FINAL
2014 Water Quality Plan

U.S. Bureau of Reclamation
Pacific Northwest Regional Office
Boise, Idaho

U.S. Army Corps of Engineers
Northwestern Division
Portland, Oregon

Bonneville Power Administration
Portland, Oregon

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List of Acronyms

2000 BiOp	*Endangered Species Act Section 7 Biological Opinion on the Reinitiation of Consultation on Operation of the Federal Columbia River Power System, including the Juvenile Fish Transportation Programs and 19 Bureau of Reclamation Projects in the Columbia Basin,* December 2000.
2008 BiOp	*Endangered Species Act Section 7(a)(2) Consultation Biological Opinion And Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation - Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(I)(A) Permit for Juvenile Fish Transportation Program (Revised and reissued pursuant to court order, NWF v. NMFS, Civ. No. CV 01-640-RE (D. Oregon)).* May 2008.
2010 Supplemental BiOp	*NOAA Fisheries Endangered Species Act Section 7(a)(2) Consultation Supplemental Biological Opinion, Supplemental Consultation On Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin, and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program*. May 2010.
2014 Supplemental BiOp	*NOAA Fisheries Endangered Species Act Section 7(a)(2) Consultation Supplemental Biological Opinion* … January 2014.
BPA	U.S. Department of Energy, Bonneville Power Administration
Corps	U.S. Army Corps of Engineers
CWA	Clean Water Act
DO	Dissolved oxygen
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FCRPS	Federal Columbia River Power System
FMS	Fixed monitoring stations
FOP	Fish Operations Plan
FPOM	Fish Passage Operations and Maintenance Coordination Team

List of Acronyms

GBT	Gas bubble trauma
kcfs	Thousand cubic feet per second
MOA	Memorandum of Agreement
NOAA Fisheries	National Oceanic and Atmospheric Administration National Marine Fisheries Service
OMP	Oversupply Management Protocol
Plan	Water Quality Plan
PUD	Public Utilities District
RCC	Reservoir Control Center (U.S. Army Corps of Engineers Northwestern Division)
Reclamation	U.S. Bureau of Reclamation
Reserves	Reserve Power Capacity
RPA	Reasonable and Prudent Alternative
SR-HC	Snake River-Hells Canyon Complex (Idaho Power Company)
SYSTDG	System Total Dissolved Gas computer model
TDG	Total Dissolved Gas
TMDL	Total Maximum Daily Load
TMT	Technical Management Team
TOR	Target Operating Range
TSP	Turbine Survival Program
USFWS	U.S. Fish and Wildlife Service

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1.0 INTRODUCTION

This Water Quality Plan (Plan) was prepared by the U.S. Army Corps of Engineers (Corps), Bureau of Reclamation (Reclamation), and Bonneville Power Administration (BPA), collectively referred to as the Action Agencies, as an update to the 2009 Water Quality Plan for Total Dissolved Gas (TDG) and Water Temperature in the Mainstem Columbia and Snake rivers as called for by the 2014 NOAA National Marine Fisheries Service (NOAA Fisheries) Federal Columbia River Power System (FCRPS) Supplemental Biological Opinion (2014 Supplemental BiOp).

This document sets forth the Action Agencies' plan to manage water quality in the mainstem Columbia and Snake rivers with respect to: (1) RPA actions that pertain to improving water quality for Endangered Species Act (ESA) listed fish identified in the 2014 Supplemental BiOp; (2) applicable total maximum daily loads (TMDL) for dissolved gas (TDG); and (3) other actions to move toward attainment of EPA-promulgated or approved State and Tribal water quality standards in the Columbia and Snake rivers. The Action Agencies intend to integrate their fish and wildlife and water quality efforts to support the objectives of the ESA, Clean Water Act (CWA), and other statutes such as the Pacific Northwest Electric Power Planning and Conservation Act.

The Action Agencies intend to continue to coordinate with NOAA Fisheries, U.S. Fish and Wildlife Service (USFWS), and the Pacific Northwest States and Tribes to resolve water quality issues related to operating Federal dams for authorized project purposes, including meeting CWA and ESA responsibilities.

The general policies of the Corps related to water quality are summarized in the *Corps Digest of Water Resources Policies and Authorities, Engineering Pamphlet 1165-2-1*, dated July 31, 1999 (Corps 1999). The Corps policy is to meet water quality standards to the extent practicable regarding nationwide operation of water resources projects:

> 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 (Corps 1999,

Section 18-3.b, page 18-5).

Reclamation decision making integrates, as practicable, all applicable environmental laws (including the CWA and ESA), Executive Orders, and Secretarial Orders.

This Plan documents structural and operational actions that have been implemented to address TDG and water temperature in the Columbia River from Lake Roosevelt at the Canadian border to the confluence with the Snake River, the Clearwater River from below Dworshak Dam to the Snake River, and from the Snake River below Brownlee Dam to the Columbia River below Bonneville Dam (Figure 1).

In addition, this Plan includes measures to address TDG and water temperature in the same geographical area as called for by the 2014 Supplemental BiOp, RPA actions 4, 6, 15, 29, and 1A as defined in the 2014-2018 Implementation Plan. It is important to understand that actions taken at a specific project or in a specific reach of the river can affect these parameters at locations downstream. It is the Action Agencies' intent to take a balanced approach and manage TDG and temperature on a system-wide basis.

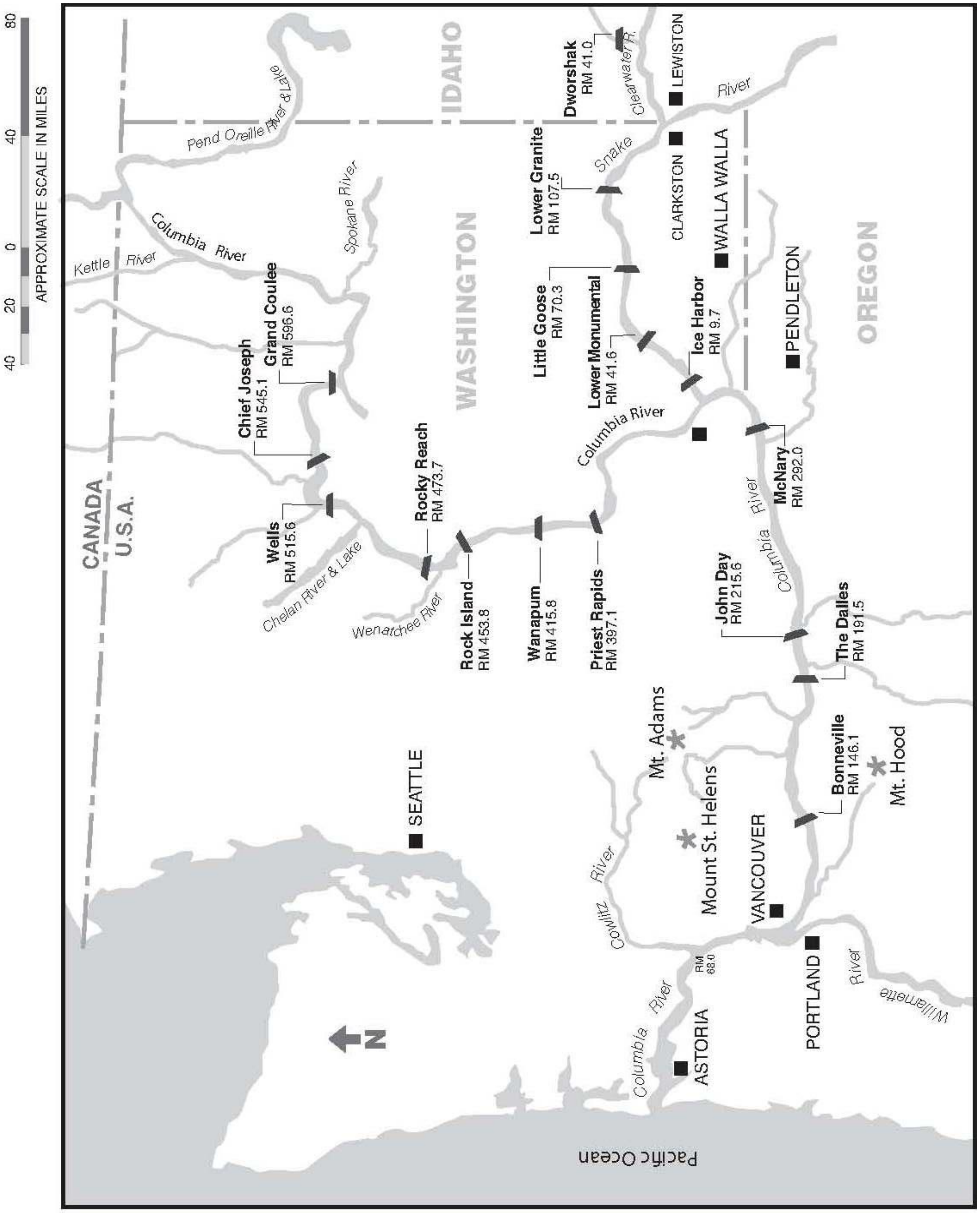

Figure 1. Map of Federal Columbia River Power System (FCRPS)

2.0 BACKGROUND

2.1 Water Quality Plan History

The Water Quality Plan was first introduced in the NOAA Fisheries' 2000 Biological Opinion (2000 BiOp) concerning the operation of the FCRPS (NOAA Fisheries 2000). In Appendix B of the 2000 BiOp, Environmental Protection Agency (EPA), NOAA Fisheries (also referred to as NMFS), USFWS, and the Action Agencies committed to develop and implement a water quality plan to support TDG and temperature improvements in the Columbia River Basin. It was recognized in the 2000 BiOp that integration of the TDG and water temperature actions of the Reasonable and Prudent Alternative (RPA) and Appendix B would promote attainment of water quality standards as well as the recovery of ESA listed species. The first Water Quality Plan, produced in April 2003, was developed in coordination with water quality regulatory agencies, other State and Federal agencies, Tribes, and private entities. Implementation of a water quality plan for the Columbia River Basin has been ongoing since 2003, with updates occurring in November 2004, November 2006, and January 2009.

2.2 2014 FCRPS Biological Opinion

The 2008 FCRPS Biological Opinion (2008 BiOp) described a comprehensive series of actions to improve the status of 13 ESA-listed salmon and steelhead species throughout their life cycle. The suite of actions defined in the RPA actions included among other things hydropower passage, water quality, estuary and tributary habitat, hatchery and predation management improvements needed to avoid or minimize harm to the species and their habitats. The actions would occur over a 10-year period, through 2018. The RPA also included an adaptive management framework to monitor and adjust implementation as necessary to achieve survival improvements identified in the 2008 BiOp. The 2008 BiOp was updated in 2009 to improve monitoring of potential uncertainties and to establish contingency measures should fish abundance decline. In 2010, NOAA Fisheries reexamined and validated the 2008 conclusions in a Supplemental Biological Opinion (2010 Supplemental BiOp).

In litigation challenging the BiOp, the Court ordered NOAA Fisheries to issue a new or supplemental biological opinion for the FCRPS by 2014.[1] In January 2014, NOAA issued a Supplemental FCRPS BiOp to address a 2011 Court Remand Order requiring more specific identification of habitat actions planned for the 2014–2018 period and requiring NOAA Fisheries to reexamine the 2008/2010 Biological Opinions. The 2014 Supplemental BiOp continues to require updates to the water quality plan and implementation of water quality actions described in RPA actions 4, 15, and 29.

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[1] *Nat'l Wildlife Fed'n v. Nat'l Marine Fisheries Serv.*, 839 F.Supp.2d 1117 (D. Or. 2011).

The 2014 Supplemental BiOp RPA action 15 – Water Quality Plan for Total Dissolved Gas and Water Temperature in the Mainstem Columbia and Snake Rivers calls for the Action Agencies to "continue to update the Water Quality Plan for Total Dissolved Gas and Water Temperature in the Mainstem Columbia and Snake Rivers (WQP) and implement water quality measures to enhance ESA-listed juvenile and adult fish survival and mainstem spawning and rearing habitat. The WQP will include the following measures to address TDG and water temperature to meet ESA responsibilities:

- Real-time monitoring and reporting of TDG and temperatures measured at fixed monitoring stations (FMS).
- Continued development of fish passage strategies with less production of TDG (e.g., removable, top, and adjustable spillway weirs) and update the System Total Dissolved Gas (SYSTDG) model to reflect modifications to spillways or spill operations.
- Continued development and use of the SYSTDG model for estimating TDG production to assist in real-time decision making, including improved wind forecasting capabilities as appropriate.
- Continued development of CE-QUAL-W2 model for estimating river temperatures from Dworshak Dam on the Clearwater and upper Snake River near the confluence with the Grand Ronde River (USGS Anatone gage) through the lower Snake River (all four Corps lower Snake River projects) to assist in real-time decision making for Dworshak Dam operations.
- Expand water temperature modeling capabilities to include the Columbia River from Grand Coulee to Bonneville dams to better assess the effect of operations or flow depletions on summer temperatures.
- Investigate alternatives to reduce total mass loading of TDG at Bonneville Dam while maintaining juvenile survival performance.
- Continued operation of the lower Snake River projects at the minimum operating pool."

The 2014 Supplemental BiOp RPA action 29 – Spill Operations to Improve Juvenile Passage call for the Corps and BPA to "provide spill to improve juvenile fish passage while avoiding high TDG supersaturation levels or adult fallback problems. Specific spill levels will be provided for juvenile fish passage at each project, not to exceed established TDG levels; i.e. either 110 percent TDG standard, or as modified by state water quality waivers, currently up to 115 percent TDG in the dam forebay and up to 120 percent TDG in the project tailwater, or if spill to these levels would compromise the likelihood of meeting performance standards (see RPA Table, RM&E Strategy 2). The dates and levels for spill may be modified through the implementation planning process and adaptive management decisions." The initial levels and dates for spill operations are identified in the RPA. Future Water Management Plans will contain the annual work plans for these operations and spill programs, and will be coordinated through the TMT. The Corps and BPA will continue to evaluate and optimize spill passage survival to meet both hydrosystem performance standards and requirement of the Clean Water Act (CWA).

3.0 TOTAL DISSOLVED GAS

This section describes the definitions, standards, and measures specific to TDG in the waters within the geographic scope of this Plan.

3.1 Spill Definitions

In various parts of the Columbia and Snake River systems, elevated levels of TDG saturation are observed where spill at dams occurs. The following describes circumstances that result in various types of spill:

- **Fish Passage Spill:** 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 Supplemental 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.

- **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 risk[2], 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.

(a) **Lack of Load Spill:** 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.

(b) **Lack of Turbine Spill:** 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 project outflow 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, but within the Fish Passage Plan turbine operating criteria 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

[2] The Corps directs operations of storage projects in the Columbia Basin to manage flood risk. Projects draft their reservoir pools in the winter and early spring to provide storage to capture part of the sping runoff, reducing peak flows in the river. This draft of reservoirs can create spill and elevated levels of gas in the river system, and while the Corps and other action agencies will work to minimize gas levels, drafting to manage flood risk takes priority.

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.

(c) **Miscellaneous spill:** Occurs when water is passed through various dam structures for other purposes. These structures include the fish ladders, juvenile fish bypass, navigation locks, ice and trash sluiceways, Bonneville Powerhouse 2 corner collector, etc. Miscellaneous spill occurs most hours during the year and especially during April through August when fish are migrating.

(d) **Special Spill Events:** Occur for the purposes of passing debris or operational and/or maintenance activities required to manage dam facilities for safety and multiple uses. These are infrequent and generally of short duration.

3.2 TDG Water Quality Standards

The following standards are the applicable TDG Water Quality Standards as currently approved by the Confederated Tribes of the Colville Reservation and the states of Idaho, Oregon, and Washington and are applicable to waters within their jurisdiction. [2]

3.2.1 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.

3.2.2 State of Idaho

I**DAPA 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.

3.2.3 State of Oregon

OAR 340-041-0031:

[2] Note: these passages are direct quotes from the standards.

- 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;

(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; and

(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 through August 31. The Environmental Quality Commission approved a modification to the 110 percent TDG water quality standard for voluntary spill at McNary, John Day, The Dalles, and Bonneville dams on the lower Columbia River, subject to 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.

3.2.4 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 1. Table 200 (1)(f) from WAC 173-201A-200, 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 DOE 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 saturation 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.

3.3 Total Maximum Daily Loads and Implementation Plans

The CWA requires that a TMDL be developed for 303(d)-listed impaired water bodies. A TMDL is a water quality improvement plan developed to meet water quality standards and protect beneficial uses. TMDLs are calculated to protect the most sensitive beneficial use and quantify the quantity (load) of a pollutant that can enter a waterbody and still meet water quality standards. A TMDL establishes compliance locations, loading capacity, and load allocations, and includes the development of an implementation plan and associated timeline. The implementation plan provides a framework of structural, operational, and on-the-ground controls that are to be implemented to reduce the pollutant and ultimately meet water quality standards. TMDLs are typically developed by States or Tribes and approved by the EPA; however, EPA may also develop a TMDL. TMDLs are a planning tool, not a rule of law or other stand-alone enforceable document. TMDLs may be used to condition exemptions, modifications, variances, permits, licenses, and certifications.

3.3.1 Total Dissolved Gas

During 2002-2004, Oregon and Washington developed TDG TMDLs for the Columbia River and lower Snake River to address the 110 percent criterion.[3] The TDG TMDL implementation plans were developed in consultation with NOAA Fisheries to coordinate the TMDL implementation with requirements of the ESA. These TMDLs provided for the development of the TDG fish passage spill condition exemption, 115 percent forebay and 120 percent tailrace limits, approved through the use of a waiver in Oregon and criteria adjustment in Washington. Both Oregon and Washington require a periodic renewal, currently 5-year periods.

