2024 Fish Passage Plan

Appendix C

Bonneville Power Administration's System Load Shaping Guidelines Regarding Turbine Operation & Peak Efficiency

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1. INTRODUCTION

1.1.1. Out-migrating juvenile salmonids have several potential routes of passage past federal multi-purpose dams on the mainstem Columbia and Snake rivers, including turbines, mechanical bypass, sluiceways, and spillways. Fish passage survival varies depending on the dam and on the route of passage. Regional efforts have focused on providing non-turbine passage routes (e.g., surface spill weirs) for juvenile fish as a means to improve fish survival through the Columbia River System (CRS). Passage of juvenile salmon and steelhead through turbines has also been reduced, but not eliminated, by implementing a modified spring spill operation that includes increased spill of up to 125% total dissolved gas (TDG) in the tailrace of most projects. However, juvenile fish will continue to pass through turbines, even if at smaller proportions, thus efforts to minimize turbine-related mortality is a priority of fishery agencies and Indian Tribes, the National Oceanic & Atmospheric Administration's Fisheries Service (NOAA Fisheries, formerly National Marine Fisheries Service [NMFS]), U.S. Army Corps of Engineers (Corps), and Bonneville Power Administration (Bonneville).

1.1.2. Kaplan turbine operating efficiency has a relatively direct effect on fish passage survival. The relationship between survival of juvenile fish passing through Kaplan turbines has historically been described as similar to that of peak efficiency up to generator limits.[1] It was this relationship that resulted in turbine operating restrictions of within ±1% of peak operating efficiency at CRS dams during the annual spring and summer downstream migrations of juvenile salmonids (or in-season peak efficiency operating period as defined in **Section 3.2)**. While peak operating efficiency has not always coincided with peak survival in turbine passage at CRS dams[2]; yet, operating within ±1% of peak efficiency tends to minimize fish mortality and has been followed to minimize turbine passage mortality.

2. TURBINE EFFICIENCY

2.1.1. For the purposes of this document, peak turbine efficiency operation shall be based on tables of operating ranges within ±1% of peak efficiency (1% range) provided by the Corps for each CRS project in the Fish Passage Plan (FPP). The Corps shall ensure that the 1% range is based on the best available information and that updates are coordinated with Bonneville and the Fish Passage Operations & Maintenance (FPOM) Coordination Team. The new tables will be coordinated with FPOM before distribution to Bonneville and the Corps. Implementation will begin within two weeks of receipt.

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[1] Long, C., and W. Marquette. 1967. *Research on fingerling mortality in Kaplan turbines.* Bureau of Commercial Fisheries, Seattle. *See also*, Bell, M. C. 1981. Unpublished Report: *Updated compendium on the success of passage of small fish through turbines.* U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon.

[2] Skalski, J., D. Mathur, and P. Heisey. 2002. Effects of turbine operating efficiency on smolt passage survival. *North American Journal of Fisheries Management* 22:1193-1200. Weiland, MA, CM Woodley, TJ Carlson, B Rayamajhi, and J Kim. 2015. *Systematic Review of JSATS Passage and Survival Data at Bonneville and The Dalles Dams during Alternative Turbine and Spillbay Operations from 2008–2012*. PNNL-24260. Report submitted to the U.S. Army Corps of Engineers, Portland District, Portland, Oregon, by the Pacific Northwest National Laboratory, Richland, Washington.

2.1.2. Operating efficiency of turbines is a result of wicket gate opening and blade angle for a given head.[3] As a result, there is a family of turbine efficiency curves for each project (or turbine design) for various head differentials. Operational decisions affecting turbine operations are based on efficiency curves for incremental changes in head, as provided by turbine manufacturers or empirical testing.

