September 5, 2023

VIA ELECTRONIC FILING

Kimberly D. Bose, Secretary
Nathaniel J. Davis, Sr., Deputy Secretary
Federal Energy Regulatory Commission
888 First Street NE
Washington, DC 20426

Re: Jackson Hydroelectric Project, FERC No. 2157
License Article 416: Process Flow Plan
10-Year Effectiveness Report

Dear Secretary Bose:

Enclosed is the 10-Year Effectiveness Report developed by Public Utility District No. 1 of Snohomish County (Snohomish PUD) pursuant to Section 5.1 of the Process Flow Plan (PF Plan) under License Article 416 for the Jackson Hydroelectric Project. This report provides data and analysis of the implementation of the PF Plan from 2011-2021. Documentation with the Aquatic Resource Committee (ARC) is included in the report's appendices.

The information provided in the report formed the basis for initial discussions with the ARC on updating the PF Plan. Based on further consultation with the ARC via a series of workshop meetings and review period, an updated PF Plan has been developed and will be filed soon under separate cover requesting FERC's review and approval.

If you have any questions on the enclosed report, please feel free to contact me.

Sincerely,

/s/ Keith Binkley

Keith M. Binkley
Natural Resources Manager
KMBinkley@snopud.com
(425) 783-1769

Enclosed: 10-Year Effectiveness Report

cc: ARC

Henry M. Jackson Hydroelectric Project
(FERC No. 2157)

Process Flow Plan
(License Article 416)

10-Year Effectiveness Report

Prepared By:

Snohomish County PUD
Public Utility District No. 1
Everett, WA

August 2023

Final – The document may be cited as:

Public Utility District No. 1 of Snohomish County (Snohomish PUD). 2023. Process Flow Plan 10-Year Effectiveness Report, for the Jackson Hydroelectric Project (FERC No. 2157). August 2023.

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ACRONYMS AND ABBREVIATIONS

A-LA	Aquatic License Article
ARC	Aquatic Resource Committee
ARIS	Adaptive Resolution Imaging Sonar
cfs	cubic feet per second
ER	Process Flow Plan 10-Year Effectiveness Report
FERC	Federal Energy Regulatory Commission
FHMP	Fisheries and Habitat Monitoring Plan
MW	megawatt
PFP	Process Flow Plan
Project	Henry M. Jackson Hydroelectric Project, FERC No. 2157
RM	River Mile
SCADA	Supervisory Control and Data Acquisition
Snohomish PUD	Public Utility District No. 1 of Snohomish County
USGS	United States Geological Survey
WY	Water year

1. Introduction

Public Utility District No. 1 of Snohomish County (Snohomish PUD) received a license on September 2, 2011 (License) from the Federal Energy Regulatory Commission (FERC) for the Henry M. Jackson Hydroelectric Project (Project) (FERC 2011). License Article 416 approved the Process Flow Plan (PFP) filed with the FERC in September 2010. Per Section 5 of the PFP, Snohomish PUD is to develop a Process Flow Effectiveness Report (ER) every 10 years analyzing the results of the monitoring components presented in the PFP and the Fisheries and Habitat Monitoring Plan (FHMP) in conjunction with the release data specific to each of the reaches of the Sultan River (Figure 1).

This ER is the first and covers activities conducted in the period 2011-2021. The report begins with a discussion of Special Purpose Flows which occur annually to stimulate a biological / behavioral response in either juvenile or adult salmonids. The report then discusses Habitat Based Flow Releases, beginning with the annual relatively low volume releases followed by the less frequently occurring high volume releases. Recommendations for modification to the PFP are provided.

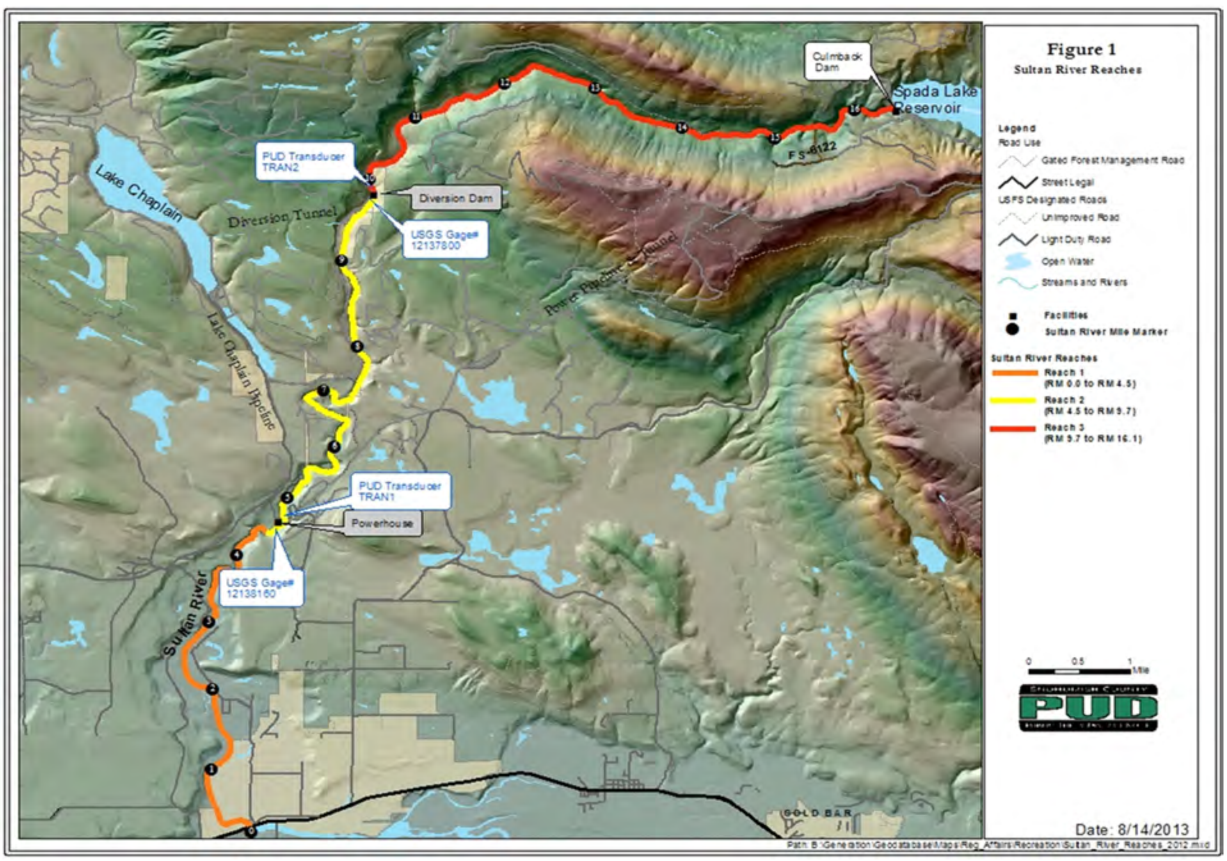


Figure 1. Sultan River reaches, facilities, and river miles.

2. Special Purpose Flow Releases

Special Purpose Flows fall into two categories: upmigration flows that occur in the fall, and outmigration flows that occur in the spring.

2.1. Upmigration

2.1.1. Program

The intent of the upmigration program is to release one pulsed flow per year, during the month of September to initiate the upstream migration of adult salmon, limit straying to other river basins, and facilitate swimming past natural and artificial barriers. The implementation of the upmigration program is intended to provide elements of a more normative hydrograph in the lower Sultan River compared to existing conditions.

During relicensing and settlement agreement discussions, there was scientific uncertainty regarding the magnitude, duration, and potential need for special purpose flows above and beyond what occurs from the Project and what occurs naturally. Monitoring requirements identified in the PFP and FHMP were to provide data for determining the need for and effectiveness of Special Purpose Flows including the upmigration flows. Results and analysis of these monitoring efforts are presented below, followed by a discussion of adaptive actions, and recommended modifications and improvements that incorporate lessons learned.

2.1.1.1. Frequency and Timing

The License requires, if necessary, one upmigration release per reach, annually during the month of September. The upmigration release typically occurs in combination with a channel flushing flow, and with a scheduled whitewater event.

2.1.1.2. Duration

The License and PFP call for each reach specific upmigration event to last for a minimum of six consecutive hours.

2.1.1.2. Magnitude (by reach)

An upstream migration flow will be achieved by meeting the following criteria bulleted below. The range was intended to allow for testing the effectiveness at different flow magnitudes during the first ten years of the License.

- <u>Reach 1</u>: Between 800 and 1200 cfs (USGS Gaging Station No. 12138160)
- <u>Reach 2</u>: Between 400 and 600 cfs (upstream of the Powerhouse at river mile [RM] 4.7)
- <u>Reach 3</u>: Between 300 and 500 cfs (upstream of the City of Everett’s Diversion Dam at RM 9.8)

2.1.2. Objectives

Three objectives are identified in Section 1.3 of the PFP that are associated with late summer/early fall, short duration pulse flow events. These include: 1) initiating the upstream migration of adult salmon, 2) limit straying to other river basins and, 3) facilitating swimming past natural and artificial barriers.

2.1.3. Assumptions

Implementation of this program was intended to mimic elements of a more normative hydrograph in the lower Sultan River compared to hydrologic conditions in place prior to the implementation of the program. It was assumed that by implementing Special Purpose Flows for upmigration, the objectives outlined in Section 2.1.2 would be accomplished.

2.1.4. Results

Under the current License, data have been collected to evaluate the effectiveness of upmigration process flows on migrating adult Chinook salmon. According to the PFP, assessment of the upmigration program will be conducted by looking at the temporal distribution of fish and the presence of redds through the spawning season. Further, the temporal distribution under the release program will be compared with the historic distribution without an upmigration release program. The primary method for evaluating this program was annual spawning ground surveys conducted in accordance with the FHMP using Washington Department of Fish and Wildlife protocols. From a biological perspective, these routine surveys allowed data to be collected prior to and following upmigration pulse flows to evaluate the benefit of the release including documentation of any effect relating to stimulating upstream migration and facilitating upstream migration above barriers. From a hydrological context, the timing of upmigration process flows across the ten-year period allowed for a comparison of normative flow to be made with hydrology from the unregulated Skykomish and Pilchuck rivers. The data presented and discussed in this section include the following:

- Date of upmigration releases
- Percentage of Chinook redds by statistical week before and after implementation
- Number and percentage of Chinook redds, by statistical week, before and after implementation of upmigration releases
- Redd counts in Reach 1 by survey date and mean/max flow (cfs) since previous survey, 2012 and 2016
- Number and percentage of marked (adipose fin clipped and/or coded wire tagged) carcasses recovered before and after implementation of upmigration releases
- Number of Chinook documented on the Adaptive Resolution Imaging Sonar (ARIS), by statistical week, in 2021

Upmigration Flow Dates

From 2011 to 2021, a total of ten upmigration releases were conducted occurring annually between statistical weeks 35 and 38 (Table 1). In 2012, the upmigration flow for Reach 1 was accomplished by operating at full generation; however due to observed early spawning of Chinook in Reach 2, the magnitude of the release for this river segment was modified and reduced after conferring with the Aquatic Resource Committee (ARC). In 2013, low inflows into the Project led to a decision to delay the upmigration flow and allow it to occur within the salmon ceiling window and in-conjunction with forecasted precipitation. In 2016, an upmigration process flow did not occur due to in-water construction activities associated with the Diversion Dam Volitional Passage Project on the Sultan River at RM 9.7. In 2021, the PFP was modified to allow upmigration releases to occur anytime during the month of September to better align with unregulated basin hydrology during this period of late summer low flow, and to limit the enticement of hatchery Chinook into the Sultan River.

Table 1. Date and statistical week for fall upmigration releases, 2011-2021.

Date of Upmigration Release	Statistical Week	Flow Range Reach 1 (CFS)	Preceding Mean Weekly Flow and Range (CFS)
9/2/2011	35	1,200	1,270 (1,210 - 1,310)
9/14/2012	37	1,200 – 1,430	343 (342 - 346)
9/17/2013	38	1,530 – 2,060	433 (321 - 960)
9/12/2014	37	1,500 – 1,760	355 (351 - 368)
9/12/2015	37	997 – 1,050	237 (209 - 252)
9/2/2017	35	802 – 1,620	346 (326 - 371)
9/8/2018	36	805 – 1,440	346 (343 - 347)
9/8/2019	36	1,210 – 1,460	324 (319 - 328)
9/11/2020	37	1,200 – 1,310	531 (345 - 743)
9/26/2021	38	1,220 – 1,450	489 (395 - 524)

Run Timing - Chinook Spawning Surveys

Chinook spawning is documented during fall escapement surveys. Pooled data representing Chinook salmon spawn timing is presented in Table 2 and illustrated in Figure 2. Years included in the analysis prior to the implementation of the upmigration process flow program were: 1994, 1997, 1999, 2001, 2002, 2007, 2009, and 2010. Temporal data for other years prior to the new operating License are not available. Run timing data during years of upmigration releases include: 2011-15 and 2017-21. Fall upmigration releases began in 2011; however high turbidity during that first year prevented fall escapement surveys. It is also worth noting that periodically, due to high river flows, turbidity, or other environmental factors, surveys were not always conducted in each statistical week, which can influence the recorded temporal distribution of redds.

Table 2. Number and percentage of total observed Chinook redds, by statistical week, prior to and after implementation of upmigration releases.

Statistical Week	*Prior to Implementation*		*After Implementation*		
	Number Redds	Percent Redds	Number Redds	Percent Redds	Percent Difference After vs Prior Implementation
35	0	0.0%	2	0.2%	0.2%
36	1	0.1%	0	0.0%	-0.1%
37	37	3.6%	74	6.2%	2.7%
38	66	6.4%	103	8.7%	2.3%
39	196	19.0%	213	18.0%	-1.0%
40	117	11.3%	285	24.1%	12.7%
41	222	21.5%	306	25.8%	4.4%
42	113	10.9%	86	7.3%	-3.7%
43	108	10.4%	52	4.4%	-6.1%
44	133	12.9%	44	3.7%	-9.1%
45	11	1.1%	16	1.4%	0.3%
46	20	1.9%	1	0.1%	-1.8%

47	0	0.0%	3	0.3%	0.3%
48	10	1.0%	2	0.0%	-1.0%
Totals	1,034	100 %	1,185	100 %	

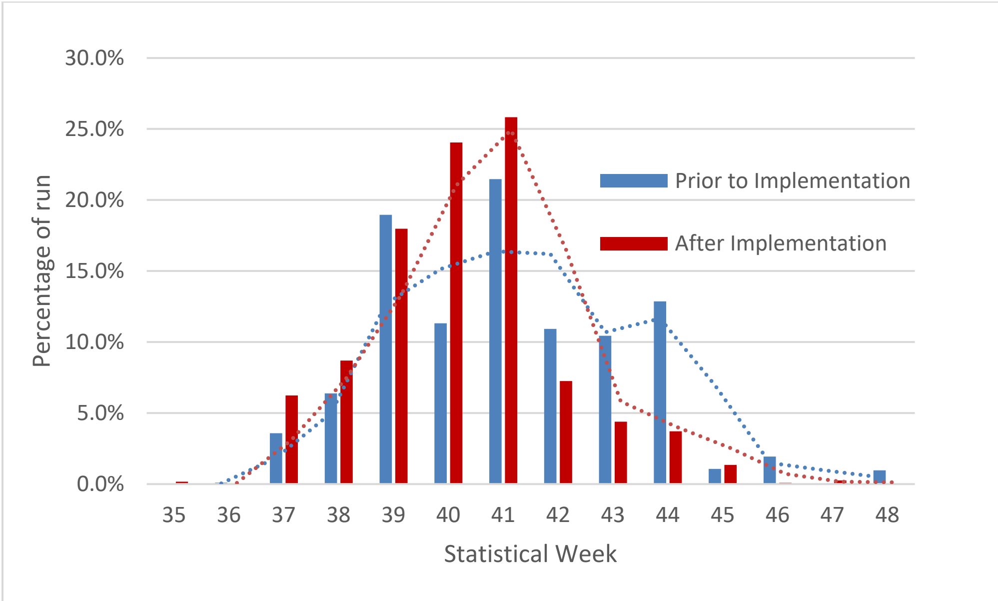


Figure 2. Percentage of total Chinook redds observed, by statistical week, prior to and after implementation of upmigration releases, with two point moving average.

The greatest difference in the timing of observed redds between prior to and after program implementation occurred in statistical week 40, which is near the peak of the Chinook run. Overall, a greater percentage of the run now spawns earlier in the Sultan River compared to the period prior to implementation of the program (Figure 2). Whereas it is typical during the early part of the Chinook run that the unregulated Skykomish and Pilchuck rivers contain low discharge and increasingly high-water temperatures, the Sultan River discharge volume, even near the prescribed minimum instream flow, provides cool, ample volumes of water which attract and provide ideal spawning conditions for Chinook salmon. Noteworthy as well, is the lack of any physical barriers restricting the upstream migration of salmon throughout the longitudinal extent of the Sultan River downstream of RM 15.8.

Table 3 contains live Chinook counts and redd observations from low water years, 2012 and 2016. This data highlights two points: 1) upstream migration is occurring at water levels below the upmigration flow threshold, and 2) Chinook salmon are successfully migrating and subsequently spawning without the need for an upmigration pulse flow. To further illustrate these points and to provide a basis to analyze the necessity of this process flow element, we provide a deeper dive into the temporal timing of Chinook spawn timing in 2012 and 2016.

The upmigration release in 2012 occurred on September 14. Results from the subsequent survey on September 26 identified 26 redds and 45 live Chinook (Table 3). Through the remainder of the season, despite low flow conditions in the Sultan River, new redds and live Chinook continued to increase to a peak of 89 redds and 140 live fish on October 12 (Table 3). In the fall of 2016, an upmigration release did not occur due to maintenance at the Jackson Project. Since inception of the upmigration process flow program in 2011, the two largest single day redd counts in Reach 1 of the Sultan River occurred in 2012 and 2016 (89 and 98 redds, respectively). These data indicate that Chinook salmon effectively migrate to and successfully spawn in the Sultan River at water levels near the minimum instream flow of 300 cfs and do not require a pulse flow to stimulate their upmigration.

Table 3. Redd counts in Reach 1 by survey date and mean/max flow (cfs) since previous survey, 2012 and 2016.

Date of Survey	New Redds	Live Chinook	Mean/Max Flow (cfs) since previous survey
9/12/2012	0	0	
9/26/2012	26	45	357/769
10/5/2012	52	128	326/346
*10/12/2012	89	140	322 /328
8/26/2016	0	0	
9/13/2016	3	12	399/558
9/23/2016	23	70	449/614
10/6/2016	98	212	383/430
*10/11/2016	37	161	605/812

*10/12/12 and 10/11/16 were the final surveys of season; river conditions were not adequate to survey for the remainder of season.

Further upstream in Reach 3 of the Sultan River, Snohomish PUD has been monitoring upstream fish migration past the City of Everett's Diversion Dam. In 2018, the ARC approved the purchase of a hydroacoustic sonar system known as ARIS. Snohomish PUD operated the ARIS underwater sonar to monitor adult Chinook migrating into Reach 3 in 2018, 2020, and 2021. In 2021, the ARIS operated from June 16 - October 30. The impetus for installing the ARIS prior to fall surveys in 2021, was that Snohomish PUD biologists were documenting an increase in hatchery origin carcasses in the Sultan early in the season and were curious about run-timing and hydrologic conditions during their upstream migration.

Table 4 shows the number of Chinook documented on the ARIS by statistical week. Coupling this temporal run timing information with hydrology from Figure 3, indicates Chinook are migrating 9.7 miles upstream from the Sultan-Skykomish confluence during low flows beginning in June and extending to mid-September. Based on these 2021 data, 52% of the Chinook encountered at the ARIS had migrated past the Diversion Dam from June through August, during a period of low-flow conditions (Table 4, Figure 3).

Table 4. Number of Chinook documented on the ARIS by statistical week in 2021.

Statistical Week	Number and Percent of Run
24	3 (2%)
25	2 (2%)
26	1 (1%)
27	2 (2%)
28	0
29	6 (5%)
30	6 (5%)
31	9 (7%)
32	4 (3%)
33	3 (2%)
34	4 (3%)
35	26 (20%)
36	33 (25%)
37	20 (15%)
38	0
39	4 (3%)
40	5 (4%)
41	0
42	1 (1%)
43	1 (1%)
Total	130
Statistical Weeks	Corresponding Months
22-26	June
27-31	July
32-35	August
36-40	September
41-44	October

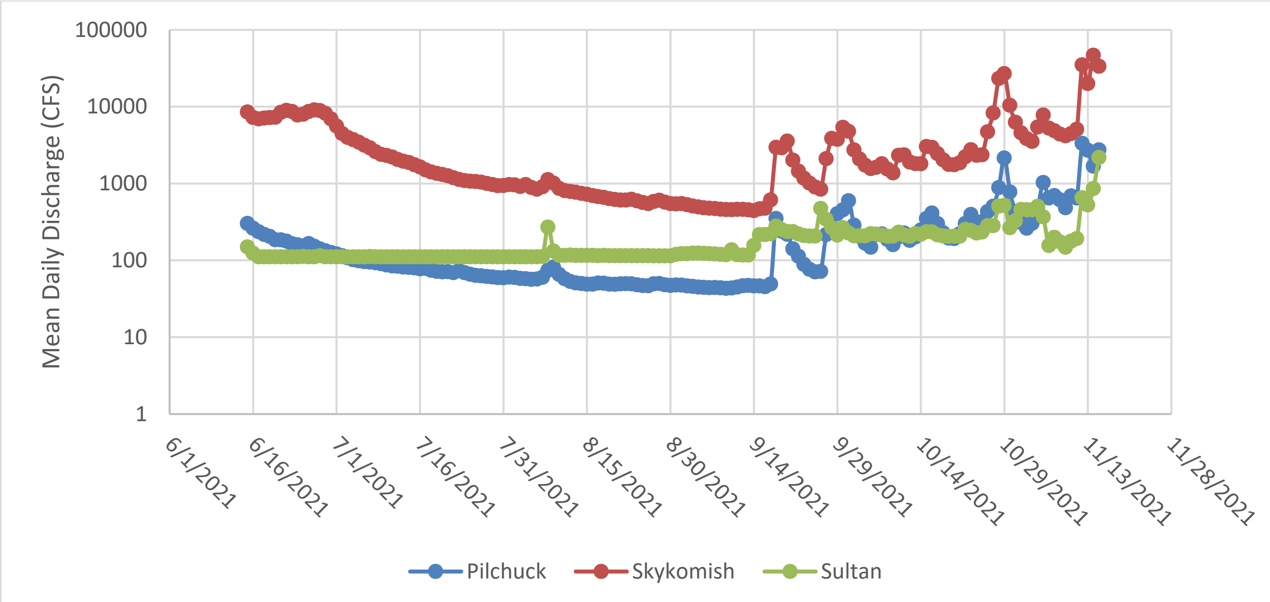


Figure 3. Mean daily discharge, June 15 – November 15, 2021, displayed for the Sultan below Diversion Dam gage, Pilchuck, and Skykomish Rivers.

Straying

The number of marked (adipose fin clipped and/or coded wire tagged) fish has increased substantially since upmigration releases began. As Table 5 shows, 4% of carcasses were marked prior to the implementation of upmigration releases and 17% have been marked since program implementation. During years 2012-2021, eight coded wire tagged Chinook have been recovered in the Sultan River: seven were from the Wallace Hatchery and one from Whitehorse Rearing Ponds on the North Fork Stillaguamish (Regional Mark Processing Center (rmpc.org)). This shift in run composition has occurred at a time of increased hatchery production. While the Wallace Hatchery has been releasing over one million summer run Chinook annually since 2002, 65% more fish were released during the 2011 to 2021 period versus the 2001 to 2010 period (Table 6).

Table 5. Number and percentage of marked (adipose fin clipped and/or coded wire tagged) carcasses during prior to and after implementation of upmigration releases.

Prior to Implementation				*After Implementation*			
Year	Total Carcasses	Number Marked	Percent Marked	Year	Total Carcasses	Number Marked	Percent Marked
2001	30	1	3%	2012	68	18	26%
2002	50	4	8%	2013	48	1	2%
2003	19	1	5%	2014	27	8	30%
2004	43	1	2%	2015	38	16	42%
2005	21	1	5%	2017	35	2	6%
2006	20	0	0%	2018	45	3	7%
2008	40	0	0%	2019	4	1	25%
2010	18	2	11%	2020	79	13	16%
				2021	62	9	15%
Total	241	10	4%	Total	406	71	17%

Table 6. Wallace Hatchery Chinook releases 2002-2022.

Release Year	Subyearling	Yearling	Total Released
2002	795,123	218,000	1,013,123
2003	1,026,549	250,000	1,276,549
2004	870,000	133,000	1,003,000
2005	1,067,700	164,843	1,067,700
2006	876,505	246,183	1,122,688
2007	1,115,372	290,000	1,405,372
2008	1,015,000	294,547	1,309,547
2009	1,168,281	261,507	1,429,788
2010	1,251,377	234,516	1,485,893
2011	1,010,000	249,740	1,259,740
2012	1,793,067	240,306	2,033,373
2013	1,071,017	112,137	1,183,154
2014	1,050,459	437,770	1,488,229
2015	1,066,315	423,608	1,489,923
2016	1,100,407	467,387	1,567,794
2017	969,316	459,000	1,428,316
2018	1,112,454	440,000	1,552,454
2019	951,832	510,928	1,462,760
2020	1,387,761	534,938	1,922,699
2021	1,183,901	544,158	1,728,059
2022	2,050,549	449,533	2,500,082

The incidence of marked carcasses is not distributed evenly throughout the spawning season. Most marked carcasses have been recovered early in the season (Figure 4). Wallace Hatchery Chinook are summer-run and, therefore, spawn earlier than Sultan natural origin Chinook which are fall run. This explains the temporal difference of marked and unmarked fish.

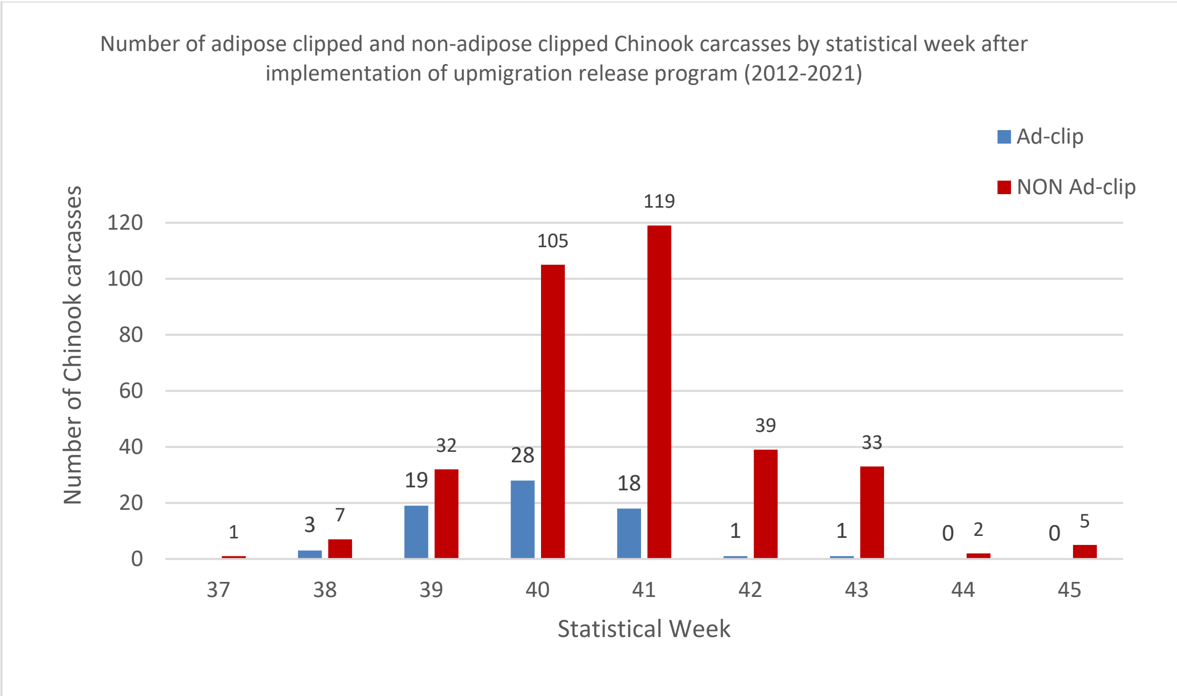


Figure 4. Number of adipose clipped and non-adipose clipped Chinook carcasses recovered during spawner surveys by statistical week after implementation of upmigration release program, 2012-21.

A suite of factors contributes to the attraction and enticement of hatchery Chinook to the Sultan River. Based on observations during spawning surveys over the past 10 years, three factors stand out: 1) disproportionately high flow volume from the Sultan River compared to the unregulated Skykomish drainage during the summer; 2) regulated water temperature control and adherence to the Washington State water temperature standard of 16 degrees Celsius; and 3) significant increase in hatchery Chinook production at the Wallace River Hatchery. An interesting data point to consider is from fall 2016 when an upmigration process flow did not occur. Carcass recoveries in the Sultan River during that year identified only 2% (one of 42) as being marked indicating hatchery origin, and the final Chinook escapement that year was the sixth highest since 2000.

Since Sultan River Chinook are not coded wire-tagged, it is not possible to determine the proportion of Chinook that stray from the Sultan River absent that information. However, by converse logic based on many years of observation during spawner surveys and documentation of new redds and new fish during periods of relatively low flows, it is inferred that operational adherence to the prescribed minimum flow and water quality requirements for the Project results in favorable conditions and a reduced probability of Chinook straying out of the Sultan. Additional data, such as, the 13% increase in hatchery Chinook carcass recoveries in the first ten-year PFP implementation period, suggest it is unlikely that adult Chinook are straying out of the Sultan River.

2.1.5. Unforeseen Consequences

As previously mentioned, the intent of the PFP is to provide elements of a more normative hydrograph in the lower Sultan River compared to existing conditions. As the hydrographs in

Appendix A indicate, the timing of the fall upmigration releases does not typically coincide with natural conditions observed in either the Pilchuck or Skykomish systems. As such, the timing and duration of these flows have the potential to entice and induce the straying of hatchery fish into the Sultan River, while providing limited benefit to natural origin fish. Operationally induced enticement can lead to changes in run composition and timing which deviates from the logic and intent behind the development and implementation of several license articles including those related to minimum flow schedules, the salmon ceiling, and downramping.

2.1.6. Adaptive Actions Undertaken

The original salmon ceiling flow restriction of 550 cfs (mean daily discharge measured at the Powerhouse gage) was modified in August 2021 to allow for a maximum of 850 cfs for no more than 36 hours during the month of September. This adjustment was intended to allow for upmigration releases to be timed to be more in line with natural hydrologic patterns.

2.1.7. Recommended Modifications

Data gathered and observations made during the first ten years of License implementation provide three conclusions related to assessing the value of the upmigration element of the process flow program.

- Even in low water years, the operational hydrology during fall in the Sultan River is conducive to stimulate upstream salmon migration without the need for an upmigration pulse flow;
- In conjunction with significant increases in hatchery Chinook production the annual upmigration pulse flow may exacerbate hatchery straying to the Sultan River; and
- The timing and magnitude associated with upmigration flows on the Sultan River deviates from the normative hydrology in unregulated systems within the Snohomish Basin.

Overall, implementation of the upmigration process flow program has not produced the intended biological benefit. In crafting this element of the PFP there was a level of scientific uncertainty related to the flow volumes and presumed benefits provided by an upstream migration release. In addition to re-establishing elements of a more normative hydrograph, the PFP identified three potential areas of biotic and hydrologic value that the upmigration program would provide: initiate the upstream migration of adult salmon, limit straying to other river basins, and facilitate swimming past natural and artificial barriers. Based on results from this ten-year evaluation period, Snohomish PUD does not believe upmigration process flows are necessary. They have unintended biological consequences such as attracting hatchery Chinook which over time, may lead to a shift in run composition and timing. After reviewing this data, Snohomish PUD proposes the following recommendations.

Moving forward, recommendations for the next ten-year cycle include:

- Suspend releases for upmigration for the next ten-year cycle and compare data to the first ten-year period to identify any differences in spawn timing patterns.

- Incorporate mid-August spawning surveys into existing protocols to document potential shifts in run timing and/or stock composition relative basin hydrology and water quality (temperature).
- Continue to gather and inspect carcasses within spawning survey index areas to determine the percent hatchery origin Chinook.
- Support co-manager fisheries management and research efforts by continuing to gather DNA, scale, and otolith samples off carcasses encountered during spawning surveys.

2.2. Outmigration

2.2.1. Program

The intent of the outmigration element of the process flow program is to release pulsed flows twice per year, during the spring, to stimulate juvenile salmonid outmigration theoretically increasing their survival. These short-duration special purpose releases are thought to bring in elements of a more normative hydrograph in the lower Sultan River compared to hydrologic conditions during the previous License. In addition, introducing outmigration pulsed flows were assumed necessary during the PFP development to increase survival of juvenile salmon and steelhead outmigrants during drought years. The sections below contain specific information within the outmigration process flow program including, frequency and timing, duration, and magnitude (by reach). Following the general components are the objectives and assumptions of the outmigration process flow program as originally considered and hypothesized during relicensing. Specific metrics in the PFP were identified for evaluating the outmigration program objectives and assumptions. Results from these efforts are presented followed by discussions of unforeseen consequences, adaptive actions, and suggested recommendations for modifications and improvements that aim to build upon the lessons learned from the first ten-year monitoring period.

2.2.1.1. Frequency and Timing

The PFP states that Snohomish PUD will discharge water, if necessary, to ensure that two outmigration flows are achieved per year. One of the annual outmigration flows shall occur in April and one of the annual migration flows shall occur in May, with a minimum of seven days separation between events. The PFP further states that one flow must occur during the day and one flow must occur at night.

2.2.1.2. Duration

The duration of these outmigration releases is to occur for a minimum of six consecutive hours.

2.2.1.3. Magnitude (by reach)

An outmigration flow will be achieved by meeting the following criteria. The range was intended to allow for testing the different flow magnitudes during the first ten years of the License.

Reach 1: Between 800 and 1,200 cfs (USGS Gaging Station No. 12138160)
Reach 2: Between 400 and 600 cfs (upstream of the Powerhouse at RM 4.7)
Reach 3: Between 200 and 400 cfs (upstream of the City of Everett’s Diversion Dam at RM 9.8)

2.2.2. Objectives

Section 1.3 of the PFP identifies two primary biological objectives of the outmigration program: stimulating juvenile salmonid outmigration and increasing survival of juvenile salmon and steelhead.

2.2.3. Assumptions

Implementation of the outmigration process flow program is intended to stimulate outmigration, result in increased survival of juvenile outmigrants, and provide elements of a more normative hydrograph compared to existing conditions.

2.2.4. Results

Since License implementation, data have been collected to evaluate the effectiveness of the outmigration process flow program. As described in the FHMP, a juvenile smolt trap was operated in the lower Sultan River to assess natural salmonid production. The lower Sultan River trap operated during nine of the first ten years after License issuance. Based on these data and direct observations, Snohomish PUD does not believe outmigration process flows are necessary, and in some instances, these pulse flows have unintended biological consequences. The following data presented and discussed below includes:

- Basin hydrology comparison – Sultan, Skykomish, Pilchuck
- Outmigration compliance events and frequency of occurrences
- Pooled regression correlating trap catch with discharge
- Examples of salmonid outmigration run timing in low and high-water years
- Examples of mean daily discharge during peak salmonid outmigration run timing
- Effect of outmigration process flows on trap catch

Basin Hydrology

The Sultan River receives on average, 163 inches of precipitation annually. The Sultan River watershed drains the least amount of land compared to the Pilchuck and Skykomish (Table 7). The collective hydrologic contributions of rainfall, accretion, and power generation has yielded an increase of 37% in mean daily flow (measured at USGS gage 12138160 Sultan River below Powerplant) during the outmigration window compared to the previous ten-year period (2001-2010) (Table 8).

Table 7. Drainage basin area (square miles) of the Skykomish upstream of the Sultan, Pilchuck, and Sultan rivers captured at the location of each USGS streamgage. Source: USGS.

River	Drainage area (sq mi)
Sky	535
Pilchuck	127
Sultan	94.2

Table 8. Mean daily flow comparison and percent change between Sultan, Skykomish, and Pilchuck rivers during the outmigration window for years 2001-2010, and 2011-2021.

Mean daily flow (cfs) for entire outmigration period 2001-2010		
Sultan	Sky	Pilchuck
647	5619	480
Mean daily flow (cfs) for entire outmigration period 2011-2021		
Sultan	Sky	Pilchuck
883	6120	571
Percent change in mean daily flow (cfs) between time-periods		
Sultan	Sky	Pilchuck
37	9	19

Discharge standardized by drainage basin area for the unregulated Skykomish and Pilchuck rivers provides context on normative flow during the outmigration period. In years 2001-2010, the discharge per drainage area ratio was 10.5 cfs/sq mi, and 3.8 cfs/sq mi for the Skykomish and Pilchuck Rivers, respectively (Table 9). The ten-year time-period to follow, 2011-2021, showed a slight to modest increase in mean daily flow at the USGS streamgage locations on the Skykomish and Pilchuck rivers, representing a 9% and 19% increase, respectively (Table 8). In each of the two time-periods, the discharge per drainage area ratio on the Sultan River was greater than the Pilchuck River despite the Pilchuck watershed draining more land. From 2011-2021 the Sultan River standardized flow represented 82% of the Skykomish River, and 208% of the Pilchuck River during the outmigration period.

Table 9. Mean daily discharge (cfs) during the outmigration window standardized per square mile of drainage area for the Skykomish, Pilchuck, and Sultan rivers, in years 2001-2010 and 2011-2021.

Mean daily discharge(cfs) per drainage area (sq mi)			
Years	Sky	Pilchuck	Sultan
2001-2010	10.5	3.8	6.9
2011-2021	11.4	4.5	9.4

Appendix A contains annual hydrographs for comparison of mean daily flow between the Sultan, Skykomish, and Pilchuck rivers (Figures A1-A11) during the period spanning 2011-2021. These figures also highlight the outmigration and upmigration periods identified in the PF Plan. Figure A-12 displays mean daily flow within the outmigration window in years 2001-2021. These figures illustrate the concept of normative flow when comparing the regulated Sultan River against the unregulated Skykomish and Pilchuck rivers and is a basis for suggesting that outmigration flows may not be necessary.

Sultan River Outmigration Compliance

Continuous hydrologic data from RM 9.8 was not available until 2018. The geomorphic response and mobilization of sediment following fish passage at the Diversion Dam was profound and conditions at the site finally equilibrated enough to re-install a permanent streamgage at RM 9.8 in 2018. The data presented in Appendix B is from the reach-specific streamgage locations, depicted in Figure 1, where compliance is monitored:

- Reach 1 – USGS Streamflow Gage No. 12138160 (downstream of Powerplant),
- Reach 2 – Immediately upstream of the Powerhouse at RM 4.7, and,
- Reach 3 – Immediately upstream of Diversion Dam at RM 9.8.

Tables in Appendix B account for the number of discrete instances by reach, where an outmigration process flow objective would have been achieved without the use of the Howell-Bunger valve at Culmback Dam. These qualifying instances of "natural[1]" outmigration flows vary from year to year. During the outmigration window in years 2018-2021, a total of 117, 104, and 80 instances of "natural" outmigration process flows occurred in Reach 1, 2, and 3, respectively. The bulk of these events occurred in 2018, and in contrast, there were 0 qualifying events beyond the 2 scheduled outmigration process flows in 2020 (Appendix B).

Stimulating Outmigration

Trap catch during the 2020 outmigration season was the lowest in the 9 years of trapping operations. The reason for such low productivity was not due to the limited number of outmigration flows, rather due to unintended consequences of a spill event that led to the highest peak flow observed since 1995. The basis for determining the relative effectiveness and overall necessity of outmigration process flows becomes apparent when the hydrologic record is applied to catch per hour data from the Sultan River smolt trap. For all species reported, trap catch was not correlated with discharge (Table 10). Figures 5 and 6 show the pooled regression for sub-yearling Chinook and chum, respectively, for all years sampled.

[1] In this context, "natural" relates to the combined hydrologic result of baseline project operations and accretion flows

Table 10. Correlation coefficient of mean daily flow and daily catch per hour, by year, for salmonids captured at the Sultan River smolt trap, RM 0.2.

Correlation coefficient r^2 (mean daily flow vs daily catch per hour)					
Trap year	0+ Chin	Pink	Chum	0+ coho	1+ coho
2012	0.00	0.04	0.14	0.02	0.01
2013	0.01		0.08	0.02	0.01
2014	0.14	0.00	0.06	0.00	0.01
2015	0.02		0.06	0.07	0.10
2016	0.03	0.09	0.18	0.02	0.13
2017	0.37		0.20	0.00	0.00
2019	0.03		0.02	0.09	0.10
2020	0.01	0.05	0.08	0.02	0.14

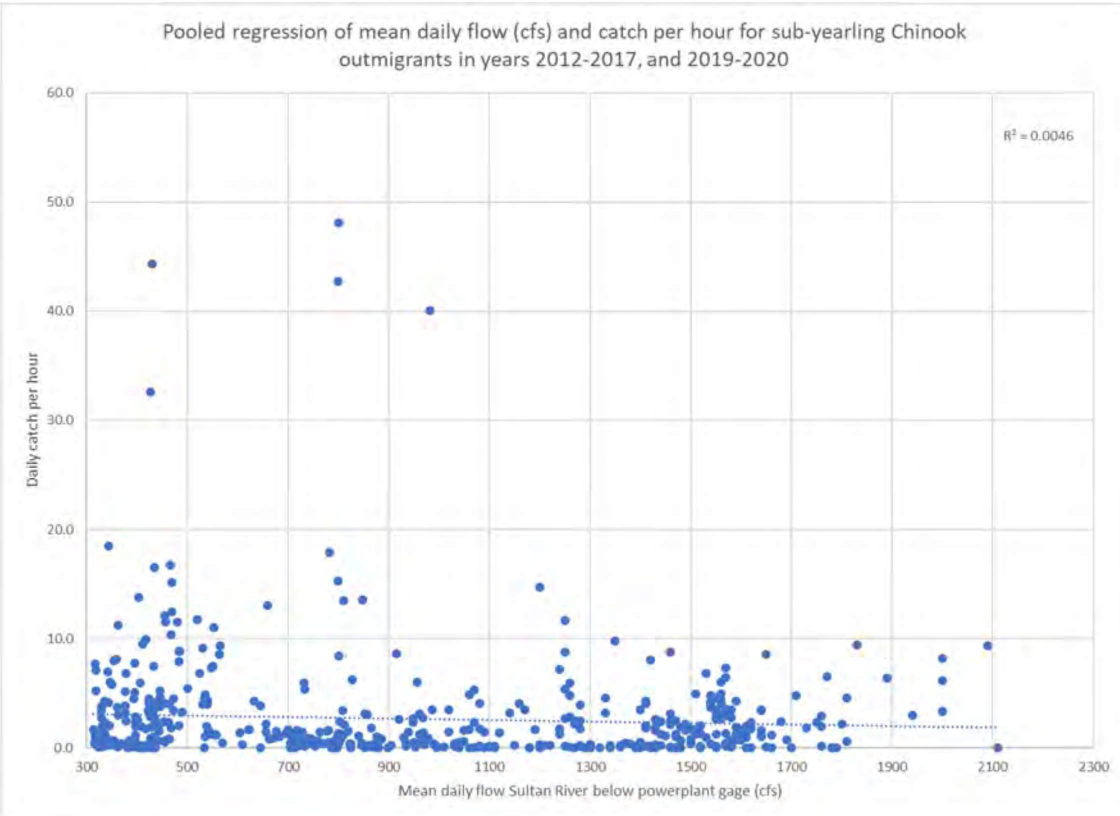


Figure 5. Pooled regression of mean daily flow (cfs) and catch per hour for sub-yearling Chinook outmigrants in year 2012-2017, and 2019-2020.

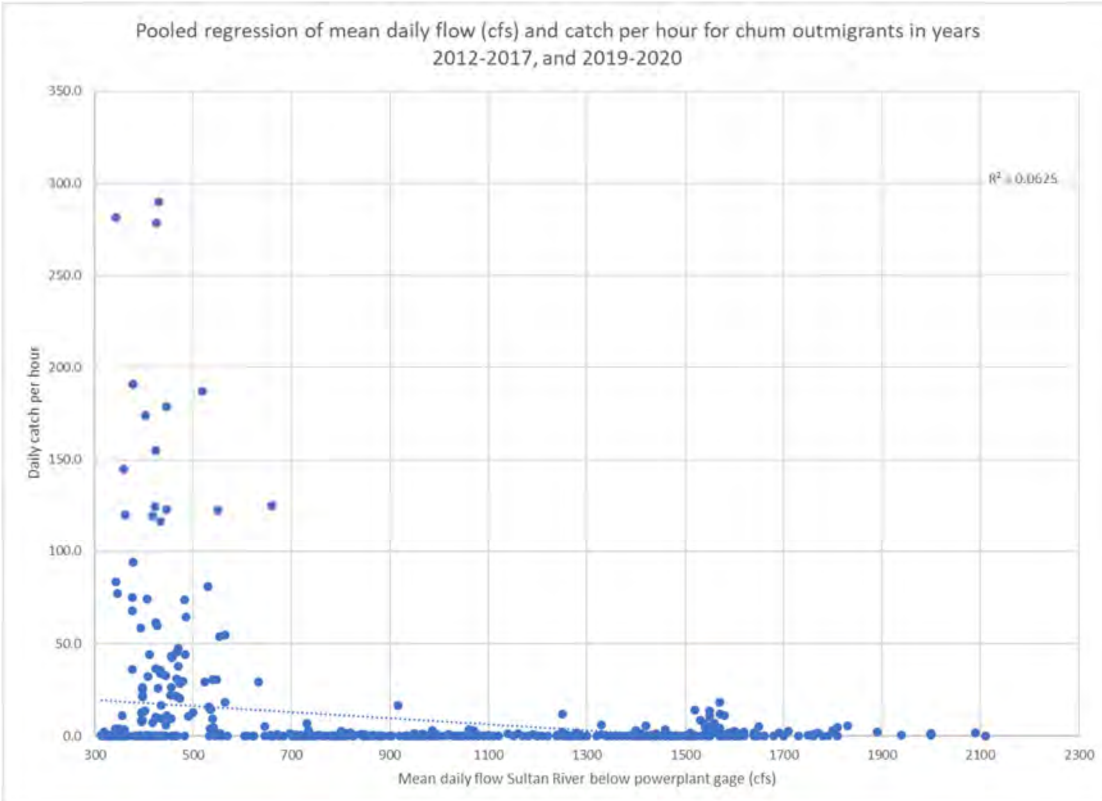


Figure 6. Pooled regression of mean daily flow (cfs) and catch per hour for sub-yearling chum outmigrants in year 2012-2017, and 2019-2020.

Figures 7–13 are select examples from years 2013–2019 that show weekly catch (focusing on sub-yearling Chinook, however, examples of chum, pink, and yearling coho are also provided), overlaid with mean daily hydrograph, and the Reach 1 minimum magnitude threshold for an outmigration process flow.

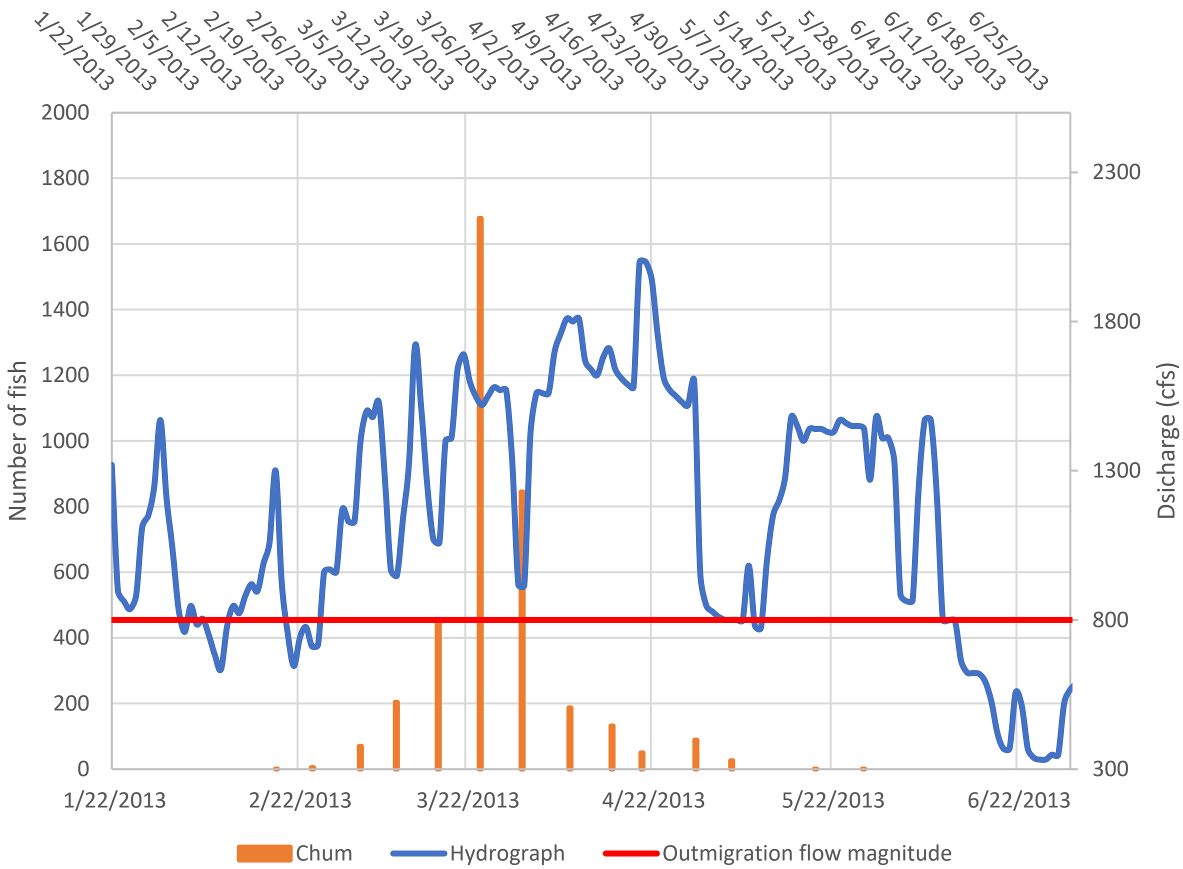


Figure 7. Weekly Chum outmigration and hydrograph of mean daily flow in the lower Sultan River, 2013.

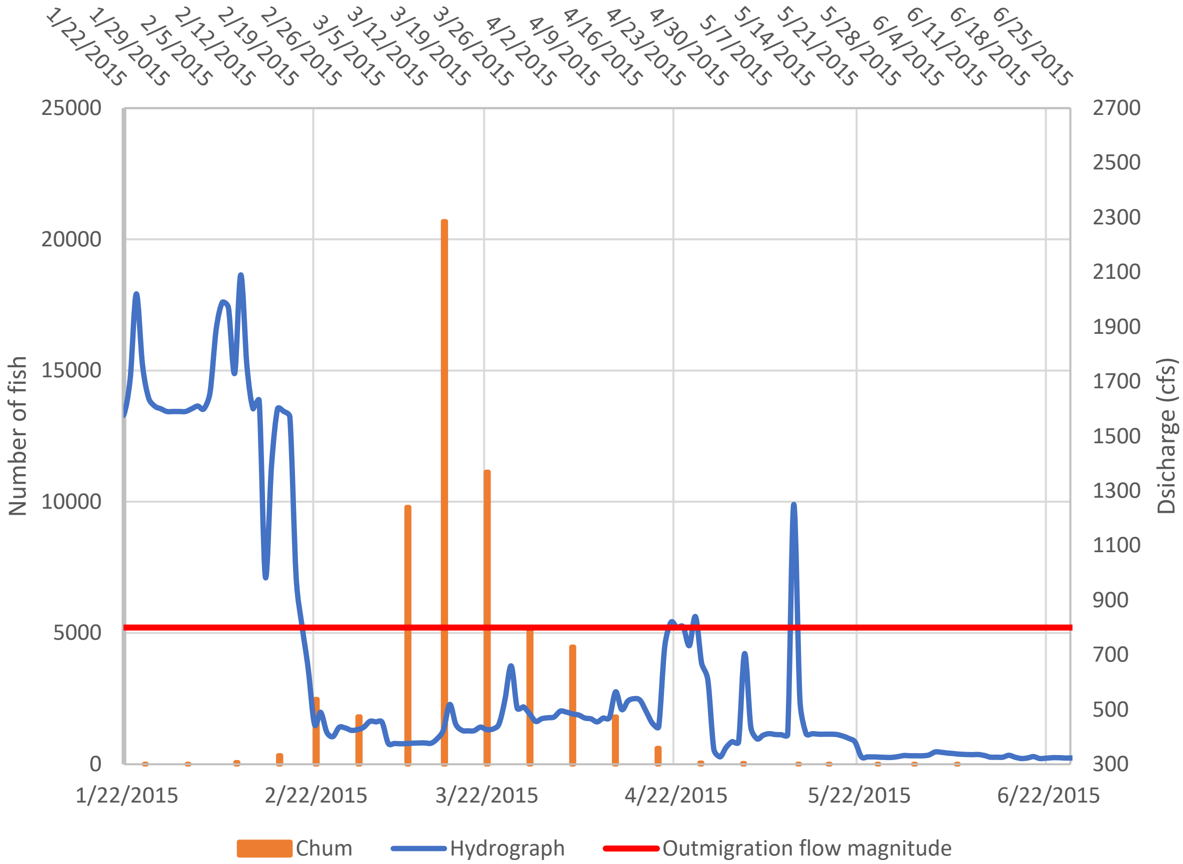


Figure 8. Weekly Chum outmigration and hydrograph of mean daily flow in the lower Sultan River, 2015.

