CENWW-ODH FONE 20 July, 2023

MEMORANDUM THRU:
Brian Vorheis, Operations Project Manager, Ice Harbor Dam

FOR Chief, Operations Division
ATTN: Scott St John / Chris Peery

SUBJECT: Submission of 2019 Adult and Juvenile Fish Facility Monitoring Report, Ice Harbor Dam.

1. Enclosed is the 2019 Adult and Juvenile Fish Facility Monitoring Report for Ice Harbor Dam as requested.

2. If you have any questions contact Ken Fone at Ice Harbor Dam, (509) 544-3137.

Kenneth R. Fone
Fisheries Biologist
Ice Harbor Dam

Enclosure

2019 ADULT AND JUVENILE FISH FACILITY MONITORING REPORT

ICE HARBOR DAM

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U.S. Army Corps of Engineers

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INTRODUCTION

This report summarizes the operation and maintenance of the adult and juvenile fish passage facilities at Ice Harbor Dam in 2019. The juvenile fish passage facility at Ice Harbor Dam consists of standard length submersible traveling screens, vertical barrier screens, 12-inch diameter orifices (36 orifices), a collection channel and dewatering structure, fish sampling facilities, and a transportation flume/pipe to the tailrace downstream from the dam. The juvenile fish collection channel is operated with approximately 300 cubic feet per second (cfs) flow (forebay head-dependent), which is the design operating flow produced by 20 of the juvenile fish passage orifices open. All but 30 cfs of the flow is removed at the primary dewatering structure and utilized as adult fish attraction water. The remaining 30 cfs flow and fish are routed through a transport pipe and flume to the fish sampling facility or directly to the tailwater.

The adult fish passage facilities at Ice Harbor are comprised of separate north and south shore systems. The north shore facilities include a fish ladder with a counting station, an adult fish collection channel, and a pumped auxiliary water supply system. The collection system includes two downstream entrances near the navigation lock wall at the base of the dam and one side entrance (which is bulkheaded off) from the spillway basin. The downstream entrance nearest the navigation lock wall is normally open for fish passage. Three electric pumps supply the auxiliary water for fish attraction flow. Two of the three pumps operate continuously during normal operation. The third pump serves as a backup in the case of a pump failure.

The south shore facilities are comprised of a fish ladder with a counting station, two south shore entrances, a powerhouse collection system, and a pumped auxiliary water supply system. The powerhouse collection system includes two downstream entrances and one side entrance (which is bulkheaded off) from the spillway basin at the north end of the powerhouse, twelve floating orifices, and a common fish transportation channel. The fishway entrances used during normal operation include: one south shore entrance nearest the powerhouse, one downstream north powerhouse entrance, and four floating orifices. Eight electric pumps are available to supply the auxiliary water for fish attraction, of which five to eight pumps are used during normal operation. Excess water from the juvenile fish bypass system (approximately 200-270 cfs depending on forebay head) was added to the south shore fish pump discharge chamber from March 25 through December 19, 2019.

RIVER CONDITIONS

Daily Ice Harbor outflows averaged 49.6 thousand cubic feet per second (kcfs) in 2019, with a peak outflow of 207.6 kcfs occurring on April 10, compared to a peak of 163.9 kcfs occurring in 2018. Spill for juvenile fish passage began April 3 and continued through August 31. The daily spill during that period averaged 21.1 kcfs, with a maximum daily spill of 153.3 kcfs occurring on April 10. River temperatures taken from unit 1 scroll case ranged from 35 °F in early March to 71 °F in late August. Water temperatures taken from the juvenile fish channel ranged from 45.9 °F to 69.6 °F during the juvenile fish sampling period of April 1 to July 15.

JUVENILE FISH FACILITY OPERATIONS AND MAINTENANCE

Sampling Summary

The Juvenile Fish Bypass was operated from March 28 to December 19, 2019. Normal operation of the facilities is to bypass all collected fish directly to the river, except when routine sampling is conducted for monitoring fish condition. Sampling for fish condition in 2019 began on April 1st and ended on July 15th. Fish were sampled twice a week during this time frame. The goal of a sampling event is to collect 100 fish of the predominant species within a four-hour period. Fish are visually counted as they come into the fish separator structure. During the beginning and the latter part of the season, migrating fish numbers can be low, so the target number of fish may not be collected during the four-hour period.

A total of 3,771 juvenile salmon and steelhead were sampled at the Ice Harbor Juvenile Fish Facility (JFF) in 2019 (Table 1), which was a 19.37% increase over the 2018 sample season (Table 2). Subyearling Chinook fry in the sample are not examined, but are included in the total number of fish sampled. A total of 142 non-target fish (incidental species) were released off of the separator or sampled in 2019 (Table 3). These incidental fish were identified, recorded, and released back into the river via the bypass. Siberian prawns and adult shad were the most commonly encountered incidental species during sampling events in 2019. Occassionally, there were juvenile lamprey observed in the separator and sample holding tank that did not show up in the lab. These lamprey most likely escaped out of the tank through holes of the water-regulating perforated plates.

Juvenile Fish Condition

The juvenile fish bypass and sampling facility are routinely inspected for debris obstructions, and operational and maintenance problems that could cause descaling and injury to fish. Areas that are periodically or annually unwatered are inspected more closely during the fish passage season and/or during the winter maintenance period.

The numbers of salmon and steelhead of each species group sampled by day in 2019 that were observed with descaling (at least 20% of surface area of one side of fish with missing scales), and the associated descaling rates (percent of fish sampled of each species group with descaling), are shown in Tables 4A and 4B. The combined annual descaling rate for all salmon and steelhead sampled in 2019 was 4.2%, which was a decrease from 7.0% in 2018 (Table 5). Sampling personnel attributed the descaling to predators (mostly birds) 32.7% of the time in 2019 and 21.2% of the time in 2018. In 2019, the highest descaling rate was 10.3% on May 13, which was just before unit 1 was taken out of service to address damaged mesh on a submersible traveling screen (STS) and vertical barrier screen (VBS). The STS and VBS sections below have more information about the damage found and the subsequent repairs that were made.

Table 1. Number of juvenile salmon and steelhead sampled per day at Ice Harbor Dam, 2019.

Date	Yearling Chinook		Sub-Yr Chinook		Steelhead		Sockeye		All	Daily
	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Coho	Total
1-Apr	28	39	0	0	8	0	0	0	0	75
4-Apr	49	46	0	0	14	1	0	0	0	110
8-Apr	49	43	0	0	42	5	0	0	0	139
11-Apr	24	24	0	0	79	9	0	0	0	136
15-Apr	27	12	0	0	87	7	0	0	0	133
18-Apr	52	28	1	0	80	16	0	0	0	177
22-Apr	28	7	0	0	137	26	0	0	0	198
25-Apr	49	19	0	0	78	16	0	0	1	163
29-Apr	81	13	0	0	35	12	0	0	0	141
2-May	67	33	0	0	44	12	0	0	0	156
6-May	70	20	0	0	64	21	0	0	0	175
9-May	60	14	0	0	58	10	0	0	0	142
13-May	23	4	0	0	105	15	0	0	0	147
16-May	31	6	2	2	78	26	0	0	0	145
20-May	50	11	5	5	34	11	23	1	2	142
23-May	34	5	10	7	45	26	39	0	6	172
27-May	19	4	36	26	35	22	5	2	13	162
30-May	1	1	48	54	21	15	3	0	2	145
3-Jun	3	1	32	73	14	8	1	1	1	134
6-Jun	2	0	37	62	15	5	0	1	2	124
10-Jun	0	1	39	63	3	2	0	0	2	110
13-Jun	0	0	7	7	1	3	0	0	0	18
17-Jun	0	0	1	7	2	0	0	0	0	10
20-Jun	1	0	7	17	1	0	0	0	0	26
24-Jun	0	0	43	66	0	1	0	0	0	110
27-Jun	0	0	44	51	0	0	0	0	0	95
1-Jul	0	0	56	41	0	0	0	0	0	97
4-Jul	0	0	51	43	0	0	0	0	1	95
8-Jul	0	0	58	36	0	1	0	0	0	95
11-Jul	0	0	39	62	2	0	0	0	1	104
15-Jul	0	0	36	58	0	0	0	0	1	95
Totals	748	331	552	680	1,082	270	71	5	32	3,771
% Totals	19.84	8.78	14.64	18.03	28.69	7.16	1.88	0.13	0.85	***