3. GUIDELINES

3.1. Objective.

3.1.1. Generally, the best operating range for turbines is within the 1% range. Operating turbines within the 1% range also typically reduces mortality of out-migrating juvenile salmonids and produces the most power for a given volume of water. During the in-season peak efficiency operating period (defined in **Section 3.2**), Bonneville and the Corps will operate turbines at lower Snake (LSN) and lower Columbia (LCOL) projects as a soft constraint within the 1% range and a hard constraint within and above the 1% range in accordance with the guidelines below. During the off-season operating period (defined in **Section 3.3**), the same soft constraints of operating turbines within the 1% range will be implemented; however, turbines may be operated within the normal operating range (including above and below 1% peak efficiency range when appropriate).

3.2. In-Season Peak Efficiency Operating Period

3.2.1. During the in-season peak efficiency operating period, Bonneville and the Corps will operate as a soft constraint within the 1% range and as a hard constraint within and above the 1% range. Bonneville and the Corps will operate the turbines at LSN and LCOL projects above the 1% range for the deployment of both contingency and balancing reserves and also to mitigate total dissolved gas (TDG) during high flow events. All required fish passage spill operations will be met prior to operating turbines above the 1% range.

During the in-season operating period, 24 hours/day, Bonneville will submit generation requests at all eight LCOL and LSN projects to operate the turbines within the 1% range (or Best Operating Point, BOP[4]) in accordance with the soft constraint. Excursions outside of the 1% range during this period, including those for reserve deployment and TDG mitigation, will be tracked using the codes in **Table C-1**.

3.2.2. The defined start and end dates for the in-season peak efficiency operating period are variable by dam:

- **(i)** Peak efficiency operating period is April 3 through August 31 for all LSN projects.
- **(ii)** Peak efficiency operating period is April 10 through August 31 for all LCOL projects.

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[3] Bell, M. C. 1981. Unpublished Report: *Updated compendium on the success of passage of small fish through turbines.* U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon.

[4] Best Operating Point (BOP) is used at Bonneville Dam Powerhouse One (Units 1-10).

3.3. Off-Season Operating Period.

3.3.1. While not required to do so in the off-season, turbines will normally run within the 1% range since it is the optimum point for maximizing energy output of a given unit of water over time. Bonneville and the Corps will operate turbines at the LCOL and LSN projects outside the 1% range if needed for power generation or mitigation of TDG. For more information on the 1% operation, see the project-specific chapters of the FPP for *Turbine Unit Operation & Maintenance*. There are no reporting requirements for this period.

3.3.2. The defined start and end dates for the off-season operating period are variable by dam.

(i) Off-season operating period is September 1 through April 2 for all LSN projects.

(ii) Off-season operating period is September 1 through April 9 for all LCOL projects.

3.4. Unit Priorities.

3.4.1. The Corps should make every effort to adhere to unit operating priorities specified in the FPP (the order in which turbines are put on- or taken off-line).

3.5. Project Priorities.

3.5.1. If units are operated outside of the 1% range, Bonneville will make every effort to assure that generation requests to Corps projects adhere to project priorities (forebay ranges, spill management, research, etc.). These priorities may be modified in season by the Action Agencies through the Regional Forum (e.g., FPOM and/or Technical Management Team (TMT)).

3.6. Coordination.

3.6.1. Coordination will occur through existing interagency mechanisms, such as the in-season adaptive management process described in the 2020 *Biological Assessment for the Operation and Maintenance of the Federal Columbia River* System (2020 CRS BA) prepared by the Corps, U.S. Bureau of Reclamation, and Bonneville (collectively referred to as the Action Agencies).

3.6.2. Coordination is also intended to allow the Action Agencies sufficient time to include system operational changes in their planning activities. Sufficient time is defined as the time needed to enter the information into GDACs (Corps) and the HERMES model (Bonneville). This can take up to two weeks to accomplish. If an emergency situation exists, implementation will begin as soon as practicable given concurrent operations, hydraulic situations, and loads.

3.6.3. Operations outside of the 1% range for limitations listed in **sections 4.1** (**System Reliability**) **4.2** (**Routine Starting**), **4.3** (**Total Dissolved Gas (TDG) Mitigation**), **4.7** (**Contingency Reserves**), and **4.8** (**Balancing Reserves**) are at the discretion of Bonneville and the Corps.

