2011 TOTAL DISSOLVED GAS ABATEMENT PLAN

WELLS HYDROELECTRIC PROJECT

Prepared by:

Bao Le
Long View Associates
Portland, Oregon

And

Beau Patterson
Public Utilities District No. 1 of Douglas County
East Wenatchee, Washington

Prepared for:

Pat Irle
Hydropower Projects Manager
Washington Department of Ecology
Yakima, Washington 98902-3452

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Executive Summary

Under the Water Quality Standards (WQS) Chapter 173-201A of the Washington Administrative Code (WAC) criteria developed by the Washington Department of Ecology (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 a dam operator 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. On a per-application basis, Ecology has approved a TDG adjustment to allow spill for juvenile fish passage past Columbia and Snake river dams (WAC 173-201A-200(1)(f)(ii)).

On the Columbia and Snake rivers there are three separate standards for the fish passage related TDG adjustment. TDG shall not exceed 125 percent in the tailrace of a dam, as measured in any one-hour period. 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 what would be caused by turbine fish passage. This TDG adjustment 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 WQS criteria for TDG in the Columbia River at the Wells Hydroelectric Project (Wells Project) while continuing to provide safe passage for downstream migrating juvenile salmonids. Public Utility District No. 1 of Douglas County (Douglas PUD), which owns and operates the Wells Project, is submitting this Gas Abatement Plan to Ecology for approval as required for receipt of a TDG adjustment at Wells Dam.

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1.0 Introduction and Background

The Wells Hydroelectric Project Gas Abatement Plan (GAP) provides details on operational and structural measures to be implemented in 2011 by Public Utility District No. 1 of Douglas County, Washington (Douglas PUD) at Wells Dam under the 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 adjustment.

The goal of the GAP is to implement a long-term strategy to achieve compliance with the Washington State WQS 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 is the owner and operator of the Wells Project and is submitting this GAP to the Washington Department of Ecology (Ecology) for approval as required for receipt of a TDG adjustment for fish passage.

Previously, Ecology has approved GAPs and issued a TDG exemption for the Wells Project. Douglas PUD submitted a GAP 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 GAP allowing a TDG adjustment in support of fish passage through February 2008. Since 2008, Douglas PUD has submitted GAPs for the fish passage season annually. The most recent GAP was approved by Ecology in 2010 (Appendix 1).

This GAP contains three sets of information. Section 1.0 summarizes the background information related to regulatory and project specific TDG information at the Wells Project. Proposed Wells Project operations and activities related to TDG management are contained in Sections 2.0 and 3.0. Section 4.0 provides a summary of compliance and physical monitoring plans, quality assurance and quality control procedures, and reporting.

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 consists of eleven spill gates that are capable of spilling a total of 1,180 kcfs. The crest of the spillway 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 dam top elevation of 795 feet above mean sea level (msl). The juvenile fish bypass (JBS) 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.

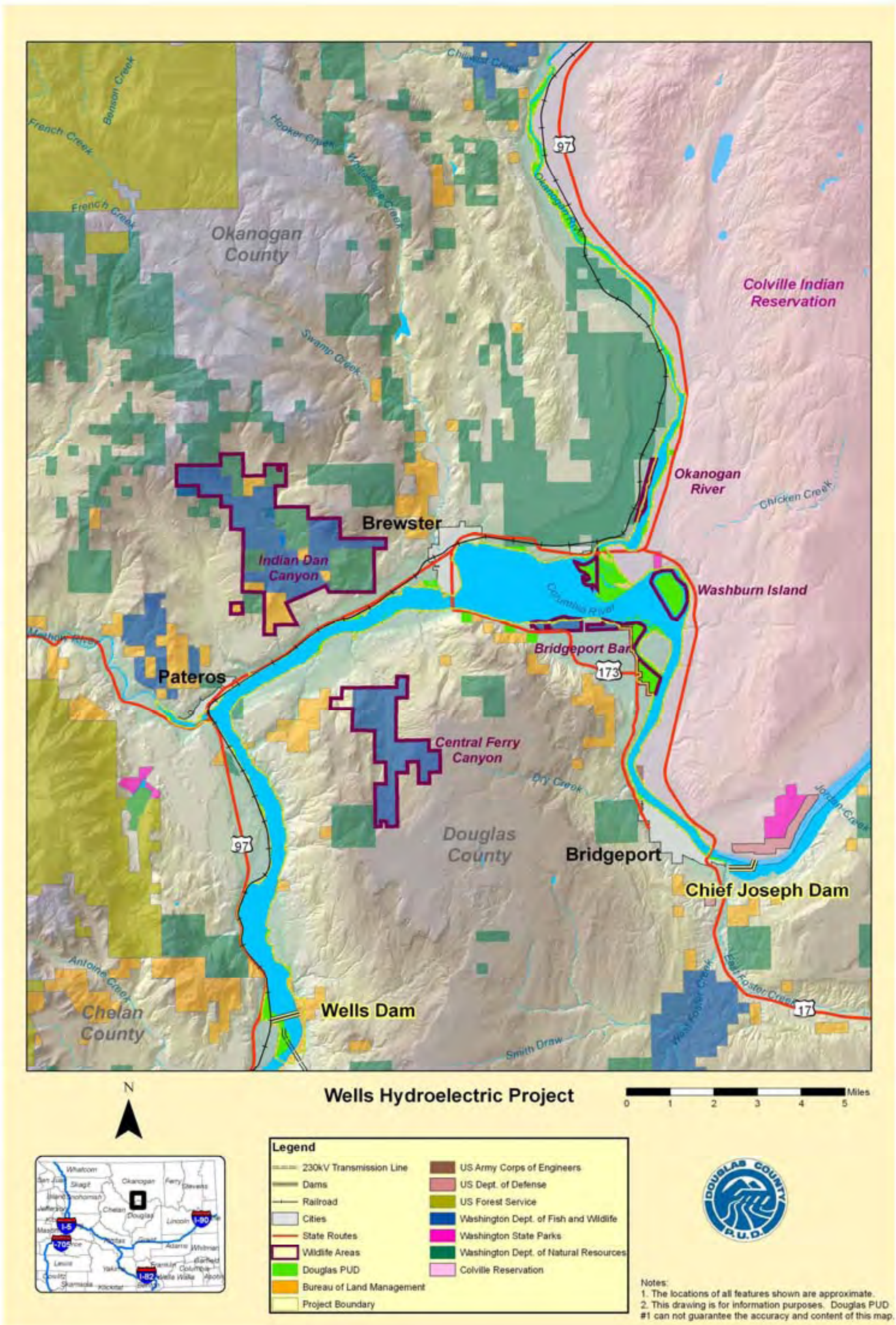

Figure 1. Map of the Wells Hydroelectric Project in Central Washington.