[1]Includes unclipped hatchery reared fish

Table 2. Number of juvenile salmon and steelhead sampled at Ice Harbor Dam, 2015-2019.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		All	
Year	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Coho	Total
2015	925	212	381	549	925	234	5	2	24	2,606
2016	641	278	321	620	966	296	27	6	25	3,180
2017	747	489	386	624	845	335	13	12	34	3,485
2018	619	333	363	545	948	264	31	18	38	3,159
2019	748	331	552	680	1,082	270	71	5	32	3,771

[1]Includes unclipped hatchery reared fish

Table 3. Collection of incidental species during sampling at Ice Harbor Dam, 2019.

Common Name	Scientific Name	Number of Fish
Channel Catfish	*Ictalurus punctatus*	1
Lamprey	*Lampetra tridentatus*	12
Walleye	*Sander vitreus*	1
Sculpin	*Cottoidea sp.*	1
Siberian Prawn	*Exopalaemon modestus*	87
Yellow Perch	*Perca flavescens*	3
Smallmouth Bass	*Micropterus dolomieu*	2
American Shad	*Alosa sapidissima*	34
Bluegill	*Lepomis macrochirus*	1
Total		142

A variety of other injuries were observed in sample fish. In general, the incidence, rate, and location of injuries on fish throughout the sampling season appeared to be random, that is, there did not appear to be a specific cause or source of injuries observed.

Total juvenile facility percent mortality for all salmon and steelhead groups combined was 0.1% in 2019, compared to 0.3% in 2018 (Table 6). Fish that are dead prior to coming into the lab are not examined for condition, but are included in the number of fish sampled. However, mortalities are checked for obvious signs of physical trauma that could have contributed to their death.

Table 4a. Number of sampled salmon and steehead with descaling at Ice Harbor Dam, 2019.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		All	
Date	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Coho	Total
1-Apr	0	0	---	---	0	---	---	---	---	0
4-Apr	0	2	---	---	1	0	---	---	---	3
8-Apr	0	0	---	---	2	1	---	---	---	3
11-Apr	0	2	---	---	3	0	---	---	---	5
15-Apr	0	0	---	---	0	0	---	---	---	0
18-Apr	1	0	---	---	2	3	---	---	---	6
22-Apr	0	0	---	---	5	1	---	---	---	6
25-Apr	1	1	---	---	4	1	---	---	---	7
29-Apr	4	0	---	---	4	1	---	---	---	9
2-May	1	0	---	---	3	0	---	---	---	4
6-May	5	0	---	---	8	1	---	---	---	14
9-May	1	0	---	---	1	4	---	---	---	6
13-May	9	0	---	---	5	1	---	---	---	15
16-May	1	0	---	---	7	0	---	---	---	8
20-May	1	0	0	0	2	2	0	0	0	5
23-May	1	1	0	0	4	3	1	---	0	10
27-May	0	1	1	0	4	3	0	0	1	10
30-May	1	0	1	2	1	2	0	---	0	7
3-Jun	1	1	0	1	1	0	0	---	0	4
6-Jun	0	---	0	0	2	0	---	0	0	2
10-Jun	---	0	0	2	0	0	---	---	0	2
13-Jun	---	---	0	0	1	0	---	---	---	1
17-Jun	---	---	0	0	0	---	---	---	---	0
20-Jun	1	---	0	0	0	---	---	---	---	1
24-Jun	---	---	3	1	---	1	---	---	---	5
27-Jun	---	---	1	3	---	---	---	---	---	4
1-Jul	---	---	3	1	---	---	---	---	---	4
4-Jul	---	---	4	1	---	---	---	---	---	5
8-Jul	---	---	3	1	---	---	---	---	---	4
11-Jul	---	---	2	2	---	---	---	---	0	4
15-Jul	---	---	2	3	---	---	---	---	0	5
Totals	28	8	20	17	60	24	1	0	1	159

--- No fish of this species sampled

[1]Includes unclipped hatchery reared fish

Table 4b. Sampling event descaling rates (%) within salmon and steelhead species groups at Ice Harbor Dam, 2019.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		All
Date	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Coho
1-Apr	0.0	0.0	---	---	0.0	---	---	---	---
4-Apr	0.0	4.3	---	---	7.1	0	---	---	---
8-Apr	0.0	0.0	---	---	4.8	20.0	---	---	---
11-Apr	0.0	8.3	---	---	3.8	0.0	---	---	---
15-Apr	0.0	0.0	---	---	0.0	0.0	---	---	---
18-Apr	1.9	0.0	---	---	2.5	18.8	---	---	---
22-Apr	0.0	0.0	---	---	3.6	3.8	---	---	---
25-Apr	2.0	5.3	---	---	5.1	6.3	---	---	---
29-Apr	4.9	0.0	---	---	11.4	8.3	---	---	---
2-May	1.5	0.0	---	---	6.8	0.0	---	---	---
6-May	7.1	0.0	---	---	12.5	4.8	---	---	---
9-May	1.7	0.0	---	---	1.7	40.0	---	---	---
13-May	39.1	0.0	---	---	4.8	6.7	---	---	---
16-May	3.2	0.0	---	---	9.0	0.0	---	---	---
20-May	2.0	0.0	0.0	0.0	5.9	18.2	0	0	0
23-May	2.9	20.0	0.0	0.0	8.9	11.5	2.6	---	0.0
27-May	0.0	25.0	2.8	0.0	11.4	13.6	0.0	0.0	7.7
30-May	100.0	0.0	2.1	3.7	4.8	13.3	0.0	---	0.0
3-Jun	33.3	100	0.0	1.4	7.1	0.0	0.0	---	0.0
6-Jun	0.0	---	0.0	0.0	13.3	0.0	---	0.0	0.0
10-Jun	---	0.0	0.0	3.2	0.0	0.0	---	---	0.0
13-Jun	---	---	0.0	0.0	100	0.0	---	---	---
17-Jun	---	---	0.0	0.0	0.0	---	---	---	---
20-Jun	100.0	---	0.0	0.0	0.0	---	---	---	---
24-Jun	---	---	7.0	1.5	---	100.0	---	---	---
27-Jun	---	---	2.3	5.9	---	---	---	---	---
1-Jul	---	---	5.4	2.4	---	---	---	---	---
4-Jul	---	---	7.8	2.3	---	---	---	---	---
8-Jul	---	---	5.2	2.8	---	---	---	---	---
11-Jul	---	---	5.1	3.2	---	---	---	---	0.0
15-Jul	---	---	5.6	5.2	---	---	---	---	0.0
Annual	3.7	2.4	3.6	2.5	5.6	8.9	1.4	0.0	3.1