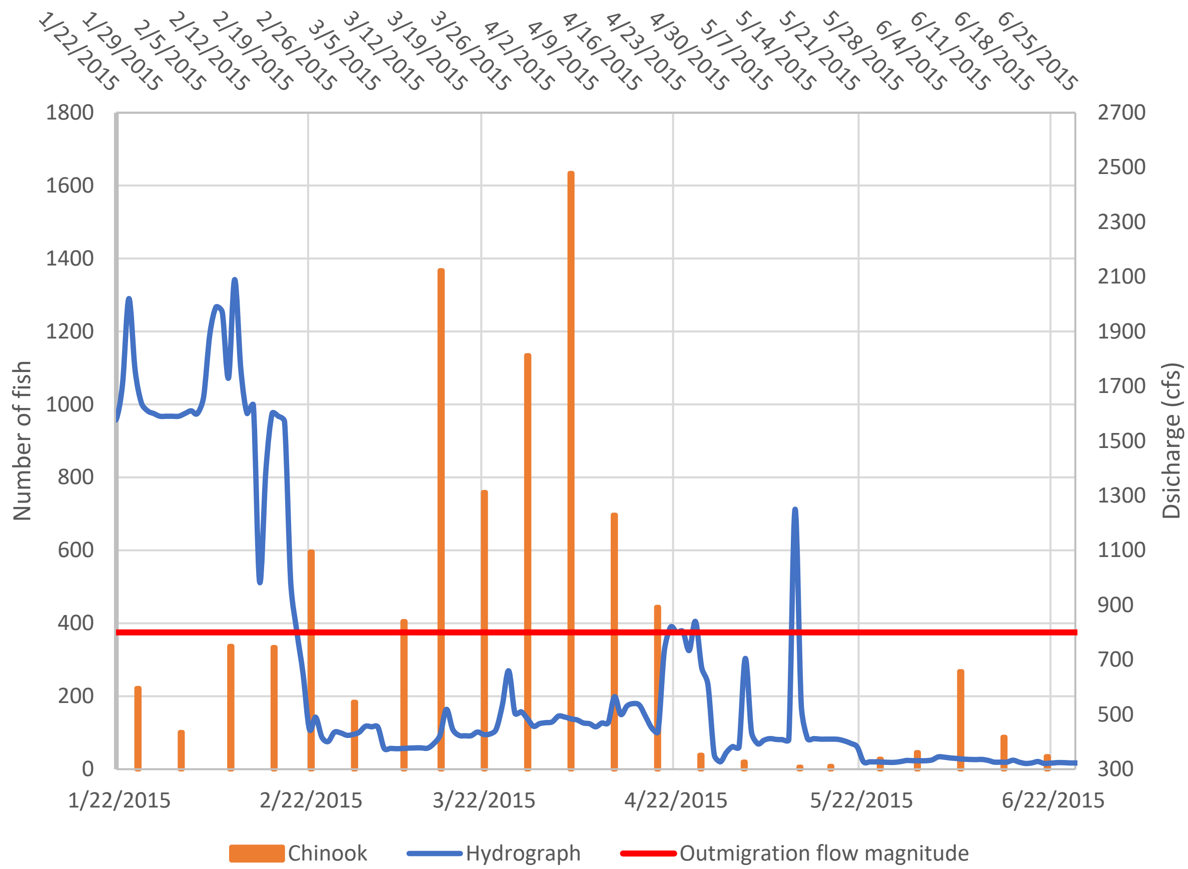


Figure 9. Weekly Chinook outmigration and hydrograph of mean daily flow in the lower Sultan River, 2015.

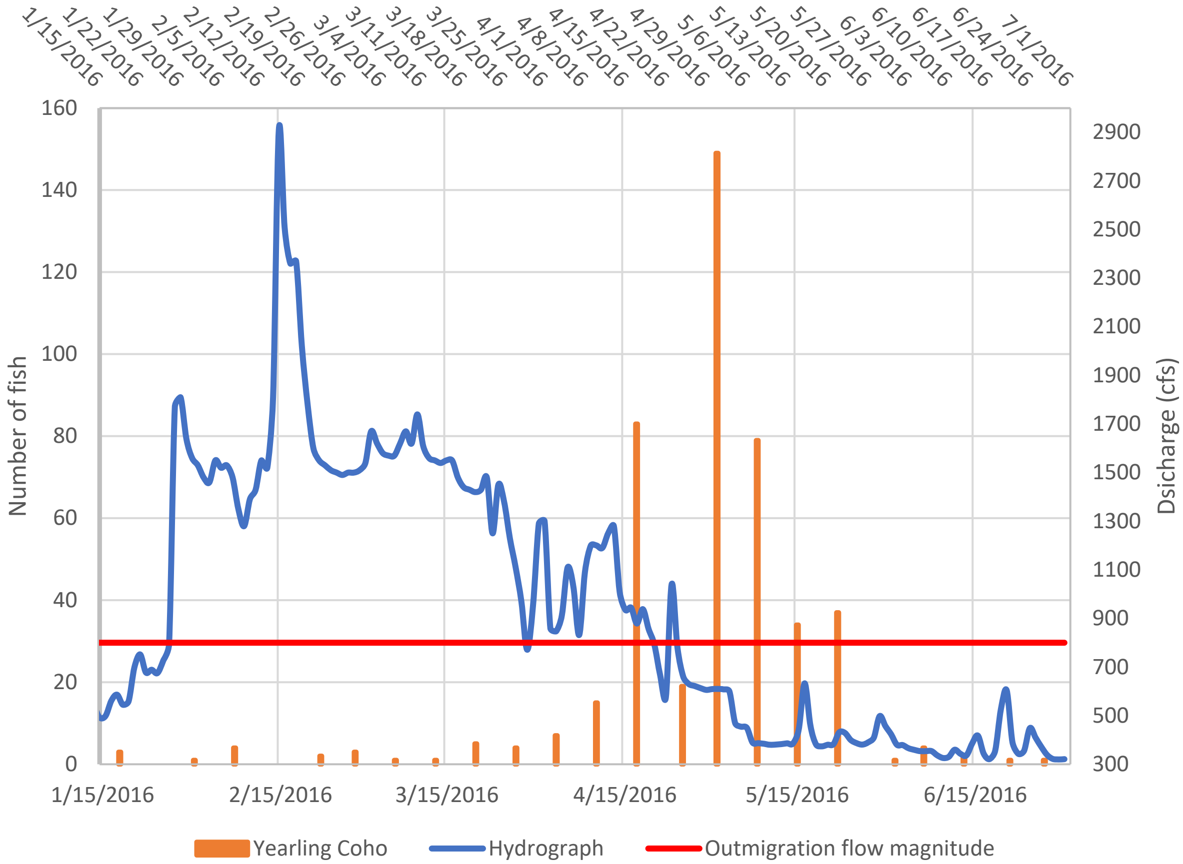


Figure 10. Weekly yearly Coho outmigration and hydrograph of mean daily flow in the lower Sultan River, 2016.

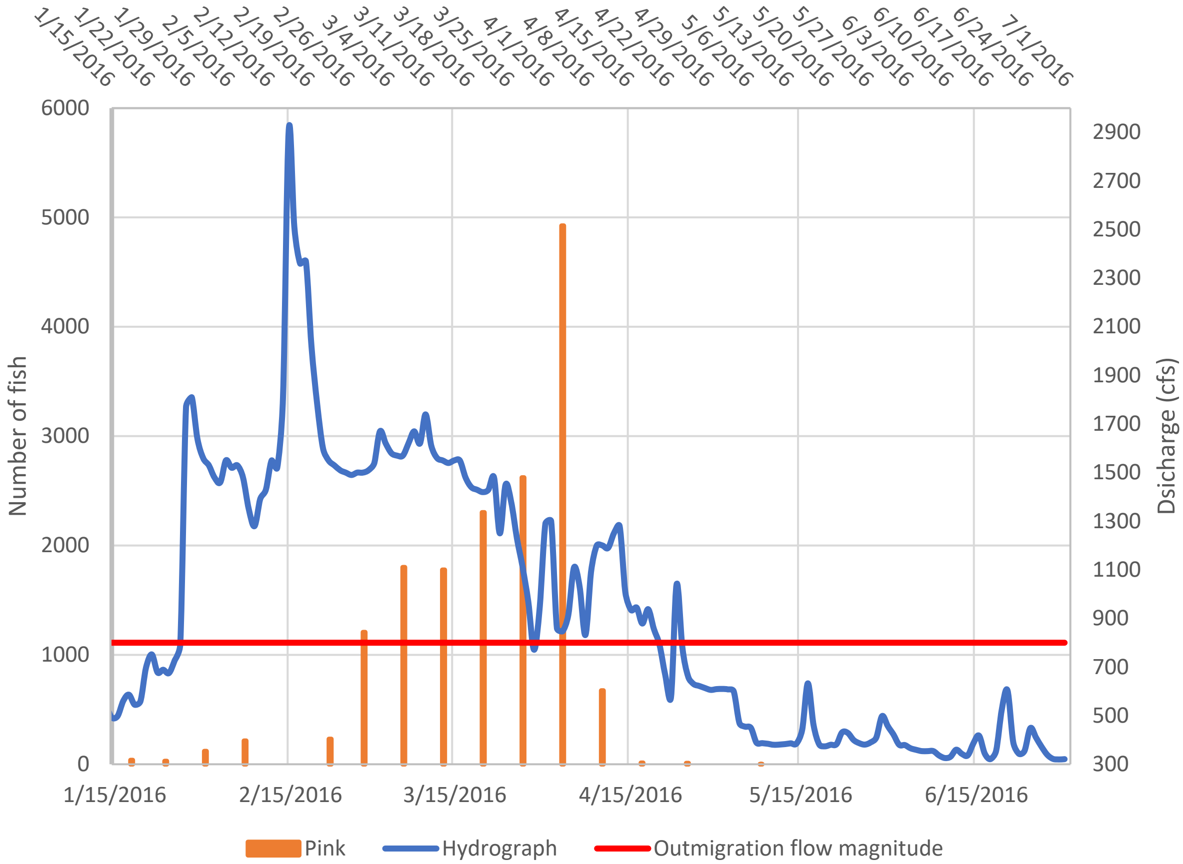


Figure 11. Weekly Pink outmigration and hydrograph of mean daily flow in the lower Sultan River, 2016.

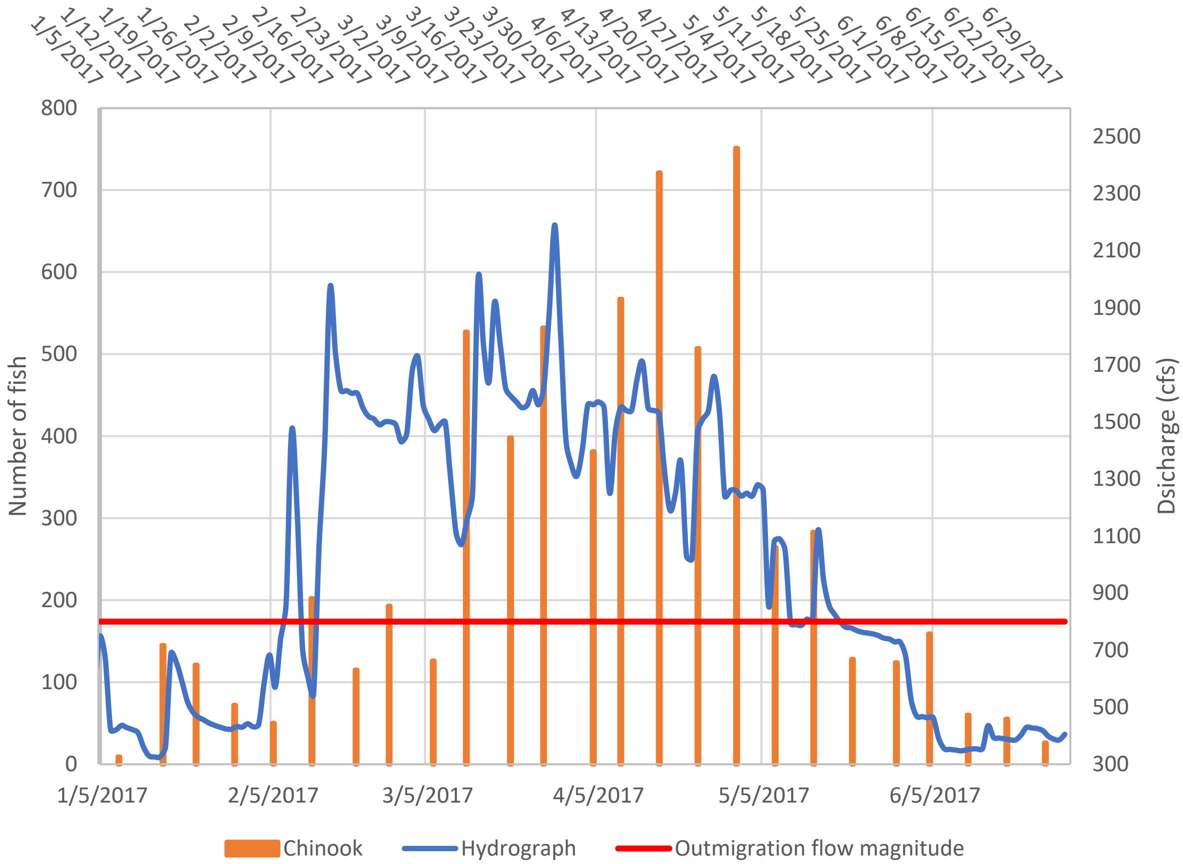


Figure 12. Weekly Chinook outmigration and hydrograph of mean daily flow in the lower Sultan River, 2017.

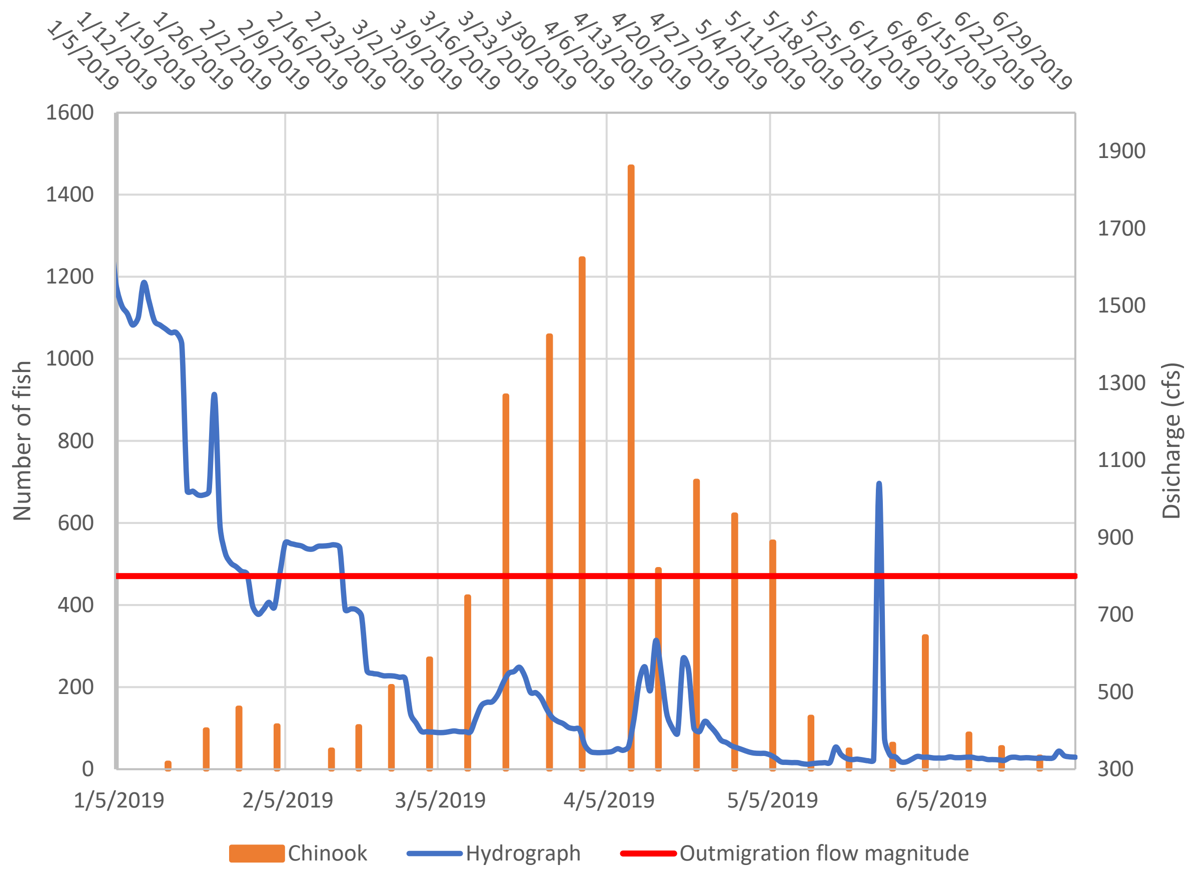


Figure 13. Weekly Chinook outmigration and hydrograph of mean daily flow in the lower Sultan River, 2019.

The examples provided above are intended to show outmigration run-timing patterns in high and low-water years. In the absence of scour effects or other biological or physical perturbations, the outmigration timing of juvenile salmonids migrating from the Sultan River generally displays in a bell-shape, normalized distribution (Figures 7-10, 12, and 13). To further investigate the relationship between hydrology and catch and to potentially identify any preference for flow within the peak of the outmigration period, Figures 14–19 below zoom in on the two-week period before and after the peak of the sub-yearling Chinook outmigration in years 2012–2015, 2017, and 2019.

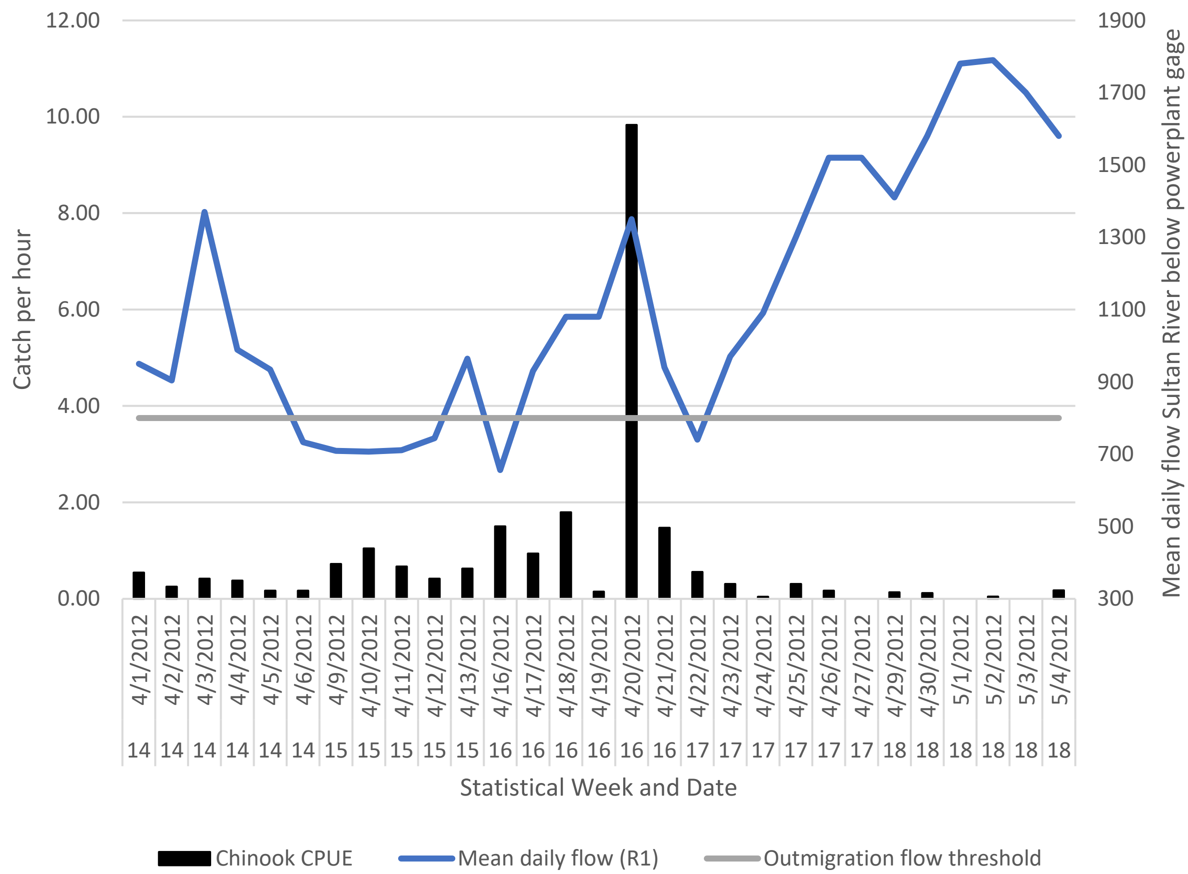


Figure 14. Chinook catch per hour and mean daily flow during peak outmigration, 2012.

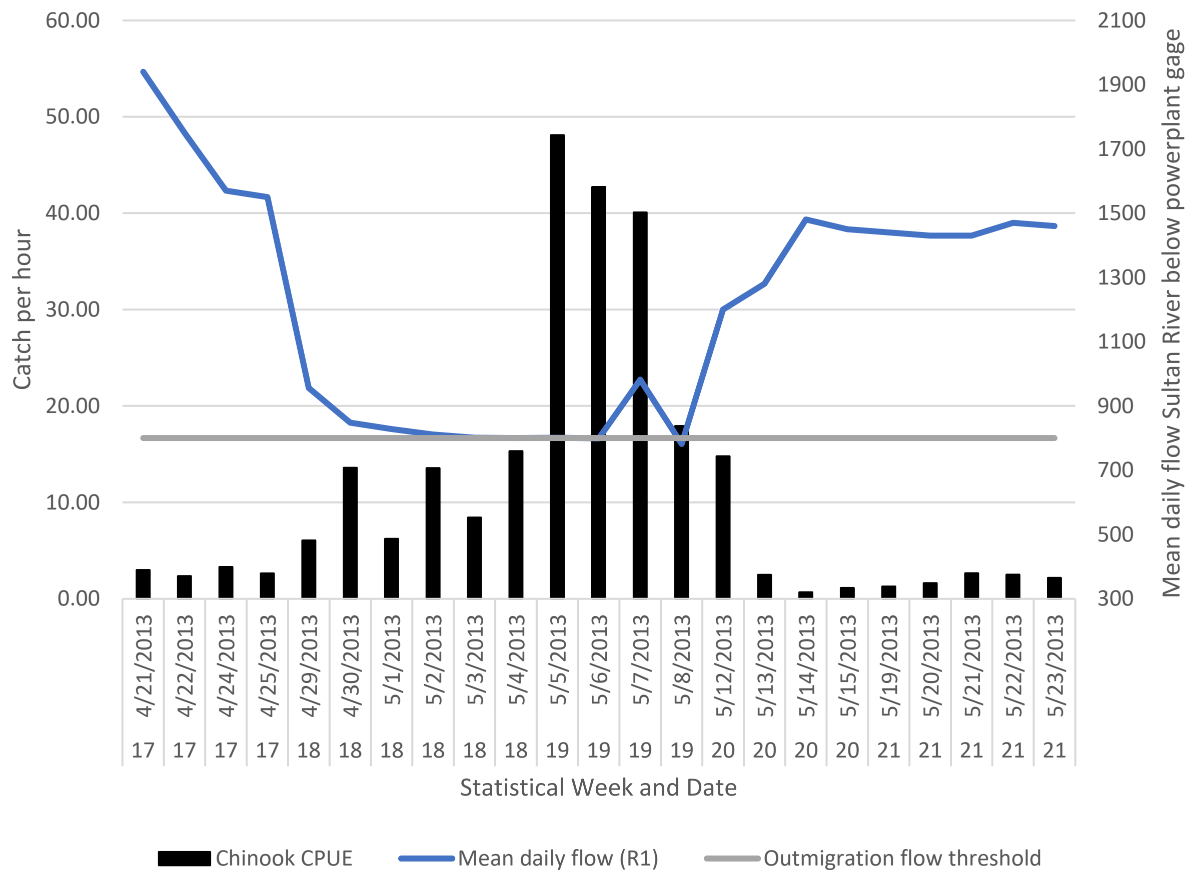


Figure 15. Chinook catch per hour and mean daily flow during peak outmigration, 2013.

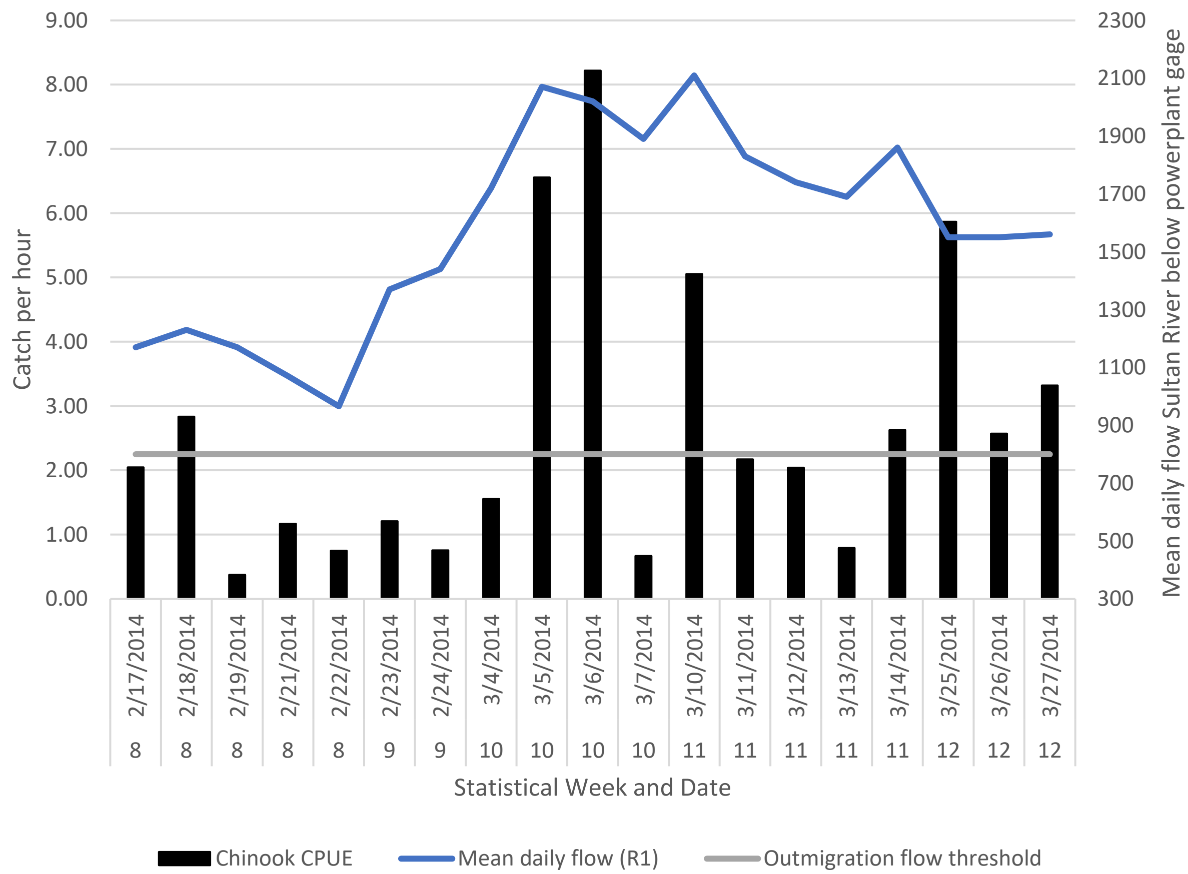


Figure 16. Chinook catch per hour and mean daily flow during peak outmigration, 2014.

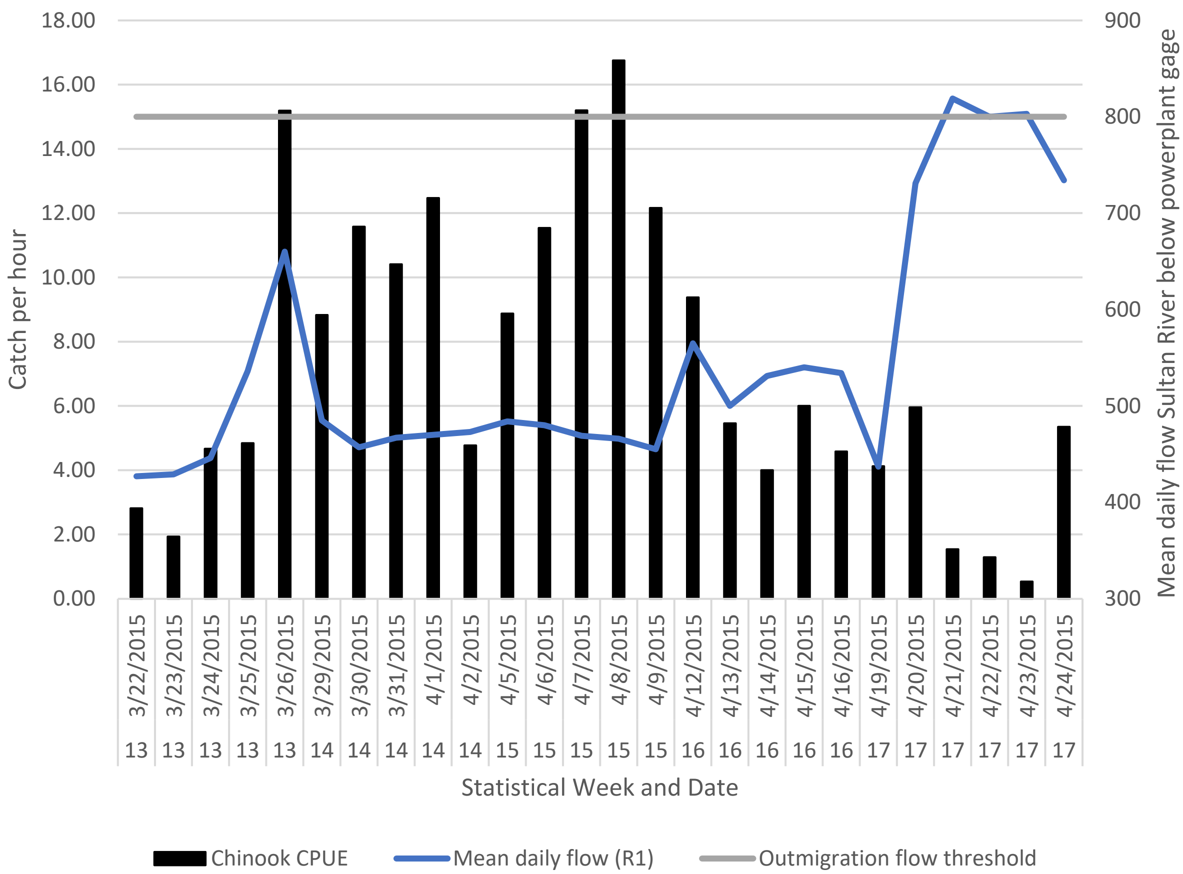


Figure 17. Chinook catch per hour and mean daily flow during peak outmigration, 2015.

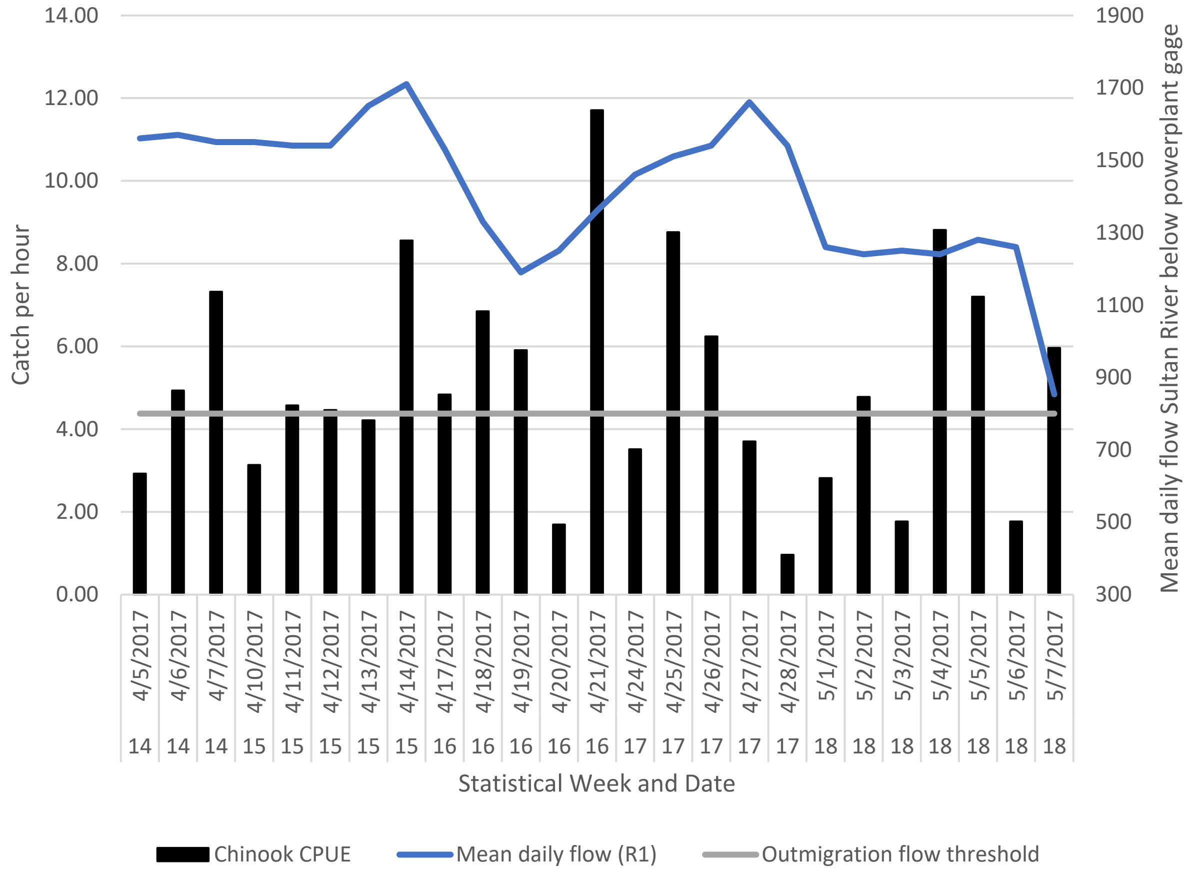


Figure 18. Chinook catch per hour and mean daily flow during peak outmigration, 2017.

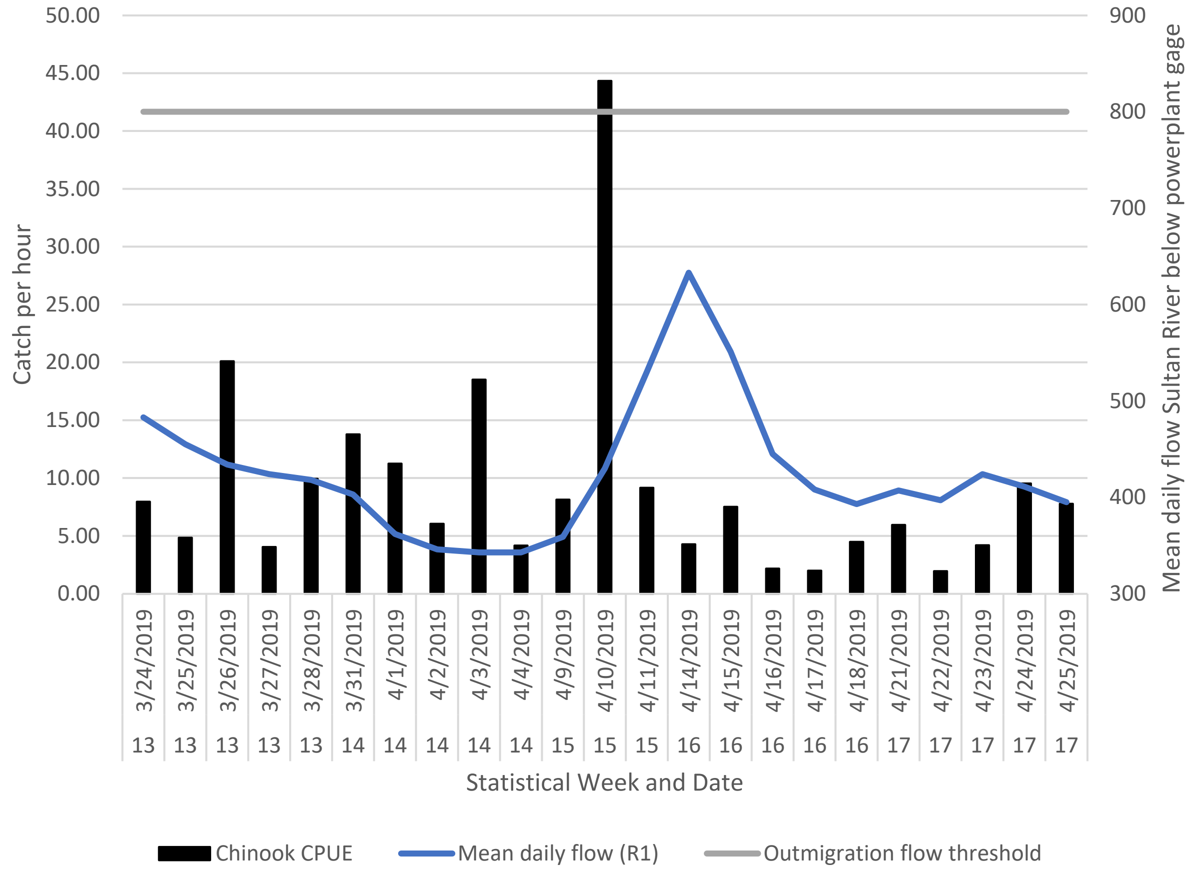


Figure 19. Chinook catch per hour and mean daily flow during peak outmigration, 2019.

These figures provide additional evidence that highlights the insignificance of flow on trap catch. In the data, there are however discrete instances where flow and catch correlate. These data points likely represent a coincidence where an increase in flow occurs during peak migration rather than from the peak flow stimulating juvenile salmonid outmigration. These examples suggest hydrologic conditions in the Sultan River during the entire outmigration period provide sub-yearling Chinook, and other juvenile salmonids sufficient flow to stimulate their downstream migration without concern over delay or freshwater residualization. This conjecture is further supported by data which indicates juvenile salmonid outmigration timing is similar in low and high-water years.

Effect of Outmigration Flows on Catch

Smolt trap catch data from the April 2012 outmigration process flow is provided in Table 11. This data highlights catch immediately before, during, and after an outmigration process flow. Noteworthy during this event was the number and overall percent of unbuttoned and dead pink salmon. While trap catch was not correlated to discharge (Figures 5 and 6), data presented in Table 11 suggests that higher flows during outmigration releases can forcefully push fish out and result in an increased incidence of vulnerable yolk-sac fry compared to the level of incidence at lower flows.

Table 11. Catch Data from Smolt Trap Operation, Lower Sultan River, April 2012.

Set	Cone Down	Cone Up	Hours Fished	Total pink	Live pink	Pink	# live pink	% pink live	Comments /Mean discharge during set (RM 4.5 / RM 9.6)
#	(Date/ Time)	(Date/ Time)		Live	w/yolk	dead	w/yolk + dead	w/yolk + dead	
50	4/1/12 8:00 AM	4/2/12 8:00 AM	24.0	208	11	3	14	7%	958 / 272 cfs
51	4/2/12 8:00 AM	4/3/12 8:00 AM	24.0	31	2	1	3	10%	913 / 156 cfs
52	4/3/12 8:00 AM	4/3/12 8:45 AM	0.8	28	4	0	4	14%	moderate debris (alder casings); beginning of process flow (1,535 / 171 cfs)
53	4/3/12 8:45 AM	4/3/12 10:25 AM	1.7	139	20	0	20	14%	moderate debris (alder casings); process flow (1,544 / 335 cfs)
54	4/3/12 10:25 AM	4/3/12 11:55 AM	1.5	79	12	1	13	16%	moderate debris (alder casings); process flow (1,706 / 557 cfs)
55	4/3/12 11:55 AM	4/3/12 4:45 PM	4.8	1451	167	22	189	13%	heavy debris (alder casings); process flow (1,976 / 557 cfs)
56	4/3/12 4:45 PM	4/3/12 7:30 PM	2.8	428	14	2	16	4%	little debris; river dropping (1,613 / 452 cfs)
57	4/3/12 7:30 PM	4/4/12 8:00 AM	12.5	89	4	1	5	6%	1,018 / 199 cfs
58	4/4/12 8:00 AM	4/5/12 8:00 AM	24.0	63	7	0	7	11%	968 / 143 cfs
59	4/5/12 8:00 AM	4/6/12 8:00 AM	24.0	136	5	0	5	4%	879 / 123 cfs
60	4/6/12 8:00 AM	4/7/12 8:00 AM	24.0	49	0	0	0	0%	734 / 121 cfs
61	4/9/12 3:20 PM	4/10/12 8:00 AM	16.7	31	0	1	1	3%	704 / 121 cfs
62	4/10/12 8:00 AM	4/11/12 8:00 AM	24.0	158	0	0	0	0%	708 / 121 cfs
63	4/11/12 8:00 AM	4/12/12 8:00 AM	24.0	101	0	1	1	1%	720 / 121 cfs
64	4/12/12 8:00 AM	4/13/12 8:00 AM	24.0	74	0	0	0	0%	784 / 123 cfs
65	4/13/12 8:00 AM	4/14/12 8:00 AM	24.0	222	0	0	0	0%	902 / 122 cfs

The comments column in Table 11, identifies mean daily discharge at the top of Reach 1 (USGS Streamflow Gage No. 12138160, RM 4.5) and Reach 2 (USGS Streamflow Gage No. 12137800, RM 9.6) during each trap set. While it is impossible to determine the river reach from which the unbuttoned pink salmon originated, the flow data provides a potential peak flow avoidance volume with a prospective goal aimed at reducing or eliminating, when possible, the unintended forcing out effect from outmigration process flows.

In broader examples, data from the Sultan River smolt trap allow the insight into catch of downstream juvenile salmonids before, during, and after outmigration process flows. This section contains Figures 20–26 which illustrate catch per week as background and visually compare to catch per hour during outmigration process flows in years 2012–2014, 2017, and 2019.

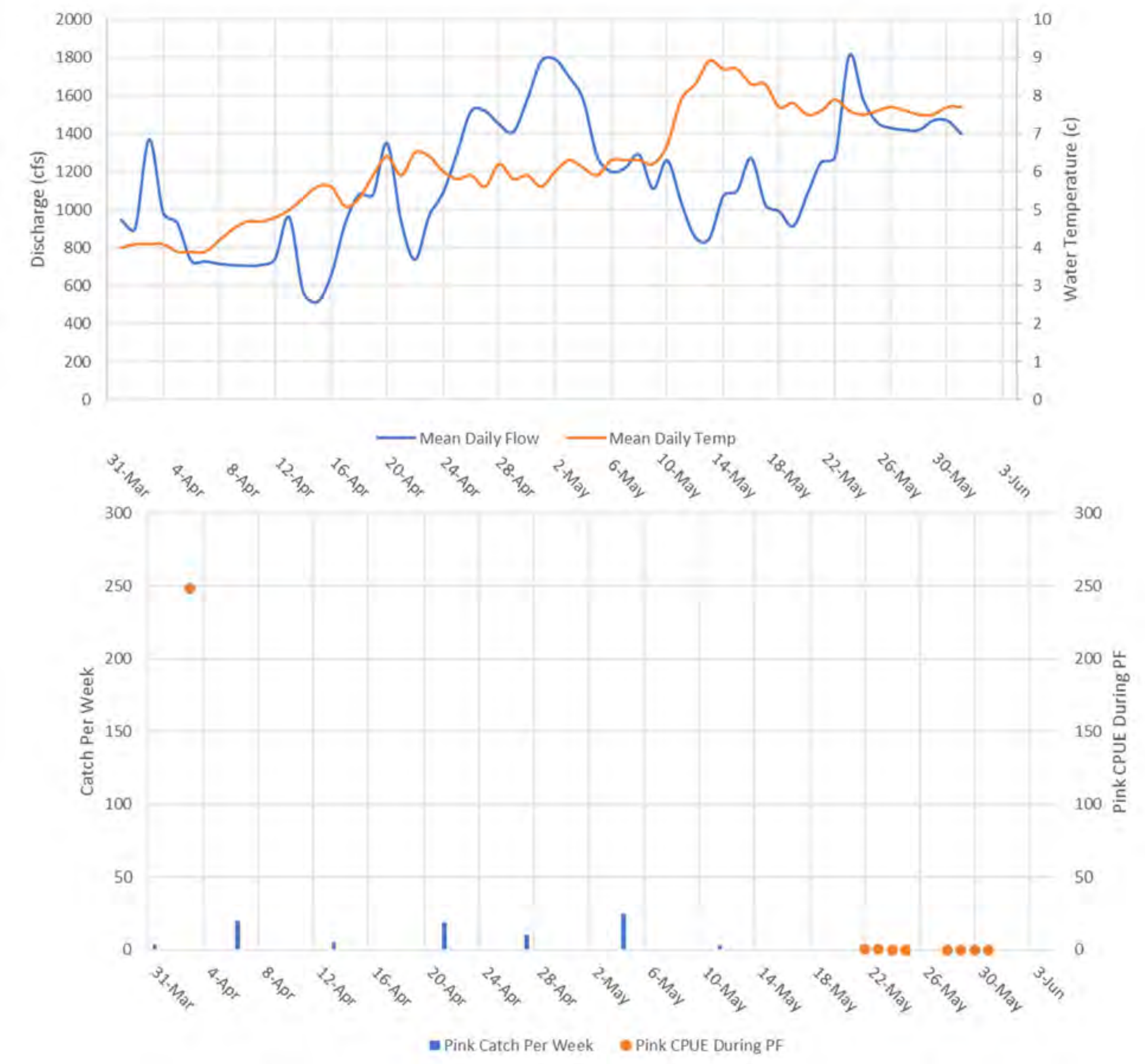


Figure 20. Pink catch per hour by week and catch per hour during outmigration flows, 2012.

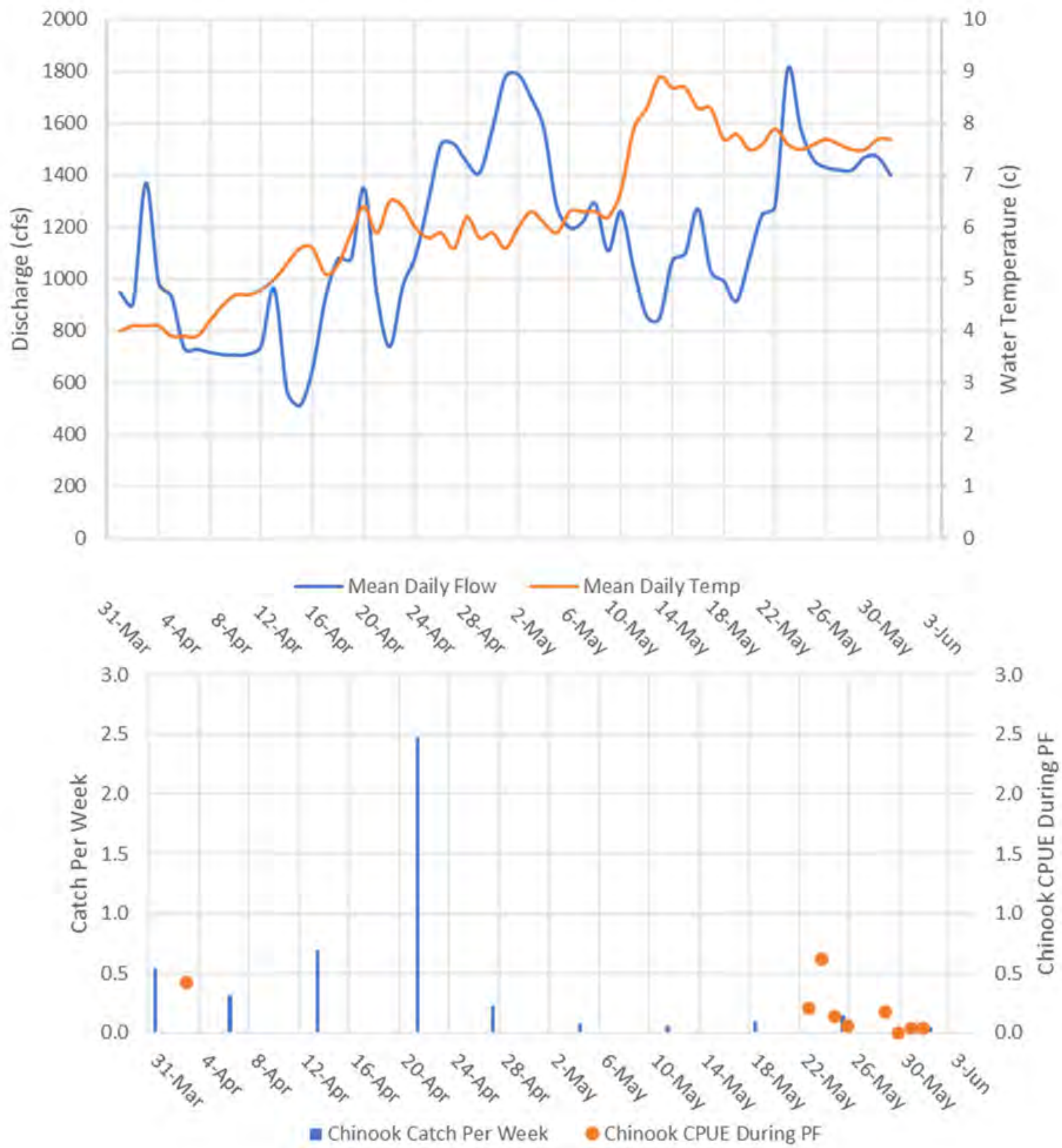


Figure 21. Chinook catch per hour by week and catch per hour during outmigration flows, 2012.

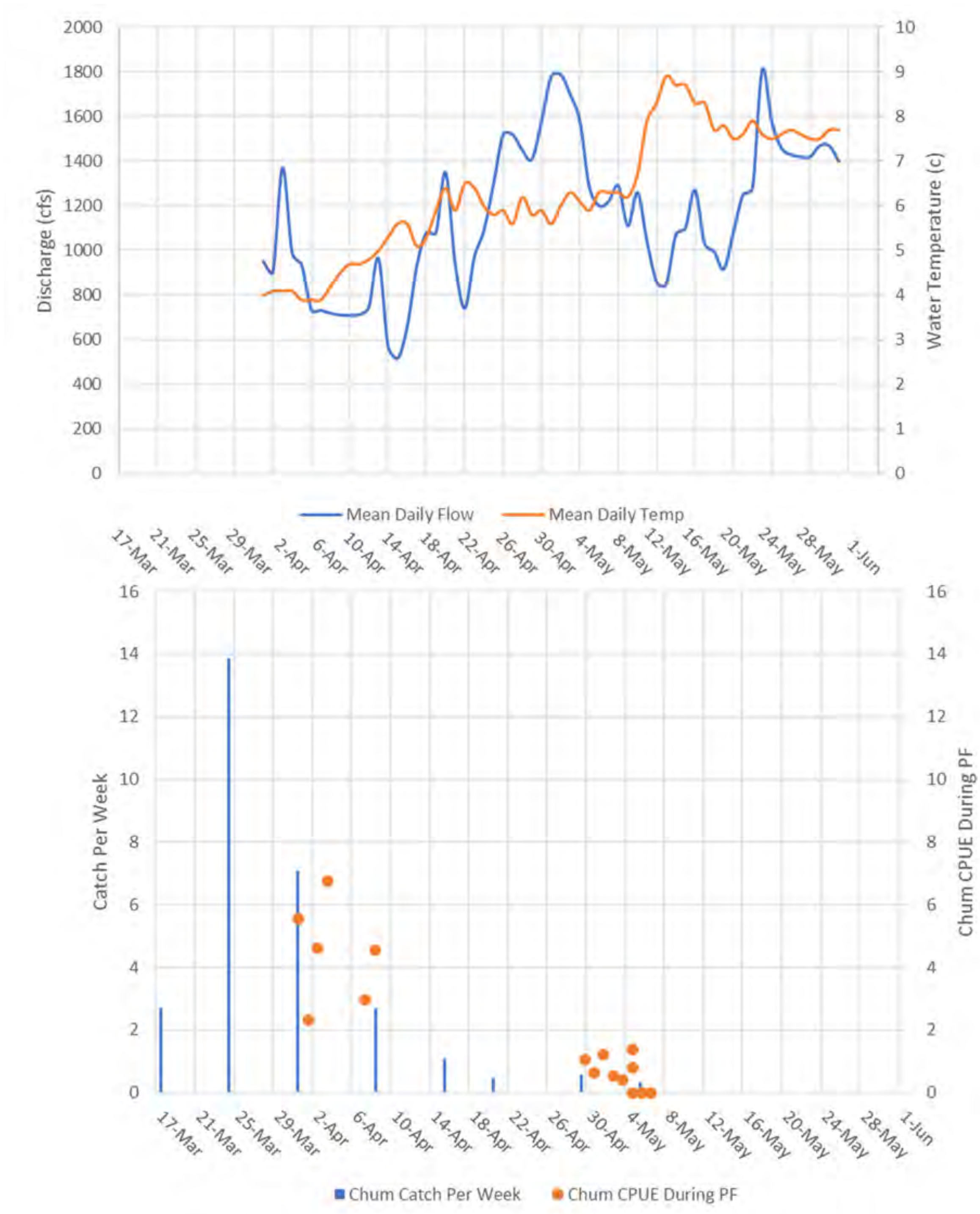


Figure 22. Chum catch per hour by week and catch per hour during outmigration flows, 2012.