The TDG TMDL specifies water quality standards, for the purpose of spill to aid juvenile fish passage at each dam, and incorporates the State of Oregon's TDG waiver and the State of Washington's TDG criteria adjustment. Compliance monitoring locations are identified at the downstream end of the aerated zone in the tailrace below each spillway in a well-mixed area (see the "Compliance Locations for TDG Load Allocations" table in each TDG TMDL [Footnote 2]). The 110 percent criterion applies during periods of non-fish passage spill and is instantaneous. Additionally, Oregon's TDG criterion for shallow water is 105 percent year round. The shallow water criterion typically applies to chum spawning below Bonneville Dam during the period of November through March.

The TDG TMDL implementation strategy outlined a two-phase approach for reducing gas levels and included an adaptive management component that allowed for realistic implementation and standard attainment. The first phase was meant to identify the activities that were planned for completion in the short term, through 2010. These activities included operational and structural changes to reduce TDG levels, as well as ensuring attainment of fish passage performance standards called for in the BiOp. The first phase of the TMDL implementation plan incorporated operational management of spill, implementation of the "fast-track" DGAS structural modifications, ESA actions, and TDG waiver criteria. The second phase identified action items that were planned for the longer term, through 2020, that included additional structural modifications to reduce TDG and meet BiOp survival goals through fish passage actions other than spilling water.

The majority of the short-term and long-term TMDL structural and operational modifications to reduce TDG have been constructed and/or implemented (see Appendix A for a summary of implemented TDG actions as of 2013). The result of implementing these measures has

[3] The TDG TMDLs are available for review at:

- Oregon: http://www.deq.state.or.us/wq/tmdls/docs/columbiariver/tdg/tmdlwqmp.pdf
- Washington: Lower Columbia TDG TMDL: http://www.ecy.wa.gov/biblio/0203004.html
- Mid-Columbia TDG TMDL: http://www.ecy.wa.gov/biblio/0403002.html
- Snake River TDG TMDL: http://www.ecy.wa.gov/biblio/0303020.html

generally allowed greater spill rates for juvenile fish passage within the TDG standard rather than decreasing the dependence on spill for meeting BiOp survival goals as was expected in the long-term TMDL strategy.

The Action Agencies are however managing TDG production through dam specific fish passage spill rates tailored to meet juvenile performance standards, and are not arbitrarily spilling to the TDG gas cap at every dam that has juvenile and adult fish passage. For most lower Columbia River and lower Snake River dams, the 2014 Supplemental BiOp calls for juvenile fish passage spill as a percent of the river flows (example 40% at The Dalles Dam both spring and summer) or an absolute juvenile fish passage spill rate (example summer Lower Monumental Dam 17 kcfs) rather than spilling to the TDG gas cap. Tailoring juvenile fish passage spill rates at each dam to meet juvenile performance standards allows for optimal management of TDG, while still achieving the requirements of the 2014 Supplemental BiOp.

3.4 Modeling

The Corps developed, maintains, and updates the SYSTDG model for the purpose of forecasting TDG levels in the Columbia River Basin. This model is used in real-time operations during the juvenile fish passage season to provide information for setting daily spill caps (see spill priority list in Section d)). The model has also been used to estimate TDG levels for proposed changes in spill or system operations in the BiOps or the 2014 Columbia River Treaty Review.

The model incorporates parameters such as total river flow, spill, wind, water temperature, forebay and tailrace elevations, and existing TDG levels in the Columbia River. The TDG levels of spillway releases are estimated using empirical equations based upon observations of TDG levels from spill in past years. The SYSTDG model predicts the average TDG levels in the forebay of a dam, the spillway, powerhouse releases, and forebay of the next downstream dam.

Reclamation is beginning to investigate adding TDG to the existing CE-QUAL-W2 model developed for Lake Roosevelt in conjunction with Portland State University. Several constituents already exist within the model framework that may serve as a surrogate until TDG can be added to the model. Reclamation is investigating dissolved oxygen (DO) as a surrogate at this time.

3.5 Structural Measures

Per the 2014 Supplemental BiOp RPA action 15, continued development of fish passage strategies with less production of TDG is (and has been) an ongoing strategy to operate the hydrosystem in accordance with both the CWA and the ESA. The structural measures in this section describe physical modifications to projects that reduce TDG loading.

3.5.1 Flow Deflectors

Spillway flow deflectors are recognized as being the most effective means of reducing the TDG production during spillway operations. These devices are built into existing spillbays and prevent flow from plunging deep into the spillway stilling basin, force higher energy flow out into the tailrace channel, and reduce the initial uptake in TDG (see Figure 2). Spillway flow deflectors also promote a rapid decrease in TDG by extending the boundaries of a more turbulent aerated plume.

The addition of spillway flow deflectors has been the primary structural alternative employed to abate TDG generation at Corps projects on the Snake and Columbia rivers. Flow deflectors have been installed at all of the Corps projects within the scope of the Plan except at The - Dalles Dam where flow deflectors were determined to be ineffective due to the shallow bathymetry downstream of the project. Table 2 summarizes the number of flow deflectors that have been installed on the Snake and Columbia River dams since the initiation of the Corps Gas Abatement Program in 1994.

While flow deflectors have been effective in TDG management, they can increase the wear and tear on spillway stilling basins. A recirculation zone develops under each flow deflector and can often cause large rocks and debris to accumulate in the stilling basin. For example in 2011, over 1000 cubic yards of rock were moved into the stilling basin at Bonneville Dam.

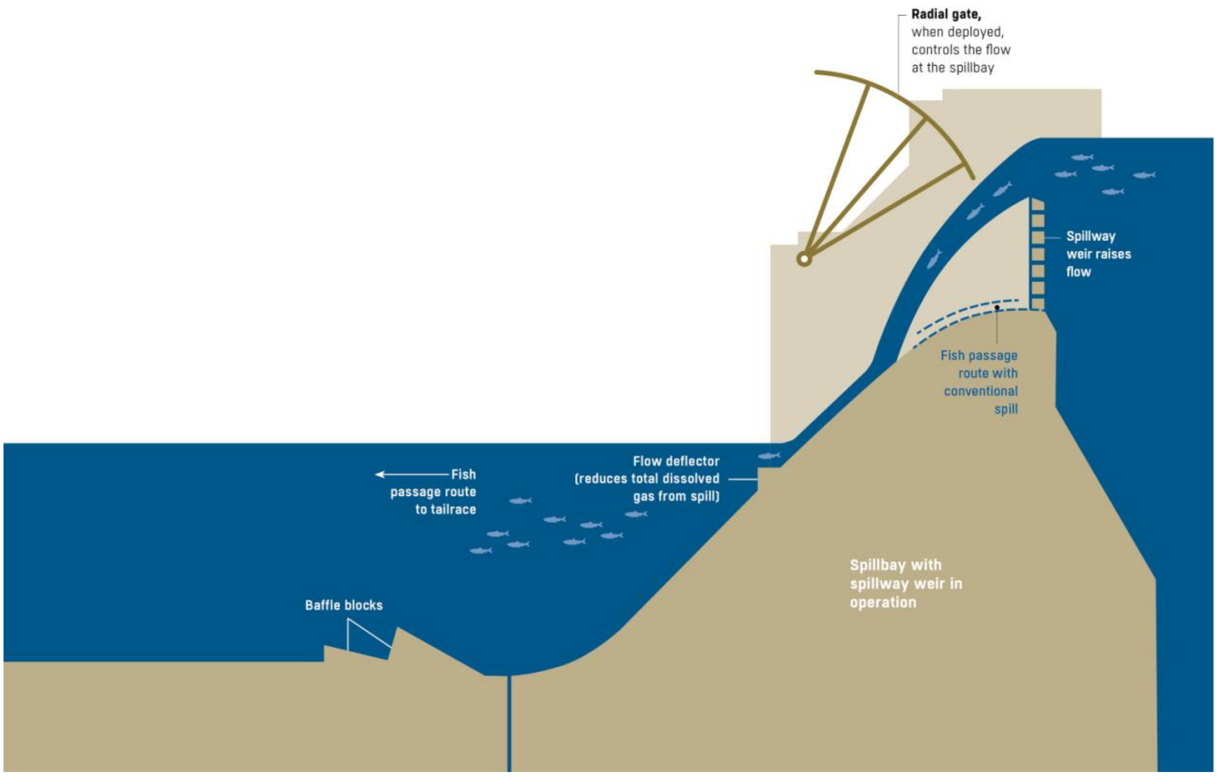

Figure 2. Spillway with Weir and Flow Deflectors

Table 2. Project summary of flow deflectors installed prior to 1995 and current.

Project	Flow Deflectors 1995	Flow Deflectors 2013	Number of New Flow Deflectors
Bonneville	12	18	6 new deflectors
The Dalles	0	0	0
John Day	0	18	18 new deflectors
McNary	18	22	4 new deflectors
Ice Harbor	0	10	10 new deflectors
Lower Monumental	6	8	2 new deflectors
Little Goose	6	8	2 new deflectors
Lower Granite	8	8	0
Chief Joseph	0	19	19 new deflectors

3.6 Fish Passage Improvements

Many of the structural modifications designed to improve juvenile fish passage result in increased effectiveness and efficiency of non-spillway and surface passage routes. The performance standard for average juvenile dam survival, as measured from the upstream face of the dam to a standardized tailrace reference point, is 96 percent for spring Chinook salmon and steelhead, and 93 percent for subyearling Chinook salmon. Through regional coordination, the Action Agencies develop and implement studies each year at a subset of projects in the lower Snake and lower Columbia rivers to measure juvenile passage performance and evaluate new or modified passage structures to ensure juvenile dam survival meets or exceeds performance standards through the term of the 2014 Supplemental BiOp.

- **Juvenile Bypass System**: Juvenile bypass system improvements are designed to increase the survival of fish that pass the powerhouse by increasing the proportion that are guided away from turbines into the bypass system (referred to as fish guidance efficiency), and improving the bypass release location in the tailrace. Guidance system improvements include installation and/or modification of submersible traveling screens or extended submersible bar screens in front of turbine units. Improvements to the location and design of bypass exit flumes ensure that bypassed fish are released into optimal tailrace conditions for quick egress and minimal risk of predation. These structural modifications increase the survival of powerhouse-passed fish.

- **Surface Passage Routes**: Surface passage routes capitalize on the natural tendency of juvenile salmonids to migrate in the upper part of the water column (Figure 3) and are now in place at all eight dams on the lower Columbia and lower Snake rivers (Table 3). Other passage routes require fish to dive 40 to 60 feet (e.g., conventional spillbays, bypass entrances), resulting in increased passage delay, lower dam passage survival, and inefficient use of spill. System monitoring indicates that through the combined effects of flow augmentation, spill, and recently installed surface passage systems that travel time has decreased resulting in faster migration**.** For the period from 2005 to 2010 mean fish travel time from Lower Granite to McNary Dam was 11.2 days, compared to 21.3 days for the same reach during preceding era from 1998 to 2004.[4] At some sites, surface passage has been provided through spillway weirs installed into one or more existing spillbays. At other sites, surface passage routes use existing and improved ice and trash sluiceways (Bonneville Powerhouse1 and The Dalles). In 2004, Bonneville Dam modified the Powerhouse 2 sluiceway to install the corner collector as a surface passage route.

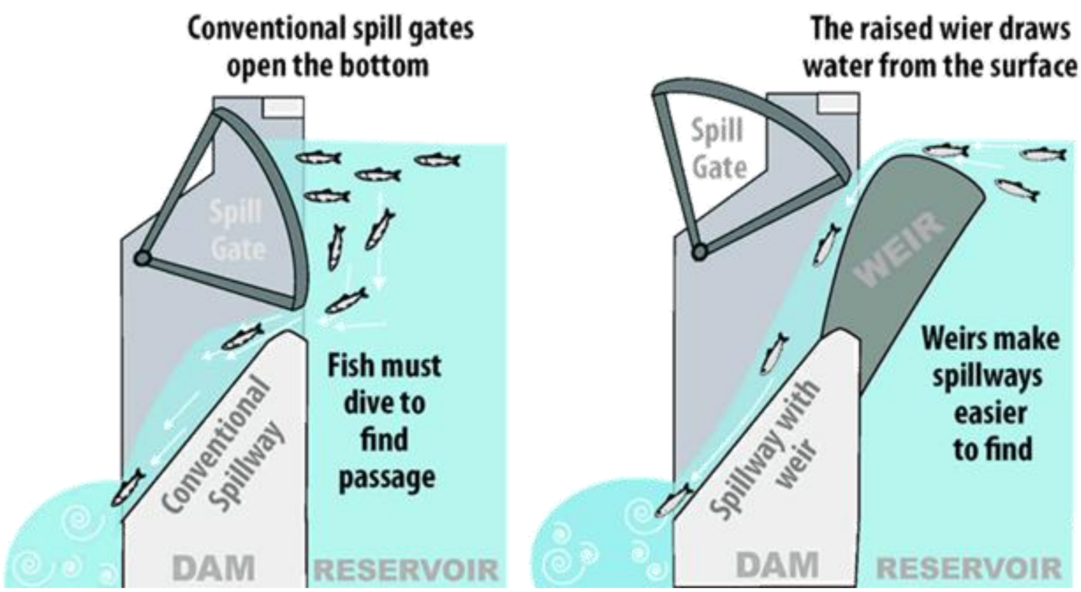

Figure 3. Fish Passage routes using conventional spill and spillway weir.

[4] http://www.salmonrecovery.gov/BiologicalOpinions/FCRPSBiOp/ProgressReports/HydroResults.aspx

Table 3. Surface passage routes at lower Snake River and lower Columbia River projects.

Project	Surface Passage Structures	Completion Year
Bonneville	Corner Collector (PH2)	2004
Bonneville	Ice & Trash Sluiceway (PH1)	Original construction
The Dalles	Ice and Trash Sluiceway	Original construction
John Day	2 Spillway Weirs	2008
McNary	2 Spillway Weirs	2007
Ice Harbor	1 Spillway Weir	2005
Lower Monumental	1 Spillway Weir	2009
Little Goose	1 Spillway Weir	2009
Lower Granite	1 Spillway Weir	2001

- **Powerhouse/Spillway Divider Walls**: At The Dalles Dam, spillway divider walls were installed in the tailrace to keep spillway-passed smolts in the main river channel and away from shallow areas where predation was a concern. In 2005, a wall was constructed between Spillbays 6 and 7. Based on biological evaluation of the wall's effectiveness, a longer wall was constructed between Spillbays 8 and 9 in 2010. By design, a spillway divider wall is intended to prevent powerhouse flows from mixing with the higher TDG spillway flows. The Dalles Dam tailrace bathymetry is exceptionally shallow (approximately 13 feet), providing feasible conditions for construction and effectiveness of a divider wall. However, the tailrace bathymetry at other projects is much deeper (at least 40 feet) and a divider wall would be cost prohibitive and likely an ineffective solution to improve fish passage or TDG management.

3.7 Operational Measures

3.7.1 Turbine Passage

Turbines at some projects have a lower rate of survival than other passage routes available to downstream-migrating juvenile fish. Some turbines present a challenging passage environment for fish, primarily due to the potential for direct impact (strike) with the turbine blades, extreme pressure changes within the turbine unit, or poor egress conditions exiting the draft tube. The Corps' Turbine Survival Program (TSP) was developed as part of the Columbia River Fish Mitigation Program to evaluate juvenile fish turbine passage and to identify turbine features and conditions that cause injury to fish at the eight Corps hydropower projects on the lower Snake and lower Columbia rivers. Based on the results of physical modeling and biological studies, the TSP identified turbine operating conditions that would improve juvenile fish survival, and recommended a target operating range (TOR) for turbines at each project. In general, operating units at higher discharges near or above the upper limit of the 1 percent peak efficiency operating range tends to reduce turbulence and provide improved conditions for fish passage. The TSP will continue to verify the recommended TORs for fish passage and will provide updates as new information becomes available. For projects where the TOR is above the existing upper 1 percent limit, the net result of implementing the recommendation would be more water passing through the turbine units, but with a higher rate of survival for juveniles passing through the turbines. Note that based on testing completed in 2012, the proportion of juvenile fish passing through non-turbine routes is now typically above 87% for spring migrants and 70% for summer migrants at the eight fish passage dams on the FCRPS[5].

3.7.2 Evolution of Spill Operations

The Corps implemented a variety of operational and structural measures to improve the survival of ESA-listed stocks in the Columbia and Snake rivers in consultation with NOAA Fisheries beginning with the listing of Snake River sockeye in 1991. The Action Agencies adopted the recommendations contained in the NOAA Fisheries biological opinions (1992-present). The 2008 BiOp recommended levels of spill for fish passage, which were implemented starting in 2009, using an adaptive management framework (NOAA Fisheries 2008). Therefore, the Action Agencies had the flexibility to modify spill rates over the 10-year implementation period of the BiOp, incorporating the best available information from research to meet BiOp juvenile dam passage performance standards. Appendix B contains excerpts of historic planned and actual spill programs compiled by the Fish Passage Center 2012.

3.7.3 Spill Patterns

Pursuant to the 2014 Supplemental BiOp RPA action 32, the Corps develops spill patterns and other project operations in coordination with regional partners through the Fish Passage Operations and Maintenance (FPOM) workgroup for inclusion in the annual Fish Passage Plan. Patterns are modified in-season as necessary through adaptive management as coordinated with FPOM and/or the TMT. Spring and summer spill operations to improve juvenile fish passage are identified in the annual Fish Operations Plan (FOP).

As a general rule, optimal spill patterns for minimizing TDG production typically tend to be a uniform pattern where there are equal amounts of spill from each spillbay across the spillway.

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5 http://www.salmonrecovery.gov/BiologicalOpinions/FCRPSBiOp/ProgressReports/HydroResults.aspx.

