US Army Corps of Engineers®
Northwestern Division

2013 DISSOLVED GAS AND WATER TEMPERATURE REPORT

Spill at Bonneville Dam

Columbia Basin Water Management Division
Reservoir Control Center
Water Quality Team

December 2013

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COLUMBIA RIVER BASIN

December 2013

Water Quality Unit
Reservoir Control Center, Columbia Basin Water Management Division
U. S. Army Corps of Engineers Northwestern Division
Portland, Oregon

Including Material Provided by:
Portland District – U.S. Geological Survey (Portland Office)
Walla Walla District – U.S. Geological Survey (Kennewick Office)
Seattle District – Columbia Basin Environmental
Corps of Engineers' Engineering Research and Development Center
Fish Passage Center

2013 TOTAL DISSOLVED GAS AND WATER TEMPERATURE REPORT COLUMBIA RIVER BASIN

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List of Acronyms

The following acronyms are used throughout this report.

BiOp	Biological Opinion
BPA	Bonneville Power Administration
Corps	U.S. Army Corps of Engineers
CRT	Columbia River Treaty
ESA	1973 Endangered Species Act
FCOP	Flood Control Operating Plan
FCRPS	Federal Columbia River Power System
FMS	fixed monitoring station
FOP	Fish Operations Plan
GBT	gas bubble trauma
kcfs	thousand cubic feet per second
kaf	thousand acre feet
Maf	million acre-feet
MOP	minimum operating pool
NOAA Fisheries	National Oceanic and Atmospheric Administration, Fisheries
NWRFC	Northwest River Forecast Center
ODEQ	Oregon Department of Environmental Quality
PUD	Public Utility District
QA	quality assurance
QC	quality control
RCC	Reservoir Control Center
Reclamation	United States Bureau of Reclamation
RPA	Reasonable and Prudent Alternative (from the Biological Opinion)
SSARR	Streamflow Synthesis and Reservoir Regulation model
TDG	total dissolved gas
TMT	Technical Management Team
TMDLs	Total Maximum Daily Loads
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VARQ	Variable Q, a variable flow associated with Libby flood control
WDOE	Washington Department of Ecology
WQS	Water Quality Standards
WY	water year

Terminology

The U.S. Army Corps of Engineers (Corps) has noted different agencies applying various definitions to common terminology. The following are the Corps' definitions used throughout this report.

2010 Supplemental BiOp: The current governing Biological Opinion for the Federal Columbia River Power System. It recommends a comprehensive series of actions to avoid jeopardizing 13 Endangered Species Act (ESA)-listed salmon and steelhead species throughout their life cycle and adverse modification of designated critical habitat.

FCRPS Action Agencies: The three Federal agencies responsible for the operation of the Federal Columbia River Power System (FCRPS) are the Corps, Bureau of Reclamation (Reclamation), and Bonneville Power Administration (BPA).

Fish Passage Spill: (sometimes called Voluntary Spill) is provided at the four lower Snake River and four lower Columbia River dams for the benefit of juvenile fish passage, in accordance with the operative biological opinions and the Clean Water Act. Fish passage spill is also provided at Dworshak Dam to provide additional water for flow augmentation and to moderate temperature in the lower Snake River. The (2014 BiOp) RPA action 29 calls for the Action Agencies to provide spill at these dams to improve juvenile fish passage, but not to exceed applicable state water quality standards for TDG. The dates and levels for spill at each dam may be modified through the implementation planning process and adaptive management decisions. At some Corps dams, the amount of spill to aid fish passage is a specified level (i.e., flow rate or percent of total river flow), while at others, the Corps spills up to the applicable state TDG criteria, referred to as the "gas cap." The maximum spill level at a given dam that meets, but does not exceed the gas cap is referred to as the spill cap.

Gas Cap: Spill up to the applicable state TDG criteria.

Hydraulic capacity: The maximum water flow rate that a hydro power facility can pass through the turbines. Capacity can be limited by outages, operating limits, and the carrying of mandatory power reserves by the project.

Involuntary Spill: In contrast to spilling for the benefit of juvenile fish passage, involuntary spill is driven largely by hydrologic capacity at each dam; the quantity of water that exceeds the capacity of a dam to either temporarily store the water upstream of the dam or pass the water through its turbines. In these circumstances, water must be released through the spillway. Involuntary spill occurs due to either **Lack of Load** or **Lack of Turbine**, but can also occur as a result of the management of reservoirs for flood control, scheduled or unscheduled turbine unit outages or transmission outages of various durations, passing debris, or any other operational and/or maintenance activities required to manage dam facilities for safety and authorized project uses.

Lack of Load Spill: This occurs when the available market for hydropower is less than the power that could be produced by the current river flow with available turbine capacity. When BPA cannot access sufficient market to sell hydropower and there is insufficient storage capability, the river flow must be released over the spillway or through other regulating outlets. Lack-of-load spill generally occurs during times of high flows (e.g., in the spring or fall when power demands are low both in California and the Pacific Northwest). Releases from upstream storage dams during high load periods (generally morning and evening) can result in high flows at downstream dams during low load periods (e.g., middle of the night), causing lack of load spill. Lack of load spill is managed on a system-wide basis to distribute TDG levels across the Federal projects using the spill priority list.

Lack of Turbine Spill: This occurs when flows exceed the hydraulic capacity of the available power generation facilities at a specific dam. Lack of turbine spill can be affected by high river flows, planned and unplanned unit outages, planned and unplanned transmission outages, and other transmission constraints. Any of these conditions physically limit the potential for hydropower production. Lack of turbine spill will generally be the amount of river flow in excess of the maximum amount that can be released through all available generators and other outlet structures (e.g., sluiceways and fish ladders). In general, when this condition occurs, the affected project will be operating at maximum generation capability to minimize the amount of spill.

Lack of turbine spill can also occur when turbines cannot be used because their capacity must be held in reserve to provide mandatory reserve power capacity (reserves) for contingencies and load balancing. **Reserves** (Reserve Power Capacity) are the amount of generation capacity above the amount currently in use that is immediately available to maintain system reliability. At projects that must carry reserve power capacity, these projects can only be loaded to the maximum available generation minus the reserve capacity allocated to that project. Spill for maintaining reserves primarily occurs at Grand Coulee, Chief Joseph, The Dalles, John Day, Bonneville, and occasionally McNary dams.

Percent TDG: Percent of total dissolved gas saturation (TDG) or concentration in the water-body. This may also appear as %TDG in the text or tables.

SSARR: The Streamflow Synthesis and Reservoir Regulation (SSARR) model is an operational hydrologic model of a river system used for flood control studies, planning studies, and daily streamflow forecasting.

Spill cap: The estimated spill rate to achieve the appropriate level of spill to meet the applicable state water quality standards (WQS), generally 115 percent in the forebay or 120 percent in the tailwater, or to meet target levels of TDG identified in the Spill Priority List. The maximum project spill level that meets but does not exceed the gas cap is referred to as the spill cap.

Spill Priority List: Identifies the order and amount of spill at the Corps' Columbia River Basin dams and Grand Coulee Dam for management of expected TDG production in the system. The Spill Priority List is primarily used to manage system-wide TDG levels throughout the year and is applicable for all spill conditions. Information from the Spill Priority List is used to guide where and to what extent BPA allocates reserves to the various projects and other actions that may limit system reserve obligations.

Spill Shift: Spill shift is the act of shifting generation from one project to another to better manage spill and TDG in the river. This is usually used at Chief Joseph Dam and Grand Coulee Dam.

TDG Instance: Instances occur when TDG levels exceed applicable state water quality standards and applicable waivers and criteria adjustments.

TMT: The Technical Management Team (TMT) is an interagency sovereign technical group responsible for making recommendations on operations for fish to the Federal agency with authority to operate FCRPS projects. This group is comprised of representatives from sovereign entities including five Federal agencies: BPA, Reclamation, National Oceanic and Atmospheric Administration (NOAA) Fisheries, U.S. Fish and Wildlife Service (USFWS), Corps, four states (Idaho, Oregon, Montana, and Washington), and participating Tribes.

Unit Outage: A unit outage is a period of time when a generating unit cannot be in operation because of maintenance or repairs.

Part 1 Program Description

1.0 Introduction

This report describes the U.S. Army Corps of Engineers' (Corps) Columbia River Basin spill and water quality monitoring program for 2013 and covers the Columbia and Snake River dams located in Washington, Idaho, and Oregon. This report was developed to meet the Corps' water quality program reporting responsibilities related to the Oregon Department of Environmental Quality (Oregon) Total Dissolved Gas (TDG) waiver, the Washington Department of Ecology (Washington) TDG criteria adjustment and the 2002 and 2003 TDG Total Maximum Daily Loads (TMDLs) for the lower Columbia and lower Snake rivers.

This report provides information requested by Oregon and Washington including weather, flow and runoff conditions for the spill season, spill quantities and durations, quantities of water spilled for fish versus spill for other reasons for each dam, information regarding project operations, data from the physical and biological monitoring programs, description and results of any biological or physical studies of spillway structures and prototype fish passage devices, and progress on implementing measures contained in the lower Columbia and Snake rivers TDG TMDL documents. This report also includes documentation on the performance of the TDG monitoring system, and the 2010 Supplemental Biological Opinion (2010 Supplemental BiOp), Reasonable and Prudent Alternative (RPA) Actions 4, 15, 26, 29, and 32.

The following is a list of the appendices included in this report. Note: Appendices with * are provided electronically on the website at:
http://www.nwd-wc.usace.army.mil/tmt/wqnew/tdg_and_temp/2013

- Appendix A* - General overview of the monitoring system with information on the fixed monitoring stations (FMS).
- Appendix B* - Dissolved Gas Monitoring Plan of Action for 2010 – 2014, updated in 2012.
- Appendix C* - Fish Operations Plan (FOP) for 2013 spill season.
- Appendix D - Reports on the FOP spill volumes for 2013.
- Appendix E* - 2013 monthly Court Reports filed with the Court during spill season. This appendix contains graphs of flow, spill and high 12-hour percent TDG average along with variance tables.
- Appendix F - Summary of TDG instance types when TDG levels exceed state WQS.
- Appendix G* - Detailed evaluation of the SYSTDG model performance during the 2013 spill season.
- Appendix H* - Dworshak summer operations.
- Appendix I* - Walla Walla District report on the Quality Assurance/Quality Control (QA/QC) review for TDG and temperature monitoring gauges at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and McNary dams.

- Appendix J*- Portland District report on the QA/QC review for TDG and temperature monitoring gauges at John Day, The Dalles, Bonneville, and the Warrendale and Camas/Washougal sites.
- Appendix K* - Seattle District report on the QA/QC review for TDG and temperature monitoring gauges at Chief Joseph Dam.
- Appendix L - Gas Bubble Trauma Monitoring and Data Reporting by the Fish Passage Center.
- Appendix M - TDG TMDL implementation summary providing an overview of the status of the Corps' TDG TMDL activities.

1.1 Clean Water Act and Endangered Species Act

1.1.1 General

TDG and water temperature are primary water quality parameters monitored by the Corps in the mainstem Columbia and Snake rivers in the states of Idaho, Oregon, and Washington. TDG and temperature may be influenced by dam water management operations (e.g., water released over the dam spillways, releases through the powerhouses and other facilities, and forebay and tailwater water surface elevations), as well as environmental factors including ambient temperatures and wind conditions.

The monitoring performed by the Corps is part of a larger interagency water quality monitoring system that includes the Reclamation and the Washington Public Utility District (PUD) monitoring systems (as conducted by Douglas County PUD, Chelan County PUD, and Grant County PUD).

1.1.2 Corps' Goals

The Corps' policy is to comply with applicable water quality standards (WQS) to the extent practicable regarding nationwide operation of water resources projects. The general policy is summarized in the **Corps Digest of Water Resources Policies and Authorities**, Engineering Pamphlet 1165-2-1, Section 18-3.b, page 18-5 dated July 30, 1999, which states:

> Although water quality legislation does not require permits for discharges from reservoirs, downstream water quality standards should be met whenever possible. When releases are found to be incompatible with state standards they should be studied to establish an appropriate course of action for upgrading release quality, for the opportunity to improve water quality in support of ecosystem restoration, or for otherwise meeting their potential to best serve downstream needs. Any physical or operational modification to a project (for purposes other than water quality) shall not degrade water quality in the reservoir or project discharges.

1.1.3 Biological Opinions

1.1.3.1 Background

During the 1990s, Snake and Columbia River salmonids were listed under the Endangered Species Act (ESA). Through ESA consultations, the Corps implemented a variety of operational and structural measures that were called for in biological opinions to improve the survival of listed salmonids. The 2010 NOAA Fisheries FCRPS BiOp (2010 Supplemental BiOp) calls for the Corps to provide spill for juvenile fish migration in the Federal Columbia River Power System (FCRPS). The Action Agencies annually develop a Fish Operations Plan (FOP) that provides detailed information on the implementation of the BiOp fish passage operations. Water management operations to reduce water temperature in the lower Snake River for the benefit of listed Snake River fall Chinook salmon have also been an objective of the FCRPS BiOps.

