Wells Hydroelectric Project
Total Dissolved Gas Abatement Plan

2010 Annual Report

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1 INTRODUCTION

The 2010 Wells Hydroelectric Project (Wells Project) Gas Abatement Plan (GAP) was approved by the Washington State Department of Ecology (Ecology) on April 9th, 2010 (Appendix 1 and Appendix 2) and was amended by Douglas PUD and Ecology on July 1, 2010. The Wells Project GAP and its associated measures are intended to meet state water quality standards for total dissolved gas (TDG). This annual report concludes the 2010 monitoring season and describes the background, operations, and results of GAP implementation at the Wells Project in 2010.

1.1 Project Description

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

The Wells Project is the chief generating resource for Douglas PUD. It includes ten generating units with a nameplate rating of 774,300 kW and a peaking capacity of approximately 840,000 kW. The design of the Wells Project is unique in that the generating units, spillways, switchyard, and fish passage facilities were combined into a single structure referred to as the hydrocombine. Upstream fish passage facilities are located on both sides of the hydrocombine, which is 1,130 feet long, 168 feet wide, with a top of dam elevation of 795 feet above mean sea level (msl).

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

1.1 Fixed Monitoring Site Locations

Two fixed monitoring stations for total dissolved gas (TDG) are located at Wells Dam, including a forebay and tailrace station. The forebay station (WEL) is located midway across the deck of Wells Dam (47° 56’ 50.28” N, 119° 51’ 54.78” W). The tailrace station is located on the left bank of the Columbia River 2.6 miles downstream of Wells Dam (47° 54’ 46.86” N, 119° 53’ 45.66” W). Hach® HYDROLAB MiniSonde instruments equipped with TDG and temperature probes are deployed approximately 15 feet below normal surface water elevation and are calibrated monthly (example in Appendix 3). Data from both stations are automatically transmitted by radio to Wells Dam, stored, and forwarded to the USACE. Weather data are recorded by Global Water, Inc. instrumentation, including an electronic barometer located on the deck of Wells Dam at 810 feet elevation.
1.2 Regulatory Framework

Washington Administrative Code (WAC) Chapter 173-201A identifies the Water Quality Standards (WQS) for surface waters in Washington State. The WQS state that TDG measurements shall not exceed 110% saturation at any point of measurement in any state water body. The WQS provide for two exceptions to this rule: (1) during natural flood flows, and (2) spill over hydroelectric projects to increase survival of downstream migrating juvenile salmon.

Natural flood flows are identified by periods in which river flow volume exceeds the seven day, 10-year frequency flood stage (7Q-10). The 7Q-10 value is defined as the highest average river flow volume observed during seven consecutive days throughout a ten-year period. The 7Q-10 flow for the Wells Project is 246,000 cubic feet per second (cfs), based on the hydrologic records from 1930 to 1998 and the USGS Bulletin 17B, “Guidelines for Determining Flood Flow Frequency” (Pickett et al. 2004). When river flow volume exceeds 7Q-10 flows, WQS permit exceedance of the 110% TDG saturation standard.

Ecology may also waive the 110% upper criterion for TDG saturation during the outmigration of juvenile salmon. The interim TDG waiver is considered by Ecology on a per-application basis and must be accompanied by an approved GAP (WAC 173-201A-200(1) (f) (ii)). On the Columbia and Snake rivers, the TDG waiver has three standards during the fish passage (spill) season: (1) TDG shall not exceed 125% saturation in the tailrace of the project as measured in any one-hour period; (2) TDG shall not exceed 120% saturation in the tailrace of the project based on the average of the twelve highest consecutive hourly readings in any one day (12C-High1); and, (3) TDG shall not exceed 115% saturation in the forebay

1 Ecology currently uses the methodology described in Appendix 5 for determining 12C-High TDG values in the tailrace and forebay of Columbia Basin hydroelectric projects.
of the next downstream project based on the average of the twelve highest consecutive hourly readings in any one day.

1.3 2010 Gas Abatement Plan Requirements

1.3.1 Operational

The Wells Project 2009 GAP introduced the latest numerical model developed by the University of Iowa’s IIHR-Hydroscience and Engineering Hydraulic Research Laboratories (IIHR Engineering). The two-phase flow computational fluid dynamics tool was used to predict hydrodynamics of TDG distribution within the tailrace of Wells Dam and further identify operational configurations that would minimize TDG production at the project. In an April 2009 report, the model demonstrated that Wells Dam can be operated to meet the TDG fish spill waiver standards during the passage season with flows up to 7Q-10 levels (246,000 cfs; Politano et al. 2009). IIHR Engineering identified the most benign spillway operation at the Wells Project was the use of a concentrated spill pattern through Spillbay No. 7 and surplus flow volume through other spillbays in a defined pattern (Politano et al. 2009). These preferred TDG operating conditions create surface-oriented flows by engaging submerged spillway lips below the ogee, thus increasing degasification at the tailrace surface, decreasing supersaturation at depth, and preventing high-TDG waters from bank attachment. These principles were the basis of the 2009 Wells Project Spill Playbook (Appendix 4a) implemented for the first time during the 2009 fish passage (spill) season as part of the GAP.

In 2010, the 2009 Wells Project Spill Playbook (Appendix 4a) was implemented again given its effectiveness in maintaining levels below TDG criteria the previous year. High Columbia River flows in June, which exceeded the preceding 15-year average flow, resulted in several exceedances of the hourly (125% maximum) and 12C-High (120%) TDG limits in the Wells Dam tailrace, and Rocky Reach forebay (115%). In response, Douglas PUD implemented an in-season analysis of the 2009 Spill Playbook and determined that full implementation of the recommendation from IIHR Engineering would require the removal of the juvenile fish bypass system flow barriers. Following the in-season analysis and consultation with the HCP Coordinating Committee, changes were made to the 2010 spill Playbook (Appendix 4b) that allowed for the removal of the juvenile fish bypass system barriers. Specifically, the Playbook was modified to state that when spill levels approach the 53 kcfs threshold, the Juvenile Bypass System barriers in spillbay 6 would be removed in order to remain in compliance with the TDG criteria in the Wells Dam tailrace and Rocky Reach Dam forebay. When spill exceeded 53 kcfs, excess spill would be directed through spillbays 6 and 7 rather than through spillbays 5 and 7 resulting in a more compact spill pattern that reduced the air-water interface surface area between spillway flows and the subsequent potential for lateral mixing and air entrainment.

Other operational requirements of the 2010 GAP included:

1. The “fish spill” season identified as the period between April 1st and August 31st, with “non-fish spill” season occurring from September 1st to March 31st, unless otherwise specified in writing by Ecology.
2. General TDG Abatement Measures to maintain compliance with TDG criteria, consistent with the juvenile salmon passage and survival standards set forth in the Anadromous Fish Agreement and Habitat Conservation Plan (HCP), are as follows:
   a. Minimize voluntary spill;
   b. Manage voluntary spill in real-time to meet TDG numeric criteria;
   c. Minimize spill, to the extent practicable, by scheduling maintenance based on predicted flows.
3. Provide an annual Gas Abatement Plan report to Ecology no later than December 31st of the same year, including:
   a. Daily flow, spill and TDG levels;
   b. Summary of exceedances and what was done to correct the exceedance(s);
   c. Results of any applicable fish passage efficiency or survival studies conducted under requirements of the HCP Agreement;
   d. Revised GAP to reflect any changes, new information or technologies. Draft GAPs shall be submitted to Ecology for review and approval by February 28th of the year to be implemented (e.g., February 28th, 2011 for the 2011 spill season).

Douglas PUD will direct all correspondence to the Hydropower Projects Manager, Department of Ecology, Central Region Office, Water Quality Program, 15 W. Yakima Avenue, Suite 200, Yakima, Washington 98902.

1.3.2 Structural

No permanent structural modifications were proposed or conducted in the 2010 monitoring season. Removal of the bypass barrier structures in Spillway 6 was implemented consistent with the in-season revision to the Spill Playbook.

2 OPERATIONS

2.1 Description of Fish-Spill Season Flow

The 2010 Fish Spill Season was April 12th through August 26th at Wells Dam. As required, TDG data is monitored during this period and transmitted to the US Army Corps of Engineers, Northwest Division on a real-time basis (www.nwd-wc.usace.army.mil). Historical data is available for download. Data from 1995 to 2010 (16 years) show that average monthly flows between April and August range from 53.4 to 300.3 thousand cfs (kcf) at the Wells Project. During this time period, flows tend to be greater and more variable in June (mean 167.1 kcf, SD ±50.75), and lowest and least variable in August (105.5 kcf, SD ±22.88, Table 1).
Table 1. Monthly total river discharge (kcfs) from the Wells Project (April-August), 1995-2010.

<table>
<thead>
<tr>
<th>Month</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Monthly Average (kcfs)</td>
<td>113.9</td>
<td>143.5</td>
<td>167.1</td>
<td>129.8</td>
<td>105.5</td>
</tr>
<tr>
<td>Minimum Monthly Average (kcfs)</td>
<td>62.9</td>
<td>55.2</td>
<td>84.5</td>
<td>53.4</td>
<td>70.4</td>
</tr>
<tr>
<td>Maximum Monthly Average (kcfs)</td>
<td>177.4</td>
<td>251.9</td>
<td>300.3</td>
<td>182.8</td>
<td>152.1</td>
</tr>
<tr>
<td>Standard Deviation (kcfs)</td>
<td>±35.98</td>
<td>±42.79</td>
<td>±50.75</td>
<td>±33.33</td>
<td>±22.88</td>
</tr>
</tbody>
</table>

Average monthly river flow at the Wells Project in 2010 was approximately 15% lower than the 16-year average (Table 2). June flows were higher than the 16-year average, while other spill season average monthly river flows at the Wells Project were considerably lower than the 16-year average. The maximum hourly flows observed (268.6 kcfs in June) exceeded the 7Q-10 value of 246.0 kcfs. There were ten instances where hourly flows at the Wells Project exceeded the 7Q-10 value, occurring June 21\textsuperscript{st}-24\textsuperscript{th}.

Table 2. Average monthly river flow volume (kcfs) during the TDG monitoring season at the Wells Project in 2010 compared to the previous 15-year average (1995-2009), by month.

<table>
<thead>
<tr>
<th>Month</th>
<th>1995-2009 Mean</th>
<th>2010 Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>113.9</td>
<td>70.7</td>
</tr>
<tr>
<td>May</td>
<td>143.5</td>
<td>112.2</td>
</tr>
<tr>
<td>June</td>
<td>167.1</td>
<td>173.0</td>
</tr>
<tr>
<td>July</td>
<td>129.8</td>
<td>119.9</td>
</tr>
<tr>
<td>August</td>
<td>105.5</td>
<td>83.6</td>
</tr>
<tr>
<td>All</td>
<td>132.0</td>
<td>111.9</td>
</tr>
</tbody>
</table>

2.2 Fish Spill Program

Wells Dam is a hydrocombine, where the spillbays are located directly above the turbine water passages. Research at Wells Dam in the mid-1980s demonstrated that a modest amount of spill could be used to effectively guide a high proportion of the downstream migrating juvenile salmon away from the turbines and into a surface oriented bypass system. A Juvenile Fish Bypass System (JBS) was subsequently developed at Wells in the late 1980s. The Wells Dam JBS was engineered based on biological research and hydraulic modeling, and utilizes constricting flow barriers deployed in five of the eleven spillbays to effectively attract and safely guide fish through the project. The Wells Project JBS has since proven to be the most efficient system on the mainstem Columbia River, providing high levels of
fish protection that has met approval of fisheries agencies and tribes (Skalski et al. 1996). The survival performance measures contained within the Federal Energy Regulatory Commission (FERC)-approved Anadromous Fish Agreement and Habitat Conservation Plan have been consistently exceeded, with a three-year survival average of 96.2% for juvenile steelhead and Chinook salmon (Bickford et al. 2001). The results from a fourth year of survival study at Wells Dam confirmed past study results by documenting that survival through the entire Wells Project is in excess of 96.4% for juvenile spring migrating anadromous fish.

### 2.3 Fish Spill Quantities and Duration

The Wells Dam JBS uses up to 2,200 cfs per spillbay, though one or more of the flow barriers may be removed to provide adequate spill capacity to respond to plant load rejection. Under normal conditions, however, the JBS will use roughly six to eight percent of the total river flow for fish guidance. The increased spill has negligible influence on TDG production (~0-2%) while providing a safe, non-turbine passage route for over 92% of the spring and 96% of the summer migration of juvenile salmonids. The JBS has been operated on a fixed schedule between April 12th and August 26th since 2003 but the HCP Coordinating Committee retains annual operating oversight that includes the potential to operate the JBS as early as April 1st and as late as August 31st to ensure that 95% of the spring and summer migration of juvenile salmonids is provided a safe, non-turbine passage route over Wells Dam.

Average spill at the Wells Project in 2010 was lower than the previous 15-year average. Average monthly spill ranged from 6.1 kcfs in April to 24 kcfs in June (Table 3). On numerous occasions between June 9 and July 2, 2010 hourly spill exceeded the approximate JBS flows. On June 17th forced spill reached the maximum hourly value for the 2010 season, 113.8 kcfs. These high spill events in June were attributed to both flow volumes in excess of the Project’s hydraulic capacity, and flows in excess of the power system needs and/or transmission system capacity.