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 (WAC) define 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. However, the standards exempt dam operators from this TDG standard when the river flow exceeds the seven-day, 10-year-frequency flood (7Q10). The 7Q10 flow is the highest calculated flow 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, coupled with a statistical analysis to develop the number from 1930 through 1998. These methods follow the United States Geological Survey (USGS) Bulletin 17B, "Guidelines for Determining Flood Flow Frequency" and determined that the 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 adjustment to the TDG standard (110 percent) to allow spill for juvenile fish passage past dams on the Columbia and Snake rivers (WAC 173-201A-200(1)(f)(ii)). This adjustment comprises three separate standards to be met by dam operators. TDG shall not exceed 125 percent in any one-hour period in the tailrace of a dam. 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 24-hour period (12C High). The increased levels of spill resulting in elevated TDG levels are authorized by Ecology to allow salmonid smolts a non-turbine downstream passage route that is less harmful 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).

A significant portion of the Wells Reservoir occupies lands within the boundaries of the Colville Indian Reservation. Wells Project operations do not affect TDG levels in tribal waters, where Tribes' TDG standard is a maximum of 110%, year-round, at all locations. This TDG standard is also EPA's standard for all tribal waters on the Columbia River, from the Canadian border to the Snake River confluence. TDG levels on the Colville Reservation portion of the mainstem Columbia River within Wells Reservoir result from the operations of the upstream Chief Joseph Dam.

1.2.1 7Q10

The 7Q10 flood flow at the Wells Project is 246 kcfs. The Project is not be required to comply with state WQS for TDG when incoming flows exceed this value.

1.2.2 Fish Spill Season

For purposes of compliance with the WQS for TDG, the "fish spill" season is April 1 through August 31; and "non-fish spill" season occurs from September 1 to March 31. During non-fish spill, Douglas PUD will make every effort to remain in compliance with the 110 percent standard. During fish spill, Douglas PUD will make every effort not to exceed an average of 120 percent as measured in the tailrace of the dam. TDG at the Wells Project also must not exceed an average of 115 percent as measured in the forebay of the next downstream dam (Rocky Reach). These averages are calculated using 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 fish spill season. Nothing in these special conditions allows an impact to existing and characteristic uses.

1.2.3 Incoming TDG Levels

Compliance with the TDG standards is not required when water reaching the Project forebay exceeds the TDG standard. During the fish spill season, TDG concentrations in the Wells Project forebay are primarily determined by the USACE's upstream water management activities at Chief Joseph Dam.

Since the completion of spill deflectors at Chief Joseph Dam in 2008, there has been a significant increase in the amount of spill at the Chief Joseph Project resulting from FCRPS-wide operations. This recent increase in the amount of spill at Chief Joseph Dam has resulted in a dramatic increase in the volume of water that is supersaturated with TDG. This mass influx of supersaturated water has resulted in significantly higher TDG concentrations observed in the forebay of Wells Dam.

Despite the total lack of fish passage at Chief Joseph Dam, the US Army Corps of Engineers has operated under the assumption that the fish passage TDG adjustment approved by Ecology applies to all FCRPS dams, rather than the eight dams with fish passage in the lower Snake and Columbia rivers. Douglas PUD does not believe that the fish passage adjustment is authorized for Chief Joseph Dam by Ecology, and that the USACE is out of compliance with Washington state WQS, as well as the EPA TDG standard and the Colville Tribe's TDG standard, whenever TDG in the Chief Joseph Dam tailrace exceeds 110%.

1.2.3.1 TMDL

In June 2004, a total maximum daily load (TMDL) was jointly established for the Mid-Columbia River and Lake Roosevelt by Ecology, the Spokane Tribe of Indians, and the U.S. Environmental Protection Agency (EPA)(Ecology et al. 2004). EPA's issuance covers all waters above Grand Coulee Dam, and all tribal waters; EPA's TMDL covers all tribal waters of the Colville Confederated Tribes, including the right bank of the Columbia River from Chief Joseph Dam downstream to the Okanogan River confluence. Ecology's issuance covers all state waters downstream from Grand Coulee Dam to the Snake River confluence.

A summary implementation strategy prepared by Ecology and the Spokane Tribe of Indians describes 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 recommended TMDL actions are currently being addressed by Douglas PUD through the implementation of Habitat Conservation Plan (HCP) 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 GAPs.

The Wells Project occupies waters both upstream and downstream of the Okanogan River. In waters upstream of the Okanogan River, the TMDL does not provide an exemption for fish passage spills (except as a temporary waiver or special condition as part of the short-term compliance period, as described in the Implementation Plan, Appendix A of the TMDL). Downstream of the Okanogan River, allocations are provided based on both the 110% criteria and the criteria established for fish passage in the Washington State water quality standards. Any allocations or exemptions for fish passage downstream of the Okanogan River may be used only after approval of a gas abatement plan (Ecology et al. 2004).

1.3 History of Operations and Compliance

1.3.1 Flows

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. There are 85,300 square miles of drainage area above Wells Dam. The natural hydrograph had low flows in November through January with high flows in May through July. Storage dams on the Columbia River and its tributaries upstream of the Wells Project in the U.S. and Canada capture spring and summer high flows to hold for release in the fall and winter months. Table 1 presents information on Columbia River flow, as measured at Wells Dam from 2001 to2010, and shows that the current hydrograph of the Columbia River is controlled by upstream storage and release regimes. Juvenile anadromous salmonid migration occurs within a regime of reduced high 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 that are designed 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 (2001-2010).

	Month											
Year	1	2	3	4	5	6	7	8	9	10	11	12
2001	96.5	88.2	73.8	62.9	55.2	84.5	53.4	70.3	62.5	56.1	70.9	79.1
2002	91.0	91.9	66.1	116.9	135.0	205.6	176.5	115.1	73.9	79.4	96.7	93.3
2003	75.7	69.9	82.2	106.7	130.7	137.6	106.2	96.4	64.0	74.6	87.7	105.5
2004	96.2	80.5	70.0	87.3	114.2	132.3	101.5	95.7	75.7	79.3	90.9	112.0
2005	102.0	104.4	94.9	85.4	122.1	130.8	136.8	107.9	67.6	78.5	90.9	91.8
2006	101.2	104.5	87.3	148.4	165.3	195.1	127.9	103.9	66.3	66.3	77.1	90.8
2007	114.5	85.3	120.3	154.7	159.2	152.0	133.0	113.1	60.0	64.4	80.2	86.8
2008	104.0	88.6	82.4	90.3	158.7	206.8	135.3	86.5	60.7	63.0	75.2	94.2
2009	107.8	80.2	71.5	111.0	122.7	146.6	103.1	74.5	53.5	58.1	80.1	101.8
2010	71.1	72.1	65.2	70.7	112.2	173.0	119.9	83.6	53.8	67.7	85.8	86.2
All	96.0	86.3	81.4	103.4	127.6	156.4	119.4	94.7	63.8	68.7	83.5	93.7

1.3.2 Spill Operations

1.3.2.1 General Operation

The Hourly Coordination Agreement is intended to integrate power operations for the seven dams from Grand Coulee to Priest Rapids. "Coordinated generation" is assigned to meet daily load requirements via Central Control in Ephrata, WA. Automatic control logic is used to maintain pre-set reservoir levels to meet load requirements and minimize involuntary spill. These pre-set reservoir levels are maintained at each project via management of a positive or negative "bias". Positive or negative bias assigns a project more or less generation based on its reservoir elevation at a given time and thus, maximizes system benefits and minimizes involuntary spill.

