

Appendix 4

Total Dissolved Gas Management Plan

Updated March 2018

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1.0 Introduction

Throughout the Columbia River System elevated levels of total dissolved gas (TDG) saturation are observed where spill occurs at U.S. Army Corps of Engineers (Corps) dams. The TDG Management Plan is included as Appendix 4 in the annual Water Management Plan. This TDG Management Plan describes voluntary and involuntary spill, use of the Spill Priority List, the process for setting spill caps, TDG management policies, and the TDG monitoring program. This Plan is consistent with the 2000 U.S. Fish and Wildlife Service (USFWS) Biological Opinion, the NOAA Fisheries 2014 Supplemental Biological Opinion (2014 Supplemental BiOp)¹, and the January 8, 2018 U.S. District Court for the District of Oregon Order for 2018 Spring Spill Operations and 2018 PIT Monitoring (including the 2018 Spring Fish Operations Plan (FOP)) (2018 Court Order).

1.1 Background

During the 1990s, Snake and Columbia River salmonids were listed under the Endangered Species Act (ESA). Through ESA consultations, the Corps implemented a variety of operational and structural measures that were called for in biological opinions to improve the survival of listed salmonids. The 2014 Supplemental BiOp calls for the Corps to provide levels of spill for juvenile fish passage at the Corps' four lower Snake River and the four lower Columbia River dams generally developed through performance standard testing. The Action Agencies typically develop a FOP annually that provides detailed information on the fish operations, including the fish passage spill program and its implementation, informed by adaptive management and the regional forum process. For spring 2018, the above mentioned 2018 Court Order requires that the Corps operate in accordance with the 2018 Spring FOP, which calls for additional spring spill from April 3 to June 20, 2018. The Action Agencies will develop a 2018 Summer FOP for the remainder of the fish passage season. The 2018 Spring and Summer FOPs will be provided as Appendix E of the Fish Passage Plan², which is also updated annually.

1.2 State Water Quality Standards

The Federal Clean Water Act establishes the aquatic life criteria for TDG of 110 percent that have been adopted by the four states (Montana, Idaho, Washington, and Oregon) and regional tribal governments. The states of Washington and Oregon have authorized exceptions (criteria adjustment and TDG standard modification, respectively) to these standards as long as the elevated TDG levels generated by fish passage spill for improved juvenile fish passage survival would not cause more harm to the fish than passing them through other passage routes, such as

¹ The 2014 Supplemental BiOp considered the Action Agencies' 2014-2018 Implementation Plan (2014-2018 IP) and incorporates both the 2008 NOAA BiOp and the 2010 Supplemental BiOp. References to the 2014 Supplemental BiOp also include, as appropriate, references to the 2008 and 2010 BiOps.

² The Fish Passage Plan may be found at the following link: <http://www.nwd-wc.usace.army.mil/tmt/documents/fpp/>

screened bypasses and turbines. The Corps will manage spill for fish passage in 2018 consistent with the State of Washington and the State of Oregon's TDG water quality standards (WQS).^{3 4}

Washington Criteria Adjustment:

- TDG must not exceed an average of 115% as measured in the forebays of the next downstream dams and must not exceed an average of 120% as measured in the tailraces of each dam (these averages are measured as an average of the 12 highest consecutive hourly readings in any one day, relative to atmospheric pressure); and
- A maximum TDG one hour average of 125% must not be exceeded during spillage for fish passage.

Oregon Standard Modification:

- Spill must be reduced when the average TDG concentration of the 12 highest hourly measurements per calendar day exceeds 120% of saturation in the tailraces of McNary, John Day, The Dalles, and Bonneville dams' monitoring stations.
- Spill must be reduced when instantaneous TDG levels exceed 125% 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.

The Corps will operate its fish passage projects in accordance with the State TDG standards described above, including applying the different state calculation methodologies. When the standards vary or conflict, the Corps will apply the more stringent standard.

2.0 Fish Passage Spill and Involuntary Spill

TDG management measures differ depending on whether the spill occurring at Corps and Reclamation dams is voluntary, i.e. spill for the benefit of juvenile fish migration through the Columbia River System; or involuntary, i.e. spill that is dictated by conditions beyond the Corps' control and require implementation of measures to manage TDG levels given these conditions. The following describes circumstances that result in various types of spill.