3.6.4. Emergency situations described in **Section 4.1** that require an immediate change in CRS operations will be coordinated directly by the Action Agencies with NOAA Fisheries as soon as practicable. If coordination of an emergency change in CRS operations cannot be completed immediately, information will be supplied to NOAA Fisheries as soon as practicable and then a summary of the emergency will be sent to TMT distribution list on the next working day.

3.7. Grand Coulee (GCL) and Chief Joseph (CHJ) Flexibility.

3.7.1. Within system reliability and firm load limitations, flexibility at GCL and CHJ will be fully used whenever possible before generation requests to LCOL and LSN projects are outside the 1% range.

4. IN-SEASON LIMITATIONS

Occurrence of the conditions described below may limit the ability of the Action Agencies to operate turbines continuously within the 1% range.

4.1. System Reliability.

4.1.1. Bonneville's ability to operate the CRS in a manner that enables the Corps to maximize operation of turbines within the 1% range is constrained by requirements to maintain system reliability (including requirements necessary for transient and voltage stability of the transmission system), and the ability to meet system response criteria. Additionally, it is necessary to maintain a margin of resource generation on-line to fulfill Northwest Power Pool (NWPP), Western Electricity Coordinating Council (WECC) and the North American Electric Reliability Council (NERC) reliability requirements. If Bonneville over-rides operations proposed for ESA-listed fish in the 2020 CRS BA as an action intended to preserve system reliability, Bonneville will provide an automated e-mail to the Corps and trigger regional notifications described in **Section 3.6.4**. For longer term emergencies, see the current *Water Management Plan,* Appendix 1 (Emergency Protocols)[5].

4.1.2. System response criteria and margin of resource generation are defined in the following documents: *Reliability Criteria for Operations (BPA)*, *Northwest Power Pool Operating Manual*, *Western Systems Coordinating Council Operations Committee Handbook*, and *North American Electric Reliability Council Operating Manual*.

4.1.3. Predictable instances of deviation from the 1% range as a consequence of prudent utility operation for control of short-term system dynamics include:

> **(i)** Routine responses to loss of generation, load or transmission within the interconnection including delivery of "Operating Reserve Obligation" to NWPP members upon request. The duration of these deviations is minimal but dependent upon recovery by the interconnection member with the problem.

[5] Water Management Plan, Appendix 1: Emergency Protocols pweb.crohms.org/tmt/documents/wmp/2021/Appendices/Appendix_1_Emergency_Protocols_July_16_2008_with-ATTACHMENT-1.pdf

(ii) Deliberate dropping of generation (i.e., instantaneous interruption of output) to preserve system integrity. This dropping could cause a brief excursion.

4.2. Routine Starts and Stops.

4.2.1. Routine starting and stopping of generation units are unavoidable deviations, usually short duration but on occasion can extend beyond the 5-minute reporting window (see **Section 5**).

4.2.2. Operations in **sections 4.3–4.8** will include notification to NOAA Fisheries at least 2 working days before implementation to allow sufficient time to evaluate effects of proposed actions (non-emergency situations).

4.3. Total Dissolved Gas (TDG) Mitigation.

4.3.1. Turbines may operate above 1% peak efficiency range to mitigate TDG production. The purpose of mitigating TDG production is to reduce the duration and magnitude of water quality standard exceedances in the tailraces of each project. The operation is expected to occur primarily when there is insufficient turbine capacity within the 1% range to generate with the available water *after* providing fish passage spill. This condition occurs most frequently in high flow periods, a time when operating above 1% range would also help manage for high TDG. If load is not available, involuntary spill will likely occur and may result in TDG levels above 125%. If load is available, turbines may operate above the 1% range. TDG management may occur at lower flows if there are a high number of turbine outages; however, the intent of this operation is to distribute flow across all available turbines at each project when possible before TDG mitigation occurs by operating the turbines above the 1% range.

