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# 2016 Fish Passage Plan

## Chapter 9 – Lower Granite Dam

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<b>Lower Granite Dam</b>	
<b>Project Acronym*</b>	LWG
<b>River Mile (RM)</b>	Snake River – RM 107.5
<b>Reservoir</b>	Lake Lower Granite
<b>Minimum Instantaneous Flow (kcfs)</b>	Dec–Feb: 0 kcfs \ Mar–Nov: 11.5 kcfs
<b>Forebay Normal Operating Range (ft)</b>	733' – 738'
<b>Tailrace Rate of Change Limit (ft/hr)</b>	1.5'/hr
<b>Powerhouse Length (ft)</b>	656'
<b>Powerhouse Hydraulic Capacity (kcfs)</b>	130 kcfs
<b>Turbine Units (#)</b>	6 (Units 1-3 BLH Kaplan; Units 4-6 Allis Chalmers Kaplan)
<b>Turbine Unit Generating Capacity (MW)</b>	Rated: 810 MW (135 MW/unit) \ Maximum: 930 MW (155 MW/unit)
<b>Gatewell Orifices</b>	36 orifices (2 per gatewell = 6 per unit). 35 w/10" diameter; 1 w/14" diameter (5A)
<b>Spillway Length (ft)</b>	512'
<b>Spillway Hydraulic Capacity (kcfs)</b>	850 kcfs
<b>Spillbays (#)</b>	8
<b>Spillway Weirs (#)</b>	1 Removable Spillway Weir (RSW) in Bay 1
<b>Navigation Lock Length x Width (ft)</b>	650' x 84' (Usable Space)
<b>Navigation Lock Max. Lift (ft)</b>	105'
<b>FISH STRUCTURE/OPERATION START DATE</b>	
<b>Transportation Research Program – NMFS **</b>	1975
<b>Submersible Traveling Screens (STS)</b>	1978
<b>Extended-Length Submersible Bar Screens (ESBS)</b>	1996
<b>Juvenile Fish Transportation Program – Corps **</b>	1981
<b>Removable Spillway Weir (RSW)</b>	2003
<b>Adult Fish Counts</b>	1969 (North Shore); 1975 (South Shore)

\*Project acronym designated by US Army Corps of Engineers, Northwestern Division, Columbia Basin Water Management Division. Due to the large number of projects managed by NWD, this acronym may differ from other acronyms used in the region. For example, a common acronym for Lower Granite is LWG. However, that acronym is assigned to another NWD project, thus the official Corps NWD acronym is LWG.

\*\*Smolt transportation and research done by NMFS via truck until 1978 when barges purchased. Corps began implementing transportation program in 1981.

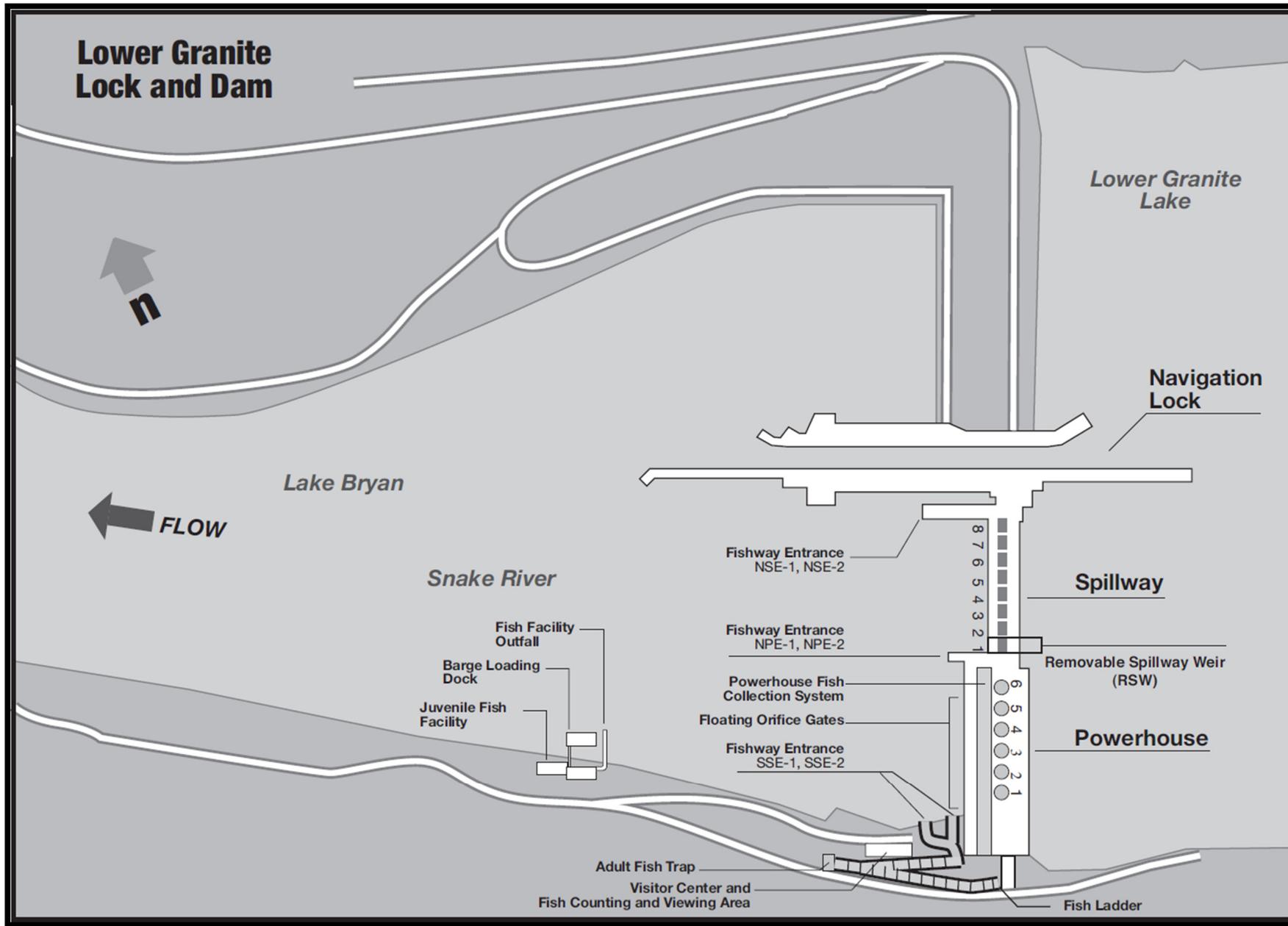


Figure LWG-1. Lower Granite Lock & Dam General Site Plan.

**Table LWG-1. Lower Granite Dam Schedule of Operations and Actions Defined in the 2016 Fish Passage Plan (FPP).**

Task Name	Start	End	FPP Section	2016											
				Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
<b>FISH PASSAGE FACILITIES</b>	<b>3/1/16</b>	<b>2/28/17</b>													
Fish Passage Season - Adult Facilities	3/1/16	12/31/16	2.4.2	Adult Facilities - Fish Passage Season											
Winter Maintenance - Adult Facilities	1/1/17	2/28/17	2.4.1	Winter											
Fish Passage Season - Juvenile Facilities	3/25/16	12/15/16	2.3.3	Juvenile Facilities - Fish Passage Season											
Winter Maintenance - Juvenile Facilities	3/1/16	3/24/16	2.3.2	Winter											
Winter Maintenance - Juvenile Facilities	12/16/16	2/28/17	2.3.2	Winter											
<b>PROJECT OPERATIONS FOR FISH PASSAGE</b>	<b>3/1/16</b>	<b>12/15/16</b>													
Turbine unit priority order	3/1/16	12/15/16	Table LWG-5	Unit Priority Order											
Turbine unit 1% operating range	4/1/16	10/31/16	4.2	Unit 1% Range											
Avian hazing	4/1/16	6/30/16	Appendix L	Avian Hazing											
Avian Wires installed NLT April 3	4/3/16	4/3/16	Appendix L	◆											
Spillway weir in service	4/3/16	8/31/16	2.3.3.6	RSW											
Spring Spill	4/3/16	6/20/16	Appendix E	Spring Spill											
Summer Spill	6/21/16	8/31/16	Appendix E	Summer Spill											
STS removal during cold weather	11/24/16	12/15/16	2.3.3.2	"Cold"											
<b>SPECIAL OPS &amp; STUDIES (Appendix A)</b>	<b>3/1/16</b>	<b>3/31/17</b>	<b>Appendix A</b>												
Juvenile Bypass System Upgrade	3/1/16	3/31/17		JFF Upgrade											
Adult Lamprey PIT study	3/1/16	5/31/16		Lamprey PIT study											
Navigation Lock annual outage	3/5/16	3/26/16		Nav											
Doble testing	8/8/16	8/12/16		Doble											
<b>TDG MONITORING</b>	<b>3/1/16</b>	<b>2/28/17</b>	<b>2.2</b>												
TDG Monitoring - Tailrace (year-round)	3/1/16	2/28/17	station LGNW	LGNW											
TDG Monitoring - Forebay	4/1/16	8/31/16	station LWG	LWG											
<b>ADULT FISH COUNTING</b>	<b>3/1/16</b>	<b>12/30/16</b>	<b>Table LWG-3</b>												
Day Video 0400-2000 PST (0500-2100 DST)	3/1/16	3/31/16		Day Video											
Day Visual 0400-2000 PST (0500-2100 DST)	4/1/16	10/31/16		Day Visual											
Night Video 2000-0400 PST (2100-0500 DST)	6/1/16	9/30/16		Night Video											
Day Video 0400-2000 PST	11/1/16	12/30/16		Day Video											
<b>REPORTS</b>	<b>3/1/16</b>	<b>3/15/17</b>	<b>2.5</b>												
Weekly Reports	3/1/16	12/31/16		Weekly Reports											
Annual Report due	3/15/17	3/15/17		◆											

## 1. **FISH PASSAGE INFORMATION**

Lower Granite Lock & Dam fish passage facilities and other structures are shown on the general site plan in **Figure LWG-1**. The schedule of Lower Granite Dam operations that are described in the Fish Passage Plan (FPP) and Appendices is included in **Table LWG-1**.

### 1.1. **Juvenile Fish Passage.**

**1.1.1. Juvenile Fish Facilities.** The juvenile fish facilities at Lower Granite Dam consist of a bypass system and juvenile transportation facilities. The bypass system contains extended-length submersible bar screens (ESBS) with flow vanes, improved modified balanced flow vertical barrier screens (VBS) , gatewell orifices, a bypass channel running the length of the powerhouse, and a bypass pipe to transport fish to the transportation facilities or the river. The transportation facilities include an upwell and separator structure to separate the juveniles from the excess water and adult fish, raceways for holding fish, a distribution system for distributing the fish among the raceways or to the barge or back to the river, a sampling and marking building, truck and barge loading facilities, and PIT-tag detection and diversion systems.

**1.1.1.1.** Maintenance of juvenile fish passage facilities that may impact juvenile fish or facility operations should be conducted during winter maintenance.