Gas Cap – refers to the applicable State TDG WQS (in percent TDG). The TDG standard for the states of Washington and Oregon is 110%. Both states have provided exceptions to the TDG standard for juvenile fish passage spill operations on the lower Snake and lower Columbia Rivers. Each state has different calculation methodologies for the different standards, and the

³ WASH. ADMIN. CODE §173-201A-200(l)(f) provides the maximum TDG criteria for each of the aquatic life use categories and displays Table 200 (l)(f) that states: "Total dissolved gas shall not exceed 110 percent of saturation at any point of sample collection." The code also addresses exceptions and adjustments, including a provision allowing for an adjustment of the TDG criteria to aid fish passage over hydroelectric dams when consistent with an approved gas abatement plan.

⁴ OR. ADMIN. R. 340-041-0031 provides in part: "the concentration of TDG relative to atmospheric pressure at the point of sample collection may not exceed 110 percent of saturation." OR. ADMIN. R. 340-041-104(3) identifies findings the Environmental Quality Commission must make for the purpose of allowing increased spill for salmon migration. See http://pweb.crohms.org/tmt/wqnew/state_tdg_waivers/or/2015_5yr.pdf

Corps applies the more stringent standard when operating under all applicable state TDG standards.

Gas Cap Spill – spill to the maximum spill level that meets, but does not exceed, the TDG criteria allowed under state law, and gas cap spill is a 24-hour operation at each lower Snake River and lower Columbia River project for spring 2018.

Spill Cap – the spill level (flow through the spillway measured in kcfs) at each project that is estimated to maximize spill to a level that meets, but does not exceed, the gas cap in the tailrace and the next downstream forebay.

Fish passage spill (or Voluntary Spill) - The Corps provides spill for the benefit of juvenile fish passage at the four lower Snake River and four lower Columbia River dams in accordance with the operative biological opinions and in a manner that is consistent with the Clean Water Act. The 2014 Supplemental BiOp RPA action 29 calls for the Action Agencies to provide spill at the four lower Snake River and four lower Columbia River projects to improve juvenile fish passage, while avoiding high TDG supersaturation levels. Specific spill levels are provided for juvenile fish passage at each project, not to exceed established TDG levels (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. Additionally, the Court Order instructs the Corps to “implement a gas cap spill operation at each of the lower Snake River projects (from April 3 through June 20) and lower Columbia River projects (from April 10 through June 15) by using the [2018] FPP spill patterns and the process and procedures set forth in the 2018 Spring FOP to establish spill caps and target spill levels.” The dates and levels for spill at each dam may be modified in-season to address both planned and routine conditions and non-routine or unplanned conditions through the implementation process and adaptive management process.

Involuntary Spill - 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 Spill** or **Over Capacity Spill**, but can also occur as a result of the management of reservoirs for flood risk⁵, 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

⁵ The Corps directs operations of storage projects in the Columbia Basin to manage flood risk. Storage reservoir pools are drafted in the winter and early spring to provide space to capture part of the spring runoff, reducing peak flows in the river. This flood risk management operation may require spill from storage reservoirs, which may result in elevated levels of TDG in the river system. The Corps and other action agencies work to manage system flood risk operations in a manner that reduces the need to spill at levels that exceed TDG water quality standards; however, there are conditions in which fulfilling the Corps’ flood risk management authorities necessitates drafting storage reservoirs.

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 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. The Spill Priority List is a lack of load TDG management plan that has been developed for involuntary spill that results in exceeding the 110 percent TDG standard when lack of load conditions require spill. The Corps works with the region to develop the Spill Priority List that identifies the order in which projects spill in order to minimize TDG system wide. See additional information on the Spill Priority List in Section 3.0 below.

- b) **Over Capacity Spill:** Occurs when flows exceed the hydraulic capacity of the available power generation facilities at a specific dam. Over capacity 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. Over capacity 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.

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

- 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.