For this reporting period, the FCRPS BiOps that the Corps is implementing are the 2000 U.S. Fish and Wildlife Service (USFWS) and the 2010 Supplemental BiOp.

1.1.3.2 USFWS and NOAA Fisheries BiOps

USFWS 2000 BiOp

According to the FCRPS actions addressed in the USFWS 2000 BiOp, operational and structural changes are to be made to reduce uncontrolled spill and the effects of high TDG at lower Columbia River dams if it is determined that bull trout are affected by the FCRPS.

NOAA Fisheries 2010 FCRPS BiOp

The 2010 NOAA Fisheries FCRPS BiOp (2010 Supplemental BiOp) RPA includes operations that have an effect on water quality: RPA Actions 4, 15, 26, 29 and 32. For the 2013 fish migration season, the U.S. District Court of Oregon ordered the Federal agencies to operate the FCRPS in accordance with the 2013 FOP, which is provided in Appendix C.

The FCRPS BiOps may be found at the following website:
http://www.salmonrecovery.gov/BiologicalOpinions/FCRPSBiOp.aspx

1.1.4 TDG Standards

The following are the applicable TDG WQS as currently approved by the Confederated Tribes of the Colville Reservation and the states of Idaho, Oregon, and Washington.

Confederated Tribes of the Colville Reservation TDG Standards:

4-8-5(e): The Water Quality Standards herein established for the TDG shall not apply when the stream flow exceeds the seven (7) day, ten (10) year frequency flood.

4-8-6 (b) (3) (E): Total Dissolved Gas shall not exceed 110 percent of saturation at any point of sample collection.

State of Idaho:
IDAPA 58.01.02-250- 01(b): The total concentration of dissolved gas not exceeding one hundred ten percent (110%) of saturation at atmospheric pressure at the point of sample collection.

State of Oregon:
OAR 340-041-0031:

- Waters will be free from dissolved gases, such as carbon dioxide, hydrogen sulfide, or other gases, in sufficient quantities to cause objectionable odors or to be deleterious to fish or other aquatic life, navigation, recreation, or other reasonable uses made of such water.
- Except when streamflow exceeds the ten-year, seven-day average flood, the concentration of TDG relative to atmospheric pressure at the point of sample collection may not exceed 110 percent of saturation. However, in hatchery-receiving waters and other waters of less than two feet in depth, the concentration of TDG relative to atmospheric pressure at the point of sample collection may not exceed 105 percent of saturation.

OAR 340-041-104(3): Total Dissolved Gas. The Commission may modify the total dissolved gas criteria in the Columbia River for the purpose of allowing increased spill for salmonid migration. The Commission must find that:

(a) Failure to act would result in greater harm to salmonid stock survival through in-river migration than would occur by increased spill;

(b) The modified total dissolved gas criteria associated with the increased spill provides a reasonable balance of the risk of impairment due to elevated total dissolved gas to both resident biological communities and other migrating fish and to migrating adult and juvenile salmonids when compared to other options for in-river migration of salmon;

(c) Adequate data will exist to determine compliance with the standards; and

(d) Biological monitoring is occurring to document that the migratory salmonid and resident biological communities are being protected;

(e) The Commission will give public notice and notify all known interested parties and will make provision for opportunity to be heard and comment on the evidence presented by others, except that the Director may modify the total dissolved gas criteria for emergencies for a period not exceeding 48 hours;

(f) The Commission may, at its discretion, consider alternative modes of migration.

The Corps received a TDG waiver on June 24, 2009, from the State of Oregon effective for the 2010-2014 spill seasons from April 1 – August 31. The Environmental Quality

Commission approved a modification to the 110 percent total dissolved gas water quality standard for fish passage spill at McNary, John Day, The Dalles, and Bonneville dams on the lower Columbia River, subject to the nine conditions. Two operational conditions have been selected from the TDG waiver list and are highlighted for the purposes of this report:

(iii) Spill must be reduced when the average TDG concentration of the 12 highest hourly measurements per calendar day exceeds 120 percent of saturation in the tailraces of McNary, John Day, The Dalles, and Bonneville dams' monitoring stations.

(iv) Spill must be reduced when instantaneous TDG levels exceed 125 percent of saturation for any 2 hours during the 12 highest hourly measurements per calendar day in the tailraces of McNary, John Day, The Dalles, and Bonneville dams' monitoring stations.

State of Washington:
WAC 173-201A-200(1)(f): Aquatic life total dissolved gas criteria. TDG is measured in percent saturation. Table 200 (1)(f) lists the maximum TDG criteria for each of the aquatic life use categories.

TABLE 200 (1)(f)
Aquatic Life Total Dissolved Gas Criteria in Fresh Water

Category	Percent Saturation
Char Spawning and Rearing	Total dissolved gas shall not exceed 110 percent of saturation at any point of sample collection.
Core Summer Salmonid Habitat	Same as above.
Salmonid Spawning, Rearing, and Migration	Same as above.
Salmonid Rearing and Migration Only	Same as above.
Non-anadromous Interior Redband Trout	Same as above.
Indigenous Warm Water Species	Same as above.

(i) The water quality criteria established in this chapter for TDG shall not apply when the stream flow exceeds the seven-day, ten-year frequency flood.

(ii) The TDG criteria may be adjusted to aid fish passage over hydroelectric dams when consistent with a department approved gas abatement plan. This plan must be accompanied by fisheries management and physical and biological monitoring plans. The elevated TDG levels are intended to allow increased fish passage without causing more harm to fish populations than caused by turbine fish passage. The following special fish passage exemptions for the Snake and Columbia rivers apply when spilling water at dams is necessary to aid fish passage:

- TDG must not exceed an average of 115 percent as measured in the forebays of the next downstream dams and must not exceed an average of 120 percent as measured in the tailraces of each dam (these averages are measured as an average of the twelve highest consecutive hourly readings in any one day, relative to atmospheric pressure); and
- A maximum TDG one hour average of 125 percent must not be exceeded during spillage for fish passage.

On June 30, 2010, Washington approved the gas abatement plan, submitted March 22, 2010. Two conditions are highlighted for the purpose of this report:

1) This approval shall extend through the end of February 2015 and apply to Corps' dams on the Columbia and Snake rivers in Washington State.

2) This approval allows spill to increase the dissolved gas levels above 110 percent of saturation to aid fish passage, but not to exceed 125 percent of saturate as a one-hour average. Gas saturation may not exceed 120 percent in the tailrace and 115 percent in the forebay of the next downstream dam as measured by the highest 12-hour, consecutively-averaged value in any one day.

1.1.5 TDG TMDL Progress

The Oregon waiver and the Washington criteria adjustment request an update on the progress of implementing actions recommended in the "TMDL for the Lower Columbia River Total Dissolved Gas (September 2002)" and the "TMDL for the Lower Snake River Total Dissolved Gas (April 2003)" reports. Appendix M provides the status of the Corps' TDG TMDL implementation activities.

1.1.6 Operating Guidelines

The Corps' Reservoir Control Center (RCC) Water Quality Unit is responsible for monitoring the TDG and water temperature conditions in the forebay and the tailwater of the Columbia and Snake River dams, and selected river sites. The Corps' district water quality staff operates and maintains the water quality gauges at the fixed monitoring stations (FMSs). In accordance with the Corps' Northwestern Division operational water management guidelines, spill levels and spill patterns at the dams are monitored and changed so that TDG levels are consistent with the applicable state WQS.

Both Oregon and Washington modified their WQS during the last five years. Prior to 2006, Oregon and Washington specified the method of calculating the "daily percent TDG" as an average of the 12 highest hourly readings (or measurements) in a given day at the forebay and the tailrace. In November 2006, Washington changed the method of calculating percent saturation TDG to "an average of the twelve highest consecutive hourly readings in any one day." For the remainder of this report, this method is referred to as the

"Washington method." Part 5 of this report provides detailed information on the TDG instances using the Oregon and Washington methods (ODEQ/WDOE respectively).

In 2008, Oregon determined that the 115 percent TDG standard and forebay gauges were no longer a component of the waiver. As a result, Oregon applies the state water quality standards to tailwater gauges only using the average of the 12 highest hourly readings in a given day (Part 5.2.4 for more information).

Changes made to these state water quality standard exceptions in recent years have not been fully applied because the Corps is operating under a Court Order to continue spill for juvenile fish as implemented in 2006 through 2013. The Corps continues to use the Camas/Washougal water quality monitoring station and calculates TDG using the 12-hour average based on the 12 highest hourly reading in any one day (Oregon method).

1.1.7 Policy on Chief Joseph Spill Operations

In 2008, 19 flow deflectors were installed at Chief Joseph Dam to reduce TDG production when spill is necessary. During testing and in actual operations, the spillway flow deflectors have successfully reduced TDG levels associated with spillway releases when inflow TDG levels are above approximately 120 percent. As a result, the Corps' spill management policy utilizes the spillway flow deflectors at Chief Joseph Dam as an effective means for moderating system TDG levels (Section 2.1.3.4).

Part 2 Program Operating Conditions

2.1 Water Year Runoff Conditions

This part provides an overview of the water year runoff and reservoir operations, including a description of the weather, water supply, and reservoir operations.

2.1.1 Weather[1]

In 2013, the region's weather was typically warmer and drier than normal. August of 2012 through July of 2013 saw Basin-wide temperature departures significantly above normal (1.7 ºF/0.8 ºC).

The Columbia River Basin WY 2013 (over the 12-month period, October 2012 – September 2013) was slightly below average in precipitation affecting Columbia River flows, and below average in the region affecting Snake River flows as shown in Table 1. The accumulative precipitation as reported by the Northwest River Forecast Center (NWRFC) for WY 2013 (from October 2012 through September 2013) was 103 percent of average (1981 to 2010) in the Columbia River above Grand Coulee Dam, 83 percent of normal in the Snake River above Ice Harbor Dam, and 93 percent of normal in the Columbia River above The Dalles Dam.

[1] 2013 Annual Report of the Columbia River Treaty, Canada and United States Entities (2013 Annual Treaty Report).

TABLE 1
Columbia River Basin Percent Precipitation
WY 2013

Location	Columbia River above Grand Coulee	Snake River above Ice Harbor	Columbia River above The Dalles
October 2012	194	130	164
November 2012	117	97	102
December 2012	84	108	94
January 2013	51	52	49
February 2013	61	47	50
March 2013	102	54	72
April 2013	114	64	87
May 2013	98	55	82
June 2013	124	61	98
July 2013	20	31	21
August 2013	83	51	75
September 2013	187	248	225
WY Average	103	83	93
Note: Percent Precipitation as percentage of the 1981-2010 average			

The first ten days of October 2012 were very dry for the Columbia River Basin. This was a continuation of the mild, extremely dry weather pattern which dominated July through September. The remainder of the month of October took a dramatic shift to very wet conditions as a subtropical moisture tap unleashed heavy rain and higher elevation snow for much of the region. The moisture tap continued for much of the remainder of the month, and, despite the slow start, by the end of the month the region had received nearly double its normal precipitation – concentrated over the northwest half of the Basin.

November and December of 2012 marked a two-month stretch of slightly above normal precipitation for the Basin (100-120%) with significantly above normal temperatures. Unlike previous years, November of 2012 brought a progressive weather pattern, with repeating pattern of relatively stormy periods and dry periods. During December, the jet stream sagged south, focusing over the southern half of the Basin. British Columbia was relatively dry, while the brunt of the storms affected the southern tier.

The New Year seemed to bring a shift in the overall weather pattern towards drier conditions. During January, high latitude blocking lead to significant stretches of relatively dry weather. Snowpack percentages for the Basin dropped 15% during the month of January (from 109% to 93%). Temperatures across the Basin were split on a north/south line with temperatures in the northern portion of the Basin being significantly warmer than average and the southern tier being significantly below average.

February's relatively dry weather pattern continued through most of the month, although the storm-blocking high pressure ridge began breaking down toward the end of the month as storms began hitting the Canadian portion of the Basin. Precipitation above The Dalles for January and February was 66% and 55% of normal respectively -- substantial shortfalls for two of the wettest months of the water year. The forecasted January-July runoff dropped below 90 Maf for over a month.

Although temperatures bounced around month-to-month during the spring of 2013, the precipitation pattern was relatively stable. During these months, the jet stream and corresponding storm track favored northern or northwest portions of the Columbia River Basin. Precipitation above Grand Coulee during the spring was slightly above normal, in contrast to precipitation above Ice Harbor, which was a significantly below normal.

March and May temperatures were well above normal, but were below normal for April. There was a significant early season warm-up during the end of March into early April that led to the first significant surge of the run-off. The peak run-off occurred during mid-May this year in response to a region-wide heat wave. This peak was a full month ahead of the normal peak, which typically occurs in June. Areas west of the Cascades broke high temperature records during this period. The peak of the run-off during the previous two years had been precipitation-driven, and we returned to the more traditional temperature-driven snowmelt runoff pattern.

June experienced an upturn in precipitation across the Basin with southern British Columbia, eastern Washington and the panhandle of Idaho having significantly above average precipitation. However, the rest of the Basin saw only average or significantly below average precipitation. As temperatures cooled and the snowpack receded, runoff slowly receded.