**1.1.2. Juvenile Fish Migration Timing.** Juvenile fish passage timing at Lower Granite Dam (**Table LWG-2**) is based on collection data from the most recent 10-year period and does not reflect fish guidance efficiency (FGE) or spillway passage. Salmon, steelhead, bull trout, lamprey, and other species are routinely counted.

**Table LWG-2. Juvenile Salmonid Passage Timing at Lower Granite Dam for Most Recent 10 Years Based on Daily & Yearly Collection Data.**

Year	10%	50%	90%	# Days	10%	50%	90%	# Days
	Yearling Chinook				Subyearling Chinook			
<b>2006</b>	20-Apr	5-May	15-May	25	26-May	5-Jun	3-Jul	38
<b>2007</b>	19-Apr	4-May	14-May	25	3-Jun	9-Jun	12-Jul	39
<b>2008</b>	26-Apr	9-May	18-May	22	31-May	20-Jun	28-Jul	58
<b>2009</b>	22-Apr	7-May	20-May	28	29-May	11-Jun	2-Jul	34
<b>2010</b>	24-Apr	4-May	21-May	27	2-Jun	9-Jun	14-Jul	42
<b>2011</b>	19-Apr	8-May	16-May	27	26-May	11-Jun	16-Jul	51
<b>2012</b>	14-Apr	27-Apr	17-May	33	29-May	13-Jun	11-Jul	43
<b>2013</b>	19-Apr	8-May	14-May	25	30-May	9-Jun	1-Aug	63
<b>2014</b>	19-Apr	4-May	17-May	28	28-May	1-Jun	12-Jul	45
<b>2015</b>	3-Apr	26-Apr	11-May	38	26-May	5-Jun	19-Jul	54
<b>10-Yr MEDIAN</b>	<b>19-Apr</b>	<b>4-May</b>	<b>16-May</b>	<b>27</b>	<b>29-May</b>	<b>9-Jun</b>	<b>13-Jul</b>	<b>44</b>
<b>10-Yr MIN</b>	<b>3-Apr</b>	<b>26-Apr</b>	<b>11-May</b>	<b>22</b>	<b>26-May</b>	<b>1-Jun</b>	<b>2-Jul</b>	<b>34</b>
<b>10-Yr MAX</b>	<b>26-Apr</b>	<b>9-May</b>	<b>21-May</b>	<b>38</b>	<b>3-Jun</b>	<b>20-Jun</b>	<b>1-Aug</b>	<b>63</b>
	Unclipped Steelhead				Clipped Steelhead			
<b>2006</b>	19-Apr	5-May	21-May	32	21-Apr	4-May	19-May	28
<b>2007</b>	1-May	10-May	21-May	20	28-Apr	7-May	20-May	22
<b>2008</b>	20-Apr	11-May	27-May	37	28-Apr	8-May	21-May	23
<b>2009</b>	22-Apr	6-May	29-May	37	21-Apr	1-May	21-May	30
<b>2010</b>	26-Apr	19-May	5-Jun	40	25-Apr	11-May	4-Jun	40
<b>2011</b>	22-Apr	13-May	31-May	39	3-Apr	6-May	20-May	47
<b>2012</b>	18-Apr	3-May	24-May	36	16-Apr	27-Apr	19-May	33
<b>2013</b>	22-Apr	13-May	19-May	27	20-Apr	9-May	17-May	27
<b>2014</b>	23-Apr	9-May	26-May	33	21-Apr	2-May	22-May	31
<b>2015</b>	16-Apr	8-May	24-May	38	11-Apr	27-Apr	18-May	37
<b>10-Yr MEDIAN</b>	<b>22-Apr</b>	<b>20-May</b>	<b>25-May</b>	<b>37</b>	<b>21-Apr</b>	<b>5-May</b>	<b>20-May</b>	<b>31</b>
<b>10-Yr MIN</b>	<b>16-Apr</b>	<b>3-May</b>	<b>19-May</b>	<b>20</b>	<b>3-Apr</b>	<b>27-Apr</b>	<b>17-May</b>	<b>22</b>
<b>10-Yr MAX</b>	<b>1-May</b>	<b>19-May</b>	<b>5-Jun</b>	<b>40</b>	<b>28-Apr</b>	<b>9-May</b>	<b>4-Jun</b>	<b>47</b>
	Coho				Sockeye (Wild & Hatchery)			
<b>2006</b>	2-May	18-May	1-Jun	30	11-Apr	12-May	28-May	47
<b>2007</b>	5-May	15-May	23-May	18	11-May	16-May	21-May	10
<b>2008</b>	6-May	10-May	22-May	16	17-May	20-May	8-Jun	22
<b>2009</b>	13-May	21-May	23-Jun	41	21-Apr	20-May	28-May	37
<b>2010</b>	6-Jun	21-May	5-Jul	29	19-May	30-May	5-Jun	17
<b>2011</b>	5-May	15-May	1-Jun	27	4-Apr	20-May	4-Jun	61
<b>2012</b>	28-Apr	18-May	26-May	28	5-May	19-May	26-May	21
<b>2013</b>	8-May	14-May	18-May	10	15-May	17-May	19-May	4
<b>2014</b>	3-May	19-May	26-May	23	8-Apr	3-May	19-May	41
<b>2015</b>	27-Apr	13-May	23-May	26	9-May	17-May	20-May	11
<b>10-Yr MEDIAN</b>	<b>5-May</b>	<b>16-May</b>	<b>26-May</b>	<b>27</b>	<b>7-May</b>	<b>18-May</b>	<b>27-May</b>	<b>22</b>
<b>10-Yr MIN</b>	<b>27-Apr</b>	<b>10-May</b>	<b>18-May</b>	<b>10</b>	<b>4-Apr</b>	<b>3-May</b>	<b>19-May</b>	<b>4</b>
<b>10-Yr MAX</b>	<b>6-Jun</b>	<b>21-May</b>	<b>5-Jul</b>	<b>41</b>	<b>19-May</b>	<b>30-May</b>	<b>8-Jun</b>	<b>61</b>

## 1.2. Adult Fish Passage.

**1.2.1. Adult Fish Facilities.** Adult fish passage facilities at Lower Granite Dam are made up of one south shore fish ladder with two entrances, a powerhouse collection system, north shore entrances with a transportation channel underneath the spillway to the powerhouse collection system, and an auxiliary water supply system. The powerhouse collection system is comprised of four operating floating orifices, two downstream entrances and one side entrance into the spillway basin on the north end of the powerhouse, and a common transportation channel. Four of the floating orifices and the two downstream entrances at the north end of the collection system are operated. North shore entrances are made up of two downstream entrances and a side entrance into the spillway basin with the two downstream entrances normally used. Auxiliary water is supplied from the tailrace by three electric pumps, as well as from the forebay through diffuser-14. Two pumps are normally used to provide required flows. Four weirs in the upper end of the ladder were outfitted with PIT-tag detectors in early 2003.

**1.2.1.1.** Maintenance of adult fish facilities is scheduled for January–February to minimize impacts on upstream migrants.

**1.2.2. Adult Fish Migration Timing & Counting.** Upstream migrants are present throughout the year and adult fish facilities are operated year-round. Adult salmon, steelhead, shad and lamprey are counted per the schedule in **Table LWG-3**, and data are posted daily at: [www.nwp.usace.army.mil/Missions/Environment/Fishdata.aspx](http://www.nwp.usace.army.mil/Missions/Environment/Fishdata.aspx). Sturgeon and bull trout are relatively infrequent and counts are posted online periodically during the passage season in *Miscellaneous Fish Counts* and summarized in the *Annual Fish Passage Report*. Yearly fish counts are used to determine peak adult migration timing (**Table LWG-4**). Time-of-day (diel) distributions of adult salmonid activity at Lower Granite Dam fishway entrances and exits are summarized in **Figure LWG-2**.

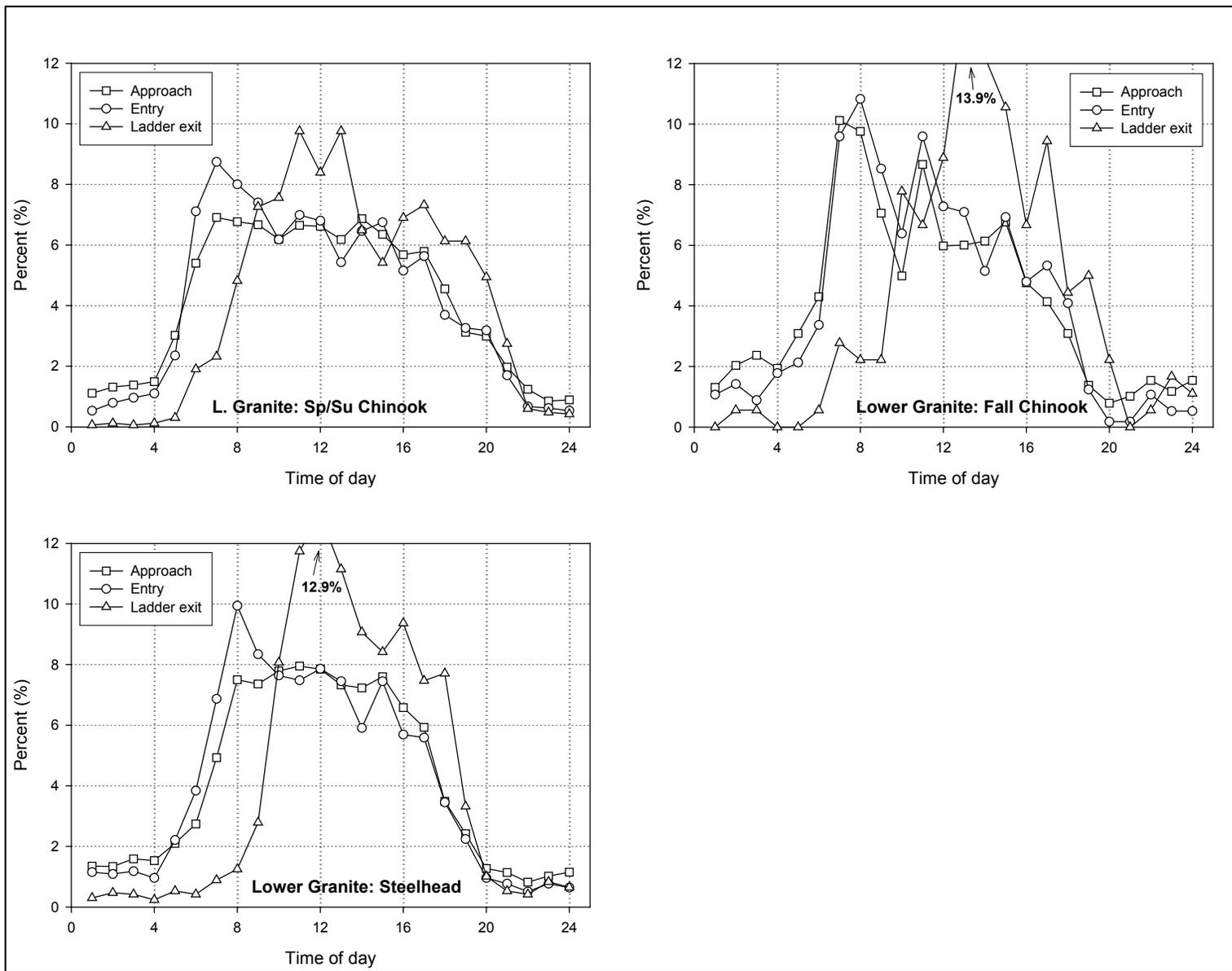
**Table LWG-3. Adult Fish Counting Schedule at Lower Granite Dam (3/1/16 – 2/29/17).**

Count Period	Counting Method and Hours *
March 1–31	Video 0400–2000 hours (PST)
April 1 – October 31	Visual 0400–2000 hours (PST)
June 1 – September 30	Night Video 2000–0400 hours (PST)
November 1 – December 30	Video 0400–2000 hours (PST)

\*All count hours in Pacific Standard Time (PST). NOTE: Daylight Saving Time (DST) is in effect Sunday, March 13 – Sunday, November 6, 2016, and count hours will be one hour later (DST = PST+1).