**Table 3.** Average hourly spill (kcfs) during the TDG monitoring season at the Wells Project in 2010 compared to the 15-year average (1995-2009), by month.

<table>
<thead>
<tr>
<th>Month</th>
<th>1995-2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std Dev</td>
</tr>
<tr>
<td>April</td>
<td>10.3</td>
<td>16.3</td>
</tr>
<tr>
<td>May</td>
<td>19.5</td>
<td>27.1</td>
</tr>
<tr>
<td>June</td>
<td>31.0</td>
<td>42.8</td>
</tr>
<tr>
<td>July</td>
<td>11.9</td>
<td>15.2</td>
</tr>
<tr>
<td>August</td>
<td>6.8</td>
<td>7.2</td>
</tr>
<tr>
<td>All Year</td>
<td>7.3</td>
<td>19.8</td>
</tr>
</tbody>
</table>
3 IMPLEMENTATION RESULTS

3.1 Fisheries Management

3.1.1 Fish Passage Efficiencies

No fish passage efficiency studies were conducted at the Wells Project in 2010. However, three years of bypass efficiency studies have shown the Wells Dam JBS to be the most efficient juvenile salmonid collection system in the Columbia River with fish passage efficiencies up to 92% for spring migrants and up to 96% for summer migrants (comprised of steelhead, Chinook, and sockeye salmon, and Chinook salmon, respectively; Skalski et al. 1996).

3.1.2 Survival Studies

In spring 2010, Douglas PUD conducted a survival verification study with yearling Chinook salmon, a required 10-year follow-up study to confirm whether the Wells Project continues to achieve survival standards of the Wells Anadromous Fish Agreement and Habitat Conservation Plan. Approximately 80,000 PIT-tagged yearling summer Chinook were released over a 30 day period in 15 replicates. The draft report determined that juvenile Chinook survival from the mouth of the Okanogan and Methow rivers averaged 96.4% over the 15 replicate releases of study fish. This result confirms the results from the three previous years of study and documents that fish survival through the Wells Project continues to exceed the 93% Juvenile Project Survival Standard required by the Habitat Conservation Plan (Bickford et al., 2010 draft). A final report will be available in early 2011.

3.2 Biological Monitoring

The 2010 Wells Project GAP includes the National Marine Fisheries Service (NMFS) recommendation to sample for Gas Bubble Trauma (GBT) in juvenile salmon when hourly tailrace TDG levels exceed 125% saturation (NMFS 2000). In 2010, no hourly TDG readings at Wells Dam forebay or in the forebay of Rocky Reach Dam exceeded 125% saturation. In the Wells Dam tailrace, there were five instances where hourly TDG exceeded 125% saturation during the 2010 TDG monitoring season. Two observations occurred on June 17\textsuperscript{th} (127.0%, 129.9%), one on June 22\textsuperscript{nd} (125.3%), and two on June 29\textsuperscript{th} (126.1%, 126.3%). There was no GBT monitoring following the June 17\textsuperscript{th} event. On June 24\textsuperscript{th} at 0800, Douglas PUD staff conducted GBT monitoring at Rocky Reach Dam in response to the June 22\textsuperscript{nd} exceedance. Relatively few juvenile salmonid outmigrants were moving through the mid-Columbia River at this time. In total, four Chinook and 13 sockeye juveniles were sampled from the Rocky Reach bypass 0800-0900. No signs of GBT were observed. On the morning of June 30\textsuperscript{th}, Chelan PUD staff conducted GBT sampling on behalf of Douglas PUD, in response to the June 29\textsuperscript{th} exceedances. Three sockeye and 18 Chinook were examined with no sign of GBT observed.

3.3 Water Quality Forums

Douglas PUD has actively participated in regional water quality forums with Ecology, Washington Department of Fish and Wildlife, NMFS, Tribal Agencies, the US Fish and Wildlife Service, the USACE, and other Mid-Columbia PUDs (i.e., Grant and Chelan counties). These meetings, ranging from the Trans-
boundary Gas Group to Columbia Basin meetings with the USACE, allow for regional coordination for monitoring, measuring, and evaluating water quality in the Columbia Basin. Douglas PUD will continue its involvement in the Water Quality Team meetings for further coordination with other regional water quality managers.

### 3.4 Physical Monitoring

#### 3.4.1 Overview

TDG monitoring at the Wells Project has occurred since 1984 when forebay stations were first established. TDG monitoring in the tailrace of Wells Dam began in 1997 by actively collecting data at four points across the width of the river. Based on these data, the location for a fixed monitoring station was established in 1998. Subsequent analysis verified that both monitoring station locations are appropriate and representative of the river conditions, particularly during high flows (EES et al. 2007; Politano et al. 2009). TDG monitoring at the Wells Project currently encompasses the fish passage season and a majority of all forced spill, beginning April 1st and continuing until September 15th. As part of Douglas PUD’s Quality Assurance/Quality Control (QA/QC) measures, the TDG sensors are serviced monthly for maintenance and calibration. Data is collected at 15-minute intervals at the Wells Project over the entire fish spill season.

#### 3.4.2 Data Evaluation and Analyses

Hourly TDG monitoring data were retrieved from the USACE, Northwest Division for three monitoring locations: the forebay of Wells Dam (WEL), tailrace of Wells Dam (WELW), and forebay of Rocky Reach Dam (RRH). The data were partitioned to include only readings obtained during the fish spill season (April 12th to August 26th). Data were stratified by monitoring site, ascending date, and ascending time. The Ecology-approved 12C-High method (Appendix 5) was used to obtain TDG measurements for comparison to numeric criteria and evaluation of compliance.

Average monthly TDG measurements during the 2010 monitoring period (April 12-August 26) ranged from 104.4% to 111.9% in the forebay of Wells Dam, from 105.9% to 113.5% in the tailrace of Wells Dam, and from 106.1% to 112.2% in the forebay of Rocky Reach Dam. Maximum monthly values were observed in June at all three monitoring locations, whereas minimum monthly values varied by month among the monitoring location (Table 4).

*Table 4.* Hourly sampling events (n) and resulting TDG (percent saturation) at the forebay of Rocky Reach Dam, the forebay of Wells Dam (WEL), and the tailrace of Wells Dam (WELW) by month, 2010.

<table>
<thead>
<tr>
<th>Month</th>
<th>Wells Dam Forebay</th>
<th>Wells Dam Tailrace</th>
<th>Rocky Reach Dam Forebay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Min</td>
<td>Mean</td>
</tr>
<tr>
<td>April</td>
<td>277</td>
<td>102.6</td>
<td>106.0</td>
</tr>
<tr>
<td>May</td>
<td>744</td>
<td>101.6</td>
<td>104.4</td>
</tr>
<tr>
<td>June</td>
<td>720</td>
<td>103.5</td>
<td>109.1</td>
</tr>
<tr>
<td>July</td>
<td>733</td>
<td>108.4</td>
<td>111.9</td>
</tr>
<tr>
<td>August</td>
<td>621</td>
<td>103.9</td>
<td>109.2</td>
</tr>
</tbody>
</table>
Monthly average 12C-High TDG saturation measurements in 2010 during the monitoring period ranged from 105% to 113% in the forebay of Wells Dam, from 107% to 115% in the tailrace of Wells Dam, and from 107% to 113% in the forebay of Rocky Reach Dam. Maximum values were observed in June and July, and minimum values were observed in April and May and again in August (Table 5).

Table 5. Descriptive statistics of daily 12-C High TDG measurements (percent saturation) from Wells Dam forebay (WEL) and tailrace (WELW) and the forebay from Rocky Reach Dam (RRH) during the 2010 monitoring season.

<table>
<thead>
<tr>
<th>Month</th>
<th>Wells Dam Forebay</th>
<th>Wells Dam Tailrace</th>
<th>Rocky Reach Forebay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Mean</td>
</tr>
<tr>
<td>April</td>
<td>104.0</td>
<td>108.0</td>
<td>107.0</td>
</tr>
<tr>
<td>May</td>
<td>103.0</td>
<td>107.0</td>
<td>105.0</td>
</tr>
<tr>
<td>June</td>
<td>105.0</td>
<td>114.0</td>
<td>110.0</td>
</tr>
<tr>
<td>July</td>
<td>111.0</td>
<td>114.0</td>
<td>113.0</td>
</tr>
<tr>
<td>August</td>
<td>106.0</td>
<td>113.0</td>
<td>110.0</td>
</tr>
<tr>
<td>All</td>
<td>106.0</td>
<td>111.0</td>
<td>109.0</td>
</tr>
</tbody>
</table>

During the 2010 monitoring season, the TDG criterion for the forebay of Wells Dam was not exceeded by operations at the Chief Joseph Dam. The TDG TMDL load allocation for Chief Joseph Dam during Phase 1 (2004-2010) allowed Chief Joseph Dam operators the criteria of the fish passage adjustment (Ecology et al. 2004). On ten occasions, between June 11th and July 27th, 12C-High values reached 113-114% at various flow conditions; however, on none of these occasions did the 12-C High value exceed the 115% criterion.

In the Wells Dam tailrace, the TDG criterion of 120% was exceeded on 4 occasions; June 22nd, June 24th, June 26th, and June 29th. Wells Dam tailrace 12C-High TDG values, which ranged from 120.5% to 123.2%, occurred during flow conditions ranging from 188.5 kcf to 268.6 kcf, the latter being above the 7Q-10 value for Wells Dam of 246.0 kcf. In the forebay of Rocky Reach Dam, the 115% 12C-High TDG criterion was exceeded on eight occasions; June 22nd-June 25th, June 27th-June 30th, and July 2nd. 12C-High values ranged from 115.6% to 120.9%. Exceedances occurred during flow conditions ranging from 169.6 kcf to 257.9 kcf. With the exception of these exceedances, which occurred in association with high river flow volumes between June 17 and July 2 which sometimes were above the 7Q10 flow, the Wells Project was in compliance with TDG Water Quality Standards.

The TDG TMDL identified a positive, linear relationship from 2002 FMS data, between the increase in Wells Dam tailrace % TDG saturation and volume of spill, described by the equation \( y = 0.1295x, R^2 = 0.921 \), where \( y \) is the absolute increase in tailrace % saturation, and \( x \) is the volume of spill in kcf (Ecology et al. 2004). This same relationship was characterized by a lower independent coefficient in 2010, \( y = 0.1144x \), indicating spill operations implemented in 2010 produced 11.6% less TDG per volume of spill compared to 2002 operations.
Regression analyses of hourly TDG values indicate that incoming waters to the forebay at Rocky Reach Dam during fish spill in 2010 have a strong and statistically significant positive relationship to TDG values in the forebay of Wells Dam. The strongest relationship was found between Wells forebay TDG and the Rocky Reach forebay TDG 15 hours later; suggesting average water particle transport time between the projects during 2010 fish spill was 15 hours (Figure 2). Throughout the fish spill season, average TDG in the Rocky Reach forebay was 1.2% higher than observed in the Wells forebay. TDG production in the Wells tailrace is a linear function of volume of spill at Wells Dam; the very tight correlation of Wells forebay TDG with Rocky Reach forebay TDG, regardless of Wells Dam spill, indicates TDG downstream from Chief Joseph Dam to Rocky Reach Reservoir is primarily a function of the mass loading of TDG due to the recent increased proportion of spill at Chief Joseph Dam. The seasonal patterns of TDG at the forebay of Wells Dam (WEL) and downstream (WELW and RRH) monitoring locations is shown in Figure 3.

**Figure 2.** Linear regression demonstrating the relationship between % TDG of water above Wells Dam and subsequent downstream % TDG in the Rocky Reach Dam forebay.

During the non-fish passage period (January 1 to April 11 and August 27 to December 31), TDG is not usually measured at the Wells forebay and tailrace fixed monitoring stations. Studies have demonstrated that non-spill flows at Wells Dam (through the turbine units and fishways) generates little
to no additional dissolved gas. Spill outside the fish passage adjustment period is rare: during the non-fish passage period, spill occurred during just 7 hourly periods, with a range of spill volumes from 500 to 8,000 cfs. Three of seven hours occurred in August during the week following the fish passage adjustment period, prior to tailrace TDG sensors being removed; spill ranged from 900 to 8,000 cfs during these events, and tailrace TDG levels ranged from 104% to 108%. During the period when sensors were removed, there were four hourly periods with spill ranging from 500 to 2,600 kcs. Spill of this magnitude would not result in any exceedances of the TDG standard at Wells Dam, with predicted TDG increases in the 0-1% range.
Figure 3. Daily 12-C High TDG measurements (percent saturation) from Wells Dam forebay (WEL) and tailrace (WELW) and the forebay from Rocky Reach Dam (RRH) during the 2010 monitoring season. Reference lines are at the 120% and 115% compliance marks.
4 DISCUSSION OF GAS ABATEMENT MEASURES

4.1 Operational

River flows in 2010 were indicative of a low water year with the notable exception of late June, when several heavy rain events created high flows and elevated TDG values in the Snake and lower Columbia River. In expectation of a drought year, the Bonneville Power Administration (BPA) had reduced discharge from Grand Coulee in May and early June and filled Grand Coulee one month earlier than normal. The subsequent heavy rain events in June, subsequent to filling Grand Coulee, resulted in unexpectedly high discharges and in addition required some drafting of Grand Coulee Reservoir. These unexpectedly elevated flows created significant challenges for the operations of the Federal Columbia River Power System (FCRPS) (BPA 2010).