Late June to early July saw a very strong high-pressure ridge develop over the West. This was the first heat wave in several years to impact the Pacific Northwest. There was a significant heat spell June 30 to July 2. Following the brief snowmelt response from this heat wave, the majority of the run-off was essentially done as flows once again dipped well below normal by mid-July.

Although summer was a bit slow getting started, that all changed for July and August as a persistent warm, dry pattern took hold over the region. As high pressure dominated, precipitation was generally shunted to the north and south around the fringes of the region.

During July and early August, only about a quarter of the normal precipitation fell over the Basin, leading to increased drought concerns. In addition, temperatures were abnormally hot, especially east of the Cascades where the marine influence was minimal. During August, dry lightning activity picked up over the Basin, combining with tinder dry fuels to lead to serious wildfire outbreaks -- the most significant fire activity in several years.

September began as a continuation of August with warm and dry conditions across much of the basin. About half way through the month, however, conditions changed drastically and a series of storms brought consistently cooler and wetter weather basin wide. A significant number of stations reported new monthly record precipitation for September.

2.1.2 Water Supply

The NWRFC April 1, 2013, forecast of January through July runoff for the Columbia River above The Dalles Dam was 91 Maf; however, the actual observed runoff volume was 97 Maf. This value is low compared to the historical average (1981-2010) January-July runoff volume of 101 Maf.

The WY 2013 total runoff volume, unregulated flow as measured at The Dalles Dam was 131 Maf, which is 100 percent of the 1981-2010 average. For WY 2013, the daily average unregulated streamflow in the basin above The Dalles Dam was approximately 15 percent lower than the WY 2012 average flow (115 percent of normal). Table 2 provides WY 2013 average monthly unregulated streamflow and the percentage of the 1981-2010 average monthly flows for the Columbia River at Grand Coulee and The Dalles dams. Unregulated flows provide a general perspective on the water supply for that month or year from rainfall or snowmelt. At The Dalles Dam, the average monthly unregulated inflow during the spring runoff was highest in May, with daily flows peaking on May 15, 2013, at 503 kcfs.

TABLE 2
Columbia River Flow in WY 2013[2]

Time Period	At Grand Coulee		At The Dalles	
	Unregulated Flow, kcfs	% of Average	Unregulated Flow, kcfs	% of Average
October 2012	46	101	77	94
November 2012	67	138	119	126
December 2012	62	156	123	134
January 2013	38	94	86	88
February 2013	37	86	87	78
March 2013	63	104	126	85
April 2013	129	108	229	99
May 2013	302	120	458	111
June 2013	311	106	408	93
July 2013	175	98	223	94
August 2013	90	96	119	95
September 2013	69	122	99	114
WY Average	116	111	179	101

Note: Unregulated Flows exclude the effects of regulation provided by storage reservoirs

2.1.3 Reservoir Operation

The following overview of reservoir operations includes a description of flood control, streamflow, operations, and 7Q10 flows.

[2] From 2013 Annual Treaty Report.

2.1.3.1 General

The WY 2013 began with Grand Coulee Dam storage at 89.7 percent full. Projected water supply forecasts for The Dalles decreased rapidly from January to February then stabilized as shown in Figure 1. The shape of the runoff at Bonneville Dam resulted in several peaks between early April and late June (Figure 2). Flows during the late April/May peak, and the late June peak, were below 300 kcfs most of the time.

Generally, reservoir operation objectives included: reaching the upper rule curve elevation on or about April 10 at the U.S. storage projects; refill on, or about June 30; and drafting reservoirs to summer draft limits. The spring seasonal flow objectives were met at Priest Rapids and McNary Dam, but not at Lower Granite Dam. The summer seasonal flow objectives were not met at either McNary Dam or Lower Granite Dam.

FIGURE 1
2013 Water Supply Forecast at The Dalles

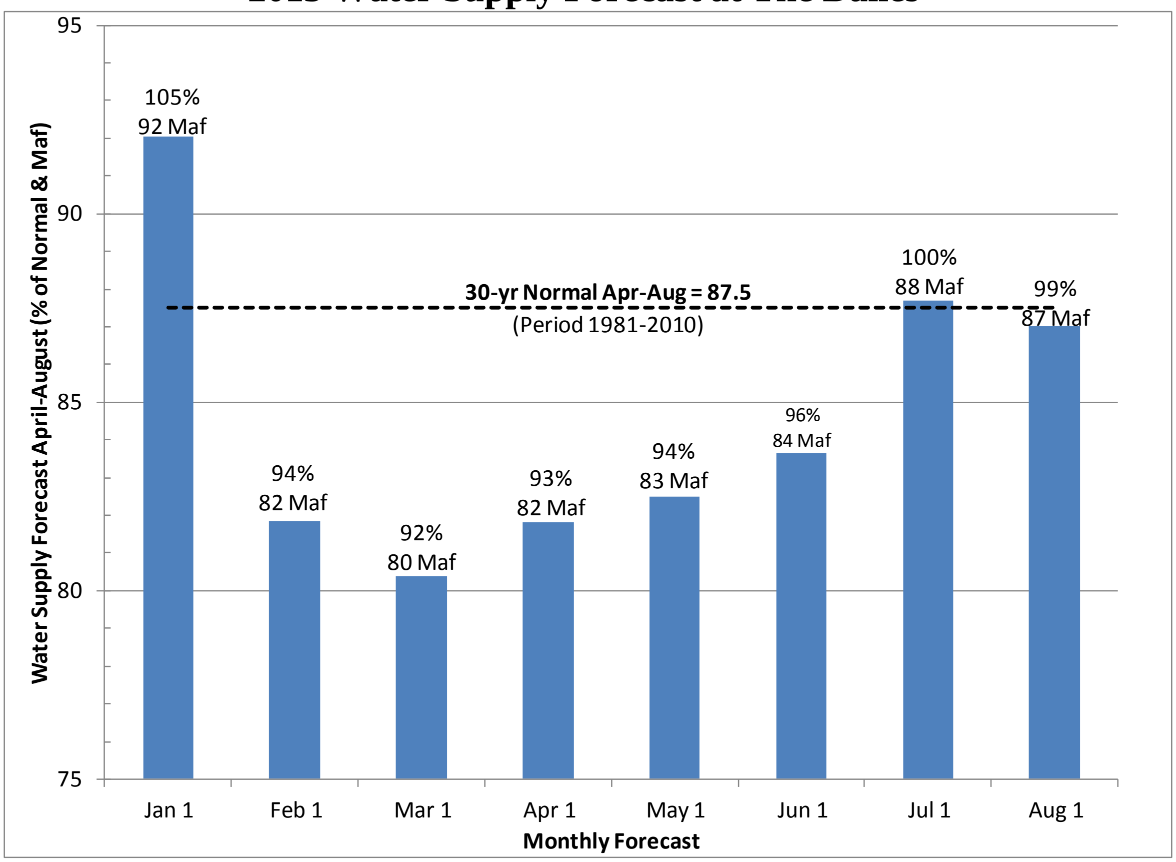
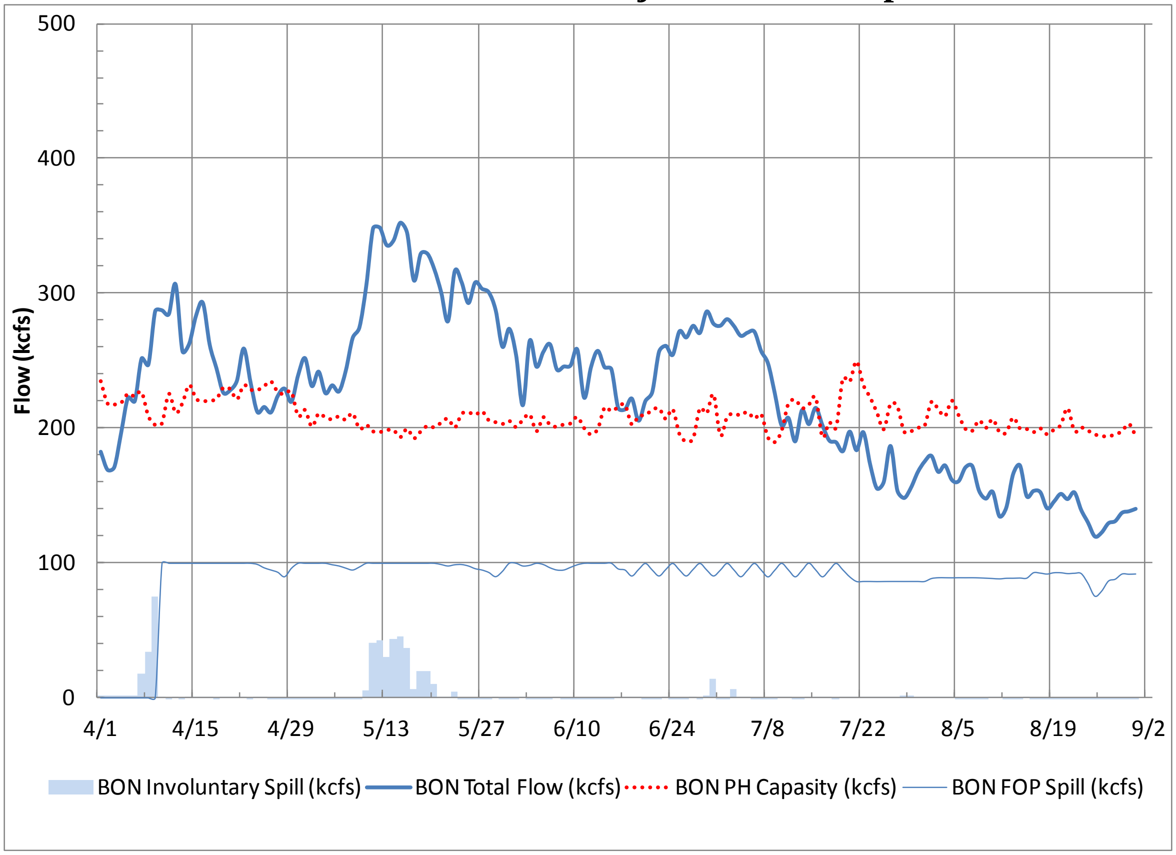


FIGURE 2
2013 Bonneville Dam Project Flow and Spill



Note: Daily powerhouse capacities provided by BPA Duty Schedulers

2.1.3.2 Flood Control

The NWRFC 2013 water supply forecasts were initially slightly above average but decreased during the season to average at all the Columbia River sub-basins with the exception of the Snake River basin where it was below average. Inflow forecasts and reservoir regulation modeling were performed weekly throughout the winter and spring. The FCRPS dams were operated to their specified flood control elevations based on the information available during the season. This included the treaty projects operating to the May 2003 Flood Control Operating Plan (FCOP) except for Libby Dam, which operated to Variable Flow (VARQ) drafts. The unregulated peak flow, based on the Corps' system regulation model (SSARR) at The Dalles Dam, was estimated at 503 kcfs on May 15, 2013, and a regulated peak flow of 338 kcfs occurred on May 11, 2013, as measured at the U.S. Geological Survey (USGS) gauge at The Dalles, Oregon. The unregulated peak stage at Vancouver, Washington, was calculated to be 18.4 feet on May 16, 2013, and the highest observed stage was 10.3 feet on May 12, 2013.

2.1.3.3 Streamflow

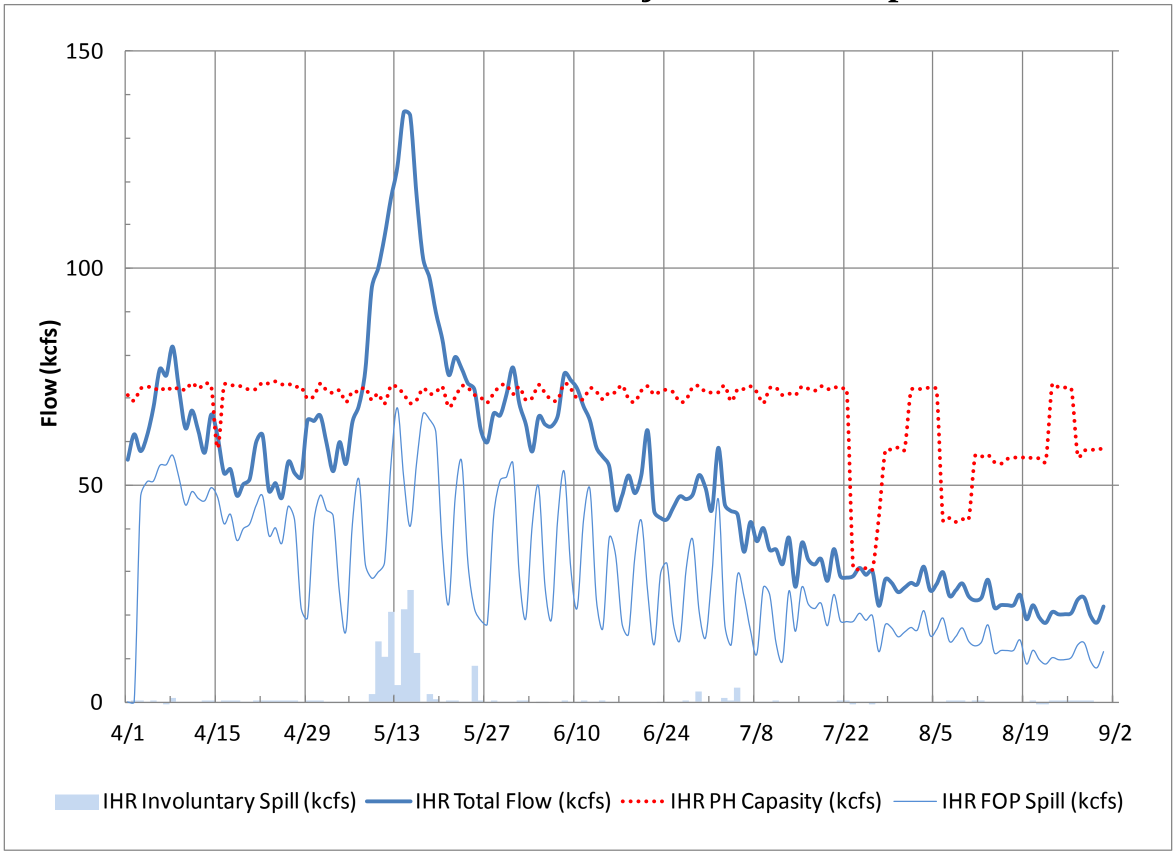
System stream flows were average in 2013 due to the average runoff volume. This resulted in average to low releases at some of the FCRPS projects as demonstrated in the three examples shown below: Bonneville for the lower Columbia, Ice Harbor for the lower Snake and Chief Joseph for the middle Columbia reach.