**Table LWG-4. Adult Fish Count Period and Peak Passage Timing at Lower Granite Dam (based on yearly counts from 1975 through most recent count year).**

Species	Counting Period	Earliest Peak	Latest Peak
Spring Chinook	Mar 1 – Jun 17	Apr 26	Jun 17
Summer Chinook	Jun 18 – Aug 17	Jun 18	Jul 17
Fall Chinook	Aug 18 – Dec 30	Sep 5	Oct 6
Steelhead	Mar 1 – Dec 30	Sep 1	Oct 16
Sockeye	Mar 1 – Oct 31	Jul 1	Jul 19
Lamprey	Apr 1 – Oct 31	Jul 18	Jul 25



**Figure LWG-2. Diel Distribution of Adult Salmonids at Lower Granite Dam Fishway Entrances and Exits (Kefer & Caudill 2008).**  
[www.nwd-wc.usace.army.mil/tmt/documents/FPOM/2010/2013\\_FPOM\\_MEET/2013\\_JUN/](http://www.nwd-wc.usace.army.mil/tmt/documents/FPOM/2010/2013_FPOM_MEET/2013_JUN/)

## 2. **FISH FACILITIES OPERATIONS**

### 2.1. **General.**

**2.1.1.** Research, non-routine maintenance activities and construction will not be conducted within 100' of any fishway entrance or exit, within 50' of any other part of the adult fishway, or directly in, above or adjacent to any fishway, unless coordinated by the Project, Walla Walla District (NWW) Operations and/or Planning or Construction office through FPOM or FFDRWG. Currently coordinated special operations related to research are described in *Special Project Operations & Studies (Appendix A)*. These distances are approximate and will be updated after data are collected and analyzed to understand where the threshold for adversely impacting adult fish behavior occurs. Alternate actions will be considered by District and Project biologists in conjunction with the Regional fish agencies on a case-by-case basis.

**2.1.2.** Emergency situations should be dealt with immediately by the Project in coordination with the Project and/or District biologist. If unavailable, the biologists will be informed of steps taken to correct the situation immediately following the incident. All activities within boat restricted zones (BRZ) will be coordinated with the Project at least 2 weeks in advance, unless it is deemed an emergency (see also **FPP Chapter 1 - Overview** for coordination guidance). On a monthly basis, as appropriate, the project biologist will provide a summary of any emergency actions undertaken for review by FPOM.

### 2.2. **Spill Management.**

**2.2.1.** See the *Fish Operations Plan (FOP)* in **Appendix E** for more information.

**2.2.2.** Spill at Lower Granite shall be distributed in accordance with patterns defined in **Table LWG-8, LWG-9, LWG-10**. Special spill for juvenile fish passage will be provided as detailed in **Appendices A and E**.

**2.2.3.** Involuntary spill is the result of river flow above powerhouse capacity, insufficient load (lack of load), turbine unit outages (forced or scheduled), or failure of a key component of the juvenile fish passage facility which forces spill to provide juvenile fish passage.

**2.2.4.** To ensure navigation safety, short-term spill adjustments may be required, including spill reduction, spill pattern adjustment, and/or spill stoppages that result in forebay exceedances of the MOP range. Actual operations will vary due to conditions such as spill patterns, turbine unit operations, experience of boat captains, etc. The Corps will make short-term spill adjustments in real-time as appropriate to provide safe navigation conditions. Additional information regarding spill-specific operations for navigation is available in the FOP (**Appendix E**).

**2.2.5.** Total dissolved gas (TDG) levels at all projects are monitored in accordance with the *TDG Monitoring Plan*, included in the *Water Management Plan* as Appendix 4 (online at: [www.nwd-wc.usace.army.mil/tmt/documents/wmp/](http://www.nwd-wc.usace.army.mil/tmt/documents/wmp/)).

### **2.3. Operating Criteria – Juvenile Fish Facilities.**

**2.3.1.** Operate from March 25 through October 31, for juvenile fish bypass, collection, and transport, and from November 1 through December 15 for adult fallbacks. Operate according to criteria defined below and in the *Corps of Engineers Juvenile Fish Transportation Plan (Appendix B)* for bypass, collection, and transport of juvenile salmonids. The transportation program may be revised in accordance with the ESA Section 10 permit and NOAA Fisheries biological opinion. Project personnel shall retain authority to dewater the juvenile fish collection system to the extent necessary to prevent frost damage to pipes and other structures during late fall and extended winter operations.

**2.3.2. Winter Maintenance Period (December 16–March 24).** Check and perform maintenance as required on the items listed below.

#### **2.3.2.1. Forebay Area and Intakes.**

- i. Remove debris from forebay and gatewell slots.
- ii. Rake trashracks just prior to the operating season.
- iii. Measure gatewell drawdown after cleaning trashracks and with ESBSs installed.
- iv. Inspect and repair gatewell; dipnet as needed.

#### **2.3.2.2. ESBS, Flow Vanes, and VBS.**

- i. After ESBSs are removed for winter maintenance, inspect for juvenile salmonid mortalities and all other incidental fish mortalities. Inspect ESBSs within a week after removal, or as soon as practical. All mortalities are to be counted, or otherwise estimated, for each ESBS and reported to CENWW-OD-T.
- ii. Maintenance completed on all screens.
- iii. Inspect ESBSs prior to installation and operate debris cleaner (dogged off on deck) to ensure proper operation.
- iv. Log results of trial run.
- v. Inspect VBSs with underwater video camera at least 1x/year; repair as needed.
- vi. Inspect flow vanes to make sure they are in good condition and all surfaces smooth. Repair as needed.
- vii. ESBSs installed in at least 4 turbine units (all 6 if possible) by March 24. Remaining ESBSs installed prior to April 1.

**2.3.2.3. Collection Channel.**

- i. Make-up water valves and float control equipment maintained and operational.
- ii. Orifice lights operational.
- iii. Orifices clean and valves operating correctly.
- iv. Orifice cycling and air backflush system operational.

**2.3.2.4. Transportation Facilities.**

- i. 42" and 72" sluice gates maintained and operating correctly.
- ii. Inclined screen clean and in good condition with no holes or damage to mesh, gaps around screen, or missing silicone.
- iii. Perforated plate smooth with no rough edges.
- iv. Wet separator and fish distribution system maintained and ready for operation.
- v. Brushes and screens on crowders in good condition; no holes or rough edges.
- vi. Crowders maintained, tested, and operating correctly.
- vii. All valves, slide gates, and switch gates maintained and in good condition.
- viii. Retainer screens in place with no holes in screens or sharp wires protruding.
- ix. Barge and truck loading pipes should be free of debris, cracks, or blockages and barge loading boom maintained and tested.
- x. All sampling equipment should be maintained and in good operating condition prior to watering up the facilities.
- xi. Maintain juvenile PIT-tag system as required (see *Columbia Basin PIT-tag Information System, General Gate Maintenance and Inspection, Walla Walla District*, February 2003). Coordinate with PSMFC.
- xii. Mini- and midi-tanks maintained and in good operating condition.

**2.3.2.5. Barges.**

- i. All engines and pumps maintained and in good operating condition.
- ii. Fish release openings and related equipment in good operating condition.
- iii. No rough edges or support beams protruding into compartments.

- iv. No brass or galvanized fittings in circulation lines.
- v. All loading hoses properly installed so fish will not hit sides of compartments or support beams when loading.
- vi. Loading hoses in good shape with rubber gaskets in cam lock fittings.
- vii. Inside edges of cam lock joints should be beveled to avoid sharp edges.
- viii. Warning systems tested and operational.
- ix. Provide net and/or deck covers.
- x. Net pens maintained and installed in barge holds for transport of steelhead kelts or juveniles as required.
- xi. Deck wash systems fully operational.
- xii. Oxygen monitoring probes installed and tested; monitoring system operational.

**2.3.2.6. Avian Predation Areas (Forebay and Tailrace).** Inspect bird wires, water cannon, and other avian deterrent devices, and repair or replace as needed. Where possible, add additional bird wires or other deterrent devices to cover areas of known avian predation activity. Prepare avian abatement contract as needed.

**2.3.2.7. Maintenance Records.** Record all maintenance and inspections.

**2.3.3. Juvenile Fish Passage Season (March 25 – December 15).** Check and perform maintenance as required on the items listed below.

**2.3.3.1. Forebay Area and Intakes.**

- i. Remove debris from forebay.
- ii. Inspect gatewell slots daily for debris, fish buildup, and contaminating substances (particularly oil). Clean gatewells before they become 50% covered with debris. If the volume of debris precludes the ability to keep the gatewell at least 50% clear, they should be cleaned at least once daily. If orifice flow or fish conditions are observed that indicate an orifice may be obstructed with debris, the orifice will be closed and backflushed to remove the obstruction. If the obstruction cannot be removed, the orifice will be closed and the alternate orifice for that gatewell slot operated. If both orifices become obstructed or plugged with debris the turbine unit will not be operated until the gatewell and orifices are cleared of debris.
- iii. If a visible accumulation of contaminating substances (e.g., oil) is detected in a gatewell and cannot be removed within 24 hours, the gatewell orifices shall be

closed immediately and the turbine unit shut down within one hour until the material has been removed and any problems corrected. A preferred method for removing oil from the water surface is to install absorbent socks, booms, or pads capable of encapsulating the material, and tie off with a rope for later disposal. Action should be taken as soon as possible to remove oil from the gateway so the orifice can be reopened to allow fish to exit the gateway. Orifices shall not be closed for longer than 48 hours.

iv. Log drawdown differentials in bulkhead slots at least once per week.

v. Remove debris from forebay and trashracks as necessary to maintain less than 1' of additional drawdown in gate slots (relative to drawdown with a clean screen). Additional raking may be required when heavy debris loads are present in the river or if fish condition indicates an issue.

vi. Coordinate cleaning effort with personnel operating juvenile collection facilities.

vii. Dip bulkhead gateway slots to remove fish prior to installing bulkhead for dewatering bulkhead slot.