In addition to accommodating high flows while meeting load requirements and Clean Water Act and Endangered Species Act requirements, Federal operators and BPA are also tasked with integrating the regions remarkable growth in wind power projects (approximately 6,000 megawatts connected to the Columbia River Basin transmission grid) resulting from renewable portfolio standards in Washington, Oregon, and California. This rapid increase in wind power requires balancing reserves to wind generators, which now consumes a significant portion of the operational flexibility of the FCRPS. In June, during the heavy rain events, wind power fluctuated between zero and almost full output as storms blew through the region. Loads remained fairly flat and low due to cool weather. Variable generation from wind, relatively low demands for electricity, and reduced operational flexibility of the system combined to create higher levels of involuntary spill at all of the federal and non-federal dams.

As part of the FCRPS Gas Abatement Plan, involuntary spill is spread incrementally across all federally owned projects to prevent excessively high total dissolved gas levels at those projects. While not part of the criteria adjustment allowed for the eight mainstem federal projects with fish passage, the Gas Abatement Plan includes spill at Grand Coulee and Chief Joseph dams as operational measures to manage TDG levels below federal projects in the Columbia River that result from involuntary spill. During Phase 1 of the TDG TMDL (Ecology et al. 2004), installation and testing of flow deflectors at Chief Joseph Dam increased allowable spill from 20 kcf to 100 kcf (BPA 2010).

The intent of the spill deflectors at Chief Joseph Dam was to further reduce TDG production in the Upper Columbia River, in addition to the reduction in TDG production reductions that results from shifting spill away from Grand Coulee and to Chief Joseph under the by joint operations of these two dams. The dramatic increase in spill volumes at Chief Joseph Dam under the last year of Phase 1 of the TDG TMDL, coupled with the BPA’s operations for integration of wind generation, resulted in less production of TDG below Grand Coulee and the federal projects with fish passage than would have occurred otherwise. Unfortunately, the integrated operations of the FCRPS to reduce TDG system-wide below federal projects, has come at the expense of increased TDG, and in particular an increase in the mass volume of water supersaturated with TDG, in the Wells Reservoir. This increase in spill operations at Chief Joseph Dam, and resulting increased mass loading of incoming waters with TDG, caused the majority of exceedances at Wells Dam in 2010.
In 2011, Chief Joseph Dam should begin to operate under Phase 2 of the TDG TMDL, as operational and structural changes to meet compliance with a ΔP load allocation of 73 mm Hg have been completed. Compliance with the Chief Joseph Dam TDG load allocation will greatly facilitate future compliance with the TDG WQS at Wells Dam and in the downstream Rocky Reach Dam forebay, as well as at other downstream projects. Operations under Phase 2 of the TDG TMDL will greatly reduce the exposure of ESA-listed salmonids and other aquatic life to elevated TDG in the Upper Columbia River.

4.2 Structural

No permanent structural modifications were proposed or conducted in the 2010 monitoring season. Removal of the bypass barrier structures in Spillway 6 was implemented consistent with the in-season revision to the Spill Playbook.

5 CONCLUSIONS

Although 2010 was a relatively low water year, it was unique given the relatively short high-water period that occurred in June due to storm events which caused high precipitation in the Columbia River basin. Coupled with variable wind generation and its impacts on FCRPS operational flexibility and low electricity demand due to cool weather, relatively higher levels of involuntary spills occurred at projects upstream of Wells Dam. This resulted in a number of observed exceedances of the 125% hourly and 12C-High daily values both in the Wells Dam tailrace and Rocky Reach forebay in the month of June. In response to these exceedances, Douglas PUD implemented in-season changes to its spill operations at the project resulting in improved TDG performance with no observed exceedances of the tailrace TDG criteria after the changes were implemented on July 1st.

At Wells Dam, river flows in June were approximately 4% higher than the 16-year average. June was the only month in 2010 where monthly flows were greater than the 16-year average. During the latter half of June, incoming flows to Wells Dam were often above 200 kcf/s and on nine occasions, hourly flows exceeded the 7Q-10 value of 246 kcf/s. Incoming TDG levels during this time period consistently ranged between 110-114% as Chief Joseph Dam spilled higher volumes of water. The outage of Unit 7 for generator rebuild at Wells Dam resulted in less generating capacity and the need to spill additional water. Outage of Unit 7 likely also contributed to higher TDG by not supporting the surface jet for spill discharged from spillbay 7. These factors, combined with minimal load requirements, high flow volumes and relatively high incoming TDG resulted in the several observed exceedances of the 125% hourly criterion (3 exceedances) and 12C-High 120% criterion (4 exceedances) in the Wells Dam tailrace, and the 12C-High 115% criterion in the Rocky Reach Forebay (8 exceedances) despite implementation of the Spill Playbook.

In response to the observed exceedances, Douglas PUD implemented in-season changes to the 2010 Spill Playbook. Specifically, the amended Spill Playbook states that when spill levels are expected to reach the 53 kcf/s threshold, the Juvenile Bypass System barriers in spillbay 6 should be removed in order to remain in compliance with the TDG criteria in the Wells Dam tailrace and Rocky Reach Dam forebay (the previous threshold for removal was 96 kcf/s). After July 1st, when spill approached the 53 kcf/s
criteria, the bypass barriers were removed and the excess spill was directed through spillbays 6 and 7 rather than through spillbays 5 and 7 (Appendix 4b) resulting in a more compact spill pattern that reduced the air-water interface surface area between spillway flows and the subsequent potential for lateral mixing and air entrainment. After implementation of changes to the spill playbook on July 1st, 8 additional events of high incoming TDG were observed (>113%) at Wells Dam with incoming TDG greater than 110% occurring regularly. Although flows were generally decreasing, no exceedances in the Wells Dam tailrace or the Rocky Reach forebay were observed. The improvement in TDG performance at Wells Dam in July and August was likely due not only to the changes implemented in spill operations at Wells Dam, but also to the changing environmental conditions that impact river flow, temperatures, load, and resulting spill from upstream projects.

Despite high levels of involuntary spill and an increasing frequency of waters with relatively higher TDG levels entering the Wells Project, 94-97% compliance with the TDG criteria is confirmation that implementation and adaptive management, as appropriate, of the Wells Project Spill Playbook is providing a useful means to meet WQS within the Wells Project, and has resulted in reductions in TDG production on a per volume spilled basis. When Chief Joseph Dam is operated in compliance with the Phase 2 TDG TMDL criteria in future years, it is anticipated that this will greatly facilitate compliance with the Washington state TDG criteria at the Wells Project.
6 REFERENCES


http://www.ecy.wa.gov/biblio/0403002.html
Appendix 1. Wells Project 2010 Gas Abatement Plan
2010 TOTAL DISSOLVED GAS ABATEMENT PLAN

WELLS HYDROELECTRIC PROJECT

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April 2010
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Executive Summary

Under the Water Quality Standards (WQS) Chapter 173-201A of the Washington Administrative Code (WAC) criteria developed by Ecology, Total Dissolved Gas (TDG) measurements shall not exceed 110 percent at any point of measurement in any state water body. The standards state that an operator of a dam is not held to the TDG standards when the river flow exceeds the seven-day, 10-year-frequency flood (7Q10). In addition to allowances for natural flood flows, the TDG criteria may be adjusted to aid fish passage over hydroelectric dams when consistent with an Ecology-approved gas abatement plan. Ecology has approved, on a per-application basis, an interim waiver to the TDG standard (110 percent) to allow spill for juvenile fish passage on the Columbia and Snake rivers (WAC 173-201A-200(1)(f)(ii)).

On the Columbia and Snake rivers there are three separate standards with regard to the TDG exemption. First, in the tailrace of a dam, TDG shall not exceed 125 percent as measured in any one-hour period. Further, TDG shall not exceed 120 percent in the tailrace of a dam and shall not exceed 115 percent in the forebay of the next dam downstream as measured as an average of the 12 highest consecutive hourly readings in any one day (24-hour period). The increased levels of spill resulting in elevated TDG levels are intended to allow increased fish passage without causing more harm to fish populations than caused by turbine fish passage. This TDG exemption provided by Ecology is based on a risk analysis study conducted by the National Marine Fisheries Service (NMFS) (NMFS 2000).

The goal of the Wells Total Dissolved Gas Abatement Plan (Gas Abatement Plan) is to implement a long-term strategy to achieve compliance with the Washington state water quality standard for TDG in the Columbia River at the Wells Hydroelectric Project (Wells Project) while continuing to provide safe passage for downstream migrating juvenile salmonids. Douglas PUD, which owns and operates the Wells Project, is submitting this Gas Abatement Plan to Washington Department of Ecology (Ecology) for approval as required for receipt of a TDG exemption at Wells Dam.

This Gas Abatement Plan summarizes the background information related to regulatory and project specific TDG information at the Wells Project (Section 1.0), discusses proposed Wells Project operations and activities related to TDG management (Section 2.0 and 3.0), and provides a summary of compliance and physical monitoring plans, the development of Quality Assurance Project Plans (QAPP), and reporting (Section 4.0).
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1.0 Introduction and Background

The Wells Hydroelectric Project Gas Abatement Plan (Gas Abatement Plan) provides details on operation and structural measures to be implemented in 2010 by Public Utility District No. 1 of Douglas County, Washington (Douglas PUD) at Wells Dam under FERC license for Project No. 2149. These measures are intended to result in compliance with the modified Washington State water quality standards (WQS) for total dissolved gas (TDG) allowed under the TDG exemption.

The goal of the Gas Abatement Plan is to implement a long-term strategy to achieve compliance with the Washington state water quality standard for TDG in the Columbia River at the Wells Hydroelectric Project (Wells Project) while continuing to provide safe passage for downstream migrating juvenile salmonids. Douglas PUD, which owns and operates the Wells Project, is submitting this Gas Abatement Plan to Washington Department of Ecology (Ecology) for approval as required for receipt of a TDG exemption at Wells Dam.

In the past, Ecology has approved Gas Abatement Plans and issued a TDG exemption at Wells Dam. Douglas PUD submitted a Gas Abatement Plan that was approved on March 27, 2003 for one year. In 2004, an extension was granted by Ecology. On March 31, 2005, Ecology approved Douglas PUD’s 2005 Gas Abatement Plan allowing a TDG exemption in support of fish passage through February 2008. In 2008 and 2009, Douglas PUD again submitted Gas Abatement Plans for the fish passage seasons which were approved by Ecology (Appendix 1).

This Gas Abatement Plan summarizes the background information related to regulatory and project specific TDG information at the Wells Project (Section 1.0), discusses proposed Wells Project operations and activities related to TDG management (Section 2.0 and 3.0), and provides a summary of compliance and physical monitoring plans, the development of Quality Assurance Project Plans (QAPP), and reporting (Section 4.0).

1.1 Project Description

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

The Wells Project is the chief generating resource for Douglas PUD. It includes ten generating units with a nameplate rating of 774,300 kW and a peaking capacity of approximately 840,000 kW. The spillway is comprised of eleven spill gates that are capable of spilling a total of 1,180 kcfs. The crest of the spillways is approximately five and a half feet above normal tailwater elevation and two feet below tailwater elevation when plant discharge is 219 kcfs. The design of the Wells Project is unique in that the generating units, spillways, switchyard, and fish passage facilities were combined into a single structure referred to as the hydrocombine. Fish passage facilities reside on both sides of the hydrocombine, which
is 1,130 feet long, 168 feet wide, with a top of dam elevation of 795 feet above mean sea level (msl). The system was developed by Douglas PUD and uses a barrier system to modify the intake velocities on all even numbered spillways (2, 4, 6, 8 and 10). The Wells Project is considered a “run-of-the-river” project due to its relatively limited storage capacity.

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

1.2 Regulatory Framework

The WQS of the Washington Administrative Code address standards for the surface waters of Washington State.

Under the WQS, TDG shall not exceed 110 percent at any point of measurement in any state water body. The standards allow that an operator of a dam is not held to the TDG standards when the river flow exceeds the seven-day, 10-year-frequency flood (7Q10). The 7Q10 flow is the highest value of a running seven consecutive day average using the daily average flows that may be seen in a 10-year period. The 7Q10 total river flow for the Wells Project was computed using the hydrologic record from 1974 through 1998 and a statistical analysis to develop the number from 1930 through 1998. The United States Geological Survey (USGS) Bulletin 17B, “Guidelines for Determining Flood Flow Frequency” was followed. The resulting 7Q10 flow at Wells Dam is 246,000 cfs (Pickett et. al. 2004).

In addition to allowances for natural flood flows, 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. Ecology may approve, on a per application basis, an interim waiver to the TDG standard (110 percent) to allow spill for juvenile fish passage on the Columbia and Snake rivers (WAC 173-201A-200(1)(f)(iii)). On the Columbia and Snake rivers there are three separate standards with regard to the TDG exemption. First, in the tailrace of a dam, TDG shall not exceed 125 percent as measured in any one-hour period. Further, TDG shall not exceed 120 percent in the tailrace of a dam and shall not exceed 115 percent in the forebay of the next dam downstream as measured as an average of the 12 highest consecutive hourly readings in any one day (24-hour period). The increased levels of spill resulting in elevated TDG levels are intended to allow increased fish passage without causing more harm to fish populations than caused by turbine fish passage. This TDG exemption provided by Ecology is based on a risk analysis study conducted by the National Marine Fisheries Service (NMFS) (NMFS 2000).