--- No fish of this species sampled

[1]Includes unclipped hatchery reared fish

Table 5. Annual descaling rates (%) for salmon and steelhead species groups sampled at Ice Harbor Dam, 2015–2019.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		All	
Year	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Coho	Total
2015	4.0	4.2	2.6	1.6	6.5	8.1	0.0	0.0	4.2	4.6
2016	0.5	1.1	0.9	0.6	3.8	2.7	0.0	0.0	0.0	1.8
2017	5.9	2.5	0.5	0.5	6.0	5.7	0.0	0.0	5.9	3.8
2018	4.4	6.1	2.5	4.0	10.7	12.5	16.7	16.7	5.3	7.0
2019	3.7	2.4	3.6	2.5	5.6	8.9	1.4	0.0	3.1	4.2

[1]Includes unclipped hatchery reared fish

Table 6. Annual mortality numbers and total mortality rate for salmon and steelhead sampled at Ice Harbor Dam, 2015-2019.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		All	% of
Year	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Clipped	Unclipped[1]	Coho	Sample
2015	0	0	0	1	0	1	0	0	0	0.1
2016	0	1	3	4	0	0	0	0	0	0.3
2017	3	0	0	2	0	0	0	1	0	0.2
2018	2	3	1	0	0	1	1	0	0	0.3
2019	0	0	0	2	1	0	0	0	0	0.1

[1]Includes unclipped hatchery reared fish

Adult Salmonid Fallbacks

Typically, there are few adult fish that fall back and are released from the separator at Ice Harbor, because of the limited operation of the separator and juvenile fish sampling. All of the 2019 fallbacks were in good condition (Table 7).

Table 7. Condition of adult salmonids released from the juvenile fish separator at Ice Harbor Dam, 2019.

Date	Species Group	Condition
8-Apr	Clipped steelhead	Good
11-Apr	Unclipped steelhead	Good
16-May	Clipped steelhead	Good
23-May	Clipped Steelhead	Good
27-May	Unclipped Chinook	Good
6-Jun	Unclipped steelhead	Good

Main Turbine Unit Cooling Water Strainer Inspections

In 2019, the main unit turbine cooling water strainers were inspected monthly for the presence of lamprey, from January to June, and in December. Additionally, strainers were cleaned when debris or fish created a pressure differential across the strainers. Juvenile shad filled the strainers quite frequently in November and December. The total number of each

species group removed were approximately: three juvenile steelhead (unknown if clipped due to deterioration), one juvenile salmonid (unknown species due to deterioration), 152 juvenile Pacific lamprey, 24,489 juvenile American shad, and 244 Siberian prawns. The only fish found alive were a few lamprey and they were released back to the river.

The total number of juvenile Pacific lamprey that were found in the turbine cooling water strainers in each of the last ten years is shown in Figure 1. In general, there has been a trend of decreasing numbers of lamprey found in the strainers since 2010. The reason for this trend is unknown without further investigation of the strainer data, lamprey population trends, and the associated environmental condtions.

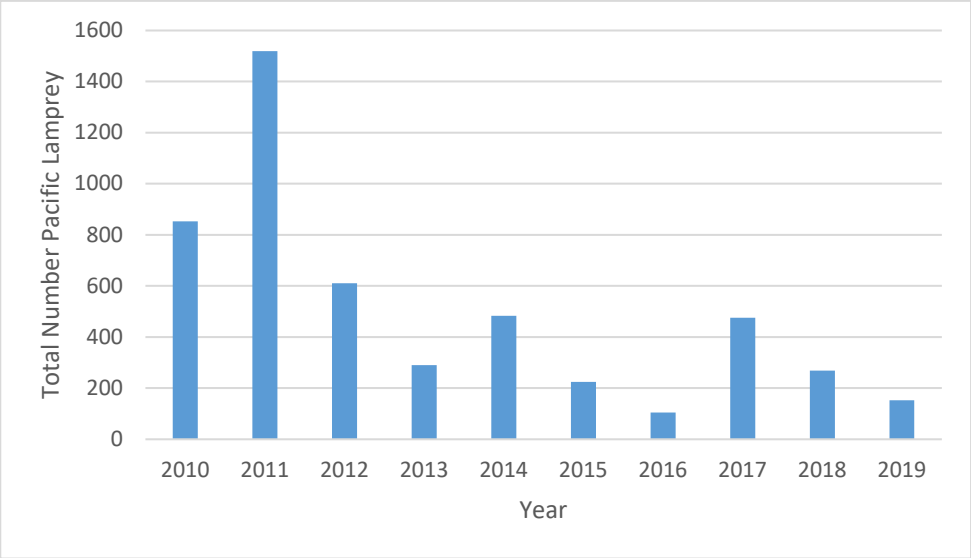

Figure 1. Yearly total number of Pacific Lamprey removed from turbine unit cooling water strainers at Ice Harbor Dam, 2010-2019.

One important factor that affects whether fish go into the unit cooling water is how the cooling water system is operated. At Ice Harbor, the cooling water is left on when a unit is not running, so fish that are in the scroll case when a unit is turned off may be more likely to get drawn into the cooling water intake (in the wall of the scroll case) than if the cooling water were shut off. Turbine units that are started and stopped frequently may be prone to attracting fish into the cooling water intake. This is why juvenile shad frequently fill the strainers at Ice Harbor.

Debris/Trash Racks

A daily maximum of 350 square yards of foreby debris was observed on June 18, 2019, compared to a maximum of 530 square yards observed on June 5, 2018. Main unit trash rack raking was completed the week of March 18. There was a relatively small amount of debris removed. No fish mortalities were found on the trash racks.

Submersible Traveling Screens

Installation of the STSs was completed on all available units on March 25, 26, and 27. An underwater video camera was used to conduct monthly inspections of STSs that were available to run since the previous inspection occurred. Screens were examined for any issues that could injure fish. The STS problems found and fixed during the season are shown in Table 8. STS inspections were attempted on April 17, but the STS could not be seen with the camera because of the high water turbidity. With the continued turbid water conditions, STS inspections were not performed until the next scheduled inspections in May. Unit 4 STSs were not installed until July 31, when preparing to return the unit to service after replacing the blade packing. Unit 3 STSs were removed for the season on May 7 after the unit was taken out of service for the runner replacement and stator rewind. The STSs for units 1 and 5 were removed on December 14 for winter maintenance, as the units were already out of service for annual maintenance. The STSs for units 4, 2, and 6 were removed on December 16, 17, and 18, respectively, for winter maintenance.

Table 8. STS problems found during inspections at Ice Harbor Dam in 2019.