Daily average total river flow on the lower Columbia River, as measured at Bonneville Dam, from April 1 through August 31, ranged from 120 kcfs to 351 kcfs, averaging 227 kcfs (Figure 2). Total river flows began to recede gradually in early June and continued a steady recession until the end of August when flows reached 120 kcfs.

On the lower Snake River as measured at Ice Harbor Dam, daily average total river flow from April 1 through August 31 ranged from 18 kcfs to 136 kcfs, averaging 51 kcfs (Figure 3). Daily average flow peaked on May 14. Flows began to recede after the May peak with a gradual recession ending the month of August at about 18 kcfs.

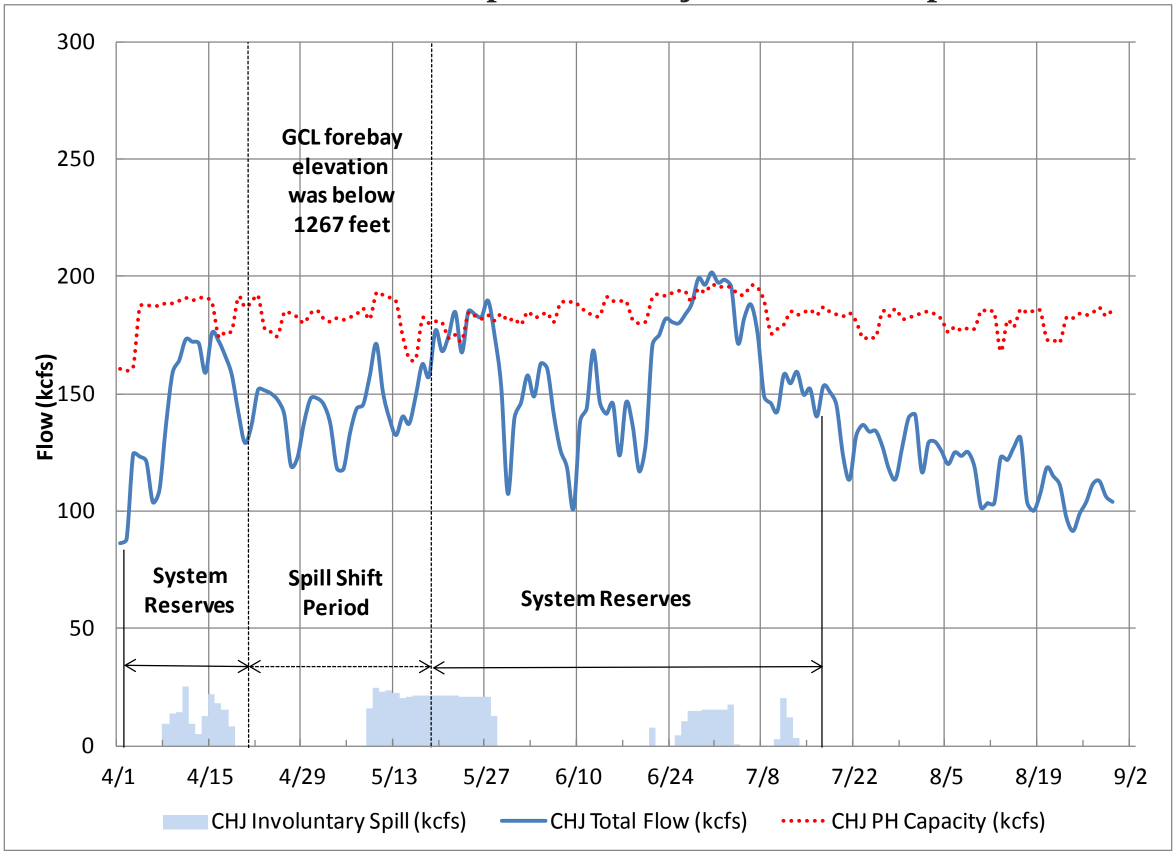
Daily average total river flows on the mid-Columbia River, as measured at Chief Joseph Dam from April 1 through August 31, ranged from 86 kcfs to 201 kcfs, averaging 142 kcfs (Figure 4). Flows peaked on June 30 and began to decrease and continued to recede until the end of August when flows dropped to 89 kcfs on August 31.

FIGURE 3
2013 Ice Harbor Dam Project Flow and Spill



Note: Daily powerhouse capacities provided by BPA Duty Schedulers

FIGURE 4
2013 Chief Joseph Dam Project Flow and Spill



Note: Daily powerhouse capacities provided by BPA Duty Schedulers

2.1.3.4 Chief Joseph Dam Operations

Spill operations at Chief Joseph Dam continued to be managed to balance system reserves and system-wide TDG levels when needed. The following discusses the three operational uses of the spillway flow deflectors at Chief Joseph Dam for moderating system TDG levels, and this year's implementation:

1. Spill/Power Shift: Under system-wide lack of load conditions, spill shift, accomplished by positioning Chief Joseph ahead of Grand Coulee in the spill priority list, is used to avoid or minimize spilling through the outlet tubes at Grand Coulee (which produce high TDG levels). Chief Joseph's additional capacity to spill with lower TDG levels than Grand Coulee Dam reduces the frequency and magnitude of spill due to lack of load at Grand Coulee.

   Implementation of the Spill Shift at Chief Joseph Dam between May 9 and May 19 (as shown in Figures 4 and 5, and Table 3) reduced percent TDG by maximizing available power generation at Grand Coulee Dam and reducing spill through the outlet tubes. Concurrently, power generation was reduced at Chief Joseph Dam while approximately 22 kcfs was spilled (Figure 4). This action effectively shifted spill from the higher TDG producing Grand Coulee Dam to the lower TDG producing Chief Joseph Dam.

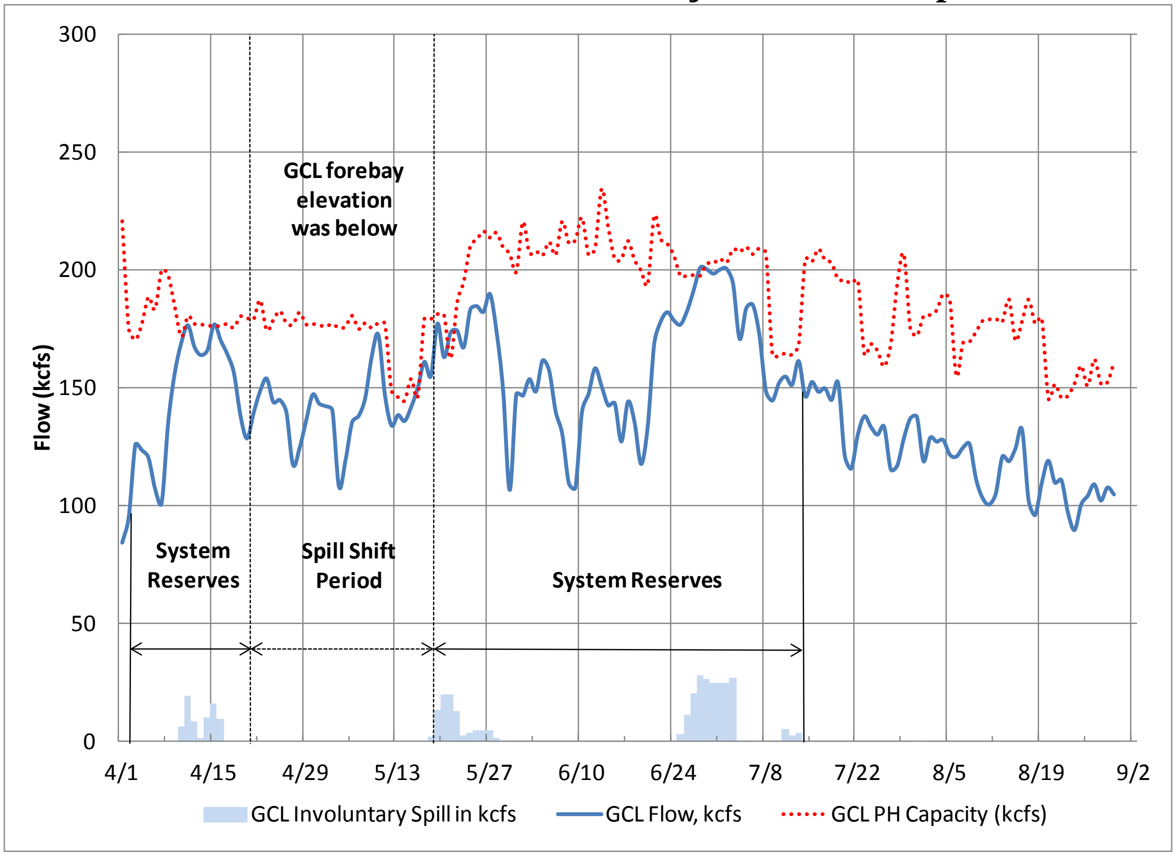
2. System Reserve Shift: Reserves are the amount of generation capacity above the amount currently in use that is immediately available when needed to maintain system reliability. Typically, Grand Coulee Dam holds a substantial amount of the system reserves in the Pacific Northwest. During periods when Grand Coulee Dam or other projects in the system need to spill to carry system reserves, project releases at Chief Joseph Dam are spilled first. This approach is used in order to move more water through the other project(s) powerhouses, which results in increased spill at Chief Joseph Dam but producing less TDG than if the spill occurred at another project in the system, thereby reducing overall system-wide TDG in the Columbia River.

   This year, from April 8 to July 13, Chief Joseph Dam carried much of the system reserves that normally would have been carried by Grand Coulee Dam, allowing Grand Coulee Dam to spill less. As shown in Figures 4 and 5, Grand Coulee Dam's available powerhouse capacity was utilized during the 2013 spill season while Chief Joseph Dam powerhouse output was reduced. This resulted in increased spill at Chief Joseph Dam to take advantage of the flow deflectors and reduced overall TDG loadings to the Columbia River.

3. TDG Degassing Operations: In very high water years when it is necessary to spill continuously through the Grand Coulee Dam outlet tubes and TDG levels can reach very high levels (128 percent and higher), the Corps uses all available options to minimize TDG levels in the river. Within the system constraints, projects in the FCRPS will increase generation and minimize spill as much as possible and correspondingly Chief Joseph will spill as much as possible to degas the high upstream TDG levels arriving at the project. This action was not needed during 2013 due to the lower system-wide flows, and lower system-wide TDG.

For more information regarding Chief Joseph Dam operations see Appendices F and G.

FIGURE 5
2013 Grand Coulee Dam Project Flow and Spill



Note: Daily powerhouse capacities provided by BPA Duty Schedulers

TABLE 3
Spill Shift Flow Rates and 12-Hour Average Percent TDG

Date	GCL Total River Flow in kcfs	GCL PH Capacity in kcfs	GCL Spill in kcfs	GCL Tailwater % TDG	CHJ Spill in kcfs	CHJ Forebay % TDG	CHJ Tailwater % TDG
05/09/13	163.3	175.5	0.0	106.9	15.8	108.5	**110.8**
05/10/13	172.4	177.5	0.0	107.5	24.6	108.6	**110.8**
05/11/13	147.0	177.2	0.0	107.6	22.9	108.9	**110.6**
05/12/13	134.0	148.9	0.0	107.6	23.3	109.1	**110.7**
05/13/13	138.4	146.1	0.0	107.8	22.5	109.0	**110.5**
05/14/13	135.9	144.7	0.0	106.3	20.5	108.6	109.7
05/15/13	141.9	153.9	0.0	106.3	21.1	108.3	**110.2**
05/16/13	149.9	146.4	0.0	108.0	21.4	108.6	**110.2**
05/17/13	161.0	179.2	0.0	107.9	21.5	108.8	**110.3**
05/18/13	155.0	179.2	2.3	107.2	21.4	108.1	**110.1**
05/19/13	177.2	181.3	13.4	107.8	21.2	107.5	109.8
Average	**152.4**	**164.6**	**1.4**	**107.4**	**21.5**	**108.5**	**110.3**

2.1.3.5 7Q10 Flow

When flows exceed the 7Q10 criteria (the average peak annual flow for seven consecutive days that has a recurrence interval of ten years), the Colville, Oregon, and Washington's TDG criteria do not apply. The 7Q10 flow criteria and the respective daily average flows for the Corps' Columbia River Basin dams are shown on Table 4 (the gray highlighted flows represent days when the 7Q10 flow criteria were exceeded). In 2013, river flows did not exceed the 7Q10 flow criteria.