1.2.1 7Q10

The 7Q10 for this project is 246 kcf. The Project will not be expected to comply with state water quality standards for TDG for incoming flows exceeding this value.

1.2.2 Fish Spill Season

At this time, for purposes of compliance with the WQS for TDG, the “fish spill” season is assumed to occur from April 1 through August 31; and “non-fish spill” season occurs from September 1 to March 31. During non-fish spill, the PUD will make every effort to remain in compliance with the 110 percent standards. During fish spill, the PUD will make every effort not to exceed an average of 120 percent as
measured in the tailrace of the dam. The Project also must not exceed an average of 115 percent as measured in the forebay of the next downstream dam. These averages are based on the twelve (12) highest consecutive hourly readings in any 24-hour period. In addition, there is a maximum one-hour average of 125 percent, relative to atmospheric pressure, during spillage for fish passage. Nothing in these special conditions allows an impact to existing and characteristic uses.

1.2.3 Incoming TDG Levels
Per the TDG exemption criteria, TDG shall not exceed 115 percent in the forebay of the next dam downstream dam as measured as an average of the 12 highest consecutive hourly readings in any one day (24-hour period). During the juvenile fish passage season, TDG concentrations in the Wells Project forebay are primarily determined by the upstream water management activities of Chief Joseph Dam. In June 2000, the USACE recommended installation of flow deflectors at Chief Joseph Dam combined with the “joint operation” of Chief Joseph Dam with Grand Coulee Dam in order to provide the greatest benefit of TDG reduction in the Mid-Columbia River. Since the completion of spill deflectors at Chief Joseph Dam in 2008 and a disproportionate amount of spill from the project resulting from joint operations, relatively higher TDG concentrations are expected in the forebay of Wells Dam.

1.2.4 TMDL
In June 2004, a total maximum daily load (TMDL) report was submitted for the Mid-Columbia River and Lake Roosevelt based on a listing of the area by Washington State on its federal Clean Water Act 303(d) list due to TDG levels exceeding state water quality standards. A summary implementation strategy prepared by Ecology and the Spokane Tribe describe proposed measures that could be used to reduce TDG levels in the Columbia River. Short-term actions primarily focus on meeting Endangered Species Act (ESA) requirements, while long-term goals address both ESA and TMDL requirements (Pickett et. al., 2004). Many of the actions recommended by the TMDL are currently being addressed by Douglas PUD through the implementation of Habitat Conservation Plan activities for anadromous salmon, the Bull Trout Monitoring and Management Plan resulting from consultation with the U.S. Fish and Wildlife Service, and requirements described in current and past Gas Abatement Plans. A status review of the TDG TMDL is planned for 2010. Due to an increase in interest in the TDG requirements, an advisory group consisting of representatives from tribes, federal and state agencies and others, have been convened to evaluate appropriate points of compliance for this TMDL. This group is called the Adaptive Management Team (AMT).

1.3 History of Operations and Compliance

1.3.1 Flows
The Columbia Basin in eastern Oregon, Washington and British Columbia has climate that is best described as desert. Flow from the Columbia River originates in the headwaters of the Canadian Rockies and picks up snow melt from tributary streams as it travels over 1,243 miles before emptying into the Pacific Ocean. The natural hydrograph had low flows in November through January with high flows in May through July. Storage dams in the U.S. and Canada on the Columbia River and its tributaries
upstream of the Wells project capture spring and summer high flows to hold for release in the fall and winter months. There are 85,300 square miles of drainage area above Wells Dam. Table 1 presents information on Columbia River flow as measured at Wells Dam in 2009 and over the past 10 years and shows the current hydrograph of the Columbia River as controlled by upstream storage and release regimes. Because the Wells Project operates in run-of-river mode with very limited active storage, juvenile anadromous salmonid migration occurs within a regime of reduced flows during the spring migration period.

In general, the hydropower system and reservoir operations in the Columbia River are coordinated through a set of complex agreements and policies to optimize the benefits and minimize the adverse effects of project operations. The Wells Project operates within the constraints of the Pacific Northwest Coordination Agreement, Canadian Treaty, Canadian Entitlement Agreement, Hourly Coordination Agreement, the Hanford Reach Fall Chinook Protection Program and the Federal Energy Regulatory Commission (FERC) regulatory and license requirements.

Table 1. Average monthly flows (kcfs) at Wells Dam, by month (2000-2009).

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<td>86.8</td>
</tr>
<tr>
<td>2008</td>
<td>104.0</td>
<td>88.6</td>
<td>82.4</td>
<td>90.3</td>
<td>158.7</td>
<td>206.8</td>
<td>135.3</td>
<td>86.5</td>
<td>60.7</td>
<td>63.0</td>
<td>75.2</td>
<td>94.2</td>
</tr>
<tr>
<td>2009</td>
<td>107.8</td>
<td>80.2</td>
<td>71.5</td>
<td>111.0</td>
<td>122.7</td>
<td>146.6</td>
<td>103.1</td>
<td>74.5</td>
<td>53.5</td>
<td>58.1</td>
<td>80.1</td>
<td>101.8</td>
</tr>
</tbody>
</table>

| All  | 110.1| 104.7| 99.5 | 116.8| 145.6| 166.7| 130.4| 106.9| 74.3 | 75.8 | 88.2 | 106.9|

1.3.2 Spill Operations

1.3.2.1 General Operation

Under the Hourly Coordination Agreement, power operations for the seven dams from Grand Coulee to Priest Rapids are coordinated to meet daily load requirements through the assignment of "coordinated generation" through Central Control hosted at the Public Utility District No. 2 of Grant County (Grant PUD). Automatic control logic is used to maintain pre-set reservoir levels in order to meet load requirements and minimize involuntary spill. These pre-set reservoir levels are maintained at each project through management of a positive or negative "bias" which assigns a project more or less generation depending on whether the reservoir elevation should be increased or decreased in order to maximize system benefits and minimize involuntary spill.
1.3.2.2 Spill for Fish

Wells Dam is a hydrocombine-designed dam where the spillway is situated directly above the powerhouse. Research at Wells Dam in the mid-1980s showed that a modest amount of spill would effectively guide a high percentage of the downstream migrating juvenile salmonids through the Juvenile Bypass System (JBS). The operation of the Wells JBS utilizes the five even numbered spillways. These spillways have been modified with constricting barriers to improve the attraction flow while using modest levels of water. These spillways are used to provide a non-turbine passage route for downstream migrating juvenile salmonids from April through August. Normal operation of the JBS uses 2.2 kcfs per spillway. During periods of extreme high flow, one or more of the JBS barriers may be removed to provide adequate spill capacity to respond to a plant load rejection.

Typically, the JBS will use approximately 6 to 8 percent of the total river flow for fish guidance. The operation of the JBS adds a negligible level of TDG (0 – 2 percent) while meeting a very high level of fish guidance and protection. This high level of fish protection at Wells Dam has met the approval of the fisheries agencies and tribes and is vital to meeting the survival performance standards contained within the FERC approved Habitat Conservation Plan (HCP) with NMFS. The Wells Project fish bypass system is the most efficient system on the mainstem Columbia River. The bypass system on average collects and safely passes 92.0 percent of the spring migrating salmonids (yearling Chinook, steelhead and sockeye) and 96.2 percent of the summer migrating subyearling Chinook (Skalski et al. 1996) (Table 2).

<table>
<thead>
<tr>
<th>Species</th>
<th>% JBS Passage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearling (spring) Chinook</td>
<td>92.0</td>
</tr>
<tr>
<td>Steelhead</td>
<td>92.0</td>
</tr>
<tr>
<td>Sockeye</td>
<td>92.0</td>
</tr>
<tr>
<td>Subyearling (summer/fall) Chinook</td>
<td>96.2</td>
</tr>
</tbody>
</table>

The JBS is utilized for protection of downstream migrating juvenile salmonids. Fish bypass operations at Wells Dam falls into two seasons, Spring Bypass and Summer Bypass. For 21 years, the status of the fish migration for both spring and summer periods was monitored by an array of hydroacoustic sensors placed in the forebay of Wells Dam. Starting in 2003, the operation of the juvenile bypass for the Wells HCP was set with fixed dates that were established based on 21 years of hydroacoustic and fyke net data. The dates for bypass operation are from April 12 through August 26. These dates bracket greater than 95% of both the spring and summer migrants. Annually, there have been as many as ten million juvenile salmonids that have migrated past Wells Dam.

Between the years 1997 and 2004, the volume of water dedicated to the JBS has ranged from 1.5 to 3.2 million acre-feet. Operation of the JBS adds a small amount of dissolved gas (0 to 2 percent) to the river while meeting a very high level of fish guidance and protection. Ecology has authorized an exemption to
the total dissolved gas standard for fish protection on the Columbia and Snake rivers. Operation of the Wells Project JBS does not produce TDG at levels that exceed the Ecology TDG exemption.

1.3.2.3 Flows in Excess of Hydraulic Capacity

The Wells Project is a “run-of-the river” project with a relatively small storage capacity. River flows in excess of the hydraulic capacity of the ten turbines must be passed over the spillways.

The forebay elevation at Wells Dam is set between 781.0 and 771.0 msl. The Wells Project has a hydraulic generating capacity of approximately 220 kcfs (ASL, 2007) and a spillway capacity of 1,180 kcfs. Data for Columbia River flows for eighty-five years at Priest Rapids yielded a peak daily average discharge of 690,000 on June 12, 1948 (USGS web page for historical flows at Priest Rapids on the Columbia River, http://waterdata.usgs.gov/wa/nwis/dv/?site_no=12472800). The hydraulic capacity of Wells Dam is well within the range of recent historical flow data.

1.3.2.4 Flow in Excess of Power Demand

Spill may occur at flows less than the Wells Project hydraulic capacity when the volume of water is greater than the amount required to meet electric power system loads. This may occur during temperate weather conditions when power demand is low or when non-power constraints on river control results in water being moved through the mid-Columbia at a different time of day than the power is required. Hourly coordination (Section 3.2) between hydroelectric projects on the river was established to minimize this situation for spill.

1.3.2.5 Gas Abatement Spill

Gas Abatement Spill is used to manage TDG levels throughout the Columbia River Basin. The Technical Management Team (including NMFS, U.S. Army Corps of Engineers, and Bonneville Power Administration) implements and manages this spill. Gas Abatement Spill is requested from dam operators from a section of the river where gas levels are high. A trade of power generation for spill is made between operators, providing power generation in the river with high TDG and trading an equivalent amount of spill from a project where TDG was low. Historically, the Wells Project has accommodated requests to provide Gas Abatement Spill. In an effort to limit TDG generated at the Wells Project, Douglas PUD has adopted a policy of not accepting Gas Abatement Spill at Wells Dam.

1.3.2.6 Other Spill

Other spill includes spill as a result of maintenance or plant load rejection. A load rejection occurs when the generating plant is forced off-line by an electrical fault, which trips breakers and shuts off the generation. At a run-of-the-river hydroelectric dam, if water cannot flow through operating turbines, then the river flow that was producing power has to be spilled until turbine operation can be restored.

These events are extremely rare, and would account for approximately 10 minutes in every ten years. Maintenance spill is utilized for any activity that requires spill to assess the routine operation of individual spillways and turbine units. These activities include checking gate operation, and all other maintenance that would require spill. The FERC requires that all spillway gates be operated once per
year. To control TDG levels associated with maintenance spill, Douglas PUD limits, to the extent practical, maintenance spill during the spill season.

1.3.3 Compliance Activities in Previous Year

1.3.3.1 Operational

The Wells Project is a “run-of-the river” project with a relatively small storage capacity. River flows in excess of the hydraulic capacity of the ten turbines must be passed over the spillways. Outside of system coordination and gas abatement spill (Douglas PUD has adopted a policy of not accepting the latter), minimization of involuntary spill has primarily focused on minimizing TDG production dynamics of water spilled based upon a reconfiguration of spillway operations. The Wells Project 2009 Gas Abatement Plan (Le and Murauskas, 2009) introduced the latest numerical model developed by the University of Iowa’s IIHR-Hydroscience and Engineering Hydraulic Research Laboratories. The two-phase flow computational fluid dynamics tool was used to predict hydrodynamics of TDG distribution within the tailrace of Wells Dam and further identify operational configurations that would minimize TDG production at the project. In an April 2009 report, the model demonstrated that Wells Dam can be operated to meet the TDG fish spill waiver standards during the passage season with flows up to 7Q-10 levels (246,000 cfs; Pickett et. al. 2004). Compliance was achieved through the use of a concentrated spill pattern through Spillbay No. 7 and surplus flow volume through other spillbays in a defined pattern. These preferred operating conditions create surface-oriented flows by engaging submerged spillway lips below the ogee, thus increasing degasification at the tailrace surface, decreasing supersaturation at depth, and preventing high-TDG waters from bank attachment. These principles were the basis of the 2009 Wells Project Spill Playbook and were fully implemented for the first time during the 2009 fish passage (spill) season.