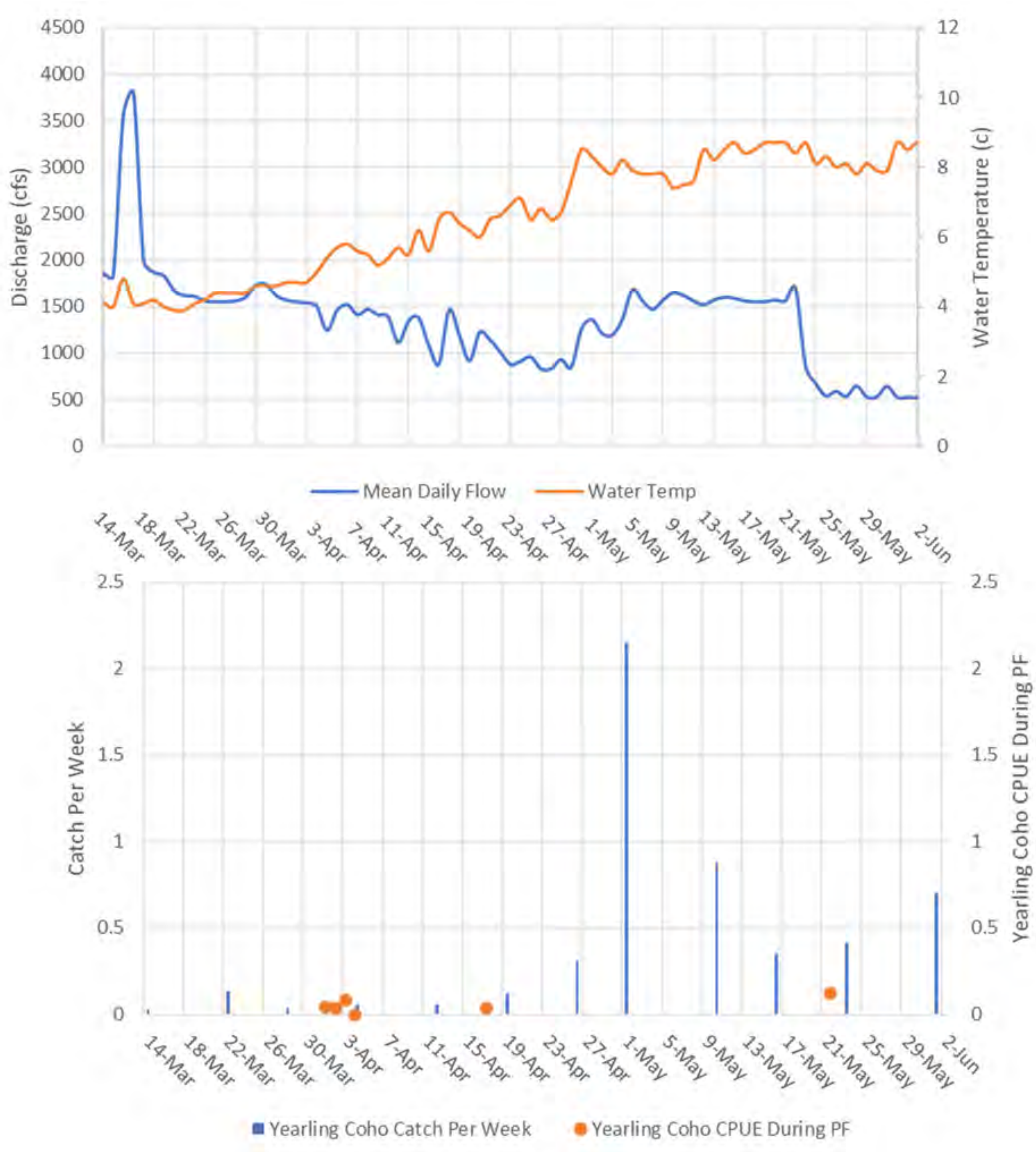


Figure 23. Yearling coho catch per hour by week and catch per hour during outmigration flows, 2014.

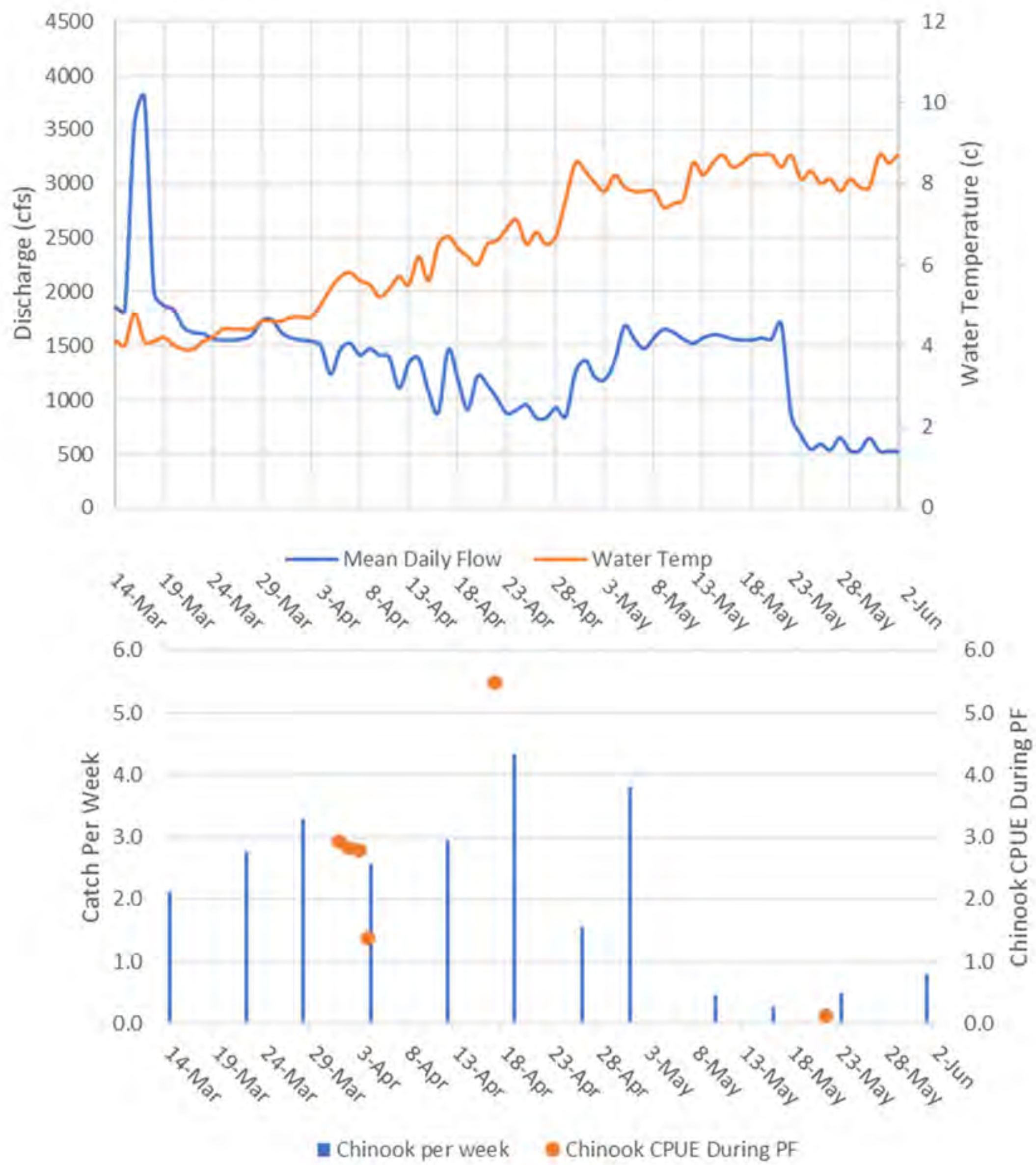


Figure 24. Chinook catch per hour by week and catch per hour during outmigration flows, 2014.

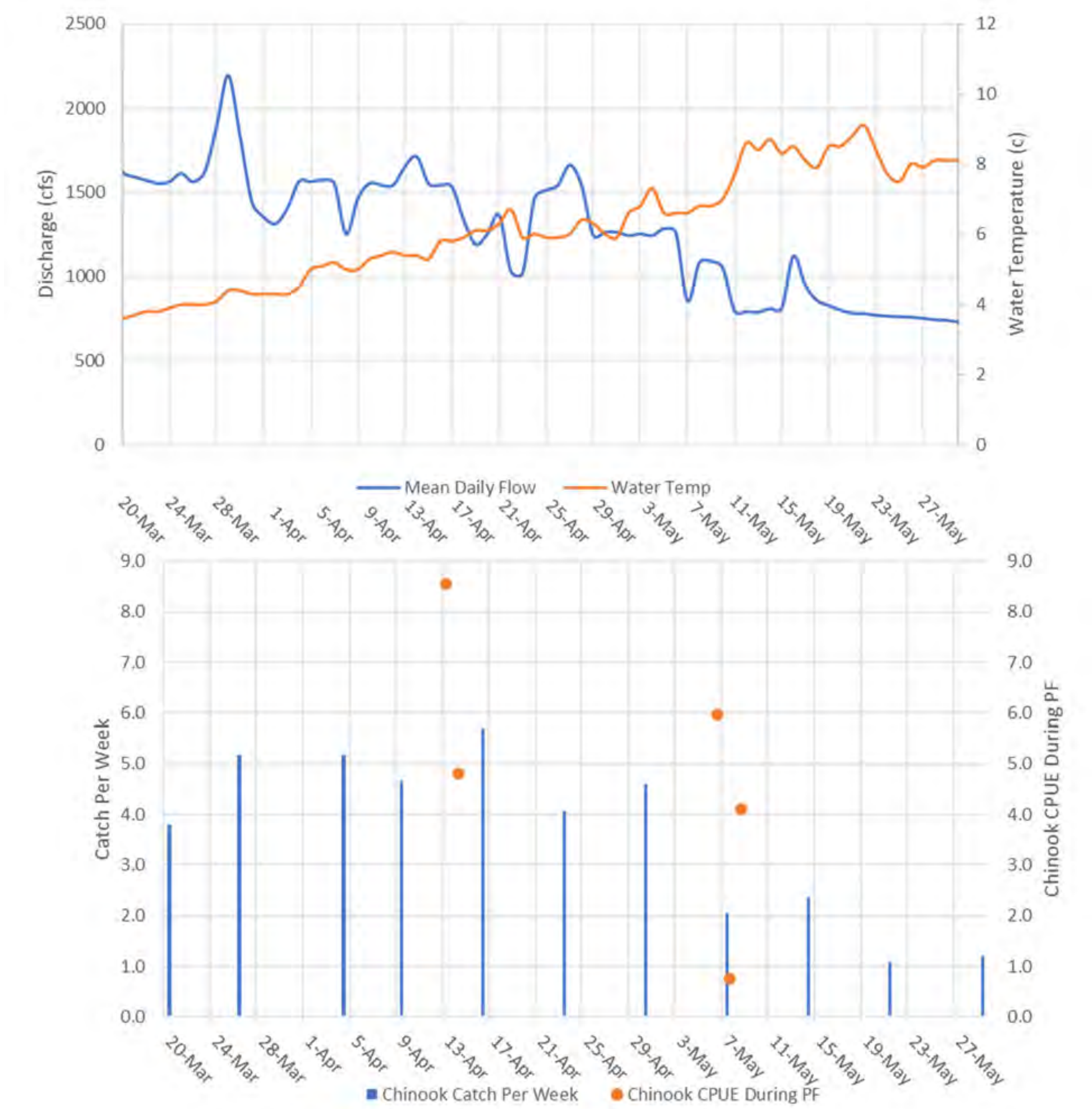


Figure 25. Chinook catch per hour by week and catch per hour during outmigration flows, 2017.

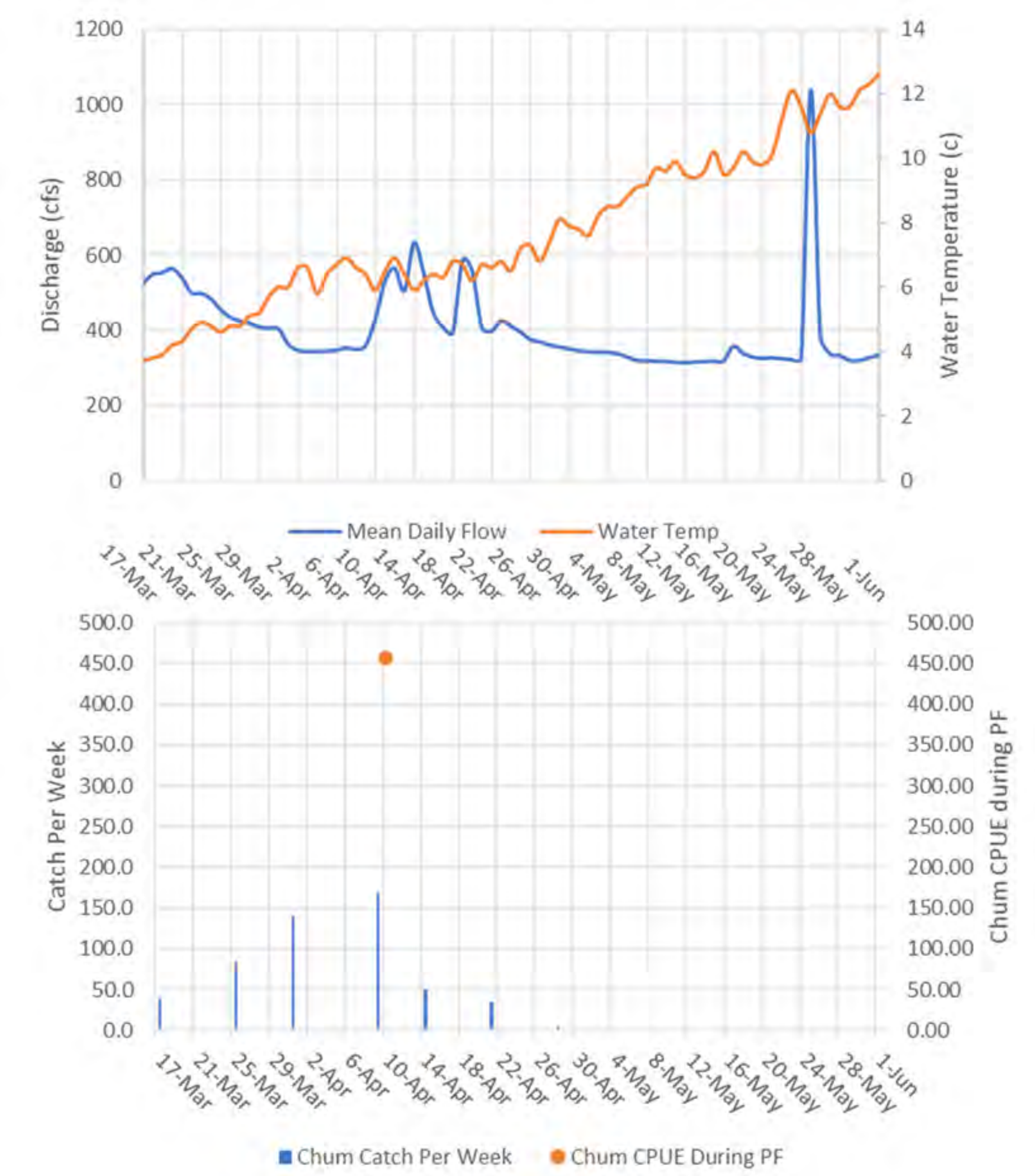


Figure 26. Chum catch per hour by week and catch per hour during outmigration flows, 2019.

Catch per hour during process flows generally resembles the weekly catch values, however, catch can also vary considerably based on species and on timing of the outmigration release. For catch during outmigration releases to be similar to the relative catch of the same week, the release has to occur when the species are actively present in the river and are either in active migration mode, or fish are not actively migrating and instead are forced out prematurely. The bulk of yearling coho, for example migrate in May, therefore, catch during an outmigration process flow in April results in very few yearling coho (Figure 23). Similarly, catch of chum and pink salmon does not occur in outmigration process flows conducted in mid to late May as these species have already migrated out of the system (Figure 20).

Table 12. Smolt trap efficiency data for Chinook, chum, and pink salmon, 2012-2021.

	Chinook			Chum			Pink		
Trap Year	Released	Captured	Efficiency (%)	Released	Captured	Efficiency (%)	Released	Captured	Efficiency (%)
2012	461	11	2.39	110	2	1.82	312	17	5.45
2013	1274	30	2.35	740	11	1.49			
2014	447	12	2.68	131	4	3.05	9645	222	2.30
2015	1587	70	4.41	12555	355	2.83			
2016	74	1	1.35	108	3	2.78	2858	38	1.33
2017	2328	54	2.32	1382	36	2.60			
2019	1967	69	3.51	20767	694	3.34			
2020	Low outmigration no efficiency releases in 2020								
2021	3715	184	4.95	4972	200	4.02			
All Years Combined	11853	431	3.64	40765	1305	3.20	12815	277	2.16

2.2.5. Unforeseen Consequences

The outmigration flow program aimed to increase juvenile salmonid survival and provide elements of a more normative hydrograph in the Sultan River compared to existing conditions. While much of the data analyzed is not concerning, unforeseen consequences such as forcing out unbuttoned yolk-sac fry is a primary concern. Additional unforeseen consequences relate to spawning disruption of ESA-listed steelhead. Pulse flows intended to stimulate juvenile outmigration occur during the prime steelhead spawning window (March – June), and likely disrupt active spawning of an ESA-listed species (T. Cox, WDFW, personal communication, 2022; JHP Whitewater Recreation Plan, 2019). Considering the predominantly confined, high gradient channel morphology in the upper river, the disruption associated with an all reaches release is likely most pronounced in the upper reaches where increases in stream power are greatest. While the timing of these scheduled releases does occur during the outmigration season, the volume of water in the Sultan River during this time of year is already normative based on hydrology comparisons with the Skykomish and Pilchuck rivers (Appendices A and B) and provides stimulation without the need of having to conduct outmigration pulse flows (Figures 5 and 6).

2.2.6. Adaptive Actions Undertaken

No adaptive management was implemented as part of this program.

2.2.7. Recommended Modifications

Data gathered and observations made during the first ten years of License implementation provide three conclusions related to assessing the value of the outmigration process flow program.

- Even in low water years spring hydrology in the Sultan River is conducive to stimulate juvenile salmonid outmigration without the need for outmigration pulse flows;
- the compliance target for duration only accounts for 0.8% of the outmigration season (April and May; 12 hours / 1,464 hours); and
- some outmigration process flows can have the unintended consequence of forcing juvenile salmonids out prior to their own volition, and likely disrupts steelhead spawning.

Overall, the implementation of the outmigration process flow program has provided limited biological and hydrologic benefit as it was originally assumed to provide. The PFP identified three benefits the outmigration program would provide: to stimulate juvenile salmonid outmigration, result in increased survival of juvenile outmigrants, and provide elements of a more normative hydrograph compared to existing conditions. After ten years of data collection, we conclude that these assumptions fell well short of their expected beneficial impact, and we propose the following recommendations.

Moving forward, and in the spirit of continued data collection and learning, recommendations for the next ten-year cycle include:

- Suspend outmigration process flows for the next ten-year cycle and compare data to the first ten-year period to identify any differences in outmigration patterns.
- Continue to document occurrences of flows that through accretion or power generation meet the outmigration flow criteria.
- Use data collected through smolt trapping operations to further define outmigration periodicity as related to environmental / hydrologic conditions.
- Collect the same biometrics for replication of future and past analysis.
- Add the documentation of all incidences of unbuttoned fry to the Standard Operating Procedures associated with operation of the rotary screw / smolt trap.
- Compare information collected on the Sultan with that collected by other agencies and/or tribes operating traps in the Snohomish Basin.
- Work with the ARC and co-managers to secure funding for more frequent operation of the smolt trap in the lower Sultan River beyond the 2 of 6-year commitment in the FHMP.
- Identify opportunities to gather reach specific production information including the operation of an upper and lower trap during the same season.

3. Habitat-Based Process Flow Releases

3.1. Flushing

The intent of the Channel Flushing element of the PFP is to provide benefits to the spawning habitat within each of three reaches of the Sultan River downstream of Culmback.

3.1.1. Program

Frequency and Timing: This element of the channel flushing program involves two releases annually, one in the spring and one in the fall. The spring release is scheduled to occur between April 1 and May 31. The fall release is scheduled to occur during the month of September. The timing was selected to theoretically occur in advance of the respective steelhead and Chinook spawning seasons although it can and has occurred coincident with active spawning.

Duration: The duration of this specific element of the channel flushing program varies between either 3 hours or 6 hours, depending on the magnitude of the release. For Reach 1, the duration of the release is not contingent on magnitude.

<u>Magnitude</u>: As previously stated, the magnitude of the flow release for channel flushing in Reach 3 and Reach 2 is intertwined with the duration of the release. Furthermore, the magnitude of the release is reach specific with the magnitude increasing further downstream. For Reach 3, the release magnitude is 600 cfs for a 3-hour release duration or 400 cfs for a longer duration of 6 hours (Table 12). Similarly, for Reach 2, the release magnitude is 700 cfs for a 3-hour release duration or 500 cfs for a longer duration of 6 hours (Table 12). For Reach 1, the magnitude is 1,500 cfs unless the elevation of Spada Reservoir is below 1,420 feet msl in which case, the release magnitude is 1,200 cfs.

Table 13. Reach-specific discharge for flushing flow compliance.

	Discharge value for Compliance (by reach)	
	3-hour duration	6-hour duration
Reach 3	600 cfs	400 cfs
Reach 2	700 cfs	500 cfs
Reach 1	1,500 cfs	

3.1.1. Objectives and Assumptions

The primary objective of this element of the PFP is to flush the streambed of fines and organic matter under the presumption that this objective is not being met absent these releases. Restated, this element of the PFP was crafted with the specific language “if necessary”, largely because of differences in opinions on the need. The supposition and ultimate impetus for implementation of the program was that it was deemed necessary despite the results of five separate investigations conducted between 1982 and 2005 (R2 Resource Consultants 2006, Shapiro and Associates 1995, Shapiro and Associates 1988, Wert 1984, Wert 1982). Information from R2’s 2005 investigation and review of past work in combination with the gravel quality analysis, resulted in the formulation of the following conclusions:

- *The spawning gravel samples collected in 1982 and 1984, prior to initiation of power generation, were of good quality.*
- *Since 1984, the magnitude and frequency of floods in the Sultan River below Culmback Dam have been reduced, consistent with intended flood protection provided by the Project.*
- *Although the magnitude and frequency of floods in the Sultan River have been reduced, the river still has sufficient capacity to transport the sediment supplied to the river from sources downstream from Culmback Dam.*
- *Under the flow regime in the Sultan River since 1984, the armor layer of gravel deposits in the Sultan River is mobilized about once every 3 to 4 years on average based on sediment transport analyses. Scour depth measurements suggest that the armor layer may be mobilized even more frequently than once every 3 to 4 years.*
- *Except for occasional disturbances associated with gold prospecting activities and potential backwater effects caused by the Skykomish River near the mouth of the Sultan River, the quality of spawning gravels collected in 1987, 1994, and 2005 has remained*

"good" and on par with pre-Project conditions. Historical operations of the Project do not appear to have caused the quality of the spawning gravels to decline.

• The persistent trend of good quality spawning gravels is consistent with reported success of Chinook salmon spawning and escapement in the Sultan River downstream from the diversion dam.

Another assumption implied through the twice annual frequency was the inference that fine sediment conditions were either so poor or that contributions were so chronic as to warrant flushing releases twice per year, 4 to 5 months apart. Another assumption was that timing of the release had to occur within weeks of active spawning to "prep the gravels" as to imply that sediment inputs were constant and that conditions were so dire that infilling would occur if scheduled further in advance. A final assumption was that the magnitude of the prescribed releases would be sufficient to mobilize the streambed and achieve the desired objectives and address the perceived need.

3.1.2. Results

Snohomish PUD staff analyzed the hydrologic record between 2018 and 2021 and tallied the number of events, by reach, that met or exceeded the magnitude and duration established as the threshold for the channel flushing element of the PFP (Appendix B). The analysis clearly indicates that during the wet months of late fall and early winter, hydrologic events frequently exceed the established reach-specific criteria of a channel flushing event with the average number of events per month over the 4-year period presented in Table 1.

Table 14. Average Number of Channel Flushing Events October through February, 2018-2021

Reach	October	November	December	January	February
3	2.5	13.5	7	5.25	15
2	6	20	14.5	30.75	32.25
1	12.25	36.5	49	85.5	66

This analysis indicates that channel flushing element of the PFP is achieved regularly and that the magnitude and duration of the twice annual releases provide no added value beyond what is typically provided during late fall and early winter under normal operations.

Turbidity data were collected early on after License issuance but it was soon determined that use of the valves at the base of Culmback Dam for these releases introduced sediment from the bottom of the reservoir and confused the analysis for flushing effectiveness. Despite the absence of this data, Snohomish PUD brings forward the following egg-to-migrant survival information and believes that it is consistent with prior investigations as to the quality of spawning habitat relative to substrate conditions and the presence of fine sediment.

One indirect overall measure of fine sediment conditions in the Sultan River during fall is the Chinook percent egg-to-migrant survival data collected during operation of the smolt trap. Absent the influence of high flow scouring events, this egg-to-migrant survival index reflects the relative success of freshwater production which for sub-yearling migrants would largely be attributed to spawning habitat conditions and interstitial conditions within the redds. The mean and median percent egg-to-migrant survival for the years that the smolt trap has been operated was 25.7 and 25.2 %, respectively (Table 14). For Chinook that spawned in the fall of 2016, when no flushing flow occurred because of fish passage construction at the Diversion Dam, the egg-to-migrant survival was 34.3 percent (Table 14).

Table 15. Chinook egg-to-migrant survival, Sultan River, 2012-2021.

Year of Trap Operation	Chinook Redds (Year)	Number of Eggs Deposited	Total Out-Migration	Percent Egg-to-Migrant Survival	Peak Flow During Incubation (cfs)
2021	277 (2020)	1,249,270	691,190	55.3	3,140
2020	34 (2019)	153,340	5,830	3.8	13,900
2019	234 (2018)	1,055,340	380,428	36.0	2,600
2017	275 (2016)	1,240,250	424,858	34.3	2,970
2016	156 (2015)	703,560	52,294	7.4	7,320
2015	146 (2014)	658,460	231,397	35.1	4,700
2014	184 (2013)	829,840	124,770	15.0	4,940
2013	390 (2012)	1,758,900	443,789	25.2	2,290
2012	53 (2011)	239,030	45,986	19.2	3,360

3.1.3. Unforeseen Consequences

Any release of this magnitude that occurs at the timing prescribed in the License article and PF Plan can be disruptive to staged or actively spawning fish.

3.1.4. Adaptive Actions Undertaken

No adaptive management was implemented as part of this program.

3.1.5. Recommended Modifications

The following recommendations for modifications to the channel flushing element of the PF Program are presented for consideration:

- Suspend releases specifically for channel flushing for the next 10-year period,
- Conduct study to further define the threshold for bed mobilization within Reach 3 and Reach 2:
  - Use study results and literature review to identify the magnitude and duration of flows that achieve flushing and maintenance objectives in the upper reaches.
  - Use study results to identify the magnitude of flow that results in scour,
  - Identify periods where incubating eggs are particularly vulnerable to scour.
- Monitor hydrologic variability during Water Year and prepare annual technical memorandum, and
- As part of the next 10-Year Process Flow Plan Effectiveness Report, incorporate collected information and evaluate whether flushing related needs are being met either through: a) normal operational hydrology or b) bi-annual channel maintenance program as brought forth under the following Channel Maintenance discussion.

3.2. Channel Maintenance

3.2.1. Program

The primary intent of the Channel Maintenance element of the PFP is to provide benefits to Reach 1 of the Sultan River. As such, all compliance related parameters are focused on Reach 1.

3.2.1.3. Frequency and Timing

The compliance magnitude for a Channel Maintenance event hinges heavily upon accretion (rainfall) which ultimately drives both the frequency and timing. While these events are controlled, the events are considered "opportunistic" as operations must be tailored and sequenced to co-occur with rainfall to achieve compliance.

In terms of frequency, Channel Maintenance is to occur four times per a Ten-Year Accounting Cycle, with not less than 4 years between events. Timing is predicated on the presence of somewhat predictable rainfall event within the lower Sultan River Basin that delivers adequate flow volumes over a duration of a least 24 hours.

3.2.1.2. Duration and Magnitude

Compliance with the Channel Maintenance requirements is achieved when (a) a target flow of at least 4,100 cfs instantaneous minimum flow in maintained for twenty-four (24) consecutive hours at USGS Gaging Station No. 12138160 (below the Powerhouse) or (b) a target flow of a least 4,100 cfs is achieved but not sustained for a 24-hour duration and the Licensee demonstrates a good faith effort by providing a maximum release flow from the Powerhouse[2], the outlet pipe located adjacent to the City of Everett's Diversion Dam, and Culmback Dam (via the Howell-Bunger and 42-inch slide valves) at the time when flow drops below 4,100 cfs for a total duration (including the target flow and maximum release) of twenty-four consecutive hours as measured at USGS Gaging Station No. 12138160.

3.2.2. Objectives and Assumptions

The objectives of the Channel Maintenance element of the PFP include:

- Formation and re-distribution of physical habitat features (riffles, pools, runs, point bars)
- Effective transport, sorting, and distribution of large woody debris (LWD) and sediment
- Alteration of channel features (increase lateral channel movement, improved connectivity between mainstem and side channel habitats)
- Creation of undercut banks

Primary assumption is that the magnitude, duration, and frequency of these events are meeting the intent and objectives of this element of the program for Reach 1. Of note is that several of these objectives are also achieved in reaches 2 and 3, despite the predominantly confined nature of the channel in these reaches. The existing infrastructure and specifically, the location of the high-capacity valves at the upper end of Reach 3, results in the introduction of significant

[2] Under conditions of high flow (>2,200 cfs) / elevated water surface, the plants "air depression" system is triggered to maintain plant output. At flows greater that 3,500 cfs, the backwater effect requires plant output to be reduced by X megawatts to prevent equipment damage.

streampower in the upper reaches which may be disproportionate when considering benefits and objectives for the entire river.

3.2.3. Results

The following executive summary excerpt from the Stillwater Sciences (2016) report highlights some of the overall general changes documented during their habitat surveys conducted after flows in the range of roughly 4,500 to 6,000 cfs. Individuals interested in delving into the Stillwater Sciences reports and data files are encouraged to do so. Upon request, Snohomish PUD will provide links to these reports.

> *Stillwater Sciences conducted a field habitat survey of the lower 2.7 miles of the Sultan River in July 2016, including four side channels (all of which had been previously surveyed). The study was undertaken to determine if any habitat changes have occurred due to a significant high-flow event that occurred in November 2015. The 2016 survey was the second such resurvey conducted since issuance of the new license for the Henry M. Jackson Hydroelectric Project (Project) in 2011. The project is operated by the Public Utility District No. 1 of Snohomish County (the District) and these habitat surveys are required by the Fisheries and Habitat Monitoring Plan under Article 410 of the license.*
>
> *Surveys conducted in 2007 and 2010, as part of the relicensing of the Project, provided the baseline data that have allowed post-2011 resurveys to determine the effects of subsequent high-flow events, of which the first occurred in March 2014 (Stillwater Sciences 2015). Table 15 lists each reach and the year they were each surveyed.*
>
> *Riverine habitat attributes recorded for this study included instream unit subtype (e.g., pools, riffles, glides, islands), measurements of wetted unit surface area dimensions (length and width), unit margin features (lengths of undercut banks and bar edges), and the distribution and characterization of large woody debris (LWD). Subsequent to the 2007 and 2010 surveys, engineered LWD structures were installed in 2012 along the margins of the mainstem and side channels, along with other channel enhancements in all four side channels.*

Table 16. Reaches surveyed and the year the survey was conducted.

Reach	Surveyed in 2007	Surveyed in 2010	Resurveyed in 2014	Resurveyed in 2016
Mainstem	Yes	No	Yes	Yes
Side Channel 1	No	Yes (partially)	Yes	Yes
Side Channel 2	No	Yes	Yes	Yes
Side Channel 3	Yes	No	Yes	Yes
Side Channel 4	No	No	Yes	Yes
		LWD INSTALLATIONS ↑ 2012	↑ HIGH FLOW MARCH 2014	↑ HIGH FLOW NOVEMBER 2015

> *As in 2014, the results of the 2016 study indicate that natural processes of wood recruitment and channel evolution have thus far resulted in modest changes to habitat attributes in the mainstem of the Sultan River since the baseline surveys were conducted. Although the mainstem is largely unchanged, the side channels have been transformed into more variable reaches with frequent pools and pool-riffle-glide complexes. This represents a marked improvement over their previous composition of primarily glide habitat dotted with some low-gradient riffles and a few small pools. Since 2012, high flows have reworked and modified the channels. This has led to a system that overall expresses a somewhat more dynamic, "natural" trajectory. For this survey, the largest positive changes observed since the 2014 survey occurred in Side Channels 2 and 4 (SC2 and SC4).*
>
> *While the presence of engineered LWD structures and LWD in the mainstem river and along the side channels has successfully stabilized the inlet to side channels, one small area in the mainstem and a longer section of Side Channel 1 (SC1) that had flowing water in 2014 at the 320 cubic feet per second (cfs) mainstem discharge were dry at a similar discharge in 2016. This change was most evident in SC1 and comprised 594 feet (ft) of dry channel with marsh and isolated interspersed pools.*
>
> *In summary, little measurable change can be documented in the mainstem as a result of this survey. However, the study results indicate that installations have initiated changes in habitat features and improved channel complexity, in terms of variability of depths and flow, in the side channels following high flows. Pool habitat has significantly increased, both in terms of the amount of surface area pools encompass and the overall number of pools observed in the study area. Based on relatively consistent results to date, future high flows are expected to interact with the installations and result in even greater side-channel habitat complexity in the future.*

Per the monitoring requirements listed in the License article, Snohomish PUD has collected additional post-high flow data that complements the data collected by Stillwater Sciences during their collective habitat surveys (Stillwater Sciences 2007, 2010, 2015, 2016, 2021). This information, collected at eight locations spanning all 3 reaches, includes channel cross-sectional profiles, Wolman (1954) Pebble Counts, and photographs. This information is presented below by site with a brief commentary on the most relevant takeaways.

<u>Reach 1 – Site 1</u>

Site 1 is located at RM 0.5 and is the most downstream location surveyed. This location is frequently backwatered under flood conditions in the Skykomish River. As such, the level geomorphic activity varies at the location. Cross-sectional measurements over time at this location indicate some aggradation reflected in the progressive development of a gravel bar between stations 150' and 230' (Figure 27). The Wolman Pebble Counts collected over time at this location suggest a relatively consistent grain size distribution (Figure 26).

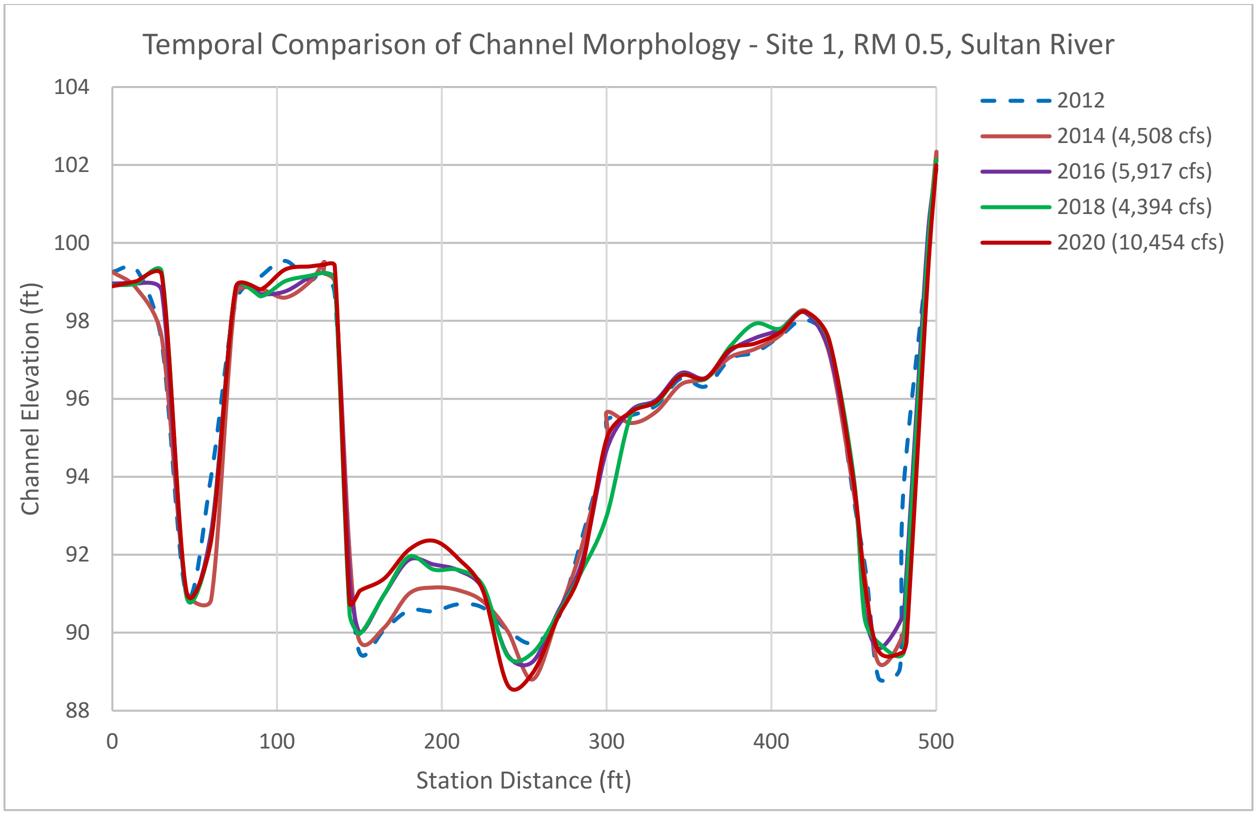


Figure 27. Temporal comparison of channel morphology, Site 1

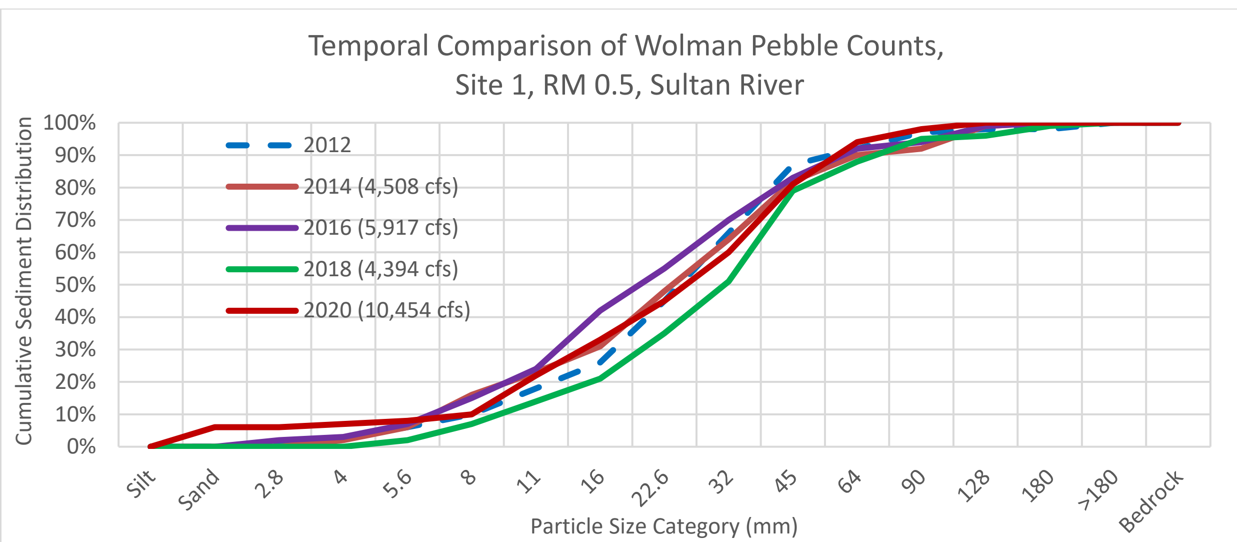


Figure 28. Temporal comparison of Wolman pebble counts, Site 1

Reach 1 – Site 2

Site 2 is located at RM 1.5 which is upstream of the inlet to Side Channel 1 and downstream of the inlet to Side Channel 2. Two islands are present along this cross-section with distinct smaller channels along the left and right banks and the main channel in the middle, between stations 200' and 300' (Figure 29). Over time, there has generally been little change detected with the notable exception being the degradation observed with channel forming flow (Figure 29). The Wolman Pebble Count collected after the 2020 flow event indicated an increase in the 22 to 45 mm size fraction undoubtedly indicative of the mobilization and deposition of those size classes (Figure 30).

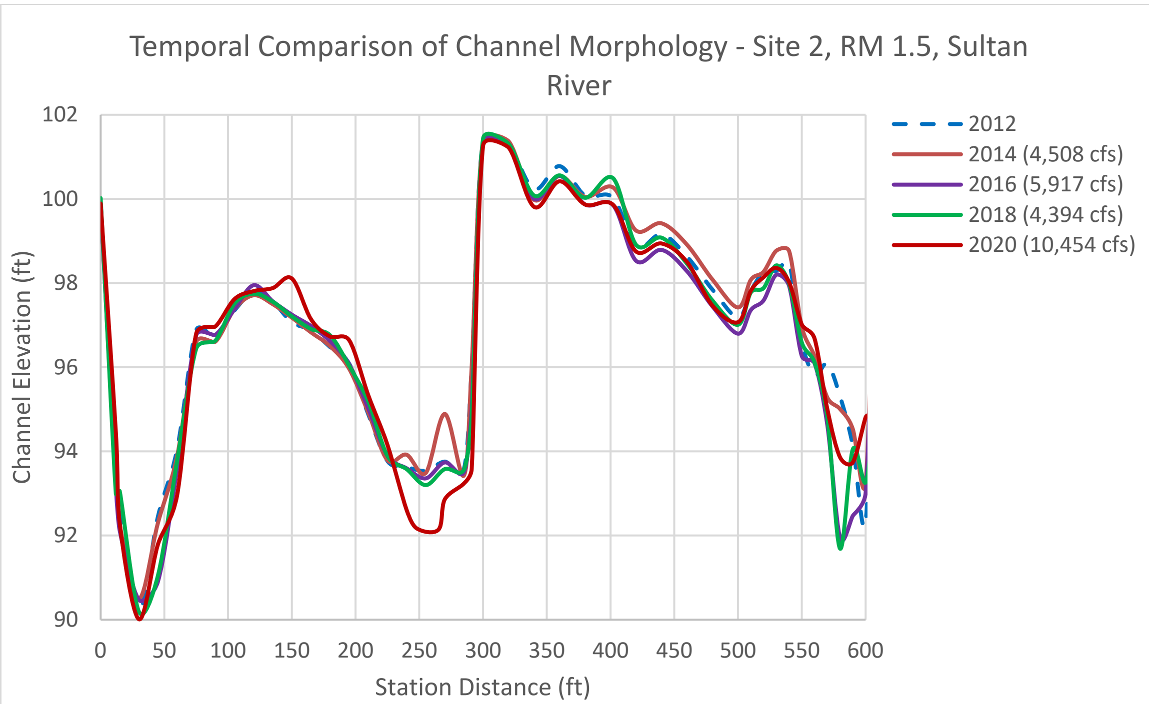


Figure 29. Temporal comparison of channel morphology, Site 2

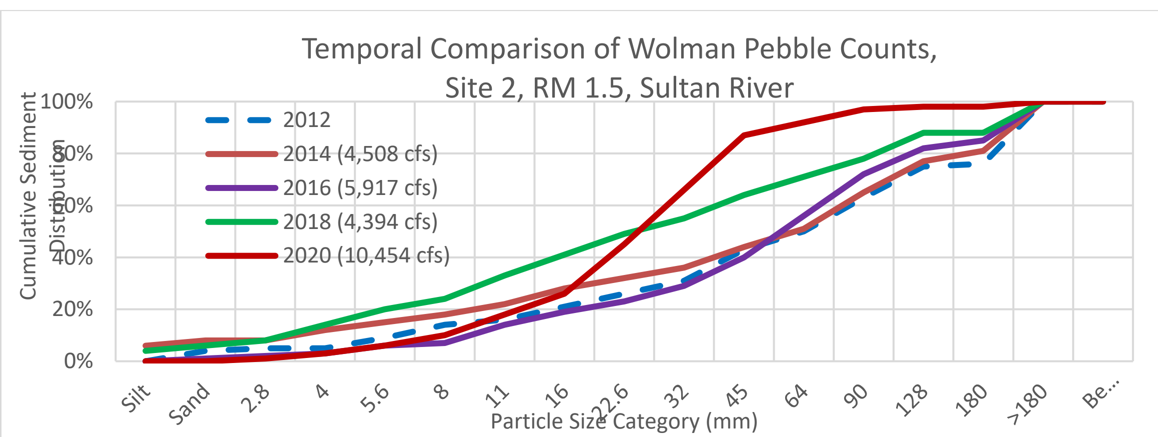


Figure 30. Temporal comparison of Wolman pebble counts, Site 2

Reach 1 – Site 3

Site 3 is located at RM 2.5, just downstream of the Trout Farm Road Recreation Site. Very little change in channel morphology was documented since implementation of the program indicative of a stable channel (Figure 31). Similarly, the Wolman Pebble Counts indicated no significant change in substrate composition over time (Figure 32).

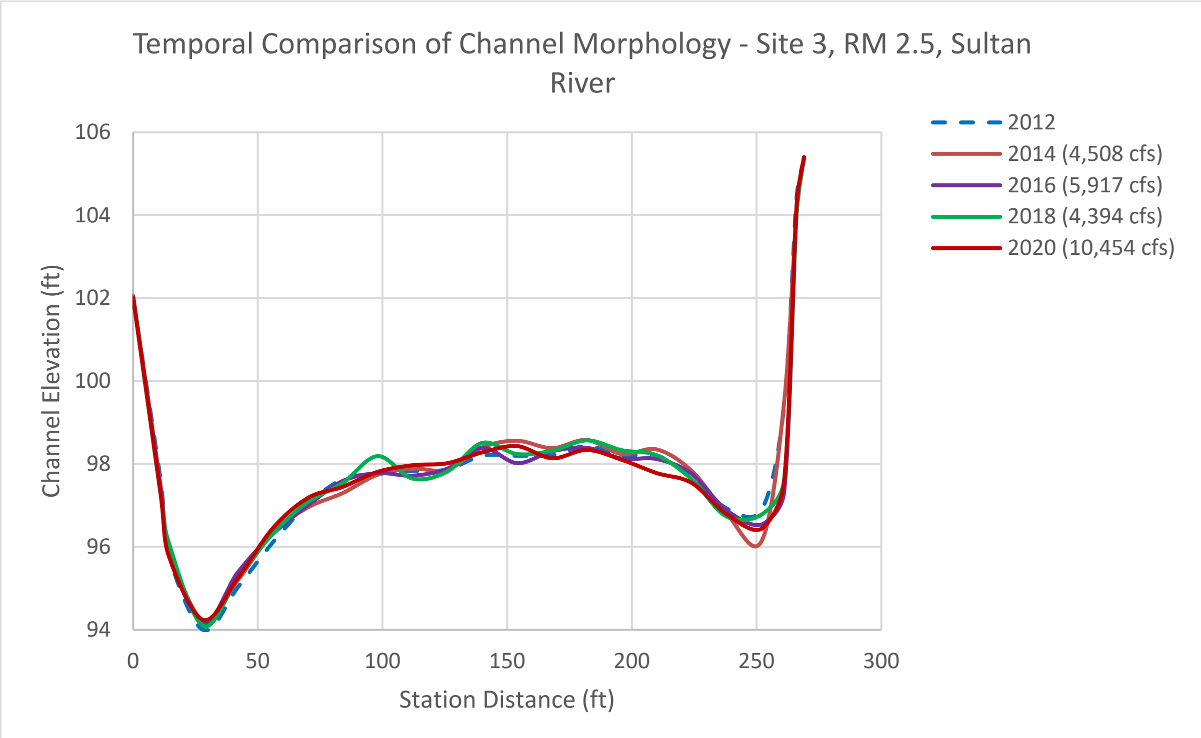


Figure 31. Temporal comparison of channel morphology, Site 3

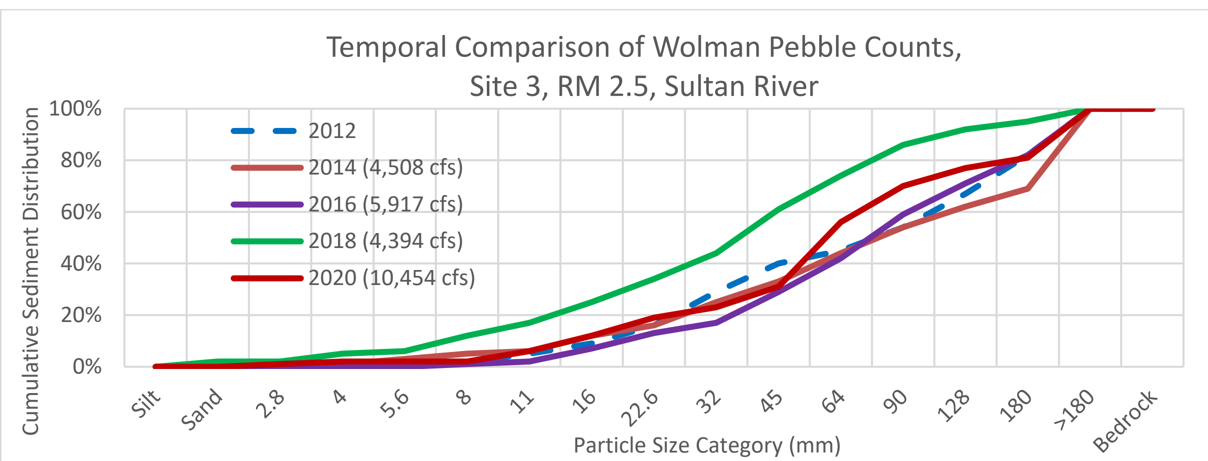


Figure 32. Temporal comparison of Wolman pebble counts, Site 3

Reach 1 – Site 4

Site 4 is located at RM 4.5, just downstream of the Powerhouse. The channel at this location has remained largely unchanged over time (Figure 33). The Wolman Pebble Counts indicate a shift in substrate composition after the channel forming flow, especially in the 5.6 to 11 mm size range (Figure 34).