3.0 Spill Priority List

The Spill Priority List identifies the order and amount of spill at the Corps’ Columbia River Basin dams and Grand Coulee Dam for management of lack of load spill and the expected TDG production system-wide. The Spill Priority List is used throughout the year during times of involuntary spill. The Spill Priority List consists of levels based on ascending TDG values, a spill rate for each project that is estimated to produce the TDG values and an order of projects.

3.1 Spill Levels

Values on the Spill Priority List serve as a reference for expected TDG production at the dams. During the period of no fish passage, the levels of the Spill Priority list are shown below:

- Level 1 – Spill flows up to 110 percent TDG in the project tailrace
- Level 2 – Spill flows up to 115 percent TDG in the project tailrace
- Level 3 – Spill flows up to 120 percent TDG in the project tailrace
- Level 4 – Spill flows up to 122 percent TDG in the project tailrace
- Level 5 – Spill flows up to 125 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

During the fish passage season, estimated spill levels are grouped into different TDG production levels on the Spill Priority List as shown in Table 1. The TDG is evaluated at the tailwater fixed monitoring stations except for Gas Cap and the Chief Joseph Dam (CHJ) Level 2 exception.

Table 1. The TDG target for each level of the Spill Priority List by project.

Project	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Fish passage projects	Gas Cap	120%	122%	125%	130%	135%
CHJ	110%	115% *	120%	122%	125%	130%
GCL	110%	115%	120%	122%	125%	130%
DWR	110%	115%	120%	122%	125%	130%

* At Chief Joseph Dam for level 2, the 115% TDG is evaluated in the Wells forebay, not the Chief Joseph Dam tailwater.

3.2 Factors for Setting Spill Priority

When establishing the order dams will spill above that required for BiOp juvenile fish passage, the following factors are considered:

- Location of Fish: Location and number of adult and juvenile fish in the migratory corridor⁶ is a factor in establishing the spill priority order on the Spill Priority List.

⁶ This type of input is often provided through a regional forum, such as TMT.

- 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.
- Location of Fish Research: When fish research is planned or in progress, those dams are low on the 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 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 or repair are placed last on priority list.
- Collector Dams: During low flow years, the collector dams where fish transport occurs (Lower Granite, Little Goose, Lower Monumental and Ice Harbor dams) are placed low on the 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 priority list depending on circumstances³.
- System-wide TDG management: Grand Coulee, Chief Joseph, Dworshak and other projects are included on the Spill Priority List to help balance system-wide TDG levels during periods of lack of load involuntary spill.

4.0 TDG Management Policy, Guidance and Considerations

The Corps will consider water quality effects along with the results of spill studies, biological evaluations, and the relationship to achieving BiOp performance standards and incorporate the following TDG management policies in its decision making:

- Manage dam operations to the extent practical in accordance with CWA and state water quality standards, modified through standard modifications and rule adjustments.
- Provide voluntary spill for fish consistent with applicable biological opinion requirements while avoiding high TDG levels or adult fallback problems. Specific spill levels will be provided for juvenile fish passage at each dam consistent with applicable State TDG standard modification or criteria adjustment and with the 2018 Court Order for 2018 Spring fish passage season.
- Operate dams to the authorized project purposes.
- Regulate flows to maximize potential for voluntary/fish passage spill.
- Discontinue or postpone non-critical unit service and maintenance schedules that create (or have potential for creating) high localized TDG levels, especially when and where high numbers of listed fish are present.
- Accommodate special spill requirements/restrictions for research, adult passage, etc. that have been coordinated with the TMT.
- Manage the system in coordination with the Bureau of Reclamation and BPA to avoid involuntary spill and minimize TDG production when possible, without jeopardizing flood risk management objectives.
- Implement the Spill Priority List discussed in Section 3.0.

- Chief Joseph Dam is not included in the Washington TDG criteria adjustment but it is used for managing system TDG during periods of involuntary spill. During periods of high runoff, it is managed up to, but to not exceed 120% TDG in the tailwater or 115% TDG in the next downstream forebay (Wells Dam forebay). Managing involuntary spill at Chief Joseph Dam is unique because TDG levels in its tailwater can be lower than in its forebay. Furthermore, Wells Dam, a non-federal dam directly downstream, has TDG requirements associated with its FERC license. These considerations are accounted for in the placement of Chief Joseph Dam ahead of Grand Coulee on the Spill Priority List, and managing for TDG in the Wells forebay (Level 2 only).