Date	Unit & Slot	Screen Location	Problem	Remedy
7-May	3A	Seam	Tear along the entire seam	Repaired
15-May	1B	Mesh &seam	Tear in mesh; separating seam	Replaced with spare STS
18-June	6A	Several seams	12” and smaller gaps	Replaced with spare STS
29-Oct	4A	Seam	Tear several feet long in seam	Replaced with spare STS
12-Nov	4A	Seam	Entire seam separation	Repaired and reinstalled

Vertical Barrier Screens

Project personnel inspected the VBSs while conducting STS inspections. Different turbine unit’s VBSs were inspected each month until they were all inspected. Unit 1 VBSs were inspected on May 15. Slot 1A VBS was found to have numerous holes and tears in the mesh, including one tear measuring approximately 2’ x 4’, in the bottom panel of the VBS. No fish were seen inside the damaged VBS. In order to repair the VBS in slot 1A, 1A STS was first removed, debris was removed from the slot, fish were dipped out of the slot, the maintenance bulkhead was installed, and then the slot was unwatered. Two holes in the VBS mesh, measuring approximately 4” in diameter, were patched. The other tears were over a closed-in section of solid metal bracing, with no way for fish to get through into the head gate slot. With the approval of the Project Biologist, the torn mesh over the solid bracing was cut off. The maintenance bulkhead was removed and the STS was reinstalled on May 21. No significant problems were found with the other VBSs inspected in 2019.

Gatewells

Gatewell slot debris was moderate at Ice Harbor Dam in 2019 and never approached the 50% coverage criteria point for mandatory cleaning. Slots were dipped for debris removal as needed prior to installing the STSs.

Orifices/Collection Channel

The floor of the juvenile fish collection channel developed a buildup of ice several inches thick over the winter. On March 20, the channel was filled using the flush water valve from the forebay to hasten the melting of ice. Orifices were opened on March 25. The collection channel is typically operated with 20 orifices open. At least one orifice is open in each gatewell slot, with the following exceptions. Both orifices were closed in individual gatewells for brief periods during the season to accommodate routine maintenance and repair, such as backflushing, STS inspections, and STS/VBS repair.

Orifices were routinely cycled and backflushed by powerhouse operators and fish facility personnel. Orifices were initially bacflushed once per day until two orifices were found to be partially obstructed on March 27. The frequency of backflushing was increased to twice per day through the end of March, then three times per day from April 1 to July 31. Backflushing occurred once per day for the remainder of the year. There were no other clogged orifices noted by fish facility personnel or powerhouse operators after March 27. Orifice lights were checked daily, and if a orifice light was found to be burned out, the orifice was closed and the other orifice in that gatewell slot was opened until the light was fixed. Burned-out orifice lights were usually promptly replaced.

Primary Dewatering Structure

During the 2017-2018 winter maintenance period, all of the water regulating weirs were discovered to have deteriorating connection brackets. This condition resulted from electrolysis caused by dissimilar metals being in direct contact with each other. Water regulating weir #10 was found to have its operating stem broken off at the connection bracket. A new weir and bracket were fabricated and installed in its place. On May 1, 2018, the operating stem was found to be disconnected from weir #10 again and the weir was sitting low in the guide slots. During the 2018 fish season, the other weirs automatically operated approximately 5% higher than normal to compensate for the inoperable weir and properly control the water level. In March of 2019, weir #10 was manually lifted to the typical operating level and chained in place. Weir #10 was repaired and five of the deteriorating weirs and connection brackets were replaced during the 2019-2020 winter maintenance period. The remaining four weirs and brackets were replaced during the 2020-2021 winter maintenance period.

A corroded, rough floor area at the entrance to the bypass flume was ground smooth and repainted during the 2018-2019 winter maintenance period. The rough floor surface may have been a source of fish descaling or injury.

The primary dewaterer mechanical screen cleaner performed fairly well in 2019. The

screen cleaner sheaves were replaced periodically during the fish season due to wear.

The juvenile fish channel, including the primary dewatering structure, was unwatered for winter maintenance on December 19, 2019. The composition of fish recovered was two clipped adult Chinook, 15 clipped adult steelhead, nine unclipped adult steelhead, one clipped adult coho, two clipped juvenile steelhead, one unclipped juvenile steelhead, and 15 channel catfish. Fish were released in good condition at the north shore forebay boat ramp.

Sampling System

During Ice Harbors 2019 sampling season, the system functioned well with no maintenance problems associated with sampling equipment.

Removable Spillway Weir

The spill season for fish passage was April 3 to August 31, 2019. In accordance with Fish Passage Plan, the removable spillway weir (RSW) was operated until August 11, 2019 when the daily average project outflow decreased below 30 kcfs and the inflow was forecasted to stay below 30 kcfs for three consecutive days. The RSW had no operational problems in 2019.

Avian Predation

The U.S. Department of Agriculture (Wildlife Services) utilized pyrotechnics to conduct land-based hazing of piscivorous birds from April 1 to June 30, 2019. In addition, boat-based hazing occurred from April 7 to June 8. Bird deterrent structures at the project include roosting deterrents, a water cannon at the juvenile fish bypass outfall pipe, and a wire array in the tailrace. Propane cannons are available to deploy as additional aids to harass birds in areas where there are continual predation problems. Piscivorous bird counts were conducted daily from April 1 to June 30, and four days per week in July (Figure 2), to track whether the harassment/deterrent program remained effective at reducing bird abundance around the dam. Land-based hazing was effective at pushing birds away from the immediate vicinity of the dam. The boat-based hazing was particularly effective at further removing birds from the downstream spillway and powerhouse tailrace zones. Double-crested cormorants were usually the most abundant piscivorous bird species observed during daily bird counts from April 1 to the middle of May. American white pelicans were then the predominant species for the rest of the bird count season. Total bird numbers decreased in June, then increased again in July. Birds may have keyed in on the juvenile shad run in the late summer through the end of the year.

Pelican numbers have increased from 2015 to 2019 and were the most abundant birds counted the last three years (Table 9). American white pelicans could not be targeted for hazing because they are a species of concern in Washington State. The number of gulls counted has decreased each year from 2015 to 2019.

The average of total daily number of cormorants, gulls, and terns counted per week in 2019 was usually within the range of averages for the same weeks over the previous four years (see Table 10). The avian abundance action trigger for increasing hazing efforts (see the Ice