#### **2.3.3.2. ESBS, VBS, and Operating Gates.**

i. ESBSs and flow vanes installed in all operating turbine units by March 24.

ii. Operate ESBSs with flow vanes attached to screen.

iii. Operate ESBSs with debris cleaners in automatic mode. Set cleaning frequency as required to maintain clean screens and good fish condition. Change cleaning frequency as needed.

iv. Inspect each ESBS by underwater video once per month in April, May, and June. Conduct similar inspections in August and October, focusing on at least three turbine units at the judgment of Project personnel. Spot check VBSs at the same time.

v. If an ESBS is damaged or fails during the juvenile fish passage season, follow procedures defined in **section 3.2.2**. In no case should a turbine unit be operated with a missing or a known non-operating or damaged ESBS, except as noted.

vi. Up to half of the project's ESBSs may be pulled after October 1 for maintenance as long as unscreened turbine units are not operated.

vii. Make a formal determination at the end of season as to the adequacy of ESBS bar screen panels and debris cleaner brush, and replace components as necessary.

viii. Measure VBS head differentials at least once per week April 1–June 30 (more frequently if required) and biweekly for the remainder of the operating

season. When a head differential of 1.5' is reached, the respective turbine unit should be operated at a reduced loading ( $\leq 110$  MW) to minimize loading on the VBS and potential fish impingement until the VBS can be cleaned. Clean VBSs as soon as possible after a 1.5' head differential is reached.

**ix.** Inspect at least two VBSs in two different turbine units between spring and summer. Both units should have been operated frequently in the spring. If a debris accumulation is noted, inspect other VBSs and clean debris as necessary.

**x.** Turbine units are to be operated with raised operating gates when ESBSs are installed (March 25–December 15) to improve fish guidance efficiency (FGE), except as provided in **section 4.3**.

**xi.** When extreme cold weather is forecasted (defined as forecasted temperatures below 20°F for  $\geq 24$  hours) between Thanksgiving and December 15, ESBSs and STSs may be removed. The project will first request special permission from CENWW-OD-T. CENWW-OD-T will inform NOAA Fisheries and FPOM of the action.

**xii.** When extreme cold weather is forecasted to occur for an extended period of time (defined as forecasted temperatures  $< 20^\circ\text{F}$  for  $\geq 24$  hours) between Thanksgiving and December 15, ESBSs and STSs may be removed. The project will first request special permission from CENWW-OD-T. CENWW-OD-T will inform NOAA Fisheries and FPOM of the action. NOAA's National Weather Service forecast for Lower Granite Dam is available at:  
<http://forecast.weather.gov/MapClick.php?lat=46.658178954000505&lon=-117.43311929599969>

### **2.3.3.3. Collection Channel.**

**i.** Orifices clean and operating. Operate at least one orifice per gateway slot (preferably the north orifice) unless a unit is scheduled out of service with non-operational fish screens. If the project is operating within the Minimum Operating Pool (MOP), additional orifices may be operated to maintain a full collection channel. If orifices must be closed to repair any part of the facility, do not close orifices in operating units with ESBSs in place for longer than 5 hours. If possible, keep to less than 3 hours. Reduce turbine unit loading to the lower end of the 1% range if deemed necessary by the project biologist. Monitor fish conditions in gatewells hourly or more frequently during orifice closure periods.

**ii.** Orifice lights operational and operating on open orifices. Orifice lights and area lights may be turned off the evening before the channel is dewatered at the end of the season (dewatering occurs on December 16 or later) to encourage fish to exit the channel volitionally. Area lights can be turned on briefly for personnel access if necessary.

**iii.** Replace all burned out orifice lights within 24 hours of notification. Orifice lights shall remain lighted 24 hours/day.

- iv. Orifice jets hitting no closer than 3' from back wall, collection channel full.
- v. Rotate orifices in fish screens slots weekly (6 open).
- vi. Orifice valves are either fully open or closed.
- vii. Backflush orifices in the bulkhead slots every four hours and more frequently if required. During periods of high fish and debris passage, April 1 through August 15, orifices should be inspected and backflushed more frequently as determined by the project biologist, to keep orifices clean. If debris is causing continual orifice plugging problems in a particular turbine unit gatewell, the respective turbine unit generation may be restricted to the lower end of the 1% peak turbine efficiency range to minimize orifice plugging problems.
- viii. If utilizing the automatic orifice backflush system, inspect as determined by the project biologist (but at least once per 8-hour shift unless coordinated differently) to ensure that the orifices are opening and closing correctly and are clear of debris. The project biologist will determine the frequency of automatic orifice cycling and back-flushing to maintain clear orifices.
- ix. Make-up water valves and associated float controls operational and maintaining stable channel flow.

#### **2.3.3.4. Transportation Facilities.**

- i. 42" and 72" sluice gates operational; 42" separator remote controller switch fully operational.
- ii. Maintain stable water conditions in upwell and separator. No holes, broken wires, or gaps in inclined screen. Operate separator and fish distribution system as designed.
- iii. Crowder screen brushes should be maintained in good operating condition, with no holes or sharp edges on crowder screens. Crowders should be in good operating condition.
- iv. All valves, slide gates, and switch gates in and around separator and raceways operational.
- v. Inspect raceway and tank retainer screens to make sure they are clean with no holes or protruding wire.
- vi. Barge and truck loading pipes, hoses, and related equipment free of debris, cracks, or blockages and in good condition. Barge loading boom in good operating condition. Barge loading boom remote control system fully operational.
- vii. Inform PSMFC, in advance if possible, of situations that cause the PIT-tag system to become inoperable (e.g., power outages) or that could result in

confounding the interpretation of PIT-tag data (e.g., bypassing fish from raceways to the river, operating in primary bypass mode without an operational full-flow detector, emergency dewatering).

### 2.3.3.5. Avian Predation Areas (Forebay and Tailrace).

- i. Bird wires and avian deterrent devices monitored to ensure they are in good condition. Any broken wires or devices should be replaced as soon as possible.
- ii. Harassment program in place to deter avian predation in areas actively used by birds and not covered by bird wires or other devices.
- iii. Project biologists shall routinely monitor project areas to determine areas of active avian predation and, if possible, adjust harassment program to cover areas or install bird wires or other deterrent devices to discourage predation activities.

### 2.3.3.6. Removable Spillway Weir (RSW).<sup>1</sup>

- i. The RSW in spillbay 1 will be in the raised position and operational on the first day of spill for juvenile fish passage.
- ii. When the RSW is in operation, spill through Bay 1 is fixed at approximately 6.8 kcfs. The spillgate shall be raised to where it does not touch flow passing down the RSW (at least nine stops).
- iii. When the National Weather Service forecasts Lower Granite inflows to exceed 200 kcfs, initiate aggressive forebay debris removal so that RSW operation will not be impeded and coordinate with RCC and CENWW-OD-T.
- iv. Complete RSW stow (complete rotation to the landing pad) when inflows exceed 260 kcfs, upstream river gauge flows are increasing, and the NWS forecasts Lower Granite inflow to exceed 300 kcfs.
- v. On or after June 21 (start of summer spill), when average daily total project outflow is less than 30 kcfs and forecasted to remain below 30 kcfs for three days or more on a declining hydrograph, the RSW will be closed and spill will be distributed in patterns for spill with no RSW in **Table LWG-9**.
- vi. When the project is not spilling, operation of the RSW for short periods of time may be requested by the Project Biologist through CENWW during low flow years if it appears the juvenile fish transportation facility and barge holding capacities will be exceeded, as described in the *Juvenile Fish Transportation Plan (Appendix B)*.

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<sup>1</sup> Spillway weirs provide surface passage routes via spillbay(s). Temporary, or Top, Spillway Weirs (*TSWs*) at Little Goose, McNary and John Day dams can be installed, uninstalled and moved between bays using the gantry crane. Removable Spillway Weirs (*RSWs*) at Lower Granite, Lower Monumental and Ice Harbor dams are “removed” by controlled descent to the bottom of the forebay.

### **2.3.3.7. Inspection and Record Keeping.**

- i. Inspect fish facilities at least once every 8 hours. Inspect facilities according to fish facilities monitoring program.
- ii. Record all maintenance and inspections.

## **2.4. Operating Criteria - Adult Fish Facilities.**

**2.4.1. Winter Maintenance Period (January 1 – end of February).** Maintenance will be scheduled to target returning the adult fish ladder to service by February 15 to the extent possible, and by no later than March 1.

**2.4.1.1.** Inspect all staff gauges and water level indicators; repair and/or clean as necessary.

**2.4.1.2.** Dewater the ladder and inspect all dewatered sections of fish facilities for projections, debris, or plugged orifices which could injure fish or impede fish passage up the ladder. The fish ladder exit trashrack must have smooth surfaces where fish pass, and must have downstream edges that are adequately rounded or padded. A spare trashrack should be on hand for use as necessary. Inspect all diffuser gratings and chambers, and the fallout fence, annually by dewatering or by using divers or video inspection techniques. All diffuser gratings and chambers are to be dewatered and physically inspected at least every 3 years. Repair deficiencies.

**2.4.1.3.** Inspect for and clean debris from the fish ladder exit. The trashrack and picketed leads must be clean and installed correctly.

**2.4.1.4.** Calibrate all water level measuring devices, as necessary, for proper facility operations.

**2.4.1.5.** Inspect all spill gates and ensure that they are operable.

**2.4.1.6.** Fish pumps maintained and ready for operation.

**2.4.1.7.** Maintain adult PIT-tag system as required. Coordinate with PSMFC.

**2.4.1.8.** Maintain the adult fish trap as required.

**2.4.1.9.** Clean debris from the diffuser-14 trashrack (entrance). Check under the diffuser-14 ladder grating for debris accumulation and remove – if necessary. Check limit switch settings on diffuser-14 controller and ensure full operation.

**2.4.2. Adult Fish Passage Season (March 1 – December 31).** The adult fish ladder may be returned to service as early as February 15 to the extent possible, and by no later than March 1.

*Note:* Little Goose pool may be operated within MOP (forebay elevation range 633'–634' msl), as part of the Corps' efforts to improve migration conditions for juvenile salmonids. This may result in some of the Lower Granite adult fishway entrances bottoming out on their sills prior to

reaching criteria depths. Continuous operation within MOP may also result in increased pumping head on the auxiliary water supply pumps, decreasing the amount of water pumped. Fish pump #1 may be run at “slow speed” to avoid frequent tripping from an overload condition while operating within MOP.

**2.4.2.1. Fishway Ladder.** Water depth over weirs: 1' to 1.3'.

- i. To facilitate proper operation of adult fishway weirgate entrances, powerhouse electricians shall raise and lower individual weirgates to check the limit switch settings and make necessary adjustments and/or begin planning for necessary repairs to occur during winter maintenance (Jan 1–end of Feb). The checks must be performed while the ladder is watered up and are expected to take approximately one hour per weirgate. Checks shall be conducted near the end of the day during the period December 15-31 when adult fish passage is minimal.

**2.4.2.2. Counting Window.** The crowder shall be opened to full count slot width when not counting. The crowder shall be open as far as possible to allow accurate counting and shall not be closed to less than 18” while counting. This will usually occur during high turbidity conditions to allow count accuracy criteria to be achieved. The counting slot has a width range of 12-30”. All equipment should be maintained in good condition. Counting window and backboard should be cleaned as needed to maintain good visibility.