TABLE 4
Dates When 7Q10 Flows Were Exceeded in 2013

Date	LWG (kcfs)	LGS (kcfs)	LMN (kcfs)	IHR (kcfs)	MCN (kcfs)	JDA (kcfs)	TDA (kcfs)	BON (kcfs)	CHJ (kcfs)
7Q10 Flow Criteria	**214**	**214**	**214**	**214**	**447**	**454**	**461**	**467**	**222**
5/1/2013	63.5	63.7	65.7	64.8	219.6	229.7	210.1	239.2	147.8
5/2/2013	61.2	61.7	64.7	66.0	234.0	244.3	227.5	251.7	147.9
5/3/2013	59.8	59.3	60.1	59.4	237.9	232.2	210.2	231.1	145.2
5/4/2013	53.4	51.8	53.4	53.2	243.0	244.2	227.9	241.7	136.9
5/5/2013	55.4	57.2	59.5	59.9	223.3	230.6	213.5	225.8	118.0
5/6/2013	54.3	53.1	56.0	54.8	220.8	211.9	195.8	231.6	117.7
5/7/2013	61.4	62.4	64.6	64.5	224.2	221.7	205.3	227.1	133.1
5/8/2013	67.1	68.5	68.9	68.3	234.5	233.3	222.7	242.6	143.5
5/9/2013	76.6	75.6	75.1	76.4	261.2	269.9	245.1	266.6	145.2
5/10/2013	93.2	91.3	93.9	95.3	286.2	269.9	255.8	274.6	157.4
5/11/2013	100.7	94.7	99.0	99.9	330.5	323.8	305.5	305.3	171.1
5/12/2013	108.5	101.9	106.0	107.3	353.7	353.5	338.3	347.7	150.5
5/13/2013	114.8	109.8	113.1	116.1	334.0	345.3	326.7	348.2	139.1
5/14/2013	125.9	120.3	120.7	123.4	330.0	318.3	301.2	335.3	132.2
5/15/2013	137.3	130.1	131.5	136.0	341.4	344.3	325.6	338.7	140.1
5/16/2013	132.7	127.8	131.0	135.2	342.8	342.5	326.4	351.9	137.1
5/17/2013	114.9	109.9	112.9	116.7	328.3	340.4	322.7	344.3	149.0
5/18/2013	101.2	98.1	100.4	102.4	311.9	303.8	286.0	309.2	162.5
5/19/2013	97.6	94.7	96.2	97.8	333.1	333.8	318.9	328.9	157.2
5/20/2013	88.7	85.1	88.5	89.8	318.6	326.5	306.0	328.9	176.8
5/21/2013	83.7	82.2	82.2	83.6	313.4	312.5	294.2	317.3	168.0
5/22/2013	75.4	74.4	76.4	75.4	286.6	283.3	270.4	300.5	174.7
5/23/2013	77.6	76.8	78.6	79.5	283.2	287.3	264.2	279.0	184.7
5/24/2013	77.4	74.2	76.3	76.9	316.2	313.6	296.9	316.2	167.5
5/25/2013	71.0	69.1	70.8	73.4	299.3	292.8	277.1	307.9	185.0
5/26/2013	68.5	68.7	72.5	72.0	295.1	294.4	273.8	292.4	183.6
5/27/2013	63.8	63.1	64.9	62.7	297.7	299.4	282.5	307.7	182.7
5/28/2013	60.6	55.3	59.1	59.8	301.7	299.6	281.3	303.0	189.5
5/29/2013	65.1	65.0	67.0	66.5	292.6	297.9	276.1	300.3	174.4
5/30/2013	63.9	63.4	64.8	66.0	280.2	273.0	257.8	287.3	152.6
5/31/2013	70.1	69.2	71.1	70.9	256.4	254.9	238.9	260.1	107.2
6/1/2013	74.4	73.9	75.5	77.1	245.1	253.6	240.6	273.4	139.3
6/2/2013	69.2	67.6	68.7	68.7	246.6	250.2	233.3	254.0	145.9
6/3/2013	63.5	61.6	63.1	64.1	232.7	211.8	194.4	216.9	157.7
6/4/2013	59.4	57.7	59.9	57.7	264.0	265.5	253.2	264.6	148.7
6/5/2013	63.4	62.6	63.5	65.7	241.5	242.4	221.8	245.4	162.6
6/6/2013	62.9	63.1	64.4	64.0	260.1	248.8	235.3	256.3	160.5
6/7/2013	63.7	61.2	62.3	63.5	266.1	264.5	247.2	261.9	140.8
6/8/2013	67.1	67.4	66.0	66.0	247.9	235.4	216.4	243.3	125.8
6/9/2013	75.0	74.2	74.8	75.6	241.3	245.8	232.1	245.5	118.3
6/10/2013	73.9	73.0	73.1	74.2	243.0	238.5	225.7	246.3	100.8
6/11/2013	72.0	71.2	70.8	72.2	246.7	248.8	232.4	258.0	138.0
6/12/2013	69.2	68.1	68.1	68.1	235.9	217.2	197.5	222.4	143.6
6/13/2013	63.8	62.2	63.3	64.8	246.9	247.7	237.1	244.9	168.3
6/14/2013	58.5	57.6	57.9	58.7	264.7	262.7	241.0	257.1	146.2
6/15/2013	57.1	55.4	56.5	56.5	242.3	238.4	223.9	245.0	141.3
6/16/2013	52.6	51.5	53.3	54.3	243.4	240.8	226.6	243.5	145.5
6/17/2013	45.9	43.3	44.8	44.3	216.1	204.2	191.0	214.8	123.4
Total Days	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Part 3 Water Quality Monitoring

The Corps monitors the water quality of reservoir releases at hydroprojects throughout the Columbia River Basin. This is done to manage system water quality as well as to manage fish passage spill operations in the Columbia River Basin. This water quality monitoring data along with dam operating data are reviewed daily as part of the process of setting spill caps to maintain TDG levels within the 110, 115 and 120 percent TDG criteria[3]. The Corps monitors and tracks instances when TDG and temperature criteria are exceeded relative to state standards and applicable waivers and criteria adjustments; and, when feasible, adjustments are made to meet the state criteria.

3.1 Fixed Monitoring Stations

TDG and water temperature are monitored throughout the Columbia River Basin via the FMS gauges. There are a total of 42 FMSs in the U.S. portion of the Columbia River Basin and 28 are operated by the Corps. Reclamation, and Chelan and Grant County PUDs each operate four stations. Two stations are operated by the Douglas County PUD. The Corps' Portland, Seattle, and Walla Walla districts operate and maintain the FMSs in the Columbia and lower Snake River basins. Portland District is responsible for eight FMSs on the lower Columbia River from John Day Dam to Camas/Washougal. The Seattle District is responsible for two FMSs in the upper Columbia Basin at Chief Joseph. Walla Walla District is responsible for 15 FMSs in the lower Snake River and Clearwater River basins, and at McNary Dam on the Columbia River. Appendix A contains detailed information on the Corps' FMS system and a map of their locations.

3.2 TDG Monitoring Plan of Action

The 2010-2014 TDG Monitoring Plan summarizes the Corps' roles and responsibilities with dissolved gas and temperature monitoring and identifies channels of communications with other cooperating agencies and interested parties. The Plan of Action summarizes what to measure, how and when to take the measurements, and how to analyze and interpret the resulting data. The TDG Monitoring Plan is provided as Appendix B of this report.

3.3 Changes in the FMS

There were no changes to the Seattle or Walla Walla Districts' FMS gauges in 2013. Portland District gauge information is discussed below.

The Bonneville Dam tailwater (Cascade Island, CCIW) TDG gauge was not operable beginning August 29, due to high velocity conditions below the spillway which caused the last welded pipe section, and sensor it housed, to break loose. The Portland District is in the process of developing a scope of work which will include improving the in-water pipe configuration to withstand the intense conditions resulting from its proximity downstream of the spillway. The design team will evaluate various options, some of which include reinforcing the in-water sensor pipe with angle iron, using a heavier weight to anchor the end

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[3] See the Annual TDG Management Plan for additional information http://www.nwd-wc.usace.army.mil/tmt/documents/wmp/2013/

of pipe, and driving steel pilings into the river bed to brace the pipe. The construction of this more robust pipe system for housing the TDG sensors needs to occur during the in-water work period which ends in February 2014. This TDG gauge is expected to be operable by the beginning of the spill season in April 2014.

3.4 Malfunctioning Gauge Occurrences

During 2013, there were five occurrences affecting nine days where a FMS gauge malfunctioned due to various reasons as shown in Table F-7 (Appendix F).

- Two occurrences at McNary tailwater gauges resulted in elevated percent TDG due to punctured membranes; therefore, the data was deleted June 26-27, 2013, and again on June 28, 2013.
- One occurrence at The Dalles forebay gauge where power was interrupted resulting in missing data, May 19-20, 2013.
- One occurrence at the Bonneville Dam where the tailwater gauge malfunction resulted in erroneous data, which was deleted, May 16-17, 2013.
- One occurrence resulted in missing data at the Bonneville Dam tailwater gauge, where the gauge was possibly lost downstream after the last section of pipe (housing the sensor) broke free. This lack of data contributed two malfunctioning gauge-days on the last two days of fish passage season, August 30-31, 2013.

Malfunctioning gauge TDG instances are noted as a Type 2a instance in Appendix F, Tables F-2, F-3A, and F-3B. Table F-2 (Appendix F) is based on raw data and is populated during real-time operations. Tables F-4 through F-6 (Appendix F) do not include the malfunctioning gauge data since these tables provide statistical information on hourly TDG levels.

3.5 QA/QC on FMS

The 2010 Supplemental BiOp, RPA Action 15, calls for "real-time monitoring and reporting of TDG and temperatures measured at fixed monitoring sites." The Corps' districts operate the FMS according to the TDG Monitoring Plan and prepare annual performance reports for the FMS operation. The 2013 reports are included as Appendices J, K, and L. Highlights from these reports are provided below.

3.5.1 Walla Walla District QA/QC

Walla Walla District is responsible for maintaining and operating the forebay and tailwater TDG FMS stations at Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and McNary dams. This work is performed through a cooperative agreement with the Kennewick office of the USGS. The highlights of the Walla Walla District QA/QC report include:

- The TDG data sets were within ±1 percent TDG of the expected value on the basis of calibration data and replicate quality-control measurements in the river.

- Data completeness for TDG data received averaged 97.8 percent for the 15 monitoring sites in 2013 (nine seasonal and six year-round).

- Data received from the individual sites ranged from 88.6 percent to 100.0 percent complete (Table I-7, Appendix I). The Peck (PEKI) and Pasco (PAQW) FMS gauges had the highest number of unreliable TDG measurements as a result of low values attributed to sedimentation in deployment pipes. Table I-8 (Appendix I) describes the individual causes for missing data.

- The TDG sensors from the 15 seasonal and annual FMS were removed from the field and calibrated in the laboratory every 3 weeks between April 2013 and August 2013. From September 2012 through March 2013, the 6 annual FMS were calibrated at 4-week intervals.

- All 175 in-situ field checks of TDG sensors with a secondary standard were within ±1percent after the deployment period.

- Of the 175 field checks for barometric pressure, 169 were within ±0.2 mm Hg of a secondary standard. The outliers occurred at the Lewiston, Pasco, and McNary tailwater stations. Of the 175 water-temperature field checks, 173 were within ±0.2°C.

The detailed QA/QC report on the Walla Walla District gauges can be found in Appendix I.

3.5.2 Portland District QA/QC

Portland District is responsible for maintaining and operating the forebay and tailwater gauges at John Day, The Dalles and Bonneville dams. This work is performed through a contract with the Oregon Water Science Center of the USGS. The highlights of the Portland District QA/QC report include:

- Data completeness for TDG data received averaged 99.2 percent for the eight monitoring sites in 2013.

- The TDG data sets were within ±1 percent TDG of the expected value on the basis of calibration data, replicate quality-control measurements in the river, and comparison to ambient river conditions at adjacent sites.

- Data received from the individual sites ranged from 97.7 percent to 100.0 percent complete. See Table J-2 (Appendix J) for individual gauge data completeness information. These results exceed the data quality criteria for data completeness, even for the Bonneville Dam tailwater FMS, which was destroyed on August 29, resulting in 2 days of missing data before the end of the spill season. Table J-3 (Appendix J) provides the causes for missing data.