River flows in 2009 were below average compared to the trailing 10-year average at the Wells Project (Table 3). Flow in 2009 was most similar to 2003-2005, and 2008. These low flow years typically begin with average flows around 100 kcf in April, gradually increasing to 130-150 kcf in May and June, and tapering off to below 70 kcf in September. TDG values for low flow years are slightly lower than, but generally indistinguishable from, the 10-year average. These below average river flow years with available TDG measurements will be used comparatively in discussion, given their similarities to the 2009 monitoring season (Table 4).

From a compliance perspective, two differences are noticeable between current and past low flow years: (1) the higher frequency of out of compliance days at the Wells Forebay, resulting from operations at Chief Joseph Dam; and, (2) the evident improvement of TDG management in the Wells Tailrace through implementation of the 2009 Wells Project Spill Playbook.

Exceedances of TDG numeric criteria of water leaving Chief Joseph Dam increased from 0.2 percent in 2003, 2004, and 2005 (1 of 549 days) to 15.1 percent in 2008 and 2009 (48 of 318 days). This represents a greater than 7,500 percent increase in the frequency of exceedances in the forebay at Wells Dam during low flow years, caused by recent changes in spill and generation management at the upstream
Chief Joseph and Grand Coulee dams. Extensive spill testing, installation of tailrace flow deflectors, and the exchange of spill for generation with Grand Coulee Dam are all likely contributing factors in this dramatic increase in TDG exceedances for water entering the Wells Project (personal communication, K. Easthouse, USACE).

Despite the lack of fish passing Chief Joseph Dam, the USACE has obtained TDG waivers for fish passage in recent years. Unlike typical TDG waivers, operators at Chief Joseph Dam have been allowed a year-round exemption from WQS for TDG (personal communication, R. Turner, USACE). This has allowed increased spill at Chief Joseph Dam and waters with increased TDG levels entering the Wells Project, resulting in TDG exceedances in the forebays of both Wells and Rocky Reach dams.

Despite the additional complicating factor of incoming waters with higher concentrations of TDG in recent years, operations at the Wells Project have improved the management of TDG at downstream compliance stations. During 2009, zero exceedances occurred in the tailrace of Wells Dam (0 of 183 days). During the last four low flow years (2003-2005, and 2008), 97.5 percent of days were in compliance (18 of 714 days). The reduction of exceedances to 0 percent in the tailrace of Wells Dam was likely a result of environmental circumstances in combination with improved operations in the Wells Project. Similarly, compliance in the downstream forebay of Rocky Reach Dam was achieved 100 percent of the time during the 2009 monitoring season. During the last four low flow years, only 93.6 percent of days were in compliance (47 of 685).

Table 3. 2009 river flows compared to 10-yr average flows (in kcfs). Spring is defined as April 12 – June 30. Summer is defined as July 1 – August 26.

<table>
<thead>
<tr>
<th>Season</th>
<th>10 Year (2000-2009) Average Flows (kcfs)</th>
<th>2009 Average Flows</th>
<th>% of 10 Year Average (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>131.2</td>
<td>127.0</td>
<td>96.8</td>
</tr>
<tr>
<td>Summer</td>
<td>108.2</td>
<td>89.0</td>
<td>82.3</td>
</tr>
</tbody>
</table>
Table 4. Average hourly flow (kcfs) and TDG (percent saturation) during the fish spill season at the Wells Project (including tailrace and forebay) 2000-2009, by month. Years of similar river flow volume to 2009 are shaded for comparison.

<table>
<thead>
<tr>
<th></th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>YR</td>
<td>Flow</td>
<td>TDG</td>
<td>Flow</td>
<td>TDG</td>
<td>Flow</td>
<td>TDG</td>
</tr>
<tr>
<td>2000</td>
<td>146</td>
<td>108</td>
<td>150</td>
<td>110</td>
<td>121</td>
<td>112</td>
</tr>
<tr>
<td>2001</td>
<td>63</td>
<td>107</td>
<td>55</td>
<td>109</td>
<td>85</td>
<td>107</td>
</tr>
<tr>
<td>2002</td>
<td>117</td>
<td>108</td>
<td>135</td>
<td>110</td>
<td>206</td>
<td>119</td>
</tr>
<tr>
<td>2003</td>
<td>107</td>
<td>106</td>
<td>131</td>
<td>109</td>
<td>138</td>
<td>112</td>
</tr>
<tr>
<td>2004</td>
<td>87</td>
<td>108</td>
<td>114</td>
<td>109</td>
<td>132</td>
<td>109</td>
</tr>
<tr>
<td>2005</td>
<td>85</td>
<td>107</td>
<td>122</td>
<td>109</td>
<td>131</td>
<td>111</td>
</tr>
<tr>
<td>2006</td>
<td>148</td>
<td>108</td>
<td>165</td>
<td>115</td>
<td>195</td>
<td>120</td>
</tr>
<tr>
<td>2007</td>
<td>155</td>
<td>109</td>
<td>159</td>
<td>112</td>
<td>152</td>
<td>112</td>
</tr>
<tr>
<td>2008</td>
<td>90</td>
<td>106</td>
<td>159</td>
<td>111</td>
<td>207</td>
<td>119</td>
</tr>
<tr>
<td>2009</td>
<td>111</td>
<td>107</td>
<td>123</td>
<td>110</td>
<td>147</td>
<td>113</td>
</tr>
<tr>
<td>All</td>
<td>117</td>
<td>107</td>
<td>146</td>
<td>110</td>
<td>167</td>
<td>114</td>
</tr>
</tbody>
</table>

1.3.3.2 Structural

No structural modifications were proposed or conducted in the 2009 monitoring season.

1.3.4 Compliance Success in Previous Year (2009)

1.3.4.1 TDG

No hourly TDG measurements were recorded above 125 percent saturation, and the 12C-High daily values did not surpass 120 percent on any given day in the tailrace of Wells Dam. The 12C-High values at the forebay of Rocky Reach Dam did not surpass 115 percent on any given day when incoming waters from Chief Joseph Dam were in compliance (12C-High < 115 percent in the forebay of Wells Dam) (Table 5). Although 2009 was a relatively low flow year compared to the past 10 years, management of TDG levels in the Wells Project showed substantial improvements over similar years of river flow. The improvement of TDG management, despite an increasing frequency of TDG exceedances in water entering the Wells Project, is confirmation that the newly implemented 2009 Wells Project Spill Playbook is providing a useful means to meet WQS within the Wells Project.

Table 5. Summary of Spill and TDG Compliance in 2009. Spring is defined as April 12 – June 30. Summer is defined as July 1 – August 26.

<table>
<thead>
<tr>
<th>Season</th>
<th>Average Daily % Spill</th>
<th>Average Daily Spill Volume (kcfs)</th>
<th>Wells Tailrace TDG Compliance (%)</th>
<th>Rocky Reach Forebay TDG Compliance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>6.8</td>
<td>134.4</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Summer</td>
<td>7.8</td>
<td>90.6</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
2.0 Proposed Operations and Activities

2.1 Operational Spill

2.1.1 Minimizing Involuntary Spill

Based on the success of last year’s operations associated with implementation of the Wells Project Spill Playbook, those operations will be followed again this year. The 2009 playbook is attached as Appendix 2.

2.2 Implementation

2.2.1 Fisheries Management Plans

Juvenile salmon and steelhead survival studies conducted at the Wells Project in accordance with the HCP have shown that the operation of the Wells Project, of which the JBS is an integral part, provides an effective means for outmigrating salmon and steelhead to pass through the Wells Project with a high rate of survival (Bickford et al. 2001)(Table 6). The Wells Anadromous Fish Agreement and Habitat Conservation Plan (Douglas PUD 2002) is the Wells Project’s fisheries management plan for anadromous salmonids, and directs operations of the Wells JBS in order to achieve the NNI standard for HCP Plan Species. The Wells JBS is the most efficient juvenile fish bypass system on the mainstem Columbia River (Skalski et al. 1996).

Table 6. 1998-2000 Wells Hydroelectric Project Juvenile Survival Study Results.

<table>
<thead>
<tr>
<th>Species</th>
<th>% Project Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearling (spring) Chinook</td>
<td>96.2</td>
</tr>
<tr>
<td>Steelhead</td>
<td>96.2</td>
</tr>
</tbody>
</table>

The HCP requires juvenile project survival studies to be repeated at Wells Dam in 2010. Final results of those studies may suggest the use of additional passage tools including the use of voluntary spill if necessary to reach survival goals of the HCP. The current phase designations (status of salmon and steelhead species reaching final survival determination) for the HCP Plan species are summarized in Table 7. Specific details regarding survival study design, implementation, analysis, and reporting are available in annual summary reports prepared and approved by the Wells HCP Coordinating Committee.
Table 7. Wells Hydroelectric Project Habitat Conservation Plan Species Phase Designations.

<table>
<thead>
<tr>
<th>Species</th>
<th>Phase Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearling (spring) Chinook</td>
<td>Phase III¹ – Standards Achieved (22-Feb-05)</td>
</tr>
<tr>
<td>Steelhead</td>
<td>Phase III – Standards Achieved (22-Feb-05)</td>
</tr>
<tr>
<td>Sockeye</td>
<td>Phase III – Additional Juvenile Studies (22-Feb-05)</td>
</tr>
<tr>
<td>Subyearling (summer/fall) Chinook</td>
<td>Phase III – Additional Juvenile Studies (22-Feb-05)</td>
</tr>
<tr>
<td>Coho</td>
<td>Phase III – Additional Juvenile Studies (27-Dec-06)</td>
</tr>
</tbody>
</table>

In 2010, Douglas PUD shall continue to operate Wells Dam adult fishways and the JBS in accordance with HCP operations criteria to protect aquatic life designated uses. Furthermore, all fish collection (hatchery broodstock and/or evaluation activities) or assessment activities that occur at Wells Dam will require approval by Douglas PUD and the HCP Coordinating Committee to ensure that such activities protect aquatic life designated uses.

Douglas PUD shall continue to operate the Wells Project in a coordinated manner toward reducing forebay fluctuations and maintaining relatively stable reservoir conditions that are beneficial to multiple designated uses (aquatic life, recreation, and aesthetics). Coordinated operations reduce spill, thus reducing the potentials for exceedances of the TDG numeric criteria and impacts to aquatic life associated with TDG.

### 2.2.2 Biological Monitoring

Douglas PUD will work with the Washington Department of Fish and Wildlife hatchery programs to monitor the occurrence of Gas Bubble Trauma (GBT) on adult broodstock collected for hatchery needs. Upon collection of brood, hatchery staff will inoculate each fish, place a marking identification tag on them and look for any fin markings or unusual injuries. NMFS has shown that GBT is low if the level of TDG can be managed to below 120 percent (NMFS 2000). They recommend that “the biological monitoring components will include smolt monitoring at selected smolt monitoring locations and daily data collection and reporting only when TDG exceeds 125 percent for an extended period of time.” Thus, biological sampling at Wells Dam of adult broodstock will only occur when hourly TDG levels in the mid-Columbia exceed 125 percent.

At most hydroelectric projects on the Columbia River, a juvenile migrant sampling station is incorporated into the JBS. This allows for the external observation of fish for signs of GBT. The signs of GBT are bubbles under the skin of the fish along the fin rays and near the eye sockets. While juvenile migrants are the choice fish for sampling when inspecting for GBT, the JBS at Wells Dam does not have facilities incorporated to allow for juvenile fish sampling and observation. As in past years, if hourly TDG levels exceed 125 percent in the tailrace of Wells Dam, Douglas PUD will request biological sampling of migrating juveniles for symptoms of GBT at the juvenile sampling facility at Rocky Reach Dam.

¹ Phase III = Dam survival >95% or project survival >93% or combined juvenile and adult survival >91% (Standard Achieved).
2.2.3 Water Quality Forums

Douglas PUD is currently involved in the Water Quality Team meetings held in Portland, Oregon. The purpose of the Water Quality Team meetings is to address regional water quality issues. This forum allows regional coordination for monitoring, measuring, and evaluating water quality in the Columbia Basin.

Douglas PUD will continue its involvement in the Water Quality Team meetings for further coordination with other regional members.

Douglas PUD is also currently involved in the Transboundary Gas Group that meets annually to coordinate and discuss cross border dissolved gas issues in Canada and the U.S. Douglas PUD will continue its involvement with the Transboundary Gas Group.

In 2009, Douglas PUD actively participated in regional water quality forums with Ecology, Washington Department of Fish and Wildlife, Tribal Agencies, the U.S. Fish and Wildlife Service, the USACE, and other Mid-Columbia PUDs (i.e., Grant and Chelan counties). These meetings, ranging from the Transboundary Gas Group to Columbia Basin meetings with the USACE, allow for regional coordination for monitoring, measuring, and evaluating water quality in the Columbia Basin. Douglas PUD will continue its involvement in such forums to further improve coordination with other regional water quality managers as detailed in section 5.1.2.

3.0 Structural Activities

No structural modifications related to spill are scheduled to occur at the Wells Project in 2010.