**2.4.2.3. Head on all Fishway Entrances.** Head range: 1' to 2'.

**2.4.2.4. North Shore Entrances (NSE-1&2).** Elevation at top of gates on sill = 625'.

- i. Operate both downstream gates.
- ii. Weir depth: 7' or greater below tailwater.

**2.4.2.5. North Powerhouse Entrances (NPE-1&2).** Elev. at top of gates on sill= 628'.

- i. Operate both downstream gates.
- ii. Weir depth: 8' or greater below tailwater. At tailwater below elevation 636', weirs should be on sill.

**2.4.2.6. Floating Orifice Gates (FOGs).** Operate four FOGs (1, 4, 7, 10). Inspect fish fallout fence for debris buildup, holes, etc.

**2.4.2.7. South Shore Entrances (SSE-1 & 2).** Elevation at top of gates on sill = 625'.

- i. Operate both gates.
- ii. Weir depth: 8' or greater below tailwater.
- iii. At tailwater below elevation 633' weirs should be on sill.

**2.4.2.8. Channel Velocity.** 1.5' to 4' per second, as measured by a "*Stevens Programmable Monitor*" connected to a flow meter in the junction pool area (meter and monitor installed and serviced every few years by Dale R. Fraser Sales and Service, P.O. Box 785, Gresham, OR 97030, 503-658-2649).

- i. To take an actual reading, turn monitor on and allow a few seconds to warm up. Record six separate velocity readings and calculate average. Information is recorded on the daily adult fishway inspection form. At the end of the inspection week, average all readings and note maximum and minimum velocity. This information is included in the weekly adult fishway report.

**2.4.2.9. Tunnel Lights.** Lights in the tunnel section under the spillway shall be on during fish passage season. The mirror that is placed so that the tunnel lights can be seen should be clean and functional.

**2.4.2.10. Head on Trashracks.**

- i. Maximum head of 0.5' on ladder exit.
- ii. Maximum head on picketed leads shall be 0.3'.
- iii. Trashrack and picketed leads installed correctly.

**2.4.2.11. Staff Gauges and Water Level Indicators.**

- i. All staff gauges should be readable at all water levels encountered during the fish passage season. Repair/clean as necessary.
- ii. Inform PSMFC, in advance if possible, of situations that cause the PIT-tag system to become inoperable (e.g. power outages) or that could result in confounding the interpretation of PIT-tag data (e.g. emergency dewatering).

**2.4.2.12. Facility Inspections.**

- i. Powerhouse operators shall inspect adult facilities once per day shift and check computer monitor information at least once during each back shift.
- ii. Project biologists shall inspect adult facilities at least three times per week. Inspect all facilities according to fish facilities monitoring program.
- iii. Picketed leads shall be checked during all inspections to ensure they are clean and in the correct position (all the way down).
- iv. Project personnel shall check calibration of fishway control system twice per month to ensure that it is kept within calibration. This may be done as part of routine fishway inspections. Deviations in readings should be reported to the electrical crew foreman for corrective action.

v. Inspect fishways daily for foreign substances (particularly oil). If substances are found, corrective actions should be undertaken immediately.

vi. Record all inspections.

**2.4.2.13. Adult Trap Holding Tanks.** Protocols for operating the adult trap for research and other activities are covered in **Appendix G**. This criterion supplements that appendix and governs use of the holding tanks for research or broodstock collection and water supply. The water supply for the trap comes from the diffuser water supply at the top of the ladder and trap operations can affect the amount of water in the ladder proper. Operating all six holding tanks may require that modifications be made to the auxiliary water supply to diffuser #14.

i. Prior to and during the period of use of any holding tanks at the Adult Trap, the COE should inspect and clean if necessary the intake to the diffuser #14 auxiliary water supply. Additionally, the COE should inspect and repair potential sources of leakage in the diffuser #14 water supply.

ii. No holding tanks can be used prior to September 1 of each year if their usage affects the amount of water passing down the fish ladder and a water depth of less than 12 inches of water is maintained over the ladder weirs.

iii. After September 1, the two smaller of the six holding tanks only may be used to hold adult fish for hatchery broodstock or other research needs if the use of more tanks will limit the ability of the LWG fish ladder to meet its depth over ladder weir criteria.

iv. Additional holding tanks may be used if modifications are made to the diffuser #14 water supply that allow a water depth of 12 inches or greater over the ladder weirs in addition to meeting the needs of the additional tanks.

## **2.5. Fish Facility Monitoring & Reporting.**

**2.5.1.** Project biologists shall inspect fish facilities at the frequencies defined in the juvenile and adult fish facilities operating criteria sections.

**2.5.2. Weekly Reports.** Project biologists shall prepare weekly reports March 1–December 31, summarizing project operations for Friday through Thursday and email to CENWW-OD-T by noon the following Monday. Reports shall provide an overview of how the project and fish passage facilities operated during the week and evaluate resulting fish passage conditions, and include:

- i. Any out-of-criteria situations observed and subsequent corrective actions taken;
- ii. Any equipment malfunctions, breakdowns, or damage along with a summary of resulting repair activities;
- iii. Adult fishway control calibrations;
- iv. ESBS and VBS inspections;
- v. Any unusual activities that occurred that may have affected fish passage.

**2.5.3. Annual Reports.** Project biologists shall prepare a draft annual *Adult and Juvenile Monitoring Report* by February 10 and a final report by March 15 summarizing operation of adult fish passage facilities for the previous year and giving a brief overview of the juvenile fish operations. The annual report shall also include a description of all actions taken to discourage avian predation at the project, with an overview of the effectiveness of the activities in discouraging avian predation.

**2.5.4.** Project biologists also inspect project facilities once per month and during dewaterings for the presence of zebra and Quagga mussels. Biologists shall provide a report to CENWW-OD-T on a monthly basis summarizing mussel inspections.

### **3. FISH FACILITIES MAINTENANCE**

#### **3.1. Dewatering and Fish Handling.**

**3.1.1.** Project biologists should be present to provide technical guidance at all project activities that may involve fish handling. All dewaterings shall be accomplished in accordance with approved *Dewatering Guidelines and Fish Salvage Plans (Appendix F)*. When river temperatures reach 70°F or greater, all adult fish handling will be coordinated through CENWW-OD-T. Dewatering and fish handling plans were reviewed and revised in 2011 to ensure that they comply with **Appendix F**.

#### **3.2. Maintenance - Juvenile Fish Facilities.**

**3.2.1. Scheduled Maintenance.** Scheduled maintenance of juvenile facilities is conducted throughout the year. Long-term maintenance or modifications of facilities, which require extended out of service periods, are conducted during the winter maintenance period (December 16–March 24). During fish passage season, parts of the facilities are maintained on a daily, weekly, or longer interval to keep them in proper operating condition.

**3.2.2. Unscheduled Maintenance.** Unscheduled maintenance is the correction of any situation that prevents facilities from operating according to criteria or that will impact fish passage or survival.

**3.2.2.1. Notification/Reporting.** Maintenance of facilities such as ESBSs, which sometimes break down during the fish passage season, will be carried out as described below. In these cases, repairs will be made as prescribed and CENWW-OD-T will be notified as soon as possible after it becomes apparent that repairs are required. The Operations Manager has the authority to initiate work prior to notifying CENWW-OD-T if a delay of the work will result in an unsafe situation for people, property, or fish. Unscheduled maintenance that will have a significant impact on fish passage shall be coordinated with NOAA Fisheries and FPOM on a case-by-case basis by CENWW-OD-T. Information required by CENWW-OD-T includes:

- i.** Description of the problem;
- ii.** Type of outage required;
- iii.** Impact on facility operation;
- iv.** Length of time for repairs;
- v.** Expected impacts on fish passage and proposed measures to mitigate them.

**3.2.2.1. ESBSs.** The ESBSs are inspected periodically throughout the juvenile migration season with a video monitoring system. If a screen is found damaged or malfunctions at any time it will be removed and either replaced with a spare or repaired. A unit shall not be operated during the juvenile bypass season with a missing, damaged or non-operating ESBS (except as detailed below). If an ESBS fails on a weekend or at night when maintenance crews are not available, the turbine unit will be shut down and generation switched to another fully screened unit. If all screened turbine units are in service, water may be spilled until the affected ESBS can be removed and repaired or replaced.

**3.2.2.1.a.** If an ESBS screen cleaner fails after 1400 hours on a regular workday or any time on a weekend, and taking the unit out of service would result in spilling above TDG state standards, the unit may be operated with the failed screen cleaner up to a maximum of 110 MWs if there is evidence that the ESBS will not plug with debris (e.g., a lack of debris in the gatewell and along the face of the powerhouse). Project personnel will pull and replace the screen the next morning, weekday or weekend inclusive. If the screen cannot be pulled and repaired the next morning, the unit will be removed from service until the screen can be repaired. If there is evidence that fish are being injured under this operation, by either observing injured fish in the gatewells or injured fish appearing on the separator, the turbine unit will be removed from service immediately. This operation will not take place when daily average river flows are less than total powerhouse capacity and the turbine unit will not be operated during power peaking operations where turbine units are being turned on and off.

**3.2.2.2. Gatewell Orifices.** Each turbine intake slot has two 10" orifices with air-operated valves in the bulkhead slot for allowing the fish to exit the slots. However, turbine unit intake 5A has one 10" orifice and one 14" orifice, both with air-operated valves. Under normal operation, 18 bulkhead slot orifices (one per gatewell slot) shall be operated. Additional bulkhead slot orifices may be operated to hasten fish departure and/or allow debris to exit gatewells as the hydraulic capacity of the gallery will allow. If an orifice becomes blocked with debris it will normally be cleaned and remain in operation. If an orifice is damaged, it will be closed and the alternate orifice for that gatewell operated until repairs can be made. If both orifices are blocked with debris, damaged, or must be closed, the turbine unit will be taken out of service until repairs can be made. If repairs will take longer than 48 hours, juvenile fish will be dipped from the gatewell with a dip basket.

**3.2.2.3. Bypass Pipe.** The bypass pipe goes from the end of the powerhouse bypass channel to the transportation facilities downstream. All juvenile fish in the bypass system must pass through this to the transportation facilities or to the tailrace. If any part of the bypass pipe is damaged, the gatewell orifices will be closed and the bypass system dewatered until repairs can be made. *Turbine units will not be operated for longer than 5 hours with ESBSs in place and orifices closed.* If possible, keep to less than 3 hours. If an outage takes longer than 5 hours, spill will be provided to bypass juvenile fish. During any orifice closure, gatewells shall be monitored by project personnel for signs of fish problems or mortality. During periods of high fish passage, orifice closure times may be much less than 5 hours depending on fish numbers and condition.

**3.2.2.4. Transportation Facilities.** The transportation facilities can be operated to either collect juveniles for the transportation program, and/or to bypass them back to the river. If part of the facility malfunctions or is damaged, efforts will first be made to bypass the fish around the damaged area. If this is not possible, the fish will be bypassed around the transportation facilities or the entire bypass system dewatered until repairs are made. Spill may be used as an alternative avenue for fish passage during a bypass system outage.