- The TDG sensors were removed from the field after 3 or 4 weeks of deployment and calibrated in the laboratory.

- All but one of the 85 in-situ field checks of TDG sensors with a secondary standard were within ±1percent TDG after 3 to 4 weeks of deployment in the river.

- All but one of the 87 field checks of barometric pressure were within ±1 mm Hg of a primary standard, and all 86 water-temperature field checks were within ±0.2°C of a secondary standard.

- The eight FMSs were calibrated every 3 weeks, except from September 2012 through March 2013, when they were calibrated at 4-week intervals.

The detailed QA/QC report on the Portland District gauges can be found in Appendix J.

3.5.3 Seattle District QA/QC

Seattle District is responsible for maintaining and operating the forebay and tailwater TDG FMS stations at Chief Joseph Dam. The highlights of the Seattle District QA/QC report include:

- Data completeness for TDG data received ranged from 100 percent at the Chief Joseph forebay station (CHJ) to 98.7 percent at the tailwater station (CHQW). Data completeness for temperature data ranged from 100 percent at the CHJ forebay station to 100 percent at the tailwater station (CHQW). Missing data were largely due to data logger/controller malfunctions and programming problems.

- For TDG data at the tailwater station (CHQW), a total of 4 hours were rejected due to slow probe response time after recalibration. At the forebay station (CHJ), a total of 2 hours were rejected due to slow probe response time after recalibration. No temperature data were rejected at stations CHJ and CHQW.

- The TDG sensors were removed from the field after 2 weeks of deployment and calibrated in the laboratory.

- A total of 18 out of 24 (75 percent) in-situ field checks of TDG sensors with a secondary standard were within ±10 mm Hg after 2 weeks of deployment in the river.

- A total of 23 out of 24 (96 percent) in-situ field checks of barometric pressure were within ±2 mm Hg of a secondary standard, and 24 out of 24 (100 percent) water temperature field checks were all within ±0.2°C.

The detailed QA/QC report on the Seattle District can be found in Appendix K.

Part 4 Fish Spill Program

4.1 Spill

Operation of the FCRPS to meet multiple purposes can result in instances of percent TDG exceeding the state water quality standards. Part 4 provides detailed information on the implementation of fish passage spill as well as involuntary spill (e.g., lack of turbine, lack of load, transmission constraints, etc.).

4.1.1 Fish Operations Plans

The 2010 Supplemental BiOp calls for the Corps to provide spill for juvenile fish migration in the FCRPS. The Action Agencies annually develop a Fish Operations Plan (FOP) that provides detailed information on the implementation of the BiOp fish passage operations. The FOP was developed in collaboration with regional sovereigns and is consistent with spill operations specified for juvenile fish passage in the 2010 Supplemental BiOp. Continuation of the annual FOP operations was included in the U.S. District Court of Oregon Opinion and Order issued August 2, 2011.

At some Corps' projects, the amount of fish passage spill is a specified level, and, at others, the Corps is to spill up to the applicable state TDG criteria -- referred to as the "gas cap." The maximum project spill level that meets but does not exceed the gas cap is referred to as the spill cap. The 2013 FOP, provided in Appendix C, describes specific fish operations implemented this year and are summarized in Table 5.

TABLE 5
2013 FOPs Spill Operations

Project	Planning Dates [A & B]	Time	Spill Amount (Not to Exceed the Spill Cap)
Lower Granite	April 3 - June 20	24 hours per day	20 kcfs
Lower Granite	June 21-August 31	24 hours per day	18 kcfs
Little Goose	April 3 - August 31	24 hours per day	30% of project outflow
Little Goose	During flows < 32 kcfs	25 hours per day	Constant spill of 7-11 kcfs
Lower Monumental	April 3 - June 20	24 hours per day	Spill cap
Lower Monumental	June 21-August 31	24 hours per day	17 kcfs
Ice Harbor	April 3 - April 28	0500-1800	45 kcfs during the day
Ice Harbor	April 3 - April 28	1800-0500	Spill cap at night
Ice Harbor	April 28 - July 13	24 hours per day	Alternating between 2-day blocks of 30% of project outflow vs. 45 kcfs during the day/spill cap at night
Ice Harbor	July 13 - August 31	0500-1800	45 kcfs during the day
Ice Harbor	July 13 - August 31	1800-0500	Spill cap at night
McNary	April 10 - June 19	24 hours per day	40% of project outflow
McNary	June 20-August 31	24 hours per day	50% of project outflow
John Day	April 10 - April 27	24 hours per day	30% of project outflow
John Day	April 27 - July 20	24 hours per day	Alternate between 2-day blocks of 30% vs. 40% of project outflow
John Day	July 20 - August 31	24 hours per day	30% of project outflow
John Day	April 10 - August 31	24 hours per day	Minimum spill is 25% of project outflow
The Dalles	April 10 - August 31	24 hours per day	40% of project outflow
Bonneville	April 10 - June 16	24 hours per day	100 kcfs
Bonneville	June 16 - July 20	24 hours per day	Alternating between 2-day blocks of 95 kcfs vs. 85 kcfs during the day/121 kcfs at night
Bonneville	July 21 - August 31	24 hours per day	75 kcfs during the day/spill cap at night
Bonneville	April 10 - August 31	24 hours per day	Minimum spill is 75 kcfs
A - No voluntary spill from April 10 to June 14 in years when forecasted seasonal average flows are less than 125 kcfs.			
B - No voluntary spill from April 3 to May 31 in years when forecasted seasonal average flows are less than 65 kcfs on the Snake River.			

4.1.2 Fish Passage Spill

Fish-passage spill, also referred to as voluntary spill, occurs for the benefit of juvenile fish migration in accordance with the operative biological opinions. The 2013 FOP established spill levels for juvenile fish passage at the four lower Snake and four lower Columbia River dams during the juvenile fish migration season. The fish passage spill called for in the 2013 FOP was to occur from April 3 to August 31 at the lower Snake River dams, and from April 10 to August 31 at the lower Columbia River dams. However, because total river flows were somewhat high, continuous involuntary spill began on April 1 at McNary (see Part 4.1.6 for more details). As coordinated with Oregon and Washington, tracking TDG instances for this report starts on April 1.

The amount of fish passage spill for the 2013 spill season at each dam is shown in Figures D-1 through D-8 and listed in Tables D-1 through D-8 (Appendix D). Additionally, weekly graphs that show the flow, FOP spill, and percent TDG for April through August are included in the monthly reports to the Court (Appendix E) which can be found at: http://www.nwd-wc.usace.army.mil/tmt/wqnew/tdg_and_temp/2013/.

4.1.3 Spring Creek Hatchery Spill

The Corps, BPA, NOAA Fisheries, and the USFWS entered into a 2008-2013 Memorandum of Agreement regarding Spring Creek National Fish Hatchery fish production reprogramming. Under the Memorandum of Agreement, a portion of the annual production was moved to the Bonneville Hatchery on Tanner Creek below Bonneville Dam, thereby eliminating the need to release fish in March from Spring Creek National Fish Hatchery and the resultant requests for spill at Bonneville Dam. As a result, there were no spill operations in March 2013 for Spring Creek National Fish Hatchery fish releases.

4.1.4 Fish Test Operations

In 2013, juvenile dam passage performance tests were conducted at Little Goose and Lower Monumental dams, but did not alter current spill operations. The intent of these studies is to assess the juvenile performance following modifications to fish facilities or operational changes at the dams. These research studies are developed and coordinated through the Anadromous Fish Evaluation Program Studies Review Work Group with NOAA Fisheries providing concurrence on the final study plan. For more information on all planned fish tests, see Appendix A of the annual Fish Passage Plan at: http://www.nwd-wc.usace.army.mil/tmt/documents/fpp/.

4.1.5 Long Term Turbine Outages

Unit outages can affect the spill volume at the dams by causing additional involuntary spill. Table 6 summarizes the long term unit outages during the 2013 spill season and identifies outages outside of the reporting period. Not all outages actually have or will result in spill or elevated TDG levels, but are included for informational purposes. There were two long-term (greater than one month) unit outages on the lower Snake River, 20 long-term unit outages on the lower Columbia River, and nine unit outages on the middle Columbia River.

TABLE 6
2013 Long Term Outages

Project	Unit	Start Date	Finish Date	Reason
Lower Granite	6	6/24/13	8/31/13	Cavitation Repair
Ice Harbor	5	7/26/12	7/22/13	Repair XW-5 breaker, annual maintenance
McNary	3	6/4/12	5/25/13	Unit 3 Asbestos & Rewind
McNary	3	6/4/13	5/25/13	Forced out, overheating bearing
McNary	14	9/22/12	7/2/13	Forced out, overheating bearing
McNary	4	6/24/13	8/31/13	Rewind
McNary	11	6/24/13	8/31/13	Rewind
John Day	6	1/7/13	8/31/13	Overhaul, thrust bearing
John Day	7	2/25/13	8/31/13	Overhaul,
The Dalles	15	9/20/12	7/25/13	Forced out, transformer gassing
The Dalles	16	9/20/12	7/25/13	Forced out, transformer gassing
The Dalles	6	4/22/13	5/29/13	Digital Governor Install
The Dalles	21	4/29/13	6/27/13	5 Yr Overhaul
The Dalles	11	5/13/13	6/21/13	Digital Governor Install
The Dalles	17	6/6/13	7/10/13	Digital Governor Install
The Dalles	1	6/24/13	7/30/13	5 Yr Overhaul and air leak repair
The Dalles	9	7/15/13	8/22/13	Digital Governor Install
Bonneville	11	9/25/12	8/31/13	forced out, damaged bearing
Bonneville	8	4/1/13	5/23/13	5 Yr Overhaul
Bonneville	16	4/29/13	6/29/13	4 Yr Overhaul, digital governor
Bonneville	1	7/23/13	8/31/13	4 Yr Overhaul, digital governor
Bonneville	12	7/22/13	8/31/13	5 Yr Overhaul, digital governor
Chief Joseph	8	2/11/13	8/5/13	Turbine Replacement
Chief Joseph	6	7/8/13	8/31/13	Turbine Replacement
Grand Coulee	5	7/11/12	8/31/13	Transformer, SF-6 breaker
Grand Coulee	6	2/14/13	8/31/13	Transformer, SF-6 breaker
Grand Coulee	10	3/9/13	8/31/13	Forced out, line 3 fire
Grand Coulee	15	10/1/13	7/31/13	5 Yr Overhaul, relay replace
Grand Coulee	20	1/22/13	5/20/13	Excitor and Governor, GDACS
Grand Coulee	24	3/5/13	8/31/13	6 Yr Overhaul, cavitation
Grand Coulee	8	6/19/13	8/31/13	Transformer, SF-6 breaker
TOTAL OUTAGES = 31				

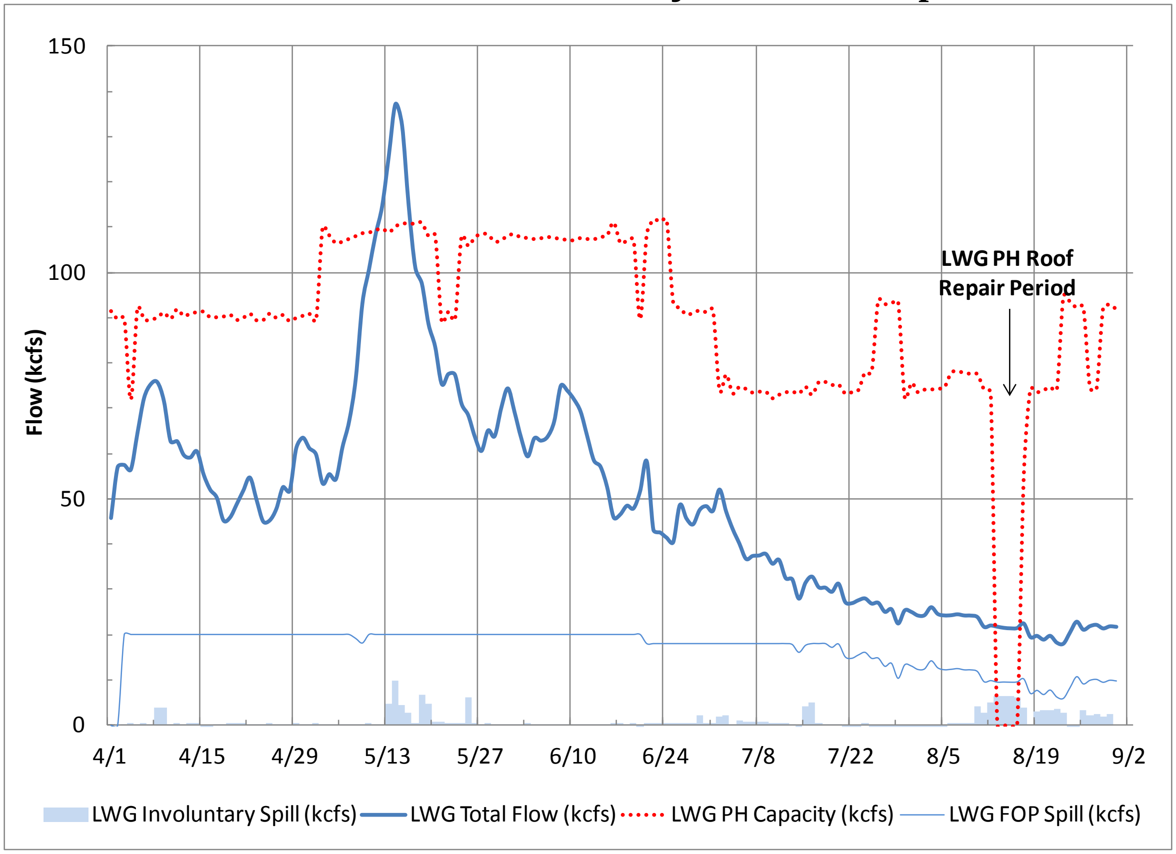
4.1.6 Involuntary Spill

Due to lack of turbine availability, lack of load, and other hydraulic conditions, involuntary spill occurred at the four lower Columbia River, the four lower Snake River dams and Chief Joseph dam.