1.3.2.2 Spill for Fish

Wells Dam is a hydrocombine design where the spillway is situated directly above the generating units. Research at Wells Dam in the mid-1980s showed that a modest amount of spill effectively guided 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 10 kcfs. 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. Between the years 1997 and 2004, the volume of water dedicated to JBS operations has ranged from 1.5 to 3.2 million acre-feet annually. The operation of the JBS adds a small amount 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 HCP with NMFS. The Wells Project JBS 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 2. Wells Hydroelectric Project Juvenile Bypass Efficiency.

Species	% JBS Passage
Yearling (spring) Chinook	92.0
Steelhead	92.0
Sockeye	92.0
Subyearling (summer/fall) Chinook	96.2

The JBS is used to protect 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. Since 2003, the operation period for the juvenile bypass has been from April 12 through August 26, and is based on these 21 years of hydroacoustic and fyke net data. These dates bracket the run timing of greater than 95% of both the spring and summer migrants. Annually, as many as ten million juvenile salmonids have migrated past Wells Dam.

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 ten-turbine hydraulic capacity must be passed over the spillways.

The forebay elevation at Wells Dam is maintained 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 kcfs 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 recorded 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 and 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 (i.e. off-peak periods). Hourly coordination (Section 3.2) between hydroelectric projects on the river was established to minimize this situation for spill. Spill is in excess of power demand provides benefit to migration juvenile salmonids. Fish that pass through the spillway survival at a higher rate relative to passage through a turbine and the turbulence in the tailrace generated by spill in excess of power demand increases tailrace velocity and reduces tailrace egress times. The reductions in tailrace egress time and increases in water turbulence and velocity reduce predation in the Wells tailrace.

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, USACE, and Bonneville Power Administration [BPA]) 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

Since the Wells Project is a "run-of-the river" project with a relatively small storage capacity, river flows in excess of the ten-turbine hydraulic capacity 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 GAP (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 Wells Dam tailrace 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 adjustment criteria 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 and volume. 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 with success. Overall, no exceedances were observed in either the Wells Dam tailrace or the Rocky Reach forebay in 2009.

In 2010, the concepts from the 2009 Spill Playbook were integrated into the 2010 Wells Project Spill Playbook given their effectiveness in maintaining levels below TDG criteria during 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% max). In response, Douglas PUD implemented an in-season analysis of the 2010 Spill Playbook and determined that full implementation of the recommendations from IIHR Engineering Laboratory would require the removal of the juvenile fish bypass system flow barriers in one spillbay. Following the in-season analysis and consultation with the HCP Coordinating Committee, changes were made to the 2010 Spill Playbook that allowed for the removal of the juvenile fish bypass system barriers in spillbay 6. Specifically, the Spill Playbook was modified to state that when spill levels approach the 53 kcfs threshold, the JBS 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. This operational configuration resulted 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.

River flows in 2010 were below average compared to the trailing 10-year average at the Wells Project (Table 3), with the exception of higher than average June flows. Flow in 2010 was most similar to 2003-2005, and 2008-2009 (Table 4). These low flow years typically begin with average flows around 100 kcfs in April, gradually increasing to 130-150 kcfs in May and June, and tapering off to below 70 kcfs in September.

Two significant observations were noted regarding compliance in 2010: (1) Unexpected June flows coupled with reduced operational flexibility created significant challenges for the Federal Columbia River Power System (FCRPS); and, (2) spill operations at Chief Joseph Dam in support of the FCRPS has contributed to the 2010 TDG exceedances at Wells Dam..

In expectation of a drought year, BPA had reduced discharge from Grand Coulee in May and early June and filled Grand Coulee storage reservoir one month earlier than normal. The subsequent heavy rain events in June resulted in unanticipated high flow volumes and, in addition, required some drafting of Grand Coulee Reservoir. These unexpected elevated flows created significant challenges for the operations of the FCRPS (BPA 2010) and the mid-Columbia PUDs.

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 approximately 3,000 megawatts of wind power 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. As part of the FCRPS GAP, involuntary spill is spread incrementally across all federally owned projects to prevent excessively high total dissolved gas levels. While not part of the criteria adjustment requested for the eight mainstem fish passage projects, the GAP includes spill at Grand Coulee and Chief Joseph dams as operational measures to manage TDG levels in the Columbia River that result from involuntary spill. During this time period, flow deflectors at Chief Joseph Dam increased allowable spill from 20 kcfs to 100 kcfs (BPA 2010).

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 kcfs and on nine occasions, hourly flows exceeded the 7Q-10 value of 246 kcfs. 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 may have contributed to 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 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 initial 2010 Spill Playbook. However, it is important to note that after the in-season analysis and modification to the Spill Playbook, only 1 exceedance (in the Rocky Reach forebay) was observed for the remainder of the fish passage season.

Despite the lack of fish passage facilities at Chief Joseph Dam, the USACE has operated under TDG adjustments for fish passage during Phase 1 of the TDG TMDL implementation (Ecology et al. 2004). 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 compliance at Wells Dam and at other fish-passing downstream projects, as well as reducing exposure to elevated TDG of ESA-listed salmonids and other aquatic life.

Table 3. 2010 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.

Season	10 Year (2001-2010)Average Flows (kcfs)	2010 Average Flows	% of 10 Year Average
Spring	129.1	118.6	91.9
Summer	107.0	85.8	80.2

Table 4. Average hourly flow (kcfs) and TDG (percent saturation) during the fish spill season at the Wells Project (including tailrace and forebay) 2001-2010, by month. Years of similar river flow volume to 2010 are shaded for comparison.

	April		May		June		July		August		All	
YR	Flow	TDG	Flow	TDG	Flow	TDG	Flow	TDG	Flow	TDG	Flow	TDG
2001	63	107	55	109	85	107	53	110	70	107	65	107
2002	117	108	135	110	206	119	177	119	115	112	137	112
2003	107	106	131	109	138	112	106	112	96	108	107	109
2004	87	108	114	109	132	109	101	111	96	109	101	109
2005	85	107	122	109	131	111	137	111	108	108	109	108
2006	148	108	165	115	195	120	128	115	104	109	134	113
2007	155	109	159	112	152	112	133	112	113	108	129	110
2008	90	106	159	111	207	119	135	113	86	111	123	111
2009	111	107	123	110	147	113	103	114	75	110	102	110
2010	80	106	112	106	173	113	120	113	86	111	118	110
All	104	107	128	110	157	113	119	113	95	109	113	110

1.3.3.2 Structural

No structural modifications are scheduled for the 2011 monitoring season, other than the removal of the JBS barriers in spillway 6 whenever spill is projected to exceed 53 kcfs for more than 8 hour.