### **3.3. Maintenance - Adult Fish Facilities.**

**3.3.1. Scheduled Maintenance.** Scheduled maintenance of a facility that must be dewatered or where maintenance will have a significant effect on fish passage will be done during the January–February winter maintenance period. Maintenance will be scheduled to target returning the adult ladder to service by February 15 to the extent possible, and by no later than March 1. Maintenance of facilities that will have no effect on fish passage may be conducted at any time. When facilities are not being maintained during the winter maintenance period, they will be operated according to normal criteria unless otherwise coordinated with NOAA Fisheries and other FPOM participants.

#### **3.3.2. Unscheduled Maintenance.**

**3.3.2.1. Notification/Reporting.** Unscheduled maintenance that will significantly affect the operation of a facility will be coordinated with NOAA Fisheries and other FPOM participants. Coordination procedures for unscheduled maintenance of adult facilities are the same as for juvenile facilities (**section 3.2.2**). If part of a facility malfunctions or is damaged during fish passage season and the facility can still be operated within criteria without any detrimental effects on fish passage, repairs may not be conducted until winter maintenance period or until fewer numbers of fish are passing. If part of a facility is damaged or malfunctions that may significantly impact fish passage, it will be repaired as soon as possible.

**3.3.2.2. Fish Ladder and Counting Station.** If any part of the ladder fails or is blocked with debris during fish passage season, efforts will first be made to correct the problem without dewatering the ladder. Trashracks, picket leads, and counting stations can sometimes be repaired or maintained without dewatering the ladder. If the fish trap malfunctions or is damaged, fish may be passed around it until repairs are made. The decision to dewater the ladder and make repairs during fish passage season or wait until the winter maintenance period will be made after coordination with the fish agencies and tribes.

**3.3.2.3. Auxiliary Water Supply (AWS).** Three electric pumps supply the auxiliary water for the fish ladder and powerhouse collection system. During normal operations and most flow conditions, two pumps are capable of providing required flows. If a pump fails during the two-pump operation, the pump on standby will be operated to make up the flows. If two pumps fail and the outage is expected to be long-term, the floating orifices should be closed and monitored in the following order: OG-4, OG-7, OG-10, OG-1. If fishway criteria still cannot be met, NSE-2 and NPE-2 will be closed and NPE-1 raised in 1' increments to provide the required 1'–2' head differential. If the head cannot be maintained by the time the top of the weir reaches 5', then SSE-1 and SSE-2 should be raised in 1' increments until 5'

below tailwater is reached. If all three pumps fail, NSE-1 and NPE-1 should be closed, the powerhouse collection channel bulkheaded off at the junction pool, and SSE-1 and SSE-2 operated at 6' below tailwater regardless of the head.

**3.3.2.4. Fishway Entrances.** The fishway entrances consist of main entrance weirs with hoists and automatic controls, and floating orifices which regulate themselves with tailwater fluctuations. If any of the automatic controls malfunction, the weirs can be operated manually by project personnel and kept within criteria. If there is a further failure which prevents an entrance from being operated manually, the weirs can usually be left in a lowered position while repairs are being conducted or the entrance closed and the water redistributed to other entrances while repairs are made. If a floating orifice fails, it will be pulled out of the water and the entrance bulkheaded off until it is repaired.

**3.3.2.5. Diffuser Gratings.** Diffuser chambers for adding auxiliary water to fish ladders and collection channels are covered by gratings attached by several different methods. Diffuser gratings are normally checked during the winter maintenance period to ensure they are in place. These inspections are done by either dewatering to physically inspect the diffuser gratings, or by using underwater video cameras, divers, or other methods. Diffuser gratings may come loose during the fish passage season due to a variety of reasons. Daily inspections of fish ladders and collection systems should include looking for any flow changes that may indicate problems with diffuser gratings. If a diffuser grating is known or suspected to have moved, creating an opening into a diffuser chamber, efforts must immediately be taken to correct the situation and minimize impacts on adult fish in the fishway. Coordination of problems should begin immediately through the established coordination procedure (see **section 3.2.2**). If possible, a video inspection should be made as soon as possible to determine the extent of the problem. If diffuser gratings are found to be missing or displaced, creating openings into the diffuser chambers, a method of repair shall be developed and coordinated with fish agencies and tribes through the established coordination procedure. Repairs shall be made as quickly as possible unless coordinated differently.

**3.3.2.6. Fallback Fence.** The fallback fence located near the north powerhouse fishway entrances shall be inspected during winter maintenance. Loose mesh on to the frame will be reattached. If any section of the netting is severely damaged, that section will be replaced.

## **4. TURBINE UNIT OPERATION & MAINTENANCE**

### **4.1. Turbine Unit Priority Order.**

**4.1.1.** From March 1 through December 15, turbine units will be operated in the order of priority defined in **Table LWG-5** in order to enhance adult and juvenile fish passage. If a turbine unit is out of service for maintenance or repair, the next unit in the priority order shall be operated.

**4.1.2.** Turbine unit priority order may be coordinated differently to allow for fish research, construction, or project maintenance activities.

**Table LWG-5. Lower Granite Dam Turbine Unit Priority Order.**

Season	Duration	Unit Priority
March 1 – December 15 Fish Passage Season	Start Units	2, 3, then 4-6 any order, then 1 <sup>a</sup>
	Stop Units <sup>b</sup>	4-6 any order, then 3, 2, 1 <sup>b</sup>
December 16 – end of February Winter Maintenance Period	Stop/Start Units	Any Order

a. Unit 1 has fixed Kaplan blades (non-adjustable) and operates in the upper 1% range. The priority order minimizes Unit 1 starts/stops and allows for the longest runtime once Unit 1 is started.

b. Stop units in reverse Start order, except run Unit 1 as long as BPA load request and required spill can be met.

#### 4.2. Turbine Unit Operating Range.

**4.2.1.** As defined in *BPA's Load Shaping Guidelines (Appendix C)*, turbine units will be operated within  $\pm 1\%$  of peak turbine efficiency (1% range) from April 1–October 31, in order to minimize mortality of juvenile fish passing through turbine units. Turbine unit discharge and power output at the lower and upper limits of the 1% range for various heads are defined in **Table LWG-6** (Units 1-3), **LWG-7** (Units 4-6). If operation outside the 1% range is necessary, Project personnel shall record the information and provide to BPA on a weekly basis according to the *Guidelines*. Operation outside of 1% range may be necessary to:

- i. Meet BPA load requirements. Load will be requested in accordance with BPA's policy, statutory requirements, and Load Shaping Guidelines (**Appendix C**);
- ii. If the draft tube is to be dewatered, the unit will be operated at full load ( $>1\%$ ) for a minimum of 15 minutes prior to installing tail logs. If not possible to load, the unit will be run at speed-no-load ( $<1\%$ ) for a minimum of 15 minutes. This is to reduce the number of fish in the unit prior to installing stop logs;
- iii. Operate a turbine unit solely to provide station service (speed-no-load); or
- iv. Comply with other coordinated fish measures.

**4.2.2.** From November 1–March 31, turbine units will continue to be operated within the 1% range except when BPA load requests require units to be operated outside the 1% range. Unit 1 has fixed Kaplan blades and can only run in the upper 1% range.

**4.2.3. Minimum Generation.** All of the lower Snake River powerhouses may be required to keep one generating turbine unit online at all times to maintain power system reliability. The minimum generation range of a turbine unit is derived from the 1% range tables below and actual unit operations, as defined in the FOP Table 1 (**Appendix E**). During low flow, there may not be enough river flow to meet this generation requirement and required minimum spill. Under these circumstances the minimum generation requirement will take precedence over the minimum spill requirement. Actual attainable minimum generation levels may vary depending on project conditions.

### **4.3. Turbine Unit Maintenance.**

#### **4.3.1. Maintenance Schedule.**

**4.3.1.1.** The turbine unit maintenance schedule will be reviewed annually by project and Operations Division biologists for fish impacts.

**4.3.1.2.** Each turbine unit requires annual maintenance that may take from two to five weeks, and is normally scheduled during the mid-July to late November timeframe. Maintenance of priority units for adult passage is normally conducted in late October through December when fewer adults are migrating.

**4.3.1.3.** Maintenance of priority units will be scheduled for winter maintenance period or when there are few fish passing the project, to the extent possible.

**4.3.1.4.** Turbine units may occasionally require overhauls to repair major problems with the turbine or generator. Overhauls may take over one year to accomplish.

**4.3.1.5.** Turbine units, governors, exciters, and control systems require periodic maintenance, calibration, and testing which may take them outside of the 1% range. This work will be scheduled in compliance with *BPA Load Shaping Guidelines (Appendix C)* to minimize impacts on juvenile fish.

#### **4.3.2. Operational Testing.**

**4.3.2.1.** Pre-Maintenance: Units may be operationally tested for up to 30 minutes before going into maintenance status by running the unit at speed-no-load and various loads within the 1% range for pre-maintenance measurements and testing, and to allow all fish to move through the unit.

**4.3.2.2.** Post-Maintenance: Units may be operationally tested after maintenance or repair while remaining in maintenance or forced outage status. Operational testing may consist of running the unit for up to a cumulative time of 30 minutes (within 1% range) before it is returned to operational status.

**4.3.2.3.** Operational testing of a unit under maintenance is in addition to a unit in run status required for power plant reliability. Operational testing may deviate from FPP priority order and may require water that would otherwise be used for spill if the unit running for reliability is at its 1% lower limit (i.e., minimum generation). Water for operational testing will be used from powerhouse allocation when possible, and diverted from spill only to the extent necessary to maintain generation system reliability.

**4.3.3. Operating Gates.**<sup>2</sup> Turbine units are to be operated with operating gates in the *raised* position to improve fish passage conditions when ESBSs are installed, except as provided below:

**4.3.3.1.** Operation of units with operating gates in the standard position shall be restricted to July 1–December 15, and shall not occur unless at least four other units are available for service. No more than one unit at a time shall be operated with operating gates in the standard operating position.

**4.3.3.2.** The Project Biologist will be notified when the operating gates are set in standard operating position, and will monitor the gatewells twice per day to observe fish condition while operating gates are in the standard position.

**4.3.3.3.** Operating gates are used to dewater units to facilitate annual maintenance. Unit outage periods will be minimized to the actual time required for maintenance by lowering operating gates in one unit to the standard operating position and connecting to hydraulic cylinders on the afternoon of the last regular workday (normally Thursday) prior to the start of the maintenance. The unit may be operated with operating gates in the standard position until 0900 hours the next regular workday (normally Monday).

**4.3.3.4.** After maintenance, the unit can be operated with one operating gate in the standard position until 0900 hours of the first regular workday after maintenance is completed.

**4.3.3.5.** If unit maintenance or raising of the operating gates is delayed beyond the times stated above, the unit shall be immediately taken out of service until work can be completed.