Although these spill patterns may be good for managing TDG, they may not necessarily be good for ESA-listed fish. The travel time, or egress, from the stilling basin of downstream migrating juvenile salmonids may be greatly increased if a spill pattern is not appropriate. In addition, adult salmonid migration could be delayed within the system if spillway patterns are not optimized, resulting in possible impacts to successful spawning. Physical models are often used to determine appropriate spill patterns to minimize both TDG and the impacts to juvenile and adult salmon in the spillway area.

3.7.4 Grand Coulee Operational Measures to Reduce TDG

If the reservoir water surface elevation is above 1265.5 feet, any necessary spill can be directed over the drum gates which produces significantly lower levels of TDG compared to spill through the outlet tubes. When the reservoir water surface elevation is below 1265.5 feet, spill is directed through the outlet tubes which tend to increase TDG levels in the river more so than spill over the drum gates. The outlet tubes have upper and mid-level outlets. Reclamation operates the upper and mid outlets combined in over/under fashion simultaneously. This operation is shown to be the most effective way to minimize TDG production when using the outlet tubes.

3.7.5 Use of Chief Joseph Flow Deflectors to Reduce TDG

The spillway flow deflectors installed at Chief Joseph Dam have been successful at reducing TDG levels in the spillway releases. During testing and in actual operations, the spillway flow deflectors reduce TDG levels associated with spillway releases when inflow TDG levels are above approximately 120 percent.

The Action Agencies identified four possible operational alternatives to utilize the spillway flow deflectors at Chief Joseph Dam to moderate system TDG levels:

a) **Spill/Power Shift**: The intent of the spill shift is to avoid spilling through the outlet tubes at Grand Coulee and utilize higher spill rates at Chief Joseph under system-wide lack of load condition (see Section 3.7.7). This is accomplished by positioning Chief Joseph ahead of Grand Coulee in the spill priority list (Section d)). The additional capacity at Chief Joseph to spill at lower TDG levels and placing it before Grand Coulee Dam in each level of the spill priority list reduces the frequency and magnitude of spill due to lack of load at Grand Coulee.

b) **System Reserve Shift**: Grand Coulee Dam holds a substantial amount of system generation reserves in the Pacific Northwest to allow for response to within hour load variability as required by the North American Reliability Council regarding reserve requirements. During periods when Grand Coulee Dam or other projects in the system need to spill to carry system generation reserves, lack of load releases at Chief Joseph

Dam are often spilled first. This approach is used in order to meet load with generation at other project(s) which tends to increase lack of load spill at Chief Joseph Dam. This operation often reduces TDG production, rather than if the lack of load spill occurred at another project in the system, thereby reducing overall system-wide TDG in the Columbia River.

c) **TDG Degassing Operations**: In very high water years when it is necessary to spill continuously through the Grand Coulee Dam outlet tubes, TDG can reach very high levels (128 percent and higher) downstream. During these periods, the Corps will use all available options to minimize TDG levels systemwide. Within system constraints, projects in the FCRPS will attempt to increase generation, while minimizing involuntary spill (or spill above BiOp requirements) at fish passage projects as much as possible and correspondingly Chief Joseph will spill as much as possible to degas high incoming TDG produced at Grand Coulee arriving at the project.

d) **TDG Neutral Spill**: During the spring and summer when TDG levels from Canada and Grand Coulee can be elevated, Chief Joseph TDG levels will exceed the standard of 110%. Typically, a project's spill caps will be reduced when tailwater TDG levels exceed the applicable standard. However, reducing spill at Chief Joseph will actually increase gas, for with no spill the tailwater TDG will consist of only the turbine releases which will match the forebay TDG levels. Therefore, to utilize the degassing properties of the flow deflectors at Chief Joseph, during periods when Chief Joseph Dam TDG levels exceed 110%, spill caps may be set to where the tailwater TDG levels approximately equal the forebay TDG levels, i.e. TDG Neutral Spill.

3.7.6 Spill Priority List

Spill priority lists are primarily used to manage system-wide TDG levels during lack of load conditions and are used throughout the year. Spill priority lists may also be utilized to inform other decisions such as how to allocate reserves to the projects or manage other system obligations. The Corps' Reservoir Control Center (RCC) prepares spill priority lists based on the factors described below and revisions are discussed in the Technical Management Team (TMT) meetings as appropriate.

Values on the spill priority list serve as a reference for expected TDG production at the dams and are applicable for all spill conditions. Estimated spill rates are grouped into different TDG production levels (spill cap targets) on the spill priority list such as the examples shown below:

- Level 1 – Spill flows up to 120 percent TDG in the fish passage project tailrace or 115 percent TDG in the next downstream forebay (whichever is less) (e.g. State TDG limits for spill to aid juvenile fish passage during the fish passage season); otherwise Level 1 consists of spill flows up to 110 percent TDG in the project tailraces

- Level 2 – Spill flows up to 120 percent TDG in the project tailrace Level 3 – Spill flows up to 122 percent TDG in the project tailrace
- Level 4 – Spill flows up to 125 percent TDG in the project tailrace
- Level 5 – Spill flows up to 127 percent TDG in the project tailrace
- Level 6 – Spill flows up to 130 percent TDG in the project tailrace
- Level 7 – Spill flows up to 135 percent TDG in the project tailrace

When establishing the order dams will spill above the FOP, the following factors are considered:

- **Location of fish**: Location and number of adult and juvenile fish in the migratory corridor is a factor in establishing the spill priority order on the spill priority list.
- **Location of high TDG**: When TDG levels are elevated (above 120 percent), dams may be shifted on the list to manage system-wide TDG levels. These decisions are coordinated with TMT members.
- **Location of fish research**: When fish research is planned or in progress, those dams are low on the spill priority list to minimize detrimental impact to the studies.
- **River reaches**: Dams are considered in one of three blocks: the lower Snake River, the lower Columbia River, and the middle Columbia River. For example, if several of the lower Snake River dams need to be moved to a lower priority on the spill priority list, then the whole block of dams (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor dams) may be moved to last position on the list.
- **Special operations**: Dams with special operations such as construction, maintenance, repair, or dam safety concerns are placed last on the spill priority list.
- **Collector dams**: During low flow years, the collector dams (Lower Granite, Little Goose, and Lower Monumental dams) are placed low on the spill priority list.
- **Special fish conditions**: If there are special fish conditions, such as disease or a special release, the dam may be moved higher or lower on the spill priority list, depending on circumstances.

- **System-wide TDG management**: Grand Coulee, Chief Joseph, Dworshak, and other projects may be used to help balance system-wide TDG levels during periods of involuntary spill.

3.7.7 Oversupply Management Protocol

Hydroelectric dams generate large amounts of electricity during high river flows, but BPA must keep electricity supply from exceeding power demand, which can jeopardize the reliability of the power system. When there is insufficient demand (e.g., lack of load), water is sent through spillways rather than through turbines to reduce generation.

In such conditions, BPA maximizes hydropower generation and offers the electricity at low or no cost. Thermal plants typically shut down, saving fuel costs, but wind energy producers have a different financial structure; most continue to operate because their contracts provide revenues that depend on continued power generation from their generating units.

In a public process with regional stakeholders, BPA developed an Oversupply Management Protocol (OMP) and filed the terms of this protocol with the Federal Energy Regulatory Commission. The current OMP is in effect through September 30, 2015. BPA continues to work with the regional stakeholders to develop a long-term solution to oversupply.

During a lack of load condition under the current OMP, BPA will take reasonably available actions to avoid displacing wind generation, such as adjusting nonessential maintenance on transmission lines so maximum capacity is available to carry large amounts of power. BPA will also attempt to maximize generation at hydropower plants and would work with the Corps and Reclamation to relieve excess runoff by potentially spilling water up to prevailing state TDG standards.

If electricity supply still exceeds demand, BPA will reduce the output of any generation that does not receive renewable energy or production tax credits, primarily thermal and small hydropower plants, to minimum generation levels that do not affect reliability, and replace the output with free federal hydropower to serve their load.

If this is still insufficient, BPA will begin replacing generation in its balancing authority area that does receive credits, primarily wind, with free Federal hydropower. BPA displaces these generators in order of least cost, based on auditable information provided by the generator owner.

3.8 Research and Studies

3.8.1 Chief Joseph Flow Deflectors Report (Degassing Analysis for 2011)

The spillway flow deflectors at Chief Joseph Dam were completed in October 2008. A field study of the TDG exchange characteristics during spillway operations was conducted in spring 2009. The addition of spillway flow deflectors on Chief Joseph Dam substantially altered the spillway TDG exchange characteristics and resulted in a significant decrease in the TDG generated by spillway releases. The TDG level (e.g. saturation) as a function of unit spillway release with and without spillway flow deflectors is shown in Figure 4. Before the deflectors, spillway flows approaching 38 thousand cubic feet per second (kcfs) resulted in 120 percent TDG in the tailwater. With flow deflectors in place, spillway flows of up to 144 kcfs generated TDG levels near 120 percent at the tailwater monitoring station. The TDG levels in spillway flows of 95 kcfs (5 kcfs per bay) were reduced from 134 percent to 118 percent.

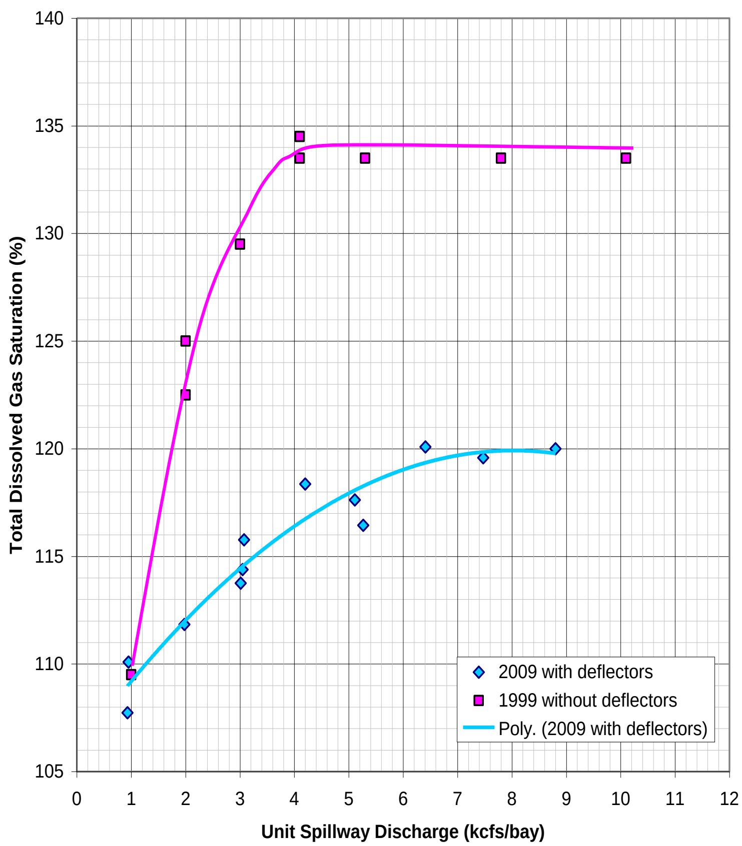


Figure 4. Chief Joseph Dam spillway deflector test results, 2009.

During 2011, background TDG levels reached 140 percent in the Chief Joseph Dam forebay due to high flows and spill operations upstream. During high forebay TDG levels (greater than 120 percent), the spill operations at Chief Joseph Dam reduced the TDG loading of the Columbia River. Figure 5 illustrates an example of this operation where the total river flow at Chief Joseph Dam of 220 kcfs was split between a powerhouse release of 100 kcfs and spillway release of 120 kcfs. The TDG level in the powerhouse releases did not change from the 140 percent TDG observed in the forebay. The TDG levels in the spillway flows were 122 percent in the tailwater, a reduction of 18 percent from levels observed in the forebay. The flow weighted TDG level in the tailwater from combined powerhouse and spillway flows was 128 percent, for a net reduction of 12 percent saturation. Figure 6 shows the total river flow and the total spill flow at Chief Joseph Dam and the corresponding forebay and tailwater TDG measurements during May 11-July 23, 2011. The spillway releases at Chief Joseph Dam lowered the TDG loading in the Columbia River throughout this time period when forebay TDG levels were above 120 percent TDG. At the peak river flow of nearly 300 kcfs and with spill up to 190 kcfs, the tailwater TDG ranged between 120 and 123 percent. These results indicate that the spillway deflectors at Chief Joseph Dam are quite effective at reducing TDG production per unit of spill at the dam and also at degassing high incoming TDG produced at projects upstream of Chief Joseph Dam.

Figure 5. TDG production results during high spill flows at Chief Joseph Dam, 2011.

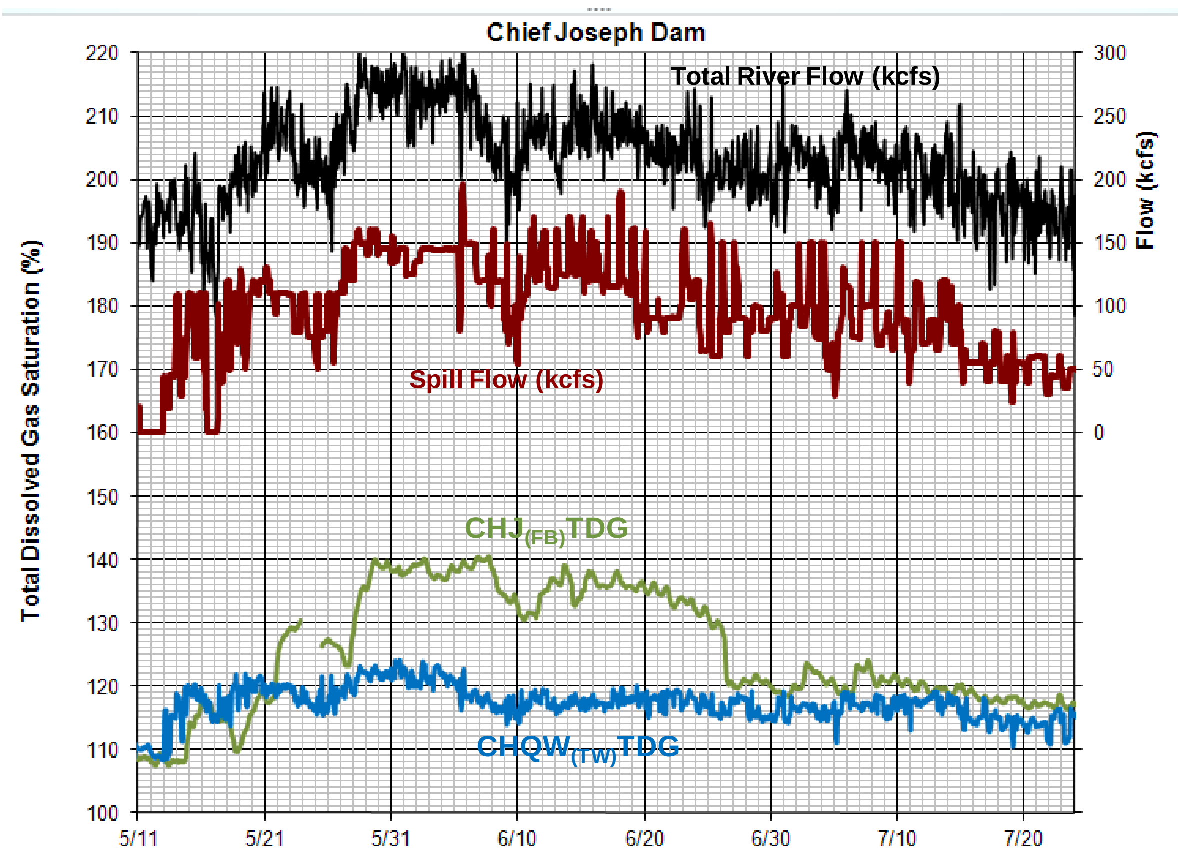


Figure 6. Hourly Chief Joseph Dam operations and observed TDG saturation, May-July, 2011.

4.0 WATER TEMPERATURE

4.1 Temperature Standards

The temperature water quality standards vary by river reach in the Columbia River Basin as shown in Table 4.

Table 4. State Water Temperature 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.

4.2 Temperature TMDLs

Oregon and Washington included the Columbia River on their 303(d) list of water quality impaired water bodies for temperature exceedances. In October 2000, the EPA entered into a Memorandum of Agreement (MOA) with the states of Oregon, Washington, and Idaho. This

MOA laid out the responsibilities for the completion of Columbia and Snake River TMDLs for TDG and temperatures. The MOA stated that each state would be responsible for developing and issuing an approvable TDG TMDL and implementation plan, and that EPA would be responsible for developing the temperature TMDL and implementation plan.[6] To date, a temperature TMDL has not been developed for the lower Columbia and Snake rivers.

The Snake River-Hells Canyon (SR-HC) TMDL was completed in July 2003 and approved by EPA in September 2004 and addresses the water bodies in the SR-HC subbasin that have been placed on the "303(d) list." This TMDL is expansive in that it covers several pollutants - nutrients, dissolved oxygen toxics, temperature, and TDG in the Snake River from near Adrian, Oregon at river mile 409, downstream to the Salmon River confluence. This TMDL was a joint effort between the Idaho Department of Environmental Quality and Oregon Department of Environmental Quality, with participation by the EPA and local stakeholders (IDEQ and ODEQ 2004).[7]

4.3 Temperature Modeling

4.3.1 CE-QUAL-W2: Lower Snake

Summertime cold-water releases from Dworshak Reservoir for the purpose of augmenting flows and reducing water temperatures in the lower Snake River have occurred since the mid-1990s. To predict the outcome of releases on downstream water temperatures, the Corps' Walla Walla District developed the CE-QUAL-W2 model for the reach starting at Dworshak Reservoir and continuing through the lower Snake River to the confluence of the Columbia River. This model was implemented in 2005 and is used every year from July through August as a management tool for attaining a temperature of 68° F, or less, at the Lower Granite Dam tailwater FMS. Without these releases from Dworshak Dam, the model showed water temperatures in the lower Snake River could reach 75° F. The results of the model runs are presented weekly to the TMT which is responsible for making recommendations on the amount and temperature of released water. The model has been updated since it was originally implemented, and refinements will continue to be made as the need arises.