1.3.3.3 Biological Monitoring

The 2010 Wells Project GAP included the National Marine Fisheries Service (NMFS) recommendation to sample for Gas Bubble Trauma (GBT) in juvenile salmon when 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 17th (127.0%, 129.9%), one on June 22nd (125.3%), and two on June 29th (126.1%, 126.3%). There was no GBT monitoring following the June 17th event. On June 24th at 0800, Douglas PUD staff conducted GBT monitoring at Rocky Reach Dam in response to the June 22nd 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 30th, Chelan PUD staff conducted GBT sampling on behalf of Douglas

PUD, in response to the June 29th exceedances. Three sockeye and 18 Chinook were examined with no sign of GBT observed.

1.3.4 Compliance Success in Previous Year (2010)

1.3.4.1 TDG

River flows in 2010 were indicative of a low water year with the notable exception of late June, when several heavy rain events and warm spring time temperatures created high flows and elevated TDG values in the Snake and lower Columbia River. During the 2010 monitoring season, TDG in the forebay of Wells Dam did not exceed 115%. The TDG TMDL load allocation for Chief Joseph Dam during Phase 1 (2004-2010) may have allowed Chief Joseph Dam operators to use the fish passage adjustment criteria (Ecology et al. 2004), in which case they would have been in compliance with the TDG criterion for the Wells Dam forebay. 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 in the spring on 4 occasions; June 22nd, June 24th, June 26th, and June 29th (Table 5). Wells Dam tailrace 12C-High TDG values, which ranged from 120.5% to 123.2%, occurred during flow conditions ranging from 188.5 kcfs to 268.6 kcfs, the latter being above the 7Q-10 value for Wells Dam of 246.0 kcfs. In the forebay of Rocky Reach Dam, the 115% 12C-HighTDG criterion was exceeded on eight occasions (seven in the spring and once in the summer) (Table 5); June 22nd-June 25th, June 27th-June 30th, and July 2nd. 12C-High values ranged from 115.6% to 120.9%. There were five exceedances of the 125% hourly TDG criterion in the Wells tailrace, three of which occurred when flows were less than the 7Q10 flow of 246 kcfs. Exceedances occurred during flow conditions ranging from 169.6 kcfs to 257.9 kcfs.

As discussed in section 1.3.3.1, weather events generating unexpected high flows in June; FCRPS -wide spill operations implemented at Chief Joseph Dam; and BPA's integration of large amounts of wind power in the region were major contributing factors to higher than normal observed TDG values at the Wells Project in 2010. Despite such conditions, adaptive management of spill operations at Wells Dam via implementation of the modified Spill Playbook resulted in improved TDG performance and significant reductions in observed exceedances of the TDG criteria (1 observed exceedance after implementation of the modified Spill Playbook).

Table 5. Summary of Spill and TDG Compliance in 2010. Spring is defined as April 12 – June 30. Summer is defined as July 1 – August 26.

Season	Average Daily % Spill	Average Daily Spill Volume (kcfs)	Wells Tailrace TDG Compliance (%)	Rocky Reach Forebay TDG Compliance (%)
Spring	9.4	13.55	95	91
Summer	7.8	8.30	100	98

1.3.4.2 Gas bubble trauma monitoring

Seven Chinook and 31 sockeye juveniles were examined at the Rocky Reach bypass sampling period following exceedances of the 125% hourly TDG standard in the Wells Dam tailrace. Each juvenile salmon was examined under magnification following sedation for evidence of bubbles in the eyes and non-paired fins, and along the lateral line. No evidence of gas bubble trauma was observed in any of the 38 fish examined. Sample sizes were small as sampling following exceedances occurred during periods of low abundance of smolts migrating downstream (L. Keller, Chelan PUD, personal communication). WDFW personnel operating the adult trapping facilities at Wells Dam were requested to monitor adults for GBT; however, no trapping occurred during this time period.

2.0 Proposed Operations and Activities

2.1 Operational Spill

2.1.1 Minimizing Involuntary Spill

Based on the success of 2009 and 2010 operations associated with implementation of the Wells Project Spill Playbook, those operations will be followed again this year with minor modification.

As discussed in Section 1.3.3.1 above, high Columbia River flows in June 2010 resulted in several exceedances at the Wells Project resulting in an in-season analysis of the 2010 Spill Playbook. Following the analysis and in consultation with the HCP Coordinating Committee, the Spill Playbook was modified to state that when spill levels approach the 53 kcfs threshold, the JBS barriers in spillbay 6 would be removed to remain in compliance with the TDG criteria in the Wells Dam tailrace and Rocky Reach Dam forebay. When spill exceeds 30 kcfs through spillway 5, excess spill will be directed through adjacent spillbay 6, resulting in a more compact spill pattern that minimizes the air-water interface surface area between spillway flows and the subsequent potential for lateral mixing and air entrainment. In February 2011, Douglas PUD, in preparation for the upcoming fish passage season, conducted an additional technical analysis of the 2010 Spill Playbook (after in-season changes) and confirmed that continued implementation, with minor modifications, would be appropriate for 2011. The 2011 Spill 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, Bickford et al. 2010 draft)(Table 6). The Wells Anadromous Fish Agreement and HCP (Douglas PUD 2002) is the Wells Project's fisheries management plan for anadromous salmonids, and directs operations of the Wells JBS to achieve the No Net Impact (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, 2010 Wells Hydroelectric Project Juvenile Survival Study Results.

Species	% Project Survival
Yearling Chinook (2010)	96.4
Yearling Chinook and Steelhead (1998, 1999, 2000)	96.2

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 HCP. Approximately 80,000 PIT-tagged yearling summer Chinook were released over a 30 day period in 15 replicates. The study 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 (Table 6). This result confirms conclusions from the three previous years of study and documents that juvenile fish survival through the Wells Project continues to exceed the 93% Juvenile Project Survival Standard required by the HCP (Bickford et al., 2010 draft). A final report will be available in early 2011.

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.

Species	Phase Designation
Yearling (spring) Chinook	Phase III[1] – Standards Achieved (22-Feb-05)
Steelhead	Phase III – Standards Achieved (22-Feb-05)
Sockeye	Phase III – Additional Juvenile Studies (22-Feb-05)
Subyearling (summer/fall) Chinook	Phase III – Additional Juvenile Studies (22-Feb-05)
Coho	Phase III – Additional Juvenile Studies (27-Dec-06)

In 2011, 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

[1] Phase III = Dam survival >95% or project survival >93% or combined juvenile and adult survival >91% (Standard Achieved).