4.0 Compliance and Physical Monitoring

4.1 Monitoring Locations

4.1.1 TDG

TDG monitoring has been implemented in the Wells Dam forebay since 1984. Douglas PUD began monitoring TDG levels in the Wells Dam tailrace in 1997 by collecting data from a boat and drifting through the tailrace at four points across the width of the river. During the transect monitoring, no TDG “hot spots” were detected; the river appeared completely mixed horizontally. A fixed TDG monitoring station was established in 1998. The placement of the fixed monitoring station was determined based upon the 1997 work and was further verified as collecting data representative of river conditions during a 2006 TDG assessment at Wells Dam (EES et. al. 2007). Results of the 2008-2009 TDG numerical modeling activities being conducted by University of Iowa/IIHR have also confirmed that the tailrace monitoring station is located at a site representative of the river, particularly during higher flows. Furthermore, locations of both forebay and tailrace sensors had to be protected to avoid sensor/data loss and damage and for safe accessibility during extreme high flows. The current locations of both the forebay and tailrace monitors took these criteria into consideration.
TFG monitoring at the Wells Project commenced on April 1 and will continue until September 15 annually. This monitoring period will encompass the operation of the Wells JBS as well as the time period river flows are at their highest and when a majority of forced spill occurs. Throughout this period, data from both forebay and tailrace sensors are transmitted by slave radio transmitters to a master radio at Wells Dam. This system is checked at the beginning of the season for communication between the probes and transmitters by technicians at Wells Dam. Total dissolved gas data are sent and logged at the Douglas PUD Headquarters’ building in 15-minute intervals. Information on barometric pressure, water temperature and river gas pressure is sent to the U.S. Army Corps of Engineers on the hour over the Internet. The four data points (15 minute) within an hour are used in compiling hourly TDG values, the 24 hour TDG average and twelve maximum hour TDG averages.

4.1.2 Water Temperature

Douglas PUD has been monitoring water temperatures throughout the Wells Reservoir and in the Wells Dam tailrace year round since 2005. Temperature monitoring locations are provided in Table 8. Temperature monitoring through the reservoir and the inundated portions of tributary streams will be performed with Onset Tidbit thermographs.

Table 8. List of Wells Reservoir and tributary temperature monitoring stations.

<table>
<thead>
<tr>
<th>River</th>
<th>Side/Mile</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Columbia</td>
<td>Left / 515.6</td>
<td>Wells Forebay*</td>
</tr>
<tr>
<td>Columbia</td>
<td>Left / 530</td>
<td>Near Brewster</td>
</tr>
<tr>
<td>Columbia</td>
<td>Left / 535.3</td>
<td>Brewster Flats</td>
</tr>
<tr>
<td>Columbia</td>
<td>Left / 544.5</td>
<td>Chief Joseph Tailrace</td>
</tr>
<tr>
<td>Columbia</td>
<td>Left / 515.5</td>
<td>Wells Dam Tailrace</td>
</tr>
<tr>
<td>Columbia</td>
<td>Right / 515.5</td>
<td>Wells Dam Tailrace</td>
</tr>
<tr>
<td>Methow</td>
<td>Right / 2.8</td>
<td>Near Pateros</td>
</tr>
<tr>
<td>Okanagan</td>
<td>Center / 10.5</td>
<td>Near Monse</td>
</tr>
<tr>
<td>Methow</td>
<td>Center / 0.4</td>
<td>Mouth of Methow</td>
</tr>
<tr>
<td>Okanagan</td>
<td>Center / 1.3</td>
<td>Mouth of Okanogan</td>
</tr>
</tbody>
</table>

4.2 Quality Assurance

4.2.1 TDG

As part of the Douglas PUD’s Quality Assurance/Quality Control (QA/QC) program, Douglas PUD’s water quality consultant will visit both TDG sensor sites monthly for maintenance and calibration of TDG instruments. Calibration follows criteria established by the USACE, with the exception of monthly rather than bi-weekly calibration of sensors. A spare probe will be available and field-ready in the event that a probe needs to be removed from the field for repairs.

The consultant will inspect instruments during the monthly site visits and TDG data will be monitored weekly by Douglas PUD personnel. If, upon inspection of instruments or data, it is deemed that repairs
are needed, they will be promptly made. Occasionally during the monthly sensor calibration, an error may develop with the data communication. These problems are handled immediately. Generally, the radio transmitters at each fixed station will run the entire season without any problems.

Douglas PUD intends to collect quality, usable data for each day over the 168-day (April 1 – September 15) monitoring season. As part of the quality assurance process, data anomalies will be removed. This would include data within a 2-hour window of probe calibration and any recording errors that result from communication problems. Data errors will prompt a technician or water quality specialist site visit, to inspect the instrument and repair or replace if necessary.

4.2.2 Water Temperature

QA/QC measures will be accomplished through calibration of thermographs at the beginning and end of a period of sensor deployment. As part of the QA/QC process, data anomalies will be identified and removed from the data set. Sensors will be deemed unreliable if calibration against a Bureau of Standard accuracy thermometer shows a variance of ± 0.2°C. Thermographs will be swapped out quarterly (every three months) with recently tested sensors to avoid data loss.

4.3 Reporting

Upon approval of the Wells Gas Abatement Plan and issuance of a Wells Project TDG exemption, Douglas PUD shall submit an annual report describing the results of all monitoring activities described within this Gas Abatement Plan. The report will be submitted to Ecology no later than December 31 of each year that the TDG exemption is active. The report will summarize all Gas Abatement Plan activities conducted for the year in which it is submitted as required by Ecology.

5.0 Conclusions

Pending approval by Ecology, implementation of the measures identified within the 2010 Gas Abatement Plan are intended to serve as a long-term strategy to maintain compliance with the Washington state water quality standard for TDG in the Columbia River at the Wells Project while continuing to provide safe passage for downstream migrating juvenile salmonids.
6.0 Literature Cited


7.0 Appendices
June 4, 2009

Josh Murauskas
Douglas County PUD No. 1
1151 Valley Mall Boulevard
East Wenatchee, WA 98802

RE: Wells Hydropower Project No. 2149
2008 Annual Gas Abatement Report and
2009 Gas Abatement Plan

Dear Josh Murauskas:

The 2009 Gas Abatement Plan for the Wells Dam is hereby approved for the 2009 fish spill season.

The results presented in the 2008 Gas Abatement Report and in other studies Douglas Public Utility District (PUD) has done over the recent months as part of the re-licensing effort are truly appreciated.

As we discussed recently, it would be helpful if the mid-Columbia PUDs could meet with Ecology to coordinate on format and content of the Gas Abatement Plans (GAPs) and Gas Abatement reports.

Following are comments on the 2008 ("annual") Gas Abatement Report. We expect these problems will be addressed in the draft and final Gas Abatement reports for the 2009 fish spill season. We would like to meet with the PUD to discuss the content of the draft report shortly after we receive it.

I. General Comments

We really appreciate the inclusion of the "2009 Playbook" as part of the GAP. This provides very useful information.
The 2008 GAP required that the following be included in the (annual) Gas Abatement Report (see Section 5.3 h):

i. Flow and TDG levels, on a daily basis, with purpose of spill (e.g., fish spill, turbine down time.)

ii. Summary of exceedances and what was done to correct the exceedances.

iii. Results of the fish passage efficiency (FPE) studies and survival per the Habitat Conservation Plan (HCP).

It is very important that this information be included in the next (2009) Annual Gas Abatement Report. Note that the purpose of spill is to be provided for each day.

II. More Specific

1) Table 4.0-1 could be made more useful to help determine: a) compliance with state water quality standards; b) impacts of incoming flows on compliance; and/or c) impacts of operation on compliance.

2) Section 4.2.4, last sentence, says the PUD “has adopted a policy of not accepting in [sic] Gas Abatement Spill at Wells Dam”. What does this mean? Did you mean “not any”? Or something else?

3) Please describe the locations of “WEL.W” (page 13) and “WEL” (page 15).

4) Need section in Chapter 4 that describes the 2008 fish management activities and any results or comments provided by the PUD at the water quality meetings.

5) It seems more appropriate to put the discussion of the historical TDG monitoring in the forebay (page 15, first paragraph) in Section 4, “History of Operations and TDG Compliance Monitoring”.

6) Where are the adult broodstock collected (page 16)?

Please let me know if you have any questions or suggestions.

Sincerely,

[Signature]

Pat Irle
Hydropower Projects Manager
Water Quality Program
Memorandum

To:       Ken Pflueger, Mike Bruno, Dub Simmons, Arlen Simon, Hank Lubean
From:     Joshua Murauskas, Shane Bickford, Duncan Hay (Oakwood Consultants)
Date:     April 21, 2009
Subject:  Wells Dam Spill Playbook, 2009

Douglas PUD has conducted several modeling assessments aimed at gaining a better understanding of the effect of spill operations on the production, transport and mixing of TDG in the Wells Dam tailrace.

Results indicate that:

1. Concentrated spill operations (as opposed to spread) reduce TDG production and increase degasification at the tailwater surface.

2. Discharge from spillbays (denoted S hereafter) located near the middle of the dam (e.g., S7) prevent water with high TDG from attaching to the shoreline.

3. Forced spill exceeding Juvenile Bypass System (JBS) flows of 2.2 kcfs must be increased to ≥ 15 kcfs to ensure that the submerged spillway lip below the ogee is engaged. The resulting force will create flows that are surface oriented, ultimately promoting degasification at the tailwater surface.

The attached Spill Strategy is based on these principles and the preferred operating conditions will help achieve compliance with the Washington State water quality standards. Further details are provided in the Wells Hydroelectric Project Updated Study Report Document submitted to the FERC on April 15th, 2009.
I. No Forced Spill

The Wells Dam JBS (even numbered spillbays, 10.0 kcs total) should be operated continuously throughout the juvenile salmon outmigration (normally April 12 to August 26). The Wells JBS is normally operated with 1.7 kcs passed through S2 and S10, and 2.2 kcs through S4, S6, and S8 (Figure 1).

<table>
<thead>
<tr>
<th>Spillbay</th>
<th>Spill (kcs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>0.0</td>
</tr>
<tr>
<td>S2</td>
<td>1.7</td>
</tr>
<tr>
<td>S3</td>
<td>0.0</td>
</tr>
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<td>2.2</td>
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<td>S5</td>
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<td>S6</td>
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</tr>
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<tr>
<td>S8</td>
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</tr>
<tr>
<td>S9</td>
<td>0.0</td>
</tr>
<tr>
<td>S10</td>
<td>1.7</td>
</tr>
<tr>
<td>S11</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**Figure 1.** Operational configuration under no forced spill (JBS only).

II. Forced Spill (≤ 53.0 kcs)

As forced spill increases, Project Operators should allocate all spill through S7 until the maximum capacity is reached through that spillbay (~43.0 kcs). This, along with the already established JBS spill (10.0 kcs) would equal 53.0 kcs (Figure 2). Over 90% of the spill events over the past decade could have been handled under this configuration.

<table>
<thead>
<tr>
<th>Spillbay</th>
<th>Spill (kcs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>0.0</td>
</tr>
<tr>
<td>S2</td>
<td>1.7</td>
</tr>
<tr>
<td>S3</td>
<td>0.0</td>
</tr>
<tr>
<td>S4</td>
<td>2.2</td>
</tr>
<tr>
<td>S5</td>
<td>0.0</td>
</tr>
<tr>
<td>S6</td>
<td>2.2</td>
</tr>
<tr>
<td>S7</td>
<td>43.0</td>
</tr>
<tr>
<td>S8</td>
<td>2.2</td>
</tr>
<tr>
<td>S9</td>
<td>0.0</td>
</tr>
<tr>
<td>S10</td>
<td>1.7</td>
</tr>
<tr>
<td>S11</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**Figure 2.** Operational configuration under spill ≤ 53.0 kcs (including JBS).
### III. Forced Spill (> 53.0 kcf.s)

After S7 reaches 43.0 kcf.s, spill should be allocated to S5. Since a minimum of 15.0 kcf.s is needed to fully engage the submerged spillway lip below the ogee, spill through S7 must be relocated to S5 (Figure 3). As flow increases, spill should continually increase through S5 until paired with S7 (e.g., 28.0 kcf.s through S5 and S7). After this point (66.0 kcf.s), both S5 and S7 can be increased until both spillbays have reached 43.0 kcf.s (96.0 kcf.s, Figure 4).

![Figure 3](image1.png)

**Figure 3.** Operational configuration under forced spill > 53.0 kcf.s (including JBS). In this instance (54.0 kcf.s of total spill), 16.0 kcf.s is allocated through S5 in order to engage the submerged spillway lip.

![Figure 4](image2.png)

**Figure 4.** Operational configuration under forced spill > 53.0 kcf.s (including JBS). In this instance (96.0 kcf.s of spill), 43.0 kcf.s is allocated through both S5 and S7.
IV. Forced Spill (> 96.0 kcf/s)

After both S5 and S7 reach 43.0 kcf/s, spill should be allocated to S9. Since a minimum of 15.0 kcf/s is needed to fully engage the submerged spillway lip below the ogee, spill through S5 should be relocated to S9 (Figure 5). As flow increases, spill can be continually increased through S5 until paired with S9 (28.0 kcf/s through S5 and S9, while S7 continues at 43.0 kcf/s). After this point, both S5 and S7 can be increased until both spillbays have reached 43.0 kcf/s, equal to discharge through S7 (139.0 kcf/s, Figure 6).