4.3.2 CE-QUAL-W2 modeling for temperature at Grand Coulee

Recently, Reclamation developed water temperature modeling capability for Grand Coulee Dam and Lake Roosevelt in order to evaluate how operations may impact tailwater temperatures. The CE-QUAL-W2 model was developed and calibrated by Portland State University under contract with Reclamation for this effort. The model spans the extent of the

[6] Details can be found at http://www.deq.state.or.us/wq/tmdls/docs/columbiariver/tdg/tmdlmoa.pdf.
[7] Details can be found at: http://www.deq.state.or.us/wq/tmdls/docs/snakeriverbasin/tmdlrev.pdf.

Lake Roosevelt pool from the dam up to the Canadian border. A qualitative analysis on modeled outputs showed that the model replicated important trends and expected outcomes. The model was used in the Columbia River Treaty Review studies and support for other studies related to water temperature in the upper Columbia River and Lake Roosevelt.

4.3.3 Lower Columbia

Water temperature models were developed for Bonneville, The Dalles, John Day, and McNary dams and forebays. WEST Consultants, Inc., developed, calibrated, and validated CE-QUAL-W2 models for these locations under contract with the Corps in 2012. Each of the models was independently peer reviewed. The models may be used in future scenarios to test the response of temperature to changes in dam operations, climate, or upstream conditions.

4.4 Operational Measures

4.4.1 Dworshak Operations

The NOAA Fisheries FCRPS BiOps, including the 2014 Supplemental BiOp, RPA action 4 calls for cold water releases from Dworshak Dam from July through August to reduce water temperatures in the lower Snake River as measured at the Lower Granite Dam tailwater FMS. Without the cold water releases from Dworshak, water temperatures on the lower Snake River could reach up to 75° F. This operation aids in migration of juvenile and adult fish in the lower Snake River and dates back to the 2000 BiOp. The TMT is responsible for making recommendations on the amount and temperature of water to be released from Dworshak Dam based on information provided by Walla Walla District.

The operation of Dworshak Dam has changed as a consequence of the need to provide this cold water. The current summer operation consists of:

1. Refilling the reservoir by about June 30 to full pool elevation of 1600 feet.

2. Draft the reservoir water surface elevation to 1535 feet by the end of August and elevation 1520 feet by the end of September.

3. Regulate outflow temperatures to attempt to maintain water temperatures at Lower Granite Dam tailwater at or below the State of Washington water quality standard of 68° F without exceeding the State of Idaho’s 110 percent TDG standard.

4.4.2 Research and Studies

Thermal Refugia

The *Location and Use of Adult Salmon Thermal Refugia in the Lower Columbia and Lower Snake Rivers* report was prepared by the Corps in coordination with the other Action Agencies to fulfill the requirements of Amendment 1 of the 2010 BiOp. This report provides a comparison of existing tributary and lower Columbia and lower Snake rivers temperature data; a summary of the Snake and Clearwater River confluence study/modeling operations and Dworshak project releases; and a compilation of the University of Idaho studies of temperature regimes during upstream migration and the use of thermal refugia by adult salmon and steelhead in the Columbia River Basin.

The report *Location and Use of Adult Salmon Thermal Refugia in the Lower Columbia and Lower Snake Rivers* includes:

(1) a comparison of existing tributary and lower Columbia and lower Snake River temperature data from the Corps' Water Management System database and the USGS National Water Information System database (http://waterdata.usgs.gov/nwis);

(2) a summary of lower Snake River temperature conditions which includes the use of the Dworshak project releases for downstream temperature moderation and the Snake and Clearwater River confluence study/modeling operations and water temperatures within the lower Snake River reservoir system; and,

(3) a summary of temperature regimes during upstream migration and the use of thermal refugia by adult salmon and steelhead in the Columbia River Basin (University of Idaho).

Temperature Monitoring Data

The Corps tracks temperature monitor data along the Clearwater River from the mouth to Dworshak Dam, the lower Snake River from the mouth to Anatone gauge, and the Columbia River from Astoria to the border with Canada. However, limited information is available from monitors on the smaller tributaries along the lower Snake and Columbia rivers. This document identifies and analyzes the temperature data that is publically available in the Corps Water Management System and the USGS National Water Information System near the confluences of the tributaries and the lower Snake and lower Columbia rivers. The existing data shows that the Clearwater (at Spalding), Umatilla and Deschutes rivers are cooler during the adult fish migration period; the Clearwater (at Orofino) and the Yakima River are substantially warmer during this timeframe and the Willamette River is about the same. The temperature data used in this analysis identifies broad thermal refugia areas along the lower Columbia and lower Snake rivers.

Lower Snake River Temperature Modeling and Operations

Significant work has been completed to develop and implement a CE·QUAL~ W2 temperature model for the lower Snake River. This report documents that the current cool water releases from Dworshak, based on modeling information, provides cooler deep water available in the lower Snake River down to the forebay of Lower Granite Dam to aid adult salmon and steelhead during upstream migration.

CE~QUAL· W2 temperature models are also currently being developed for the lower Columbia River from Pasco, Washington to the forebay of Bonneville Dam, including McNary, John Day and The Dalles reservoirs. Once completed, these CE·QUAL-W2 models will have the capability of producing hourly longitudinal in·reservoir temperature profiles for each reservoir and hourly tail water temperature estimates.

Use of Thermal Refugia by Salmon and Steelhead

Use of thermal refugia by radio-tagged adult salmon and steelhead along the lower Snake and lower Columbia rivers is well documented through the work done by the University of Idaho's Cooperative Fish and Wildlife Research Unit. However, aside from the sites discovered along the margins of the Bonneville and The Dalles reservoirs, there has been little systematic mapping of thermal refugia along the Columbia~Snake River migration corridor or in spawning tributaries. Important gaps along the migration route include downstream from Bonneville Dam, in the mid~Columbia upstream from Priest Rapids Dam, and in the Snake River upstream from the Clearwater River confluence.

Adult salmonid use of thermal refugia potentially has both positive and negative effects on upstream migrants. Presumed benefits of refugia use include reduced metabolic costs, reduced physiological stress, reduced negative temperature effects on maturation and gamete quality, and increased survival. Indirect negative effects of refugia use include migration delay, exposure to pathogens, permanent straying (i.e., loss from the source population), predation risk, and delayed effects from fisheries contact (i.e., catch and release, gillnet fallout, etc.).

5.0 MONITORING AND EVALUATION

5.1 Physical Monitoring

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. Reclamation and Chelan and Grant County Public Utility Districts (PUD) each operate four stations; and two stations are operated by the Douglas County PUD. The Corps' Portland, Seattle, and Walla Walla Districts operate and maintain the remaining 28 FMSs in the

Columbia River and lower Snake River basins. The 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 five FMSs in the upper Columbia River Basin at Chief Joseph, Albeni Falls, and Libby dams. The 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 C provides a map of the FMS system.

The 2014-2018 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.[8]

5.2 Biological Monitoring

The Fish Passage Center monitors juvenile salmonids for gas bubble trauma (GBT) at the mid-Columbia, lower Columbia, and lower Snake rivers sites. Fish are 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 are Lower Granite, Little Goose, and Lower Monumental dams.

Sampling occurs 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 spill is implemented. The goal of the sampling program is to sample 100 salmonids of the most prevalent species (limited to Chinook salmon 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 salmon and steelhead are sampled through the spring at all the sampling sites. Once subyearling Chinook salmon predominate in the smolt collections, the program shifts from sampling yearling Chinook salmon and steelhead to sampling subyearling Chinook salmon, which continues through the end of August. The Fish Passage Center provides a summary of the monitoring results collected annually.[9]

[8] The plan can be found at http://www.nwd-wc.usace.army.mil/tmt/wqnew/tdg_and_temp/2012/app_b.pdf.
[9] See the Annual TDG and Temperature Reports at http://www.nwd-wc.usace.army.mil/tmt/wqnew/.

6.0 Future Measures to Address TDG and Temperature and Plan Implementation

The following represents a list of potential future actions that could be investigated and considered should the planned actions result in outcomes that are inconsistent with BiOp water quality or CWA objectives. The Action Agencies recognize that some or all of these actions may not prove to be feasible or appropriate when fully evaluated.

1. Operational Spill Management Actions

Operational spill management actions include possible evaluation and adjustments to the existing spill patterns or spill rates to further reduce TDG at a project, system-wide, or provide improved fish survival. The addition of an extended spillway deflector in spillbay 2 at Ice Harbor Dam may help reduce TDG production at that project. In addition, the development of new turbine designs (Ice Harbor unit 2 and unit 3 replacements are scheduled to begin installation in 2015) and juvenile fish screened bypass system improvements, such as those planned at Lower Granite and Bonneville Dam Powerhouse II (2014-2018), will further increase the survival of fish passing through non-spillway passage routes. As the survival of juvenile fish passing through non-spillway passage routes increases, the reliance on higher spill levels that significantly increase system-wide TDG may be reduced.

2. Spill Priority List Modifications

Spill priority list modifications focused on system-wide TDG reductions through use of the spill priority list which could include adding other projects to the list or providing flexibility in the order for short durations during high flows.

3. Monitoring/Modeling

Monitoring and modeling actions could be implemented to address both TDG and water temperature. These actions could include evaluation of existing monitoring data and continued improvements and use of existing models.

4. Study/Research

Study and research actions could focus on both TDG and temperature, but would be dependent upon regional need and funding availability. Additional studies for water quality would likely be tied to fish passage needs especially if climate change becomes a driver for these types of actions.

5. Communication Actions

These actions promote opportunities to include water quality issues in planning and operational decisions and increase regional understanding of how TDG is a system-wide issue. It is important to recognize how operational modifications may impact water quality in another area or on a system-wide basis.

7.0 LITERATURE CITED

Parenthetical Reference	**Bibliographic Citation**
Corps 1999	U.S. Army Corps of Engineers. 1999. *Digest of Water Resources Policies and Authorities, EP 1165-2-1*. U.S. Army Corps of Engineers, Washington, D.C. July 30, 1999.
Corps 2011	U.S. Army Corps of Engineers. 2011. 2*011 Dissolved Gas and Water Temperature Report*. U.S. Army Corps of Engineers, Northwestern Division, Columbia Basin Water Management Division, Reservoir Control Center, Water Quality Team, Portland, Oregon. December 2011.
Fish Passage Center 2012	Fish Passage Center. 2012. Historical Spill Summary 1981 to 2011. Fish Passage Center. April 18, 2012.
IDEQ and ODEQ 2004	Idaho Department of Environmental Quality and Oregon Department of Environmental Quality. 2004. *Snake River-Hells Canyon Total Maximum Daily Load (TMDL)*. State of Idaho, Department of Environmental Quality, Boise, Idaho and State of Oregon, Department of Environmental Quality, Pendleton, Oregon. Submitted July 2003, Revised June 2004.
NOAA Fisheries 2000	NOAA National Marine Fisheries Service. 2000. *Endangered Species Act Section 7 Biological Opinion on the Reinitiation of Consultation on Operation of the Federal Columbia River Power System, including the Juvenile Fish Transportation Programs and 19 Bureau of Reclamation Projects in the Columbia Basin*, December 21, 2000.

Parenthetical Reference	Bibliographic Citation
NOAA Fisheries 2008	NOAA National Marine Fisheries Service. 2008. *Endangered Species Act Section 7(a)(2) Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. Consultation for the Operation and Maintenance of 10 U.S. Bureau of Reclamation Projects and 2 Related Actions in the Upper Snake River Basin above Brownlee Reservoir*. Consultation Conducted by: NOAA National Marine Fisheries Service, Northwest Region. May 5, 2008.
NOAA Fisheries Service 2008a	NOAA National Marine Fisheries Service. 2008. *Supplemental Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of Upper Snake and Other Tributary Actions*. NOAA National Marine Fisheries Service, Northwest Region. May 5, 2008.
NOAA Fisheries 2010	NOAA National Marine Fisheries Service. 2010. *NOAA Fisheries Endangered Species Act Section 7(1)(2) Consultation Supplemental Biological Opinion, Supplemental Consultation On Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin, and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program*. NOAA National Marine Fisheries Service, Northwest Region. May 2010.
NOAA Fisheries 2014	NOAA National Marine Fisheries Service. 2014. *Endangered Species Act Section 7(1)(2) Supplemental Biological Opinion, Consultation Supplemental Biological Opinion, Supplemental Consultation On Remand for Operation of the Federal Columbia River Power System*. NOAA National Marine Fisheries Service, Northwest Region. January 2014.

APPENDICES

Appendix A – 2013 TDG TMDL Implementation Summary (Annual TDG and Temp Report – Appendix M)

Appendix B – Historical Summary of Planned Spill (FPC report – appendix tables only)

Appendix C – Map of Fixed Monitoring Stations in the Basin

Appendix A

2013 TDG TMDL

Implementation Summary

(2013 Annual TDG and Temperature Report – Appendix M)

ERRATA: Revised in July, 2014

Introduction

This appendix provides a summary of the status of the short-term, operational and long-term Corps TDG TMDL implementation activities recommended in the Summary Implementation Strategy (SIS) of the TDG TMDLs for the lower Columbia River (approved by EPA on November 18, 2002) and the lower Snake River (approved by EPA on September 30, 2003). The SIS incorporates actions described and analyzed by the NOAA Fisheries in the 2000 and 2004 Biological Opinions and by the Corps in the Dissolved Gas Abatement Study (DGAS). The SIS was developed in consultation with NOAA Fisheries, so that TMDL implementation would be coordinated with requirements of the ESA. Both Phase I short-term and Phase II long-term measures are described with specific TDG and spill reduction measures. Phase I was in effect through 2011. Phase II began after 2010 and continues through 2020; however, some action items began before the projected year of 2011. In addition, supplemental activities, which are above and beyond what the TMDL requires, were taken from 2002 to present that provide benefits for TDG and fish survival.

The TMDL Summary Implementation Actions:

The following summary tables provide an overview of the status of the short-term and long-term Corps TDG TMDL implementation activities. Tables A-1 and A-2 provide the current status of the Phase I (short-term) TDG TMDL implementation actions. Implementation actions in Table A-1 are directly related to achievement of the water quality standard, where actions in Table A-2 are indirectly related to this standard. Table A-3 provides the operational implementation actions that are used to minimize TDG. Table A-4 provides the current status of the Phase II (long-term) TDG TMDL implementation activities. Table A-5 provides a summary of supplemental TMDL activities. These supplemental activities were undertaken in addition to Phase I and Phase II measures.

TABLE A-1
PHASE I – SHORT-TERM TMDL IMPLEMENTATION ACTIVITIES
Structural Implementation Actions

2000 Biological Opinion Action Item Description	Status	Estimated Completion Date	Actual Completion Date
Ice Harbor Deflectors	Deflectors in bays 2 - 5 (1996); bays 6 - 9 (1997); and bays 1 and 10 (1998;) construction completed.	1998	1998
John Day Deflectors	Deflectors in bays 2 - 19; construction completed.	1998	1998
John Day Deflectors	Deflector in bay 20; construction completed.	2011	2011
All Projects - Survival based spill caps at all dams (e.g. 40% at The Dalles).	Studies are on-going.	N/A	N/A
Bonneville Endbay Deflectors	Deflectors in all interior bays 1-17; construction completed for bays 1-3 and 16-18 in 2002.	2002	2002
McNary Endbay Deflectors	Deflectors in bays 1, 2, 21, 22 construction completed.	2002	2002
Lower Monumental Endbay Deflectors	Deflectors in bays 1 and 8 construction completed. Repairs to bay 2 deflector. Preliminary studies were completed.	2003	2003
Lower Monumental Endbay Deflectors	Post RSW installation testing has been completed.	2009	2009
Little Goose Endbay Deflectors	Construction of deflectors in bay 1 and 8 completed.	2009	2009
Little Goose Endbay Deflectors	Evaluate and test after Temporary Spillway Weir (TSW) installed which was completed in 2009. Testing was planned for two years but was reduced to one year.	2009	2009
Chief Joseph Deflectors	Construction of spill bay deflectors completed October 2008.	2008	2008
Chief Joseph Deflectors	Post-deflector spill test to check TDG exchange properties during spillway discharges completed.	2009	2009
The Dalles Deflectors	No deflectors planned at this time; spillway survival completed 2012.	N/A	N/A
John Day Endbay Deflectors	End bay #20 constructed 2009-2010. Bay #1 not considered, would interrupt fish attraction flow.	2010	2010
Little Goose Spillway Divider Wall	Not under consideration at this time.	N/A	N/A
Divider Walls at Appropriate Dams	(See below for itemized list of divider walls.)		
John Day Spillwall	No spillwall planned at this time since not cost effective due to depth of stilling basin.	N/A	N/A
The Dalles Spillwall	The first spillwall construction completed between bays 6 and 7.	2004	2004
The Dalles Spillwall	Biological evaluations after first spillwall was installed. Full project evaluations occurred in 2004 and 2005; a spillway specific evaluation occurred in 2006. Completed.	2006	2006
The Dalles Spillwall	Construction of a larger and longer spillwall between bays 8 and 9 began in 2008. Completed.	2010	2010
The Dalles Spillwall	Biological evaluations after spillwall construction completed.	2010-12	2010-12

PHASE I – ADDITIONAL SHORT-TERM TMDL IMPLEMENTATION ACTIVITIES

Structural Implementation Actions

2000 Biological Opinion Action Item Description	Status	Estimated Completion Date	Actual Completion Date
Bonneville Powerhouse 2 Corner Collector (B2CC)	Construction of corner collector in powerhouse 2 completed.	2004	2004
Bonneville Powerhouse 2 Fish Guidance Efficiency (FGE) Improvement	Installed turning vanes on Submerged Traveling Screens (STS). Installed ceiling gap closure device.	1997	1997
Bonneville Powerhouse 2 FGE Improvement	Decision document completed FY05 – FGE and in-take improvements. Modified Vertical Barrier Screens (VBS).	2008	2008
Bonneville Powerhouse 2 FGE Improvement	Completed biological evaluations after new designed VBS.	2009	2009
Lower Granite Removable Spillway Weir (RSW)	RSW construction completed.	2001	2001
Lower Granite RSW	Testing of spring and summer migrants after RSW construction was completed. Testing spanned three years from 2005 to 2007.	2007	2007
The Dalles Turbine Intake Blocks	Construction of turbine intake blocks was completed.	2001	2001
The Dalles Turbine Intake Blocks	Testing was performed and results showed that block hydraulics were harmful to fish. All were removed. Completed.	2004	2004
Lower Monumental Bypass Outfall Relocation	Relocation completed. Evaluated in 2012-2013.	2012	2012
The Dalles Sluiceway Outfall Relocation	Not being investigated at this time; current sluiceway being used as is.	N/A	N/A
Bonneville Powerhouse 1 Surface Bypass or Extended Screens	Biological evaluations completed but biological benefits were out weighted by cost, thus suspending progress.	2002	2002
Bonneville sluiceway improvement study	Finished letter report for modification of B1 sluiceway chain gates.	2007	2007
Bonneville sluiceway improvement	Removed the Juvenile Bypass System (JBS) channel.	2009	2009
Bonneville sluiceway improvement	Construction of 3 automated sluicegates begin in 2008. Completed.	2009	2009

TABLE A-2

PHASE I – OPERATIONAL TMDL IMPLEMENTATION ACTIONS

Operational Action	Status
Scheduling routine turbine maintenance and repair during low-power load and river flow periods.	Ongoing
Preventative maintenance of turbines to prevent breakdown.	Ongoing
System management of water release from upstream storage reservoirs to minimize involuntary spill at dams in the TMDL area.	Ongoing
Optimizing power purchasing to allow maximum use of powerhouse capacity and minimization of involuntary spill. This has become more complex with the increase in wind energy in the Columbia River Basin.	Ongoing
Testing various spill patterns to find the most effective for fish passage and TDG production. If spill pattern produces undesirable results, modify spill pattern.	Ongoing

TABLE A-3

LONG TERM – PHASE II TMDL IMPLEMENTATION ACTIVITIES

Fish Passage Actions That Support TDG Water Quality Goals

(Actions from 2011 through 2020.)