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 potential 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. The JBS at Wells Dam does not have facilities 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 Rocky Reach juvenile bypass sampling facility.

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 is to address regional water quality issues. This forum allows regional coordination for monitoring, measuring, and evaluating water quality in the Columbia River 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 2010, 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 Trans-boundary Gas Group to meetings with the USACE, allow for regional coordination for monitoring, measuring, and evaluating water quality in the Columbia River Basin. Douglas PUD will continue its involvement in such forums to further improve coordination with other regional water quality managers.

3.0 Structural Activities

No structural modifications related to spill are scheduled to occur at the Wells Project in 2011. As in 2010, high flow volume and spill may require JBS barrier removal.

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 conducted by University of Iowa/IIHR have also confirmed that the tailrace monitoring station is located at a site representative of the mixed river flow, 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.

TDG monitoring at the Wells Project typically commences on April 1 and continues until September 15 annually. This monitoring period will encompass the operation of the Wells JBS as well as when 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. TDG 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 USACE 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 the average of the twelve highest consecutive hourly readings in a day (24-hour period).

4.1.2 Water Temperature

Douglas PUD has been monitoring water temperatures around 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 is performed with Onset Tidbit thermographs.

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

River	Side/Mile	Location
Columbia	Left / 515.6	Wells Forebay*
Columbia	Left / 544.5	Chief Joseph Tailrace
Columbia	Left/515.5	Wells Dam Tailrace
Columbia	Right/515.5	Wells Dam Tailrace
Methow	Right / 2.8	Near Pateros
Okanogan	Center / 10.5	Near Monse

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 National Institute of Standards and Technology standard reference thermometer shows a variance of ± 0.2°C. Thermographs will be replaced quarterly (every three months) using recently tested sensors to avoid data loss.

4.3 Reporting

Upon approval of the Wells GAP and issuance of a Wells Project TDG adjustment, Douglas PUD shall submit an annual report describing the results of all monitoring activities described within this GAP. The report will be submitted to Ecology no later than December 31 of each year that the TDG adjustment is approved. A draft GAP report will be submitted to Ecology for review no later than December 31 of each year that the TDG adjustment is approved. The annual report will summarize all GAP 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 2011 GAP are intended to serve as a long-term strategy to maintain compliance with the Washington State WQS 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

ASL Environmental Sciences (ASL). 2007. Turbine Discharge Measurements by Acoustic Scintillation Flow Meter at Units 1 and 2, Wells Hydroelectric Project, Pateros, Washington, August 2006. Prepared by ASL Environmental Sciences Inc. Prepared for Public Utility District No. 1 of Douglas County, East Wenatchee, WA.

Bickford, S. A., J. R. Skalski, R. Townsend, S. McCutcheon, R. Richmond, R. Frith and R. Fechhelm. 2001. Project survival estimates for yearling summer steelhead migrating through the Wells Hydroelectric Facility, 2000.

Bickford, S.A., T. Kahler, R. Townsend, J.R. Skalski, R. Richmond, S. McCutcheon and R. Fechhelm. Project survival estimates for yearling Chinook migrating through the Wells Hydroelectric Project, 2010 draft. (2010 spring migrant survival verification study).

Bonneville Power Administration (BPA). 2010. Columbia River high-water operations [June 1-14, 2010]. September 2010. 12 pages. DOE/BP-4203.

EES Consulting, Carroll, J., ENSR, and Parametrix. 2007. Total Dissolved Gas Production Dynamics Study. Wells Hydroelectric Project. FERC No. 2149. Prepared by EES Consulting, Joe Carroll, ENSR, and Parametrix. Prepared for Public Utility District No. 1 of Douglas County, East Wenatchee, WA.

Le, B and J. Murauskas. 2009. Total Dissolved Gas Abatement Plan. Wells Hydroelectric Project. April 2009. Prepared for Washington Department of Ecology, Yakima, Washington, 98902-3452.

National Marine Fisheries Service (NMFS). 2000. Endangered Species Act – Section 7 Consultation: Biological Opinion. Consultation on Remand for Operation of the Columbia River Power System and 19 Bureau of Reclamation Projects in the Columbia Basin. F/NWR/2004/00727. November 30, 2005. Pages 5-6, 5-7, 5-53, 10-9, and Appendix E: Risk Analysis.

Pickett, P., H. Rueda, M. Herold. 2004. Total Maximum Daily Load for Total Dissolved Gas in the Mid-Columbia River and Lake Roosevelt. Submittal Report. Washington Department of Ecology, Olympia, WA. U.S. Environmental Protection Agency, Portland, OR. June 2004. Publication No. 04-03-002.

Skalski, J. R, G. E. Johnson, C. M. Sullivan, E. Kudera and M. W. Erho. 1996. Statistical Evaluation of Turbine Bypass Efficiency at Wells Dam on the Columbia River, Washington. Canadian Journal of Fisheries and Aquatic Science. Volume 53, No. 10, 1996. Pages 2188-2198.

Washington Department of Ecology, Spokane Tribe of Indians and U.S. Environmental Protection Agency. 2004. Total Maximum Daily Load for Total Dissolved Gas in the Mid-Columbia River and Lake Roosevelt: Submittal Report. Accessed online December 7, 2010 at: http://www.ecy.wa.gov/biblio/0403002.html

7.0 Appendices

Appendix 1. Letter from Pat Irle on Gas Abatement Plan for 2010.

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
15 W Yakima Ave, Ste 200 • Yakima, WA 98902-3452 • (509) 575-2490

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,

Pat Irle
Hydropower Projects Manager
Water Quality Program

Appendix 2. Wells Hydroelectric Project Spill Playbook, 2011.

Memorandum

To: Ken Pflueger, Mike Bruno, Arlen Simon, Hank Lubean, Tom Kahler, Brian Hicks
From: Beau Patterson, Shane Bickford
Date: xxx, 2011
Subject: 2011 Wells Dam Spill Playbook

The 2009 Wells Dam Spill Playbook was based on the TDG production dynamics modeling conducted by the University of Iowa's IIHR-Hydroscience and Engineering Hydraulic Research Laboratories. The two-phase flow computational fluid dynamics (CFD) model 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. There were no TDG exceedances during the 2009 spill season, and the 2009 playbook was again implemented in 2010.

From June 17 to July 2, 2010 we had a few exceedances of hourly (125% max) and 12C-High (120% max) TDG concentrations in the Wells tailrace, and more prolonged exceedances in the Rocky Reach forebay (115% max). These were due to a complex interaction of record cool temperatures, very high seasonal precipitation, unusual spill operations of the upstream dams, and dentated spill patterns at Wells when spill exceeded 53 kcfs. As a result, we changed the 2010 spill playbook mid-season to improve compliance with state and federal water quality standards for TDG. While we had improved compliance with the TDG water quality standard after the revision was implemented, and some indication of improved TDG performance, the lack of exceedances is also attributable to declining flow volumes.