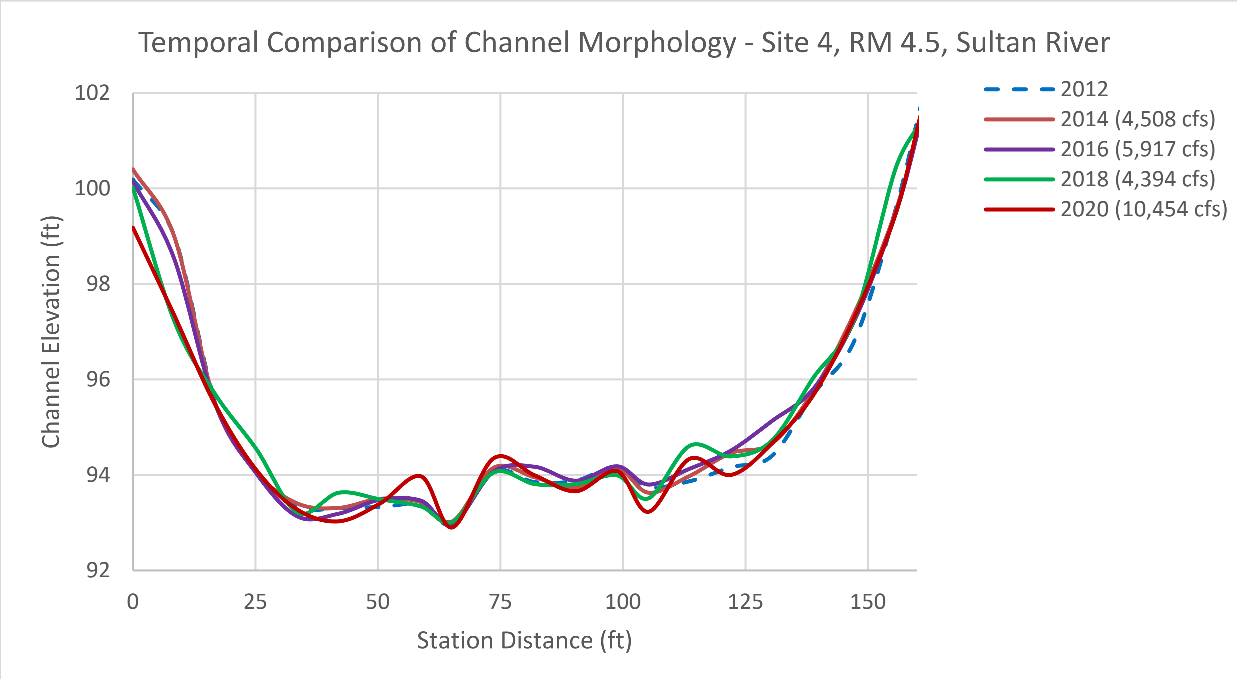
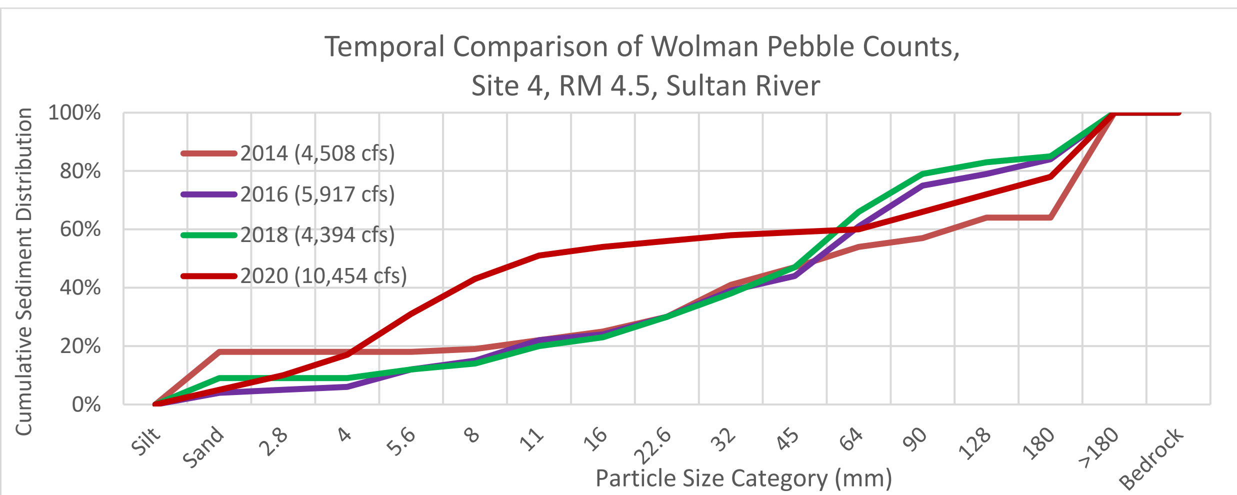


Figure 33. Temporal comparison of channel morphology, Site 4



*no 2012 Site 4 data

Figure 34. Temporal comparison of Wolman pebble counts, Site 4

Reach 2 – Site 5

Site 5 is located at RM 4.9, just upstream from the Powerhouse. Minor changes in channel morphology were observed over during the first 10 years since License issuance (Figure 35). Similarly, modest changes in substrate composition were noted until the Channel Forming Event of 2020 (Figure 36). The observed changes in substrate were likely attributed to the active sediment transport underway during that event. In 2021, Snohomish PUD continued with a pilot project it initiated to refine our understanding of the thresholds for activation of the bed and attendant sediment transport and mobilization. While most of the instrumentation was lost (buried or dislodged), the accelerometer deployment within lower Reach 2 did remain providing a single data source. The data from this particular accelerometer suggests that transport may be initiated at a discharge of around 1,240 cfs (Figure 37).

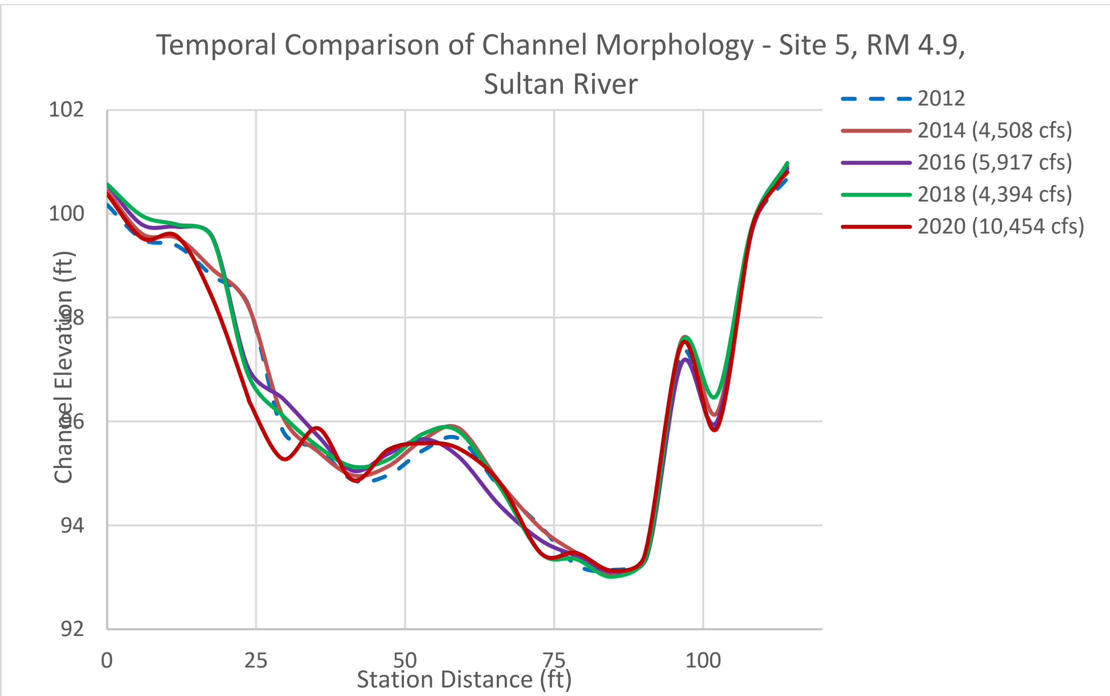


Figure 35. Temporal comparison of channel morphology, Site 5

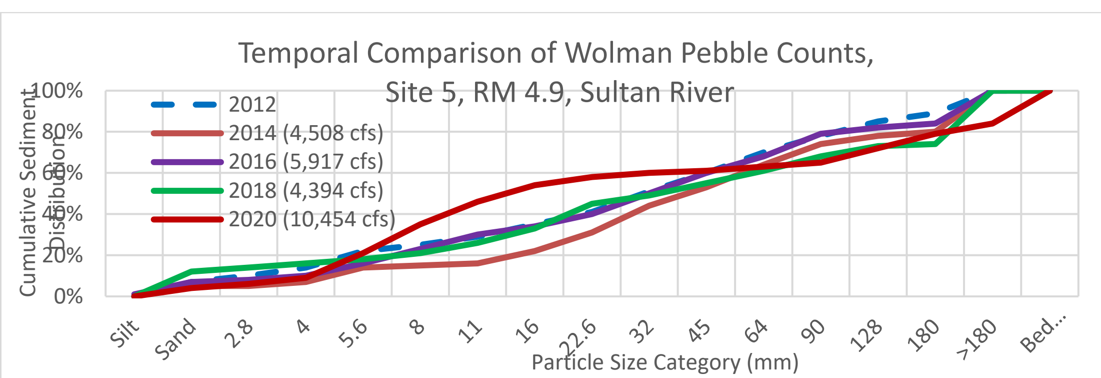


Figure 36. Temporal comparison of Wolman pebble counts, Site 5

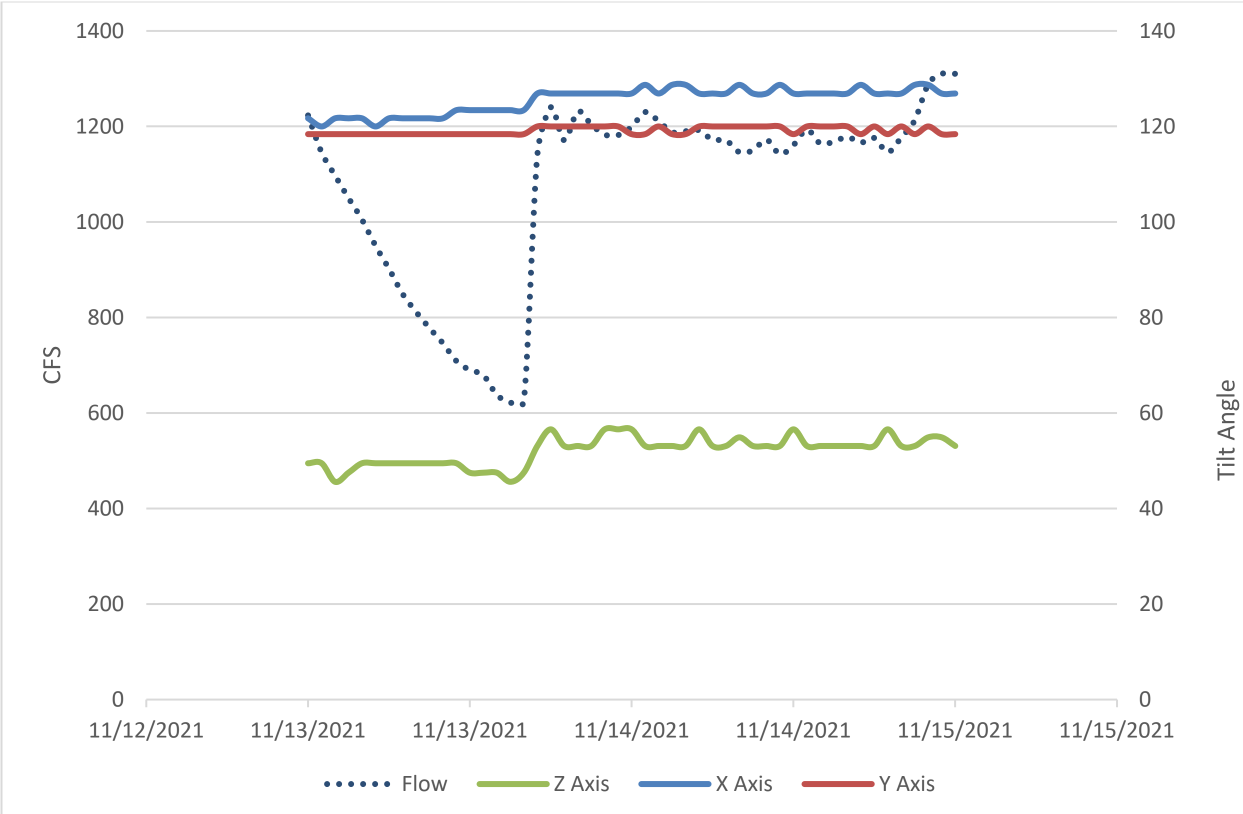


Figure 37. Substrate movement in response to flow, as detected by accelerometer deployed near RM 4.7

Reach 2 – Site 6

Moving further upstream, Site 6 is located at RM 9.5, just downstream of the Diversion Dam. The channel morphology has shifted over time in response the transport of sediment from sources further upstream in Reach 3 including much from immediately upstream of the Diversion Dam in association with fish passage related changes to the infrastructure at the Diversion Dam. The passage project was completed late in 2016 and subjected to the first major flow event in early 2018. Significant deposition was noted at Site 6 after that event and then remobilized after the major event in 2020 (Figure 38). The Wolman Pebble Counts for Site 6 are also indicative of a very active channel with shifting substrate composition (Figure 39). Accelerometers deployed at this site are buried under a large deposit of fine gravel and have not yet been recovered.

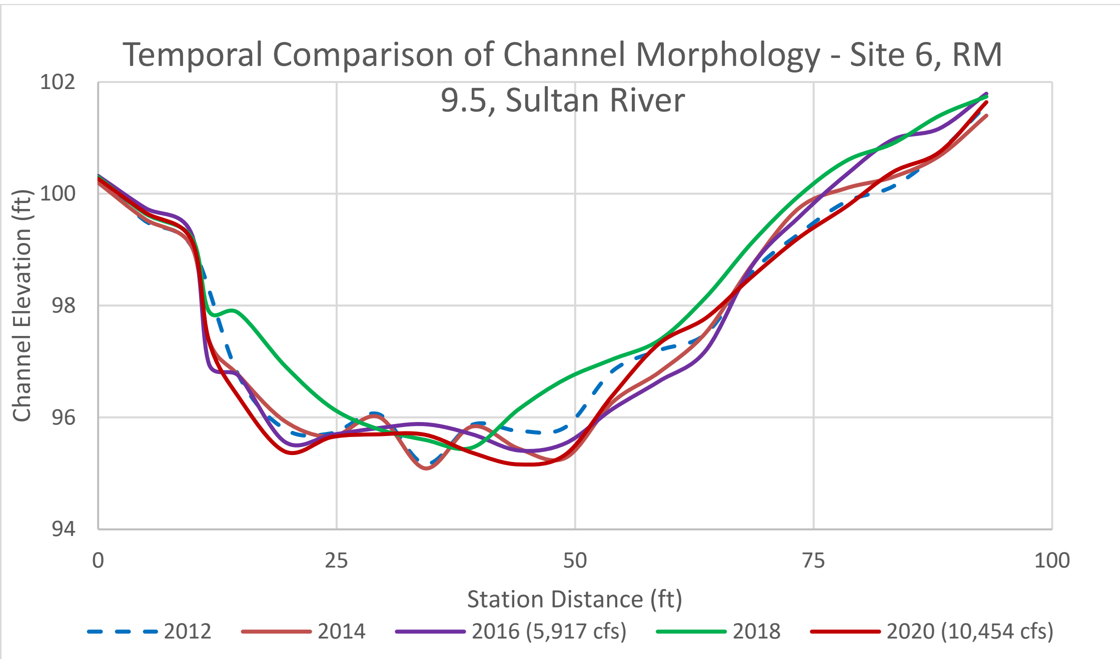


Figure 38. Temporal comparison of channel morphology, Site 6

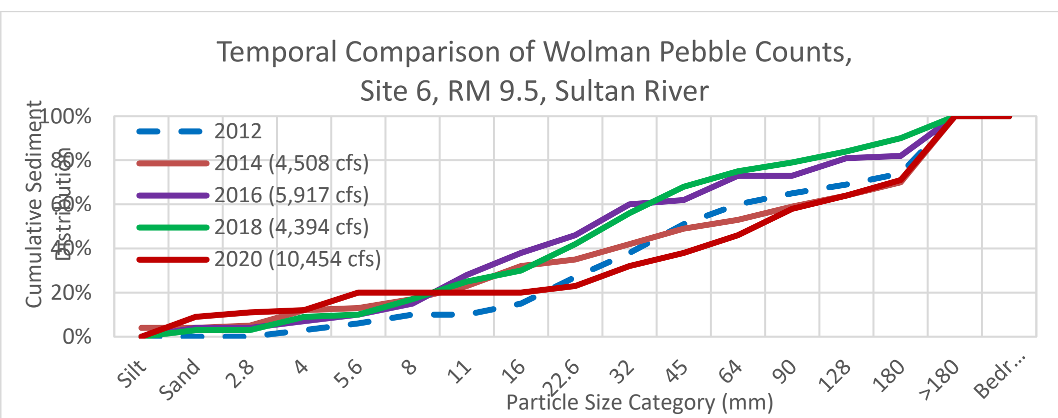


Figure 39. Temporal comparison of Wolman pebble counts, Site 6

Reach 3 – Site 7

Site 7 is located a RM 9.8, just upstream of the Diversion Dam. The site has seen the most dramatic changes in channel morphology over time and since implementation of fish passage at the Diversion Dam and the elimination of the forebay impoundment (Figure 40). Modifications of the sluiceway at the Diversion Dam to provide volitional fish passage involved excavating to the historic channel elevation. As intended, this changed initiated significant head cutting upstream as the channel grade adjusted and material was transported. These changes are captured in pictures taken before and after the site was subjected to the high flows of 2018 and then 2020 (Figures 41, 42, 43, and 44). The Wolman Pebble Counts also imply a progressive coarsening and shifting of the landscape in terms of substrate composition (Figure 45). The accelerometers at this site are buried under approximately 4 feet of gravel in an expansive deposit.

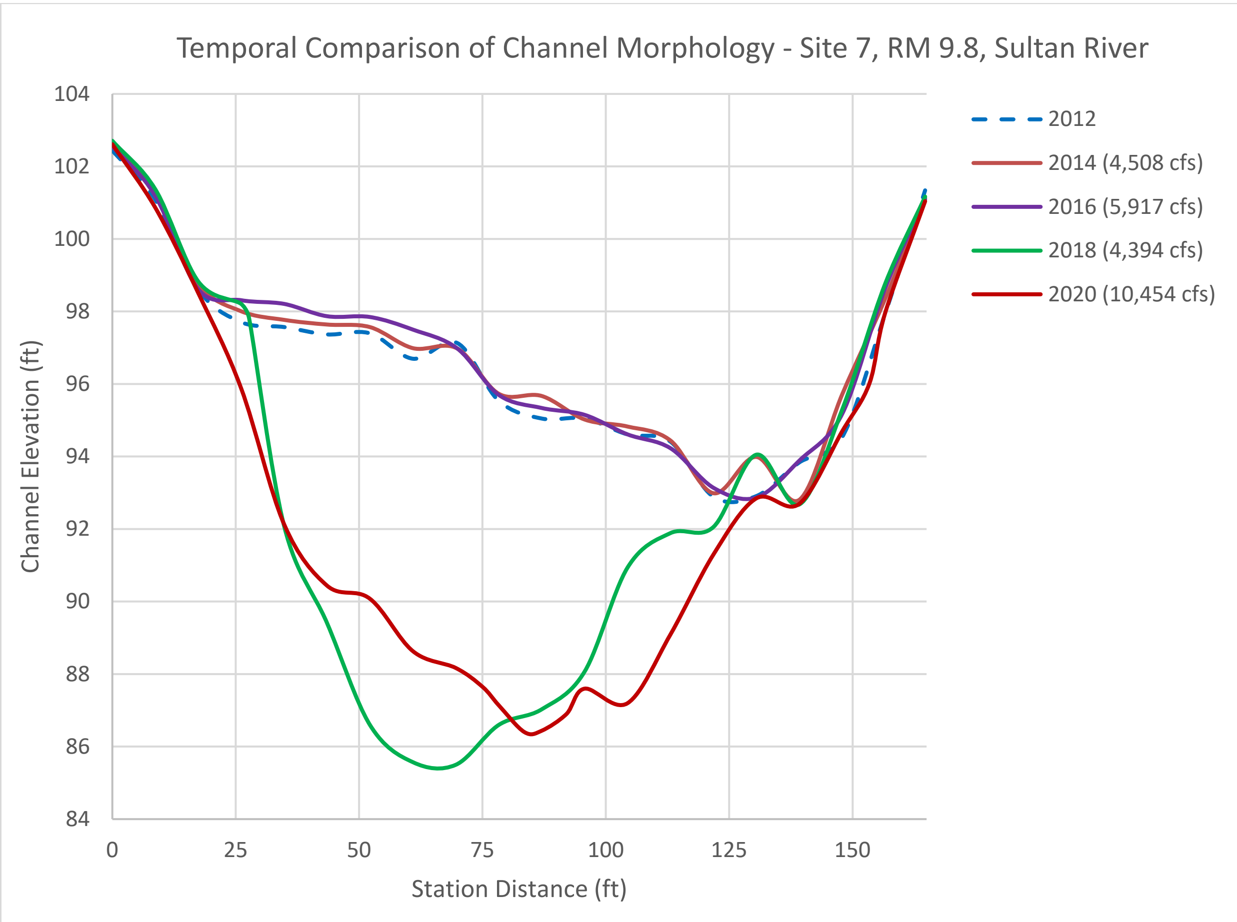


Figure 40. Temporal comparison of channel morphology, Site 7

Figure 41. Habitat Transect (left to right bank), Site 7, 2012.

Figure 42. Habitat Transect (left to right bank), Site 7, 2020.

Figure 43. Habitat Transect (right to left bank), Site 7, 2012.

Figure 44. Habitat Transect (right to left bank), Site 7, 2020.

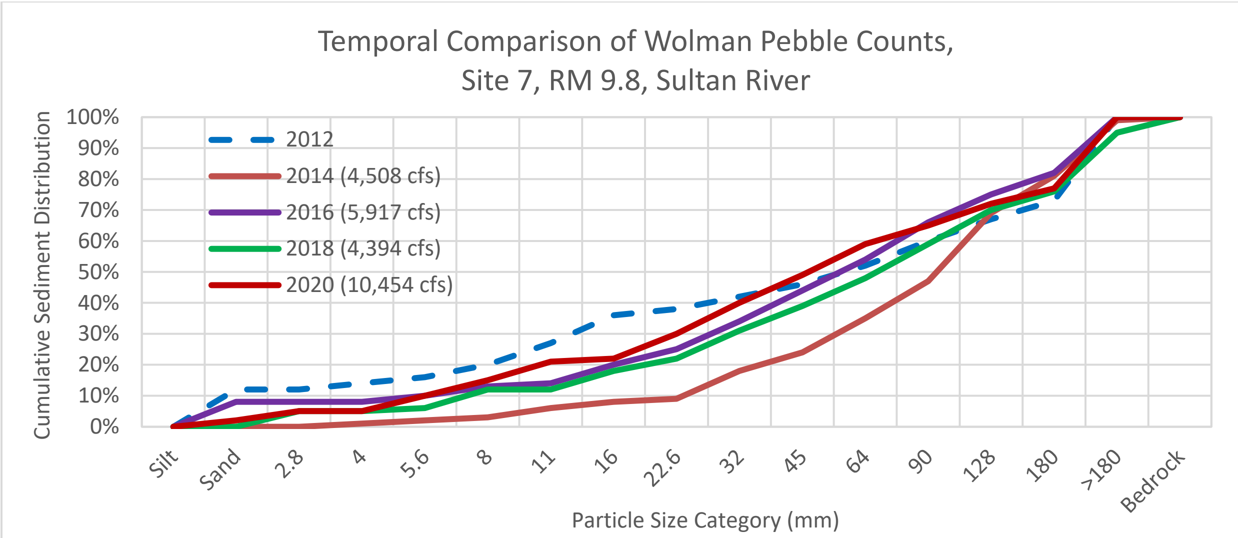


Figure 45. Temporal comparison of Wolman pebble counts, Site 7

Reach 3 – Site 8

Site 8 is located at RM 14.3, immediately upstream of the famed Stringer Bridge. This site is also immediately downstream of a historic massive landslide that continues to be a significant source of gravel supplied to the river. While this site is boulder dominated, the channel morphology at this site reflects a very active channel with degradation evident after the 2020 flow event (Figure 46). The Wolman Pebble Counts suggest a shift in substrate composition with a removal of some of the smaller size fractions (Figure 47).

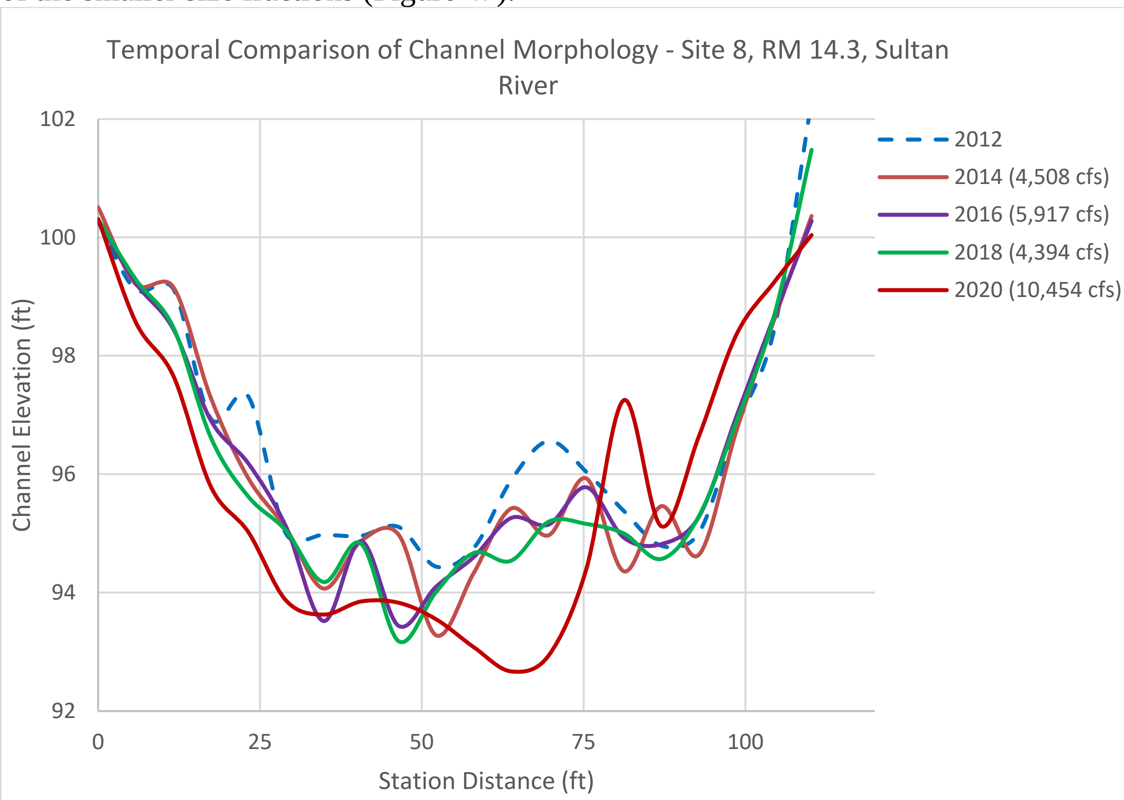


Figure 46. Temporal comparison of channel morphology, Site 8

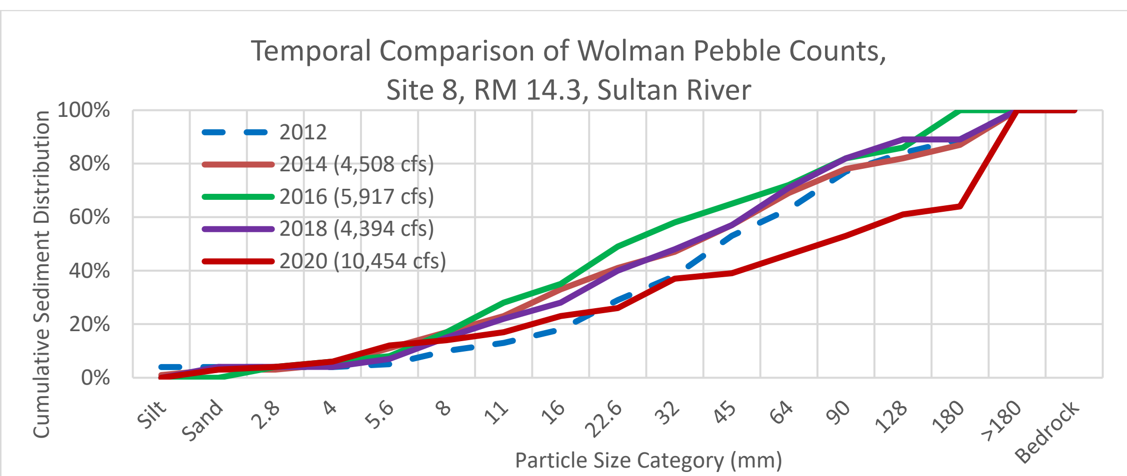


Figure 47. Temporal comparison of Wolman pebble counts, Site 8

3.2.4. Unforeseen Consequences

Use of both the Howell-Bunger (variable capacity up to 946 cfs, at full pool) and Slide (fixed capacity of 1,165 cfs, at full pool) valves simultaneously to achieve the flow magnitude desired for channel maintenance in Reach 1 has consequences that were not fully identified during the development and crafting of the License article. The release location at the base of Culmback Dam (RM 16.1) for these high-volume flows for the benefit of aquatic habitat in lower Reach 1, 13 miles downstream, has a disproportionate impact on the relatively confined, high gradient reaches of the Sultan River located upstream of the Powerhouse (Reach 2 and Reach 3). Depending on timing, these releases can induce scour and be destructive to eggs incubating in the gravel in these reaches. While past studies have defined the approximate threshold for incipient motion, Snohomish PUD has conducted studies to refine the level of understanding and is committing to furthering those investigations. Limited information from the installation of accelerometers indicates that sediment transport in lower Reach 2 is initiated at flows of approximately 1,200 cfs (Figure 37). This value is consistent with the past transport related investigations (GeoEngineers 1984) and is cause for concern when implementation high flow releases, especially those that rely on the use of the Slide valve.

Again, the data from the operation of the smolt trap can provide valuable insight into the relationship between high flow and freshwater production. The magnitude of flow required to induce scour varies by reach with the required flow being greatest for Reach 1 and least for Reach 3 owing to the prevalent channel morphology within each reach. High flows, that potentially induce scour, have a far greater probability of occurring further upstream in the river. This probability is increased and exacerbated by the location of the release point for channel maintenance flows. Furthermore, the effects of scour can vary from year to year depending of spawning distribution. This effect is evident when comparing 2013 and 2014, two consecutive years with similar peak flows but variable Chinook spawning distribution owing to the presence of pink salmon. In pink years, Chinook more frequently elect to use the reaches above the Powerhouse in an attempt to avoid the high densities of pink salmon. In 2013 (a pink year), 55 percent of the returning Chinook spawned upstream of the Powerhouse. In contrast, in 2014, 43 percent of the Chinook spawned upstream of the Powerhouse. When subjected to similar peak flow events during incubation, the net result during the non-pink year of 2014 was higher percent egg-to-migrant survival and greater overall production, despite lower escapement (

Table 1). These data highlight high flow impacts and how the scheduling of high flow releases should be considered reach specific impacts and the spawning distribution of ESA listed stocks.

Table 17. Percent Egg-to-Migrant Survival versus Peak Flow During Incubation.

Year of Trap Operation	Chinook Redds (Year)	Number of Eggs Deposited	Total Out-Migration	Percent Egg-to-Migrant Survival	Peak Flow During Incubation (cfs)
2021	277 (2020)	1,249,270	691,190	55.3	3,140
2020	34 (2019)	153,340	5,830	3.8	13,900
2019	234 (2018)	1,055,340	380,428	36.0	2,600
2017	275 (2016)	1,240,250	424,858	34.3	2,970
2016	156 (2015)	703,560	52,294	7.4	7,320
2015	146 (2014)	658,460	231,397	35.1	4,700
2014	184 (2013)	829,840	124,770	15.0	4,940
2013	390 (2012)	1,758,900	443,789	25.2	2,290
2012	53 (2011)	239,030	45,986	19.2	3,360

3.2.5. Adaptive Actions Undertaken

No adaptive management was identified for this program.

3.2.6. Recommended Modifications

The first 10 years of implementation of the PFP clearly indicate that controlled releases for channel maintenance purposes tend to underperform in terms of meeting the full range of desired objectives within Reach 1. This general realization has been recognized and acknowledged by the ARC and has led to discussions around the implementation of more pronounced physical interventions in Reach 1. The thinking is that the desired objectives have the best chance of being met through these interventions, coupled with the occurrence of both controlled releases and uncontrolled spill events.

An adaptive approach to implementation of the PFP over the next 10 years could include an enhanced focus on potential impacts to fish during this period of recovery period for ESA listed stocks. Actions could be undertaken to fine tune our understanding of the threshold for bed mobilizing events with the intent to balance the stimulation of habitat related processes across the landscape with actions that reduce the potential for scour events in newly colonized and/or vulnerable habitats. Implementation of this approach could support greater life history resiliency and boost freshwater production during recovery.

- Reduce the magnitude and increase the frequency of individual Channel Maintenance events,
- Move towards adaptive / scheduled events that are resource protective and consider either every other year events or events occurring no more three (3) years apart,
- Integrate within season information on Chinook run timing, spawning distribution, site specific water temperature, and developmental stage when scheduling events to limit scour related impacts,
- Continue to explore more aggressive physical interventions as part of the Fish Habitat Enhancement fund and Side Channel and Large Woody Debris Plan in the lower river that promote the attainment of habitat related objectives.

Implementation of a channel maintenance program with greater frequency but of a reduced magnitude, including complete reliance on the use of solely the Howell-Bunger valve, could lead to development of a predictable program tailored to balance and meet the comprehensive needs of the fish and habitat resources along the entire river.

Given what we have learned over the first 10 years since implementation, it is prudent to revisit the basis for determining the appropriate discharge magnitude to achieve the desired fish and habitat objectives along the entire river downstream of Culmback Dam. While 4,140 cfs is the bankfull discharge value (Qbf) in Reach 1 based on the instream flow study (R2 Resource Consultants 2009), a value less than that may have the same level of general effectiveness (Qeff) and simultaneously be less destructive to fish and aquatic resources in reaches 2 and 3 and especially so, if timed carefully. Schmidt and Potyondy (2004) state that the initiation of coarse sediment transport can occur at 60-80 percent of Qbf.

With the reduced magnitude of 70 percent Qbf (2,898 cfs) and same duration of 24 hours, a greater level of control and predictability would be possible. The increased frequency could be implemented in a way where these events are scheduled / timed to occur during even years when Chinook are move heavily distributed in the lower river and therefore less likely to be impacted by the relatively high flow releases from Culmback Dam. This action would also support stock rebuilding and recovery. These releases could be predictably scheduled to occur in late November if not provided naturally during the preceding 6 weeks, prior to November 15. In terms of frequency, 5 scheduled channel maintenance events would be required during the 10-year accounting cycle as compared 4 in the current program. The program could be structured and implemented so that no more than 3 years occurs between channel maintenance events and that such events do not occur in years when a channel forming event has occurred. This frequency and magnitude would ensure that the bed in the upper river is regularly mobilized addressing any flushing related concerns and that sediment and large woody debris transport processes remain intact.

3.3. Channel Formation

3.3.1. Program

The primary intent of the Channel Forming element of the PFP is to provide benefits to Reach 1 of the Sultan River. As such, all compliance related parameters are focused on Reach 1.

3.3.1.3. Frequency and Timing

The frequency and timing of Channel Forming Flow events is difficult to predict because the compliance magnitude for these event hinges heavily upon either perfect sequencing with significant and sustained accretion (rainfall) and/or spill. In terms of probability, conditions for a Channel Forming Event are mostly likely to manifest between the months of November and March and may occur during periods of intense rain, rain on snow, or rapid snowmelt. While, theoretically, a Channel Forming Event could occur in a controlled manner, the events are subject to precise forecasting and are very difficult to manage for in terms of operations and logistics. Operationally, the execution of these events is considered highly “opportunistic” as valve operations and the controlled release of roughly 2,200 cfs need to be perfectly sequenced to co-occur with a sustained rainfall event delivering a cumulative accretion at the Powerhouse gage of roughly 4,300 cfs to achieve compliance. These challenges were apparent during November 2015 as Snohomish PUD made its initial attempt at executing a Channel Forming Event during an intense, but short-lived rainfall event. In reality, compliance with the magnitude target is most likely to be achieved under an uncontrolled spill condition. Furthermore, the Morning Glory Spillway Rating Curve (Figure 48) indicates that the compliance flow is most likely to occur when the reservoir elevation is over 1,453 feet msl for a sufficient duration. Hydrologic modeling indicates that the probability of a spill of this magnitude occurring in any given year is about 10 to 12%.

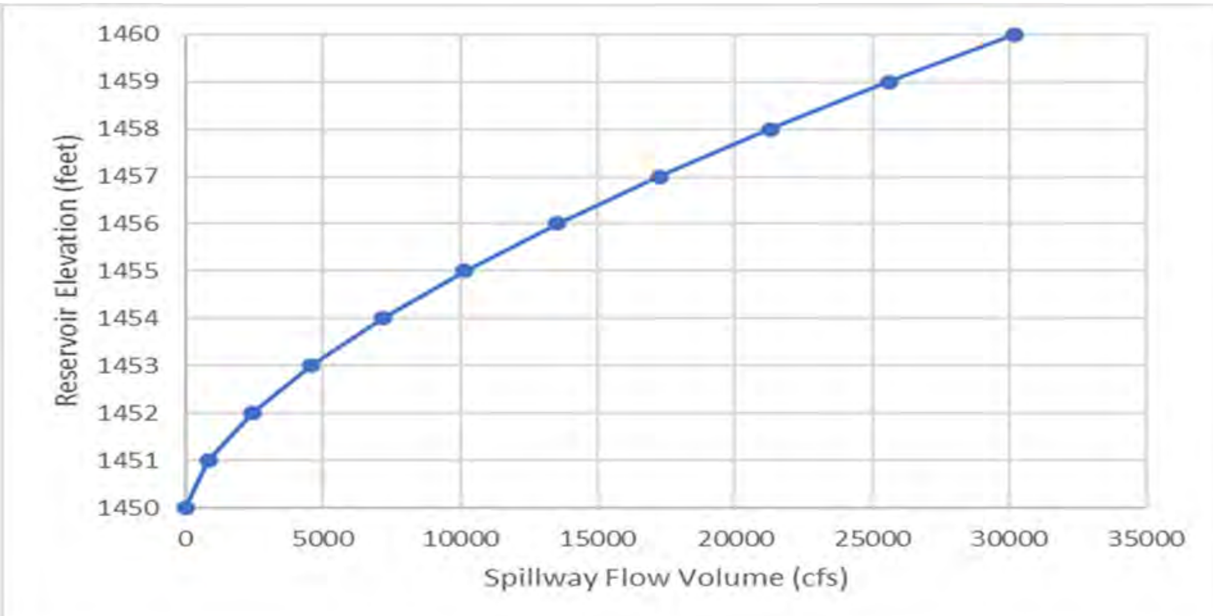


Figure 48. Morning Glory Spillway Rating Curve, Culmback Dam

In terms of compliance frequency, Channel Forming Flow events are to occur once per Ten Year Accounting Cycle.

3.3.1.2. Duration and Magnitude

Compliance with the Channel Forming Flow requirements is achieved when (a) a target flow of at least 6,500 cfs instantaneous minimum flow in maintained for twenty-four (24) consecutive hours at USGS Gaging Station No. 12138160 (below the Powerhouse) or (b) a target flow of a least 6,500 cfs is achieved and the Licensee provides a maximum release flow from the Powerhouse, the outlet pipe adjacent to the City of Everett's Diversion Dam, and Culmback Dam (via the Howell Bunger and 42-inch slide valves) for twenty-four (24) consecutive hours at the time when flow drops below 6,500 cfs for a total duration (including the target flow and maximum release) of twenty-four (24) consecutive hours as measured at USGS Streamflow Gage No, 12138160, or (c) the Licensee provides a maximum release flow from the Powerhouse, the outlet pipe located adjacent to the City of Everett's Diversion Dam, and Culmback Dam (via the Howell Bunger and 42-inch slide valves) for twenty-four (24) consecutive hours that is timed to achieve, to the extent feasible, a target flow of 6,500 cfs at USG Streamflow Gage No. 12138160.

3.3.2. Objectives and Assumptions

The objectives of the Channel Formation element of the PFP include:

- Formation and re-distribution of physical habitat features (riffles, pools, runs, point bars)
- Effective transport, sorting, and distribution of LWD and sediment
- Alteration of channel features (increase lateral channel movement, improved connectivity between mainstem and side channel habitats)
- Creation of undercut banks

3.3.3. Results

Since issuance of the new License in 2011, there have two flow events, both under conditions of uncontrolled spill, that can be used to inform the effectiveness of these types of events when it comes to channel formation and the achievement of the desired objectives articulated in the PF Plan. During the initial 10-year period, the first event occurred between November 17 and November 18 (Figure 49). The mean discharge over the 24-hour duration for compliance was 6,016 cfs, with a range between 4,620 and 7,320 cfs. While below the 6,500 cfs threshold value, this event was deemed a Channel Forming event under provision C of Aquatic License Article 8 which states that the component flow is achieved when the Licensee provides a maximum release flow for twenty-four (24) consecutive hours that is timed to achieve, to the extent possible, a target flow of 6,500 cfs. At the time, the designation of this event as a Channel Forming event triggered a comprehensive survey of habitat conditions in the lower river which was conducted by Stillwater Sciences and presented in their 2016 report. Roughly 5 years later, a second flow / spill event occurred between February 1 and February 2, 2020, which was substantially greater in volume (Figure 50) and was the largest flow event since 1995. The 2020 event was over the compliance threshold of 6,500 cfs for a period of 26.75 hours with a range in discharge between 6,540 and 13,900 cfs and an average of 10,454 cfs. Owing to the magnitude, this event was subsequently designated as the Channel Forming event for the 10-year reporting period with the PF log and other records changed to reflect that. With that designation, a comprehensive survey of habitat in the lower river was triggered and again commissioned to be conducted by Stillwater Sciences. Given the rarity of spill events of this magnitude, Snohomish PUD opted to voluntarily expand the scope of the 2020 habitat to include the entire river downstream of Culmback Dam. With the baseline established in 2007 during relicensing, the 2020 survey provides a solid basis for comparison of flow induced changes over that 13-year span and most notably those attributed specifically to the 2020 event. In addition, because this was the largest peak flow event since November 29, 1995, it effectively resets the baseline for future surveys and change detection over time because of the state-of-the-art LiDAR and imagery techniques employed.

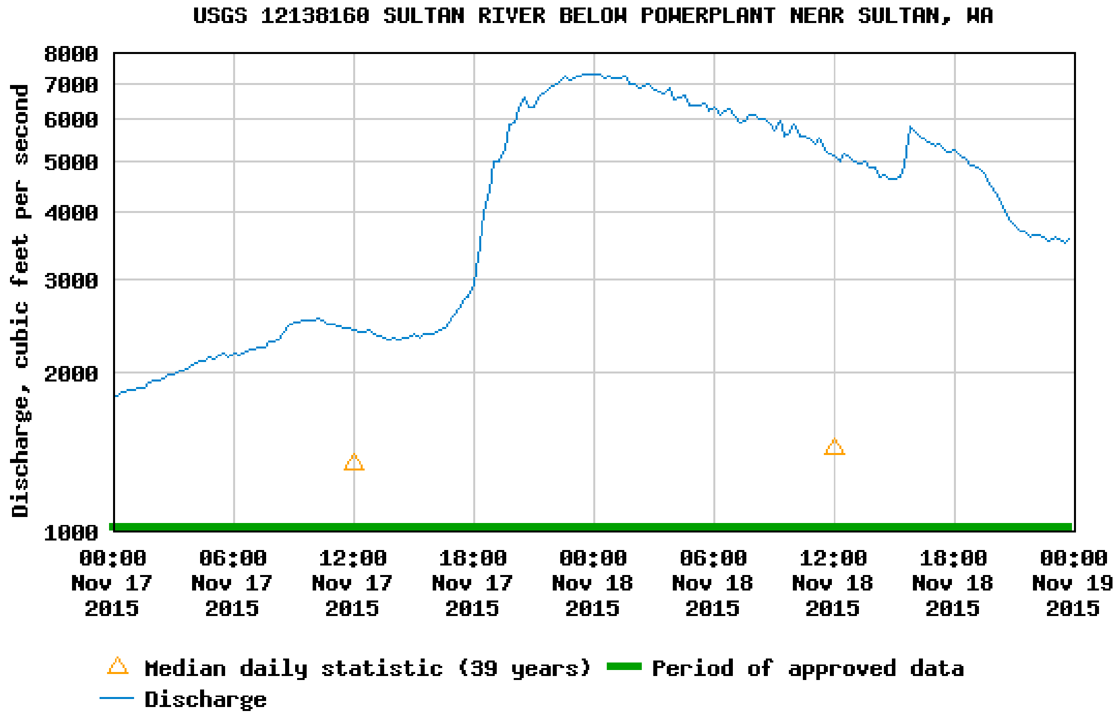


Figure 49. USGS hydrograph for the Sultan River below Powerplant compliance location, November 17-18, 2015.

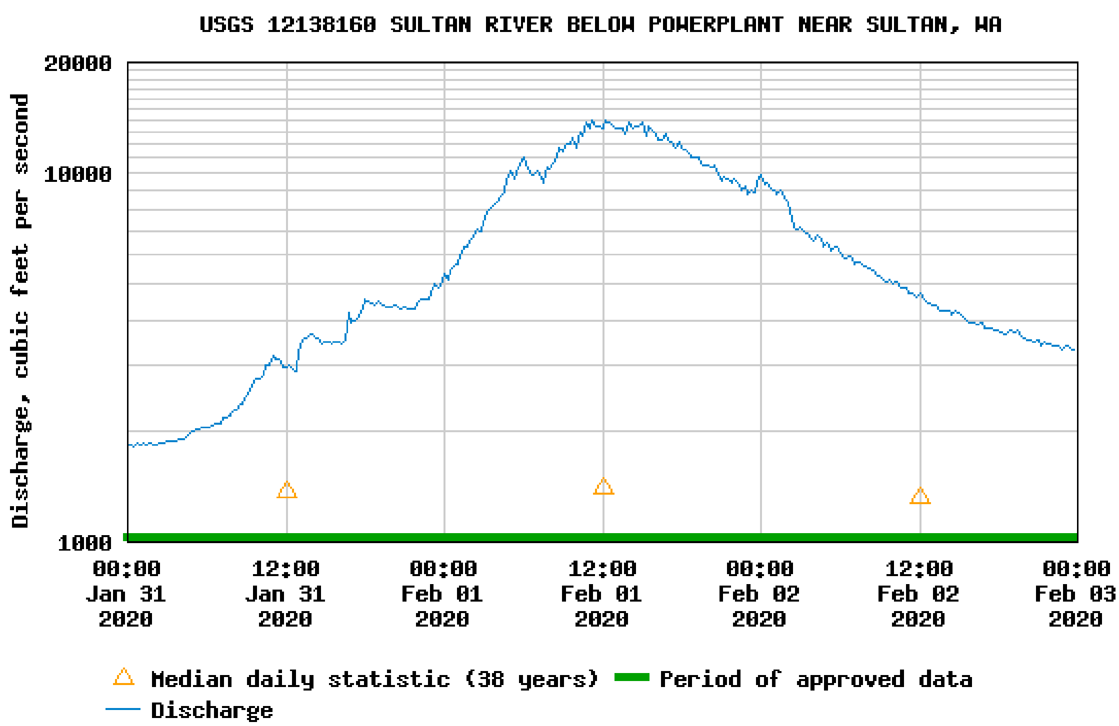


Figure 50. USGS hydrograph for the Sultan River below Powerplant compliance location, February 1-2, 2020.

The following executive summary excerpt from the Stillwater Sciences report highlights some of the overall changes documented during their habitat survey.

> *Stillwater Sciences conducted a riverine habitat survey that entailed characterization and measurement of aquatic habitat features in the river corridor from Culmback Dam (river mile [RM] 16.5) to its confluence with the Skykomish River (RM 0). The study was separated into two efforts that included a survey of the lower 2.7 miles of the Sultan River and its four side channels ("Lower Reach") and a survey of the uppermost (RM 2.7-16.5) Sultan River (Upper Reach"). The Lower Reach habitat survey is required by the Comprehensive Settlement Agreement for the Henry M. Jackson Hydroelectric Project (Project), which includes Culmback Dam operated by the Snohomish Public Utility District (the District). The requirement for a habitat survey was triggered by a significant high-flow event that occurred in winter 2020. Additional tasks executed as part of this work included data synthesis, mapping, analysis, and reporting of all collected data.*
>
> *Previous surveys were conducted in 2007 and 2010 to provide baseline data as part of the relicensing of the Project and to determine the effects of prior high-flow events that occurred in March 2014 (as reported in Stillwater 2015) and November 2015 (Stillwater 2016).*
>
> *Table 17 lists each reach and the year they were surveyed. Riverine habitat attributes recorded for these studies include in-stream unit subtype (e.g., pools, riffles, glides, islands), measurements of wetted unit surface area dimensions (length and width), unit margin features (lengths of undercut banks and bar edges), and the distribution and characterization of large woody debris (LWD). Subsequent to the 2007 and 2010 surveys, habitat enhancements were made to the Lower Reach including the installation of engineered large wood jams along the margins of the mainstem and side channels, and side-channel enhancements including contouring, dredging, reconnection of historic channels as well as establishment of new channels in select locations.*

Table 18. Reaches surveyed and the year the survey was conducted.

Reach	Surveyed in 2007?	Surveyed in 2010?	2012	Surveyed in 2014?	Surveyed in 2016?	Surveyed in 2020?
Mainstem (Lower Reach)	Yes	No	LWD installations	Yes	Yes	Yes
Mainstem (Upper Reach)	Yes	No		No	No	Yes
Side channel 1	No	Yes (partial)		Yes	Yes	Yes
Side channel 2	No	Yes		Yes	Yes	Yes
Side channel 3	Yes	No		Yes	Yes	Yes
Side channel 4	No	No		Yes	Yes	Yes
				↑ High flow March 2014	↑ High flow November 2015	↑ High flow January & February 2020

While it may not be possible to directly attribute habitat changes in the Sultan River system to the winter 2020 storm event, the 2020 study shows that habitat diversity continues to increase when comparisons are made between the 2020 study and studies conducted in 2007, 2010, 2014, and 2016.

Habitat diversity, or number of habitat units within the Study Area, has increased between 2007 and 2020 with most of the changes occurring within the side channels in the lowermost Sultan River (Figures 51-53). Locally, changes in aquatic habitat within the side channels are often occurring near the inlets of these channels and in other reaches where large wood and jams are providing complexity and habitat formation. Overall, low-gradient riffles, pools, and glides are the most abundant habitat subtypes and are represented almost equally in terms of surface area across the Study Area.

Large wood continues to accumulate throughout the Study Area. When comparing the amount of LWD throughout the Sultan River system, the number of LWD jams increased by 186% from 2007 to 2020 and the overall density of LWD pieces and jams increased throughout the Study Area. Between 2016 and 2020, the number of LWD jams in the Lower Reach increased threefold. While much of the LWD is situated above the wetted channel during low flow conditions in the Lower Reach, the remainder of the wood lies within the channel and will likely provide habitat complexity and habitat formation during periods of low and high flow (Figure 53).

Figure 51. Erosion of right bank along lower Side Channel 3 after Channel Forming event of 2020.

Figure 52. Deposit of large woody debris in lower Side Channel 3 after Channel Forming event of 2020.

Figure 53. Racking of large woody debris on Engineered Log Jam 1 at the head of Side Channel 4 after Channel Forming event of 2020.

In addition to the documented changes in habitat diversity, side channel engagement, and large wood dynamics captured in the Stillwater survey, Snohomish PUD’s established channel cross sections in the lower river reveal some interesting changes in response to the high flow events of November 2015 and February 2020.

For Site 1, near Reese Park, what is noticeable is the aggradation between Station 150’ and Station 230’, as measured from the left bank (Figure 54). The development of this pronounced gravel bar is likely attributed to several factors including the increased mobilization and transport of smaller sized gravel upstream of the site and a reduction in stream power at the site either as a result of a more active wider channel including Side Channel 4 or the presence of a backwater effect which often occurs when the Skykomish River is above flood stage. The degradation of the channel near Station 250’ is also worth noting in that it clearly establishes the channel thalweg. Near Station 470’, some modest infilling of Side Channel 4 is evident. This side channel is far more geomorphically active than the extension of Side Channel 1 near Station 50’. This is not surprising given the extreme low gradient of the extension relative to the prevailing gradient within Side Channel 4.

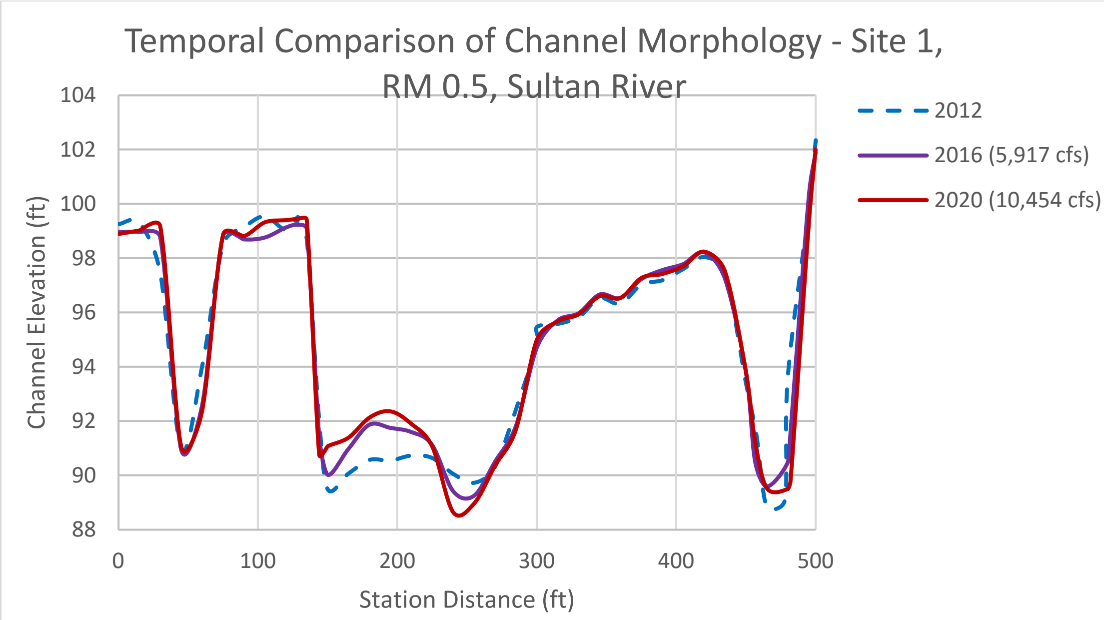


Figure 54. Channel cross section: Site 1, RM 0.5 (2012 baseline, 2016, and 2020)

The temporal changes documented at the channel cross section established at Site 2, RM 1.5 are most evident in the main channel, near Station 250’, and along the right bank within Side Channel 2 (Figure 55). These subtle geomorphic changes are believed to reflect altered flow routing as a result of the placement of ELJ 8, upstream along the left bank, coupled with the significant accumulation of wood and fine sediment on the “island” in the proximity of Station 150’.