2000 Biological Opinion Action Item Description	Status	Estimated Completion Date	Actual Completion
John Day Top Spillway Weir (TSW)	Construction of 2 TSWs completed in bays 15 and 16.	2008	2008
John Day TSW	Moved 2 TSWs from bays 15 and 16 closer to powerhouse in bays 18 and 19.	2010	2010
John Day TSW	Biological testing after TSW construction is completed. Ongoing.	2010-14	---
Removable Spillway Weirs (RSWs) at Lower Monumental, Little Goose and Ice Harbor dams	See Details below	See Details below	See Details below
Lower Monumental RSW	Construction completed.	2008	2008
Lower Monumental RSW	Evaluation and testing after RSW construction completed. Began 2008 and completed 2009.	2009	2009
Little Goose TSW	Construction and Installation of Temporary Spillway Weir (TSW) completed.	2009	2009
Little Goose TSW	Testing occurred during 2012.	2014	---
Ice Harbor RSW	RSW construction completed.	2005	2005
Ice Harbor RSW	Post - construction testing occurred in 2009-2010.	2010	2010
McNary Bypass Improvements (New Outfall Flume)	Completed in 2012, and post-construction testing completed.	2012	2012
McNary Bypass Improvements (temperature)	A prototype model has been developed by M. Schneider to assist with temperature issues.	2013	---
Lower Monumental Extended Screens	Extended screens are suspended because of the cost-to-benefit ratio.	Unknown	Unknown
John Day Extended Screens	Tested prototype performed well. Shelved due to information indicating lower SARs for bypassed fish and high O&M costs.	2003	2003
All Projects - Spill Effectiveness Studies	Ongoing, site-specific as warranted. Study done when performance standard testing is undertaken.	Site-specific	Site-specific
Predator Removal and Abatement	Ongoing at Lower Columbia River projects including avian hazing and wires, pike minnow removal and seas lion hazing (see below).	N/A	N/A
The Dalles Predator Removal and Abatement	Ongoing pikeminnow removal program at Lower Columbia River dams. Funded by BPA. Ongoing.	N/A	N/A
Bonneville Predator Removal and Abatement	Sea Lion Exclusion Device constructed and installed.	2007	2007
All Projects - Improved O&M	Ongoing.	N/A	N/A
Bonneville Powerhouse 1 Minimum Gap Runners	See details below.	See Details below	See Details below
Bonneville PH1 - Unit 10	Construction of unit 10 began in 2009 and was completed in 2010.	2010	2010
Bonneville PH1 - Unit 1-6, 9	Units 1,2,3,4,5,6,9 completed.	1990-2007	1990-2007
Bonneville PH1 - Unit 7	Construction completed on unit 7.	2007	2007
Bonneville PH1 - Unit 8	Construction completed on unit 8.	2008	2008
All Projects - Implement Turbine Survival Program Results	Ongoing. Work being done in support of IHR turbine development in 2014. Biological testing will follow at IHR once new turbine units installed.	N/A	N/A

TABLE A-3 (continued)

LONG TERM – PHASE II TMDL IMPLEMENTATION ACTIVITIES
Fish Passage Actions That Support TDG Water Quality Goals PHASE II – LONG-TERM TMDL IMPLEMENTATION ACTIVITIES
Fish Passage Actions That Support TDG Water Quality Goals

2000 Biological Opinion Action Item Description	Status	Estimated Completion Date	Actual Completion
John Day Top Spillway Weir (TSW)	Construction of 2 TSWs completed in bays 15 and 16.	2008	2008
John Day TSW	Moved 2 TSWs from bays 15 and 16 closer to powerhouse in bays 18 and 19.	2010	2010
John Day TSW	Biological testing after TSW construction is completed. Ongoing.	2010-14	---
Removable Spillway Weirs (RSWs) at Lower Monumental, Little Goose and Ice Harbor dams	See Details below	See Details below	See Details below
Lower Monumental RSW	Construction completed.	2008	2008
Lower Monumental RSW	Evaluation and testing after RSW construction completed. Began 2008 and completed 2009.	2009	2009
Little Goose TSW	Construction and Installation of Temporary Spillway Weir (TSW) completed.	2009	2009
Little Goose TSW	Testing occurred during 2012.	2014	---
Ice Harbor RSW	RSW construction completed.	2005	2005
Ice Harbor RSW	Post - construction testing occurred in 2009-2010.	2010	2010
McNary Bypass Improvements (New Outfall Flume)	Completed in 2012, and post-construction testing completed.	2012	2012
McNary Bypass Improvements (temperature)	A prototype model has been developed by M. Schneider to assist with temperature issues.	2013	---
Lower Monumental Extended Screens	Extended screens are suspended because of the cost-to-benefit ratio.	Unknown	Unknown
John Day Extended Screens	Tested prototype performed well. Shelved due to information indicating lower SARs for bypassed fish and high O&M costs.	2003	2003
All Projects - Spill Effectiveness Studies	Ongoing, site-specific as warranted. Study done when performance standard testing is undertaken.	Site-specific	Site-specific
Predator Removal and Abatement	Ongoing at Lower Columbia River projects including avian hazing and wires, pike minnow removal and seas lion hazing (see below).	N/A	N/A
The Dalles Predator Removal and Abatement	Ongoing pikeminnow removal program at Lower Columbia River dams. Funded by BPA. Ongoing.	N/A	N/A
Bonneville Predator Removal and Abatement	Sea Lion Exclusion Device constructed and installed.	2007	2007
All Projects - Improved O&M	Ongoing.	N/A	N/A
Bonneville Powerhouse 1 Minimum Gap Runners	See details below.	See Details below	See Details below
Bonneville PH1 - Unit 10	Construction of unit 10 began in 2009 and was completed in 2010.	2010	2010
Bonneville PH1 - Unit 1-6, 9	Units 1,2,3,4,5,6,9 completed.	1990-2007	1990-2007
Bonneville PH1 - Unit 7	Construction completed on unit 7.	2007	2007
Bonneville PH1 - Unit 8	Construction completed on unit 8.	2008	2008
All Projects - Implement Turbine Survival Program Results	Ongoing. Work being done in support of IHR turbine development in 2014. Biological testing will follow at IHR once new turbine units installed.	N/A	N/A

TABLE M-5
SUPPLEMENTAL TMDL IMPLEMENTATION ACTIVITIES
Fish Passage Actions That Support TDG Water Quality Goals

2000 Biological Opinion Action Item Description	Status	Estimated Completion Date	Actual Completion Date
Ice Harbor Modernization, Turbine Runner Prototype.	Construction of new Turbine Runners. Ongoing Kaplan Runner installation contract award in 2015 for unit 2 with completion in 2016, fixed runner in unit 3 during 2016, fixed runner in unit 1 in 2017-2018.	2015-2018	---
McNary Temporary TSW	Construction of TSW completed on bays 20 and 22.	2007	2007
McNary Temporary TSW	The TSWs were moved to various bays to optimize for surface fish passage. Move spanned two years from 2008 to 2009.	2009	2009
McNary Temporary TSW	Biological testing after TSW construction was completed. Testing spanned three years from 2007 to 2009.	2009	2009
McNary Modernization	Biological testing completed 10/26/07. Testing spanned three years from 2005 to 2007.	2007	2007
Bonneville Powerhouse 2 Behavioral Guidance System (BGS)	Behavioral Guidance System (BGS) for improved guidance for yearling and subyearling chinook to the B2CC installation completed.	2008	2008
Bonneville spillway gate re-design	Bonneville spillway gate re-design of 18 gates began in 2008. Completed.	2009	2009

Appendix B

Historical Spill Summary 1981 to 2011

Fish Passage Center Report

April 18, 2012

Planned Spill Operations

Each year throughout the history of the spill program, there has been a planned operation for spill at each of the Federal hydroelectric projects. Actual spill levels may have been greater than the planned spill levels as a result of high river flows that exceeded powerhouse capacity, or river flow levels that exceeded the energy needs. The following tables are based on the pre-season plans for each year and capture the essence of the planned operation of each project by the spring and summer season.

Season/Project	1983	1984	1985	1986	1987
SPRING					
Lower Granite	No spill (unless surplus spill available and spring Chinook dominate)	No spill (unless surplus spill available and spring Chinook dominate)	No spill	No spill	No spill
Little Goose	Same as Lower Granite	Same as Lower Granite	No spill	No spill	No spill
Lower Monumental	Up to 50% of flow, for up to 5 hours when fish # > 15K	Up to 50% of flow, for up to 5 hours when fish # > 15K	50% of flow 2000 to 0600	50% of flow 2000 to 0600	55% of flow for 3 hours (or more if needed) beginning at 2000, when fish # > 15K
Ice Harbor	40% of flow, for up to 4 hours if sluiceway less effective than screened bypass at LGR & LGO	No spill	30% of flow 2000 to 0600	No spill	No spill
McNary	No spill	No spill	No spill	No spill	No spill
John Day	Spill 50% of flow 1 hr before sunset for several hours when fish # >30K/d	Spill 50% of flow 1 hr before sunset for several hours when fish # >30K/d	50% of river flow exceeding the capacity of screened units 2000 to 0600	No spill	No spill
The Dalles	No spill	No spill	24% of river flow 1000-2000 (if warranted and if non firm energy)	5% of daily average flow	No spill
Bonneville	No spill	Spill above capacity of PH1 and units 11,12,17, & 18	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)
SUMMER					
Lower Granite	No spill	No spill	No spill	No spill	No spill
Little Goose	No spill	No spill	No spill	No spill	No spill
Lower Monumental	No spill	No spill	50% of flow 2000 to 0600 to July 15	50% of flow 1800 to 0600	100% for 8 hours, 15 days out of 45 day period
Ice Harbor	No spill	No spill	No spill	No spill	No spill
McNary	No spill	No spill	No spill	No spill	No spill
John Day	No spill	Spill 50% of flow 1 hr before sunset for several hours when fish # >30K/d	36% of river flow 1800 to 0600	36% of river flow 1800 to 0600	Spill 18% of flow for 3 hours (or more if necessary) when fish # >30K/d
The Dalles	No spill	No spill	5% of daily average flow	No spill	No spill
Bonneville	No spill	Spill above capacity of PH1 and units 11,12,17, & 18	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)

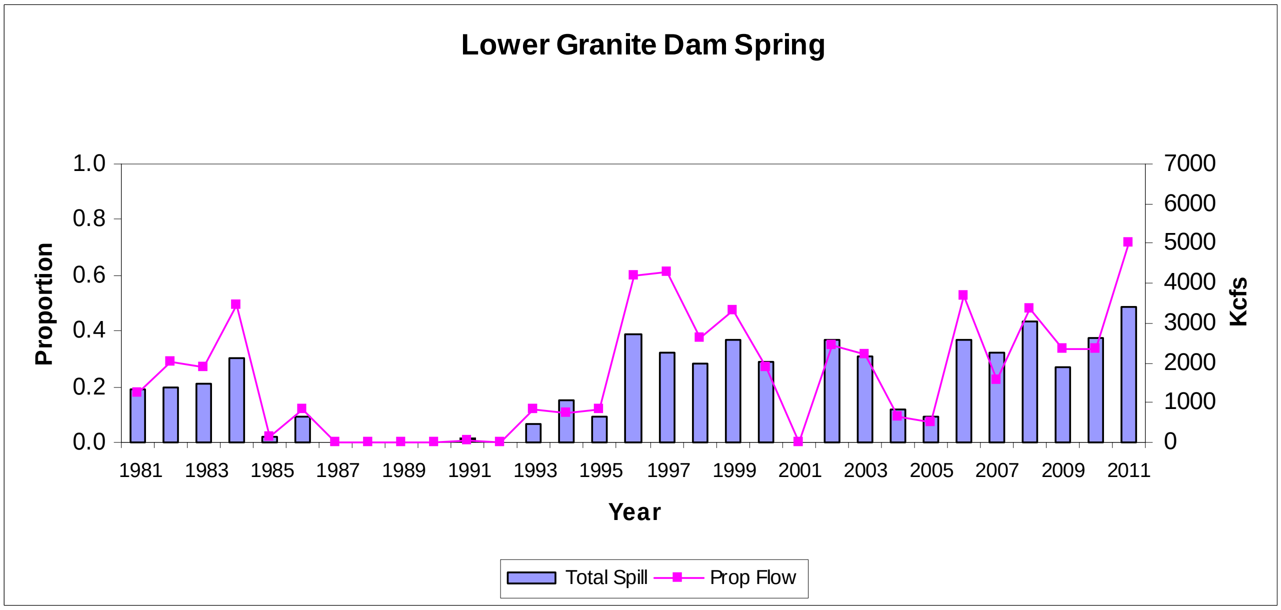
Season/Project	1988	1989	1990	1991	1992
SPRING					
Lower Granite	No spill	No spill	No spill	No spill	No spill
Little Goose	No spill	No spill	No spill	No spill	No spill
Lower Monumental		70% of flow 1800 to 0600	70% of flow 1800 to 0600	70% of flow 1800 to 0600	40% of flow 1800 to 0600
Ice Harbor	No spill	25% of flow 1800 to 0600	25% of flow 1800 to 0600	25% of flow 1800 to 0600	60% of flow 1800 to 0600
McNary	No spill	No spill	No spill	No spill	No spill
John Day	No spill	No spill	No spill	No spill	No spill
The Dalles	No spill	10% of daily average flow	10% of daily average flow	10% of daily average flow	10% of daily average flow
Bonneville	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)
SUMMER					
Lower Granite	No spill	No spill	No spill	No spill	No spill
Little Goose	No spill	No spill	No spill	No spill	No spill
Lower Monumental		70% of flow 1800 to 0600	70% of flow 1800 to 0600	70% of flow 1800 to 0600	43% of flow 1800 to 0600
Ice Harbor	No spill	25% of flow 1800 to 0600	25% of flow 1800 to 0600	25% of flow 1800 to 0600	30% of flow 1800 to 0600
McNary	No spill	No spill	No spill	No spill	No spill
John Day	5% of daily average flow	20% of flow 2000 to 0600	20% of flow 2000 to 0600	20% of flow 2000 to 0600	20% of flow 2000 to 0600
The Dalles	No spill	5% of daily average flow	5% of daily average flow	5% of daily average flow	5% of daily average flow
Bonneville	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)