Recommendations for 2011 operations, from a TDG management perspective, include:

1. Minimize spill.

2. Forced Spill (≤ 53.0 kcfs). Switch the priority for forced spill less than 53 kcfs from spillbay 7 to spillbay 5. Units 4 and 5 should be operated to support spill from spillbay 5.

3. If spill exceeds 53 kcfs, or is predicted to exceed 40 kcfs for more than 8 hours, remove the Juvenile Bypass System (JBS) barriers in spillbay 6.

4. When spill exceeds 30 kcfs in spillbay 5 and JBS barriers have been removed in spillbay 6, shift at least 15.0 kcfs from spillbay 5 to spillbay 6 (i.e., 27.2 kcfs and 15.0 kcfs through spillbays 5 and 6, respectively). Support spill through spillbays 5 and 6 by operating units 4, 5 and 6.

5. Reinstall the JBS barriers if total spill is predicted to remain below 40 kcfs for more than four days.

Operate the powerhouse to maximize utilization and total release through the center units (3-6, 8, and 7 if operational) when forced spill is occurring.

I. No Forced Spill

The Wells Dam JBS (even numbered spillbays, 10.0 kcfs 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 kcfs passed through *S2* and *S10*, and 2.2 kcfs through *S4*, *S6*, and *S8* (Figure 1).

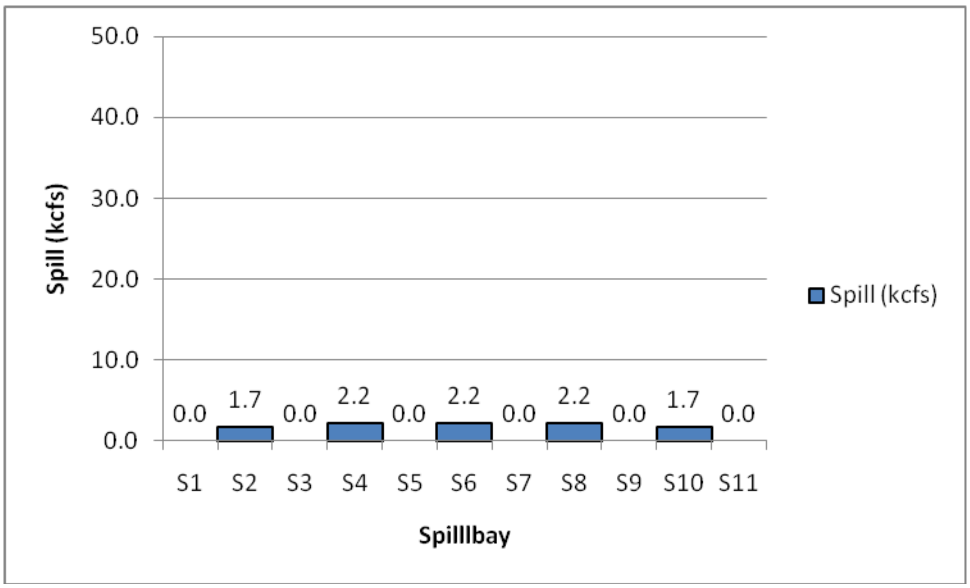

Figure 2. Operational configuration under no forced spill (JBS only).

II. Total Spill ≤ 53.0 kcfs, JBS barriers in place

As forced spill increases, Project Operators should allocate all spill through *S5* until the maximum capacity is reached through that spillbay (~43.0 kcfs). Note that *S5* spill requires support of generation flows from units 4 and 5 to minimize TDG production. This, along with the already established JBS spill (10.0 kcfs) would equal 53.0 kcfs (Figure 2). Over 90% of the spill events over the past decade could have been handled under this configuration.

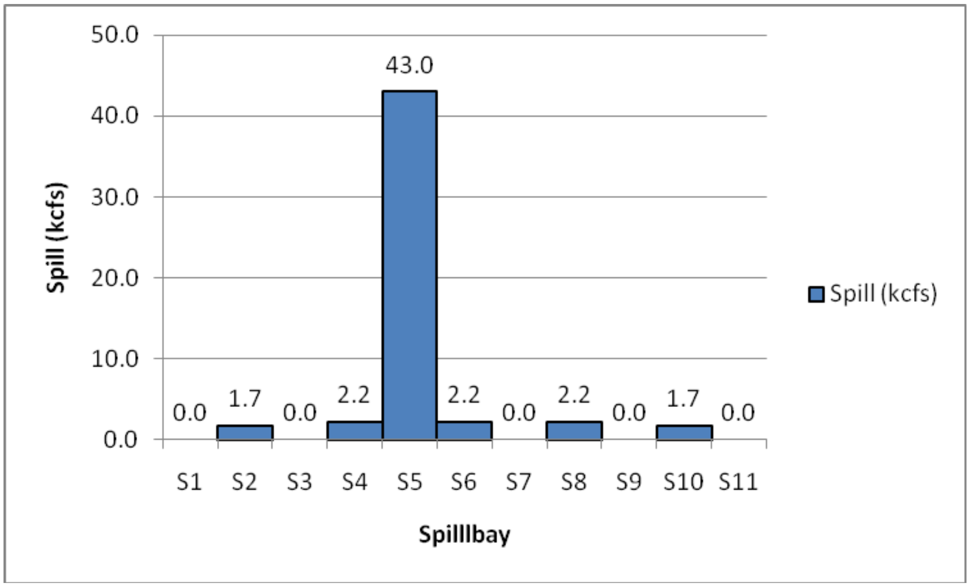

Figure 3. Operational configuration under spill ≤ 53.0 kcfs (including JBS).

III. JBS Barrier Removal Criteria

When either of the following occurs, remove the JBS barrier in *S6*:

Spill in *S5* reaches 30 kcfs and total spill is expected to exceed 40kcfs for more than 8 hours, *or* total spill is expected to exceed 53 kcfs. After the JBS barrier is removed from *S6* and when flow through S5 is at least 30kcfs, shift 15 kcfs to *S6* (Figure 3). It is best to have generating units 4, 5, and 6 operating to support this spill configuration. Once at least 15 kcfs is being spilled through *S6*, spill can be allocated to *S5* until 43.0 kcfs is reached.