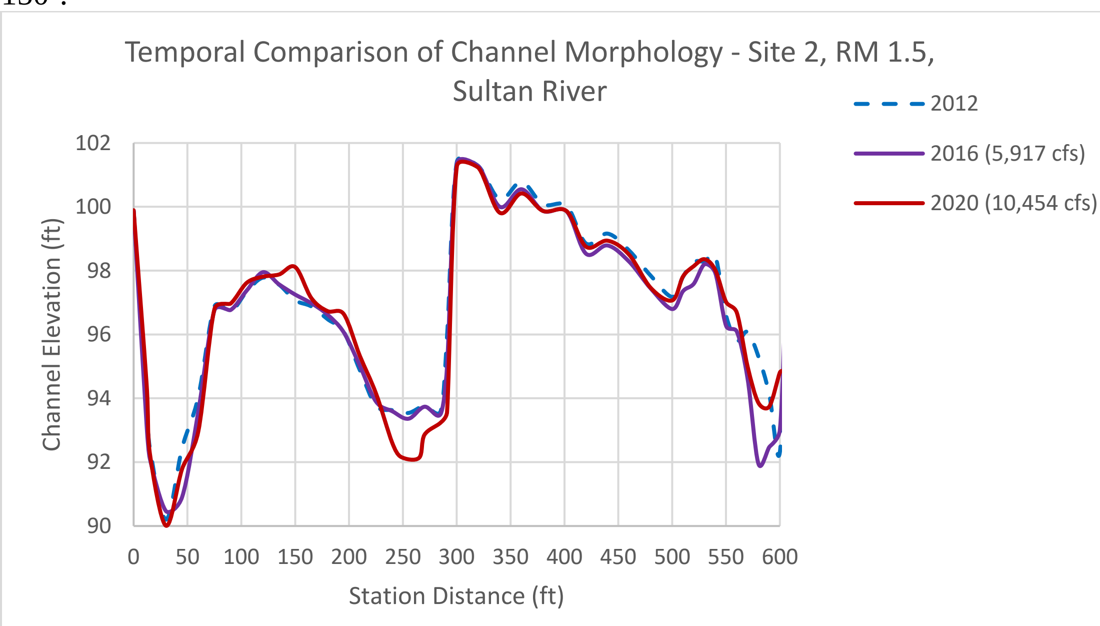


Figure 55. Channel cross section: Site 2, RM 1.5 (2012 baseline, 2016, and 2020)

No pronounced changes over time were evident at Site 3, just downstream of Snohomish PUD’s Trout Farm Road Recreation Site (Figure 56). This undoubtedly reflects the presence of a very stable channel feature.

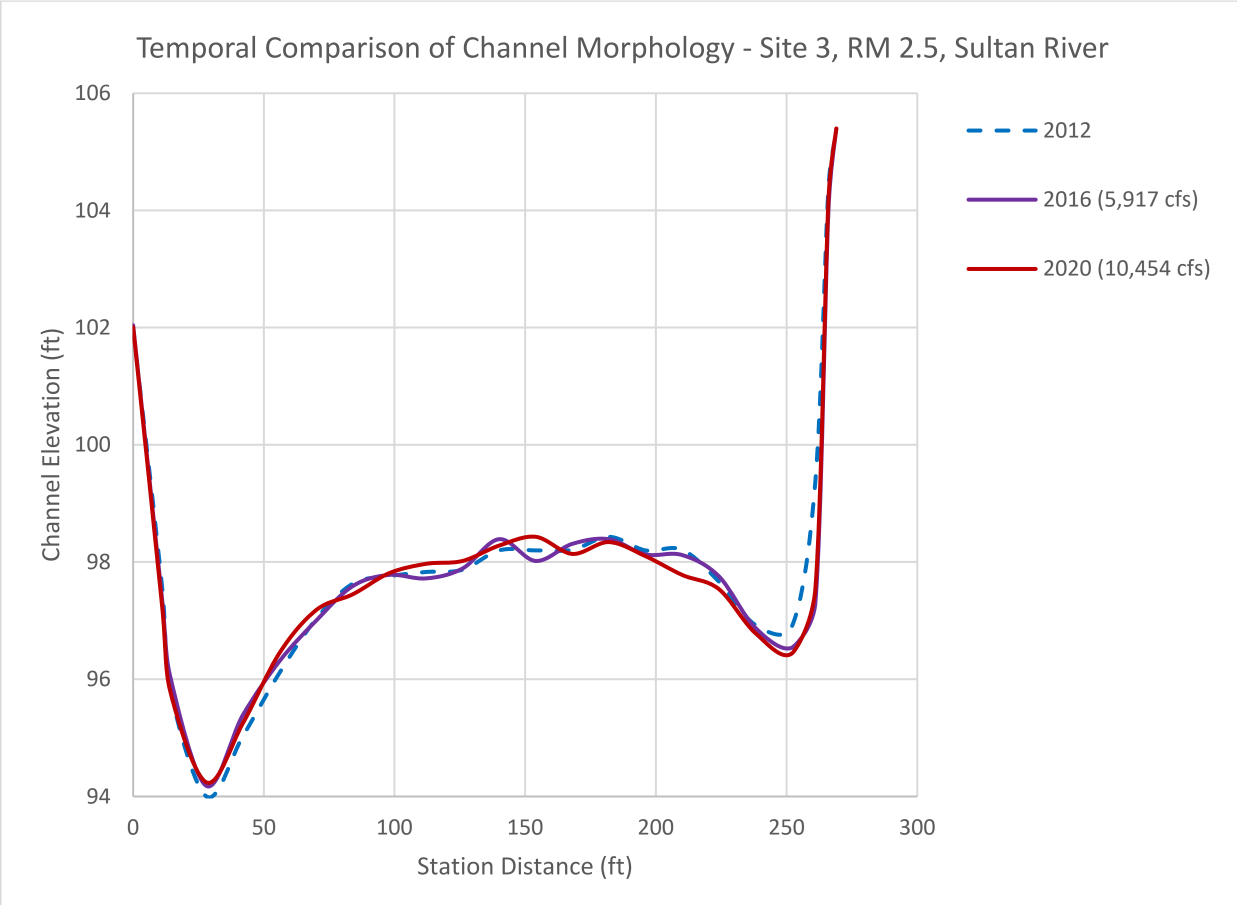


Figure 56. Channel cross section: Site 3, RM 2.5 (2012 baseline, 2016, and 2020)

No pronounced changes over time were evident at Site 4, just downstream of the Jackson Powerhouse (Figure 57). This also undoubtedly reflects the presence of very stable channel features at this location.

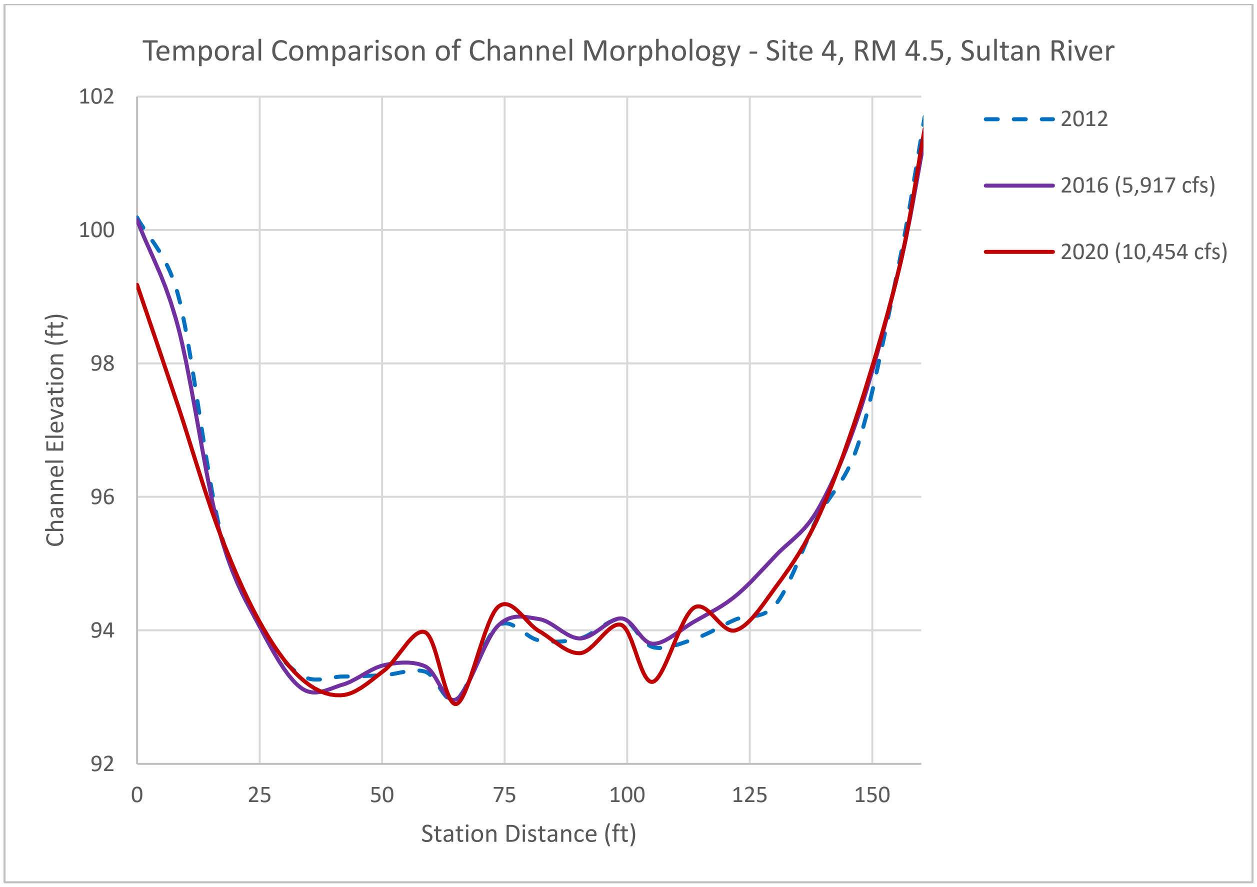


Figure 57. Channel cross section: Site 4, RM 4.5 (2012 baseline, 2016, and 2020)

3.3.4. Unforeseen Consequences

No unforeseen consequences have been identified for this PFP element.

3.3.5. Adaptive Actions Undertaken

No adaptive actions occurred since issuance of the License for this PFP element.

3.3.6. Recommended Modifications

In consideration of the fact that Channel Forming events rely heavily on the occurrence of spill which is largely an event outside the control of Snohomish PUD and beyond the level of control in place with the Project, there are no recommendations for modifications or improvements to this element of the PFP for the next 10-year period. Snohomish PUD will continue to integrate state of the art forecasting in its ongoing hydrologic modeling efforts and track changes that may occur as climate change advances and the probability of intense high inflow conditions increases.

4. Literature

GeoEngineers, Inc. 1984. Phase 1 Report River Gravel Quantity Study, Henry M. Jackson Hydroelectric Project (Sultan River Project), Snohomish County, Washington for Public Utility District No. 1 of Snohomish County

R2 Resource Consultants, Inc. 2006. Spatial and Temporal Comparison of Spawning Gravel Quality in the Sultan River, Washington. Prepared for Snohomish County Public Utility District No. 1.

R2 Resource Consultants, Inc. 2009. Determination and Evaluation of Habitat – Flow Relationships in the Sultan River, Washington – Sultan River Instream Flow Study – RSP 3. Prepared for Snohomish County Public Utility District No. 1.

Schmidt, L. and J. Potyondy. 2004. Quantifying Channel Maintenance Instream Flows: An Approach for Gravel-Bed Streams in the Western United States. Gen. Tech. Rep. RMRS-GTR-128. Forth Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 33 p.

Shapiro and Associates, Inc. 1988. Evaluation of the textural composition of Sultan River salmonid spawning gravels following hydroelectric project construction, prepared for Snohomish County Public Utility District No. 1.

Shapiro and Associates, Inc. 1995. Evaluation of the textural composition of Sultan River salmonid spawning gravels following hydroelectric project construction, prepared for Snohomish County Public Utility District No. 1.

Stillwater Sciences. 2007. Study Plan 18: riverine, riparian, and wetland habitat assessment technical report. Prepared by Stillwater Sciences for Snohomish County Public Utility District No. 1.

Stillwater Sciences. 2010. Sultan River geomorphic assessment of side channel enhancement opportunities. Prepared by Stillwater Sciences for Snohomish County Public Utility District No.1.

Stillwater Sciences. 2015. Sultan River riverine habitat monitoring. Prepared by Stillwater Sciences, Portland, Oregon for Snohomish County Public Utility District No.1.

Stillwater Sciences. 2016. Sultan River riverine habitat monitoring. Prepared by Stillwater Sciences for Snohomish County Public Utility District No.1.

Stillwater Sciences. 2021. Sultan River riverine habitat monitoring. Prepared by Stillwater Sciences for Snohomish County Public Utility District No.1.

Wert, M.A., C.R. Steward, and F. Winchell. 1982. Baseline evaluation of the textural composition of Sultan River salmonid spawning gravels, prepared for Snohomish County Public Utility District No. 1.

Wert, M.A., C.R. Steward, and F. Winchell. 1984. Evaluation of the textural composition of Sultan River salmonid spawning gravels following hydroelectric project construction, prepared for Snohomish County Public Utility District No. 1.

Wolman, G. M. 1954. A method of sampling coarse river-bed material. Transactions, American Geophysical Union 35, Number 6. Stillwater

Appendix A

Mean Daily Discharge for Skykomish, Sultan and Pilchuck Rivers

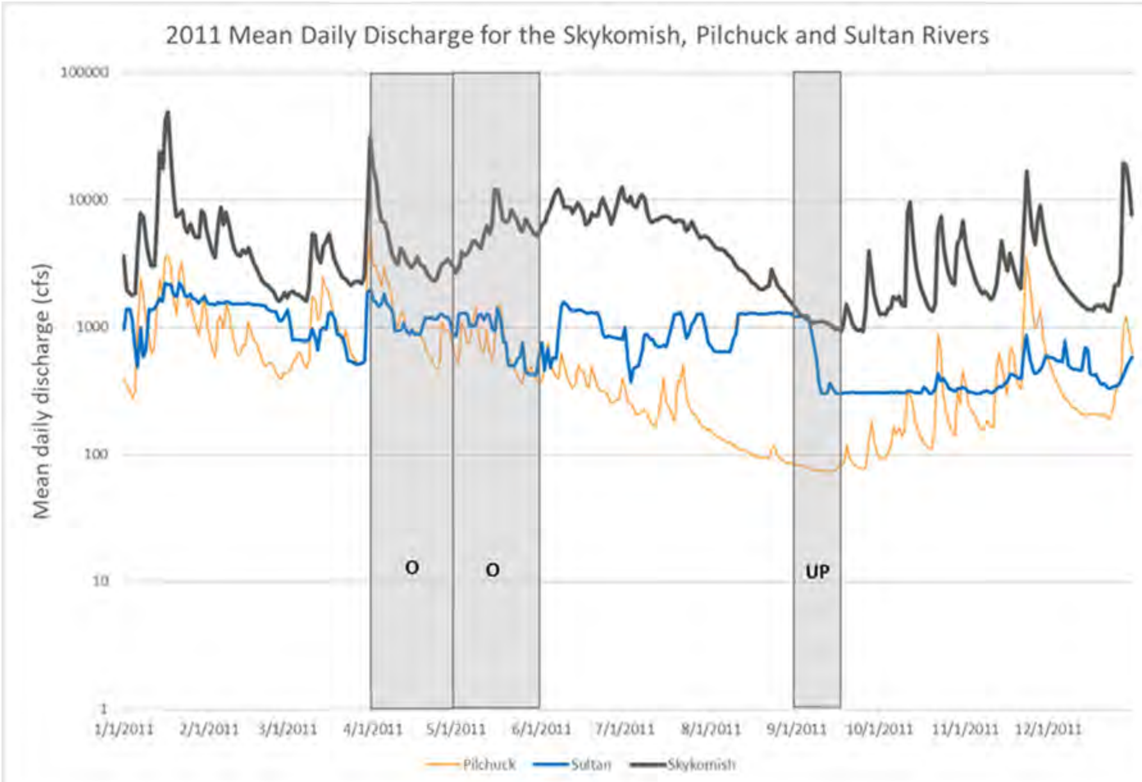


Figure A-1

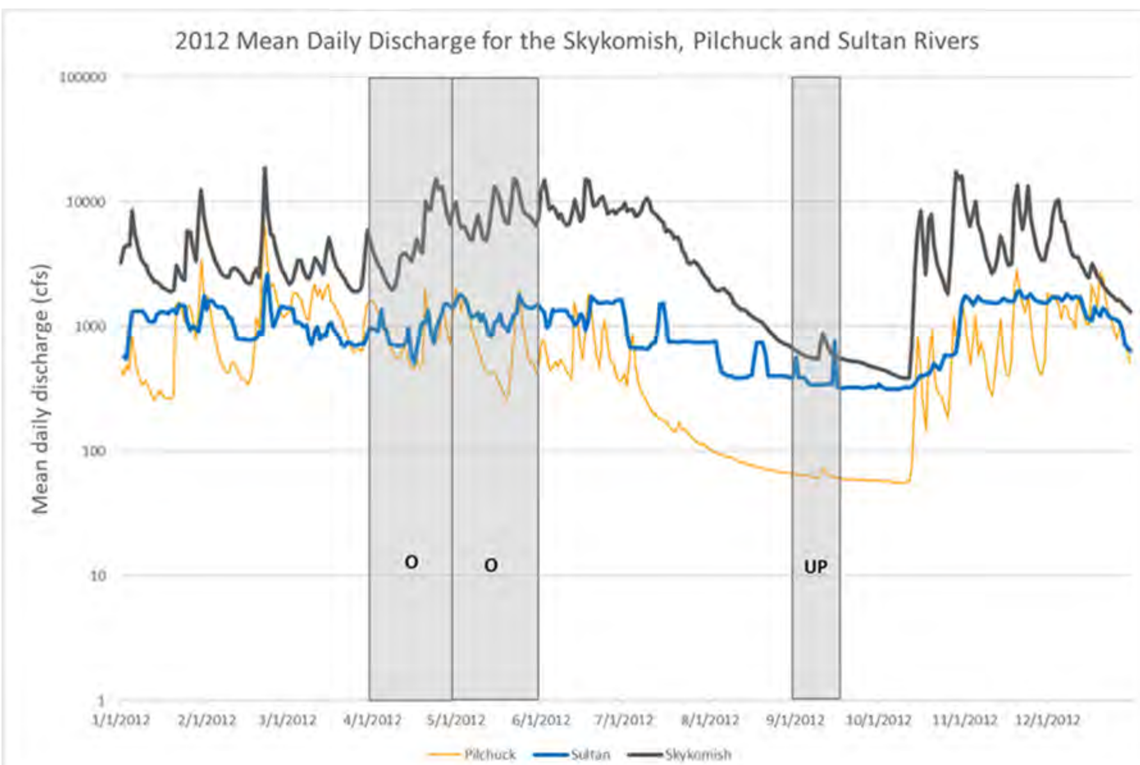


Figure A-2

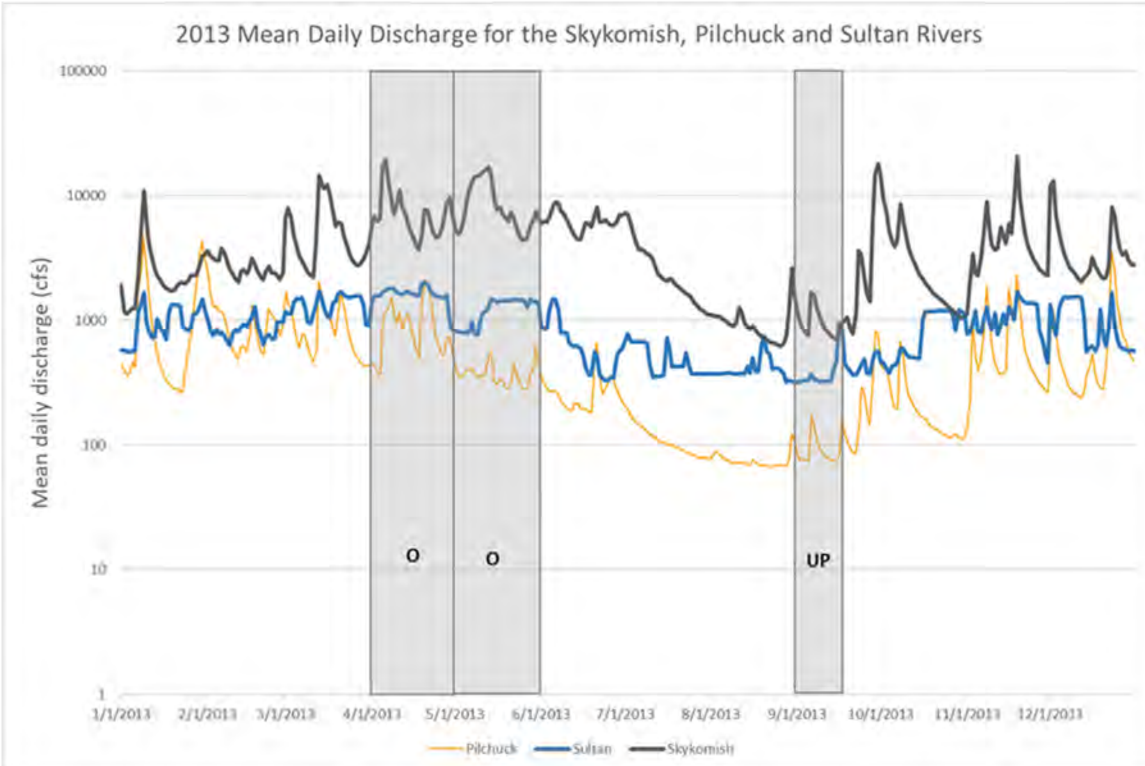


Figure A-3

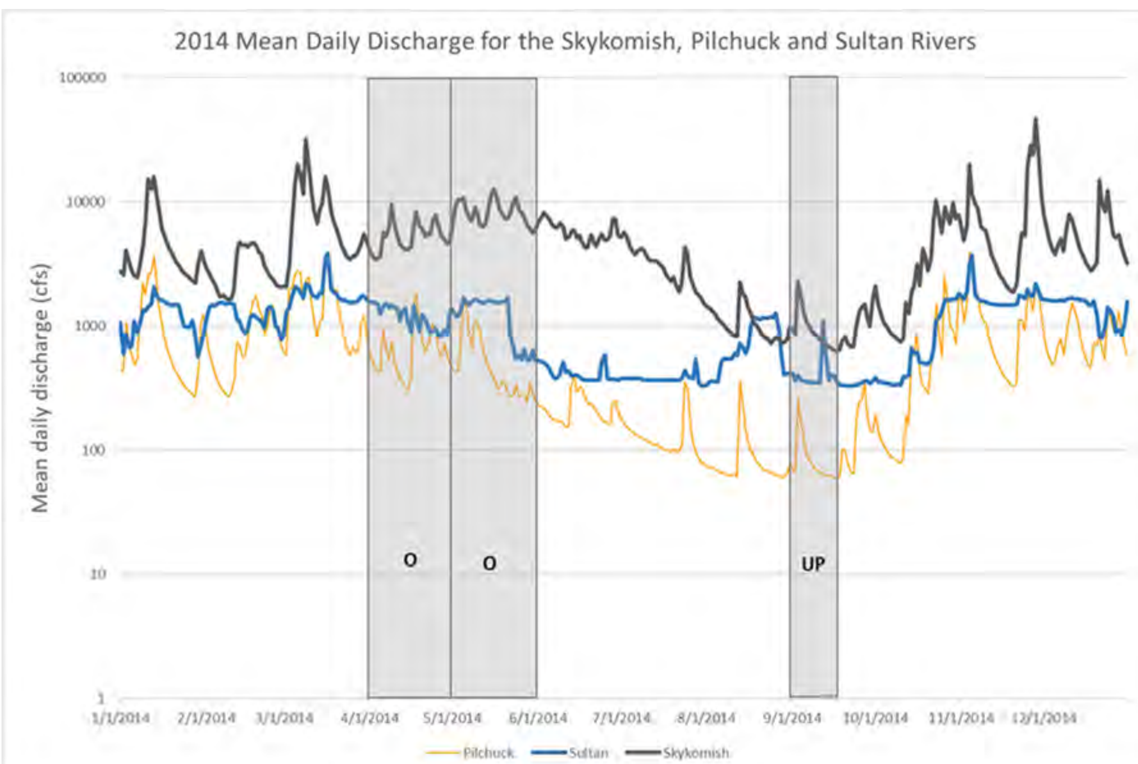


Figure A-4

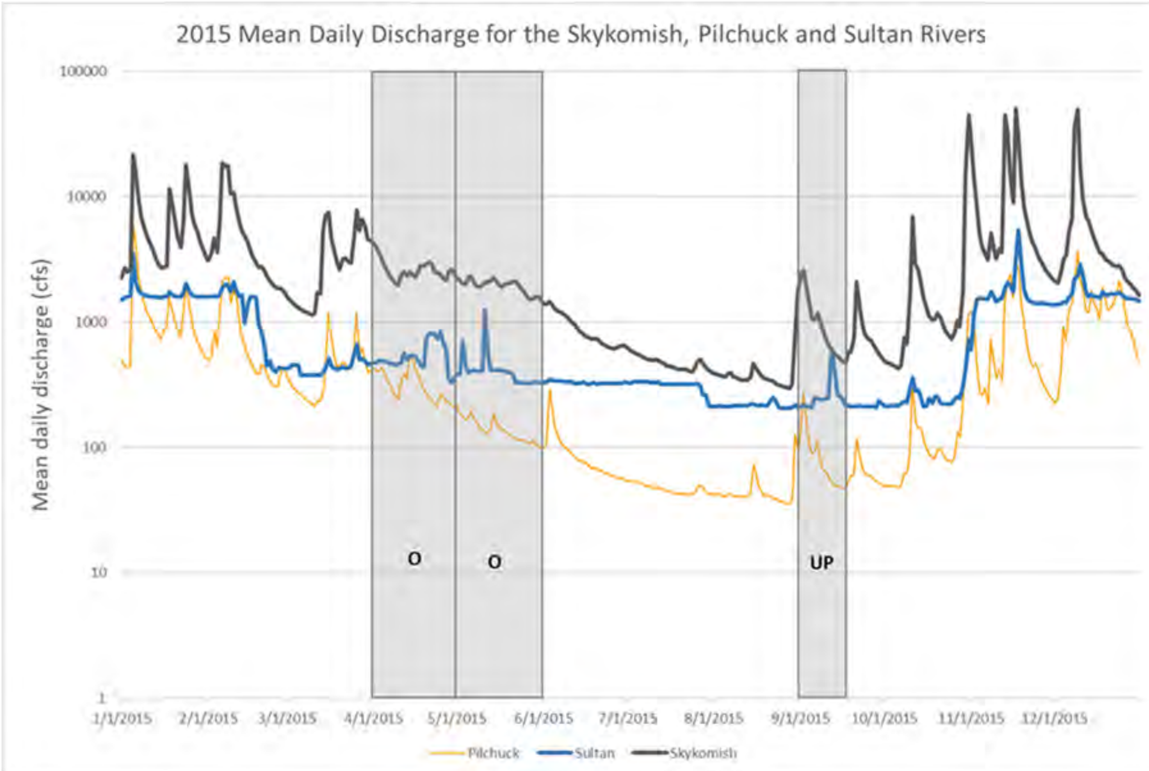


Figure A-5

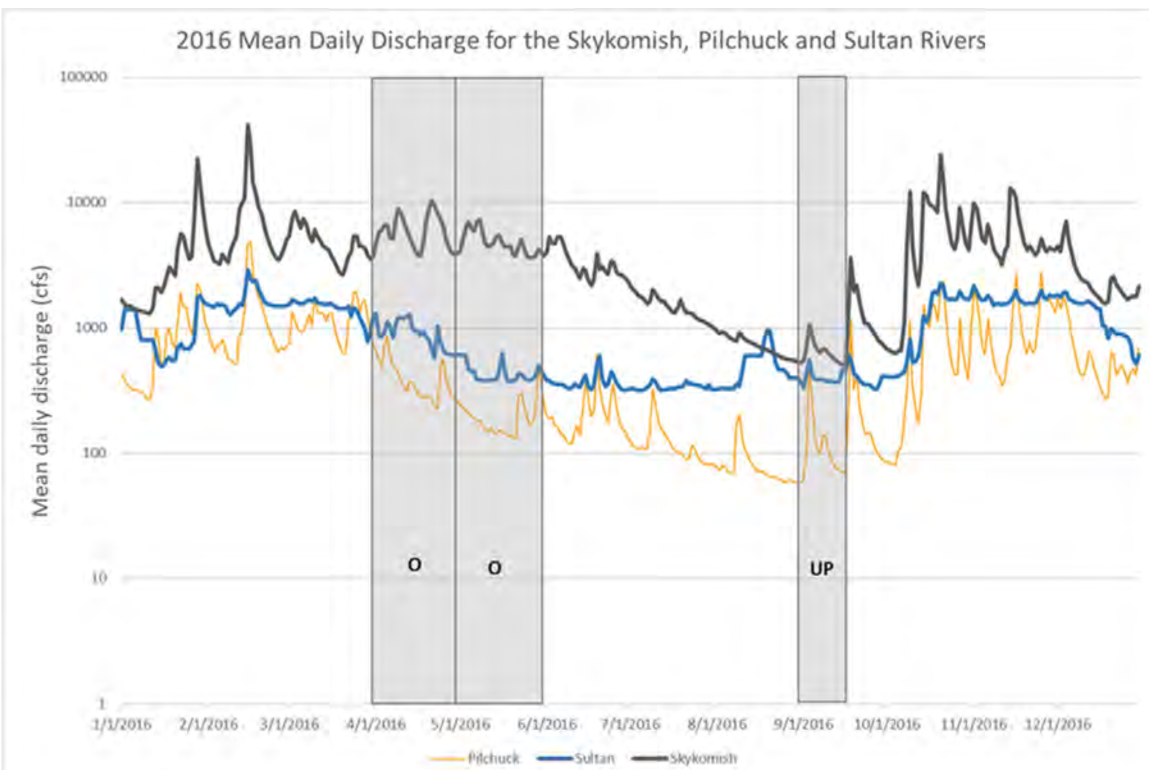


Figure A-6

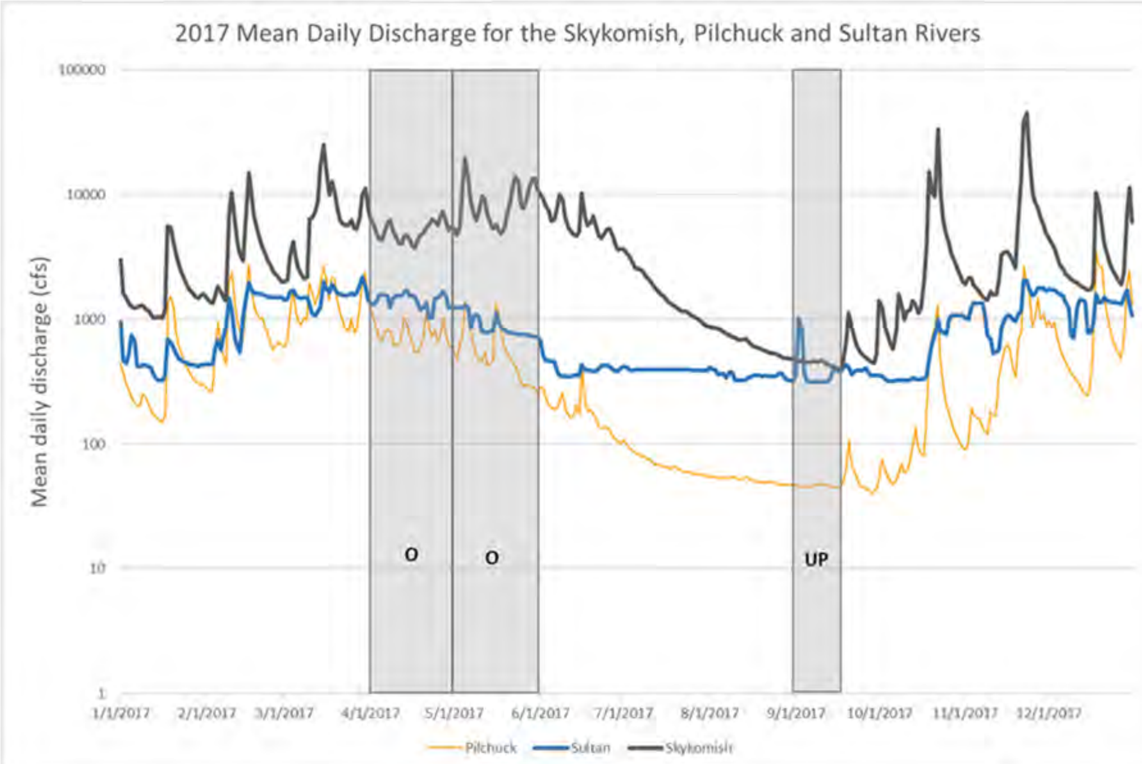


Figure A-7

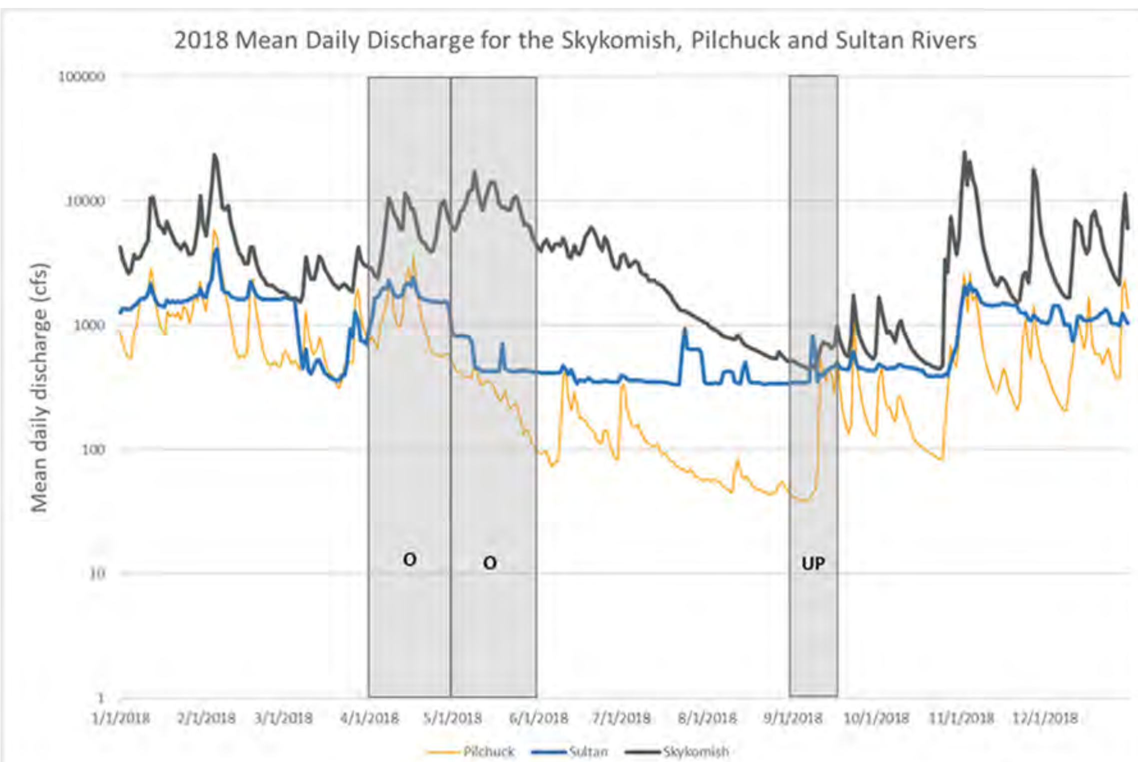


Figure A-8

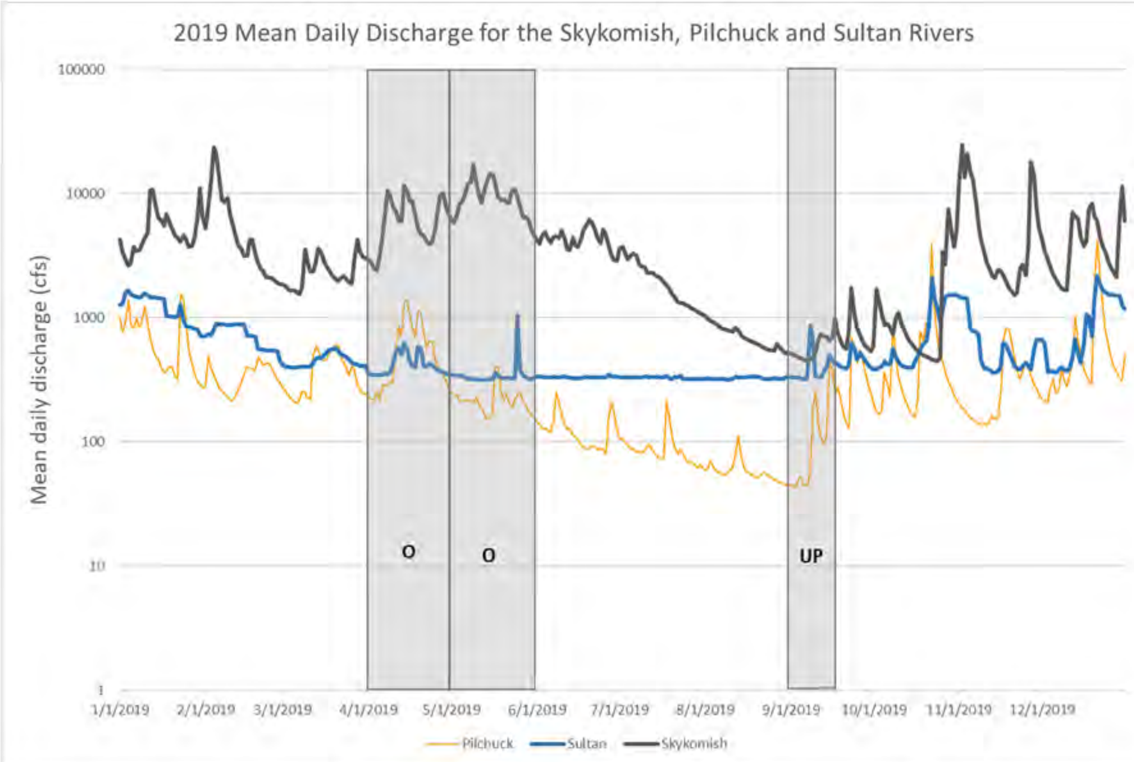


Figure A-9

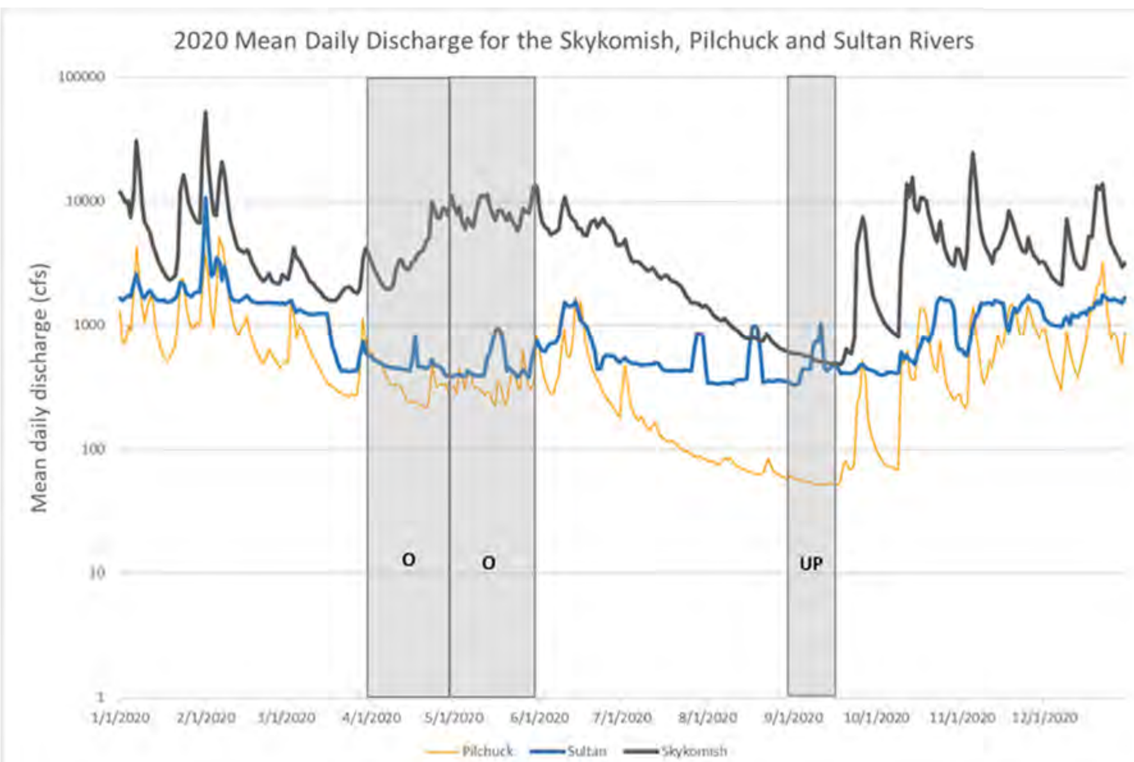


Figure A-10

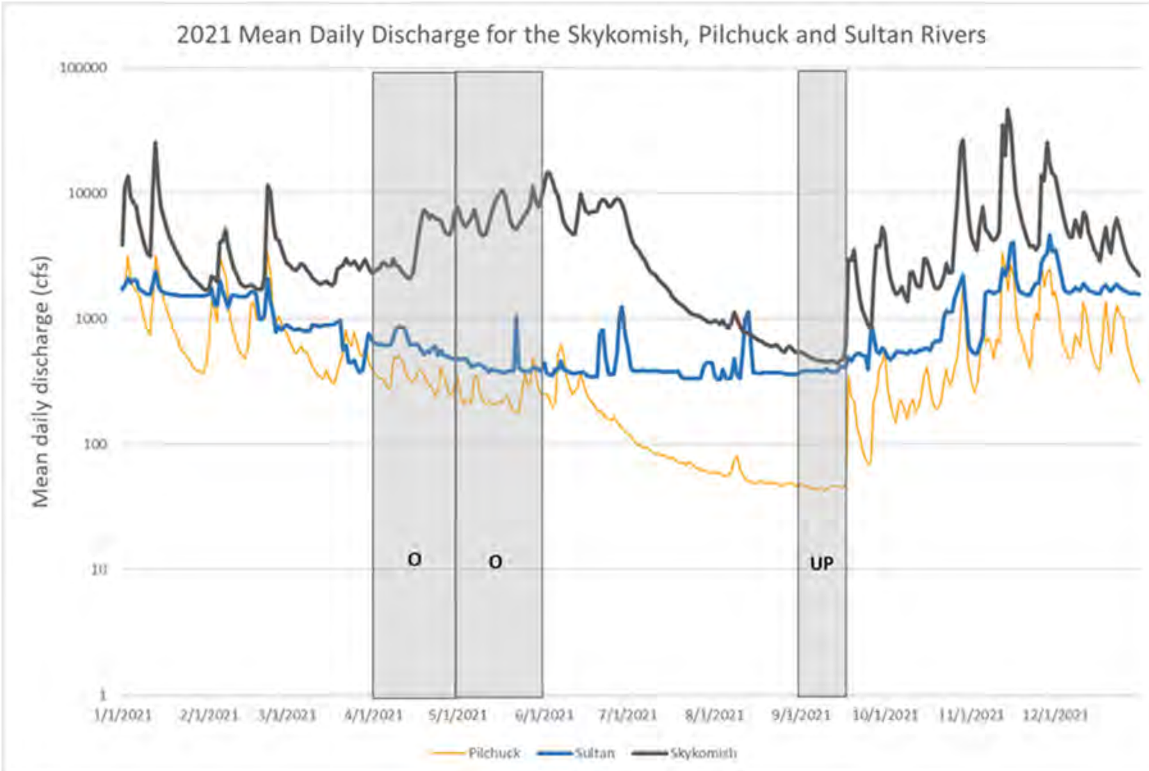


Figure A-11

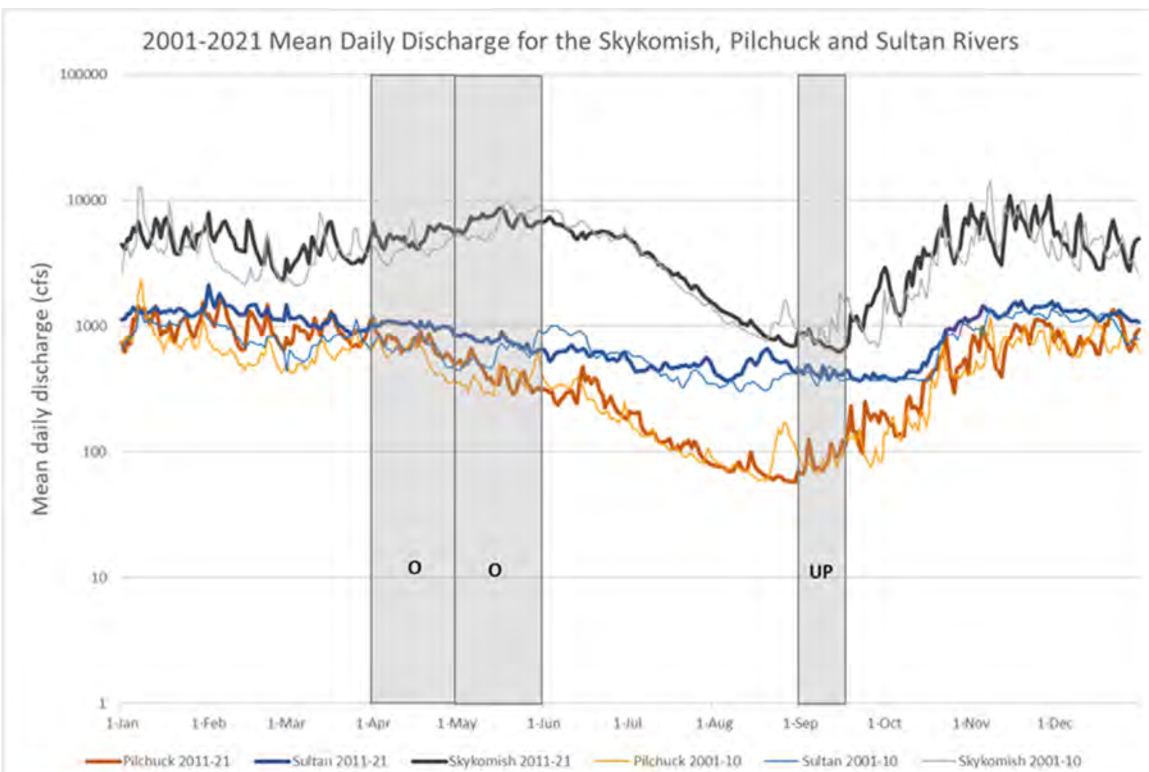


Figure A-12

Appendix B

Number of discrete instances over a 4-year period where mean 6-hour discharge exceeded the threshold for upmigration, outmigration, and channel flushing flow requirements, 2018-2021.

Objective	Reach	January					February					March					April					May				
		2018	2019	2020	2021	Total	2018	2019	2020	2021	Total	2018	2019	2020	2021	Total	2018	2019	2020	2021	Total	2018	2019	2020	2021	Total
Outmigration	1	124	116	124	124	488	112	0	116	107	335	39	0	68	81	188	116	1	0	0	117	19	0	13	0	32
Outmigration	2	91	4	61	36	192	84	0	43	23	150	88	0	11	21	120	95	9	0	0	104	48	0	0	0	48
Outmigration	3	16	5	60	34	115	35	0	42	23	100	77	3	16	33	129	62	15	0	3	80	0	0	0	0	0
Upmigration	1	124	116	124	124	488	112	4	116	107	339	39	0	68	81	188	116	0	0	0	116	19	0	13	0	32
Upmigration	2	91	4	61	36	192	84	0	43	23	150	88	0	11	21	120	95	7	0	0	102	48	0	0	0	48
Upmigration	3	5	2	30	20	57	20	0	39	14	73	53	0	6	32	91	38	3	0	0	41	0	0	0	0	0
Flushing	1	81	19	118	124	342	112	0	100	52	264	23	0	6	2	31	108	0	0	0	108	0	0	0	0	0
Flushing	2	59	0	33	31	123	74	0	38	17	129	36	0	4	6	46	92	0	0	0	92	45	0	0	0	45
Flushing	3	2	0	15	4	21	16	0	38	6	60	13	0	2	2	17	24	0	0	0	24	0	0	0	0	0

*All totals exclude scheduled process flows events.

Objective	Reach	June					September					October					November					December				
		2018	2019	2020	2021	Total	2018	2019	2020	2021	Total	2018	2019	2020	2021	Total	2018	2019	2020	2021	Total	2018	2019	2020	2021	Total
Outmigration	1	0	0	45	13	58	1	2	0	0	3	3	41	41	34	119	120	18	104	100	342	120	57	121	124	422
Outmigration	2	0	0	6	0	6	3	1	0	3	7	0	12	20	10	42	26	4	13	66	109	14	17	30	30	91
Outmigration	3	2	0	4	0	6	4	11	1	6	22	4	13	20	10	47	28	4	17	75	124	15	16	33	24	88
Upmigration	1	0	0	45	13	58	1	2	0	0	3	3	41	41	34	119	120	2	104	100	326	120	32	121	124	397
Upmigration	2	2	0	6	0	8	3	1	0	3	7	0	12	20	10	42	26	3	13	66	108	14	17	30	30	91
Upmigration	3	0	0	0	0	0	2	2	0	1	5	0	5	10	6	21	18	2	5	65	90	8	11	18	16	53
Flushing	1	0	0	7	0	7	0	0	0	0	0	0	24	10	15	49	35	2	10	99	146	0	32	40	124	196
Flushing	2	0	0	0	0	0	2	0	0	1	3	0	6	11	7	24	17	3	4	56	80	7	12	20	19	58
Flushing	3	0	0	0	0	0	1	0	0	0	1	0	4	3	3	10	10	2	2	40	54	4	6	7	11	28

Appendix C

Consultation Regarding Draft Report

Presler, Dawn

From: Presler, Dawn
Sent: Tuesday, September 6, 2022 10:39 AM
To: Anne Savery; Brock Applegate; Jeff Garnett; Jennifer Bailey; Mike Rustay; Monica Kannadaguli; Nate Morgan; Richard Vacirca; Tom O'Keefe; 'elizabeth.babcock@noaa.gov'
Cc: Andrew McDonnell; Keith Binkley
Subject: JHP (FERC No. 2157) - DRAFT 10-Year Effectiveness Report for Process Flow Plan for your 30-day review and comment period
Attachments: PF Plan 10 Year Effectiveness Report_reducedsize.pdf

Dear ARC Members,
Attached is the Jackson Hydro Project's DRAFT 10-Year Effectiveness Report for Process Flow Plan for your 30-day review and comment period. Comments, if any, are **due by October 6**. As always, an email is appreciated too indicating that you have no comments and/or concur with the report. We have a **meeting scheduled for September 20 from 9:00-11:00** to discuss the data and recommendations (let me know if you need me to resend this calendar appointment). Please take some time to review the report and recommendations prior to that meeting.

In the meanwhile, if you have questions regarding the attached, please let us know. Wishing you a wonderful week.

Cheers,
Dawn Presler

(she, her, hers)
Sr. Environmental Coordinator
Generation – Natural Resources
Snohomish County PUD No. 1
Everett, WA

(425) 783-1709 (work)

Presler, Dawn

From: Anne Savery <asavery@tulaliptribes-nsn.gov>
Sent: Monday, October 3, 2022 8:41 AM
To: Presler, Dawn
Cc: Binkley, Keith; McDonnell, Andrew
Subject: Re: Comment letter for process flows

Thank you Dawn, I really appreciate it.

Yes, getting all of us on a call off schedule is a challenge.

Anne

Anne Savery
Hydrologist
503-984-0667

____

From: Presler, Dawn <DJPresler@SNOPUD.com>
Sent: Monday, October 3, 2022 8:09:08 AM
To: Anne Savery
Cc: Binkley, Keith; McDonnell, Andrew
Subject: RE: Comment letter for process flows

WARNING: This email originated outside of our organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

____

Hi Anne - yes, that sounds reasonable. Thanks for the heads up! (I hope to find some dates that work for everyone with the new doodle poll and will be sending out meeting invites hopefully this afternoon.)