**4.3.4. Dewatering Units.** Dewatering turbine units should be accomplished in accordance with project dewatering plans. If the turbine unit draft tube is to be dewatered, operate unit with full load for a minimum of 15 minutes prior to installing tail logs. If not possible to load, run unit at speed-no-load for minimum of 15 minutes. This is to reduce the number of fish in the scroll case prior to installing stop logs. If a turbine unit is out of service for maintenance for an extended period of time without tailrace stop logs in place, efforts should be made to not open the wicket gates if the scroll case must be dewatered at a later date without the unit being spun beforehand.

**4.3.5. Doble Testing.** See **Appendix A** for yearly test schedule. Transformer Doble testing is required every three years, or more frequently if there is a known problem with a transformer, and requires the associated turbine units to be out of service for 3–5 workdays. Doble testing is normally scheduled for August or early September in conjunction with other scheduled unit maintenance to minimize impacts on fish passage. To conduct testing, the transmission lines must be disconnected from the transformers and normal generation stopped. One turbine unit will operate at speed-no-load (approximately 5 kcfs) to provide project power and operation of fish passage facilities (station service). Spill may be provided to meet minimum required project discharge during testing. If Doble testing will impact priority units for fish passage, adult passage timing should be considered to minimize impacts to migrating adults. Available units will be operated in accordance with FPP priority order and within the 1% range.

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<sup>2</sup> Operating gates may also be referred to as “head” gates at some projects. The terms are interchangeable.

**4.3.5.1.** Lower Granite transformer T1 or T2 bank Doble testing requires daily full line outages. Unit 5 will be run at speed-no-load (approximately 5 kcfs) daily to supply station service power. When T1 is tested, T2 (Units 5-6) will be returned to service at night and T1 (Units 1-4) will remain OOS for the duration of the Doble test. When T2 is tested, T1 (Units 1-4) will be returned to service at night and T2 (Units 5 and 6) will remain OOS for the duration of the Doble test. In years when Doble testing is to be performed it will normally be scheduled to begin the second full week in August from 0600-1800 hours. Details of Doble testing will be included in the Lower Granite weekly ESA report.

**4.3.6. Turbine Unit Outages during High Flows.** During high spring flows, turbine unit outages for inspecting fish screens, repairing research equipment (e.g., hydroacoustic or radio-telemetry), and/or other fish items may cause increased spill in order to maintain reservoir levels within operating ranges. This may result in TDG exceeding standards. It is important that this work be conducted when scheduled to ensure that facilities are working correctly and not injuring migrating fish, and that important fish research data are collected. To facilitate this work, reservoir storage may be utilized to minimize impacts from taking turbine units out of service and increasing spill.

**4.3.6.1.** At Lower Granite, this special operation shall take place when flow is above 120 kcfs or when increasing spill will result in TDG exceeding standards. The activities covered under these operations will be coordinated with TMT whenever possible.

**4.3.6.2.** For scheduled inspection or repair of research equipment, reservoirs shall be drafted to MOP and allowed to fill to 1' above the MOP forebay range as work is accomplished. After the work, reservoirs will be drafted back to MOP. When inspection or repair work can be scheduled ahead of time, the following process will be followed:

- i.** Project personnel shall schedule unit outages through the approved outage scheduling procedure by noon Tuesday of the week prior to the outage.
- ii.** Project personnel shall also contact CENWW-OD-T and RCC by the same time period and inform them of the intended work.
- iii.** RCC will coordinate work activities through TMT.
- iv.** After coordination with the TMT, RCC shall issue a teletype issuing instructions to project and BPA personnel for the scheduled work.
- v.** Spill will be increased by one spillbay stop setting (about 1.7 kcfs) above passing inflow to lower the level of Lower Granite pool to MOP prior to the scheduled work taking place.
- vi.** When work takes place, additional spill will not be provided and the reservoir will be allowed to refill until the reservoir is 1' above the MOP range (a 2' pondage from where the pool was when the work started). At this point, screen inspections shall stop. (At Snake River projects, this should allow about one normal workday for the scheduled work.)
- vii.** At the conclusion of the work, the reservoir shall be drafted back down to MOP utilizing a one spillbay stop increase in spill above passing inflow.

**viii.** If work (e.g., screen inspections) is not finished, project personnel shall schedule another turbine unit outage for a date where it can be implemented.

**4.3.6.3.** If the work is of an emergency nature that does not normally require the unit to be taken out of service (e.g., failed hydroacoustic transducer vs. failed fish screen), and cannot wait for the above process to be implemented, project personnel shall notify CENWW-OD-T and RCC for approval. If approved, the unit shall be taken out of service and the reservoir level may be operated up to 1' above the MOP range. At this point, the unit must be returned to service and the reservoir will be drafted back to the MOP range using one spillbay stop setting above passing inflows.

**Table LWG-6. Lower Granite Dam Turbine Units 1, 2, 3 Power (MW) and Flow (cfs) at Upper and Lower Limits of the  $\pm 1\%$  Peak Efficiency Operating Range.** <sup>a, b</sup>

Project Head (feet)	Turbine Units 1 <sup>b</sup> , 2, 3							
	With ESBSs				No ESBSs			
	1% Lower Limit		1% Upper Limit		1% Lower Limit		1% Upper Limit	
	(MW)	(cfs)	(MW)	(cfs)	(MW)	(cfs)	(MW)	(cfs)
<b>85</b>	<b>69.9</b>	<b>11,938</b>	<b>116.2</b>	<b>19,863</b>	<b>65.7</b>	<b>10,897</b>	<b>120.6</b>	<b>20,010</b>
86	70.6	11,922	118.5	20,007	66.4	10,882	123.0	20,155
87	71.4	11,906	120.8	20,146	67.2	10,868	125.4	20,296
88	72.2	11,890	123.1	20,282	67.9	10,853	127.8	20,434
89	73.0	11,875	125.4	20,415	68.6	10,839	130.2	20,568
<b>90</b>	<b>73.7</b>	<b>11,859</b>	<b>127.7</b>	<b>20,544</b>	<b>69.3</b>	<b>10,826</b>	<b>132.6</b>	<b>20,698</b>
91	74.6	11,849	128.1	20,346	70.2	10,817	133.0	20,500
92	75.5	11,839	128.5	20,152	71.0	10,808	133.3	20,305
93	76.3	11,829	128.8	19,963	71.8	10,799	133.7	20,115
94	77.2	11,818	129.2	19,777	72.6	10,790	134.1	19,929
<b>95</b>	<b>78.1</b>	<b>11,808</b>	<b>129.5</b>	<b>19,596</b>	<b>73.4</b>	<b>10,781</b>	<b>134.4</b>	<b>19,747</b>
96	79.1	11,825	129.7	19,385	74.4	10,797	134.6	19,536
97	80.2	11,841	129.8	19,179	75.4	10,813	134.7	19,329
98	81.2	11,857	130.0	18,978	76.4	10,827	134.9	19,126
99	82.3	11,872	130.1	18,780	77.4	10,842	135.0	18,928
<b>100</b>	<b>83.3</b>	<b>11,887</b>	<b>130.3</b>	<b>18,586</b>	<b>78.3</b>	<b>10,855</b>	<b>135.2</b>	<b>18,734</b>
101	84.2	11,890	132.0	18,637	79.2	10,858	137.0	18,785
102	85.1	11,892	133.7	18,687	80.0	10,860	138.8	18,836
103	86.0	11,895	135.4	18,736	80.9	10,863	140.6	18,885
104	86.9	11,897	137.2	18,784	81.7	10,865	142.4	18,934
<b>105</b>	<b>87.8</b>	<b>11,899</b>	<b>138.9</b>	<b>18,830</b>	<b>82.5</b>	<b>10,867</b>	<b>144.2</b>	<b>18,981</b>

a. Tables revised to reflect new information using the 2004 Unit 3 NS index test and the 1962 model test regarding extended-length submersible bar screens.

b. Unit 1 restricted to operate in upper 1% range (approximately 17-19 kcfs) due to welded runner blades (non-adjustable) in 2012 to address cracks in the link pins from shear fatigue. This restriction of Unit 1 operation will continue until the unit is restored to an adjustable-blade Kaplan.

**Table LWG-7. Lower Granite Dam Turbine Units 4, 5, 6 Power (MW) and Flow (cfs) at Upper and Lower Limits of the  $\pm 1\%$  Peak Efficiency Operating Range. <sup>a</sup>**

Project Head (feet)	Turbine Units 4, 5, 6							
	With ESBSs				No ESBSs			
	1% Lower Limit (MW) (cfs)		1% Upper Limit (MW) (cfs)		1% Lower Limit (MW) (cfs)		1% Upper Limit (MW) (cfs)	
85	83.9	13,761	107.2	17,586	85.1	13,602	116.0	18,546
86	85.0	13,769	108.9	17,652	86.1	13,600	117.9	18,616
87	86.1	13,777	110.7	17,717	87.2	13,597	119.8	18,685
88	87.1	13,784	112.4	17,780	88.2	13,595	121.7	18,751
89	88.2	13,791	114.2	17,841	89.2	13,592	123.5	18,816
90	89.3	13,798	115.9	17,900	90.3	13,589	125.4	18,879
91	90.3	13,778	117.1	17,878	91.4	13,598	126.8	18,856
92	91.2	13,759	118.4	17,857	92.5	13,607	128.1	18,834
93	92.1	13,740	119.6	17,836	93.7	13,615	129.4	18,812
94	93.1	13,722	120.8	17,815	94.8	13,623	130.8	18,791
95	94.0	13,703	122.0	17,795	95.9	13,630	132.1	18,769
96	95.1	13,707	122.6	17,676	96.9	13,620	132.7	18,645
97	96.1	13,711	123.1	17,560	97.9	13,609	133.3	18,523
98	97.2	13,714	123.7	17,446	98.9	13,599	133.9	18,403
99	98.3	13,717	124.2	17,335	99.9	13,589	134.5	18,285
100	99.4	13,720	124.8	17,225	100.9	13,579	135.0	18,170
101	100.4	13,724	126.0	17,227	101.9	13,579	136.4	18,172
102	101.4	13,728	127.3	17,229	102.9	13,580	137.8	18,174
103	102.5	13,731	128.6	17,230	104.0	13,580	139.1	18,175
104	103.5	13,735	129.8	17,232	105.0	13,581	140.5	18,177
105	104.5	13,739	131.1	17,233	106.0	13,581	141.9	18,179

a. Tables revised to reflect new information using the 2004 Unit 3 NS index test and the 1975 model test regarding extended-length submersible bar screens.

## **5. FOREBAY DEBRIS REMOVAL**

Debris at projects can impact fish passage conditions. Debris can plug or block trashracks, VBSs, gatewell orifices, dewatering screens, separators, and facility piping resulting in fish impingement, injuries and/or descaling. Removing debris from the forebay is sometimes necessary to maintain safe and efficient fish passage conditions, navigation and other project activities. Debris can be removed from the forebay by physical removal (e.g., using boats to encircle the debris with log booms and tow it to shore where it can be removed with a crane, or using a crane and scoop from the top of the dam to remove forebay debris) or by passing the debris through the spillway with special spill and/or powerhouse operations. The preferred option is to physically remove debris when possible to avoid passing debris to the next downstream project. However, this is not always possible as some projects do not have forebay debris removal capability. In this case, the only viable alternative is to pass the debris via spill.