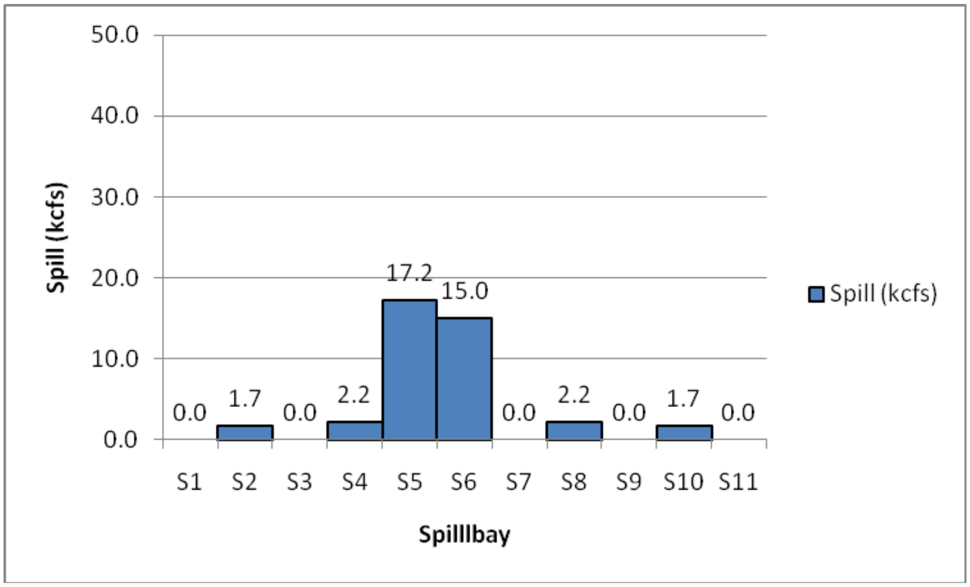

Figure 3. Operational configuration once spill reaches 30 kcfs in S5 and is expected to be above 40 kcfs for more than 8 hours (JBS removed). Shift sufficient spill from S5 to maintain a minimum of 15 kcfs spill at S6. Note that the 15.0 kcfs includes the existing 2.2 kcfs JBS flow.

IV. Short duration decreases in Forced Spill (<53.0 kcfs) and JBS Barriers in *S6* Removed

If after removal of JBS barrier in *S6*, total spill drops below 53 kcfs (between 10-53 kcfs), and is expected to stay in this range for only a short period (4 days or less), direct spill through *S6* up to 15 kcfs (total spill < 22.9 kcfs). When total spill exceeds 22.8 kcfs, direct the remainder of spill through *S5*.

V. Forced Spill (> 53.0 kcfs) and JBS Barriers in *S6* Removed

After *S5* reaches 43.0 kcfs, additional spill should be allocated to *S6* (*S6* is already spilling at least 15.0 kcfs need to fully engage the submerged spillway lip below the ogee). As flow increases, spill should continually increase through *S6* until paired with *S5* (e.g., 43.0 kcfs through *S5* and 26.0 kcfs through *S6*) (Figure 4). Eventually, *S6* will reach 43.0 kcfs (93.8 kcfs, Figure 5).

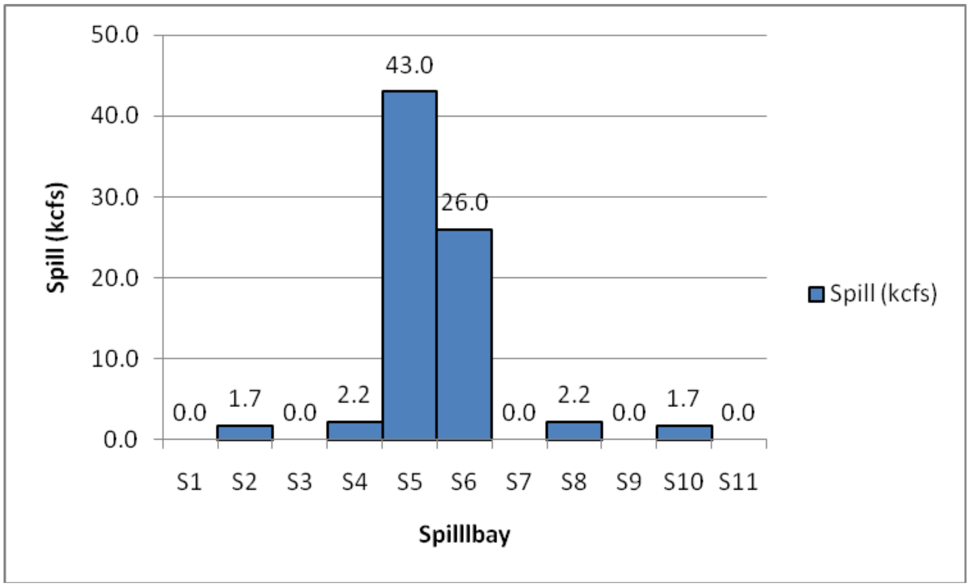

Figure 4. Operational configuration under forced spill > 53.0 kcfs (including JBS flow, with removal of JBS barriers in *S6*). In this instance spill has reached the 43.0 kcfs maximum in S5 and additional spill is being allocated to S6 (26.0 kcfs).

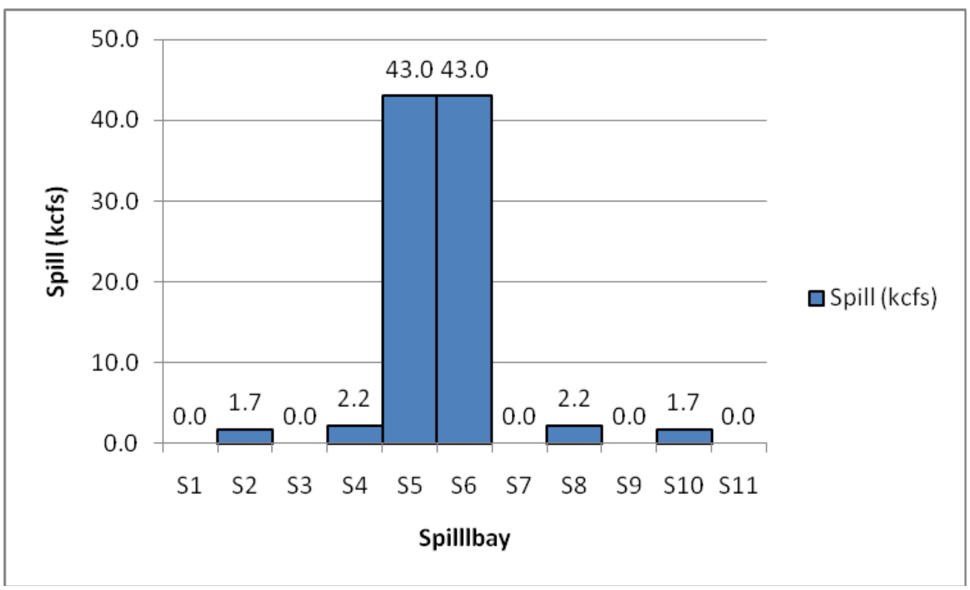

Figure 5. Operational configuration under forced spill > 53.0 kcfs (including JBS). In this instance (93.8 kcfs of spill), S6 has been fully allocated and 43.0 kcfs is now allocated through both *S5* and *S6*.