Cheers,
Dawn

-----Original Message-----
From: Anne Savery <asavery@tulaliptribes-nsn.gov>
Sent: Monday, October 3, 2022 7:57 AM
To: Presler, Dawn <DJPresler@SNOPUD.com>
Subject: Comment letter for process flows

CAUTION: THIS EMAIL IS FROM AN EXTERNAL SENDER.
Do not click on links or open attachments if the sender is unknown or the email is suspect.

____

Hi Dawn

Would it be possible for me to submit the Tribes letter by COB October 10th? I have two all day meetings early this week and realize I will have not sufficient time to devote to our comments until later.

Thanks for considering.

Anne

Anne Savery
Hydrologist
503-984-0667

Presler, Dawn

From: Garnett, Jeffrey A <jeffrey_garnett@fws.gov>
Sent: Friday, October 7, 2022 12:09 AM
To: Presler, Dawn; asavery@tulaliptribes-nsn.gov; Brock Applegate; Jennifer Bailey; Mike Rustay; Monica Kannadaguli; Nate Morgan; Richard Vacirca; Tom O'Keefe; elizabeth.babcock@noaa.gov
Cc: McDonnell, Andrew; Binkley, Keith; Garnett, Jeffrey A

Subject: RE: [EXTERNAL] JHP (FERC No. 2157) - DRAFT 10-Year Effectiveness Report for Process Flow Plan for your 30-day review and comment period

Dawn,

USFWS has the following general comments concerning the recommendations from SnoPUD related to upmigration, outmigration, and flushing flows found within the 10-Year Effectiveness Report. Suspending flows for 10 years appears drastic, and USFWS would appreciate that SnoPUD and the ARC consider other, less aggressive measures to modify and test effectiveness of these flows. If there is concurrence among members of the ARC that these flows, as previously implemented, are ineffective, we suggest one or more of the following strategies:

- Altering the timing or magnitude of flows;
- Reducing the number of annual flow events (in the case of outmigration and flushing flows), or;
- Suspending flows for a shorter duration than 10 years. This provides the ARC recourse if undesirable/unintended effects become apparent well before the end of the 10 year period. A shorter suspension would allow the ARC to re-evaluate flow effectiveness and either continue with the suspension or reinstitute flows. A statistically robust comparison could still occur with a smaller data set of suspended flows.

I also have concerns that other variables may confound a comparison of the previous 10 years to a 10 year suspension of upmigration, outmigration, and flushing flows. For example, the continuation of whitewater flows may effectively serve as a process flow and make a comparison challenging.

Finally, the 10-Year Effectiveness Report states that outmigration flows as previously implemented “likely disrupts steelhead spawning.” Has this been documented in the Sultan River with empirical data? If not, I would advocate for testing this hypothesis before using it to make long term management decisions; therefore, I would appreciate seeing data that supports this claim. In the event data does exist supporting the hypothesis, I believe identifying ways to modify the timing and/or magnitude of flows, as indicated above, would be a prudent first step before suspending flows for 10 years.

Thank you for the opportunity to comment, and I look forward to continued discussions.

Jeff

Jeffrey Garnett
U.S. Fish and Wildlife Service | Lacey, WA
360-701-6838 (new number)
jeffrey_garnett@fws.gov
(he/him/his)

From: Presler, Dawn <DJPresler@SNOPUD.com>
Sent: Tuesday, September 6, 2022 10:39 AM
To: asavery@tulaliptribes-nsn.gov; Brock Applegate <brock.applegate@dfw.wa.gov>; Garnett, Jeffrey A <jeffrey_garnett@fws.gov>; Jennifer Bailey <JBailey@everettwa.gov>; Mike Rustay <mike.rustay@co.snohomish.wa.us>; Monica Kannadaguli <mkan461@ecy.wa.gov>; Nate Morgan <nate.morgan@ci.sultan.wa.us>; Richard Vacirca <richard.vacirca@usda.gov>; Tom O'Keefe <okeefe@americanwhitewater.org>; elizabeth.babcock@noaa.gov
Cc: McDonnell, Andrew <AWMcdonnell@SNOPUD.com>; Binkley, Keith <KMBinkley@SNOPUD.com>
Subject: [EXTERNAL] JHP (FERC No. 2157) - DRAFT 10-Year Effectiveness Report for Process Flow Plan for your 30-day review and comment period

Dear ARC Members,
Attached is the Jackson Hydro Project's DRAFT 10-Year Effectiveness Report for Process Flow Plan for your 30-day review and comment period. Comments, if any, are **due by October 6**. As always, an email is appreciated too indicating that you have no comments and/or concur with the report. We have a **meeting scheduled for September 20 from 9:00-11:00** to discuss the data and recommendations (let me know if you need me to resend this calendar appointment). Please take some time to review the report and recommendations prior to that meeting.

In the meanwhile, if you have questions regarding the attached, please let us know. Wishing you a wonderful week.

Cheers,
Dawn Presler
(she, her, hers)
Sr. Environmental Coordinator
Generation – Natural Resources
Snohomish County PUD No. 1
Everett, WA

(425) 783-1709 (work)

Presler, Dawn

From: Anne Savery <asavery@tulaliptribes-nsn.gov>
Sent: Tuesday, October 11, 2022 10:33 AM
To: Presler, Dawn
Subject: TTT annotated PFP plan
Attachments: PF Plan 10 Year Effectiveness Report_TTT comments.pdf

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Hi Dawn

Here is the Tribes' comments within the report, I'm still working on the letter and will have that to you today.

Thanks for the grace on getting it in.

Anne

Anne Savery
Hydrologist
503-984-0667

Presler, Dawn

From: Anne Savery <asavery@tulaliptribes-nsn.gov>
Sent: Tuesday, October 11, 2022 3:38 PM
To: Presler, Dawn
Cc: Mike Crewson; Kurt Nelson; Daryl Williams
Subject: Tulalip Tribes comment letter with separate appendix
Attachments: Sultan River PFP _ TTT comments.pdf; Appendix to Tulalip Letter.pdf

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Thanks Dawn!

Best

Anne

Anne Savery
Hydrologist
503-984-0667

Presler, Dawn

From: Anne Savery <asavery@tulaliptribes-nsn.gov>
Sent: Tuesday, October 11, 2022 3:41 PM
To: Garnett, Jeffrey A; Presler, Dawn; Brock Applegate; Jennifer Bailey; Mike Rustay; Monica Kannadaguli; Nate Morgan; Richard Vacirca; Tom O'Keefe; elizabeth.babcock@noaa.gov
Cc: McDonnell, Andrew; Binkley, Keith
Subject: Re: [EXTERNAL] JHP (FERC No. 2157) - DRAFT 10-Year Effectiveness Report for Process Flow Plan for your 30-day review and comment period
Attachments: Sultan River PFP _ TTT comments.pdf; Appendix to Tulalip Letter.pdf; PF Plan 10 Year Effectiveness Report_TTT comments.pdf

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Attached are our comments and an annotated report. Looking forward to discussing the report with you all.

Anne

Anne Savery
Hydrologist
503-984-0667

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From: Garnett, Jeffrey A <jeffrey_garnett@fws.gov>
Sent: Friday, October 7, 2022 12:08:55 AM
To: Presler, Dawn; Anne Savery; Brock Applegate; Jennifer Bailey; Mike Rustay; Monica Kannadaguli; Nate Morgan; Richard Vacirca; Tom O'Keefe; elizabeth.babcock@noaa.gov
Cc: McDonnell, Andrew; Binkley, Keith; Garnett, Jeffrey A
Subject: RE: [EXTERNAL] JHP (FERC No. 2157) - DRAFT 10-Year Effectiveness Report for Process Flow Plan for your 30-day review and comment period

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Dawn,

USFWS has the following general comments concerning the recommendations from SnoPUD related to upmigration, outmigration, and flushing flows found within the 10-Year Effectiveness Report. Suspending flows for 10 years appears drastic, and USFWS would appreciate that SnoPUD and the ARC consider other, less aggressive measures to modify and test effectiveness of these flows. If there is concurrence among members of the ARC that these flows, as previously implemented, are ineffective, we suggest one or more of the following strategies:

* Altering the timing or magnitude of flows;
* Reducing the number of annual flow events (in the case of outmigration and flushing flows), or;
* Suspending flows for a shorter duration than 10 years. This provides the ARC recourse if undesirable/unintended effects become apparent well before the end of the 10 year period. A shorter suspension would allow the ARC to re-evaluate flow effectiveness and either continue with the suspension or reinstitute flows. A statistically robust comparison could still occur with a smaller data set of suspended flows.

I also have concerns that other variables may confound a comparison of the previous 10 years to a 10 year suspension of upmigration, outmigration, and flushing flows. For example, the continuation of whitewater flows may effectively serve as a process flow and make a comparison challenging.

Finally, the 10-Year Effectiveness Report states that outmigration flows as previously implemented "likely disrupts steelhead spawning." Has this been documented in the Sultan River with empirical data? If not, I would advocate for testing this hypothesis before using it to make long term management decisions; therefore, I would appreciate seeing data that supports this claim. In the event data does exist supporting the hypothesis, I believe identifying ways to modify the timing and/or magnitude of flows, as indicated above, would be a prudent first step before suspending flows for 10 years.

Thank you for the opportunity to comment, and I look forward to continued discussions.

Jeff

Jeffrey Garnett
U.S. Fish and Wildlife Service | Lacey, WA
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Cheers,

Dawn Presler
(she, her, hers)
Sr. Environmental Coordinator
Generation – Natural Resources
Snohomish County PUD No. 1
Everett, WA

(425) 783-1709 (work)

October 11, 2022

Keith Binkley
Snohomish PUD
PO Box 1107
Everett, WA 98206

Dear Mr. Binkley,

The Tulalip Tribes submit these comments on the Sultan River Process Flow Plan Draft 10 Year Effectiveness Report along with an annotated version of the report. The Tribes appreciate the effort the Snohomish County Public Utility District staff (the District) has put into monitoring and assessing how the process flows affected salmon and salmonid habitat. Overall, we agree that the upmigration, outmigration and flushing flows are not achieving the stated goals. The Tribes do not agree that upmigration flows are attracting hatchery strays and find the evidence provided by the District to be unconvincing. Data presented on scour was limited and weak; there does appear to be some bed mobilization, however not a significant change between the flows presented. Channel forming and maintenance flows should be continued at the currently prescribed intervals; it is our conclusion that the channel maintenance flows are set too low to produce the outcomes described in the report.

The Tulalip Tribes reserved the right to take fish in their usual and accustomed fishing places pursuant to the Treaty of Point Elliot of January 22, 1855 (12 Stat. 927). The Tulalip Tribes are the only tribe on record with federally reserved Treaty Rights in the area. These usual and accustomed treaty fishing areas include the freshwater areas of the Snohomish-Snoqualmie-Skykomish river basins and certain marine waters of the Puget Sound through which fish propagated in such basins pass. *U.S. v. Washington,* 459 F. Supp. 1020, 1038 (W.D. Wash. 1978); *U.S. v. Washington,* 626 F. Supp. 1405, 1527 (W.D. Wash. 1985), *Aff'd*, 841 F.2d 317 (9th Cir. 1988). The Tulalip Tribes are co-managers of fisheries and fish habitat with the federal government and Washington State.

Background

During relicensing studies and negotiations, the District, agencies and a recreation representative studied how components of the hydrograph changed pre- and post-Project. Inter and intra-seasonal flow variability was found to be lacking on the post-project hydrograph throughout the basin. Over the life of the project, the Sultan River has had reduced interaction with the floodplain, side channels were disconnected, riparian encroachment occurred on gravel bars and the lower river planform was reduced to a wide and shallow single thread. The committee understood that flows alone would not address habitat formation, bedload transport, gravel redistribution or restoration of a patchwork dynamic within the riparian zone. The flows would need to be coupled with in channel LWD installments, boulder placement and possible manipulation of tree cover on forested islands to allow for gravels to mobilize.

Since 2011, the flow regime may have changed beyond the process flow and minimum flow adjustments made in the License; yet the current flow regime has not been compared to the two previous flow regimes, pre and post project. Power generation and other operational features should be described in the report – to explain the number of 'process flows' described in the report Appendix. It may be the case that the high number of process flows produced outside of those required by the license have no effect on fish or habitat, however they remain undefined and unanalyzed. Minimum instream flows were raised from 200 cfs to 300 cfs in 2011, the effects of which are unanalyzed, likely have the greatest positive impact on temperatures, flow and salmon survival in the Sultan and Skykomish Rivers.

Tulalip and the District have discussed Sultan River Chinook in the broader context of the Skykomish population and are disappointed to not find the information shared reflected in this report. During the meetings, the Tribes provided data and analysis regarding the District's assertion that upmigration flows attract hatchery Chinook. Tulalip now shares the information with the ARC regarding the Skykomish summer Chinook population, the summer and fall signatures of Chinook returning to the Sultan River, issues with data quality in the District's analysis and a need for genetic analysis of the fall-signature Chinook returning to the Sultan River Chinook.

The Tribes also point to need for adaptive management of late summer and early fall flows, shifting the focus to maximizing temperature benefits to preserve the health and lives of returning adult Chinook in the Sultan as well as the Skykomish River. We have found the District very amenable to discussing temperature (cold water refugia) benefits the Sultan can provide to the Skykomish River in our discussion (see Appendix), and look forward to expanding that conversation to the ARC. It is our hope that as a group we can craft a flow regime for the late summer and fall to improve temperature and flow conditions for the Skykomish summer Chinook population by reallocating certain process flows that don't meet the goals to higher purposes.

Upstream Migration

In part, the original intent of upstream migration was to address a missing component of the fall hydrograph, a pulse to cue fish to migrate into the Sultan River. This upmigration flow was identified as missing in the RSP 23: IHA/RVA study that addressed Sultan River flows pre- and post- hydropower project. The post-project flows showed a lack of fall pulses in comparison to the pre-project flows. Fall pulse flow frequency, magnitude and duration were identified and were found to be correlated to fall precipitation events. Over the course of negotiations in the FERC relicensing project, the parties compromised on the current upmigration regime, goals and objectives.

Concurrently, the parties negotiated a new minimum instream flow, which increased from 200 cfs to 300 cfs. The effects of the new minimum instream flow were not considered in the context of upmigration. It may be the case that the new minimum instream flow creates conditions that allow for suitable flow and temperatures for upmigration, however this has not been assessed. The Tulalip Tribes define upmigration as including adult holding, this is very important in the context of adult survival and temperature – which weren't explicitly called out as goals in the upmigration flow.

Results (p. 7) Data presented and discussed in the results section include comparisons of numbers and proportions of Chinook redds and adipose fin-clipped fish in years before and after implementation of the upmigration flow releases that have numerous data limitations, flaws, omissions which result in conclusions that are not supported by the data (managed by Tribes and WDFW) (see also our comments under P.12 Straying).

Magnitude (P.8) License required flow magnitudes were not achieved on the whole. Low flows were half of goal, average was only 70% of target. If flow targets were not met, it is possible the unused portion of the water is available for future use?

TARGET	CFS	Achieved	CFS	
Min	1500	Min	802	53%
Max	2300	Max	2,060	90%
Average	1900	Average	1,336	70%

Upmigration Flow Dates (P.8): Upmigration flow dates were not achieved overall, often in the face of on the ground decisions: In 2016, construction prevented the release, delayed in 2012 *"…due to observed early spawning of Chinook in Reach 2, the magnitude of the release for this river segment was modified and reduced after conferring with the Aquatic Resource Committee (ARC)."* And again in 2013, when upmigration flow releases were delayed *due to low flows until precipitation was forecasted...* And then in 2021, the PFP was modified to allow upmigration releases to be delayed until the end of September *"… to better align with unregulated basin hydrology during this period of late summer low flow, and to limit the enticement of hatchery Chinook into the Sultan River*."

Tulalip can no longer support a late season upmigration flow, nor changes in the volume of flow released in the late summer and fall in the future, despite the fact the Process Flow Plan was modified in 2021 to allow for the change in timing. The Tribes encourage the ARC and the District to expand our thinking around upmigration flows to include adult holding. Survival of adult fish to spawning will depend on the Project providing thermal refugia in the late summer and early fall and far outweighs a need for upmigration flows. The Tribes have started conversations with the District on this matter (See Appendix, Temperature).

Run Timing - Chinook Spawning Surveys (P.9)
Issues with data
The years included in the analysis to assess potential changes in run timing PRIOR to Upmigration flow implementation in 2011 were: 1994, 1997, 1999, 2001, 2002, 2007, 2009, and 2010. The only years of data that are usable for assessing percentages of Hatchery Origin Spawners (HOS) versus percentage of Natural Origin Spawners (NOS) are 1997-2001, due to an otolith marking study that created a sounder data set (Rawson, Kramer and Volk 2001). (See Appendix; Upmigration – Run Timing for more detail). In short, the other years used in the report to assess hatchery versus natural origins for redd deposition or run timing should not be used due to poor quality.

Tulalip would appreciate more information on the results of redd surveys and sample collections pre and post 2011. The first year of implementation of the upmigration flow (2011) surveys were not done due to severe turbidity and perhaps subsequently, the lowest escapement (synthesized estimate of 50 Chinook) was recorded. It is also possible that prior to 2011, low carcass survey effort may have produced low sample collections. 2007 had low survey effort,

low sample collections (<20) that is used for assessments of run timing, redd deposition and hatchery / wild fractions before implementation.
2007 – 14 samples, 1 hatchery Chinook
2009 – 13 samples, 1 hatchery Chinook
2010 – 17 samples, 2 hatchery Chinook
2011 – 2 samples

Pre-implementation, small sample sizes plus a small number of hatchery Chinook provides an average of 10 fish sampled per year. Post-implementation, the average number of fish sampled per year was five times more than pre-implementation. Assuming redd surveys are commensurate with carcass sampling frequency, increasing survey effort by orders of magnitude after the upmigration releases would bias run timing variation before/after assessments. The timing of primary redd deposition in weeks 38-41 shown in Table 2 is what might be expected after the upmigration flows that occurred mainly in weeks 36-38, after which the redd counts increase, which is also normal spawn timing for Skykomish summer Chinook.

P. 10 Figure 2 and text claim a greater percentage of the Sultan River Chinook now spawns earlier when compared to the period prior to implementation of the program, but there is no evidence that a shift in run timing occurred as result of the program. Other considerations would be fish migrate earlier in response to environmental factors; higher minimum instream flow and unprecedented high temperatures that have had documented effects on fish run timing throughout the entire region.

The Tribes don't agree with the District's conclusion that a greater percentage of the run now spawns earlier in the Sultan River compared to the period prior to implementation. The use of data with low effort sampling and low numbers creates questions. The District did not consider strong background annual variation and stochasticity in fish abundance, adult return and upstream migration timing, strong seasonal variation in timing and intensity of precipitation and flow unrelated to events in the Sultan River.

The Tribes do not think that conclusions made based on Table 3 (live Chinook counts and redds) that argue that Chinook successfully migrate and spawn without the need for the upmigration flows are supported. While the report does not provide data for an upmigration flow in 2016, for the rest of the years, other than 2021, upmigration flow occurs in ~ 2nd week of Sept (average is 9/10). In 2012, the only other example given, flow release occurred on 9/14/2012, after which all of the redds were deposited.

Table 4. Shows almost 2/3rds of the live fish counted moving upstream in a 3-week period from week 35-37 (last week Aug to first 2 weeks Sept) right after the upmigration flows. Upstream migration should be expected to occur well before spawning, much less peak spawning, which voids the argument for "early" return timing in early- to mid-September. That time period is the normal peak spawn timing for the summer Chinook in the Skykomish basin. The timing presented in the report is actually later than average return timing for live adult summers, although we do see native, natural-origin summer Chinook returning as late as October in the South Fork Skykomish River. Given the variability in timing of summer Chinook returns, and

the District's assumption that the Sultan stock are fall Chinook, we later suggest a genetic analysis of fish returning to the Sultan River.

The Tribes point out that the District asserts the upmigration flows attract hatchery fish that return early, yet the early fish are in the system before the process flow release. At the same time saying the flows have little to no influence on upmigration of the later fish. This is a conundrum; the timing of fish returns may have more to do with the increased minimum instream flow or other environmental factors.

Straying (P. 12/13) Tulalip encourages the District and ARC to consider the Sultan River Chinook as part of the Skykomish population, rather than as an isolated entity. The patterns in abundance and hatchery fractions observed in the Sultan are exact mirrors of the patterns observed throughout the basin (Figure 1). The patterns in abundance and hatchery fractions have nothing to do with flow management in the Sultan River and everything to do with climate change that drives marine survival and freshwater productivity. This includes low summertime flows and peak temperatures that exacerbate the overwhelming effects of increasing flooding magnitude and scour that impacts egg to fry survival.

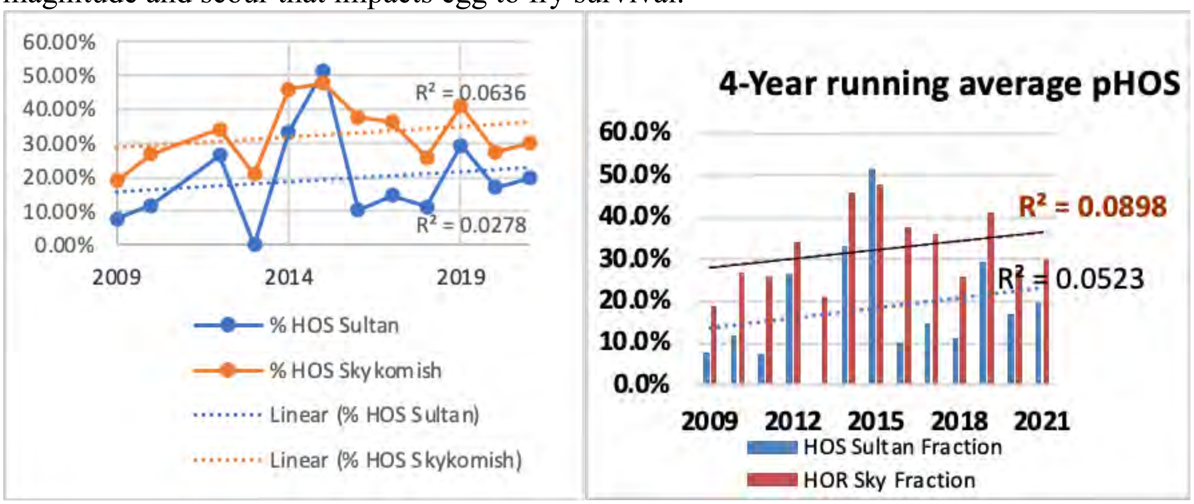

Figure 1. Over a period of moderately increasing hatchery fractions, pHOS (annual and 4-year average) is not Increasing at a higher rate in Sultan vs Skykomish Rivers. Over the past 12 years, instead pHOS peaked during the presence of warm water "the Blob' in the Skykomish River (2015 and 2019). HOS – Hatchery Origin Salmon

Tulalip agrees there is a signal of *moderately* increasing hatchery influence during this period, *but not due to flow management or hatchery releases and not increasing at a higher rate in the Sultan than in the Sky*, indicating fish are *not* being drawn into the Sultan, the increase is a *lower rate than in the Skykomish* (Figure 1). 2015 is an exception, due to the warm water in the Skykomish, the Sultan provided thermal refugia and contributed to the survival of adults in both rivers.

The Sultan and Skykomish summer Chinook are the same population. The District should take pride in the increased abundance and increased influence of the Sultan Chinook contribution to the overall population. The Sultan River average escapement before 2011 was 372 fish and rose to an average of 507 fish after the implementation of the new minimum instream flow and the upmigration releases. This is an increase of 136%. The proportion of the Sultan escapement to the Skykomish escapement averaged 11.7% before and 16% after implementation. What we see during this period is everything went up – increasing fractions of HOS in the Sultan are increasing abundance in the basin, Figure 2.

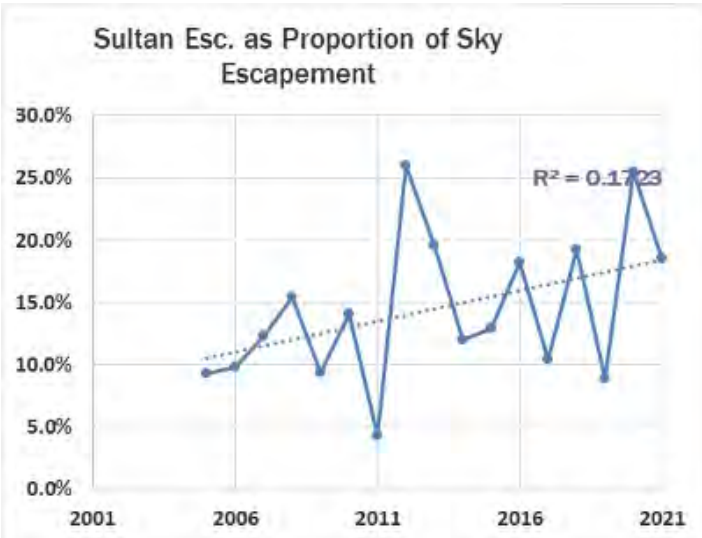

Figure 2. Sultan Escapement relative to Skykomish increases after implementation of MIF and Upmigration flows.

Page 13. There are three fatal flaws with this sentence: "During years 2012-2021, *eight* coded wire tagged Chinook have been recovered in the Sultan River: seven were from the Wallace Hatchery and one from Whitehorse Rearing Ponds on the North Fork Stillaguamish (Regional Mark Processing Center (rmpc.org). *This shift in run composition* has occurred *at a time of increased hatchery production*. While the Wallace Hatchery has been releasing over one million summer run Chinook annually since 2002, 65% more fish were released during the 2011 to 2021 period versus the 2001 to 2010 period (Table 6)."

Eight (8) tag recoveries over decade, less than one CWT recovered per year, cannot be used to demonstrate a *shift in run composition*, it is just poor data. Otoliths provide 30 times more recoveries than CWTs. Typically, in co-managers annual escapement estimates that break out H/W contribution rates, we resort to using surrogate fractions from adjacent basins to estimate H/W fractions when sample collections are small, i.e. less than 20 fish per year, as in 2007, 2009, 2010 and 2011 on the Sultan. The larger average number of carcasses sampled for H/W origin after the upmigration flows started is ~50. So, the comparison uses lopsided/skewed sampling effort for only partial years before vs after and very small sample collections that should not be used to estimate fractions. The suggestion the increase in hatchery fish is due to an increase in Wallace River Hatchery releases is incorrect. Referring to Table 6 in PFP report shows the number of Wallace River hatchery subyearling summer Chinook released, which agrees with Figure 3 below. The peak in 2012 is a group of escaped Yearlings, which would not contribute to returns until 2016/2017. Yet, the highest fraction of hatchery returns in the Sultan occurred in 2015, when temperatures were high throughout the basin (Figure 1).

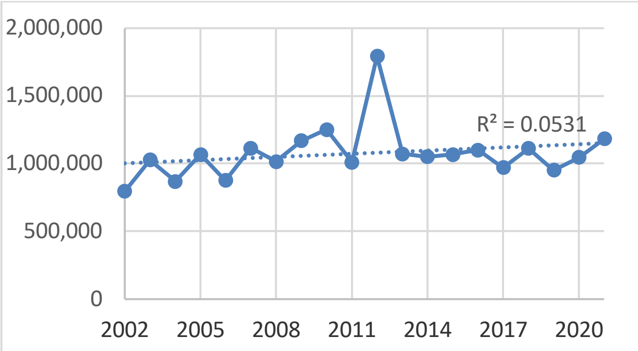

Figure 3: Wallace River subyearling Chinook releases have remained steady for the last 20 years. Data from Mike Crewson Equilibrium Brood Snohomish Data, Puget Sound Management Plan.

P 14. *"Wallace Hatchery Chinook are summer-run and, therefore, spawn earlier than Sultan natural origin Chinook which are fall run. This explains the temporal difference of marked and unmarked fish."* The Skykomish population are summers, and the TRT said Chinook in the Sultan are considered to be part of the Skykomish summer Chinook population, not a separate fall population.

Figure 4 and text: The conversations between the District and Tulalip about the ratio of Hatchery Origin Spawners versus Natural Origin Spawners throughout the Skykomish population are not reflected in these results. The ratio of hatchery to wild fish returns increases on the years of lowest abundance; this is due to wild fish declining at a higher rate than hatchery fish. This is a system wide phenomenon, not a Sultan specific issue. The increased hatchery fractions are not due to increased hatchery releases – see Figures 1 and 3 above. There was no increase in subyearlings ($R^2 = 0.05$). The cause of increased HOS in the basin is a multi-level environmental crisis including decreased summer and fall discharge, increased temperatures, delayed fall rains and flooding.

The Tulalip Tribes suggest a study of the Skykomish Chinook population substructure to review the genetics of summer Chinook, October returning summer Chinook at Sunset Falls and the summer and fall components of the Sultan River Chinook. The fall return can be due to a natal fall signature, or it could be a remnant of non-native Green River fall lineage. Tulalip suggests a group conversation with NWIFC geneticist Adrian Spidle to further explore this study.

The Tribes point out that *out of basin hatchery fish* return to the Skykomish and Snoqualmie Rivers. In 2017, 29% of returns were out of basin and 78% of out of basin returns were hatchery fish. This likely has an impact in the Sultan River and can be sorted out with genetic analysis.

Table 1. Percent hatchery origin spawners (pHOS), percent return out of basin origin, percent out of basin hatchery returns.

Ret year	total Sky pHOS	Out of basin	% oob of hatchery
2021	30%	6%	19%
2020	27%	11%	39%
2019	41%	20%	48%
2018	26%	5%	21%
2017	36%	8%	22%
2016	38%	29%	78%
			38%

P. 15. 2.1.5. Unforeseen Consequences
"*As such, the timing and duration of these flows have the potential to entice and induce the straying of hatchery fish into the Sultan River, while providing limited benefit to natural origin fish. Operationally induced enticement can lead to changes in run composition and timing…"* The District has not produced evidence to support any of the three assertions.

2.1.6. Adaptive Actions Undertaken
"The original salmon ceiling flow restriction of 550 cfs (mean daily discharge measured at the Powerhouse gage) was modified in August 2021 to allow for a maximum of 850 cfs for no more than 36 hours during the month of September. This adjustment was intended to allow for upmigration releases to be timed to be more in line with natural hydrologic patterns."- Tulalip can no longer support a September release. Temperature relief is needed throughout August and September to ensure the survival of adults to spawning.

2.1.7. Recommended Modifications
Even in low water years, the operational hydrology during fall in the Sultan River is conducive to stimulate upstream salmon migration without the need for an upmigration pulse flow- This was not demonstrated.
In conjunction with significant increases in hatchery Chinook production the annual upmigration pulse flow may exacerbate hatchery straying to the Sultan River- This was not demonstrated.

The timing and magnitude associated with upmigration flows on the Sultan River deviates from the normative hydrology in unregulated systems within the Snohomish Basin. AND*: "Overall, implementation of the upmigration process flow program has not produced the intended biological benefit.* - Yes, and we agree.

Suspend releases for upmigration for the next ten-year cycle and compare data to the first ten-year period to identify any differences in spawn timing patterns. – The Tribes strongly disagree, we support reconfiguring upmigration and other flows to support better temperatures to increase adult Chinook survival. Tulalip disagrees with *"re-establishing elements of a more normative hydrograph…"*

“Snohomish PUD does not believe upmigration process flows are necessary. They have unintended biological consequences such as attracting hatchery Chinook which over time, may lead to a shift in run composition and timing.” - This was not demonstrated; new minimum flow regime likely plays a large role in upmigration.

Incorporate mid-August spawning surveys into existing protocols to document potential shifts in run timing and/or stock composition relative basin hydrology and water quality (temperature). There is already published literature documenting the shift in seasonal timing of hydrology throughout the Pacific Northwest that is having a much larger effect on run timing and seasonal water quality and quantity than theoretical effects on fitness.

Adaptive management:
Tulalip suggests a discussion regarding how the Sultan River process and other flows can be managed to 1) increase adult Chinook survival and fitness for upstream migration and spawning and 2) manage temperatures in the Sultan and the Skykomish River during August and September to reduce stress and disease.

Since relicensing, Tribes and others have noted that extreme, greatly worsening environmental conditions tax summer Chinook during prolonged summertime holding. These issues are promulgated by intensifying effects of climate change and were, unfortunately, not thoroughly considered during relicensing. If preserving ESA listed Chinook is a priority, then *maximizing the thermal refugia benefits* that the Spada Lake reservoir provide for holding summer Chinook should clearly be the new top priority. Prioritizing salmon recovery by providing sustained releases of cool water over the last ~ two months (August and September) during the adult summer Chinook upmigration / holding period before spawning would preserve the health and fitness of the fish in the Sultan and Skykomish Rivers.

Summer low flows, high temperatures and lack of rearing also greatly affect yearling Chinook. Yearling Chinook are an important aspect of the summer Chinook life history, as yearlings have an average of 3.96 times the survival to adult return of subyearlings

The record low flows greatly truncate upstream migration and movement into tributaries and force spawning in thalwegs, where newly deposited summer Chinook eggs are most vulnerable to the near-certain flooding and redd scour that is increasing in frequency and intensity from changes in precipitation and temperature. The Tribes point out in the channel maintenance and forming flow sections that the majority of scour appears to be in the thalweg of representative cross sections.

Flow shaping and temperature benefits: Gradual ramping of flow above the MIF to provide thermal refugia up to a sustained beneficial level, or a series of smaller gradually ramped beneficial flows should be explored. Late summer low flows and high temperatures combine to reduce fitness of fish through disease outbreaks, interruption of oogenesis and egg ripening and pre-spawn mortality. Thermal refugia have well-documented physiological benefits that would greatly aid any poikilothermic salmon under the extremely stressful environmental conditions that Skykomish Chinook are enduring for several months of holding before they spawn, which are particularly stressful for the most valuable females that drive productivity and abundance.[1]

References Cited:

Rawson, K, C. Kramer, and E. Volk. 2001. Estimating the Abundance and Distribution of Locally Hatchery-Produced Chinook Salmon Throughout a Large River System Using Thermal Mass-Marking of Otoliths. NPAFC Technical Report No. 3. Pp. 31-34.

---

[1] Snohomish basin water temps exceed Washington State standards for Chinook at all life stages, particularly adults during summer. These increased metabolic energy demands are "built in" to additional energy demands needed for swimming during upstream migration and holding, final gamete maturation, increased immune resistance warding off increased disease incidence and intensity that differentially affects the most precious females right before spawning. Females expend greater amounts of energy for oogenesis and are known to be more vulnerable to mortality from stressors than more abundant and hardy male salmon- namely, increased susceptibility of females to increased pathogenicity of opportunistic infectious pathogen replication under the warm holding conditions (namely *Flexibacter columnaris*, a top pathogen of increasing concern throughout the state observed to cause severe mortality in spring and summer Chinook. This includes >90% in-river mortality last year in Nooksack spring Chinook and up to 50% in-hatchery mortality in Skykomish summer Chinook in several recent years due to columnaris (also observed in other natural spawning populations in the Skykomish basin), and has been increasingly observed to cause substantial mortality in adult salmon elsewhere, especially gravid females nearing maturity.- Increased virulence with increasing water temperature is widely documented in the fish health literature for MANY infectious fish pathogens, affecting MANY fish species, especially all of the salmonids. Reduced flows decrease waterborne dilution and effective rearing volume, e.g. resulting in higher fish densities in smaller holding areas, pools, resulting in reduced dilution and more direct contact, closer proximity for waterborne transmission of more stressed and injured fish, potentially shedding more pathogens when sick or immunocompromised, that then enter the smaller volumes and flows to potentially end up at higher waterborne concentrations that are more infective, that all increase horizontal (fish-to-fish) pathogen transmission. Survivors that successfully fight of the elevated temps, stress and disease conditions and make it through the entire summer must summon more energy for final maturation, metamorphosis, upstream migration, redd formation, final spawning and redd defense that tax metabolic demands beyond their limits, particularly considering their depleted immunological response toward the end of the fasted state just before spawning and the high water temps.

Outmigration

- Do outmigration flows increase turbidity – that may enhance survival.
- 2.2.3 – are there floodplain features (e.g. oxbows) that need these flushing flows to trigger outmigration?
- Figures 5 and 6 are not particularly useful, not sure why they are using linear regression on a data set that appears to need normalization and appears to be nonlinear.
- Figures 7 – 13, the graphs do not depict helpful information. The migration timing appears to be mainly genetic, with periodic responses to flows.
- Figure 15 appears suspect. Catch per hour values are extremely high and happened during the same time as the peak in coho outmigration. Could some of these fish be coho yearlings?
- Page 34, April is a little late to see so many unbuttoned pink, but not unusual, and you cannot attribute mortalities and unbuttoned individuals to scour events. Mortalities in the trap are likely with debris, mentioned in table 11.
- Figures 20 -26, most of these figures are not particularly informative, because additional pulse flows did not occur during migration period. There is no explanation as to why the District included the PFs in the graphs, were these flows from precipitation or project operations? and there doesn't seem to be a magnitude attached to the PFs.
- 2.2.5 Unforeseen Consequences. Impacts to steelhead from outmigration flows. They suggest that might be a problem based on the comments from one person, this is not robust information and needs to be investigated.

Adaptive Management

Tulalip agrees the outmigration flows may not be necessary, however we do not agree to suspend the flows for 10 years. The Tribes recommend reallocating flows to a time when fish are in need of additional support and would like to use the water in the summer/fall to provide thermal refugia.

Flushing Flows The interest in flushing flows was generated by the obvious algal mats and assorted scum on the gravels in Reach 3. It is not clear the flushing flows are necessary, since Reach 3 experiences a wider range of flows in the summer. Tulalip suggests banking the water for other uses, rather than suspending the flows for 10 years.

- Under the hydrologic events that occurred under the study period, I would agree that they were probably sufficient to address the concern in this section.
- Table 14, how were outmigration estimates calculated, they seem awfully high some years?

Channel Maintenance and Forming Flows

Background

The alteration of the hydrograph by the Jackson Hydropower Project was analyzed during the relicensing procedure. An IHA-RVA study compared the pre- and post-project hydrograph to determine what portions of the hydrograph had been altered. The resource agencies and recreational group had keen interest in attempting to restore aspects of the hydrograph that would restore variability and perform functions to support the ecosystem.

Post 2011, project operations included the prescribed process flows, however these weren't the only changes to the hydrograph. The District may want describe to the ARC how and when project operations have changed; greater energy production in summer, reservoir management and other actions that have produced increases in the hydrograph, the seasonality of the changes and how those changes could affect fish or the river.

The 2007 IHA-RVA (see R2- RSP 23 IHA-RVA) analysis revealed the frequency of high flow pulses decreased in Reach 1, while the duration of the remaining pulses has increased. It is assumed ramping and other project operations greatly affect the duration. The frequency and duration of high flow pulses decreased in Reaches 2 and 3 because of Project Operations (see R2 RSP 23 IHA-RVA report). The magnitude of high flow pulse has decreased in Reach 1, but the duration has increased. (Table A-3) Magnitude and duration of high flow pulses have both decreased in Reach 2 (see R2-RSP 23 IHA-RVA).

Table A-3. **Percentile distribution of magnitude and duration of annual extreme water conditions in Sultan River at the upstream end of Reach 1 under pre- and post-Project conditions.**

	Pre-Project Conditions					Post-Project Conditions				
Parameter	10%	25%	50%	75%	90%	10%	25%	50%	75%	90%
1-day minimum	4.8	6.5	7.6	8.7	11.0	166.3	177.5	189.5	195.5	238.6
3-day minimum	4.9	6.5	7.8	9.0	11.4	167.6	182.0	190.2	197.0	246.5
7-day minimum	5.0	7.1	8.2	9.4	12.3	169.3	187.7	195.2	203.4	252.7
30-day minimum	6.3	8.2	9.9	14.7	23.7	172.0	193.4	206.0	240.3	307.9
90-day minimum	20.2	50.0	83.9	132.5	228.3	204.5	222.5	270.4	373.5	470.7
1-day maximum	4,544	5,895	10,320	12,390	16,610	1,731	2,025	2,385	4,580	11,680
3-day maximum	2,454	4,163	6,790	8,691	9,893	1,596	1,806	1,985	3,270	7,665
7-day maximum	2,181	2,838	4,231	5,041	5,988	1,535	1,646	1,850	2,508	4,910
30-day maximum	1,276	1,628	2,033	2,413	3,426	1,028	1,422	1,630	1,831	2,879
90-day maximum	941	1,239	1,402	1,581	2,081	857	1,098	1,293	1,471	2,012
Number of zero-flow days	0	0	0	0	0	0	0	0	0	0
Base flow index	0.007	0.009	0.010	0.013	0.021	0.193	0.226	0.271	0.329	0.430

Appendix A: R2_IHA RVA_RSP 23 – the project decreased the magnitude of all maximum flows in Reach 1. Negotiations for process flows focused on the altered hydrograph and attempted to restore variability to the Sultan River annual hydrograph.

The pre-project 50% exceedance 1-day max and 3 day max floods were 10,320 and 6,790 cfs respectively. These flows were assumed to approximate the range of bankfull flows which form habitat, maintain and transform the riparian zone, recruit LWD, sort gravels and maintain connection with side channels. The frequency and duration of high flow pulses influence bedload transport, channel sediment textures, and duration of substrate disturbances. The reduced magnitude and frequency of low and high flow pulses post-Project affect the channel form, gravel/cobble size and distribution and formation and maintenance of pool features. Channel maintenance flows were negotiated and settled by the committee at 4,100 cfs for 24 hours; there are limitations to the amount of water the Project can deliver. It is clear the channel maintenance flows selected in the relicensing process are much lower than what occurred in the Sultan before the project. It is likely the flows are not approaching the threshold to do in channel work, especially in the absence of roughness features.

Originally it was envisioned that the channel maintenance flows would interact with 5 engineered LWD jams placed in the main stem of Reach 1. One goal was to increase pool habitat; there was and still is one mainstem pool in the lower reach. Bar apex jams were intended to capture LWD moving during channel maintenance flows and building in size. Bank jams were intended to = create pools for salmon. Later during implementation the LWD jams were moved to maintain the upstream openings of side channels due to restrictions placed on water elevation rise by FEMA. The placement of the jams unfortunately reduced the effectiveness of the channel maintenance flows due to the lack of roughness in the mainstem.

Channel Maintenance – most of the Tribes' comments are imbedded in the PFP document.

- Please add water surface elevations to the cross-sections.
- Figure 37, what is depicted on the graph needs to be clarified.
- 3.2.4, based on the results of the accelerometer, sediment transport in that cross section is initiated at 1,200 cfs; at best, this estimate is a starting point for cross section and not likely applicable elsewhere. If the intent here is to say this flow level is analogous to a flow level that causes bed scour, the Tribes do not fully agree. A better understanding of depth of scour and what flow levels reach depths to impact redds is needed. Additional data is needed to make that case. It also may not be the case for Reach 1.
- Table 16. There is no description of how Total Out-Migration was calculated in the narrative. The 2021 outmigration number in the table is greater than what Tulalip calculated for the entire Skykomish in 2021.
- Based on the survey information, the channel maintenance flows that were studied appeared to have very little effect on channel form or features leading the Tribes to wonder if the targeted flow event is high enough.
- Based on past in-stream actions, more enhancements/restoration (i.e. creation of holding areas) should still be an objective in Reach 1.

Pages 51 - 61 The PFP provides several graphics of channel cross sections and Wolman pebble counts. There are changes in sediment dynamics occurring at higher flows, as evidenced by the changes in cross sectional area and the changes in percentage of clast sizes in the Wolman Pebble Counts. The lower river is not as dynamic as hoped, however the large channel width in Reach 1, lack of roughness features and undisturbed forested islands create resistance to bedload transport. There are portions of the river where sediment dynamics responding to flows, particularly in the thalweg of the channel. The Tribes have expressed concerns about low summer flows causing Chinook to spawn in the thalweg, which increases vulnerability to redd scour. The Tribes note that pool habitat in Reach 3 has decreased from 40-28% from 2007 to 2020 (Stillwater 2022, Sultan Riverine Habitat Monitoring Report).

Figure 37. The data presented in the graph are not easily interpreted, nor is one sample sufficient to determine the substrate movement. It is agreed that having massive bedload transport events is not particularly desirable when there is a goal of protecting salmonid eggs from scour, however the changes wrought in the cross sections do not appear that the sediment transport on the Sultan is particularly intense. More clarity about incipient motion of particle sizes at cross sections is warranted.

Adaptive Management The Tribes recommend continuing the channel maintenance flows. Tulalip is unconvinced these flows are having detrimental impacts on salmon resources. The need for a wider variety of spawning options outside of the thalweg should be addressed by the ARC.

Five more log jams are to be placed in the Sultan River and it is the Tribes' recommendation to have them designed and placed in the lower mainstem to increase LWD, pools and the effectiveness of channel maintenance flows. Tulalip would also like to see other projects in the Sultan meant to increase habitat diversity and sediment sorting.

Channel Forming Flows

The Tulalip Tribes find that channel forming flows remain a necessary event in the Sultan River and believe that every effort should be made to meet the flow magnitude and duration for these events in the remainder of the license.

Thank you for the opportunity to comment. If you have questions you can contact Anne Savery asavery@tulaliptribes-nsn.gov, Mike Crewson mcrewson@tulaliptribes-nsn.gov or Kurt Nelson knelson@tulaliptribes-nsn.gov .

Sincerely

Anne Savery

CC: ARC committee – electronic transmittal

Daryl Williams, Tulalip Tribes

Appendix to Tulalip Letter

Temperature

Discussions between the District and Tulalip Tribes regarding temperature in Sultan and Skykomish River

From: Kurt Nelson
Sent: Monday, August 22, 2022 2:26 PM
To: Mike Crewson; 'Binkley, Keith'
Cc: Daryl Williams; Anne Savery
Subject: RE: FLIR Flight in 2021?

I told them to install at the railroad crossing. I think that is what you suggested.

Kurt

From: Mike Crewson <mcrewson@tulaliptribes-nsn.gov>
Sent: Monday, August 22, 2022 1:55 PM
To: Kurt Nelson <knelson@tulaliptribes-nsn.gov>; 'Binkley, Keith' <KMBinkley@SNOPUD.com>
Cc: Daryl Williams <darylwilliams@tulaliptribes-nsn.gov>; Anne Savery <asavery@tulaliptribes-nsn.gov>
Subject: Re: FLIR Flight in 2021?

Kurt do you know where in the Wallace they are putting that?

Sent from my Verizon, Samsung Galaxy smartphone
Get Outlook for Android

From: Kurt Nelson <knelson@tulaliptribes-nsn.gov>
Sent: Monday, August 22, 2022 1:34:23 PM
To: 'Binkley, Keith' <KMBinkley@SNOPUD.com>
Cc: Mike Crewson <mcrewson@tulaliptribes-nsn.gov>; Daryl Williams <darylwilliams@tulaliptribes-nsn.gov>; Anne Savery <asavery@tulaliptribes-nsn.gov>
Subject: RE: FLIR Flight in 2021?

Hi Keith,

Unfortunately, they have not deployed them yet. I think we will have them in next week. I know it is largely too late but I was still hoping to still capture the transition to cooler temperatures that align with spawning. I think something Mike was looking for. One will be placed about a half mile below the Sultan junction in the Skykomish; one in the Wallace; one just above the Wallace junction in the Skykomish; another at the Gold Bar revetment; and the last one just downstream of the WDFW Boat Launch at Big Eddy.

Kurt

-----Original Message-----
From: Binkley, Keith <KMBinkley@SNOPUD.com>
Sent: Monday, August 22, 2022 1:13 PM
To: Kurt Nelson <knelson@tulaliptribes-nsn.gov>
Cc: Mike Crewson <mcrewson@tulaliptribes-nsn.gov>; Daryl Williams <darylwilliams@tulaliptribes-nsn.gov>; Anne Savery <asavery@tulaliptribes-nsn.gov>
Subject: RE: FLIR Flight in 2021?

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____

Hey Kurt - curious did you get your array of temperature loggers installed? It will be interesting to closely track temperature trends now that we have dropped below median flow values at the Gold Bar gage.

Keith

https://waterdata.usgs.gov/nwis/uv?cb_00010=on&cb_00060=on&cb_00065=on&format=gif_default&site_no=12134500&period=22&begin_date=2022-08-15&end_date=2022-08-22

-----Original Message-----
From: Binkley, Keith <KMBinkley@SNOPUD.com>
Sent: Wednesday, June 01, 2022 6:03 PM
To: Kurt Nelson <knelson@tulaliptribes-nsn.gov>
Cc: Mike Crewson <mcrewson@tulaliptribes-nsn.gov>; Daryl Williams <darylwilliams@tulaliptribes-nsn.gov>; Anne Savery <asavery@tulaliptribes-nsn.gov>; Eleazer, Edward J (DFW) <Edward.Eleazer@dfw.wa.gov>; Verhey, Peter A (DFW) <Peter.Verhey@dfw.wa.gov>; Brock Applegate <brock.applegate@dfw.wa.gov>
Subject: Re: FLIR Flight in 2021?

That is good to hear. Yes, we have probes at RM 13.2 and 14.1 on the Skykomish which are downstream and upstream of the Sultan, respectively. We also have one at RM 0.2 on the Sultan.

Sent from my iPhone

> On Jun 1, 2022, at 4:59 PM, Kurt Nelson <knelson@tulaliptribes-nsn.gov> wrote:
>
> Keith,
>
> We have been discussing installing an array of temperature loggers in the Skykomish from just upstream of Gold Bar to some distance below the Sultan (not sure yet). Snohomish County seemed to think that PUD was monitoring water temperatures around the mouth of the Sultan.
>

> Kurt
>
> -----Original Message-----
> From: Binkley, Keith <KMBinkley@SNOPUD.com>
> Sent: Wednesday, June 1, 2022 4:34 PM
> To: Mike Crewson <mcrewson@tulaliptribes-nsn.gov>; Kurt Nelson <knelson@tulaliptribes-nsn.gov>; Daryl Williams <darylwilliams@tulaliptribes-nsn.gov>; Anne Savery <asavery@tulaliptribes-nsn.gov>
> Cc: Eleazer, Edward J (DFW) <Edward.Eleazer@dfw.wa.gov>; Verhey, Peter A (DFW) <Peter.Verhey@dfw.wa.gov>; Brock Applegate <brock.applegate@dfw.wa.gov>
> Subject: RE: FLIR Flight in 2021?
>
> WARNING: This email originated outside of our organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.
> ___________________________________
>
> Thanks for thinking outside the box on this - advancing climate change kind of demands this. The way I am thinking this Cold Water Refuge designation on the lower Skykomish could work is by having it kick in under extreme hydrologic and/or temperature conditions. As I looked at potential real-time metrics from the Skykomish at Gold Bar gage, I discovered that temperature isn't monitored there. I got a quote from the USGS to add this and I believe the PUD can commit to cover this for a couple years, at least. Once we full capability in place, we could start tracking when things are heading south. We would obviously need to figure out an appropriate geographic extent. I am cc'ing Brock, Pete, and Ed on this to solicit WDFW's thoughts on this as I don't want to put the cart out in front of the horse.
>
> Keith
>
> -----Original Message-----
> From: Binkley, Keith
> Sent: Friday, May 20, 2022 10:24 AM
> To: Mike Crewson <mcrewson@tulaliptribes-nsn.gov>; Kurt Nelson <knelson@tulaliptribes-nsn.gov>; Daryl Williams <darylwilliams@tulaliptribes-nsn.gov>; Anne Savery <asavery@tulaliptribes-nsn.gov>
> Subject: RE: FLIR Flight in 2021?
>
> Here ya go
>
> Thanks for sending them Kurt
>
> -----Original Message-----
> From: Mike Crewson <mcrewson@tulaliptribes-nsn.gov>
> Sent: Thursday, May 19, 2022 11:54 AM
> To: Binkley, Keith <KMBinkley@SNOPUD.com>; Kurt Nelson <knelson@tulaliptribes-nsn.gov>; Daryl Williams <darylwilliams@tulaliptribes-nsn.gov>; Anne Savery <asavery@tulaliptribes-nsn.gov>
> Subject: Re: FLIR Flight in 2021?
>
> I would agree with that and I sure would like to see those images
>
> Sent from my Verizon, Samsung Galaxy smartphone Get Outlook for
> ___________________________________

> From: Binkley, Keith <KMBinkley@SNOPUD.com>
> Sent: Thursday, May 19, 2022 9:53:23 AM
> To: Kurt Nelson <knelson@tulaliptribes-nsn.gov>; Daryl Williams <darylwilliams@tulaliptribes-nsn.gov>; Anne Savery (asavery@tulaliptribes-nsn.gov) <asavery@tulaliptribes-nsn.gov>; mcrewson@tulaliptribes-nsn.gov <mcrewson@tulaliptribes-nsn.gov>
> Subject: RE: FLIR Flight in 2021?
>
> WARNING: This email originated outside of our organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.
> ________________________________
>
> And ultimately wondering if designating the area around the confluence as a "Cold Water Refuge" would make sense and if there would be an appetite for that.
>
>
>
> As always, I appreciate your perspectives.
>
>
>
> Keith
>
>
>
> From: Binkley, Keith
> Sent: Thursday, May 19, 2022 8:39 AM
> To: 'Kurt Nelson' <knelson@tulaliptribes-nsn.gov>
> Subject: RE: FLIR Flight in 2021?
>
>
>
> Thanks - I am just trying to get the best sense of the Sultan's influence on the Skykomish and the graphics from those efforts are very enlightening and informative.
>
>
>
> Keith
>
>
>
> From: Kurt Nelson <knelson@tulaliptribes-nsn.gov<mailto:knelson@tulaliptribes-nsn.gov>>
> Sent: Thursday, May 19, 2022 8:36 AM
> To: Binkley, Keith <KMBinkley@SNOPUD.com<mailto:KMBinkley@SNOPUD.com>>
> Subject: RE: FLIR Flight in 2021?
>
>
>
> CAUTION: THIS EMAIL IS FROM AN EXTERNAL SENDER.