Season/Project	1993 (1993 BIOP)	1994 (1994-1998 BIOP)	1995 (1995 BIOP)	1996 (1995 BIOP)	1997 (1995 BIOP)
SPRING					
Lower Granite	No spill	No spill	Flow<100Kcfs, No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)	Flow<100Kcfs No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)	Flow<100Kcfs, No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)
Little Goose	No spill	No spill	Flow<85 Kcfs, No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 35 Kcfs)	Flow<85 Kcfs, No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 35 Kcfs)	Flow<85 Kcfs, No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 35 Kcfs)
Lower Monumental	No spill	No spill	Flow<85 Kcfs, No spill; otherwise 81% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)	Flow<85 Kcfs, No spill; otherwise 81% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)	Flow<85 Kcfs, No spill; otherwise 81% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)
Ice Harbor	60% up to a max of 25 kcfs (1800-0600)	60% up to max of 25 kcfs (1800-0600)	27% of instantaneous flow day/night (gas cap approx 25 Kcfs)	27% of instantaneous flow day/night (gas cap approx 25 Kcfs)	27% of instantaneous flow day/night (gas cap approx 25 Kcfs)
McNary	No spill	No spill	50% of instantaneous flow (1800-0600) (gas cap approx 120 Kcfs)	50% of instantaneous flow (1800-0600) (gas cap approx 120 Kcfs)	50% of instantaneous flow (1800-0600) (gas cap approx 120 Kcfs)
John Day	No spill	No spill	33% of instantaneous flow (1800-0600) (gas cap approx 50 Kcfs)	33% of instantaneous flow (1800-0600) (gas cap approx 50 Kcfs)	33% of instantaneous flow (1800-0600) (gas cap approx 50 Kcfs)
The Dalles	10% day/night	10% (2000-0400)	64% of instantaneous flow day/night (gas cap approx 230 Kcfs)	64% of instantaneous flow day/night (gas cap approx 230 Kcfs)	64% of instantaneous flow day/night (gas cap approx 230 Kcfs)
Bonneville	70 % FPE – 75 Kcfs day/gas cap (110%) night	70 % FPE – 75 Kcfs day/gas cap (110%) night	75 Kcfs day/100% night(gas cap approx 120 Kcfs)	75 Kcfs day/100% night(gas cap approx 120 Kcfs)	75 Kcfs day/100% night(gas cap approx 120 Kcfs)
SUMMER					
Lower Granite	No spill	No spill	No spill	No spill	No spill
Little Goose	No spill	No spill	No spill	No spill	No spill
Lower Monumental	No spill	No spill	No spill	No spill	No spill
Ice Harbor	60% up to a max of 25 kcfs (1800-0600)	30% up to max of 25 kcfs (1800-0600)	70% of instantaneous flow day/night	70% of instantaneous flow day/night	70% of instantaneous flow day/night
McNary	No spill	No spill	No spill	No spill	No spill
John Day	20% (2000-0600)	20% (2000-0600)	86% (2000-0600)	86% (2000-0600)	86% (2000-0600)
The Dalles	5% day/night	5% (2000-0400)	64% of instantaneous flow day/night	64% of instantaneous flow day/night	64% of instantaneous flow day/night
Bonneville	50% FPE – 75 Kcfs Day/gas cap (110%) night	50% FPE – 75 Kcfs day/gas cap (110%) night	75 Kcfs day/100% night	75 Kcfs day/100% night	75 Kcfs day/100% night

Season/Project	1998 (1998 Supplemental BIOP)	1999 (1998 Supplemental BIOP)	2000 (Spill Plan Agreement)	200 1 (2000 BIOP)	200 2 (2000 BIOP)
SPRING					
Lower Granite	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)
Little Goose	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<85 Kcfs, No spill ; Gas cap 1800-0600 (approx 60 Kcfs)
Lower Monumental	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 40 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 40 Kcfs)	Flow<85 Kcfs, No spill; Gas cap day/night (approx 40 Kcfs)	Flow<85 Kcfs, No spill; Gas cap day/night (approx 40 Kcfs)	Flow<85 Kcfs, No spill; Gas cap day/night (approx 40 Kcfs)
Ice Harbor	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75	45 Kcfs day/gas cap night (approx 75
McNary	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)
John Day	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)
The Dalles	64% day/night	64% day/night	40% day/night	40% day/night	40% day/night
Bonneville	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)
SUMMER					
Lower Granite	No spill	No spill	No spill	No spill	No spill
Little Goose	No spill	No spill	No spill	No spill	No spill
Lower Monumental	No spill	No spill	No spill	No spill	No spill
Ice Harbor	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75	45 Kcfs day/gas cap night (approx 75
McNary	No spill	No spill	No spill	No spill	No spill
John Day	180 Kcfs not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour
The Dalles	64% day/night	64% day/night	40% day/night	40% day/night	40% day/night
Bonneville	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)

Season/Project	2003 (2000 BIOP)	2004 (2000 BIOP)	2005 (2004 BIOP)	2006 (Court Order)	2007 (Court Order)
SPRING					
Lower Granite	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<70 Kcfs, No spill; 70-85 Kcfs, Spill through April 20; Flow > 85 Kcfs; Gas cap 1800-0600 (approx 45 Kcfs)	20 kcfs day/night	20 kcfs day/night
Little Goose	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<70 Kcfs, No spill; 70-85 Kcfs, Spill through April 20; Flow > 85 Kcfs; Gas cap 1800-0600 (approx 60 Kcfs)	30% day/night	30% day/night
Lower Monumental	Flow<85 Kcfs, No spill; Gas cap day/night (approx 40 Kcfs)	Flow<85 Kcfs, No spill; Gas cap day/night (approx 40 Kcfs)	Flow<70 Kcfs, No spill; 70-85 Kcfs, Spill through April 20; Flow > 85 Kcfs; 45-50% of outflow	40 Kcfs day/night	Gas Cap day/night
Ice Harbor	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs (0500 to 1800)/gas cap night (approx 75 Kcfs)	45 Kcfs (0500 to 1800)/gas cap night (approx 75 Kcfs)	30% day/night vs. 45 Kcfs day/gas cap night
McNary	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	40% day/night
John Day	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	60% of outflow until June 20 (1800-0600;1900-0600): Starting June 21; 30% of outflow	60% night (1800-0600 to May 15;1900-0600 after May 15)	0 day / 60% night
The Dalles	40% day/night	40% day/night	40% day/night	40% day/night	40% day/night
Bonneville	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	100 kcfs day/night	100 kcfs day/night
SUMMER			**(Court Order)**		
Lower Granite	No spill	No spill	Spill in excess of the flow necessary for station service	18 kcfs day/night	18 kcfs day/night
Little Goose	No spill	No spill	Spill in excess of the flow necessary for station service	30% day/night	30% day/night
Lower Monumental	No spill	No spill	Spill in excess of the flow necessary for station service	17 Kcfs day/night	17 Kcfs day/night
Ice Harbor	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	Spill in excess of the flow necessary for station service	45 Kcfs (0500 to 1800)/gas cap night (approx 75 Kcfs)	30% day/night vs. 45 Kcfs day/gas cap night
McNary	No spill	No spill	Spill in excess of 50 Kcfs flow	Alternate between 40% day/night and 60% day/night	40% day/night vs. 60% day/night
John Day	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	30% of outflow for 24 hrs	30% of outflow for 24 hrs	30% day/night
The Dalles	40% day/night	40% day/night	40% day/night	40% day/night	40% day/night
Bonneville	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 kcfs day / gas cap night

Season/Project	2008 (Court Order)	2009 (Court Order)	2010 (Court Order)	2011 (Court Order)	2014 (BiOp)
SPRING					
Lower Granite	20 kcfs day/night	20 kcfs day/night	20 kcfs day/night	20 kcfs day/night	20 kcfs day/night
Little Goose	30% day/night 14 nights of gas cap spill	30% day/night (To accommodate new spillway weir testing, 14 nights of gas cap spill used in 2008 will not occur)	30% day/night	30% day/night	30% day/night
Lower Monumental	Gas Cap day/night	Gas Cap day/night	Gas Cap day/night	Gas Cap day/night	Gas Cap day/night
Ice Harbor	0% day/night vs. 45 Kcfs day/gas cap night	45 kcfs / gas cap on non- test days; 30% day/night vs. 45 Kcfs day/gas cap night	April 3-April 28: 45 kcfs/Gas Cap April 28-June 20: 30%/30% vs. 45 kcfs/Gas Cap	April 3-April 27: 45 kcfs/Gas Cap April 28- mid July 30%/30% vs. 45 kcfs/Gas Cap	April 3-April 27: 45 kcfs/Gas Cap April 28-mid July 30%/30% vs. 45 kcfs/Gas Cap
McNary	40% day/night	40% day/night	40% day/night	40% day/night	40% day/night
John Day	0 day / 60% night	30% day/night on pre-test days; 30% day/night vs.40 day/night	30% day/night on pre-test days; Testing 30% day/night vs.40% day/night	30% day/night on pre-test days; Testing 30% day/night vs.40% day/night	30% day/night on pre-test days; Testing 30% day/night vs.40% day/night
The Dalles	40% day/night	40% day/night	40% day/night	40% day/night	40% day/night
Bonneville	100 kcfs day/night	100 kcfs day/night	100 kcfs day/night	100 kcfs day/night	100 kcfs day/night
SUMMER					
Lower Granite	18 kcfs day/night	18 kcfs day/night	18 kcfs day/night	18 kcfs day/night	18 kcfs day/night
Little Goose	30% day/night	30% day/night	30% day/night	30% day/night	30% day/night
Lower Monumental	17 Kcfs day/night	17 kcfs day/night	17 kcfs day/night	17 kcfs day/night	17 kcfs day/night
Ice Harbor	30% day/night vs. 45 Kcfs day/gas cap night	45 kcfs/gas cap on non-test days; 30% day/night vs. 45 Kcfs day/gas cap night	June 21-July 12: 30%/30% vs. 45 Kcfs/Gas Cap July 13-August 31: 45 Kcfs/Gas Cap	June 21-July 12: 30%/30% vs. 45 Kcfs/Gas Cap July 13-August 31: 45 Kcfs/Gas Cap	June 21-July 12: 30%/30% vs. 45 Kcfs/Gas Cap July 13-August 31: 45 Kcfs/Gas Cap
McNary	40% day/night vs. 60% day/night	40% day/night vs. 60% day/night	50% day/night	50% day/night	50% day/night
John Day	30% day/night	30% day/night on non-test days; 30% day/night or 40% day/night on test days	30% day/night on non-test days; 30% day/night or 40% day/night on test days	30% day/night on non-test days; 30% day/night or 40% day/night on test days	30% day/night on non-test days; 30% day/night or 40% day/night on test days
The Dalles	40% day/night	40% day/night	40% day/night	40% day/night	40% day/night
Bonneville	75 kcfs day / gas cap night	85 or 75 kcfs day/gas cap night (85 kcfs day through July 20, then 75 kcfs day through August 31)	Testing (June 16-July 20): 85 Kcfs/121 Kcfs vs. 95 Kcfs/95 Kcfs Post-Testing (July 21- August 31): 75 Kcfs/Gas Cap	Testing (June 16-July 20): 85 Kcfs/121 Kcfs vs. 95 Kcfs/95 Kcfs Post-Testing (July 21- August 31): 75 Kcfs/Gas Cap	Testing (June 16-July 20): 85 Kcfs/121 Kcfs vs. 95 Kcfs/95 Kcfs Post-Testing (July 21- August 31): 75 Kcfs/Gas Cap



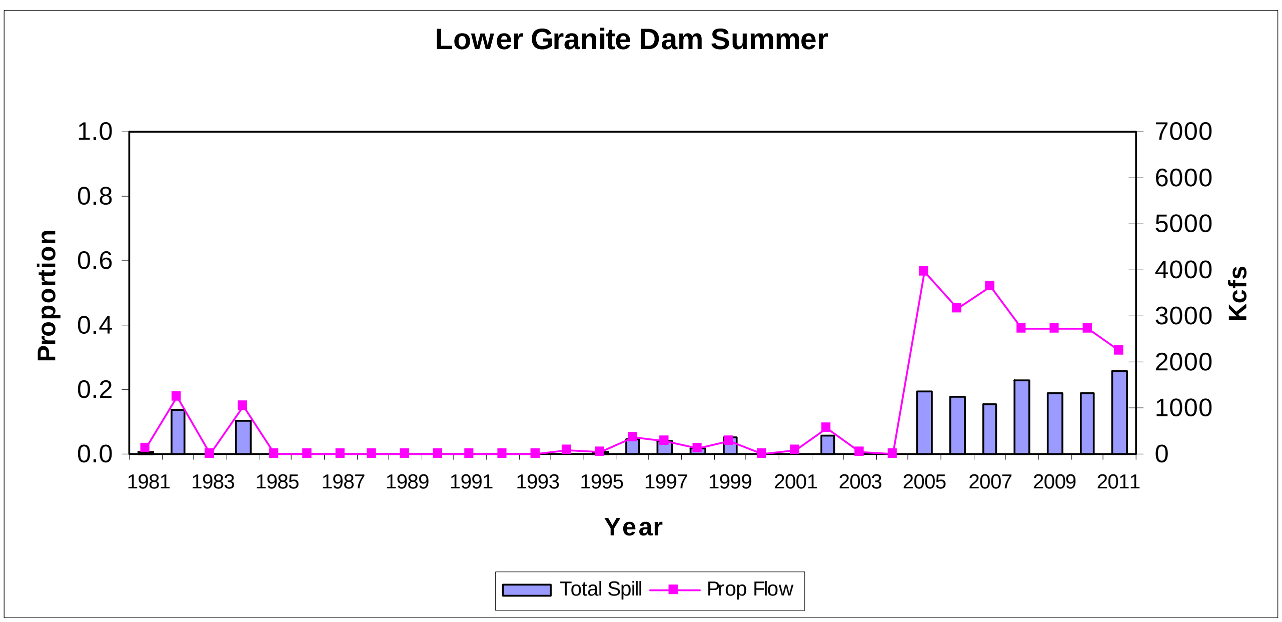
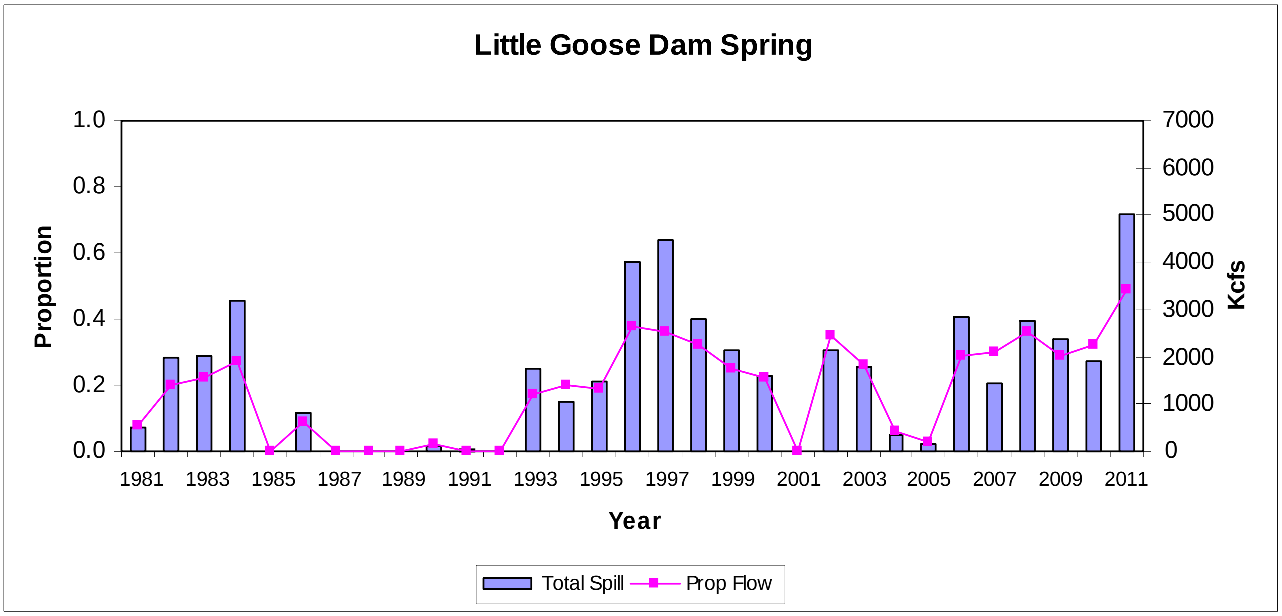


Figure B-1. Total spill (Kcfs) for spring (April 3 to June 20) and summer (June 21-August 31) at Lower Granite Dam, and spill as a proportion of total flow for the same time period.