The Corps will continue to coordinate with the States of Oregon and Washington on voluntary fish passage spill,⁷ and provide technical information to inform the process. Future spill operations may be modified through the implementation planning process and adaptive management.

5.0 TDG Monitoring Program

The management of spill at each dam is based on TDG levels measured at specific forebay and tailwater fixed monitoring stations (FMS). The current locations of these gauges are based on extensive studies that have been conducted since 1996.

In support of the spill management program, a TDG monitoring program has been established and is described in the Dissolved Gas Monitoring Plan of Action. This monitoring program is revised to include changes in the FMS system and evaluated by regional representatives.

A copy of the 2015 – 2018 Dissolved Gas Monitoring Plan of Action can be obtained from this website: http://www.nwd-wc.usace.army.mil/tmt/wqnew/tdg_monitoring/2015-18.pdf

6.0 Procedure for Setting Spill Caps

As referenced in the 2018 Court Order and the 2018 Spring FOP, the Corps will manage TDG as set forth in Section 2 of the 2018 Spring FOP and the attachment entitled “Procedure for Setting 2018 Spring Spill Caps”. Summer spill operations will return to levels consistent with the 2014 Supplemental BiOp.

⁷ The Corps coordinates with the State of Washington on voluntary fish passage spill at the lower Snake and lower Columbia River projects; and with the State of Oregon on voluntary fish passage spill at the lower Columbia River projects.

Procedure for Setting 2018 Spring Spill Caps

U.S. Army Corps of Engineers, Northwestern Division
Columbia Basin Water Management - Reservoir Control Center

In its April 3, 2017, Amended Opinion and Order, the U.S. District Court for the District of Oregon ordered increased spill (spill to the maximum spill level that meets, but does not exceed, the Total Dissolved Gas (TDG) criteria allowed under state law,⁸ referred to as “gas cap” hereafter) to begin in the spring 2018 migration season at the U.S. Army Corps of Engineers’ (Corps) four lower Snake River and four lower Columbia River fish passage projects. Consistent with the Court’s order, the Corps, the other Action Agencies, and NOAA Fisheries, in coordination with regional sovereigns, developed fish passage spill operations for the 2018 spring migration season at the eight fish passage projects.

Although the Corps has implemented fish passage spill to meet performance standards in the 2008 NOAA Fisheries Biological Opinion, as supplemented in 2010 and 2014, including up to gas cap levels at certain fish passage projects, the Corps has never operated to the gas cap spill level at all fish passage projects throughout the spring migration season. In order to successfully implement gas cap spill for the spring 2018 migration season, the Corps will apply the following procedures.

1. TDG Water Quality Standards (WQS).
 - a. Each day from April 3 to June 20 (lower Snake River projects) and from April 10 to June 15 (lower Columbia River projects), project spill caps⁹ will be reviewed and adjusted so as not to exceed the applicable State TDG water quality standards (WQS). Daily 12-hour TDG concentrations will be calculated using hourly TDG data from fixed monitoring stations (FMS) placed in the tailrace and next downstream forebay of each project, in accordance with the applicable state’s methodology, which includes rounding TDG levels to the nearest whole number.
 - b. At the four lower Snake River projects, only the State of Washington TDG WQS of 120/115% TDG apply.

⁸ Washington Criteria Adjustment: TDG must not exceed an average of 115% as measured in the forebays of the next downstream dams and must not exceed an average of 120% as measured in the tailraces of each dam (these averages are measured as an average of the 12 highest consecutive hourly readings in any one day, relative to atmospheric pressure); and a maximum TDG one hour average of 125% must not be exceeded during spillage for fish passage. WASH. ADMIN. CODE §173-201A-200(l)(f).

Oregon Standard Modification: Spill must be reduced when the average TDG concentration of the 12 highest hourly measurements per calendar day exceeds 120% of saturation in the tailraces of McNary, John Day, The Dalles, and Bonneville dams’ monitoring stations, and spill must be reduced when instantaneous TDG levels exceed 125% 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. OR. ADMIN. R. 340-041-0031 and 340-041-104(3).