> Do not click on links or open attachments if the sender is unknown or the email is suspect.
>
> ________________________________
>
> Keith,
>
>
>
> We did a thermal infrared Imagery flight in 2021 and 2020.
>
>
>
> Kurt
>
>
>
> From: Binkley, Keith <KMBinkley@SNOPUD.com<mailto:KMBinkley@SNOPUD.com>>
> Sent: Wednesday, May 18, 2022 3:47 PM
> To: Kurt Nelson <knelson@tulaliptribes-nsn.gov<mailto:knelson@tulaliptribes-nsn.gov>>
> Subject: FLIR Flight in 2021?
>
>
>
> WARNING: This email originated outside of our organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.
>
> ________________________________
>
> Hey Kurt - did you guys do a FLIR flight of the Skykomish in 2021?
>
>
>
> Keith

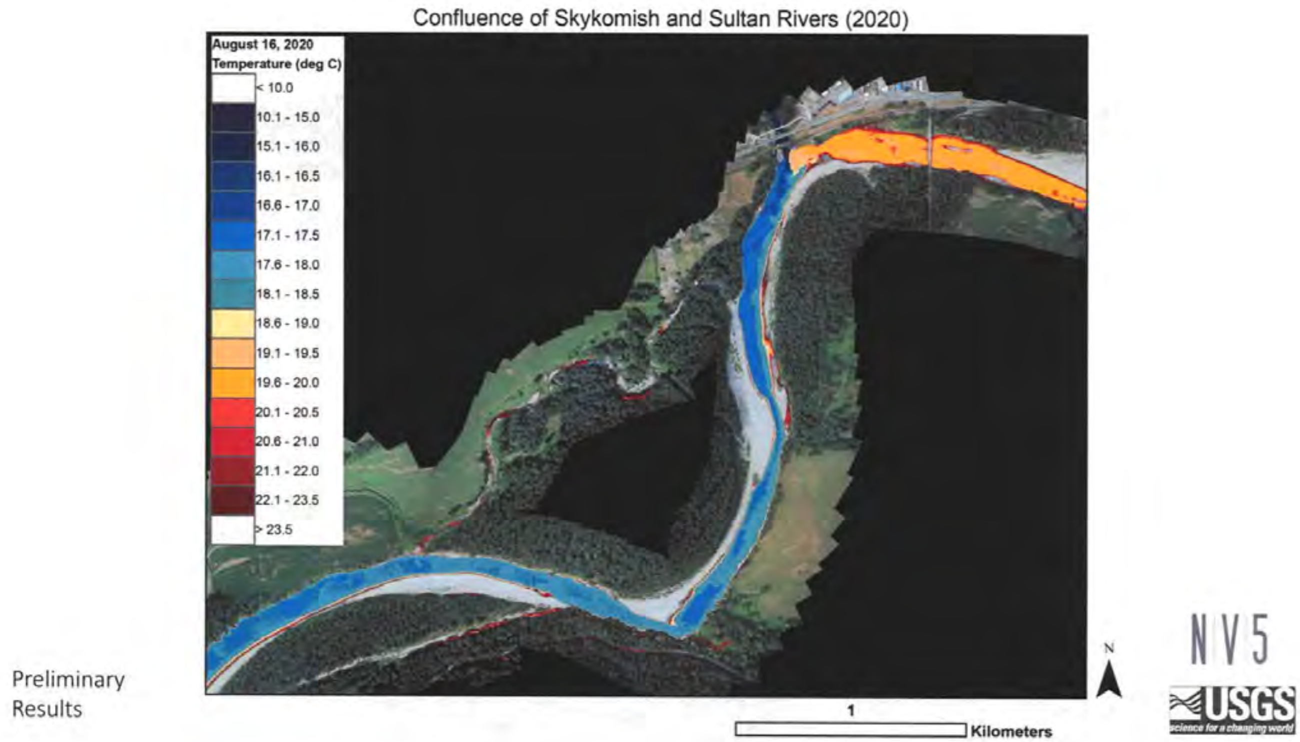


Figure 1. FLIR data showing cooling influence of Sultan River on Skykomish River, August 16, 2020. Sultan below Powerhouse: Temp 10.6C, discharge 339 cfs. Skykomish discharge 1,150 cfs.

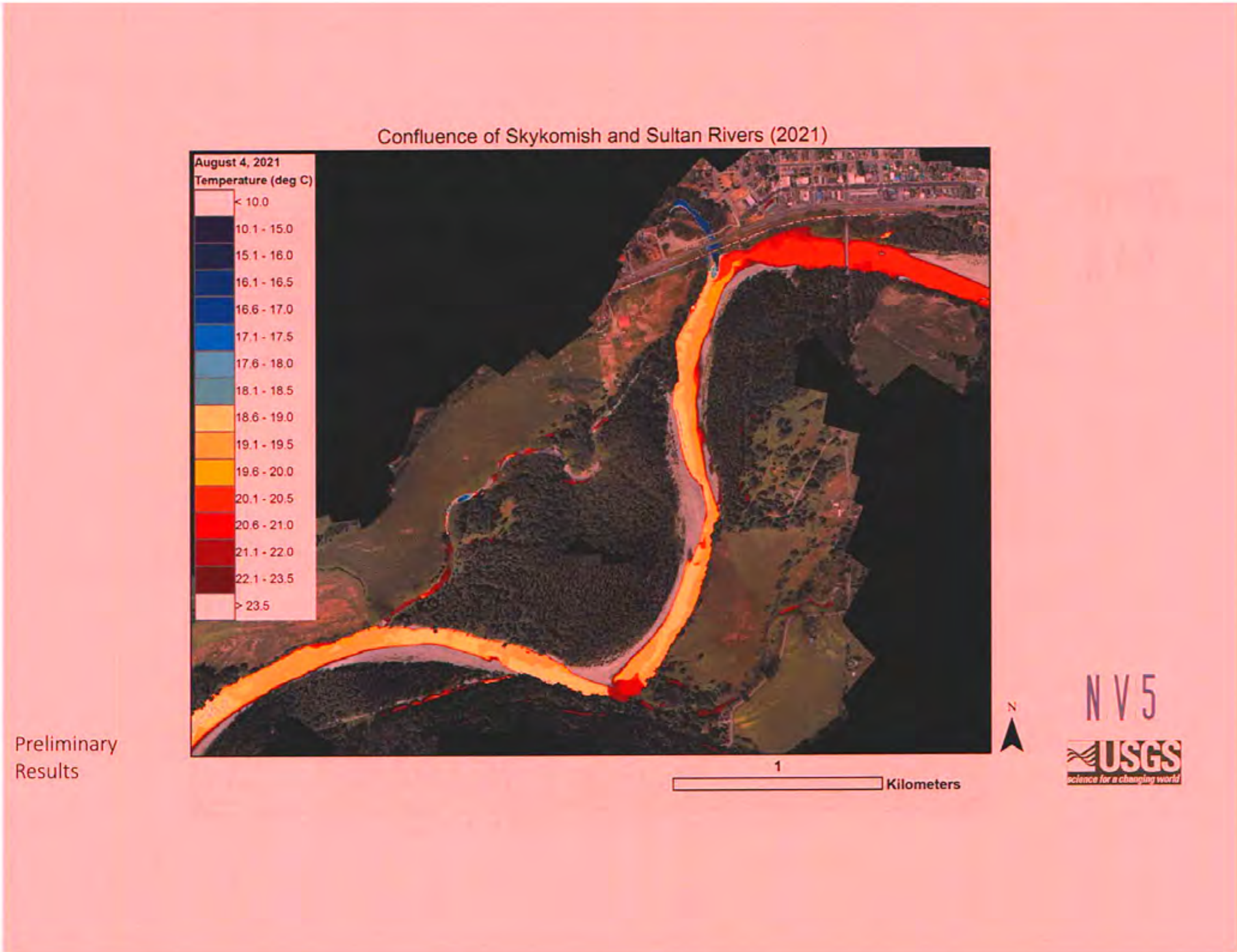


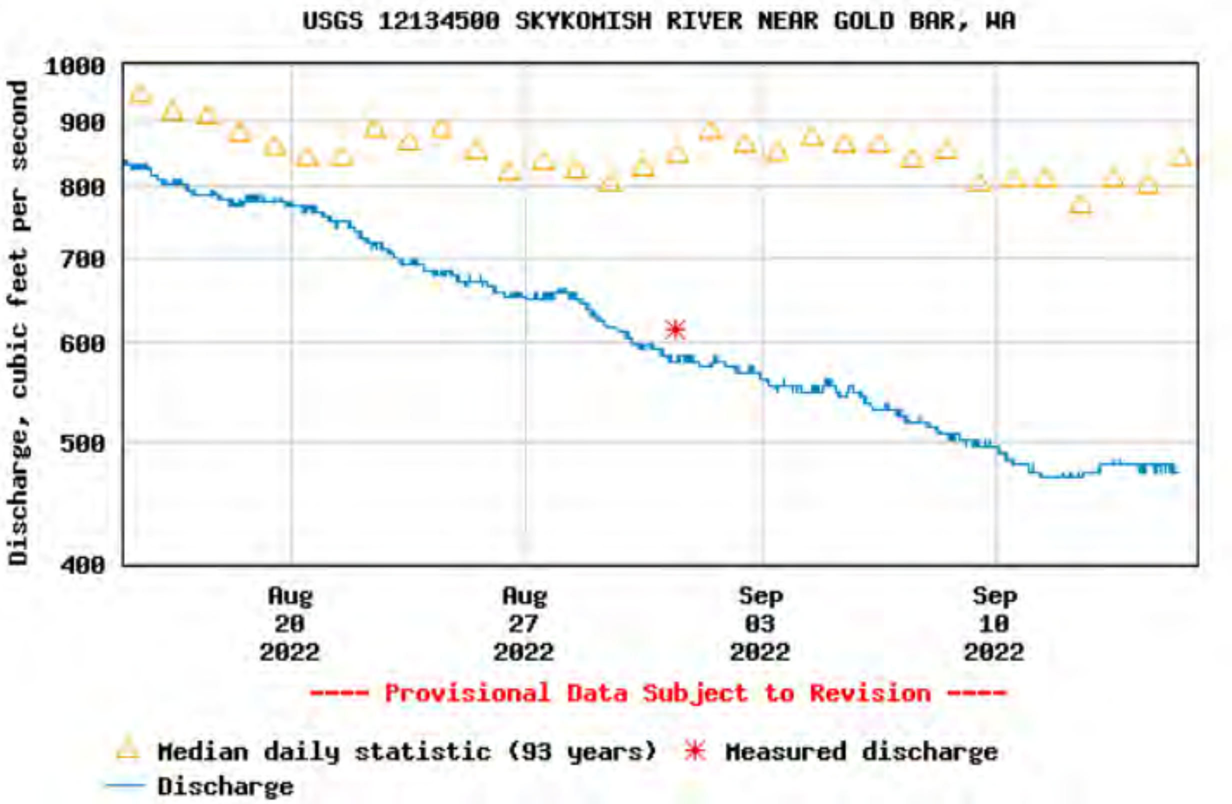
Figure 2. FLIR data showing cooling influence of Sultan River on Skykomish River, August 4, 2021. Sultan River below Powerhouse Temperature 14.7C, discharge 370 cfs. Skykomish River discharge 694 cfs. Relatively warm temperatures on the Sultan reduces impact on Skykomish River temperature despite similarity of relative discharges.

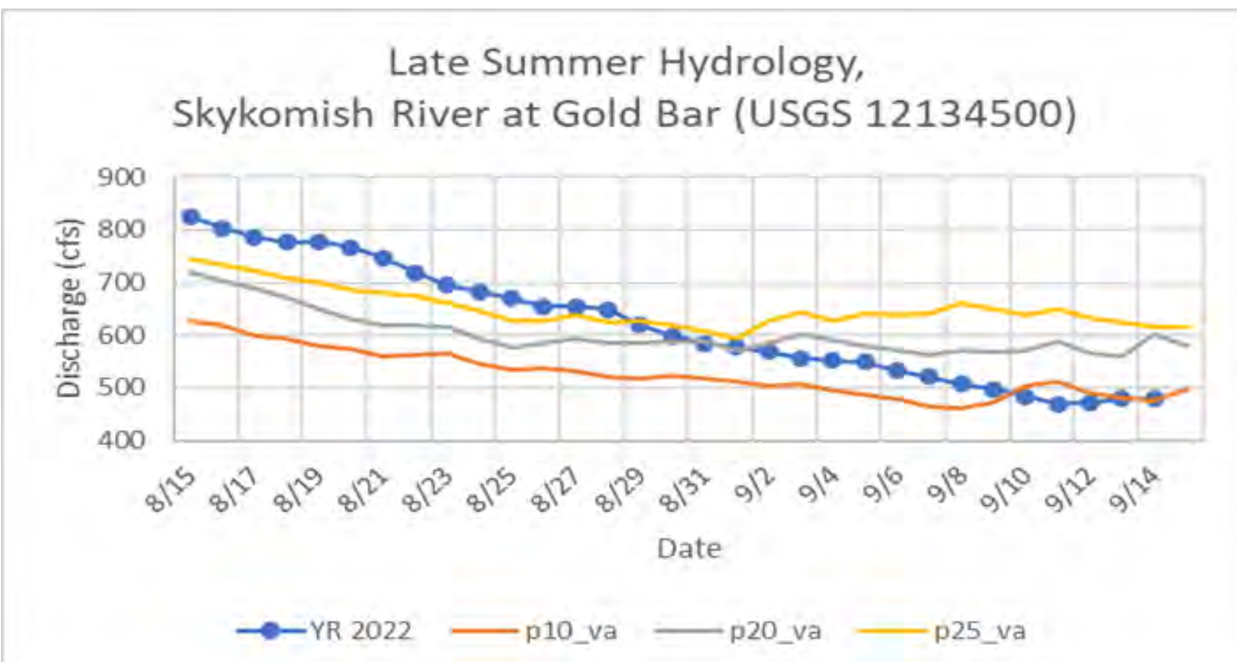
From: Binkley, Keith <KMBinkley@SNOPUD.com>
Sent: Thursday, September 15, 2022 11:13 AM
To: Anne Savery <asavery@tulaliptribes-nsn.gov>; Mike Crewson <mcrewson@tulaliptribes-nsn.gov>; Kurt Nelson <knelson@tulaliptribes-nsn.gov>
Cc: McDonnell, Andrew <AWMcdonnell@SNOPUD.com>
Subject: Climate Change - Late Summer Hydrology and Temperature

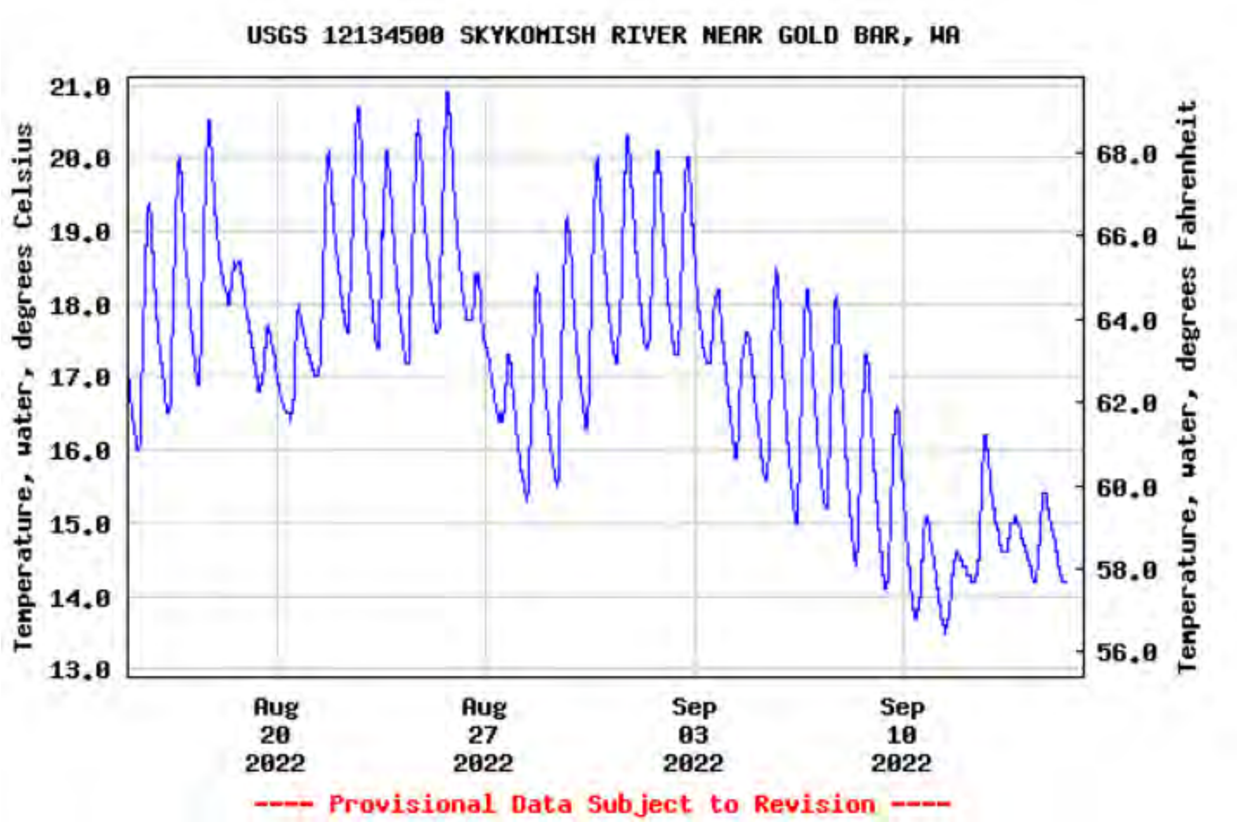
---

Anne / Kurt / Mike – this is a follow-up to a conversation we began earlier this year around temperatures in the Skykomish and Sultan during late summer. As you can see, flows in the Sky have been well below the median values since mid-August and below the 20 percentile since early September. As one would expect, this coincides with multiple days where water temperatures exceed 19 degrees C, especially during the latter half of August. As climate change advances and in the interest of doing what we can to prevent pre-spawning mortalities in the reach of the lower Skykomish downstream of the Sultan, we should begin discussing some concepts for adjusting our operations. As Anne can attest, changes are not always easy to make in the FERC realm but if we frame them as adaptive management and all the stakeholders see the value, it is doable. I am reaching out now as we just came through and are on the other side of the most thermally stressful period and we have a fair amount of time to develop some operational tools and craft a plan for implementation. Let's plan to discuss.

Keith


USGS 12134500 SKYKOMISH RIVER NEAR GOLD BAR, WA
Discharge, cubic feet per second
1000
900
800
700
600
500
400
Aug 20 2022
Aug 27 2022
Sep 03 2022
Sep 10 2022
---- Provisional Data Subject to Revision ----
Median daily statistic (93 years)
Measured discharge
Discharge


Late Summer Hydrology,
Skykomish River at Gold Bar (USGS 12134500)
Discharge (cfs)
900
800
700
600
500
400
8/15
8/17
8/19
8/21
8/23
8/25
8/27
8/29
8/31
9/2
9/4
9/6
9/8
9/10
9/12
9/14
Date
YR 2022
p10_va
p20_va
p25_va



Anne Savery
Mon 9/19, 4:54 PM
I'm all for a discussion of this. Thanks Keith Anne Anne Savery Hydrologist 503-984-0667

Mike Crewson
Thu 9/15, 4:09 PM
Sounds great KeithSounds great Keith

Sent from my Verizon, Samsung Galaxy smartphone

USGS gage Skykomish at Gold Bar – temp and discharge
https://waterdata.usgs.gov/nwis/uv?site_no=12134500

UPMIGRATION

RUN TIMING (Page 9). Report says the years included in the analysis to assess potential changes in run timing PRIOR to Upmigration flow implementation in 2011 were: 1994, 1997, 1999, 2001, 2002, 2007, 2009, and 2010.

Issues with Data: It is not possible to ID the numbers or timing of hatchery / wild fish from 1994 due to the lack of 100% marking and tagging of hatchery releases and hatchery/natural carcass sampling of the escapements, nor in 2002 when it was not possible to determine the fractions of Hatchery origin spawner (HOS) versus Natural orgin spawners (NOS) fractions due to the large unmarked and untagged Wallace release in 2000 (broodyear 1999) affecting return years 2002-2004. The only early years possible to do this are 1997-2001 due to an otolith marking study (Rawson, Kraemer and Volk 2001). Hatchery subyearling Chinook releases that occurred annually through broodyear 1999 (release year 2000). Tulalip fish were largely unclipped during this period as well. Those years should not be used if redd deposition or run timing is looked at by hatchery/natural origins, which it is in this report.

Genetics

Sky summers and falls have coexisted for centuries and re: the very low level of genetic structure within the PS Chinook ESU and similarity between all of the Skykomish Chinook populations, this perceived risk is unfounded. While several studies have shown lower relative reproductive success in naturally-spawning, hatchery-origin steelhead relative to that of natural-origin steelhead, there are no studies that have demonstrated reduced productivity or reproductive success attributable to hatchery genetic effects (reduced fitness) in salmon. For Chinook salmon, differences in RRS or relative productivity attributable to origin (hatchery or natural) either did not continue to the second generation (Ford et al. 2012), were confounded by size (Sard et al. 2015), were not significantly different (Anderson et al. 2013), or in the 2017 Snohomish study (Crewson et al. 2017), were confounded by size, sex, and location. In the Snohomish study, genetic-based parentage analysis revealed that spawning location ($P<0.00001$), fork length ($P < 0.00001$), and origin ($P = 0.008$) were highly significant predictors of reproductive success and sex ($P = 0.042$) was a significant factor, whereas brood year was not ($P = 0.622$). A study of genetic diversity among the Puget Sound ESU Chinook salmon (Ruckelshaus et al 2006) indicates a very low level of genetic structure between Green River and Snohomish fall Chinook ($F_{st} <0.005$), which implies a high rate of gene flow between the two populations. If Green River HORs, which are genetically indistinguishable from Green River NORs, were to stray into the Snoqualmie, they would add little risk on top of the amount of gene flow that is already occurring. We do have a relative reproductive success (RRS) information on hatchery influence. Baseline Bayesian clustering analyses of Snoqualmie Chinook show they are basically fall chinook with a north sound influence, similar to Green River. We also can tell if Green River fish from the hatchery are straying to the Snoqualmie any more or less than natural origin Green River fish currently or historically. Genetic load, or the selection pressure for a phenotype that is not the optimum, affecting population fitness, is not limited to hatcheries. Hatchery environments are not the only source of genetic load on wild populations, other environmental changes are as well, like flooding, temperature, or contamination that are all major factors in the Snohomish. Ecological interactions from hatchery- to natural-origin fish are not nearly of the magnitude, or as pervasive or ubiquitous, as anthropogenic ecological risks. The latter include, among many, climate-based increases in the intensity and frequency of flooding, warming temperature regimes, and other climactic changes affecting freshwater and ocean productivity and foodweb assemblages, or toxic compounds released into rivers, estuaries and marine habitats that dwarf the scale of deleterious ecological interactions to natural-origin fish. If we applied HSRG standards to these sources of genetic load, using the Burger-Lynch rule, these habitat alterations would be found to be intolerable. Thinking about the various risks in this way allows for more common denominators in considering the ecological risks presented in different Hs, and to manage accordingly.

Henry M. Jackson Hydroelectric Project
(FERC No. 2157)

Process Flow Plan
(License Article 416)

DRAFT
Ten-Year Effectiveness Report

Prepared By:

Snohomish County PUD
Public Utility District No. 1
Everett, WA

September 6, 2022

Preliminary Draft – This document has been peer-reviewed by Snohomish PUD for accuracy and formatting based on the knowledge and information existing at the time of its preparation; however, it is a preliminary document that may be updated based on new or additional information, unforeseen or changed conditions, data analysis, design modification, etc. The document may be cited as:

Public Utility District No. 1 of Snohomish County (Snohomish PUD). 2022. Draft Process Flow Plan 10-Year Effectiveness Report, for the Jackson Hydroelectric Project (FERC No. 2157). September 2022.

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ACRONYMS AND ABBREVIATIONS

A-LA	Aquatic License Article
ARC	Aquatic Resource Committee
ARIS	Adaptive Resolution Imaging Sonar
cfs	cubic feet per second
ER	Process Flow Effectiveness Report
FERC	Federal Energy Regulatory Commission
FHMP	Fisheries and Habitat Monitoring Plan
MW	megawatt
PFP	Process Flow Plan
Project	Henry M. Jackson Hydroelectric Project, FERC No. 2157
RM	River Mile
SCADA	Supervisory Control and Data Acquisition
Snohomish PUD	Public Utility District No. 1 of Snohomish County
USGS	United States Geological Survey
WY	Water year

1. Introduction

Public Utility District No. 1 of Snohomish County (Snohomish PUD) received a license on September 2, 2011 (License) from the Federal Energy Regulatory Commission (FERC) for the Henry M. Jackson Hydroelectric Project (Project) (FERC 2011). License Article 416 approved the Process Flow Plan (PFP) filed with the FERC in September 2010. Per Section 5 of the PFP, Snohomish PUD is to develop a Process Flow Effectiveness Report (ER) every 10 years analyzing the results of the monitoring components presented in the PFP and the Fisheries and Habitat Monitoring Plan (FHMP) in conjunction with the release data specific to each of the reaches of the Sultan River (Figure 1).

This ER is the first and covers activities conducted in the period 2011-2021. The report begins with a discussion of Special Purpose Flows which occur annually to stimulate a biological / behavioral response in either juvenile or adult salmonids. The report then discusses Habitat Based Flow Releases, beginning with the annual relatively low volume releases followed by the less frequently occurring high volume releases. Recommendations for modification to the PFP are provided.

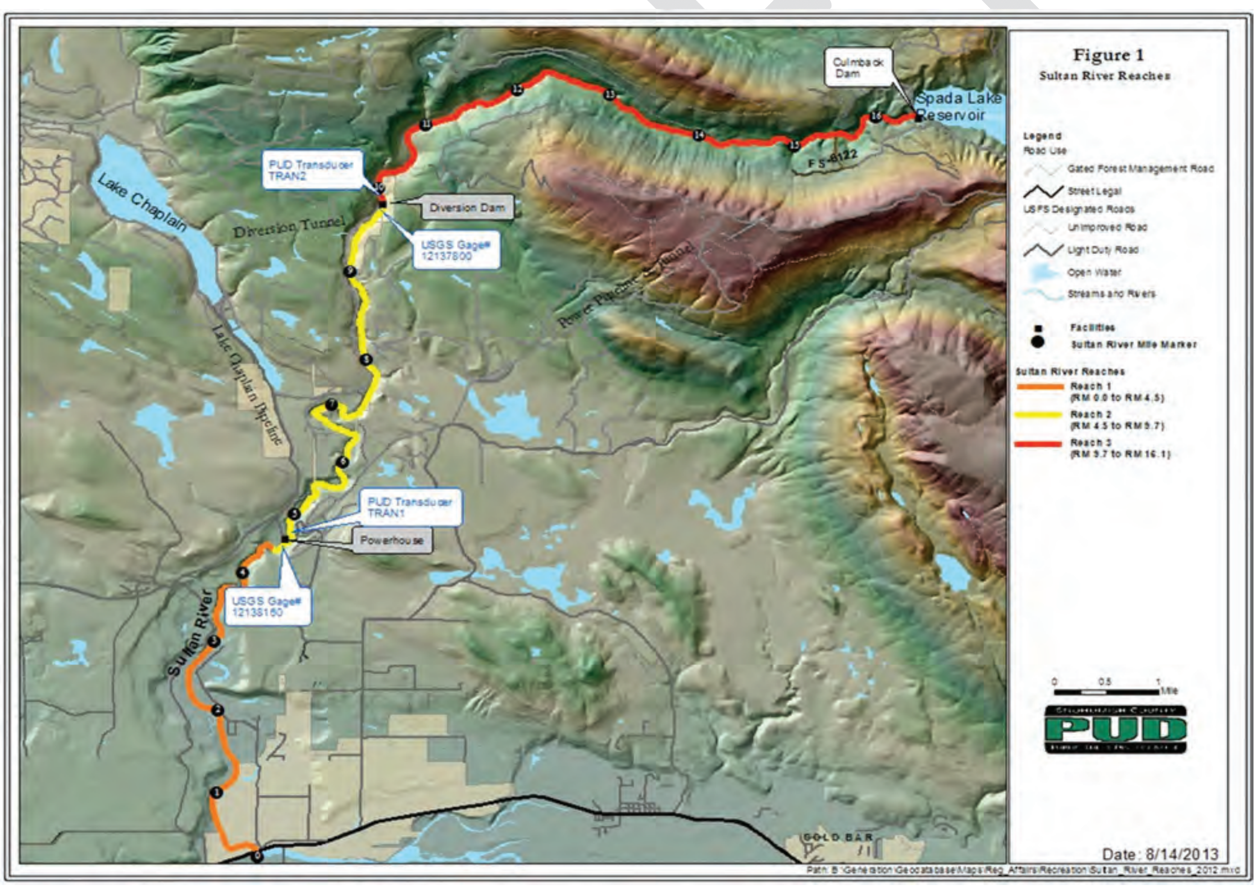

Figure 1. Sultan River reaches, facilities, and river miles.

2. Special Purpose Flow Releases

Special Purpose Flows fall into two categories: upmigration flows that occur in the fall, and outmigration flows that occur in the spring.

2.1. Upmigration

2.1.1. Program

The intent of the upmigration program is to release one pulsed flow per year, during the month of September to initiate the upstream migration of adult salmon, limit straying to other river basins, and facilitate swimming past natural and artificial barriers. The implementation of the upmigration program is intended to provide elements of a more normative hydrograph in the lower Sultan River compared to existing conditions.

During relicensing and settlement agreement discussions, there was scientific uncertainty regarding the magnitude, duration, and potential need for special purpose flows above and beyond what occurs from the Project and what occurs naturally. Monitoring requirements identified in the PFP and FHMP were to provide data for determining the need for and effectiveness of Special Purpose Flows including the upmigration flows. Results and analysis of these monitoring efforts are presented below, followed by a discussion of adaptive actions, and recommended modifications and improvements that incorporate lessons learned.

2.1.1.1. Frequency and Timing

The License requires, if necessary, one upmigration release per reach, annually during the month of September. The upmigration release typically occurs in combination with a channel flushing flow, and with a scheduled whitewater event.

2.1.1.2. Duration

The License and PFP call for each reach specific upmigration event to last for a minimum of six consecutive hours.

2.1.1.2. Magnitude (by reach)

An upstream migration flow will be achieved by meeting the following criteria bulleted below. The range was intended to allow for testing the effectiveness at different flow magnitudes during the first ten years of the License.

- Reach 1: Between 800 and 1200 cfs (USGS Gaging Station No. 12138160)
- Reach 2: Between 400 and 600 cfs (upstream of the Powerhouse at river mile [RM] 4.7)
- Reach 3: Between 300 and 500 cfs (upstream of the City of Everett's Diversion Dam at RM 9.8)

2.1.2. Objectives

Three objectives are identified in Section 1.3 of the PFP that are associated with late summer/early fall, short duration pulse flow events. These include: 1) initiating the upstream migration of adult salmon, 2) limit straying to other river basins and, 3) facilitating swimming past natural and artificial barriers.

Summary of Comments on Microsoft Word - PF Plan 10 Year Effectiveness Report

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Number: 1 Author: Anne Savery Date: 10/10/2022 4:13:19 PM

This is about the initial premises of a single pulse release for "upmigration" purposes that would not occur outside of the normal hydrograph when it is needed the most given we continue to see predictable records and opportunity for a revised approach to account for increasingly prolonged holding under record temps that exceed state standards and record low flows that truncate distribution and force spawning in thalwegs most vulnerable to redd scour and the increasing frequency and intensity of flooding all from climate change

2.1.3. Assumptions

Implementation of this program was intended to mimic elements of a more normative hydrograph in the lower Sultan River compared to hydrologic conditions in place prior to the implementation of the program. It was assumed that by implementing Special Purpose Flows for upmigration, the objectives outlined in Section 2.1.2 would be accomplished.

Fish tend to spawn in the same places, so was this the appropriate test?

2.1.4. Results

Under the current License, data have been collected to evaluate the effectiveness of upmigration process flows on migrating adult Chinook salmon. According to the PFP, assessment of the upmigration program will be conducted by looking at the temporal distribution of fish and the presence of redds through the spawning season. Further, the temporal distribution under the release program will be compared with the historic distribution without an upmigration release program. The primary method for evaluating this program was annual spawning ground surveys conducted in accordance with the FHMP using Washington Department of Fish and Wildlife protocols. From a biological perspective, these routine surveys allowed data to be collected prior to and following upmigration pulse flows to evaluate the benefit of the release including documentation of any effect relating to stimulating upstream migration and facilitating upstream migration above barriers. From a hydrological context, the timing of upmigration process flows across the ten-year period allowed for a comparison of normative flow to be made with hydrology from the unregulated Skykomish and Pilchuck rivers. The data presented and discussed in this section include the following:

The fall process flow may be achieving an unquantified objective of cooling the Skykomish River and preventing pre spawn mortality

- Date of upmigration releases
- Percentage of Chinook redds by statistical week before and after implementation
- Number and percentage of Chinook redds, by statistical week, before and after implementation of upmigration releases
- Redd counts in Reach 1 by survey date and mean/max flow (cfs) since previous survey, 2012 and 2016
- Number and percentage of marked (adipose fin clipped and/or coded wire tagged) carcasses recovered before and after implementation of upmigration releases
- Number of Chinook documented on the Adaptive Resolution Imaging Sonar (ARIS), by statistical week, in 2021

if there was no PFP in 2016, why is it included in the analysis?

Upmigration Flow Dates

Did we bank the water on the upmigration flows that didn't happen; or the ones that did not meet average flow target?

From 2011 to 2021, a total of ten upmigration releases were conducted occurring annually between statistical weeks 35 and 38 (Table 1). In 2012, the upmigration flow for Reach 1 was accomplished by operating at full generation; however due to observed early spawning of Chinook in Reach 2, the magnitude of the release for this river segment was modified and reduced after conferring with the Aquatic Resource Committee (ARC). In 2013, low inflows into the Project led to a decision to delay the upmigration flow and allow it to occur within the salmon ceiling window and in-conjunction with forecasted precipitation. In 2016, an upmigration process flow did not occur due to in-water construction activities associated with the Diversion Dam Volitional Passage Project on the Sultan River at RM 9.7. In 2021, the PFP was modified to allow upmigration releases to occur anytime during the month of September to better align with unregulated basin hydrology during this period of late summer low flow, and to limit the enticement of hatchery Chinook into the Sultan River.

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Number: 1 Author: Anne Savery Date: 10/10/2022 4:14:42 PM

Fish tend to spawn in the same places, so was this the appropriate test?

Number: 2 Author: Anne Savery Date: 10/10/2022 5:35:25 PM

The fall process flow may be achieving an unquantified objective of cooling the Skykomish River and preventing pre spawn mortality

Number: 3 Author: Anne Savery Date: 9/19/2022 5:10:32 PM

what is normative flow defined as and in what system?

Number: 4 Author: Anne Savery Date: 9/19/2022 5:11:35 PM

we may need to see data in other reaches, since upmigration flow wasn't limited to Reach 1 concerns

Number: 5 Author: Anne Savery Date: 10/10/2022 4:16:39 PM

before and after implementation is problematic in the annual time series due to lack of sampling before the upmigation flows were initiated and within year, is confounded by the flow manipulations occurring just prior to normal Skykomish Chinook spawn timing ashten "causative" of some increase, or not, which can vary from year to year relative to climate effects, which are assumed to be constant

Number: 6 Author: Anne Savery Date: 9/19/2022 5:14:44 PM

if there was no PFP in 2016, why is it included in the analysis?

Number: 7 Author: Anne Savery Date: 10/10/2022 5:35:13 PM

KN: Was it agreed that assessment would only take place in Reach 1. Guessign the flows would be more effective in Reach 3 where there are likely more low flow barriers - channels with a higher gradient.

Number: 8 Author: Anne Savery Date: 10/10/2022 5:39:20 PM

Did we bank the water on the upmigration flows that didn't happen; or the ones that did not meet average flow target?

Number: 9 Author: Anne Savery Date: 9/19/2022 5:13:35 PM

This change may not be something the Tulalip Tribes can agree to long term; in light of need for temperature relief for ESA listed Chinook holding in the Skykomish.

Number: 10 Author: Anne Savery Date: 10/10/2022 5:37:59 PM

Use 'attraction' rather than 'enticement'.

By 2021 Snohomish PUD and Tulalip had had several conversations regarding the PUD concerns about straying into the Sultan River. We will address the issue in depth in our letter.

Table 1. Date and statistical week for fall upmigration releases, 2011-2021.

Date of Upmigration Release	Statistical Week	Flow Range Reach 1 (CFS)
9/2/2011	35	1,200
9/14/2012	37	1,200 – 1,430
9/17/2013	38	1,530 – 2,060
9/12/2014	37	1,500 – 1,760
9/12/2015	37	997 – 1,050
9/2/2017	35	802 – 1,620
9/8/2018	36	805 – 1,440
9/8/2019	36	1,210 – 1,460
9/11/2020	37	1,200 – 1,310
9/26/2021	38	1,220 – 1,450

Run Timing - Chinook Spawning Surveys

Chinook spawning is documented during fall escapement surveys. Pooled data representing Chinook salmon spawn timing is presented in Table 2 and illustrated in Figure 2. Years included in the analysis prior to the implementation of the upmigration process flow program were: 1994, 1997, 1999, 2001, 2002, 2007, 2009, and 2010. Temporal data for other years prior to the new operating License are not available. Run timing data during years of upmigration releases include: 2011-15 and 2017-21. Fall upmigration releases began in 2011; however high turbidity during that first year prevented fall escapement surveys. It is also worth noting that periodically, due to high river flows, turbidity, or other environmental factors, surveys were not always conducted in each statistical week, which can influence the recorded temporal distribution of redds.

Table 2. Number and percentage of total observed Chinook redds, by statistical week, prior to and after implementation of upmigration releases.

Statistical Week	*Prior to Implementation*		*After Implementation*		
	Number Redds	Percent Redds	Number Redds	Percent Redds	Percent Difference After vs Prior Implementation
35	0	0.0%	2	0.2%	0.2%
36	1	0.1%	0	0.0%	-0.1%
37	37	3.6%	74	6.2%	2.7%
38	66	6.4%	103	8.7%	2.3%
39	196	19.0%	213	18.0%	-1.0%
40	117	11.3%	285	24.1%	12.7%
41	222	21.5%	306	25.8%	4.4%
42	113	10.9%	86	7.3%	-3.7%
43	108	10.4%	52	4.4%	-6.1%
44	133	12.9%	44	3.7%	-9.1%
45	11	1.1%	16	1.4%	0.3%
46	20	1.9%	1	0.1%	-1.8%
47	0	0.0%	3	0.3%	0.3%
48	10	1.0%	2	0.0%	-1.0%
Totals	1,034	100 %	1,185	100 %	

Number: 1 Author: Anne Savery Date: 10/10/2022 5:40:17 PM

KN: what were the existing flows? Is this a bankfull event?

Number: 2 Author: Anne Savery Date: 10/10/2022 4:20:09 PM

It was not possible to ID the numbers of Hatchery/Wild fish in 1994 or 2002. Those years should not be used. Please provide the sample collection data for 1997, 1999, or 2001 in the Sultan when this was done with otolith analysis.

Number: 3 Author: Anne Savery Date: 9/19/2022 5:07:20 PM

Number: 4 Author: Anne Savery Date: 10/10/2022 5:41:37 PM

KN: Initial viewing of this data appears to shift the spawning slightly and narrow the spawning timing.

Number: 5 Author: Anne Savery Date: 9/19/2022 5:18:26 PM

AS:This needs to be looked at by year and compared to brood year.

Also, compare run timing by week with Wallace.

Number: 6 Author: Anne Savery Date: 10/10/2022 4:23:34 PM

MC: these are what might be expected as these are redds deposited after the upmigration flows that occurred mainly in weeks 36-38, after which the redd counts increase, but during normal spawn timing

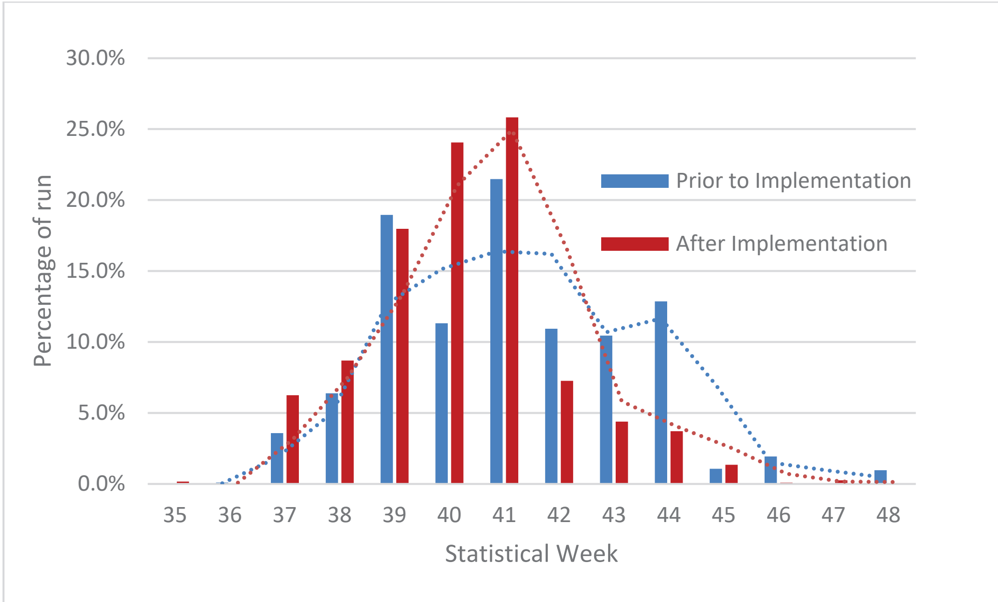

Figure 2. Percentage of total Chinook redds observed, by statistical week, prior to and after implementation of upmigration releases, with two point moving average.

The greatest difference in the timing of observed redds between prior to and after program implementation occurred in statistical week 40, which is near the peak of the Chinook run. Overall, a greater percentage of the run now spawns earlier in the Sultan River compared to the period prior to implementation of the program (Figure 2). Whereas [illegible] typical during the early part of the Chinook run that the unregulated Skykomish and Pilchuck rivers contain low discharge and increasingly high-water temperatures, the Sultan River discharge volume, even near the prescribed minimum instream flow, provides cool, ample volumes of water which attract and provide ideal spawning conditions for Chinook salmon. Noteworthy as well, is the lack of any physical barriers restricting the upstream migration of salmon throughout the longitudinal extent of the Sultan River downstream of RM 15.8.

Table 3 contains live Chinook counts and redd observations from low water years, 2012 and 2016. This data highlights two points: 1) upstream migration is occurring at water levels below the upmigration flow threshold, and 2) Chinook salmon are successfully migrating and subsequently spawning without the need for an upmigration pulse flow. To further illustrate these points and to provide a basis to analyze the necessity of this process flow element, we provide a deeper dive into the temporal timing of Chinook spawn timing in 2012 and 2016.

The upmigration release in 2012 occurred on September 14. Results from the subsequent survey on September 26 identified 26 redds and 45 live Chinook (Table 3). Through the remainder of the season, despite low flow conditions in the Sultan River, new redds and live Chinook continued to increase to a peak of 89 redds and 140 live fish on October 12 (Table 3). In the fall of 2016, an upmigration release did not occur due to maintenance at the Jackson Project. Since inception of the upmigration process flow program in 2011, the two largest single day redd counts in Reach 1 of the Sultan River occurred in 2012 and 2016 (89 and 98 redds, respectively).

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Number: 1 Author: Anne Savery Date: 10/10/2022 4:26:58 PM
AS: yes Chinook are returning earlier, but the outmigration flows don't appear to attract the fish

Number: 2 Author: Anne Savery Date: 10/10/2022 5:42:35 PM
KN: do you mean low flow barriers and at existing MIF?

Number: 3 Author: Anne Savery Date: 10/10/2022 4:28:52 PM
MC: This is not supported. While the report does not provide data for an upmigration flow in 2016, for the rest of the years, other than 2021, it occurs in ~ 2nd week of Sept (average is 9/10), like in 2012, the only other year mentioned here where date of the flow release is provided, it was on 9/14/2012, after which all of the redds were deposited and this is presumably the same for 2016 where all of the redds would be deposited after the flow release

Number: 4 Author: Anne Savery Date: 10/10/2022 4:35:41 PM
showing the hydrograph wouldbe helpful here in order to see if there are any naturally occurring pulses.

These data indicate that Chinook salmon effectively migrate to and successfully spawn in the Sultan River at water levels near the minimum instream flow of 300 cfs and do not require a pulse flow to stimulate their upmigration.

Table 3. Redd counts in Reach 1 by survey date and mean/max flow (cfs) since previous survey, 2012 and 2016.

Date of Survey	New Redds	Live Chinook	Mean/Max Flow (cfs) since previous survey
9/12/2012	0	0	
9/26/2012	26	45	357/769
10/5/2012	52	12	326/346
*10/12/2012	89	14	322 /328
8/26/2016	0	0	
9/13/2016	3	12	399/558
9/23/2016	23	70	449/614
10/6/2016	98	212	383/430
*10/11/2016	37	161	605/812

*10/12/12 and 10/11/16 were the final surveys of season; river conditions were not adequate to survey for the remainder of season.

Further upstream in Reach 3 of the Sultan River, Snohomish PUD has been monitoring upstream fish migration past the City of Everett's Diversion Dam. In 2018, the ARC approved the purchase of a hydroacoustic sonar system known as ARIS. Snohomish PUD operated the ARIS underwater sonar to monitor adult Chinook migrating into Reach 3 in 2018, 2020, and 2021. In 2021, the ARIS operated from June 16 - October 30. The impetus for installing the ARIS prior to fall surveys in 2021, was that Snohomish PUD biologists were documenting an increase in hatchery origin carcasses in the Sultan early in the season and were curious about run-timing and hydrologic conditions during their upstream migration. Table 4 shows the number of Chinook documented on the ARIS by statistical week. Coupling this temporal run timing information with hydrology from Figure 3, indicates Chinook are migrating 9.7 miles upstream from the Sultan-Skykomish confluence during low flows beginning in June and extending to mid-September. Based on these 2021 data, 52% of the Chinook encountered at the ARIS had migrated past the Diversion Dam from June through August, during a period of low-flow conditions (Table 4, Figure 3).

Table 4. Number of Chinook documented on the ARIS by statistical week in 2021.

Statistical Week	Number and Percent of Run
24	3 (2%)
25	2 (2%)
26	1 (1%)
27	2 (2%)
28	0
29	6 (5%)
30	6 (5%)

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Number: 1 Author: Anne Savery Date: 9/19/2022 7:37:32 PM

It appears that some sort of pulses may be cueing salmon to move into the system?

Also there is probably a temperature component.

Number: 2 Author: Anne Savery Date: 9/19/2022 7:42:47 PM

how much of this do you think is related to water temperature?

are these are fall or summer chinook?

31	9 (7%)
32	4 (3%)
33	3 (2%)
34	4 (3%)
35	26 (20%)
36	33 (25%)
37	20 (15%)
38	0
39	4 (3%)
40	5 (4%)
41	0
42	1 (1%)
43	1 (1%)
Total	130
Statistical Weeks	Corresponding Months
22-26	June
27-31	July
32-35	August
36-40	September
41-44	October

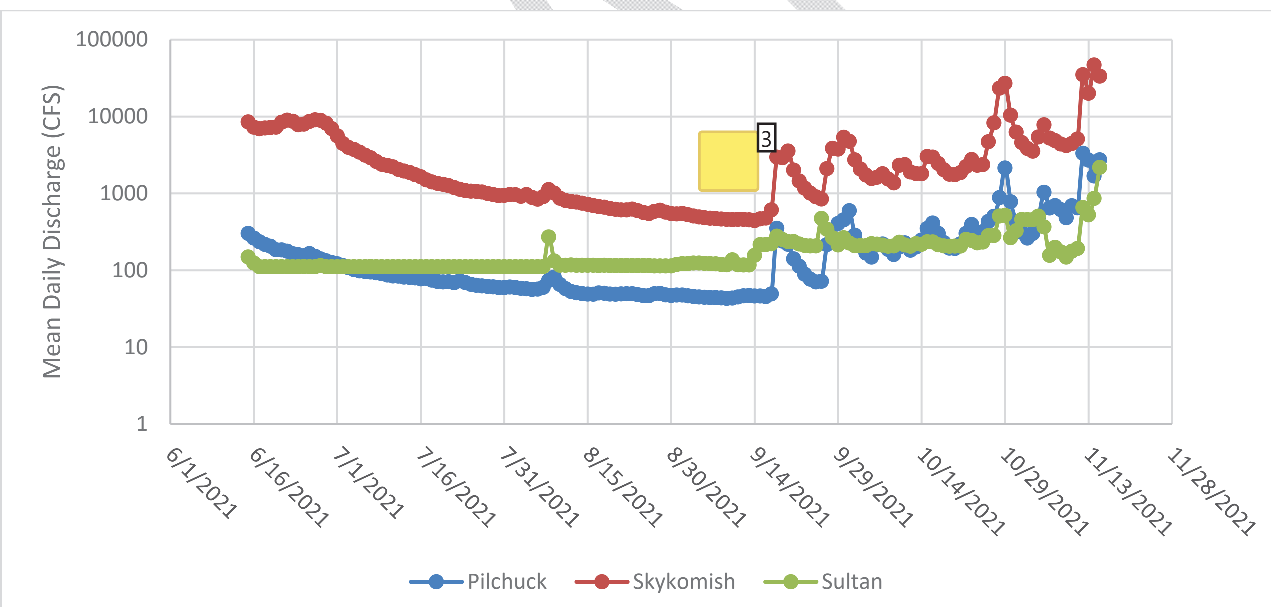

Figure 3. Mean daily discharge, June 15 – November 15, 2021, displayed for the Sultan below Diversion Dam gage, Pilchuck, and Skykomish Rivers.

Straying

The number of marked (adipose fin clipped and/or coded wire[illegible]ed) fish has increased substantially since upmigration releases began. As Table 5 sh[illegible] 4% of carcasses were marked prior to the implementation of upmigration releases and 17% have been marked since program

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Number: 1 Author: Anne Savery Date: 10/10/2022 4:44:09 PM

MC: 2/3 of fish arriving weeks 35-37

Number: 2 Author: Anne Savery Date: 9/19/2022 7:43:52 PM

AS: interesting that Reach 3 is getting fish earlier than Reach 1 and that Reach 1 peaks in Weeks 40 and 41.

How much is this a temperature story? How much is this a run size story? How much of this is a relative flow and temp between Sky and Sultan?

Number: 3 Author: Anne Savery Date: 9/19/2022 7:46:19 PM

do you have weekly data on fish returns in the Pilchuck and Sky?

Number: 4 Author: Anne Savery Date: 10/10/2022 5:46:32 PM

KN: When you report it as a percentage it supports their narrative. What if the number of NOR decreased for some reason - an issue the Mike has mentioned. When the situation is the same number of hatchery fish are entering but there are fewer NOR's implementation. During years 2012-2021, eight coded wire tagged Chinook have been recovered in the Sultan River: seven were from the Wallace Hatchery and one from Whitehorse Rearing Ponds on the North Fork Stillaguamish (Regional Mark Processing Center (rmpc.org)). This shift in run composition has occurred at a time of increased hatchery production. While the Wallace Hatchery has been releasing over one million summer run Chinook annually since 2002, 65% more fish were released during the 2011 to 2021 period versus the 2001 to 2010 period (Table 6).

Table 5. Number and percentage of marked (adipose fin clipped and/or coded wire tagged) carcasses during prior to and after implementation of upmigration releases.

Prior to Implementation				*After Implementation*			
Year	Total Carcasses	Number Marked	Percent Marked	Year	Total Carcasses	Number Marked	Percent Marked
2001	30	1	3%	2012	[illegible]	18	26%
2002	50	4	8%	2013	48	1	2%
2003	19	1	5%	2014	27	8	30%
2004	43	1	2%	2015	38	16	42%
2005	21	1	5%	2017	35	2	6%
2006	20	0	0%	2018	45	3	7%
2008	40	0	0%	2019	4	1	25%
2010	18	2	11%	2020	79	13	16%
				2021	62	9	15%
Total	241	10	4%	Total	406	71	17%

Table 6. Wallace Hatchery Chinook releases 2002-2022.