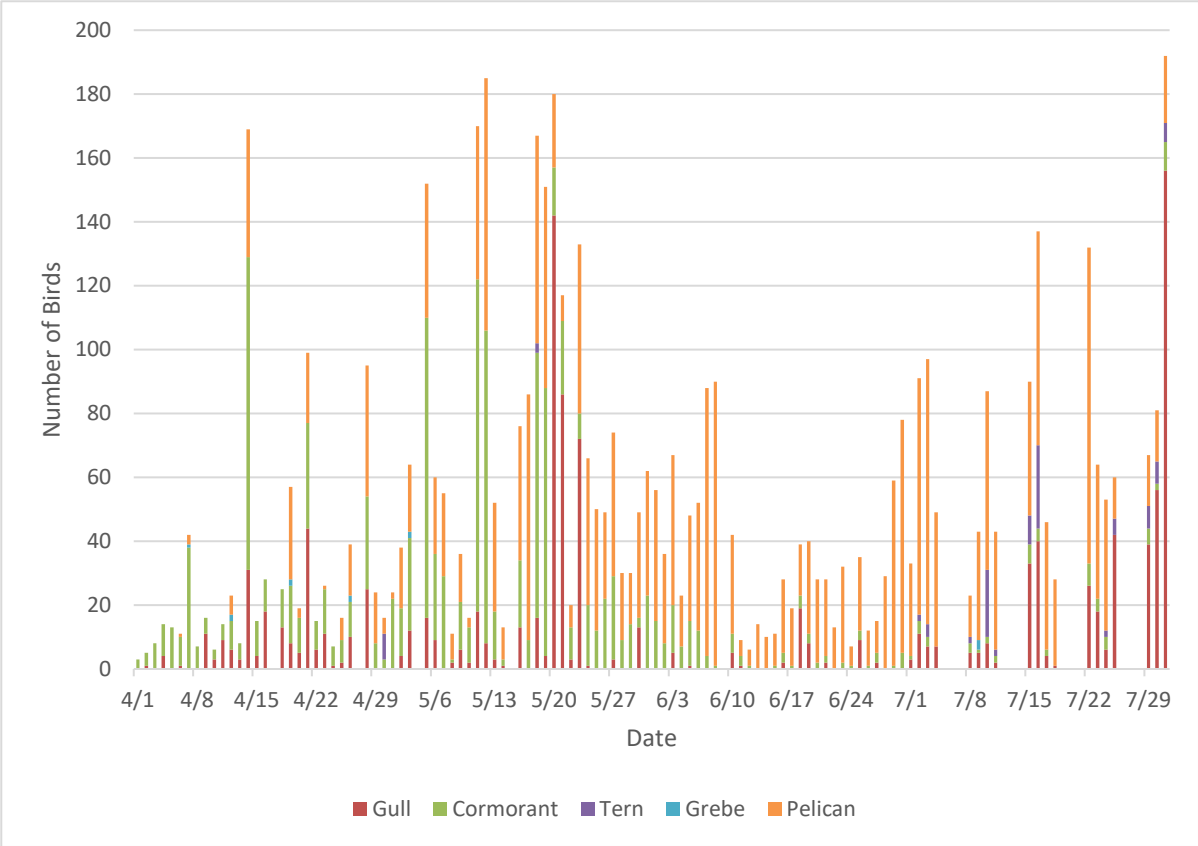

Figure 2. Daily number of piscivorous birds counted at Ice Harbor Dam, 2019.

Harbor section of Appendix L of the Fish Passage Plan) was reached on eight days during the spring. However, the bird counts on some of those days occurred just before hazing began for the day or when boat-based hazing was not actively occurring. The other occurrences where the action trigger was met were generally isolated events and not on continuous days. Gulls and cormorants were spread out in different observation zones during these events and were not targeting a specific fish passage route. The scheduled hazing effort and methods already in use adequately reduced spikes in bird numbers.

The bird-deterrent hydrocannon at the juvenile fish bypass outfall pipe was turned off on November 25, 2018, and it was left off for the remainder of the juvenile fish passage season. The water line for the hydrocannon developed a significant leak from one of its couplings in the fall of 2018. Access to fix the leak is only by boat, working off of an extension ladder at typical tailwater elevations. The repair was going to be attempted at the end of March, 2019, but increased river flows and spill created unsafe conditions to do the work and the leaky coupling was not repaired in 2019. The hydrocannon was not operated due to the diminished water jet and risk of burning out the pump if it went dry with the leak on the water line. Wildlife Services personnel were requested to pay increased attention for the need to haze birds at the end of the outfall pipe. They periodically reported a few cormorants in the vicinity of the outfall pipe that they hazed.

Table 9. Total numbers of gulls, cormorants, terns, grebes, and pelicans counted at Ice Harbor Dam, 2015-2019.

Year	Gulls	Cormorants	Terns	Grebes	Pelicans
2015	2,085	2,177	10	4	1,328
2016	1,785	2,380	95	10	2,035
2017	1,390	1,134	47	27	2,071
2018	1,372	1,691	23	12	3,027
2019	1,173	1,419	104	12	2,758

Table 10. Total daily counts of gulls, cormorants, and terns averaged per week at Ice Harbor Dam, 2015-2019.

Week	2015	2016	2017	2018	2019
April 3-9	8	15	16	34	15
April 10-16	16	52	36	53	31
April 17-23	51	62	52	44	26
April 24-30	44	58	30	55	16
May 1-7	37	66	35	33	34
May 8-14	61	73	62	52	41
May 15-21	50	28	36	44	71
May 22-28	37	27	13	42	26
May 29- June 4	27	22	10	17	15
June 5- 11	20	19	3	2	7
June 12-18	16	17	4	2	4
June 19-25	13	19	5	1	5
June 26-July 2	57	20	1	3	5
July 3-9	45	22	2	4	9
July 10-16	48	41	13	10	39
July 17-23	47	29	11	11	16
July 24-30	67	42	24	17	44

Recommendations for the Juvenile Fish Facility

1. Repaint the interior of the juvenile fish bypass pipe/flume and separator exit flume. The inside surfaces of the pipe and flumes have peeling paint and corroded areas, which create rough spots that could possibly descale or injure fish.
2. Extend the air bubbler screen cleaning system under the entire unwatering floor screen in the primary dewatering structure. This system would serve as a reliable extra cleaning system in the event of failure of aging components of the mechanical screen cleaner.
3. Install a crowding mechanism in the juvenile collection channel that would encourage adult fish to exit.
4. Replace the black iron water line for the outfall pipe hydrocannon with stainless steel to prevent corrosion. Install a walkway alongside the outfall pipe to provide access to the outfall pipe and hyrocannon water line to conduct inspections and maintenance.

5. Install a fish release chute connecting to the main bypass pipe downstream of the JFF lab. This would permit fish rescued during certain unwatering events to be more easily returned to the tailrace via the bypass pipe.
7. Install stairs on the hillside to provide a direct and safe walking path between the JFF and tailrace deck level.
8. Pave the road and parking area inside the JFF and provide curbing that would direct any water runoff away from the juvenile facility and the hillside. Pavement would provide stable ground for heavy equipment access and setup as needed to perform maintenance and repairs.

Research

Biological testing of unit 2 with the new runner took place in September and October. Pacific Northwest National Laboratory personnel released sensor fish into the turbine intake to collect data to characterize the physical environment fish are exposed to when passing by the new turbine blades. Normandeau researchers carried out a direct injury/survival study of fish passing through unit 2 scroll case and draft tube. Research results showed 98% survival of fish released through the unit.

Blue Leaf Environmental personnel monitored adult lamprey passage and salmon behavior at the newly installed lamprey passage structure (LPS) at the south shore entrance #2 of the south fish ladder. Didson cameras were placed to view the entrance and exit of the LPS. Review of the imagery showed that lamprey were using the LPS and salmon attraction to the LPS was minimal.

ADULT FISH FACILITY

Operations and Maintenance

The south shore fish ladder (SFL) and north shore fish ladder (NFL) were operated for fish passage for most of the year. The fish ladders were unwatered one at a time for annual winter maintenance in January and February. In 2019, adult fish counting occurred from January 1 to February 28 and April 1 to October 31. The number of adult salmonids and adult lamprey counted passing Ice Harbor Dam is shown in Table 11 for each fish ladder. For all species groups, the SFL was used more than the NFL. The total count for each species group, except coho salmon, was below the previous ten-year averages.

The upper SFL was unwatered for inspection and maintenance from January 2 to February 11, 2019. One unclipped juvenile steelhead was removed from the flow-control section of the upper fish ladder, and released in good condition into the forebay off of the roadway deck. Other fish were evacuated down to the the turning pool just upstream of tailwater level in the ladder, where they were removed, transported, and released in mostly good condition at the Levey Park boat ramp. There were four unclipped juvenile Chinook salmon and 1 unclipped juvenile steelhead that died while being removed from the turning pool or that were missed during evacuation and died later. The lower SFL (channel) was unwatered over several days and

fish were removed on January 14, and released in good condition at Levey Park boat ramp. The species composition of rescued fish is shown in Table 12 below.