Involuntary spill started on April 1 at McNary Dam, which was the earliest of all the lower Columbia River dams for a total of 61 days. Lower Granite Dam started involuntary spill on April 8, which was the earliest of all the lower Snake River dams. The other six lower Columbia and lower Snake River dams started involuntary spill from April 7 to May 13. Involuntary spill at Bonneville Dam occurred for 17 days intermittently from April 7 to July 3 (Figure 2). The Dalles Dam had involuntary spill for 12 days intermittently from April 8 to July 5. John Day Dam had involuntary spill for 20 days intermittently from April 8 to July 5.

On the lower Snake River, Ice Harbor Dam had involuntary spill that occurred for 12 days during fish passage season (Table D-8, Appendix D). Lower Granite Dam had involuntary spill for nine days intermittently from April 8 to May 25 (Figure 6). Lower Granite Dam also had involuntary spill for 24 days during August due to powerhouse roof repairs and doble testing. Little Goose Dam had involuntary spill for nine days intermittently from April 8 to May 25. Lower Monumental Dam had involuntary spill for four days intermittently from May 13 to May 19.

FIGURE 6
2013 Lower Granite Dam Project Flow and Spill



Note: Daily powerhouse capacities provided by BPA Duty Schedulers

The FOP spill tables in Appendix D indicate amounts spilled at the lower Columbia River and Snake River dams. Actual spill rates were the same or slightly higher than the estimated FOP spill rates at most projects. This was due to the average flows on the lower Columbia River and below average runoff on the lower Snake River. The impact of average flows on the lower Columbia River and below average runoff on the lower Snake River on TDG levels was significant because of the shape of the runoff and duration of the flows, which reduced the lower than average number of instances.

As a result, there were 226 TDG instances system-wide, with the following instance types:

- 77 Type 1 condition instances (flows in excess of powerhouse capacity)
- 0 Type 1a condition instances (outages of hydropower equipment)
- 24 Type 2 condition instances (outage of non-generating equipment)
- 9 Type 2a condition instances (malfunctioning FMS gauge)
- 116 Type 3 condition instances (TDG exceedances due to uncertainties when using best professional judgment, SYSTDG model and forecasts)

Table 11 contains the 2013 summary of instance types and compares it with the 2005-2012 summaries. Part 5 also provides more detailed information on dam specific TDG instances. Table F-3A and Table F-3B (Appendix F) provide more detailed information on TDG instances for the lower Snake River and lower Columbia River projects respectively.

4.2 SYSTDG Model

A statistical evaluation of SYSTDG's performance was conducted to assess how well the model estimated percent TDG. The predictive errors that SYSTDG computed in 2013 compared favorably with the predictive errors from previous years. A summary of the predictive error for each FMS can be found in Appendix G, Tables G1-G8.

4.2.1 2013 Improvements Made to SYSTDG:

The following improvements were made to the SYSTDG model in 2013:

1. SYSTDG was upgraded to pull data directly from the Corps' CWMS database. This improvement was mostly completed during 2013, but some additional work still remains. It is anticipated that this effort will be completed in 2014.

2. The feature of adding or changing the various spill patterns was added to SYSTDG in 2012 and updated in 2013.

3. The proposed SYSTDG improvements listed in the 2012 statistical analysis (Appendix G) were not incorporated into the model during 2013 due to time and resource constraints.

4.3 TDG Monitoring Studies

TDG monitoring studies are periodically scheduled to investigate significant structural or operational changes of the spillway. These studies are designed to support TDG monitoring and management functions, provide updates to TDG gas abatement goals associated with the TDG TMDL, and to update the SYSTDG model. During the 2013 spill season, there were no supplemental TDG monitoring studies conducted at Federal projects on the Columbia or Snake Rivers. If funding and appropriate water conditions are available, studies should be conducted below Grand Coulee and Chief Joseph to better refine the TDG production and exchange equations in the model.

Part 5 Instances of TDG Exceeding WQS

During 2013, most TDG instances occurred when powerhouse capacity was exceeded. As shown in Figures 2 through 6, total river flows exceed powerhouse capacities on the lower Columbia and lower Snake rivers for just a few weeks. This resulted in reduced amounts of involuntary spill and low numbers of TDG instances. Part 5 discusses the TDG instances.

5.1 TDG Instance Calculation Methods

Calculations and reporting in Part 5 are consistent with the Corps' Operating Guidelines described above in Part 1.1.6. Unless otherwise specified, all TDG instances discussed in this report use the Oregon calculation method (i.e., the average of the highest 12-hour values over the 24 hour day).

5.2 TDG Instances

5.2.1 110 percent TDG Instances

In 2013, TDG instances were tracked using the Colville Confederated Tribes WQS of 110 percent in the forebay and tailwater of the Chief Joseph Dam in the middle Columbia River. Table F-6 (Appendix F) shows that there were 1,817 hourly TDG instances in the Chief Joseph Dam tailwater and 1,722 hourly TDG instances in the Chief Joseph forebay. The maximum TDG for the Chief Joseph Dam was 115 percent in the forebay and 116 percent in the tailwater.

5.2.2 115 percent and 120 percent TDG Instances

Table 7 provides a summary of TDG instances for 2005 through 2013 spill seasons. As indicated in Table 7, there were 226 TDG instances in 2013. This value represents the fourth lowest number of instances since recording began in 1999. Average flows on the Columbia River and low flows on the Snake River resulted in fewer gauges (13 of 19) having TDG instances in April through August period. The Camas/Washougal forebay, Ice Harbor forebay, and the Bonneville Dam forebay and tailwater gauges had the most TDG instances in 2013. The six gauges without TDG instances include Lower Granite Dam forebay, Little Goose tailwater, Chief Joseph forebay and tailwater, John Day tailwater, and the Dalles tailwater.

TABLE 7
2005 - 2013 Spill Seasons
Number of TDG Instances Exceeding WQS

Fixed Monitoring Stations	2013 Qty.	2012 Qty.	2011 Qty.	2010 Qty.	2009 Qty.	2008 Qty.	2007 Qty.	2006 Qty.	2005 Qty.	9 Year Average
Lower Granite Forebay	0	0	0	0	0	0	0	0	0	0
Lower Granite Tailwater	8	8	59	15	15	35	0	28	0	19
Little Goose Forebay	17	22	51	14	19	34	0	24	0	20
Little Goose Tailwater	0	7	47	7	0	23	0	19	0	11
Lower Monumental Forebay	11	38	68	14	26	54	11	56	6	32
Lower Monumental Tailwater	8	14	62	14	21	32	7	29	7	22
Ice Harbor Forebay	44	45	70	31	44	55	31	51	3	42
Ice Harbor Tailwater	4	11	57	11	25	31	0	22	3	18
Chief Joseph Forebay	0	31	50	--	--	--	--	--	--	27
Chief Joseph Tailwater	0	4	3	--	--	--	--	--	--	2
McNary Forebay	12	63	33	11	4	21	6	31	8	21
McNary Tailwater	5	74	54	23	5	28	1	32	1	25
John Day Forebay	7	40	18	1	9	14	0	20	2	12
John Day Tailwater	0	35	18	0	7	17	3	38	3	13
The Dalles Forebay	9	41	24	0	11	17	8	40	6	17
The Dalles Tailwater	0	33	19	0	0	2	0	10	0	7
Bonneville Forebay	33	87	38	14	32	27	3	51	3	32
Bonneville Tailwater	21	102	73	27	24	57	0	61	0	41
Camas/Washougal	47	103	48	52	66	68	29	63	16	55
Total Number of TDG Instances	**226**	**758**	**792**	**234**	**308**	**515**	**99**	**575**	**58**	**396**

Note: *Does not include days when 7Q10 flows were exceeded (See Table 9)

5.2.3 Instances of TDG Exceeding 125 percent WQS

During the 2013 spill season, there were no instances (excluding days when 7Q10 flow was exceeded[4]) of hourly TDG exceeding the Washington one-hour standard of 125 percent TDG, Table F-4 (Appendix F). This is fourth time no instances greater than 125 percent TDG have occurred in the last 10 years as shown in Table F-5 (Appendix F). This is due to average flows on the Columbia River and below average flows on the lower Snake River and the shape of the runoff, which were represented by a single small peak on the lower Snake River, and three minor peaks on the lower Columbia River. Additional information is shown in the graphs of the 12-hour percent TDG for the lower Snake and Columbia River dams in the monthly court reports (Appendix E).

5.2.4 TDG Instances in Oregon (Additional Information)

Oregon requested the following additional information in Table 8 identifying TDG instances that occurred at the dams covered by the Oregon TDG waiver. In 2013, there were 26 TDG instances which exceeded the 120 percent TDG standard in the reservoir tailwater. The TDG instances are approximately 4.2 percent of 612 possible spill days (4 gauges x 153 days), from April 1 through August 31. There were zero instances that exceeded 125 percent for two hours.

[4] There were no days at any project where flows exceeded the 7Q10 flow in 2013.

TABLE 8
2013 Spill Season
Number of TDG Instances Exceeding Oregon WQS

Fixed Monitoring Stations	April 1 - August 31 120% TDG Instances	April 1 - August 31 125% TDG Instances	7Q10 Flow Days	Instances between April 1- April 10
McNary Tailwater	5	0	0	1
John Day Tailwater	0	0	0	0
The Dalles Tailwater	0	0	0	0
Bonneville Tailwater	21	0	0	0
Total Number of Exceedances for Oregon	**26**	**0**	**0**	**1**

5.2.5 7Q10 Flows Days

During 2013, flows on the mid-Columbia, lower Columbia and lower Snake rivers were so low that there were zero days when the 7Q10 flow criteria was exceeded (See Table 4 and 9).

TABLE 9
Number of Days
When 7Q10 Flows Were Exceeded In 2013

Fixed Monitoring Stations	Number of 7Q10 Days
Lower Granite Forebay	0
Lower Granite Tailwater	0
Little Goose Forebay	0
Little Goose Tailwater	0
Lower Monumental Forebay	0
Lower Monumental Tailwater	0
Ice Harbor Forebay	0
Ice Harbor Tailwater	0
Chief Joseph Forebay	0
Chief Joseph Tailwater	0
McNary Forebay	0
McNary Tailwater	0
John Day Forebay	0
John Day Tailwater	0
The Dalles Forebay	0
The Dalles Tailwater	0
Bonneville Forebay	0
Bonneville Tailwater	0
Camas/Washougal	0
Total Number of 7Q10 Days	**0**

5.2.6 Comparison of Annual TDG Instances

Table 10 shows that the number of daily TDG instances above the WQS in 2013 was below the nine-year average. This low number is attributed to the low flows, 69 percent of normal January-July runoff at Lower Granite, and 96.4 percent of normal January-July runoff at The Dalles Dam[5]. The TDG instance data for 2011 through 2013 includes TDG instances at the Chief Joseph Dam forebay and tailrace. Table 10 shows that TDG gauges exceeded WQS on 8 percent of the spill days during 2013, which was the third lowest percentage during the last nine years.

TABLE 10
2005 - 2013 Annual Comparison of TDG Instances Exceeding WQS

Year	Days in Spill Season[1]	Number of Days of Instances	Percent of Days Exceeding TDG Standard (%)	Percent of Days Consistent With TDG Standard (%)	Percent of Normal Runoff at TDA[2]
2013	2907	226	7.8	92.2	96.0
2012	2907	758	26.1	73.9	121.0
2011	2907	793	27.3	72.7	134.0
2010	2504	234	9.3	90.7	78.9
2009	2504	308	12.3	87.7	84.1
2008	2504	515	20.6	79.4	92.5
2007	2504	99	4.0	96.0	89.2
2006	2504	575	23.0	77.0	131.4
2005	2754	69	2.5	97.5	93.5
Average	**2666**	**397**	**15**	**85**	**102**

[1] Days in Spill Season based on number of gages x days in spill season.

[2] The Dalles Jan-Jul Avg (1971-2000) =107.3 MAF

Note: 2011-2013: Number of spill days based on 19 gages x 153 days from April 1-August 31 (includes Chief Joseph).

Note: 2006-2010: Number of spill days based on 8 gages x 151 days plus 9 gages x 144 days.