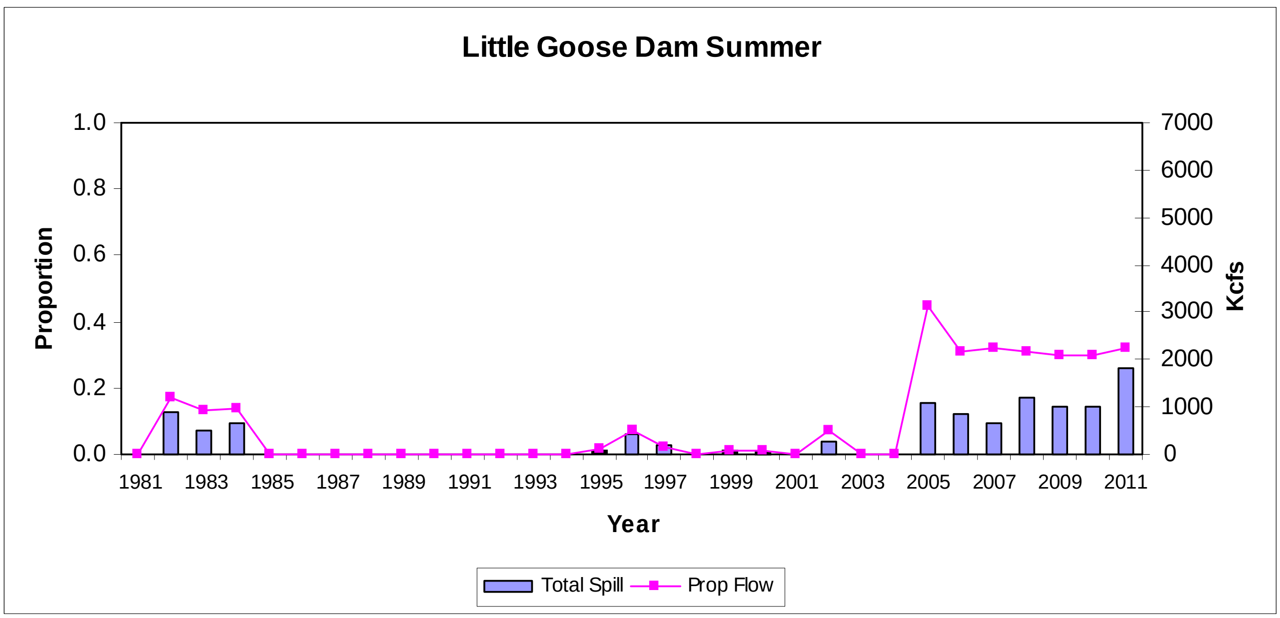
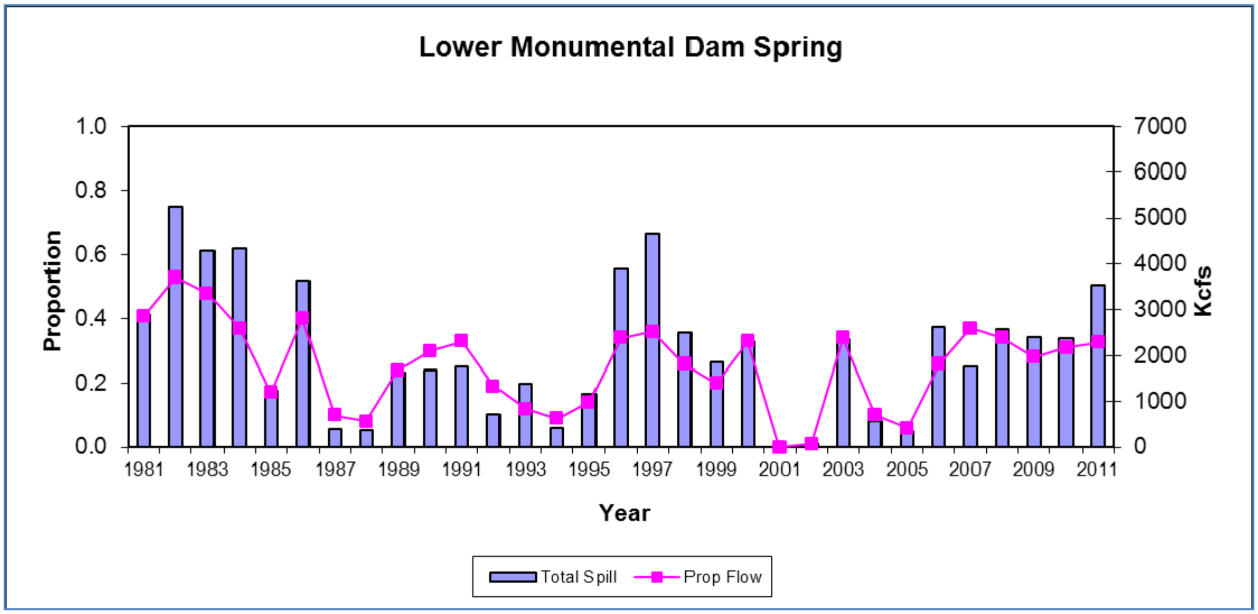


Figure B-2. Total spill (Kcfs) for spring (April 3 to June 20) and summer (June 21-August 31) at Little Goose Dam, and spill as a proportion of total flow for the same time period.



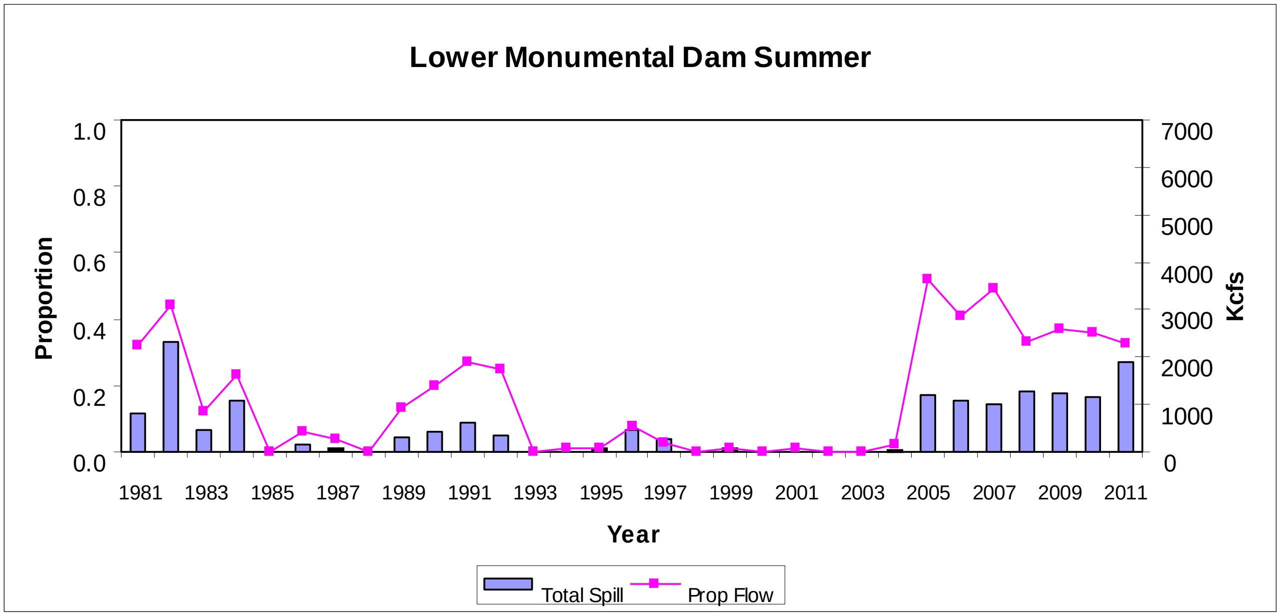
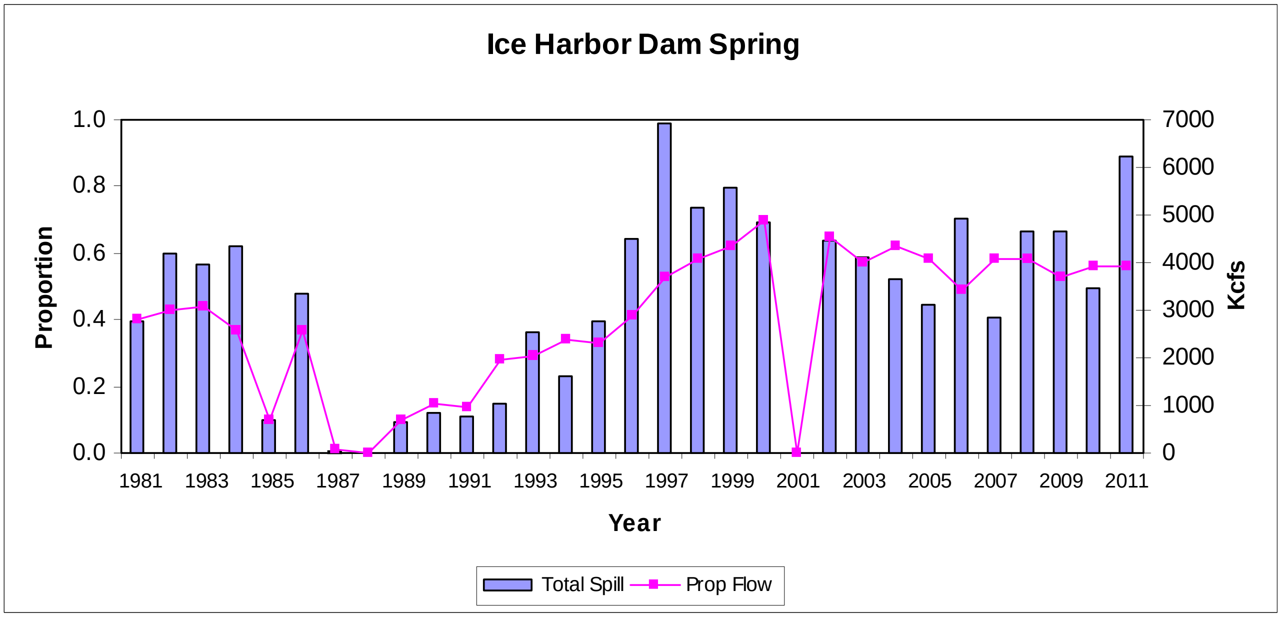


Figure B-3. Total spill (Kcfs) for spring (April 3 to June 20) and summer (June 21-August 31) at Lower Monumental Dam, and spill as a proportion of total flow for the same time period.



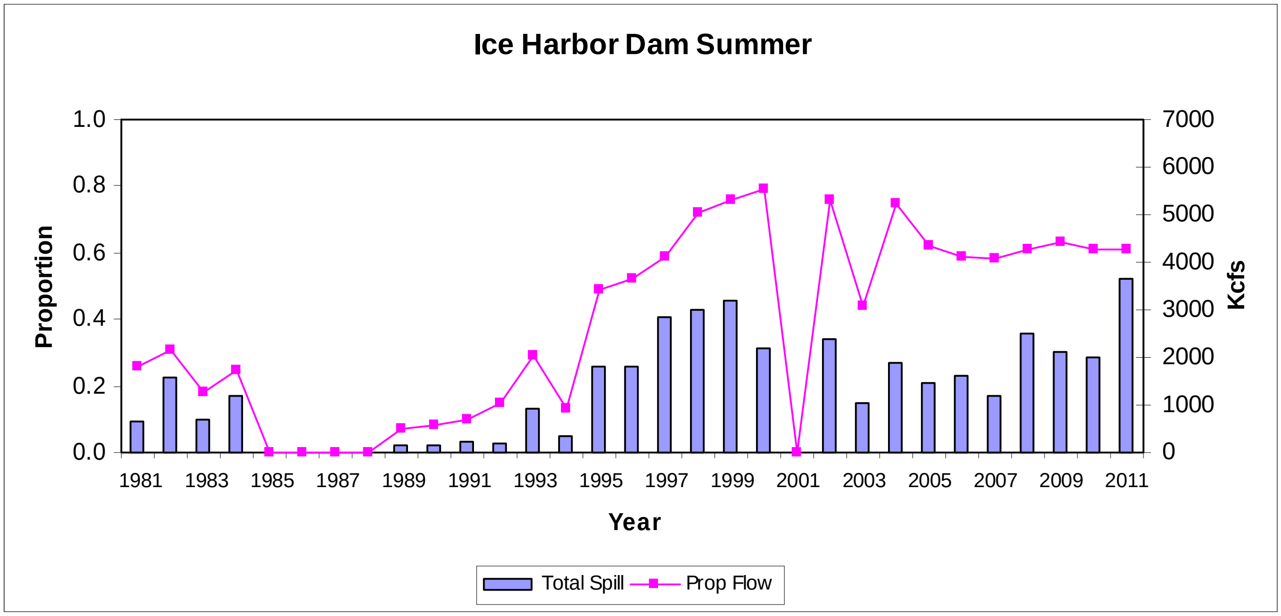
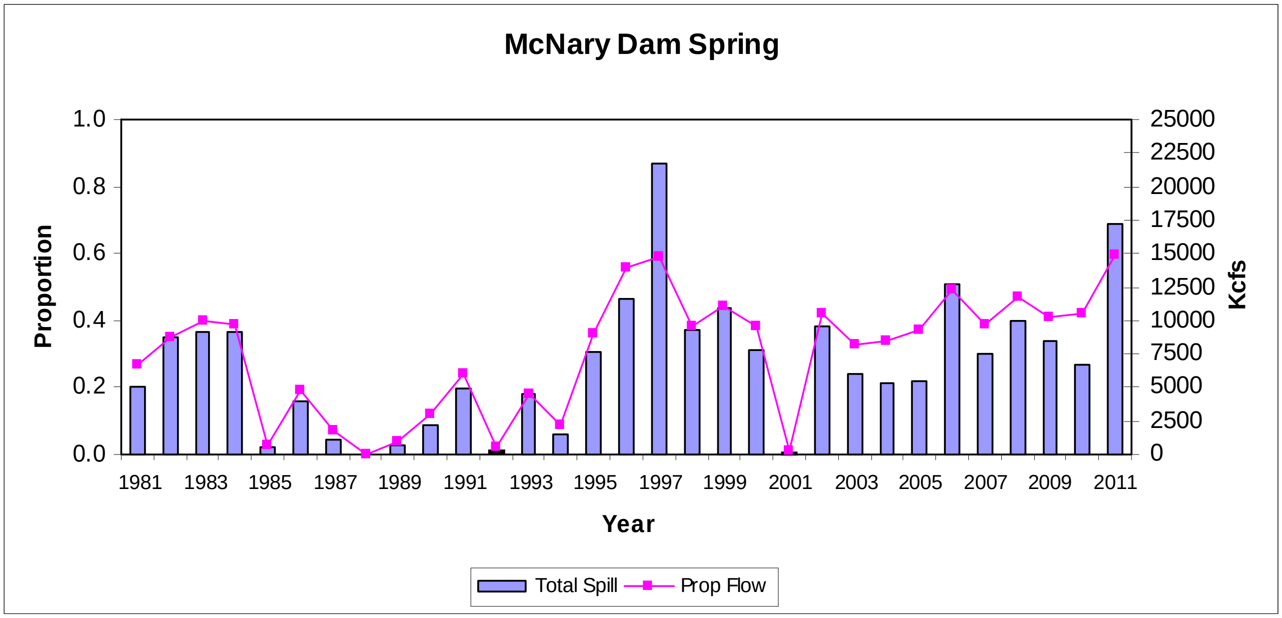


Figure B-4. Total spill (Kcfs) for spring (April 3 to June 20) and summer (June 21-August 31) at Ice Harbor Dam, and spill as a proportion of total flow for the same time period.



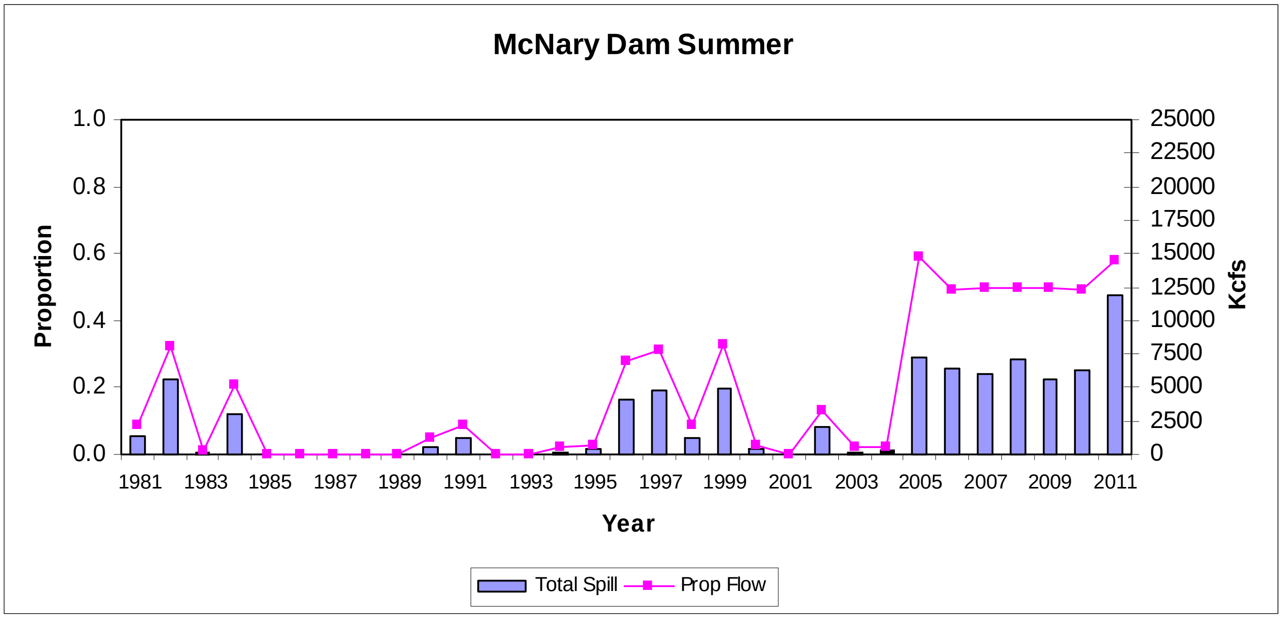
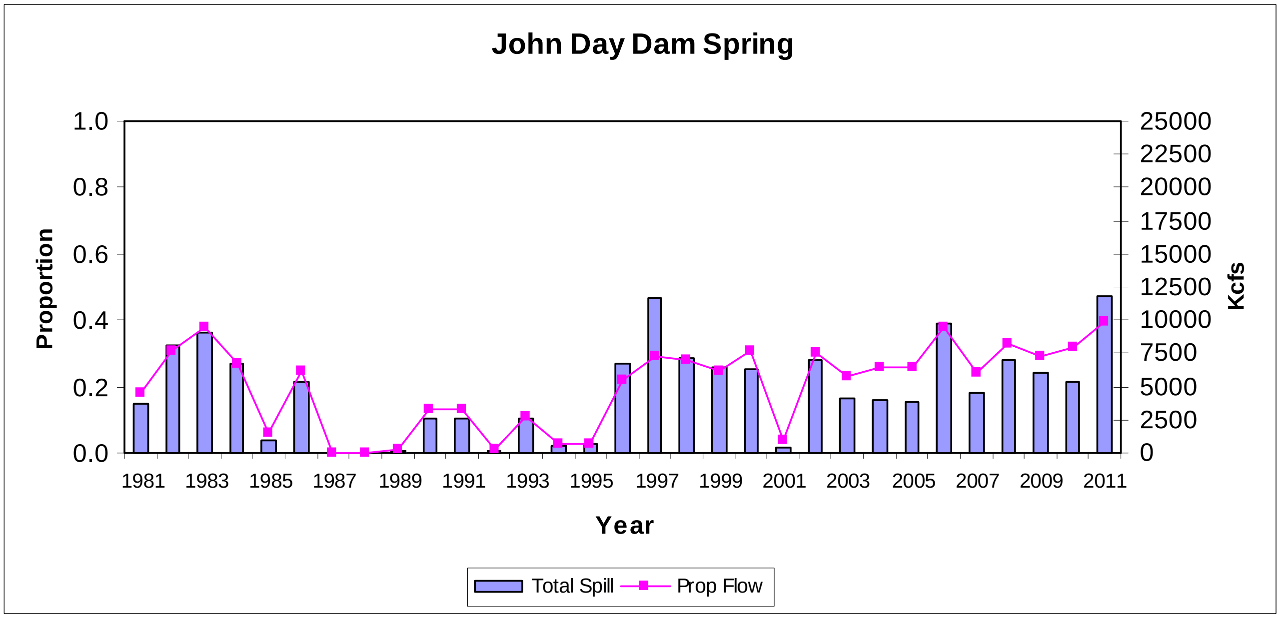


Figure B-5. Total spill (Kcfs) for spring (April 10 to June 30) and summer (July 1 - August 31) at McNary Dam, and spill as a proportion of total flow for the same time period.