Table 11. Number of adult fish passing Ice Harbor Dam in 2019, and average of previous ten years.

	Chinook	Chinook Jack	Steelhead Clipped	Steelhead Unclipped	Sockeye	Coho	Coho Jack	Lamprey
SFL	34,694	8,993	9,747	18,065	282	6,094	351	202
NFL	8,388	970	1,465	2,547	38	3,232	21	69
Total (SFL + NFL)	43,082	9,963	11,212	20,612	320	9,326	372	271
Ten-Year Avg. (SFL + NFL)	124,149	31,377	109,982	38,813	977	4,310	410	608

Table 12. Areas at Ice Harbor Dam unwatered in 2019 requiring possible fish removal.

Date	Unwatering Activity	Fish Removed and Released in the River[1]
2,11-Jan	Upper south fish ladder	2 unclipped Chinook, 5 clipped Chinook jacks, 3 unclipped Chinook jacks, 1 clipped steelhead, 38 unclipped juvenile Chinook, 2 clipped juvenile steelhead, 2 unclipped juvenile steelhead, 1 shad, 13 juvenile shad, 6 smallmouth bass, 1 crayfish
14-Jan	Lower south fish ladder	2 clipped steelhead, 2 unclipped steelhead, 1 clipped juvenile steelhead, 3 juvenile steelhead[2], 1 black crappie, 4 channel catfish, 1 smallmouth bass
31-Jan	Unit 2 scroll case	None
31-Jan	Unit 4 draft tube	14 chanel catfish, 3 juvenile sturgeon
4-Feb	Unit 2 draft tube	7 juvenile sturgeon, 1 sucker
14-Feb	Upper north fish ladder	1 clipped juvenile steelhead
17,18-Apr	Upper south fish ladder	Approximately 50 smolts (mostly steelhead)
24-Apr	Unit 2 tailrace stoplogs	None
3-May	Unit 3 scroll case	None
5-May	Unit 3 draft tube	None
8-May	Unit 3 scroll case	None
8-May	Unit 3 draft tube	3 juvenile sturgeon
17-May	Gatewell 1A	Approximately 30 smolts (released into gatewell 1C)
12-Aug	Unit 4 tailrace stoplogs	Approximately 30 Siberian prawns
15-Aug	Unit 6 scroll case	2 channel catfish, 1 juvenile sturgeon
18-Sep	Unit 6 draft tube	8 channel catfish, 1 sturgeon, 1 sucker
19-Dec	Juvenile fish channel	2 clipped Chinook, 1 coho, 15 clipped steelhead, 9 unclipped steelhead, 2 clipped juvenile steelhead, 1 unclipped juvenile steelhead, 15 channel catfish

[1]Fish were adults unless noted as juveniles
[2]Not checked for adipose clip

The SFL upper diffuser (diffuser 12) grating has deteriorated sections with holes that were patched in previous years. In 2019, additional holes were patched with pieces of perforated plate. All of the diffuser 12 grating was replaced in kind with spare galvanized grating in 2020. The SFL channel diffuser grating was observed to be intact and in fair condition.

The upper NFLwas unwatered from February 14 to February 28, 2019. One clipped juvenile steelhead was removed from the flow-control section of the upper fish ladder, and released in good condition into the forebay off of the navigation lock guide wall. Other fish were evacuated down to tailwater level in the lower fish ladder. The lower NFL was not unwatered and the channel diffuser grating was inspected with a ROV. The channel grating was observed to be in good shape.

Maintenance work performed on both ladders included: debris removal, cleaning picketed leads and staff gages, adult fish counting/viewing window cleaning, and maintenance of auxiliary water supply pumps. Debris was light in both fish ladders.

Some of the tailwater staff gauges are in disrepair, and replacement of these gauges may require divers to install. The cleaning of dirty tailwater and channel staff gauges either require personnel access via a crane and man basket, or entry into the channel during the winter maintenance period. The Project Biologist is coordinating with maintenance staff at the dam for assistance with cleaning these staff gauges and replacement of damaged gauges.

North powerhouse entrance weir gate #2 (NFE-2) selsyn dial was slipping and going out of calibration towards the end of 2018. During the winter maintenance period, a new dial was installed, but the gear ratio of the new dial was incorrect for the selsyn. Consequently, the elevation display for NFE-2 was far from being accurate. The adjacent entrance (NFE-1) was used in place of NFE-2 for the 2019 season to allow for repair/replacement of the dial. Unfortunately NFE-1 does not have a dial installed, so the elevation reading of the weir gate was obtained from the PLC in the control room or fish facility.

The picketed leads at the NFL count station were in the lowered position from March 1 to March 13, due to the hoist not working until it was fixed on March 13. The picketed leads at both count stations were in the lowered position for adult fish counting from March 28 to November 2.

Diffuser 12 was found to be inoperable on April 14, with the depth over the stationary weirs well below criteria. The upper south fish ladder and diffuser 12 chamber had to be unwatered to repair the diffuser valve. The upper south fish ladder was unwatered on April 16 and 17, and fish facility staff attempted to evacuate several thousands of smolts in the ladder to tailwater level, but it was not possible to get them all. On April 18, the water flow in the upper ladder had decreased, requiring immediate rescue of approximately 50 smolts at the south fish count station and release into the juvenile fish bypass flume. At least 75 smolts are estimated to have died from the stress of exposure and handling during the fish evacation/recovery operation. The one pump that had been providing constant flush water down the ladder from the forebay had been moved into the diffuser valve chamber on April 18, where it cycled on and off with the water level in the chamber. The diffuser 12 valve stem was found to be disconnected from the valve. The repairs were completed and the fish ladder was watered back up and returned to normal operation on April 19.

The LPS was fabricated and installed at the south shore entrance #2 (SFE-2) during the winter maintenance period. The LPS was open for lamprey passage from July 17 to October 2.

The start date of July 1 for having the LPS open was not met because of delays in getting lamprey passage monitoring equipment installed at the LPS.

On July 30, the north fish ladder entrance #1 (NEW-1) weir gate was observed to be raised about 6' out of the water. The PLC that controls the weir apparently malfunctioned, causing NEW-1 weir to raise out of the water and block fish passage into the ladder. The weir would not go down and was getting bound up in the guide slot, even with the auxiliary water supply pumps and upper diffuser (diffuser 10) shut off. On August 1, north fish ladder entrance #2 (NEW-2) weir was lowered down to sill in place of NEW-1 weir for the rest of the year. The problem with the NEW-1 weir was addressed during the winter of 2020.

During the night of October 28, a northeast wind picked up and caused waves and turbulence that broke loose the south fish ladder exit debris boom. The boom struck and broke the air piping for the bubbler at the ladder exit. Milfoil and sticks flowed into the exit and plugged up the picketed leads at the fish count station, causing the water level upstream of the leads to rise and overflow out of the ladder. The picketed leads were raised until the following morning to reduce the water level and allow the debris to pass. There were no fish found on the ground. The debris boom was re-attached on November 5.

Summary of Fish Recovery Operations

Areas that were unwatered in 2019 that required Fish Facility personnel presence for possible fish rescue/evacuation are listed in Table 12. The total number of fish handled during unwatering events in 2019 was approximately 285. The species composition of fish handled is shown in Table 12.

Adult Fish Trap Operation

The adult fish trap was not used in 2019.