Note: 2005: Number of spill days are based on 18 gages x 153 days from April 1-August 31 (includes Warrendale).

Note: 2006-2009: Spill season started Apr 3 for lower Snake River and April 10 for lower Columbia River.

5.2.7 Types of Daily TDG Instances

Beginning in 2003, Oregon and the Technical Management Team (TMT) requested the Corps track the causes of TDG instances where percent TDG exceeded WQS. Table F-1 (Appendix F) provides a listing of the three causes or TDG instance types. The Corps tracked the daily TDG instance types for the forebay and tailwater of each of the Corps' FCRPS dams during the 2013 spill season. Each type of TDG instance represents conditions that cause daily average percent TDG to exceed WQS. The 2013 tracking results compared with prior years are summarized in Table 11. Daily details by dam can be found in Appendix F. The daily TDG instance type designation given for each occurrence is based on the Corps' determination of causation.

[5] 30-year historical runoff period, 1981-2013.

During the 2013 spill season, there were a total of 226 instances out of 2,907 gauge-days in which the TDG levels were above the TDG criteria. This value is significantly lower than the nine-year average of 397 instances. Certain types of TDG instances, such as Types 1 and 2a, associated with high flows and malfunctioning gauges respectively, may occur every year and are a normal part of reservoir operations. Efforts continue to reduce daily instances when possible.

TABLE 11
2005 - 2013 Spill Seasons
Types and Numbers of TDG Instances

9 Year Average	2013	2012	2011	2010	2009	2008	2007	2006	2005	TYPE	DEFINITION
290	77	646	637	166	191	421	5	441	29	**1**	TDG levels exceed the TDG standard due to exceeding powerhouse capacity at run-of-river projects resulting in spill above the BiOp fish spill levels.
11	0	0	52	1	1	1	1	45	0	**1a**	Planned and unplanned outages of hydro power equipment including generation unit, intertie line, or powerhouse outages.
6	24	18	0	0	1	1	0	13	0	**2**	TDG exceedances due to the operation or mechanical failure of non-generating equipment.
18	9	49	64	7	17	11	0	1	1	**2a**	Malfunctioning FMS gauge, resulting in fewer TDG or temperature measurements for setting TDG spill caps.
72	116	45	39	60	98	81	93	75	39	**3**	TDG exceedances due to uncertainties when using best professional judgment, SYSTDG model and forecasts.
397	**226**	**758**	**792**	**234**	**308**	**515**	**99**	**575**	**69**	**Totals**	

5.2.8 Recurring High TDG Instances

There were three locations that had a high number of TDG instances during the 2013 spill season: Camas/Washougal, Ice Harbor forebay, and Bonneville Dam forebay. The following is a discussion about each of these high TDG instance gauges.

5.2.8.1 Ice Harbor Forebay

The Ice Harbor forebay gauge had a total of 44 TDG instances (See Table 7) during the 2013 spill season. Ice Harbor forebay has an average of 42 TDG instances per year over the last nine years, which is the second highest amount among the FCRPS TDG gauges. As indicated on Table F-3A (Appendix F), the 44 TDG instances were classified as 10 Type 1 instances and 34 Type 3. The majority of TDG instances being classified as Type 3 indicate that the best professional judgment, using the SYSTDG model and making forecasts were the predominant factor influencing the number of TDG instances at this gauge.

5.2.8.2 Bonneville Dam Forebay

The Bonneville Dam forebay gauge had a total of 33 TDG instances (See Table 7) during the 2013 spill season. Bonneville Dam forebay gauge has an average of 32 TDG instances per year over the last nine years, which is the fourth highest amount among the FCRPS

TDG gauges. As indicated on Table F-3B (Appendix F), the 33 TDG instances were classified as 6 Type 1 instances and 27 Type 3. The majority of TDG instances being classified as Type 3 indicate that the best professional judgment, using the SYSTDG model and making forecasts were the predominant factor influencing the number of TDG instances at this gauge.

5.2.8.3 Camas/Washougal

The Corps continues to use the Camas/Washougal gauge as done in previous years that court ordered operations have been in effect. The Camas/Washougal FMS represents a theoretical forebay for the lowest reach of the Columbia River.

The Camas/Washougal gauge had a total of 47 TDG instances (See Table 7) during the 2013 spill season. Camas/Washougal gauge has an average of 55 TDG instances per year over the last nine years, which is the highest amount among the FCRPS TDG gauges.

As indicated on Table F-3B (Appendix F), the 47 TDG instances were classified as 10 Type 1 instances, one Type 2 instance and 36 Type 3 instances. The majority of TDG instances being classified as Type 3 indicate that the best professional judgment, using the SYSTDG model and making forecasts were the predominant factor influencing the number of TDG instances at this gauge.

5.3 TDG Instances - Washington Calculations

Part 5.3 provides the detail tracking of the Washington method of calculating TDG instances.

5.3.1 Oregon and Washington Methods

In 2008, Washington WQS revised the method of calculating the daily average to using the 12 highest consecutive hours. The Corps calculated the number of TDG instances using this method for comparison purposes for the 2013 spill season (excluding 7Q10 days) and the results are summarized in Table 12. A summary of instances for the years 2008 through 2013 are shown in Table 13.

TABLE 12
2013 Comparison of High 12-hour Average TDG instances Calculation Methods

Fixed Monitoring Stations	Continuous High 12-hour Average (Washingon)	Daily High 12-hour Average (Oregon)
Lower Granite Forebay	0	0
Lower Granite Tailwater	8	8
Little Goose Forebay	19	17
Little Goose Tailwater	0	0
Lower Monumental Forebay	13	11
Lower Monumental Tailwater	8	8
Ice Harbor Forebay	47	44
Ice Harbor Tailwater	3	4
Chief Joseph Forebay	0	0
Chief Joseph Tailwater	0	0
McNary Forebay	14	12
McNary Tailwater	8	5
John Day Forebay	9	7
John Day Tailwater	0	0
The Dalles Forebay	10	9
The Dalles Tailwater	0	0
Bonneville Forebay	35	33
Bonneville Tailwater	21	21
Camas/Washougal	58	47
Total Number of Instances	**253**	**226**
Forebay Instances	**205**	**180**
Tailwater Instances	**48**	**46**

TABLE 13
2008 – 2013 Comparison of TDG Instances Calculation Methods

Year	Number WDOE - TDG Instances	Number ODEQ/WDOE - TDG Instances
2013	253	226
2012	835	758
2011	831	792
2010	275	234
2009	341	308
2008	561	515
Average	**516**	**472**

Part 6 Gas Bubble Trauma Monitoring

6.1 Biological Monitoring Highlights

The Fish Passage Center compiles a report of gas bubble trauma (GBT) monitoring results collected in 2013 (included as Appendix L). The following is a summary of biological monitoring results.

The monitoring of juvenile salmonids in 2013 for gas bubble trauma was conducted at mid-Columbia, lower Columbia, and lower Snake River sites. Fish were collected and examined for signs of GBT at Bonneville and McNary dams on the lower Columbia River, and at Rock Island Dam on the mid-Columbia River. The Snake River monitoring sites were Lower Granite Dam, Little Goose Dam, and Lower Monumental Dam.

Sampling occurred two days per week at the Columbia River sites and one day a week at each of the Snake River sites during the time period that fish passage spill was implemented. The goal of the sampling program was to sample 100 salmonids of the most prevalent species (limited to Chinook and steelhead) during each day of sampling at each site, with the proportion of each species sampled dependent upon their prevalence at the time of sampling. Yearling Chinook and steelhead were sampled through the spring at all the sampling sites. Once subyearling Chinook predominated at sampling sites, the program shifted from sampling yearling Chinook and steelhead to sampling subyearling Chinook, which continued through the end of August.

Examinations of fish were conducted using variable magnification (6x to 40x) dissecting scopes. The eyes and unpaired fins of specimens were examined for the presence of bubbles. The bubbles present in the fins were quantified using a ranking system based on the percent area of the fins covered with bubbles as shown in Table L-1 (Appendix L).

The action criteria for GBT is established as 15 percent of fish showing any signs of GBT, or 5 percent of fish sampled showing signs of fin GBT greater than or equal to rank 3. Neither of these two action criteria was met in 2013.[6]

In 2013, a total of 13,558 juvenile salmonids were examined for GBT between April and August as shown in Table L-2 (Appendix L). Fin signs were found in 42 or 0.31% percent of the total fish sampled at all sites as shown in Table L-3 (Appendix L). The fish that were examined and determined to have signs of GBT exhibited the fin signs that were most often rank 1 where less than 5 percent of a fin area was covered with bubbles. No signs of rank 2 or 3 were seen in 2013, but one fish with rank 4 was encountered at Rock Island Dam in early July. Table L-4 (Appendix L) compares the 2013 estimates of the overall percentage of fish with signs of GBT to past years' estimates. The overall annual incidence of GBT in 2013 was in the lower range among the past 17 years.

[6] From 2009-2012, reports received from the FPC inadvertently specified "rank 1" rather than "rank 3" as the metric to be used to determine the action criteria for GBT. The FPC discovered this error in 2013; therefore, this report reflects the correction and that "rank 3" was used to determine the action criteria for GBT. Also see memo, FPC 151-13, dated December 20, 2013.

Part 7 Water Temperature

The following provides information on the state and tribal WQS for water temperature; information regarding Dworshak Dam operations for flow augmentation and water temperature moderation; and the Corps' water temperature modeling.

7.1 State Water Quality Standards for Temperature

The water temperature standards for the lower Columbia and Snake rivers as defined by the states of Idaho, Oregon, Washington, and the Colville Confederated Tribes are shown in Table 14.

TABLE 14
State Temperature Water Quality Standards

River	Reach	WA Standard[1]	OR Standard[2]	ID Standard[3]	Colville Confederated Tribes[4]
Lower Columbia	Mouth to RM-397, (Priest Rapids)	1-DMax of 20^{o}C			
	Mouth to RM-309, OR WA Border		7-DADMax of 20.0^{o}C		
Middle Columbia	Priest Rapids, RM-397 to Grand Coulee, RM-596.6	7-DADMax of 17.5^{o}C			Max. of 18.0^{o}C Chief Joseph Dam to the Northern Reservation Boundary
Upper Columbia	Grand Coulee, RM 596.6 to the Border				
Upper Columbia	RM-596 to US-Canadian Border	7-DMAX of 16^{o}C			
Lower Snake	Mouth to WA-ID Border	1-DMax 20.0^{o}C			
Clearwater				1-DADMax of 19^{o}C (Max. 22.0^{o}C)	

1. See Washington DEQ document, WAC 173-201A Table 602 and Table 200(1)(c).
2. OAR 340-041-0028, Section 4(d).
3. IDAPA 58.01.02-250-02(b).
4. Colville Confederated Tribe Water Quality Standard 4-8-6(b)(3)(F).

Definitions:
"1-DADMax" or "1-day maximum temperature" is the highest water temperature reached on any given day. This measure can be obtained using calibrated maximum/minimum thermometers or continuous monitoring probes having sampling intervals of thirty minutes or less.

"7-DADMax" or "7-day average of the daily maximum temperatures" is the arithmetic average of seven consecutive measures of daily maximum temperatures. The 7-DADMax for any individual day is calculated by averaging that day's daily maximum temperature with the daily maximum temperatures of the three days prior and the three days after that date.

7.2 Dworshak Operations

The 2010 Supplemental BiOp, RPA Action 4, calls for actions at Dworshak Dam during the salmon migration to meet flow and temperature objectives for the lower Snake River. Appendix H contains a summary of the Dworshak Dam operations for flow augmentation and temperature moderation.

Dworshak Reservoir outflows were managed to maintain water temperatures at Lower Granite Dam tailwater below 68^{o} F as shown on Figure H-1 (Appendix H). These operations began on July 1 and continued through September 21, when the Dworshak

Reservoir elevation reached 1,520 feet. These operations resulted in a peak discharge rate of 13.1 kcfs (an average release rate of 8.62 kcfs) resulting in a total volume of 1.42 Maf being released for the summer period. Dworshak Dam releases remained below 110 percent TDG in the tailwater, and the release temperatures averaged 46.4ºF (temperatures ranged between 42.5º F and 47.6º F) during the summer period. Seasonal average release temperatures during flow augmentation season from 2000-2013 are shown on Figure H-2 (Appendix H). Dworshak Dam operations were coordinated at TMT meetings seven times from June through September 2013, as shown on Table H-1(Appendix H). The resulting Lower Granite Dam tailwater daily average temperature exceeded 68^{o} F, from July 1 to September 30, for six days (Table 15), but did not exceed 69.0^{o} F.

7.3 Water Temperature Modeling

The 2010 Supplemental BiOp, RPA Action 15 calls for the following: Expand water temperature modeling capabilities to include the Columbia River from Grand Coulee Dam to Bonneville Dam to better assess the effects of operations or flow depletions on summer temperatures. Progress continued during 2013 to achieve this capability through the Corps funding the development of a tool that allows modelers to run and send data from the regulation model (ResSim) to a water quality model (HEC-RAS and CE-QUAL-W2) that would also run under the same interface. This is an on-going project.