VI. Forced Spill (> 93.8 kcfs) and JBS Barriers in *S6* Removed

After both *S5* and *S6* reach 43.0 kcfs, spill can also be allocated to *S7*. Since a minimum of 15.0 kcfs is needed to fully engage the submerged spillway lip below the ogee, spill through *S6* should be relocated to *S7* (Figure 6). As flow increases, spill can be continually increased through *S7* until paired with *S6* (30.0 kcfs through S6 and S7, while S5 continues at 43.0 kcfs). After this point, both *S6* and *S7* can be increased until all three spillbays have reached 43.0 kcfs (136.8 kcfs of spill, Figure 7).

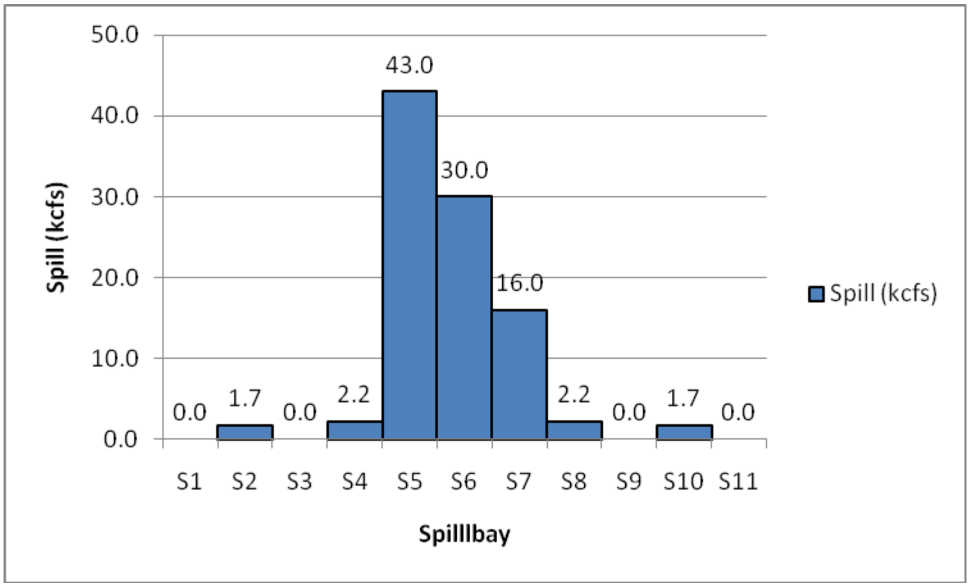

Figure 6. Operational configuration under forced spill > 96.0 kcfs. In this instance (96.8 kcfs of total spill), spill from *S6* is relocated to *S7* to maintain concentrated flow with *S5*. A spill of 16.0 kcfs is maintained in *S7* as to engage the submerged spillway lip.

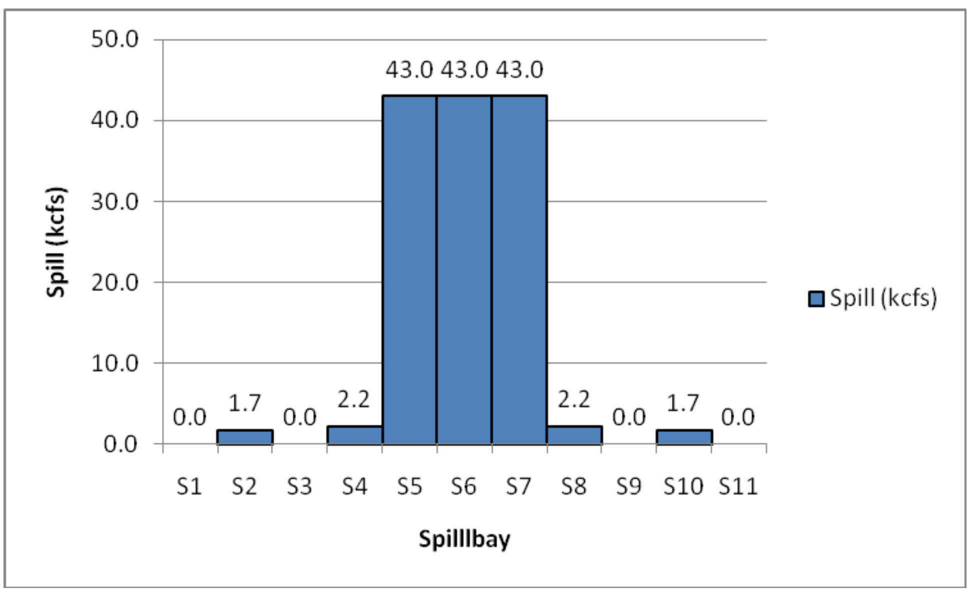

Figure 7. Operational configuration under forced spill > 96.0 kcfs (with removal of JBS barriers in *S6*). In this instance (136.8 kcfs of total spill), 43.0 kcfs is allocated through *S5*, *S6*, and *S7*.

Forced Spill (> 136.8 kcfs)

Forced spill exceeding 136.8 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 each 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).

VII. JBS Re-Installment Criteria

Once spills of less than 40.0 kcfs are predicted for at least four days, JBS barriers should be re-installed in *S6*.

I. Spill Lookup Table

Operation	Total Spill	*S1* -	*S2* JBS	***S3***	*S4* JBS	***S5***	*S6* JBS	***S7***	*S8* JBS	***S9***	*S10* JBS	*S11* -
						Spillbay Number						
I. No Forced Spill	10.0	0.0	1.7	0.0	2.2	0.0	2.2	0.0	2.2	0.0	1.7	0.0
II. Spill (≤ 53.0 kcfs), min.	11.0	0.0	1.7	0.0	2.2	1.0	2.2	0.0	2.2	0.0	1.7	0.0
II. Spill (≤ 53.0 kcfs), max.	53.0	0.0	1.7	0.0	2.2	43.0	2.2	0.0	2.2	0.0	1.7	0.0
III. Spill (> 53.0 kcfs, *S6* JBS out), min.	54.0	0.0	1.7	0.0	2.2	31.2	15.0	0.0	2.2	0.0	1.7	0.0
III. Spill (> 53.0 kcfs, *S6* JBS out), max.	93.8	0.0	1.7	0.0	2.2	43.0	43.0	0.0	2.2	0.0	1.7	0.0
IV. Spill (> 93.8 kcfs, *S6* JBS out), min.	96.8	0.0	1.7	0.0	2.2	43.0	38.8	15.0	2.2	0.0	1.7	0.0
IV. Spill (> 93.8 kcfs, *S6* JBS out), max.	136.8	0.0	1.7	0.0	2.2	43.0	43.0	43.0	2.2	0.0	1.7	0.0
V. Spill (>137.0 kcfs), min.	137.0	0.0	1.7	15.0	2.2	43.0	43.0	28.2	2.2	0.0	1.7	0.0
V. Spill (>137.0 kcfs), max.	-	*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 *S5*, *S6*, *S7*, *S3*, and *S9* (in that order).