Auxiliary Water Supply

The auxiliary water supply (AWS) pumps were operating or available for operation to help maintain fish entrance criteria in 2019, with the exceptions listed below in Table 13. AWS pumps were turned off, taken out of service, or forced out of service during the fish passage season to facilitate maintenance, operations, or emergency repairs (Table 13). Six to eight AWS pumps were operated to maintain criteria in the south fish ladder, depending on tailwater elevation. Two AWS pumps were operated to maintain criteria in the NFL. In-season maintenance and minor repairs can be performed on the pumps that are in standby. Each north shore pump operates at 350 cfs and each south shore pump operates at 300 cfs. In addition,

approximately 270 cfs of excess water from the juvenile fish collection channel is added to the south shore AWS pump discharge chamber.

Table 13. AWS pump outages and significant events requiring pumps to be shut off at Ice Harbor Dam in 2019.

Date	Pump Number (#), or How Many Pumps Affected	Pump Outage Description or Reason for Turning Off	Duration that entrance head/depth was out of criteria
March 1 to late May	SFL #1	Changed oil, installed heater	In criteria
March 15	All NFL pumps	Feeder line testing	7.6 hours
April 10	Five to eight SFL pumps	Pumps off to prevent flooding of the powerhouse warehouse when tailwater was very high	7.3 hours
April 14-16	All SFL pumps	Pumps off to reduce fish in ladder prior to unwatering ladder to fix diffuser #12	Approximately 48 hours
April 27-30	NFL #2	Impeller jammed with drbris	7 minutes
June 11	All NFL pumps	Pumps off to allow debris to drop off the pump intake trash racks	1.9 hours
August 26	SFL #4, #8, one at a time	Checked circuits for pump cooling fans	In criteria
October 8	Three SFL pumps	Voltage loss from transformer when switching station service	2.8 hours
Nov. 25	All NFL pumps	Pumps off for ROV inspection of NEW-1 weir gate guide slot	4.6 hours
Dec. 5-9	SFL #1	Relace leaky seal on lower gearbox	In criteria
Dec. 11-31	SFL #1	Excessive noise coming from pump	In criteria

Adult Fishway Inspections

Ice Harbor project fisheries personnel conducted visual inspections of the fish ladders during the adult fish passage season of March 1 to December 31, 2019. In addition, the powerhouse operators conducted daily limited inspections of the fishways. Fish facility staff averaged 2.9 fishway inspections per week with 126 inspections completed. The inspections were conducted by visually inspecting various areas of the fishways and recording readings from staff gages, fishway entrance hoists motor selysns, meters, and tape measures. The data compiled was entered into an Excel spreadsheet (Appendix 1). Fisheries staff also collected data on flow discharge, AWS pump and turbine unit operation, and juvenile fish orifice operation. In addition, estimates of the amount of debris that accumulated in the forebay, fish ladder exits, and gatewells were made. When the fishway was out of criteria, the powerhouse operator was notified to make adjustments to the fishway control system or arrange for repairs as needed. The combined fish passage data collected was used to compose weekly reports on the status of the fish facility operations and maintenance (See Ice Harbor section 2.5.2 of the 2019 Fish Passage Plan).

Automated Fishway Control System

In the 2019 fish season, water levels were automatically measured with a sonar-based level sensing system manufactured by Milltronics using the Multi Ranger model. A

Programmable Logic Control Center (PLC) processed the signals from the Multi Ranger and displayed the readings on a panel in the control room. The PLC interfaces with process level controllers to raise or lower the three entrance weir gates in service as needed. The remote terminal units control the fishway weir gates according to set points that either control the gates at a depth below tailwater or a channel to tailwater head differential. Panels in the control room, JFF, and north fish ladder entrance deck display the following information: channel and tailwater elevation in feet above mean sea level (MSL) for the north shore, north powerhouse, and south shore entrances; elevation in feet above MSL for the weir gates; water depth at the gates; channel/tailwater differential; and set points for the gate depths and the channel/tailwater differential.

The readings from the automated fishway control system were compared to the visual inspection results to ensure that the readings were comparable and the fishways were operated within criteria. Any significant discrepancies between the readings were reported to the electricians for calibration. However, tailwater transducers cannot be accurately calibrated when spill is occurring. The time difference between reading a staff gage and checking the PLC display may have been as much as 120 minutes. The time difference between the automated and visual readings may give different inspection results due to operational changes, such as changing spill volumes, switching units, and water elevation fluctuations.

Inspection Results

Adult fishway inspection results for 2019 are shown in Table 14. Deviations from criteria can be caused by fluctuating water elevations readings at the staff gages during spill. Observable water elevations during spill can vary as much as one foot on either side of the average elevation, which significantly contributes to incorrect visual readings falsely indicating an out of criteria event. Another contributor to out of criteria events are misread staff gauges that are difficult to read because they are dirty or damaged. When a staff gauges become unreadable or is missing, a tape measure is used to measure the distance to the water from the deck to calculate water elevations. The use of a tape measure increases the chances of human error to obtain the measurements. Another consideration is the location of the staff gages in relationship to the water level sensing transducer. Some staff gauges are located at least several feet from the corresponding transducers. This condition makes accurate calibration impossible due to the relationship between the sensing equipment and the staff gage not being linear. The suitability of the present locations of the staff gauges and transducers for providing representative water surface elevations will be further evaluated.

Channel Velocity: The water velocity in the south shore channel junction pool was below criteria [criteria of 1.5-4.0 feet per second (fps)] on 21.8% of the inspections, compared to 6.8% of inspections in 2018. Higher spring flows in 2019 lead to high tailwater conditions from mid-April to mid-May. When the tailwater and channel elevations are high, more of the stationary weirs in the fish ladder are submerged, slowing the velocity of the water coming down the ladder into the junction pool. The out of criteria readings ranged from 0.0-1.4 fps. The 0.0 fps reading occurred when the south shore AWS pumps were turned off to prevent flooding in the warehouse of the dam.

Table 14. Adult Fishway Inspection Results at Ice Harbor Dam, 2019

Criteria and Locations	No. in Numerical Criteria/ No. in Sill Criteria/ No. of Inspections	% In Numerical Criteria/ % in Sill Criteria	Not Enough Depth/Differential			Too Much Depth/Differential		
			No./% Within 0.01-0.1 Foot	No./% Within 0.11-0.2 Foot	No./% >0.2 Foot	No./% Within 0.01-0.1 Foot	No./% Within 0.11-0.2 Foot	No./% >0.2 Foot
	97	78.2	***	***	***	***	***	***
Channel Velocities	***	***	***	***	***	***	***	***
	124							
Differentials								
South Fish Ladder								
	125	100.0	***	***	***	0	0	0
Ladder Exit	***	***	***	***	***	0.0	0.0	0.0
	125							
	124	99.2	0	0	1	0	0	0
Ladder Weirs	***	***	0.0	0.0	0.8	0.0	0.0	0.0
	125							
	123	98.4	***	***	***	0	2	0
Counting Station	***	***	***	***	***	0.0	1.6	0.0
	125							
North Fish Ladder								
	126	100.0	***	***	***	0	0	0
Ladder Exit	***	***	***	***	***	0.0	0.0	0.0
	126							
	123	97.6	0	1	1	0	0	1
Ladder Weirs	***	***	0.0	0.8	0.8	0.0	0.0	0.8
	126							
	126	100.0	***	***	***	0	0	0
Counting Station	***	***	***	***	***	0.0	0.0	0.0
	126							
Collection Channels								
	111	89.5	0	1	1	1	5	5
South Shore Entrance	***	***	0.0	0.8	0.8	0.8	4.0	4.0
	124							
North Powerhouse Entrance	122	98.4	1	0	1	0	0	0
	***	***	0.8	0.0	0.8	0.0	0.0	0.0
	124							
	99	78.6	2	2	5	3	6	9
North Shore Entrance	***	***	1.6	1.6	4.0	2.4	4.8	7.1
	126							
Weir Depths								
	68	54.8	0	0	1	***	***	***
SFE-1	55	44.4	0.0	0.0	0.8	***	***	***
	124							
	56	45.2	1	2	7	***	***	***
NFE-1	60	48.4	0.8	1.6	5.6	***	***	***
	124							
	63	50.0	0	1	2	***	***	***
NEW-1 or NEW-2	60	47.6	0.0	0.8	1.6	***	***	***
	126							

Ladder Exits: The north and south fish ladder exit head differentials were in criteria (≤0.3 feet) during all inspections. There were no significant debris accumulations on the ladder exit trash racks causing the differentials to get above 0.2', and they were typically 0.1' or less.