4.4. Coordinated Fishery Operations.

4.4.1. In the event that coordinated fishery operations and approved fish research are not in accord with operating turbines in the 1% range, operational modifications will be coordinated through processes outlined in **Section 3.6**.

4.5. Transport Projects.

4.5.1. Resolution of conflicts between spill management and turbine operation within the 1% range at transport projects during transport season shall be determined through the coordination process in **Section 3.6**, and in accordance with transportation guidelines based on in-season flow and fish passage information.

4.6. Routine Maintenance and Testing.

4.6.1. All units at all projects must undergo maintenance and associated testing. The testing necessitates deviation from the 1% range for periods of up to two hours and will be reported as described in **Section 5**. Scheduling of maintenance testing that exceeds two hours will be coordinated through the process outlined in **Section 3.6**.

4.7. Contingency Reserves

4.7.1. Bonneville deploys contingency reserves to meet energy demands caused by unexpected events such as transmission interruption or failure of a generator. Bonneville cannot predict the exact timing, magnitude, and the location of the need to deploy contingency reserves, which makes pre-coordination for each individual event impossible. Bonneville may depend on turbine operations above the 1% range for the deployment of contingency reserves.

4.8. Balancing Reserves

4.8.1. Bonneville is responsible for CRS grid reliability, which requires the use of balancing reserves to follow sub-hourly power demand and supply fluctuations. Since supply must equal demand for power second-by-second, power generation must increase and decrease automatically as demand for power changes. Furthermore, within its Balancing Authority, Bonneville integrates the use of other renewable power sources (e.g. wind and solar) and balancing reserves compensate for within-hour changes in wind and solar generation. Bonneville may depend on turbine operations above the 1% range for the deployment of balancing reserves.

4.9. Other.

4.9.1. There may be cases that an excursion was not explainable or caused by human error. Reporting will be consistent with **Section 5**.

5. QUALITY CONTROL

5.1.1. Significant deviations outside of the 1% range as defined below will be recorded. Data on unit status will be compiled by Bonneville during the in-season peak efficiency operating period by project and provided to the COE monthly. Documentation will be kept when excursions:

- **(i)** exceed 15 minutes in duration; and/or
- **(ii)** occur 5 or more times exceeding 5 minutes within 1 calendar day.

5.1.2. The reason (limitation or other factor) for the excursions will be kept in project logs at each dam as well as inserted into the spreadsheet provided by Bonneville using the reason codes listed in **Table C-1**. The Corps will annually provide a report to NOAA Fisheries of reportable excursions from the 1% range during the in-season peak efficiency operating period (defined in **Section 3.2**).

5.1.3. Upon request of TMT, a case-by-case brief explanation of the reason(s) for unit operation outside the 1% range, the date and length of time of the excursion, will be provided by the appropriate parties. For the report, the following numerical codes will be used to explain excursions outside the 1% range. The codes provide a more simplified method of tracking excursions than using the listed limitations in **Section 4**.

Table C-1. Codes for Reporting Excursions Outside the 1% Peak Efficiency Range.

Code	Reason
1	Equipment reporting errors, including lack of data (GDAC or AGC not operating correctly and not recording readings, dead-band and precision issues, etc.)
2	Modified spill operations in support of BiOp or court order (requested flow augmentation, coordinated fish operation)
3	O&M requirements (fish screen inspection, trash raking, Doble testing, dam safety, etc.)
4	Operational tests (index testing, testing or calibrating new or repaired equipment)
5	Bonneville requested operation (request operation via AGC)
6	Turbine start-up or stops longer than 5 minutes
7	Emergency conditions or system failures, including transmission system emergencies, remedial action schemes (RAS), or others as described in 4.1. *System Reliability*.
8	Fish research
9	Human error
10	Unknown causes
11	Other (Please specify)
12	TDG mitigation
13	Contingency reserve deployment
14	Balancing reserve deployment