⁹ Spill cap is the maximum spill level (flow through the spillway measured in kcfs) at each project that is estimated to meet, but not exceed, the gas cap in the tailrace and the downstream forebay. The Corps manages “gas cap spill” by establishing spill caps for each project (which constitute the “target spill” levels for each project) and operates each project to achieve the target spill levels to the extent feasible.

- c. The lower Columbia River borders the states of Washington and Oregon, therefore both states' TDG WQS apply to McNary, John Day, The Dalles, and Bonneville projects. The Corps will operate to the more restrictive state TDG WQS at these projects in order to maintain TDG within all applicable state standards.

2. Spill Caps.

- a. Spill caps will be set starting at Lower Granite Dam (the most upstream fish passage project) and adjusted in downstream order to Bonneville Dam in response to resulting TDG levels.
- b. Spill caps at a project will be set at the maximum level to meet, but not exceed, TDG criteria allowed under state law in the tailrace and the downstream forebay; therefore the Corps will set each project's spill cap using whichever FMS is most likely to exceed the gas cap at each project on a given day. At many projects, the downstream forebay often limits spill caps, rather than the tailrace (i.e., the next downstream forebay is at or near 115%, but the project tailrace is below 120%).
- c. Spill cap estimates are influenced by several factors that cannot be precisely predicted, including (1) environmental conditions, such as total flow, wind, ambient temperature, barometric pressure, incoming TDG from upstream projects, and travel time from the upstream project tailrace to the next downstream project forebay¹⁰; and (2) project operations, such as spill level, spill pattern, tailwater elevation, proportion of flow through the turbines, and project configuration. As a result, in many instances, spill caps will not always meet gas cap (i.e., actual TDG levels may be above or below the gas cap).
- d. Specifically, maintaining gas cap spill at all eight projects will be challenging as water travel time to the next downstream project must be factored into making spill cap adjustments. Observed TDG responses to spill cap adjustments at a project will be evident within 24 hours in the tailrace, however it can take up to 5 days, depending on water travel time, to reach the next downstream forebay.

3. Daily Process used to Set Spill Caps.

- a. Daily data review. Each day Corps staff will review observed spill levels and resulting TDG data, flow and weather forecast information, tailwater elevation, unit outage information, and other water quality data. In addition, staff will assess the need for a spill cap adjustment.
- b. Run SYSTDG Model.¹¹ The SYSTDG model will be used when appropriate as a real-time operations tool to forecast the TDG production levels for all the projects. As warranted, Corps staff will cross-check projected spill caps with SYSTDG model simulation results to make appropriate spill cap adjustments. It may be necessary to run several simulations until the appropriate spill caps for all projects are determined, since a change at one project affects projects downstream.

¹⁰ Water travel time between projects varies depending on flow and can range from 1-5 days on the lower Snake River and from 1-3 days on the lower Columbia River during gas cap spill operations.

¹¹ Comprehensive spill review, which includes SYSTDG modeling when appropriate, will occur during regular work week hours. The Corps will continue the current spill review process for holidays and weekends, i.e., a condensed spill review process will be implemented considering observed data and applied engineering judgment. SYSTDG model runs are not likely to occur for the condensed review.

- c. Determine spill cap. Corps staff will use the data review and SYSTDG modeling steps described above to determine the appropriate spill caps based on their best professional judgment. Initially, the Corps anticipates making relatively small adjustments in spill caps to allow TDG levels to equilibrate because large and frequent adjustments at multiple projects could lead to overcompensation in setting spill caps and result in fluctuations of high or low TDG levels.
 - d. Notification. Spill cap adjustments will be provided to each project and BPA duty schedulers daily or as changes are made. Corps staff will typically complete the daily spill cap process by 1400 hours.
 - e. Coordination with regional sovereigns. Spill caps will be posted to the Corps website each day. Updates on spill operations will be provided at Technical Management Team (TMT) meetings.
4. Other Considerations. In addition to the factors described above that may influence spill levels, there are other considerations described in the 2018 Fish Operations Plan that may result in adjustments to spill levels that are different than gas cap spill. See Section 4.1 of the 2018 Spring FOP for a list of these considerations.