Ladder Weirs: The depth over the stationary weirs in the north fish ladder was in criteria (1.0-1.3 feet) on 97.6% of fishway inspections. The depth over the stationary weirs that was above criteria may have resulted from observer error in reading the staff gauge. The two depths that were below criteria occurred when the forebay was lowered to accommodate repairs to the Lower Monumental fish barge loading dock. The flow through diffuser #10 was probably also reduced by debris that was partially obstructing the intake all year. The flow from the diffuser was still adequate to meet criteria under normal forebay elevations. The debris on the intake trash rack was blown off with an air hose during the 2020 winter maintenance period.

The depth over the stationary weirs in the south fish ladder was well below criteria on one inspection, after the failure of diffuser #12 on April 14. The fish ladder was unwatered to make the emergency repairs and the ladder was returned to full operation on April 19.

Counting Stations: The differential across the north shore picketed leads was in criteria (≤0.3 feet) on all inspections. The differential across the south shore picketed leads was out of criteria (criteria of ≤0.3 feet) on two inspections, due to the buildup of filamentous algae on the leads. In both cases, the leads were cleaned shortly after the inspections. From mid-summer to early fall, periodic cleaning of the south shore picketed leads up to several times a day was necessary to keep the differential in criteria.

South Shore Entrance (SFE-1): The SFE-1 weir gate depth was in criteria (≥ 8 feet or on sill) on 99.2% of inspections, compared to 93.2% of inspections in 2018. The weir gate depth was well below criteria when the breaker for the weir gate tripped on April 11. Over the weekend, the operator partially opened the adjacent entrance (SFE-2) to bring the high south shore channel/tailwater differential into criteria. On April 15, an electrician reset the breaker and the south shore entrances were restored to normal operating configuration. The weir gate was in sill criteria on 44.4% of inspections, primarily when tailwater was lower from mid-summer to the end of the year.

North Powerhouse Entrance (NFE-1): The NFE-1 weir gate depth was in criteria (≥ 8 feet or on sill) on 93.6% of inspections. The weir gate was in sill criteria on 48.4% of inspections, compared to 40.9% of inspections in 2018. The two gate dephs that were out of criteria in March may have been due to getting the gate elevation reading off of the PLC an hour or more after writing down the corresponding tailwater elevation. Almost all of the other out of criteria depths occurred because the gate was in manual control and the operator did not notice that the tailwater elevation had gone down. NFE-1 gate was operated in manual control rather than automatic mode during most or all of the spill season to reduce the wear and tear on the gate machinery. When the weir gates are in automatic mode the machinery can become worn and damaged from repeatedly operating to adjust to the fluctuating tailwater level caused by spill.

North Shore Entrance (NEW-1, NEW-2): The NEW-1 or NEW-2 weir gate depth was in criteria (≥ 8 feet or on sill) on 97.6% of inspections, compared to 91.0% of inspections in 2018. The

weir gate was in sill criteria on 47.6% of inspections. The out of criteria depth at NEW-1 on March 15 was because of a power outage to the entire north fish ladder for 5 kv feeder line testing. The out of criteria entrance depth in June was due to the gate being in manual control and the tailwater level going down, as occurred at NFE-1. NEW-1 weir gate was out of criteria on the August 1 inspection after the gate closed because of a PLC malfunction and could not be lowered back down. NEW-2 was opened in place of NEW-1 for the rest of the year.

Fish Collection Channel/Tailwater Head Differential: The south shore entrance channel/tailwater head differential was in criteria (1 - 2 feet) on 89.5% of inspections, compared to 97.0% of inspections in 2018. There was almost no head differential on the April 10 inspection when all of the south shore AWS pumps were shut off to prevent flooding in the warehouse. Most of the other entrance head criteria breaches occurred in the summer and fall when tailwater was low and may be attributed to the south shore tailwater or channel transducer needing calibration, and/or the head differential being on the high side with seven AWS pumps running.

The north powerhouse entrance head differential was in criteria (1-2 feet) on 98.4% of inspections, compared to 94.7% of inspections in 2018. The entrance head differentiall was well below criteria on April 10 when all of the south shore AWS pumps were shut off to prevent warehouse flooding. A head differential that was slightly below criteria occurred when tailwater increased and NFE-1 weir gate was in manual control.

The north shore powerhouse entrance head differential was in criteria (1-2 feet) on 78.6% of inspections, compared to 89.4% of inspections in 2018. The very low entrance head differentials on three inspections resulted from the north shore AWS pumps being without power during the 5 kv feeder line testing in March, and NEW-1 weir gate being stuck on sill because of the water pressure against the gate during the high tailwater/channel conditions in April. There was no attraction flow to the north fish ladder entrance on the August 1 inspection when NEW-I gate was closed due to the PLC malfunction. Several channel/tailwater differentials that were out of criteria, including a 5.6' differential on July 8, were attributed to the difficulty of getting an accurate staff gauge or tape measure reading with the turbulent north shore tailwater conditions during spill, or observer error when using the tape measure or reading the staff gauge. Many out of criteria differentials were due to the NEW-1 weir gate being in manual control because of the spill and the operator not noticing that the tailwater elevation had changed. The north shore tailwater or channel transducer may also have been in need of calibration. Most of the high head differentials in November and early December were due to low tailwater levels, with two north shore AWS pumps still needing to be operated to meet minimum head criteria.

Recommendations for the Adult Fish Facility

1. Continue to repair south fish ladder mud valves in the auxiliary water supply conduit to facilitate unwatering the lower ladder for inspection and maintenance.
2. Remove the accumulated silt in the south shore AWS conduit that is clogging the mud valves and blocking access to some of the mud valves and sluice gates for inspection and maintenance.
3. Rehabilitate fish ladder entrance weir gates and hoisting equipment.

4. Install a handrail along the outside edge of the north and south shore fish ladders to allow routine in-season inspection of the entire fish ladders and to facilitate safer unwatering and fish evacuation procedures for personnel.
5. Replace the debris booms and attachment systems at the north and south shore fish ladder exits. The log booms are prone to detachment under high winds.
6. Proactively replace fish ladder diffuser grating as needed.
7. Replace broken/dirty staff gauges and guides so that the gauges are easier to clean and read.
8. Relocate staff gages and transducer units as needed so the staff gage and the automated fishway control system readings will be more precise.
9. Install an audible alert on the automated control system PLC when the fish ladder entrance criteria is not being met.