.2	17.90	17.7	0.2	752	852	952	1053	0.3	0.3	0.3	0.2
RRH	60048	03/28/11	14:00	747.0	6.20	6.3	-0.1	744	842	942	1041	0.4	0.7	0.7	0.8
RRH	37607	04/25/11	14:20	709.8	11.40	11.4	0.0	710	810	911	1011	0.0	0.0	-0.2	-0.2
RRH	37607	05/25/11	15:35	737.4	10.80	10.7	0.1	737	837	937	1038	0.1	0.1	0.1	-0.1
RRH	37607	06/30/11	11:20	742.5	14.60	14.5	0.1	745	844	944	1044	-0.3	-0.2	-0.2	-0.2
RRH	37607	07/27/11	15:05	741.6	17.80	17.7	0.1	742	842	942	1042	-0.1	-0.1	-0.1	-0.1
RRH	37607	08/24/11	14:05	739.0	19.70	19.5	0.2	739	839	939	1040	0.0	0.0	0.0	-0.1
RRH	37607	09/28/11	12:20	751.8	18.30	18.2	0.1	750	850	950	1051	0.2	0.2	0.2	0.1

APPENDIX F

Response to Comments

Page, Section, Etc.	Agency Comment	Chelan PUD Response
Page 15	As described on page 15 of this report, the 401 Water Quality Certification (Section 5.4(1)(b)) requires a study of different spillway configurations at Rocky Reach to determine whether TDG can be further reduced without adverse effects on fish passage. This report indicates that Chelan PUD will develop a plan to study these effects during the winter of 2010/2011. This is great, except we hope you mean 2011/2012!	Thank you for catching that. The date has been changed in the report.
Page 20	We also appreciate your plan to study Gas Bubble Trauma (GBT), in accordance with the 401 Certification Section 5.4(1)(c), per page 20 of the [report]. Hopefully, this plan can be developed this winter, in consultation with the Department of Ecology and the Washington State Department of Fish and Wildlife.	We are hoping to get this developed this winter and may want to discuss further at our next Quarterly Meeting.
Page 11-12	Good suggestion presented on pp 11-12 regarding counting days of non-compliance. If you provide the write-up in a word document or email, I can forward to HQ. (Or you could send directly to Chad Brown, cc me.)	Chelan PUD would be happy to provide this in a word document or email and will do so in the near future.
General	In compliance with Section 5.4(1)(a) (regarding monitoring) and 5.4(4) (regarding annual reports), Chelan PUD should present results of monitoring with respect to operations during the non-fish spill season. We recommend that the results be included in this report with the other results of TDG monitoring *or* presented in a separate, short report by January 31st, [2012]. Please let us know your preference.	Chelan PUD had originally planned to report non-fish spill monitoring results in the March 1 submittal (401 Section 5.7(8)), as September-December data is not available for the Draft Report submitted in October. However, since it is now January, a summary of results has been included in this FINAL Report in new Section 3.4.4.
Executive Summary	In the Executive Summary, the statement is made: "All exceedances occurred during the May-June period of high flows in the Columbia River, when flows often exceeded the 7Q10 flows." This can be confusing as written because (as you explain later in the report) when flow flows exceed the 7Q10, the water quality criteria don't apply. Could you clarify to better describe your high level of compliance (see Section 3.4.3)?	Noted. Language has been revised to provide more clarity.
3.4.3	Could you provide a table that summarizes the results presented in Section 3.4.3?	Table 9 has been modified to reflect the revised results presented in Section 3.4.3.
Appendix D	And in Appendix D you could use red to highlight the values that both a) exceed the 120 or 115 standard *and* b) occur when flows are less than their 7Q10 values.	Noted and done.
Page 13	Do you have any ideas why Rock Island had 8.7 kcfs lower maximum hourly flow than Rocky Reach on June 5 (per page 13)?	This is a result of the margin of error for spill discharges. Reported hourly flow at each project is a sum of the turbine and spillway discharges. Spillway discharges are not metered, but rather calculated, resulting in some margin of error that can be observed.
Page 15	On page 15, it is stated that the standard spill pattern was deviated from in June 2010 at Rock Island in an attempt to maintain compliance. How successful was this?	I have added a bit more information here to better clarify.

Page 21	22% of steelhead with signs of GBT sounds really high, although it was not your fault (p. 21). Was this information shared with NOAA Fisheries.	Yes, this information was shared with NOAA Fisheries via the HCP Coordinating Committee.
Figures 9 and 11	Figures 9 and 11 indicate there is little to no correlation between spill and TDG change at each of the projects. However, for Rock Island there seems to be a broad range of change in TDG (forebay to tailrace; to a 4% increase); there also seemed to be a distinct rise in TDG from mid June to August 19th (Figure 12). It would be very helpful to determine the cause. One hypothesis might be that incoming TDG levels affect the increase in TDG in the tailrace. Would a higher level in the forebay increase the levels in the tailrace by even more (e.g. from an increase of 2% to an increase of 4 or 5% - see Table 8). This appears to be the case at the Wells Project. Has it been tested at Rock Island before?	Chelan PUD is not exactly sure what is being asked here. We would be happy to discuss at our next Quarterly Meeting.
Page 26	On page 26, the statement is made, regarding Rock Island, that "The average……change in percent TDG from the forebay to the tailrace was an increase of 0.78%, ranging from a decrease of 2.9% to an increase of 5.9%." This does not seem to be reflected in the either of the Rock Island figures (11 and 12) or Table 8, but seems closer to the values for Rocky Reach (figures 9 and 10).	Thank you for catching this. I am not sure where that data came from, but it has been replaced with the correct data.
3.4.3	In calculating percent compliance (Section 3.4.3), please eliminate the days with 7Q10 flows or 115% incoming values from the calculations…….	Percent compliance has been calculated as suggested and revised in the final report.
Table 10	In Table 10 (page 34), two ** are used in several places in the table. What do they indicate?	Note added below the table that defines the **. (**24 days of on/off spill test for sockeye.)
Table 10	Also in Table 10, far right hand column, what is meant when two values appear?	A single * has been added to that column heading and a note added at the bottom that explains what the * means. (*Percentage of daily average river flow at Rocky Reach. Two values in this column represents two different spill levels during the season (first value is the spill level for yearling Chinook and steelhead, second value is the spill level for sockeye.)
General	"FMS" refers to "Fixed Monitoring Station" (not site).	Noted and changed where used in the report.