### **5.1. Debris Spill Coordination.**

All special spills (other than normal spill patterns for ongoing spill operations) and project operations for passing debris will be coordinated prior to the operations taking place. Each project shall contact CENWW-OD-T at least two workdays prior to the day they want the special project operations for spilling to pass debris. Project personnel shall provide CENWW-OD-T the reason for the debris spill request including an explanation of project facilities impacted by debris, the date and time of the requested spill, and any special powerhouse or other operations required to move the debris to the spillway. Using information provided by the project, CENWW-OD-T shall coordinate the special operations with RCC, NOAA Fisheries and FPOM. When a debris spill is coordinated and approved, RCC shall issue a teletype detailing the specifics of the special operations.

### **5.2. Emergency Debris Spills.**

Emergency spills may be implemented if necessary to pass woody debris that are accumulating in front of the spillbay weir(s), compromising the safe, unobstructed passage of fish. The operating project will immediately spill the woody debris to remove the obstructions to fish passage. The operating project will notify CENWW-OD-T of the emergency spill as soon as possible to provide notification to RCC, NOAA Fisheries and FPOM.

**Table LWG-8. Lower Granite Dam Spring Spill Patterns with RSW.** <sup>a, b</sup>

LWG Spring Spill Patterns with RSW - # Gate Stops per Spillbay								Total Stops	Spill
Bay 1 <sup>b</sup>	Bay 2	Bay 3	Bay 4	Bay 5	Bay 6	Bay 7	Bay 8	(#)	(kcfs)
RSW		1		1	1	1	1	5	15.2
RSW		1	1	1	1	1	1	6	16.9
RSW	1	1	1	1	1	1	1	7	18.6
RSW	1	1	2	1	1	1	1	8	20.4
RSW	1	1	2	1	1	1	2	9	22.2
RSW	1	1	2	2	1	1	2	10	24.0
RSW	1	1	2	2	2	1	2	11	25.8
RSW	1	2	2	2	2	1	2	12	27.7
RSW	2	2	2	2	2	1	2	13	29.5
RSW	2	2	2	2	2	2	2	14	31.3
RSW	2	2	3	2	2	2	2	15	33.2
RSW	2	2	3	3	2	2	2	16	35.0
RSW	2	2	3	3	3	2	2	17	36.9
RSW	2	3	3	3	3	2	2	18	38.7
RSW	3	3	3	3	3	2	2	19	40.6
RSW	3	3	4	3	3	2	2	20	42.4
RSW	3	3	4	4	3	2	2	21	44.3
RSW	3	3	4	4	4	2	2	22	46.2
RSW	3	4	4	4	4	2	2	23	48.0
RSW	4	4	4	4	4	2	2	24	49.9
RSW	4	4	4	4	4	2	3	25	51.7
RSW	4	4	4	4	4	3	3	26	53.6
RSW	4	4	5	4	4	3	3	27	55.5
RSW	4	4	5	5	4	3	3	28	57.3
RSW	4	4	5	5	5	3	3	29	59.2
RSW	4	5	5	5	5	3	3	30	61.0
RSW	5	5	5	5	5	3	3	31	62.9
RSW	5	5	5	5	5	3	4	32	64.8
RSW	5	5	5	5	5	4	4	33	66.6
RSW	5	5	6	5	5	4	4	34	68.5
RSW	5	5	6	6	5	4	4	35	70.3
RSW	5	5	6	6	6	4	4	36	72.2
RSW	5	6	6	6	6	4	4	37	74.1
RSW	6	6	6	6	6	4	4	38	75.9

**a.** This table defines patterns in increments of one gate stop per row. Spill (kcfs) is calculated as a function of the total number of stops plus RSW spill at forebay elevation 734.0 ft.

**b.** RSW in Bay 1= fixed spill of ~6.8 kcfs at forebay 734.0 ft. Tainter gate does not regulate flow and should be raised  $\geq 9$  stops to not interfere with RSW flow. When total project outflow is  $< 30$  kcfs, RSW will be closed and spill distributed in patterns in **Table LWG-9**.

**Table LWG-9. Lower Granite Dam Spill Patterns with No RSW (Bay 1 Closed).** <sup>a, b</sup>

LWG Spill Patterns with No RSW - # Gate Stops per Spillbay								Total Stops (#)	Spill (kcfs)
Bay 1	Bay 2	Bay 3	Bay 4	Bay 5	Bay 6	Bay 7	Bay 8		
CLOSE							1	1	1.7
CLOSE	1						1	2	3.4
CLOSE	1			1			1	3	5.1
CLOSE	1			1		1	1	4	6.8
CLOSE	1	1		1		1	1	5	8.5
CLOSE	1	1		1		1	2	6	10.3
CLOSE	2	1		1		1	2	7	12.1
CLOSE	2	1		1	1	1	2	8	13.7
CLOSE	2	1	1	1	1	1	2	9	15.4
CLOSE	2	1	1	2	1	1	2	10	17.2
CLOSE	2	1	1	2	1	2	2	11	19.0
CLOSE	2	2	1	2	1	2	2	12	20.8
CLOSE	2	2	1	2	2	2	2	13	22.6
CLOSE	2	2	2	2	2	2	2	14	24.5
CLOSE	2	2	2	2	2	2	3	15	26.4
CLOSE	2	2	2	2	2	3	3	16	28.3
CLOSE	3	2	2	2	2	3	3	17	30.2
CLOSE	3	3	2	2	2	3	3	18	32.1
CLOSE	3	3	3	2	2	3	3	19	34.0
CLOSE	3	3	3	2	3	3	3	20	35.9
CLOSE	3	3	3	3	3	3	3	21	37.8
CLOSE	3	3	3	3	3	3	4	22	39.6
<b>CLOSE</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>4</b>	<b>4</b>	<b>23</b>	<b>41.4</b>
CLOSE	4	3	3	3	3	4	4	24	43.2
CLOSE	4	4	3	3	3	4	4	25	45.0
<b>CLOSE</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>3</b>	<b>3</b>	<b>4</b>	<b>4</b>	<b>26</b>	<b>46.8</b>
CLOSE	4	4	4	3	4	4	4	27	48.6
<b>CLOSE</b>	<b>4</b>	<b>28</b>	<b>50.4</b>						
CLOSE	4	4	4	4	4	4	5	29	52.3
<b>CLOSE</b>	<b>5</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>5</b>	<b>30</b>	<b>54.2</b>
CLOSE	5	4	4	4	4	5	5	31	56.1
CLOSE	5	5	4	4	4	5	5	32	58.0
<b>CLOSE</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>4</b>	<b>4</b>	<b>5</b>	<b>5</b>	<b>33</b>	<b>59.9</b>
CLOSE	5	5	5	4	5	5	5	34	61.8
CLOSE	5	5	5	5	5	5	5	35	63.7
CLOSE	5	5	5	5	5	5	6	36	65.6
CLOSE	5	5	5	5	5	6	6	37	67.5

a. This table defines patterns in increments of one gate stop per row. Spill (kcfs) is calculated as a function of the total number of stops at forebay elevation 734.0 ft (**bold** patterns evaluated w/ Corps' LWG 1:80 physical model).

b. When total project outflow is < 30 kcfs, RSW will be closed and spill distributed in patterns in this table.

**Table LWG-10. [pg 1 of 2] Lower Granite Dam Summer Spill Patterns with RSW. <sup>a, b</sup>**

LWG Summer Spill Patterns with RSW - # Gate Stops per Spillbay								Total Stops (#)	Spill (kcfs)
Bay 1 <sup>b</sup>	Bay 2	Bay 3	Bay 4	Bay 5	Bay 6	Bay 7	Bay 8		
RSW								0	6.8
RSW		1						1	7.9
RSW		2						2	9.6
RSW		3						3	11.4
RSW		4						4	13.1
RSW		4				1		5	14.9
RSW		4			1	1		6	16.6
RSW		4			1	1	1	7	18.4
RSW		4		1	1	1	1	8	20.1
RSW	1	4		1	1	1	1	9	21.9
RSW	1	4	1	1	1	1	1	10	23.6
RSW	1	5	1	1	1	1	1	11	25.4
RSW	1	5	1	2	1	1	1	12	27.1
RSW	1	5	1	3	1	1	1	13	28.9
RSW	1	5	1	4	1	1	1	14	30.6
RSW	1	5	1	5	1	1	1	15	32.4
RSW	1	5	1	5	1	2	1	16	34.1
RSW	1	5	1	5	1	3	1	17	35.9
RSW	1	5	1	5	1	4	1	18	37.6
RSW	1	5	1	5	1	5	1	19	39.4
RSW	1	5	2	5	1	5	1	20	41.1
RSW	1	5	3	5	1	5	1	21	42.9
RSW	1	5	4	5	1	5	1	22	44.6
RSW	1	5	5	5	1	5	1	23	46.4
RSW	1	5	5	5	2	5	1	24	48.1
RSW	1	5	5	5	3	5	1	25	49.9
RSW	1	5	5	5	4	5	1	26	51.6
RSW	1	5	5	5	5	5	1	27	53.4
RSW	1	5	5	5	5	5	2	28	55.1
RSW	1	5	5	5	5	5	3	29	56.9
RSW	1	5	5	5	5	5	4	30	58.6
RSW	1	5	5	5	5	5	5	31	60.4
RSW	2	5	5	5	5	5	5	32	62.1
RSW	3	5	5	5	5	5	5	33	63.9
RSW	4	5	5	5	5	5	5	34	65.6
RSW	5	5	5	5	5	5	5	35	67.4
RSW	5	5	6	5	5	5	5	36	69.1
RSW	5	5	6	6	5	5	5	37	70.9
RSW	5	6	6	6	5	5	5	38	72.6
RSW	5	6	6	6	6	5	5	39	74.4
RSW	5	6	6	6	6	6	5	40	76.1
RSW	5	6	6	6	6	6	6	41	77.9
RSW	6	6	6	6	6	6	6	42	79.6
RSW	6	6	7	6	6	6	6	43	81.4
RSW	6	6	7	7	6	6	6	44	83.1
RSW	6	7	7	7	6	6	6	45	84.9
RSW	6	7	7	7	7	6	6	46	86.6

LWG Summer Spill Patterns with RSW - # Gate Stops per Spillbay								Total Stops (#)	Spill (kcfs)
Bay 1 <sup>b</sup>	Bay 2	Bay 3	Bay 4	Bay 5	Bay 6	Bay 7	Bay 8		
RSW	6	7	7	7	7	7	6	47	88.4
RSW	6	7	7	7	7	7	7	48	90.1
RSW	7	7	7	7	7	7	7	49	91.9
RSW	7	7	8	7	7	7	7	50	93.6

a. This table defines patterns in increments of one gate stop per row. Spill (kcfs) is calculated as a function of the total number of stops plus RSW spill at forebay elevation 734.0 ft.

b. RSW in Bay 1= fixed spill of ~6.8 kcfs at forebay 734.0 ft. Tainter gate does not regulate flow and should be raised  $\geq 9$  stops to not interfere with RSW flow. When total project outflow is  $< 30$  kcfs, RSW will be closed and spill distributed in patterns in **Table LWG-9**.