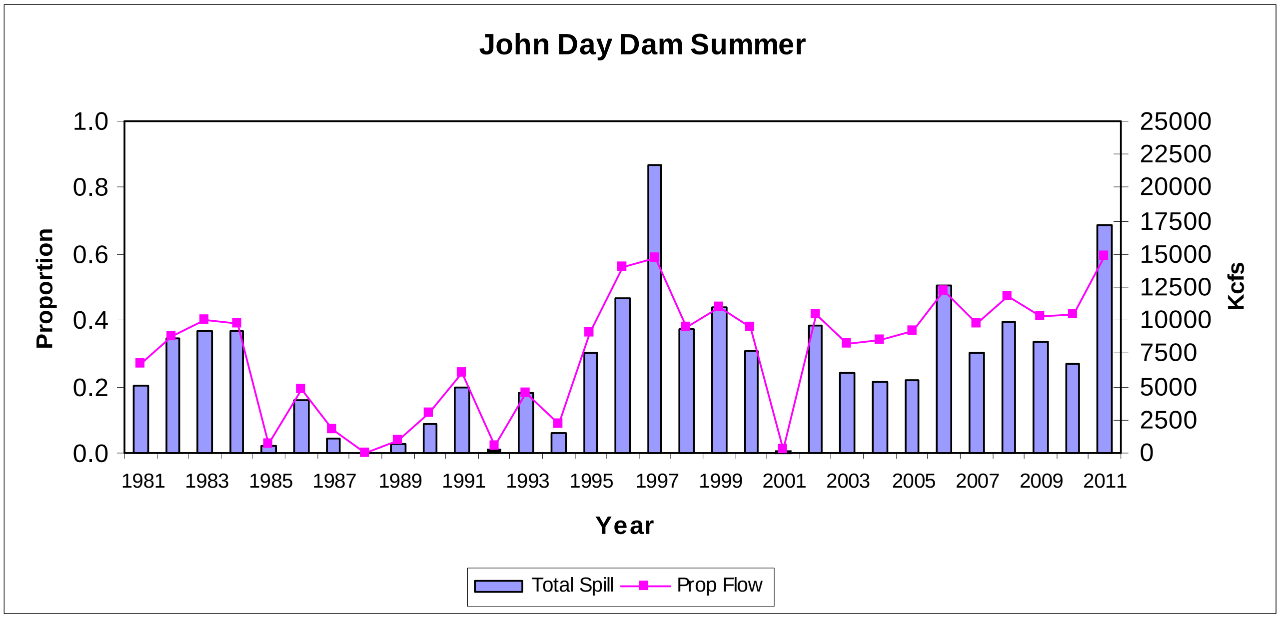
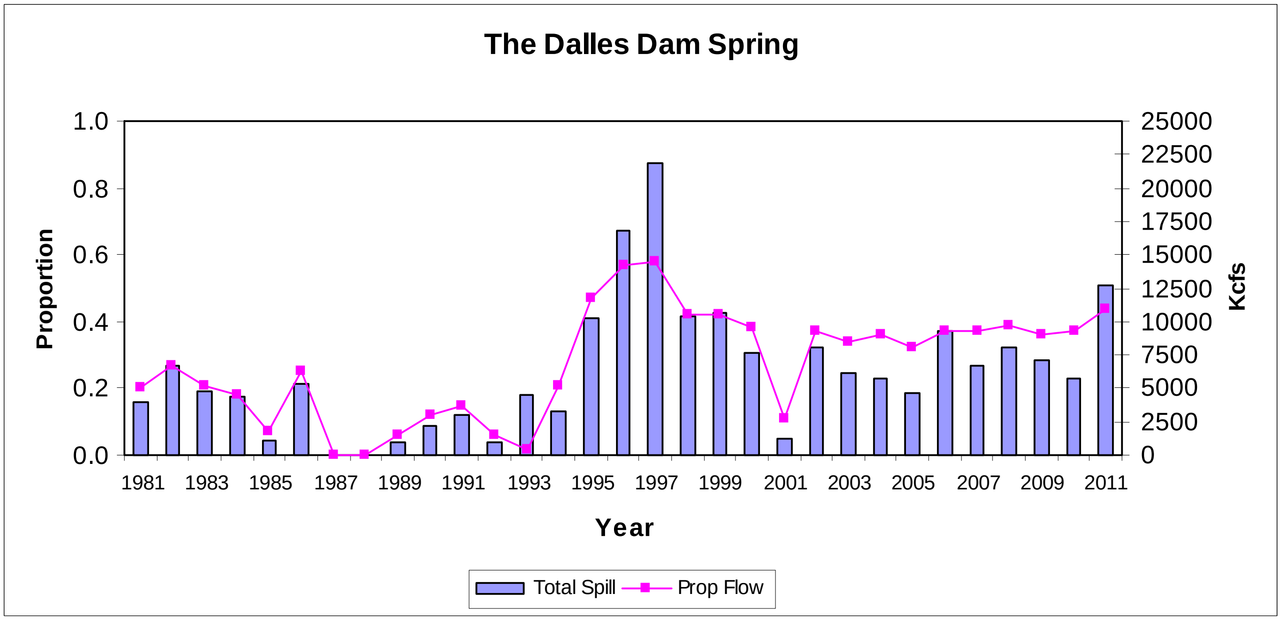


Figure B-6. Total spill (Kcfs) for spring (April 10 to June 30) and summer (July 1 - August 31) at John Day Dam, and spill as a proportion of total flow for the same time period.



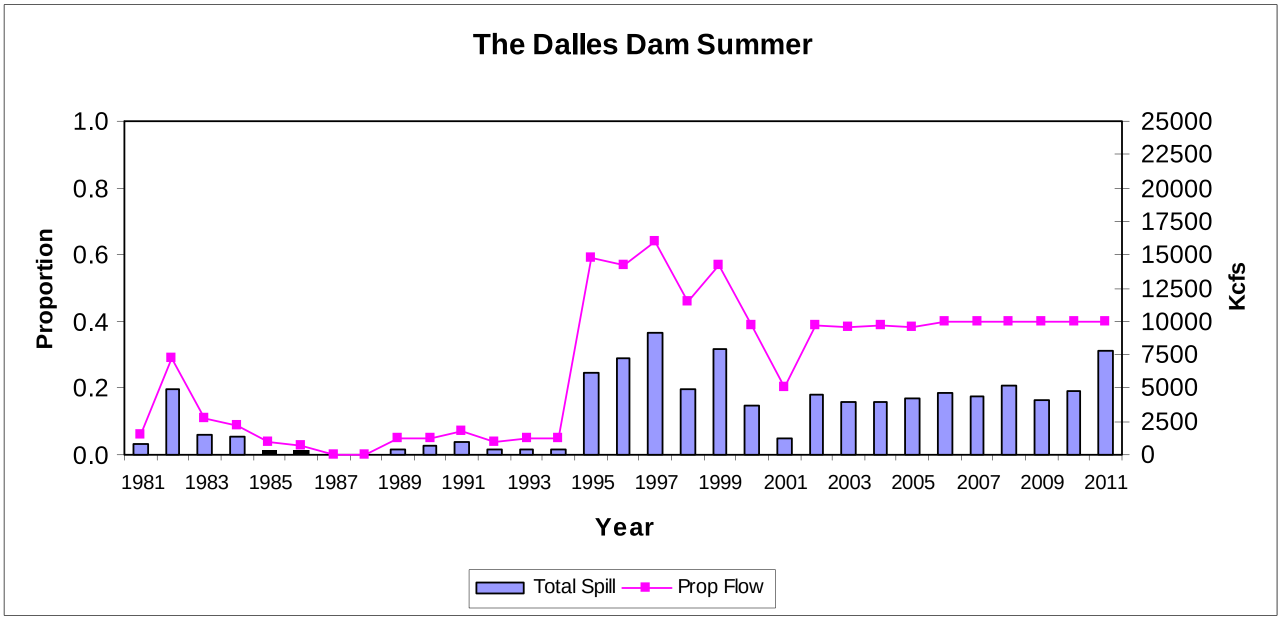
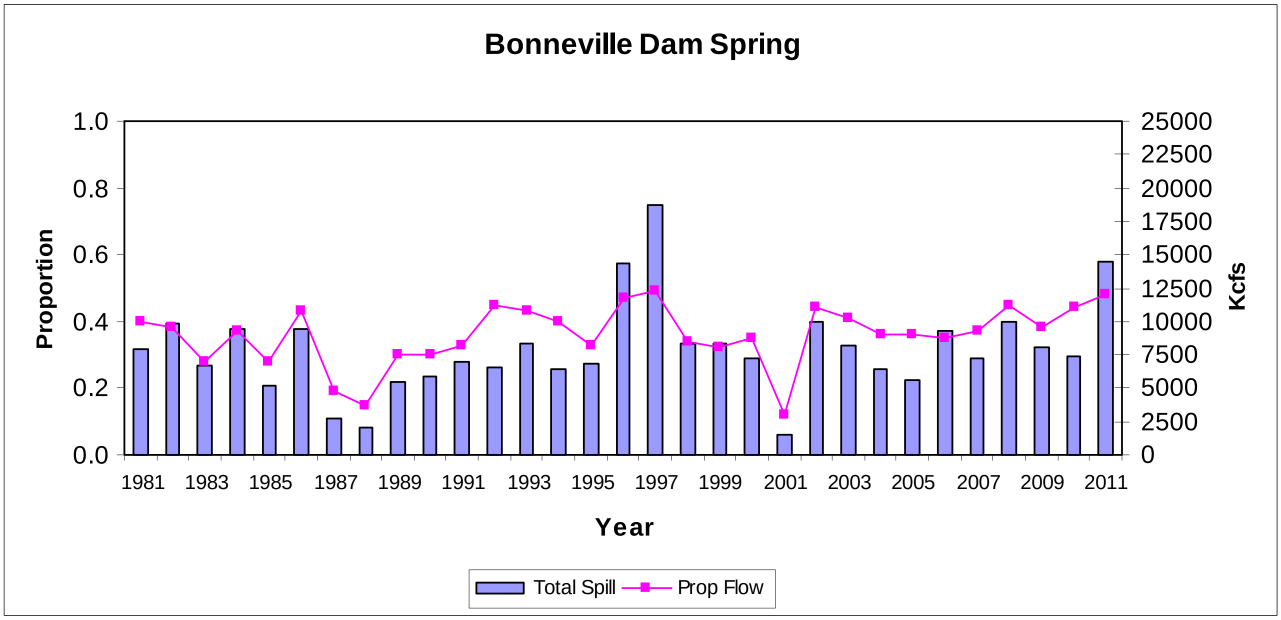


Figure B-7. Total spill (Kcfs) for spring (April 10 to June 30) and summer (July 1 - August 31) at The Dalles Dam, and spill as a proportion of total flow for the same time period.



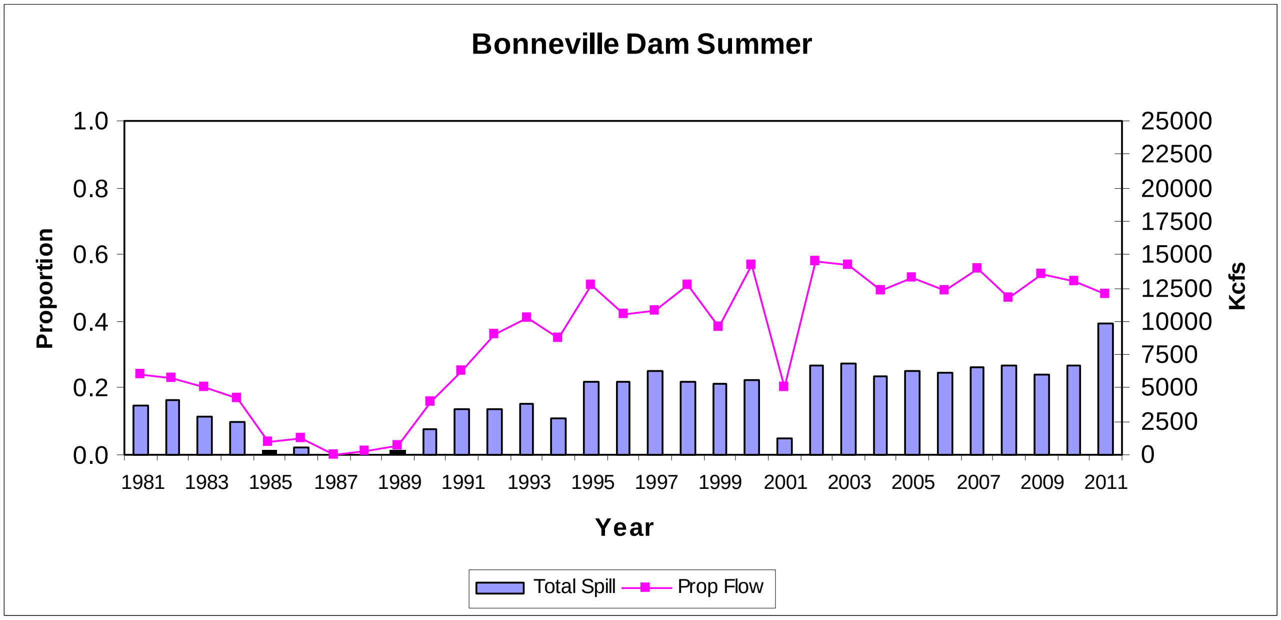


Figure B-8. Total spill (Kcfs) for spring (April 10 to June 30) and summer (July 1 - August 31) at Bonneville Dam, and spill as a proportion of total flow for the same time period.

APPENDIX C

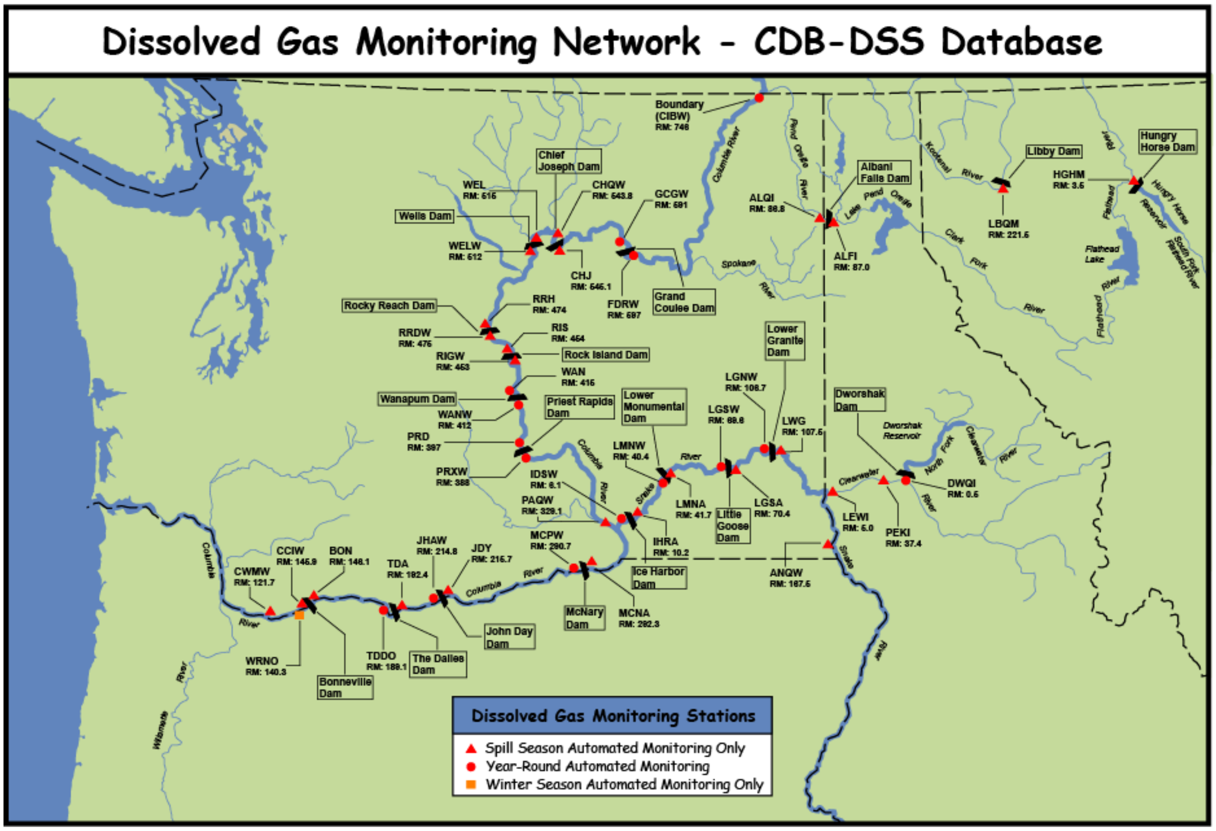


Figure C-1. 2014-2018 FMS Monitoring Network