![Figure 5. Operational configuration under forced spill > 96.0 kcf/s (including JBS). In this instance (97.0 kcf/s of total spill), 16.0 kcf/s is allocated through S9 in order to engage the submerged spillway lip.](image)

![Figure 6. Operational configuration under forced spill > 96.0 kcf/s (including JBS). In this instance (139.0 kcf/s of total spill), 43.0 kcf/s is allocated through S5, S7, and S9.](image)
V. Forced Spill (> 96.0 kcf) and JBS Barriers in S6 Removed

After both S5 and S7 reach 43.0 kcf, spill can also be allocated to S6, provide the JBS barrier has been removed. Since a minimum of 15.0 kcf is needed to fully engage the submerged spillway lip below the ogee, spill through S5 (or S9 if scenario IV is in play) should be relocated to S6 (Figure 7). As flow increases, spill can be continually increased through S5 until paired with S6 (30.0 kcf through S5 and S6, while S7 continues at 43.0 kcf). After this point, both S5 and S6 can be increased until all three spillbays have reached 43.0 kcf (136.8 kcf of spill, Figure 8).

Figure 7. Operational configuration under forced spill > 96.0 kcf (with removal of JBS barriers in S6). In this instance (96.8 kcf of total spill), spill from S5 is relocated to S6 to maintain concentrated flow with S7. A spill of 16.0 kcf is maintained in S5 as to engage the spillway lip below the ogee.

Figure 8. Operational configuration under forced spill > 96.0 kcf (with removal of JBS barriers in S6). In this instance (136.8 kcf of total spill), 43.0 kcf is allocated through S5, S7, and S9.
VI. Forced Spill (> 139.0 kcfs)

Forced spill exceeding 139.0 kcfs rarely occurs (less than 0.5%). If these conditions arise and total river flow exceeds 246.0 kcfs, then 7Q-10 conditions are occurring and Wells Dam is exempt from the TDG standards. Under this situation, Project Operators may perform any combination of operations to ensure that flood waters are safely passed. Also, at this point, JBS barriers will likely be removed allowing additional flexibility to spill up to 43 kcfs through S2, S4, S6, and S8. Project Operators may pass spill through S3 in a similar fashion to operations mentioned above (starting at a minimum of 15.0 kcfs to ensure that spillway lips are engaged).
# I. Spill Lookup Table

<table>
<thead>
<tr>
<th>Operation</th>
<th>Total Spill</th>
<th>S1 JBS</th>
<th>S2 JBS</th>
<th>S3 JBS</th>
<th>S4 JBS</th>
<th>S5 JBS</th>
<th>S6 JBS</th>
<th>S7 JBS</th>
<th>S8 JBS</th>
<th>S9 JBS</th>
<th>S10 JBS</th>
<th>S11 JBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. No Forced Spill</td>
<td>10.0</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>0.0</td>
<td>2.2</td>
<td>0.0</td>
<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>II. Spill (≤ 53.0 kcfs), min.</td>
<td>20.0</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>0.0</td>
<td>2.2</td>
<td>10.0</td>
<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>II. Spill (≤ 53.0 kcfs), max.</td>
<td>53.0</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>0.0</td>
<td>2.2</td>
<td>43.0</td>
<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>III. Spill (&gt; 53.0 kcfs), min.</td>
<td>54.0</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>16.0</td>
<td>2.2</td>
<td>28.0</td>
<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>III. Spill (&gt; 53.0 kcfs), max.</td>
<td>96.0</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>43.0</td>
<td>2.2</td>
<td>43.0</td>
<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
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</tr>
<tr>
<td>IV. Spill (&gt; 96.0 kcfs), min.</td>
<td>97.0</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>28.0</td>
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<td>43.0</td>
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<td>16.0</td>
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<tr>
<td>IV. Spill (&gt; 96.0 kcfs), max.</td>
<td>139.0</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>43.0</td>
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<td>43.0</td>
<td>2.2</td>
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</tr>
<tr>
<td>V. Spill (&gt; 96.0 kcfs, S6 JBS out), min.</td>
<td>96.8</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>16.0</td>
<td>30.0</td>
<td>43.0</td>
<td>2.2</td>
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<tr>
<td>V. Spill (&gt; 96.0 kcfs, S6 JBS out), max.</td>
<td>136.8</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>43.0</td>
<td>43.0</td>
<td>43.0</td>
<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>V. Spill (&gt;139.0 kcfs), min.</td>
<td>140.0</td>
<td>0.0</td>
<td>1.7</td>
<td>16.0</td>
<td>2.2</td>
<td>43.0</td>
<td>2.2</td>
<td>43.0</td>
<td>2.2</td>
<td>28.0</td>
<td>1.7</td>
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<tr>
<td>V. Spill (&gt;139.0 kcfs), max.</td>
<td>-</td>
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<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

*Operators may adjust as needed.*

*TDG exemption in place when total river flows exceed 246.0 kcfs.*

Notes:
1. No spill through S1 and S11 as to minimize interference with fish ladders.
2. Even-numbered spillbays are designated as the Juvenile Bypass System (JBS).
3. Primary spillbays for forced spill are S7, S5, S9, and S3 (in that order).
Appendix 2. Letter of 2010 GAP approval from Washington Department of Ecology
April 9, 2010

Beau Patterson
Douglas County PUD No. 1
1151 Valley Mall Boulevard
East Wenatchee, WA 98802

RE: Wells Hydropower Project No. 2149
    2010 Total Dissolved Gas Abatement Plan

Dear Beau -

The 2010 Total Dissolved Gas Abatement Plan for Wells Dam is hereby approved for the 2010 fish spill season, in accordance with WAC 173-201A-200(1)(f)(ii).

Two minor comments:

1) The draft Gas Abatement Plan report for this year should be submitted to Washington State Department of Ecology (Ecology) by October 31, 2010.

2) The next annual draft Gas Abatement Plan (for 2011) should be submitted to Ecology by February 28th, 2011, at the latest, so that we can prepare comments and Douglas County Public Utility District can address those comments by April 1st, 2011, the date that fish spill is expected to begin.

Thanks for your high quality work.

Sincerely,

[Signature]
Pat Irlé
Hydropower Projects Manager
Water Quality Program
Appendix 3. Example Hach® HYDROLAB MiniSonde calibration report from the 2010 monitoring season
Calibration Report

Client: Public Utility District No. 1 of Douglas County

Date: 26-Jul-10
Arrival Time: 10:10
Departure Time: 10:45

Site: WEL

Calibration Type: Field

Date: 26-Jul-10
Time: 10:20

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<tr>
<td>TDG 100%</td>
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<td>TDG 113%</td>
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<td>N / C</td>
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<td>TDG 126%</td>
<td>935.7</td>
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<td>N / C</td>
</tr>
<tr>
<td>TDG 139%</td>
<td>1035.7</td>
<td>1037</td>
<td>N / C</td>
</tr>
</tbody>
</table>

TDG membrane ID: DPUD-10-01

Integrity Check: Pass

Comments:
## Calibration Report

**Client:** Public Utility District No. 1 of Douglas County

<table>
<thead>
<tr>
<th>Date</th>
<th>Site: WELW</th>
</tr>
</thead>
<tbody>
<tr>
<td>26-Jul-10</td>
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</tbody>
</table>

**Arrival Time:** 11:15  
**Departure Time:** 11:55

**Calibration Type:** Field

<table>
<thead>
<tr>
<th>Date</th>
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<td>26-Jul-10</td>
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</tbody>
</table>

**BP Station:** 736 mmHg

<table>
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<tr>
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<td>19.2</td>
<td>N / C</td>
</tr>
<tr>
<td>TDG 100%</td>
<td>736</td>
<td>737</td>
<td>N / C</td>
</tr>
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<td>836</td>
<td>837</td>
<td>N / C</td>
</tr>
<tr>
<td>TDG 126%</td>
<td>936</td>
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<td>N / C</td>
</tr>
<tr>
<td>TDG 139%</td>
<td>1036</td>
<td>1037</td>
<td>N / C</td>
</tr>
</tbody>
</table>

**TDG membrane ID**

| TDG membrane ID | DPUD-10-02 |

**Integrity Check**

| Integrity Check | Pass |

**Comments:**
Appendix 4a. Wells Project 2010 Spill Playbook
Douglas PUD has conducted several modeling assessments aimed at gaining a better understanding of the effect of spill operations on the production, transport and mixing of TDG in the Wells Dam tailrace.

Results indicate that:

1. Concentrated spill operations (as opposed to spread) reduce TDG production and increase degasification at the tailwater surface.

2. Discharge from spillbays (denoted S hereafter) located near the middle of the dam (e.g., S7) prevent water with high TDG from attaching to the shoreline.

3. Forced spill exceeding Juvenile Bypass System (JBS) flows of 2.2 kcfs must be increased to ≥ 15 kcfs to ensure that the submerged spillway lip below the ogee is engaged. The resulting force will create flows that are surface oriented, ultimately promoting degasification at the tailwater surface.

The attached Spill Strategy is based on these principles and the preferred operating conditions will help achieve compliance with the Washington State water quality standards. Further details are provided in the Wells Hydroelectric Project Updated Study Report Document submitted to the FERC on April 15th, 2009 and in the 2010 Gas Abatement Plan submitted and approved by Ecology in April 2010.
I. No Forced Spill

The Wells Dam JBS (even numbered spillbays, 10.0 kcf total) should be operated continuously throughout the juvenile salmon outmigration (normally April 12 to August 26). The Wells JBS is normally operated with 1.7 kcf passed through S2 and S10, and 2.2 kcf through S4, S6, and S8 (Figure 1).

II. Forced Spill (≤ 53.0 kcf)

As forced spill increases, Project Operators should allocate all spill through S7 until the maximum capacity is reached through that spillbay (~43.0 kcf). This, along with the already established JBS spill (10.0 kcf) would equal 53.0 kcf (Figure 2). Over 90% of the spill events over the past decade could have been handled under this configuration.

Figure 1. Operational configuration under no forced spill (JBS only).

Figure 2. Operational configuration under spill ≤ 53.0 kcf (including JBS).
III. Forced Spill (> 53.0 kcfs)

After S7 reaches 43.0 kcfs, spill should be allocated to S5. Since a minimum of 15.0 kcfs is needed to fully engage the submerged spillway lip below the ogee, spill through S7 must be relocated to S5 (Figure 3). As flow increases, spill should continually increase through S5 until paired with S7 (e.g., 28.0 kcfs through S5 and S7). After this point (66.0 kcfs), both S5 and S7 can be increased until both spillbays have reached 43.0 kcfs (96.0 kcfs, Figure 4).

Figure 3. Operational configuration under forced spill > 53.0 kcfs (including JBS). In this instance (54.0 kcfs of total spill), 16.0 kcfs is allocated through S5 in order to engage the submerged spillway lip.

Figure 4. Operational configuration under forced spill > 53.0 kcfs (including JBS). In this instance (96.0 kcfs of spill), 43.0 kcfs is allocated through both S5 and S7.
IV. Forced Spill (> 96.0 kcf/s)

After both S5 and S7 reach 43.0 kcf/s, spill should be allocated to S9. Since a minimum of 15.0 kcf/s is needed to fully engage the submerged spillway lip below the ogee, spill through S5 should be relocated to S9 (Figure 5). As flow increases, spill can be continually increased through S5 until paired with S9 (28.0 kcf/s through S5 and S9, while S7 continues at 43.0 kcf/s). After this point, both S5 and S7 can be increased until both spillbays have reached 43.0 kcf/s, equal to discharge through S7 (139.0 kcf/s, Figure 6).

**Figure 5.** Operational configuration under forced spill > 96.0 kcf/s (including JBS). In this instance (97.0 kcf/s of total spill), 16.0 kcf/s is allocated through S9 in order to engage the submerged spillway lip.

**Figure 6.** Operational configuration under forced spill > 96.0 kcf/s (including JBS). In this instance (139.0 kcf/s of total spill), 43.0 kcf/s is allocated through S5, S7, and S9.
V. Forced Spill (> 96.0 kcf) and JBS Barriers in S6 Removed

After both S5 and S7 reach 43.0 kcf, spill can also be allocated to S6, provided the JBS barrier has been removed. Since a minimum of 15.0 kcf is needed to fully engage the submerged spillway lip below the ogee, spill through S5 (or S9 if scenario IV is in play) should be relocated to S6 (Figure 7). As flow increases, spill can be continually increased through S5 until paired with S6 (30.0 kcf through S5 and S6, while S7 continues at 43.0 kcf). After this point, both S5 and S6 can be increased until all three spillbays have reached 43.0 kcf(136.8 kcf of spill, Figure 8).

![Figure 7: Operational configuration under forced spill > 96.0 kcf (with removal of JBS barriers in S6). In this instance (96.8 kcf of total spill), spill from S5 is relocated to S6 to maintain concentrated flow with S7. A spill of 16.0 kcf is maintained in S5 as to engage the spillway lip below the ogee.](image)

![Figure 8: Operational configuration under forced spill > 96.0 kcf (with removal of JBS barriers in S6). In this instance (136.8 kcf of total spill), 43.0 kcf is allocated through S5, S7, and S9.](image)
VI. Forced Spill (> 139.0 kcfs)

Forced spill exceeding 139.0 kcfs rarely occurs (less than 0.5%). If these conditions arise and total river flow exceeds 246.0 kcfs, then 7Q-10 conditions are occurring and Wells Dam is exempt from the TDG standards. Under this situation, Project Operators may perform any combination of operations to ensure that flood waters are safely passed. Also, at this point, JBS barriers will likely be removed allowing additional flexibility to spill up to 43 kcfs through S2, S4, S6, and S8. Project Operators may pass spill through S3 in a similar fashion to operations mentioned above (starting at a minimum of 15.0 kcfs to ensure that spillway lips are engaged).
## I. Spill Lookup Table

<table>
<thead>
<tr>
<th>Operation</th>
<th>Total Spill</th>
<th>S1</th>
<th>S2 (JBS)</th>
<th>S3</th>
<th>S4 (JBS)</th>
<th>S5</th>
<th>S6 (JBS)</th>
<th>S7</th>
<th>S8</th>
<th>S9</th>
<th>S10 (JBS)</th>
<th>S11</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. No Forced Spill</td>
<td>10.0</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>0.0</td>
<td>2.2</td>
<td>0.0</td>
<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>II. Spill (≤ 53.0 kcfs), min.</td>
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<td>2.2</td>
<td>0.0</td>
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<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>II. Spill (≤ 53.0 kcfs), max.</td>
<td>53.0</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>0.0</td>
<td>2.2</td>
<td>43.0</td>
<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>III. Spill (&gt; 53.0 kcfs), min.</td>
<td>54.0</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>16.0</td>
<td>2.2</td>
<td>28.0</td>
<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>III. Spill (&gt; 53.0 kcfs), max.</td>
<td>96.0</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>43.0</td>
<td>2.2</td>
<td>43.0</td>
<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>IV. Spill (&gt; 96.0 kcfs), min.</td>
<td>97.0</td>
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<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>28.0</td>
<td>2.2</td>
<td>43.0</td>
<td>2.2</td>
<td>16.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>IV. Spill (&gt; 96.0 kcfs), max.</td>
<td>139.0</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>43.0</td>
<td>2.2</td>
<td>43.0</td>
<td>2.2</td>
<td>43.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>V. Spill (&gt; 96.0 kcfs, S6 JBS out), min.</td>
<td>96.8</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>16.0</td>
<td>30.0</td>
<td>43.0</td>
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<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>V. Spill (&gt; 96.0 kcfs, S6 JBS out), max.</td>
<td>136.8</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>43.0</td>
<td>43.0</td>
<td>43.0</td>
<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>V. Spill (&gt;139.0 kcfs), min.</td>
<td>140.0</td>
<td>0.0</td>
<td>1.7</td>
<td>16.0</td>
<td>2.2</td>
<td>43.0</td>
<td>2.2</td>
<td>43.0</td>
<td>2.2</td>
<td>28.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>V. Spill (&gt;139.0 kcfs), max.</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: (1) No spill through S1 and S11 as to minimize interference with fish ladders. (2) Even-numbered spillbays are designated as the Juvenile Bypass System (JBS). (3) Primary spillbays for forced spill are S7, S5, S9, and S3 (in that order).

Operators may adjust as needed.

TDG exemption in place when total river flows exceed 246.0 kcfs.
Appendix 4b. Wells Project 2010 Spill Playbook, 2010 Mid-season Revision
Memorandum

To: Ken Pflueger, Mike Bruno, Dub Simmons, Arlen Simon, Hank Lubean, Tom Kahler
From: Beau Patterson, Shane Bickford
Date: July 1, 2010
Subject: Wells Dam Spill Playbook, 2010 mid-season revision

On June 11, Shane provided the 2010 Wells Dam Spill Playbook. Since then, we have had a few exceedances of hourly (125% max) and 12C-High (120% max) TDG concentrations in the tailrace, and more prolonged exceedances in the Rocky Reach forebay (115% max). These are likely due to a complex interaction of record cool temperatures, very high seasonal precipitation, unusual operations of the upstream dams, and dentated spill patterns at Wells when spill exceeds 53kcfs. As a result, we are changing the 2010 spill playbook to improve compliance with state and federal water quality standards for TDG.

These changes are included in the accompanying 2010 Spill Playbook, which replaces the June 11 version. Items of note:

When spill levels are expected to reach the 53 kcfs threshold, the District should remove the Juvenile Bypass System barriers in spillbay 6 in order remain in compliance with the TDG standards in the Wells tailrace and Rocky Reach forebay. There is no change in spill operations for spill less than 53 kcfs, except the JBS barrier in spillbay 6 has been removed to allow for quick response to spill requirements in excess of that amount. When spill exceeds 53 kcfs, excess spill is directed through spillbays 6 and 7 rather than through spillbays 5 and 7.

Please contact Shane or Beau if there are any questions. If spill is projected to no longer exceed 53kcfs for the remainder of the fish spill season, the spillbay 6 JBS barrier should be reinstalled. Anything you can do to maximize flow through the turbines, and minimize forced spill in excess of the JBS spill, will improve the gas situation.

Thank you for your patience and understanding as we try to determine how to best manage TDG at Wells Dam.
I. No Forced Spill

The Wells Dam JBS (even numbered spillbays, 10.0 kcs total) should be operated continuously throughout the juvenile salmon outmigration (normally April 12 to August 26). The Wells JBS is normally operated with 1.7 kcs passed through S2 and S10, and 2.2 kcs through S4, S6, and S8 (Figure 1).

![Figure 1. Operational configuration under no forced spill (JBS only).](image1)

II. Forced Spill (≤ 53.0 kcs)

As forced spill increases, Project Operators should allocate all spill through S7 until the maximum capacity is reached through that spillbay (~43.0 kcs). This, along with the already established JBS spill (10.0 kcs) would equal 53.0 kcs (Figure 2). Over 90% of the spill events over the past decade could have been handled under this configuration.

![Figure 2. Operational configuration under spill ≤ 53.0 kcs (including JBS).](image2)
III. Forced Spill (> 53.0 kcf) and JBS Barriers in S6 Removed

After S7 reaches 43.0 kcf, spill should be allocated to S6, following the required removal of the JBS barriers in S6. Since a minimum of 15.0 kcf is needed to fully engage the submerged spillway lip below the ogee, spill through S7 must be relocated to S6 (Figure 3). As flow increases, spill should continually increase through S6 until paired with S7 (e.g., 28.0 kcf through S6 and S7). After this point (63.8 kcf), both S6 and S7 can be increased until both spilloys have reached 43.0 kcf (93.8 kcf, Figure 4).

Figure 3. Operational configuration under forced spill > 53.0 kcf (including JBS flow, with removal of JBS barriers in S6). In this instance (54.0 kcf of total spill), 18.2 kcf is allocated through S6 in order to engage the submerged spillway lip.

Figure 4. Operational configuration under forced spill > 53.0 kcf (including JBS). In this instance (93.8 kcf of spill), 43.0 kcf is allocated through both S6 and S7.

IV. Forced Spill (> 93.8 kcf)

After both S6 and S7 reach 43.0 kcf, spill can also be allocated to S5. Since a minimum of 15.0 kcf is needed to fully engage the submerged spillway lip below the ogee, spill
through S6 should be relocated to S5 (Figure 7). As flow increases, spill can be continually increased through S5 until paired with S6 (30.0 kcf through S5 and S6, while S7 continues at 43.0 kcf). After this point, both S5 and S6 can be increased until all three spillbays have reached 43.0 kcf (136.8 kcf of spill, Figure 8).

![Figure 5](image1.png)

**Figure 5.** Operational configuration under forced spill > 96.0 kcf. In this instance (96.8 kcf of total spill), spill from S5 is relocated to S6 to maintain concentrated flow with S7. A spill of 16.0 kcf is maintained in S5 as to engage the spillway lip below the ogee.

![Figure 6](image2.png)

**Figure 6.** Operational configuration under forced spill > 96.0 kcf (with removal of JBS barriers in S6). In this instance (136.8 kcf of total spill), 43.0 kcf is allocated through S5, S6, and S7.

### V. Forced Spill (> 136.8 kcf)

Forced spill exceeding 136.8 kcf rarely occurs (less than 0.5%). If these conditions arise and total river flow exceeds 246.0 kcf, then 7Q-10 conditions are occurring and Wells Dam is exempt from the TDG standards. Under this situation, Project Operators may
perform any combination of operations to ensure that flood waters are safely passed. Also, at this point, JBS barriers will likely be removed allowing additional flexibility to spill up to 43 kcfs through S2, S4, S6, and S8. Project Operators may pass spill through S3 in a similar fashion to operations mentioned above (starting at a minimum of 15.0 kcfs to ensure that spillway lips are engaged).
## I. Spill Lookup Table

<table>
<thead>
<tr>
<th>Operation</th>
<th>Total Spill</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>S6</th>
<th>S7</th>
<th>S8</th>
<th>S9</th>
<th>S10</th>
<th>S11</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. No Forced Spill</td>
<td>10.0</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>0.0</td>
<td>2.2</td>
<td>0.0</td>
<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>II. Spill (≤ 53.0 kcf), min.</td>
<td>11.0</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>0.0</td>
<td>2.2</td>
<td>1.0</td>
<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>II. Spill (≤ 53.0 kcf), max.</td>
<td>53.0</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>0.0</td>
<td>2.2</td>
<td>43.0</td>
<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>III. Spill (&gt; 53.0 kcf, S6 JBS out), min.</td>
<td>54.0</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>0.0</td>
<td>15.0</td>
<td>31.2</td>
<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
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</tr>
<tr>
<td>III. Spill (&gt; 53.0 kcf, S6 JBS out), max.</td>
<td>93.8</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>0.0</td>
<td>43.0</td>
<td>43.0</td>
<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>IV. Spill (&gt; 93.8 kcf, S6 JBS out), min.</td>
<td>96.8</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>15.0</td>
<td>38.8</td>
<td>43.0</td>
<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>IV. Spill (&gt; 93.8 kcf, S6 JBS out), max.</td>
<td>136.8</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>2.2</td>
<td>43.0</td>
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<td>2.2</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
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<tr>
<td>V. Spill (&gt;137.0 kcf), min.</td>
<td>137.0</td>
<td>0.0</td>
<td>1.7</td>
<td>15.0</td>
<td>2.2</td>
<td>28.2</td>
<td>43</td>
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<tr>
<td>V. Spill (&gt;137.0 kcf), max.</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: (1) No spill through S1 and S11 as to minimize interference with fish ladders. (2) Even-numbered spillbays are designated as the Juvenile Bypass System (JBS). (3) Primary spillbays for forced spill are S7, S6, S5, S9, and S3 (in that order).
Appendix 5. Letter from Washington Department of Ecology describing 12C-High TDG calculation
April 2, 2008

TO:       Columbia and Snake River Dam Spill Operators

FROM:    Chris Maynard, Hydropower Coordinator, Washington State Department of Ecology

RE:       Method for averaging 12 consecutive daily average high IDG readings in any one day

I have been asked to clarify how Ecology expects operators to measure TDG during fish passage spill on the Columbia and Snake Rivers.

Washington's previous 1997 total dissolved gas (TDG) Water Quality Standards (WQS) for fish spill on the Snake and Columbia Rivers required TDG measurements to be taken at least hourly and the 12 highest measurements averaged over the course of a day. A day was assumed to be a 24 hours period although the start and end time were never clearly defined. The operators averaged measurements and reported based on a calendar day, starting at 12 a.m. and ending at 12 a.m. The term 'day' did not need to be defined because averaging any high TDG from midnight to midnight captured all high IDG readings. Often the high readings for tailraces would occur during the early hours after midnight and in the evening hours with a period of lower readings in between during the day. This is because fish spill often occurs more at night.

The revised 2006 Washington WQS require measuring the average of the 12 highest consecutive hours in any one day. This is because at 120% IDG or less, studies have shown that aquatic organisms experience the most TDG harm from consecutive exposure, not intermittent exposure throughout a 24 hour period. High IDG and corresponding spills tend to occur during consecutive blocks of time. Measuring midnight to midnight breaks up the consecutive period of nightly high TDG.

Beginning during the 2008 spill season, the operators should use the following method to average and report the 12 consecutive hourly 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 1:00 a.m. This hour is averaged with the previous day's last 11 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 12 hour average to nearest whole number.
Rationale for the rolling average: The standards say “in any one day”, but a day need not be a calendar day. Defining a day as starting at a set hour (like midnight) and ending 24 hours later leaves only twelve 12-hour blocks to average within 24 hours. If a period ends at midnight, night spill TDG measurements would be cut off during the middle of the night and the consecutive readings of the highest spill period would not be averaged since the period from 12 midnight on would not be counted with the previous day. So a rolling 12-hour average makes the most sense. This method best captures consecutive hours of high TDG not only below dams that spill at night, but also for dams that vary their hours of spill from nighttime. It also captures consecutive forebay reading which measure TDG from the upstream dam hours later.

The accompanying table shows an example of how the TDG should be tracked and averaged as a rolling average. It shows what hours will be reported for a day: the highlighted green and blue hours are those that are averaged each hour to report as May 19th. The first period evaluated for May 19th reporting begins with the first hour’s measurements of the day. Since the previous 12 hour measurements are needed for a consecutive average, eleven of those hours (in the first highlighted column) will necessarily occur on May 18th. The next hour’s measurement is then evaluated with the eleven hours previous, and so on through the day until the last measurement at midnight. There are now twenty-four averaging periods, and the highest average (ending at 2 a.m. May 19th) is chosen to report for May 19th.

Cc: Agnes Lut, ODEQ
    Margaret Filardo, FPC
    WQT
    Pat Irle, Ecology
    Marcie Mangold, Ecology