Release Year	Subyearling	Yearling	Total Released
2002	795,123	218,000	1,013,123
2003	1,026,549	250,000	1,276,549
2004	870,000	133,000	1,003,000
2005	1,067,700	164,843	1,067,700
2006	876,505	246,183	1,122,688
2007	1,115,372	290,000	1,405,372
2008	1,015,000	294,547	1,309,547
2009	1,168,281	261,507	1,429,788
2010	1,251,377	234,516	1,485,893
2011	1,010,000	249,740	1,259,740
2012	1,793,067	240,306	2,033,373
2013	1,071,017	112,137	1,183,154
2014	1,050,459	437,770	1,488,229
2015	1,066,315	423,608	1,489,923
2016	1,100,407	467,387	1,567,794
2017	969,316	459,000	1,428,316
2018	1,112,454	440,000	1,552,454
2019	951,832	510,928	1,462,760
2020	1,387,761	534,938	1,922,699
2021	1,183,901	544,158	1,728,059
2022	2,050,549	449,533	2,500,082

Number: 1 Author: Anne Savery Date: 9/19/2022 8:32:01 PM

AS: 2015 was the year of the hot blob in the ocean and terrible stream flows and high percentage of HOR in the Skykomish population. The Sultan did have a higher percentage of HOR than the Sky that year However, the Sultan consistently has a lower percentage of HOR than the Skykomish River.

We would do well to remember that the Sultan River is a part of a system and not isolated from the whole.

Number: 2 Author: Anne Savery Date: 10/10/2022 4:50:08 PM

MC: some of these years have very poor data and making inferences from a low sample size can be problematic. Further post license sampling was much higher, which can introduce a sampling bias.

Number: 3 Author: Anne Savery Date: 10/10/2022 5:47:50 PM

KN: Do these years of higher numbers correspond to years where flows in the Skykomish were extremely low and maybe hot?

The incidence of marked carcasses is not distributed evenly throughout the spawning season. Most marked carcasses have been recovered early in the season (Figure 4). Wallace Hatchery Chinook are summer-run and, therefore, spawn earlier than Sultan natural origin Chinook which are fall run. This explains the temporal difference of marked and unmarked fish.

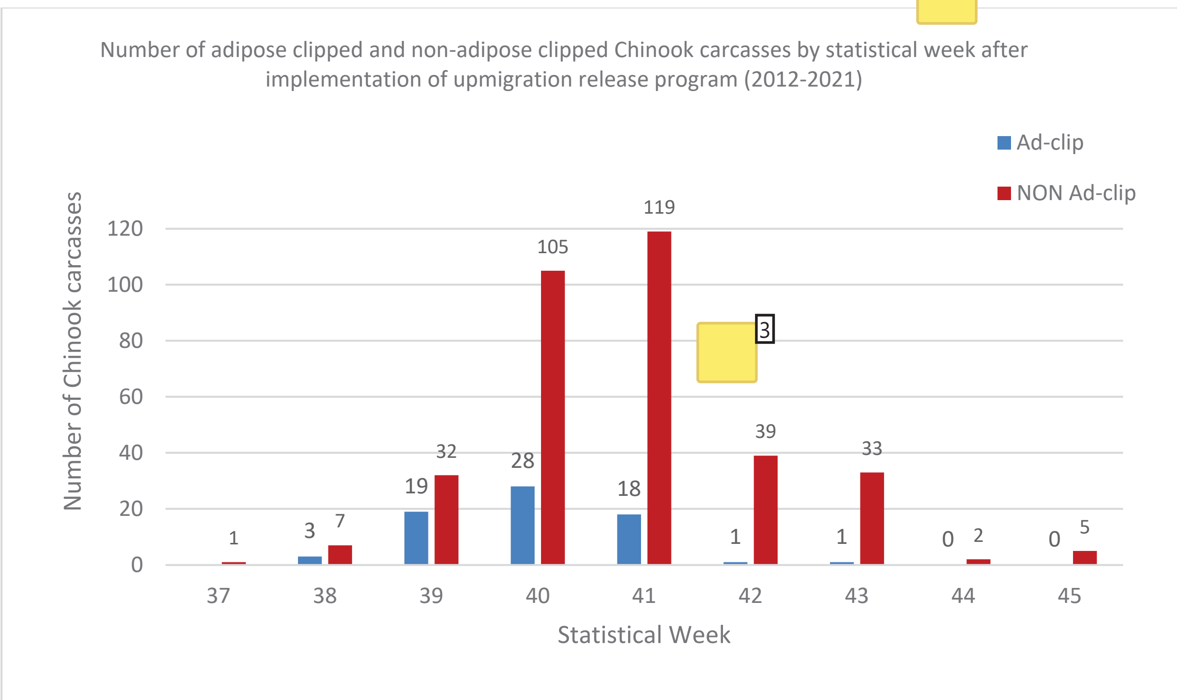

Figure 4. Number of adipose clipped and non-adipose clipped Chinook carcasses recovered during spawner surveys by statistical week after implementation of upmigration release program, 2012-21.

A suite of factors contributes to the attraction and en[illegible]ment of hatchery Chinook to the Sultan River. Based on observations during spawning surveys over the past 10 years, three factors stand out: 1) disproportionately high flow volume from the Sultan River compared to the unregulated Skykomish drainage during the summer; 2) regulated water temperature control and adherence to the Washington State water temperature standard of 16 degrees Celsius; and 3) significant increase in hatchery Chinook production at the Wallace River Hatchery. An interesting data point to consider is from fall 2016 when an upmigration process flow did not occur. Carcass recoveries in the Sultan River during that year identified only 2% (one of 42) as being marked indicating hatchery origin, and the final Chinook escapement that year was the sixth highest since 2000.

Since Sultan River Chinook are not coded wire-tagged, it is not possible to determine the proportion of Chinook that stray from the Sultan River absent that information. However, by converse logic based on many years of observation during spawner surveys and documentation of new redds and new fish during periods of relatively low flows, it is inferred that operational adherence to the prescribed minimum flow and water quality requirements for the Project results in favorable conditions and a reduced probability of Chinook straying out of the Sultan. Additional data, such as, the 13% increase in hatchery Chinook carcass recoveries in the first

Number: 1 Author: Anne Savery Date: 10/10/2022 4:51:59 PM

MC: Not just Wallace, the rest of Sky are summers, and I think the TRT said Chinook in the Sultan are considered to be part of the Skykomish summer Chinook population, not a separate fall population. The blue bars mimic the run timing of wild summer Chinook in the basin, not just Wallace, which is indistinguishable and founded from Sunset Falls, which BTW has October-returning fish that still genetically assign to summer Chinook. I have asked a geneticist to look into this who is very interested and willing to take a look at population substructure now that we have many more samples than when this was looked at back in 2006. We should discuss possibilities for greatly improving this as well as increasing scrutiny of current PUD assumptions of Sultan as a unique population (see next para). This can be due to natal fall signature, or it could be a remnant Green River fall signature. NORs return into October at Sunset and return as early as May in the basin. NORs comprise on average 70% of the fish in the Skykomish, which includes the Wallace (79% NOR outside of the Wallace River).

But, regarding the possibility of the Sultan fallish signature being due to non-native Green River lineage influence, I think there could be some evidence for this but I need to ask Adrian Spidle, NWIFC geneticist, to re-examine this. He examined Chinook DNA composition of returns to Wallace River Hatchery, Sunset Falls and elsewhere throughout the basin from samples I collected over several years WAY back in ~2006- ?- by origin (hatchery vs wild), return timing (month of return to Wallace River Hatchery week of return to Sunset Falls), AND by location (Sunset Falls, Wallace River Hatchery, and other primary natural spawning aggregations). While Bayesian lineage clustering showed that Chinook returning to Wallace River Hatchery from June through late-September from 2005 and 2006 clustered closely with the native Skykomish River Chinook summer Chinook spawning aggregations including Sunset Falls (all Sunset returns through October), a small number of Chinook returning in October to Wallace River Hatchery had a greater affinity to Snoqualmie or Green River fall Chinook than to Skykomish River summer Chinook as sampled in earlier months (A. Spidle, NWIFC, M. Crewson and K. Rawson, Tulalip Tribes, and P. Moran, NOAA NMFS, unpublished data). We need to revisit the old data, analyze the already genotyped data, and run the remaining samples that are still on the shelf, not just for the Sultan, but for the rest of the basin.

I seem to remember Sultan looking more fall-ish but that the number of samples analyzed at that time was very limited. Since then, we have collected many more samples, and they all need to be analyzed- this will be part of the conversation with the geneticist

Number: 2 Author: Anne Savery Date: 10/10/2022 5:48:47 PM

AS, MC, KN: Sultan fish are not fall run, they are summer run. We suggest genetics work in our letter.

Number: 3 Author: Anne Savery Date: 9/19/2022 7:48:46 PM

AS: It seems there is a case being made to say process flows don’t attract Chinook as well as a case that process flows attract hatchery fish.

The conversations you have had with Tulalip about the ratio of Hatchery Origin Spawners versus Natural Origin Spawners throughout the Skykomish population are not reflected in the discussion.

Also, some years the fish returns are really low and the ratio of hatchery to wild fish returns increases. This is a system wide phenomenon, not a Sultan specific issue.

Number: 4 Author: Anne Savery Date: 9/19/2022 9:15:00 PM

MC: The data I have for 2016 is 10.3% are HOR on the sultan, not 2% HOR on the Sky was 34%. The average annual HOR% on the Sultan is 14%. So again, you are saying the flows don’t attract Chinook and then you are saying the flows attract hatchery fish.

ten-year PFP implementation period, suggest it is unlikely that adult Chinook are straying out of the Sultan River.

2.1.5. Unforeseen Consequences

As previously mentioned, the intent of the PFP is to provide elements of a more normative hydrograph in the lower Sultan River compared to existing conditions. As the hydrographs in Appendix A indicate, the timing of the fall upmigration releases does not typically coincide with natural conditions observed in either the Pilchuck or Skykomish systems. As s[illegible] the timing and duration of these flows have the potential to entice and induce the straying of hatchery fish into the Sultan River, while providing limited benefit to natural origin fish. Operationally induced enticement can lead to changes in run composition and timing which deviates from the logic and intent behind the development and implementation of several license articles including those related to minimum flow schedules, the salmon ceiling, and downramping.

2.1.6. Adaptive Actions Undertaken

The original salmon ceiling flow restriction of 550 cfs (mean daily discharge measured at the Powerhouse gage) was modified in August 2021 to allow for a maximum of 850 cfs for no more than 36 hours during the month of September. This adjustment was intended to allow for upmigration releases to be timed to be more in line with natural hydrologic patterns.

2.1.7. Recommended Modifications

Data gathered and observations made during the first ten years of License implementation provide three conclusions related to assessing the value of the upmigration element of the process flow program.

- Even in low water years, the operational hydrology during fall in the Sultan River is conducive to stimulate upstream salmon migration without the need for an upmigration pulse flow;
- In conjunction with significant increases in hatchery Chinook production the annual upmigration pulse flow may exacerbate hatchery straying to the Sultan River; and
- The timing and magnitude associated with upmigration flows on the Sultan River deviates from the normative hydrology in unregulated systems within the Snohomish Basin.

Overall, implementation of the upmigration process flow program has not produced the intended biological benefit. In crafting this element of the PFP there was a level of scientific uncertainty related to the flow volumes and presumed benefits provided by an upstream migration release. In addition to re-establishing elements of a more normative hydrograph, the PFP identified three potential areas of biotic and hydrologic value that the upmigration program would provide: initiate the upstream migration of adult salmon, limit straying to other river basins, and facilitate swimming past natural and artificial barriers. Based on results from this ten-year evaluation period, Snohomish PUD does not believe upmigration process flows are necessary. They have unintended biological consequences such as attracting hatchery Chinook which over time, may lead to a shift in run composition and timing. After reviewing this data, Snohomish PUD proposes the following recommendations.

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Number: 1 Author: Anne Savery Date: 10/10/2022 5:15:09 PM

You have not made an adequate case for this statement. The Sultan River Chinook are not separate from the Skykomish summer Chinook. A fall signature may exist, however it does not mean Sultan fish are different from Sky population - Tulalip suggests genetic work in our comment letter.

Number: 2 Author: Anne Savery Date: 10/10/2022 5:15:06 PM

Number: 3 Author: Anne Savery Date: 10/10/2022 5:19:53 PM

Tulalip finds there is a greater need for temperature relief in the Sultan river and confluence with the Skykomish in late August/September than the need for an upmigration flow at this point.

Number: 4 Author: Anne Savery Date: 10/10/2022 5:23:45 PM

it would be informative to show the hydrograph for the Sultan for the summer/fall of each year in order to determine if other pulses occurred.

Number: 5 Author: Anne Savery Date: 10/10/2022 5:51:07 PM

KN, AS: Here you say again that the PFP does not help Chinook migrate into the Sultan and then that the flows increase hatchery strays which are Chinook.

Moving forward, recommendations for the next ten-year cycle include:

- Suspend releases for upmigration for the next ten-year cycle and compare data to the first ten-year period to identify any differences in spawn timing patterns.
- Incorporate mid-August spawning surveys into existing protocols to document potential shifts in run timing and/or stock composition relative basin hydrology and water quality (temperature).
- Continue to gather and inspect carcasses within spawning survey index areas to determine the percent hatchery origin Chinook.
- Support co-manager fisheries management and research efforts by continuing to gather DNA, scale, and otolith samples off carcasses encountered during spawning surveys.

2.2. Outmigration

2.2.1. Program

The intent of the outmigration element of the process flow program is to release pulsed flows twice per year, during the spring, to stimulate juvenile salmonid outmigration theoretically increasing their survival. These short-duration special purpose releases are thought to bring in elements of a more normative hydrograph in the lower Sultan River compared to hydrologic conditions during the previous License. In addition, introducing outmigration pulsed flows were assumed necessary during the PFP development to increase survival of juvenile salmon and steelhead outmigrants during drought years. The sections below contain specific information within the outmigration process flow program including, frequency and timing, duration, and magnitude (by reach). Following the general components are the objectives and assumptions of the outmigration process flow program as originally considered and hypothesized during relicensing. Specific metrics in the PFP were identified for evaluating the outmigration program objectives and assumptions. Results from these efforts are presented followed by discussions of unforeseen consequences, adaptive actions, and suggested recommendations for modifications and improvements that aim to build upon the lessons learned from the first ten-year monitoring period.

2.2.1.1. Frequency and Timing

The PFP states that Snohomish PUD will discharge water, if necessary, to ensure that two outmigration flows are achieved per year. One of the annual outmigration flows shall occur in April and one of the annual migration flows shall occur in May, with a minimum of seven days separation between events. The PFP further states that one flow must occur during the day and one flow must occur at night.

2.2.1.2. Duration

The duration of these outmigration releases is to occur for a minimum of six consecutive hours.

2.2.1.3. Magnitude (by reach)

An outmigration flow will be achieved by meeting the following criteria. The range was intended to allow for testing the different flow magnitudes during the first ten years of the License.

Reach 1: Between 800 and 1,200 cfs (USGS Gaging Station No. 12138160)
Reach 2: Between 400 and 600 cfs (upstream of the Powerhouse at RM 4.7)

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Number: 1 Author: Anne Savery Date: 10/10/2022 5:27:56 PM

AS, MC: A better use of the water would be to help reduce high temperatures

Number: 2 Author: Anne Savery Date: 9/19/2022 9:19:45 PM

AS: More work needs to be done to understand the escapements in the Sultan in context with the Skykomish basin.

In some cases the fish counts are occurring a full week after the process flow, which does not create a sound logic for confirming or denying the effectiveness of the process flow.

The PUD should also overlay water conditions (flow and temp) in the larger basin and understand that fish are going to move toward cooler water. This is an artifact of the WQ requirements placed by the State. PLUS the higher minimum instream flow requirement for the new license - flows rose from 200 to 300 cfs.

Number: 3 Author: Anne Savery Date: 10/10/2022 5:29:23 PM

MC: Co-Managers ESTIMATE the PROPORTION based on otolith analysis, not clipped fish. The only clipped fish used in estimating H:N fractions after all otoliths are read, are the ones clipped but not otolith-marked, which are out-of-basin fish that are not thermally marked (all Snohomish region Chinook are otolith marked, excepting 2021 incubation flow problem that nixed Wallace oto marking that BY)- so only a handful of fish annually estimated this way and both hatcheries have DIT roups comprising hundreds of thousands of fish not clipped. The otoliths tell us what hatchery and broodyear the fish are from. This enables us to know, e.g., that 31% of the hatchery fish in the Sky, on average are from out of basin as are 73% of the hatchery fish in the Snoqualmie, which wasn't figured into anything, and those are all fall Chinook that would introgress more with the Green River fall leftovers in the Sultan

Number: 4 Author: Anne Savery Date: 10/10/2022 5:53:49 PM

Assistance paying for analysis would be welcome as well as continued cooperation with sharing survey data.

Number: 5 Author: Anne Savery Date: 10/10/2022 5:54:50 PM

KN: do the releases cause increased turbidity?

Number: 6 Author: Anne Savery Date: 10/10/2022 5:31:59 PM

KN: this is a short duration and likely not a signficant enough volume or time to initiate a response.

Reach 3: Between 200 and 400 cfs (upstream of the City of Everett's Diversion Dam at RM 9.8)

2.2.2. Objectives

Section 1.3 of the PFP identifies two primary biological objectives of the outmigration program: stimulating juvenile salmonid outmigration and increasing survival of juvenile salmon and steelhead.

2.2.3. Assumptions

Implementation of the outmigration process flow program is intended to stimulate outmigration, result in increased survival of juvenile outmigrants, and provide elements of a more normative hydrograph compared to existing conditions.

2.2.4. Results

Since License implementation, data have been collected to evaluate the effectiveness of the outmigration process flow program. As described in the FHMP, a juvenile smolt trap was operated in the lower Sultan River to assess natural salmonid production. The lower Sultan River trap operated during nine of the first ten years after License issuance. Based on these data and direct observations, Snohomish PUD does not believe outmigration process flows are necessary, and in some instances, these pulse flows have unintended biological consequences. The following data presented and discussed below includes:

- Basin hydrology comparison – Sultan, Skykomish, Pilchuck
- Outmigration compliance events and frequency of occurrences
- Pooled regression correlating trap catch with discharge
- Examples of salmonid outmigration run timing in low and high-water years
- Examples of mean daily discharge during peak salmonid outmigration run timing
- Effect of outmigration process flows on trap catch

Basin Hydrology

The Sultan River receives on average, 163 inches of precipitation annually. The Sultan River watershed drains the least amount of land compared to the Pilchuck and Skykomish (Table 7). The collective hydrologic contributions of rainfall, accretion, and power generation has yielded an increase of 37% in mean daily flow (measured at USGS gage 12138160 Sultan River below Powerplant) during the outmigration window compared to the previous ten-year period (2001-2010) (Table 8).

Table 7. Drainage basin area (square miles) of the Skykomish upstream of the Sultan, Pilchuck, and Sultan rivers captured at the location of each USGS streamgage. Source: USGS.

River	Drainage area (sq mi)
Sky	535
Pilchuck	127
Sultan	94.2

Number: 1 Author: Anne Savery Date: 9/28/2022 1:01:41 PM

AS: How much of the increase is due to project management changes versus the required outmigration flows?

Table 8. Mean daily flow comparison and percent change between Sultan, Skykomish, and Pilchuck rivers during the outmigration window for years 2001-2010, and 2011-2021.

Mean daily flow (cfs) for entire outmigration period 2001-2010		
Sultan	Sky	Pilchuck
647	5619	480
Mean daily flow (cfs) for entire outmigration period 2011-2021		
S[illegible]	Sky	Pilchuck
[illegible]	6120	571
Percent change in mean daily flow (cfs) between time-periods		
Sultan	Sky	Pilchuck
37	9	19

Discharge standardized by drainage basin area [illegible]he unregulated Skykomish and Pilchuck rivers provides context on normative flow during the outmigration period. In years 2001-2010, the discharge per drainage area ratio was 10.5 cfs/sq mi, and 3.8 cfs/sq mi for the Skykomish and Pilchuck Rivers, respectively (Table 9). The ten-year time-period to follow, 2011-2021, showed a slight to modest increase in mean daily flow at the USGS streamgage locations on the Skykomish and Pilchuck rivers, representing a 9% and 19% inc[illegible]e, respectively (Table 8). In each of the two time-periods, the discharge per drainage area ratio on the Sultan River was greater than the Pilchuck River despite the Pilchuck watershed draining more land. From 2011-2021 the Sultan River standardized flow represented 82% of the Skykomish River, and 208% of the Pilchuck River during the outmigration period.

Table 9. Mean daily discharge (cfs) during the outmigration window standardized per square mile of drainage area for the Skykomish, Pilchuck, and Sultan rivers, in years 2001-2010 and 2011-2021.

Mean daily discharge(cfs) per drainage area (sq mi)			
Years	Sky	Pilchuck	Sultan
2001-2010	10.5	3.8	6.9
2011-2021	11.4	4.5	9.4

Appendix A contains annual hydrographs for comparison of mean daily flow between the Sultan, Skykomish, and Pilchuck rivers (Figures A1-A11) during the period spanning 2011-2021. These figures also highlight the outmigration and upmigration periods identified in the PF Plan. Figure A-12 displays mean daily flow within the outmigration window in years 2001-2021. These figures illustrate the concept of normative flow when comparing the regulated Sultan River

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Number: 1 Author: Anne Savery Date: 9/28/2022 1:04:24 PM

this likely has more to do with project operations.

Number: 2 Author: Anne Savery Date: 10/10/2022 6:23:12 PM

AS: Arent you generating more power at this higher flow? What percentage of the mean daily flow does an outmigration flow account for?

Number: 3 Author: Anne Savery Date: 9/19/2022 9:55:18 PM

AS: how does discharge per drainage area ratio compare pre project? I'd assume it is a great deal higher. What proportion of this change has anything to do with the required outmigration flows?

Number: 4 Author: Anne Savery Date: 9/28/2022 1:05:04 PM

AS: the sultan is a flashy basin, put this into context between mean daily and increased pulses, since you are saying the pulses are the issue.

Number: 5 Author: Anne Savery Date: 10/3/2022 2:16:57 PM

the graphs show the fish are following a genetic signature to outmigrate.

Flows caused scour and death to pink salmon? Evidence shows it isn't the case, Table 11 - attributed the dead pinks to scouring events, but it is more likely the pinks died becasue there was debris in the trap, along with the fish, they died in the trap. 2012 must have been cold, in normal years, pink migration is on the downtrend in April.

Trapping through the release flows, none of the figures are informative, Figure 24, CPUE increased with flow, but they aren't saying there is a relationship, with chinook, there is a relationship. What were the trap efficiencies? that should be included in the report.

CPUE should decrease with discharge based on cross sectional area, but CPUE seems to increase with discharge.

against the unregulated Skykomish and Pilchuck rivers and is a basis for suggesting that outmigration flows may not be necessary.

Sultan River Outmigration Compliance

Continuous hydrologic data from RM 9.8 was not available until 2018. The geomorphic response and mobilization of sediment following fish passage at the Diversion Dam was profound and conditions at the site finally equilibrated enough to re-install a permanent streamgage at RM 9.8 in 2018. The data presented in Appendix B is from the reach-specific streamgage locations, depicted in Figure 1, where compliance is monitored:

- Reach 1 – USGS Streamflow Gage No. 12138160 (downstream of Powerplant),
- Reach 2 – Immediately upstream of the Powerhouse at RM 4.7, and,
- Reach 3 – Immediately upstream of Diversion Dam at RM 9.8.

Tables in Appendix B account for the number of discrete instances by reach, where an outmigration process flow objective would have been achieved without the use of the Howell-Bunger valve at Culmback Dam. These qualifying instances of "natural[1]" outmigration flows vary from year to year. During the outmigration window in years 2018-2021, a total of 117, 104, and 80 instances of "natural" outmigration process flows occurred in Reach 1, 2, and 3, respectively. The bulk of these events occurred in 2018, and in contrast, there were 0 qualifying events beyond the 2 scheduled outmigration process flows in 2020 (Appendix B).

Stimulating Outmigration

Trap catch during the 2020 outmigration season was the lowest in the 9 years of trapping operations. The reason for such low productivity was not due to the limited number of outmigration flows, rather due to unintended consequences of a spill event that led to the highest peak flow observed since 1995. The basis for determining the relative effectiveness and overall necessity of outmigration process flows becomes apparent when the hydrologic record is applied to catch per hour data from the Sultan River smolt trap. For all species reported, trap catch was not correlated with discharge (Table 10). Figures 5 and 6 show the pooled regression for sub-yearling Chinook and chum, respectively, for all years sampled.

[1] In this context, "natural" relates to the combined hydrologic result of baseline project operations and accretion flows

Number: 1 Author: Anne Savery Date: 9/19/2022 10:09:08 PM

so the peak flow flushed all of the fish out?

Number: 2 Author: Anne Savery Date: 9/19/2022 10:10:59 PM

i'm not sure we expected to catch more fish during an outmigration flow, since the fish have more flowpaths to follow to outmigrate, also outmigration from reach 3 wouldn't neccessarily result in fish capture out the smolt trap

Number: 3 Author: Anne Savery Date: 9/19/2022 10:27:27 PM

you are comparing 2 natural systems to a highly regulated system that shaves every peak off

Table 10. Correlation coefficient of mean daily flow and daily catch per hour, by year, for salmonids captured at the Sultan River smolt trap, RM 0.2.

Correlation coefficient r^2 (mean daily flow vs daily catch per hour)					
Trap year	0+ Chin	Pink	Chum	0+ coho	1+ coho
2012	0.00	0.04	0.14	0.02	0.01
2013	0.01	[illegible]	0.08	0.02	0.01
2014	0.14	0.00	0.06	0.00	0.01
2015	0.02		0.06	0.07	0.10
2016	0.03	0.09	0.18	0.02	0.13
2017	0.37		0.20	0.00	0.00
2019	0.03		0.02	0.09	0.10
2020	0.01	0.05	0.08	0.02	0.14

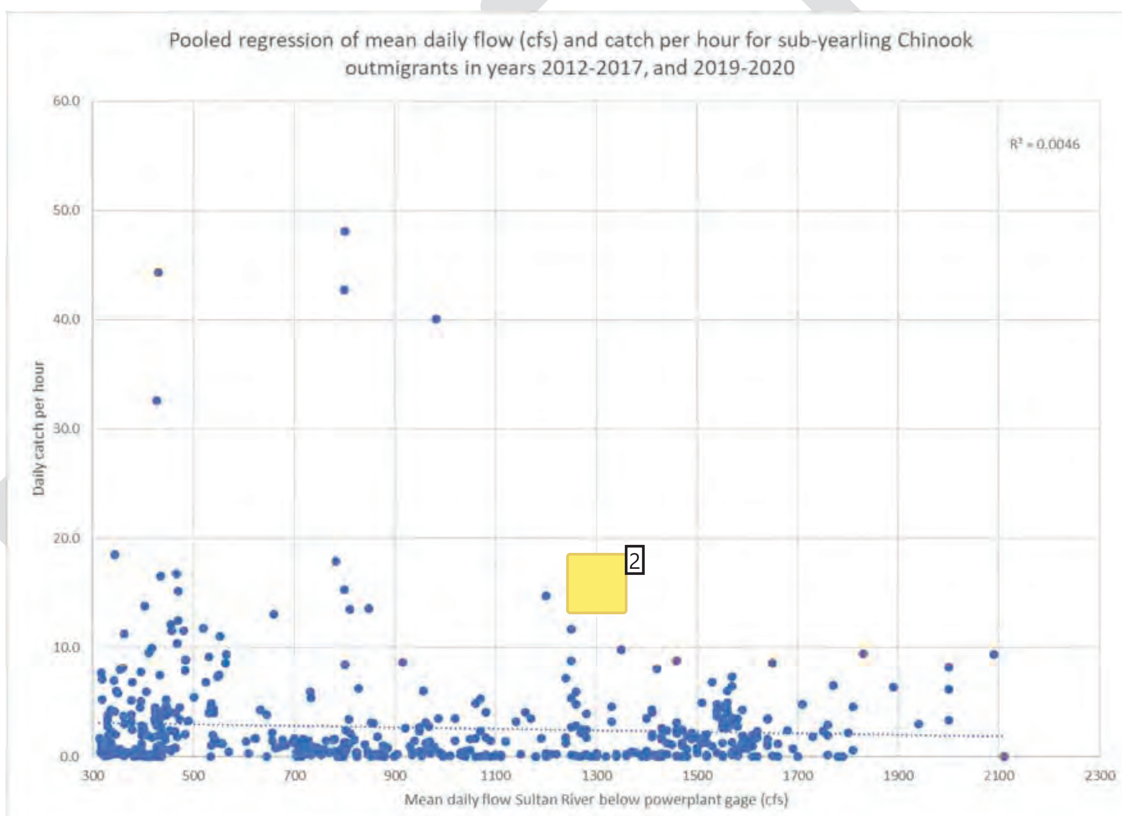

Figure 5. Pooled regression of mean daily flow (cfs) and catch per hour for sub-yearling Chinook outmigrants in year 2012-2017, and 2019-2020.

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Number: 1 Author: Anne Savery Date: 9/19/2022 10:28:21 PM

AS: how does this compare to other smolt traps

Number: 2 Author: Anne Savery Date: 10/10/2022 6:25:25 PM

KN: Should not be a linear regression. Should have normalized the data and used a nonlinear regression

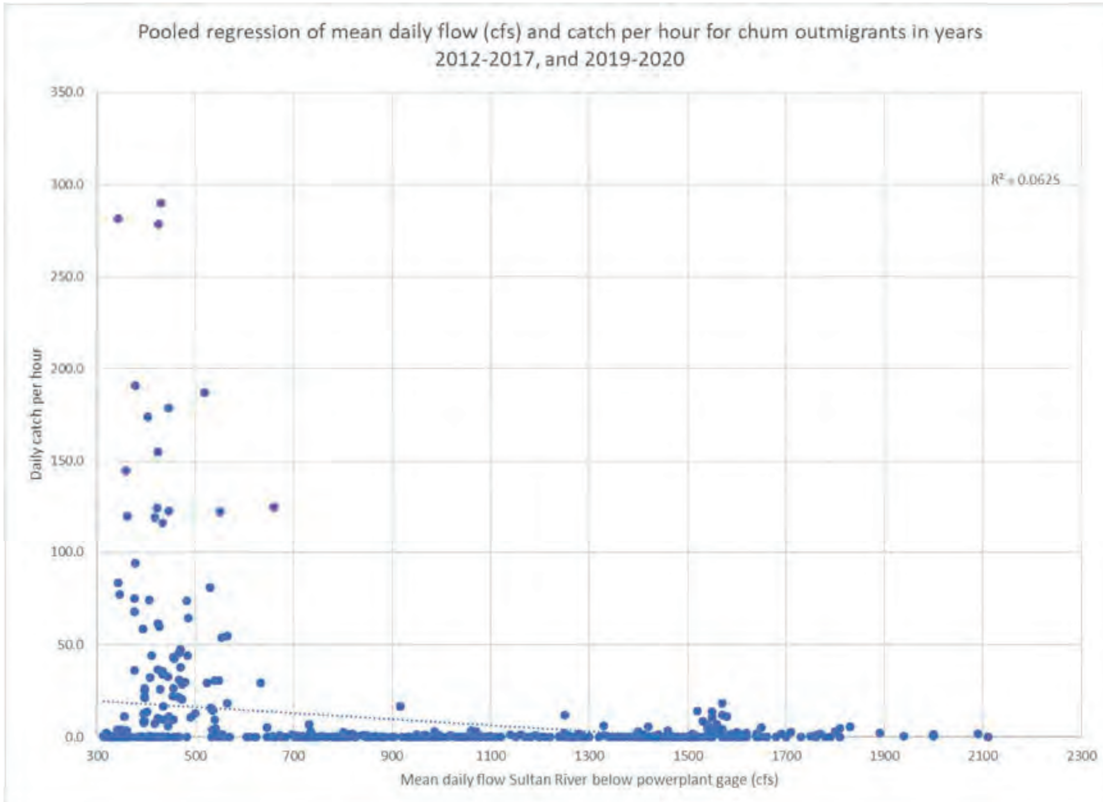

Figure 6. Pooled regression of mean daily flow (cfs) and catch per hour for sub-yearling chum outmigrants in year 2012-2017, and 2019-2020.

Figures 7–13 are select examples from years 2013–2019 that show weekly catch (focusing on sub-yearling Chinook, however, examples of chum, pink, and yearling coho are also provided), overlaid with mean daily hydrograph, and the Reach 1 minimum magnitude threshold for an outmigration process flow.

Number: 1 Author: Anne Savery Date: 10/10/2022 6:26:30 PM

KN: where is discharge point?

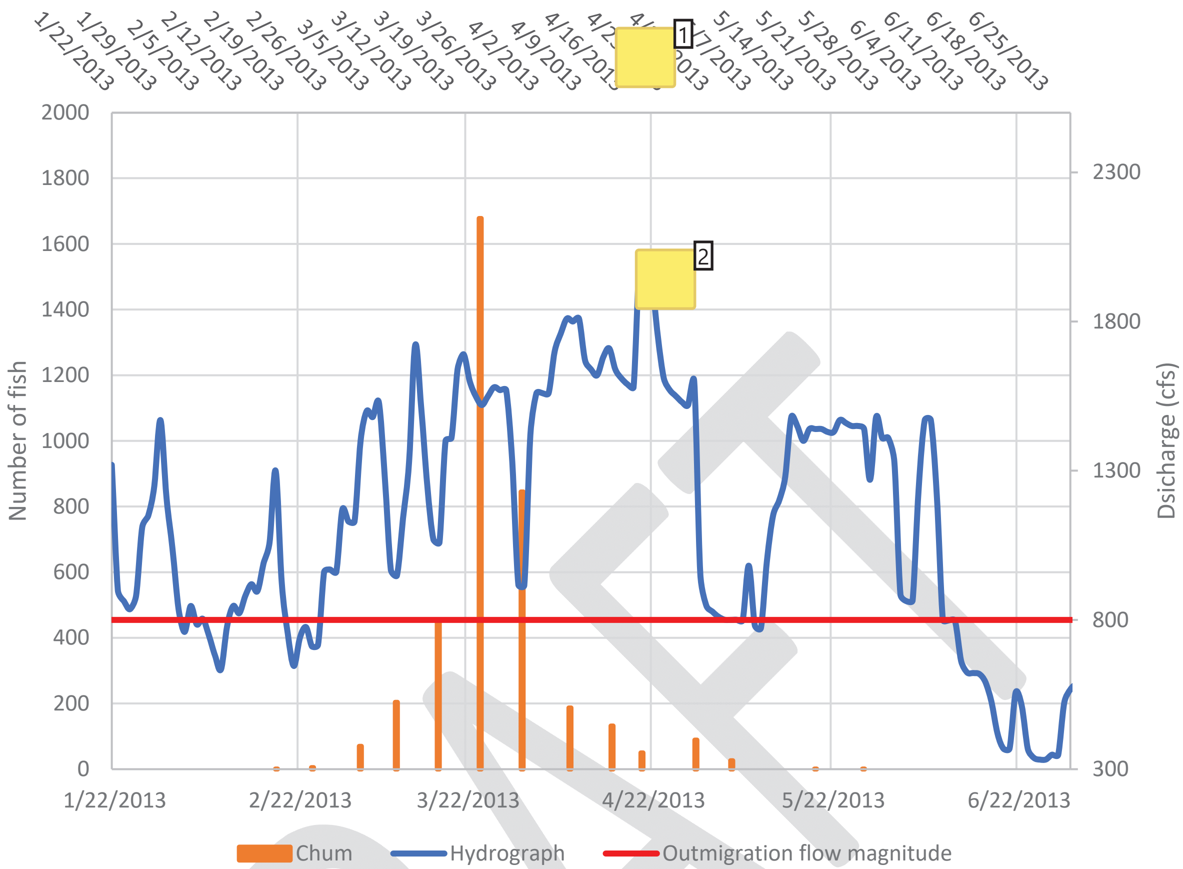

Figure 7. Weekly Chum outmigration and hydrograph of mean daily flow in the lower Sultan River, 2013.

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Number: 1 Author: Anne Savery Date: 9/20/2022 6:47:47 AM

AS: indicating the dates of the process flow would be useful

Number: 2 Author: Anne Savery Date: 10/10/2022 6:28:32 PM

KN: Does occur generally during the ascending limb of the hydrograph

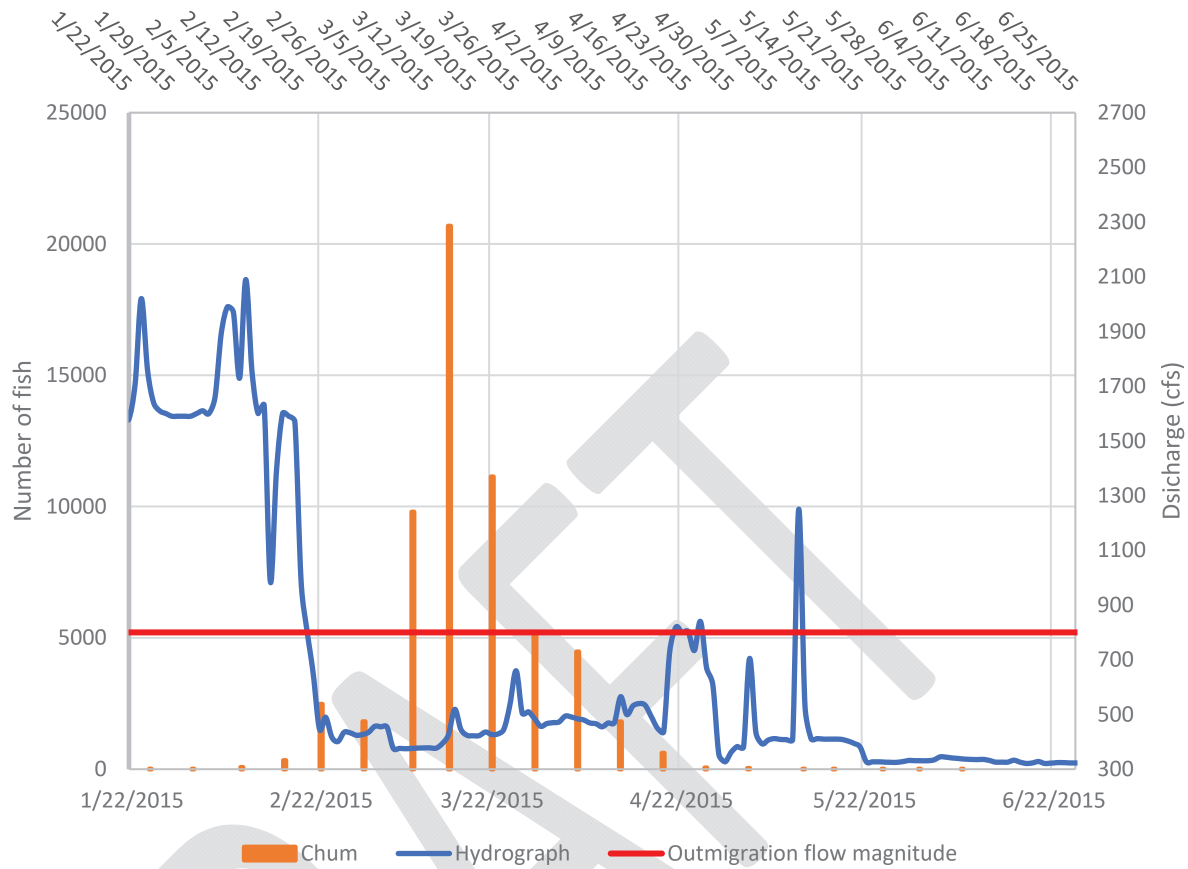
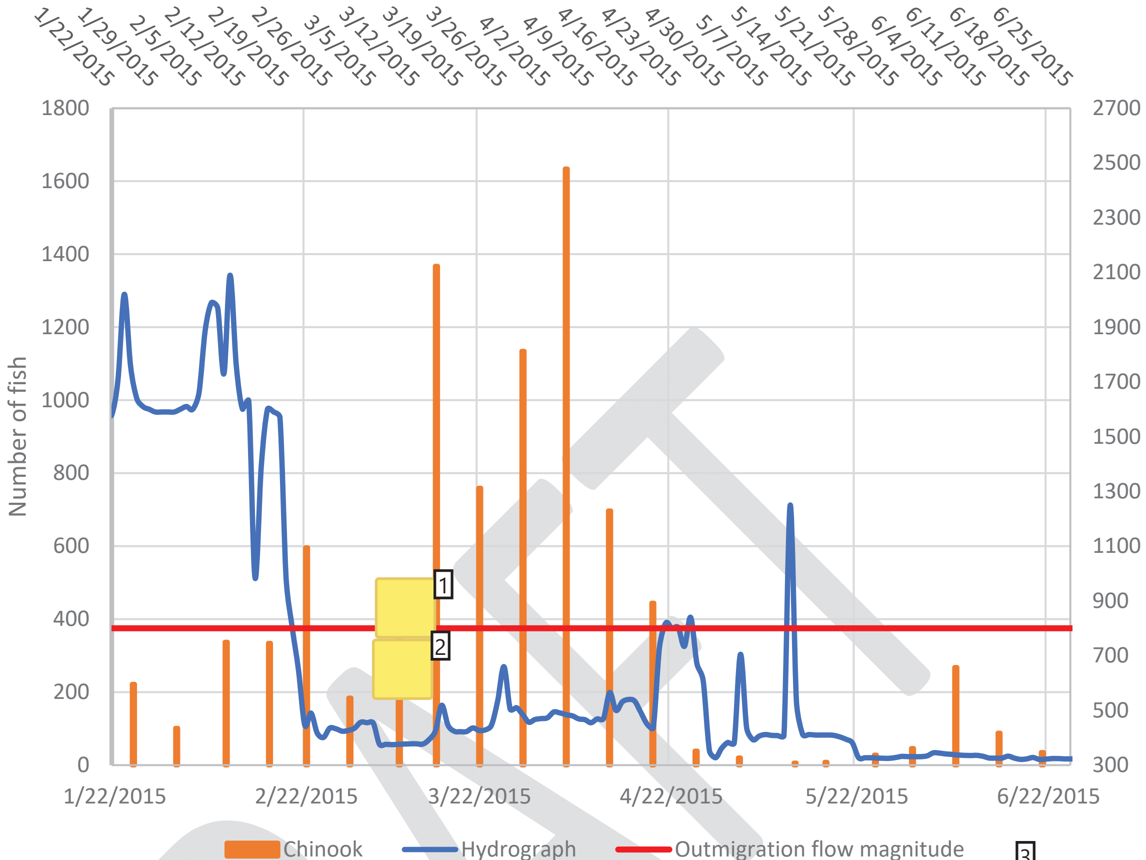


Figure 8. Weekly Chum outmigration and hydrograph of mean daily flow in the lower Sultan River, 2015.



3

escapement in 2012 was 917 - there is high catch in low flows

Figure 9. Weekly Chinook outmigration and hydrograph of mean daily flow in the lower Sultan River, 2015.

Number: 1 Author: Anne Savery Date: 9/19/2022 10:34:55 PM

what is the total number of fish estimated to have left the system during the outmigraiton period?

Number: 2 Author: Anne Savery Date: 9/19/2022 10:33:40 PM

aren't you catching more because the flow is low and you have the smolt trap in the thalweg?

Number: 3 Author: Anne Savery Date: 9/20/2022 7:06:42 AM

escapement in 2012 was 917 - there is high catch in low flows

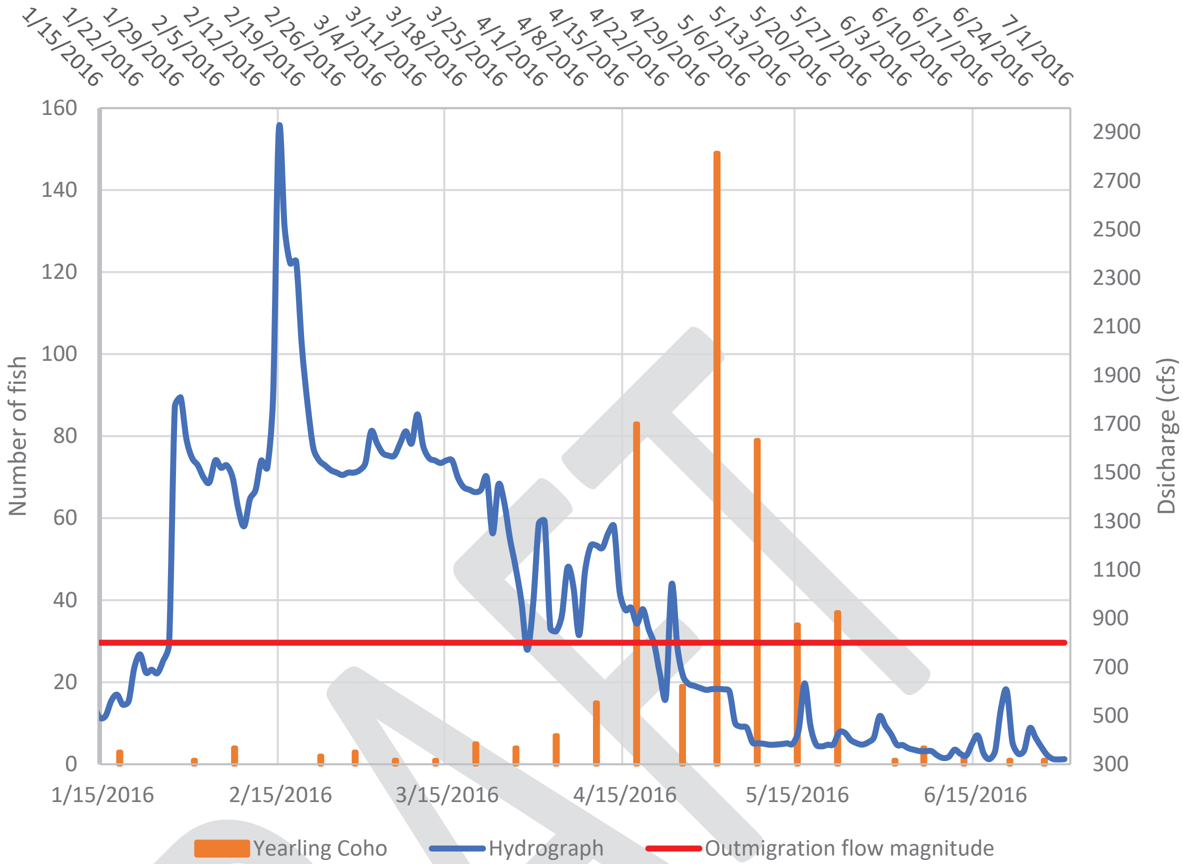


Figure 10. Weekly yearly Coho outmigr[illegible]n and hydrograph of mean daily flow in the lower Sultan River, 2016.

Number: 1 Author: Anne Savery Date: 10/10/2022 6:29:26 PM

KN: There doesn’t appear to be a sound reasoning for which dates are presented. Perhaps showing all of the years would be better?

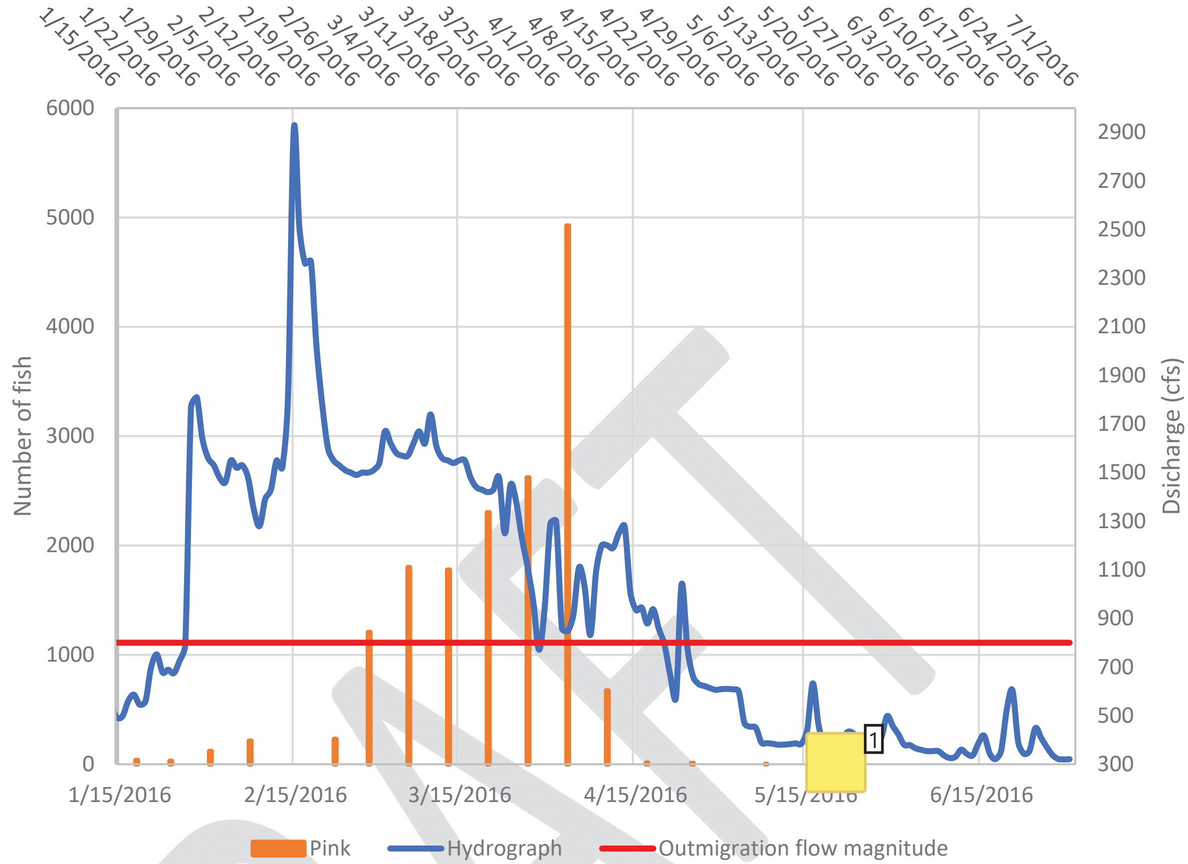
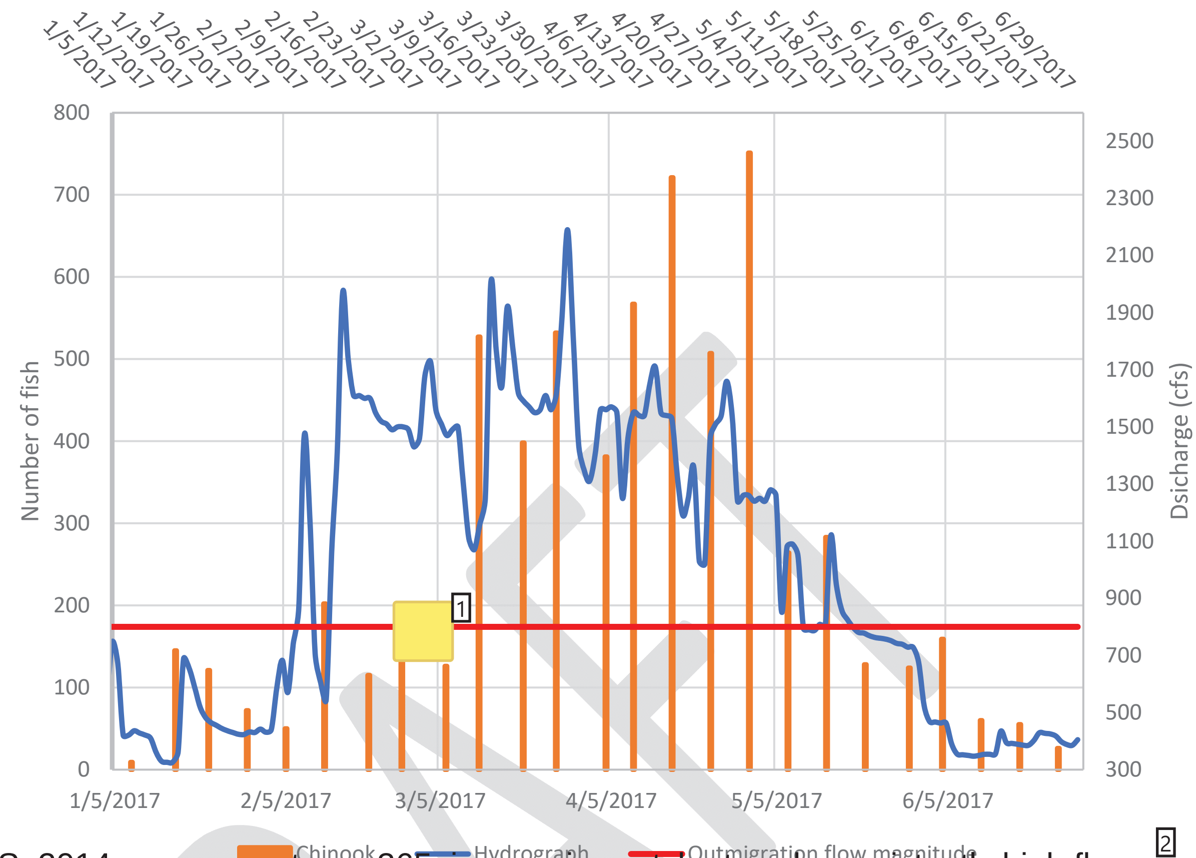


Figure 11. Weekly Pink outmigration and hydrograph of mean daily flow in the lower Sultan River, 2016.

Number: 1 Author: Anne Savery Date: 10/10/2022 6:32:58 PM

AS: how was pink mortality in the trap each year?



AS: 2014 escapement was 365, impressive catch at such consistently high flows - what was reason for frequency of high flows?

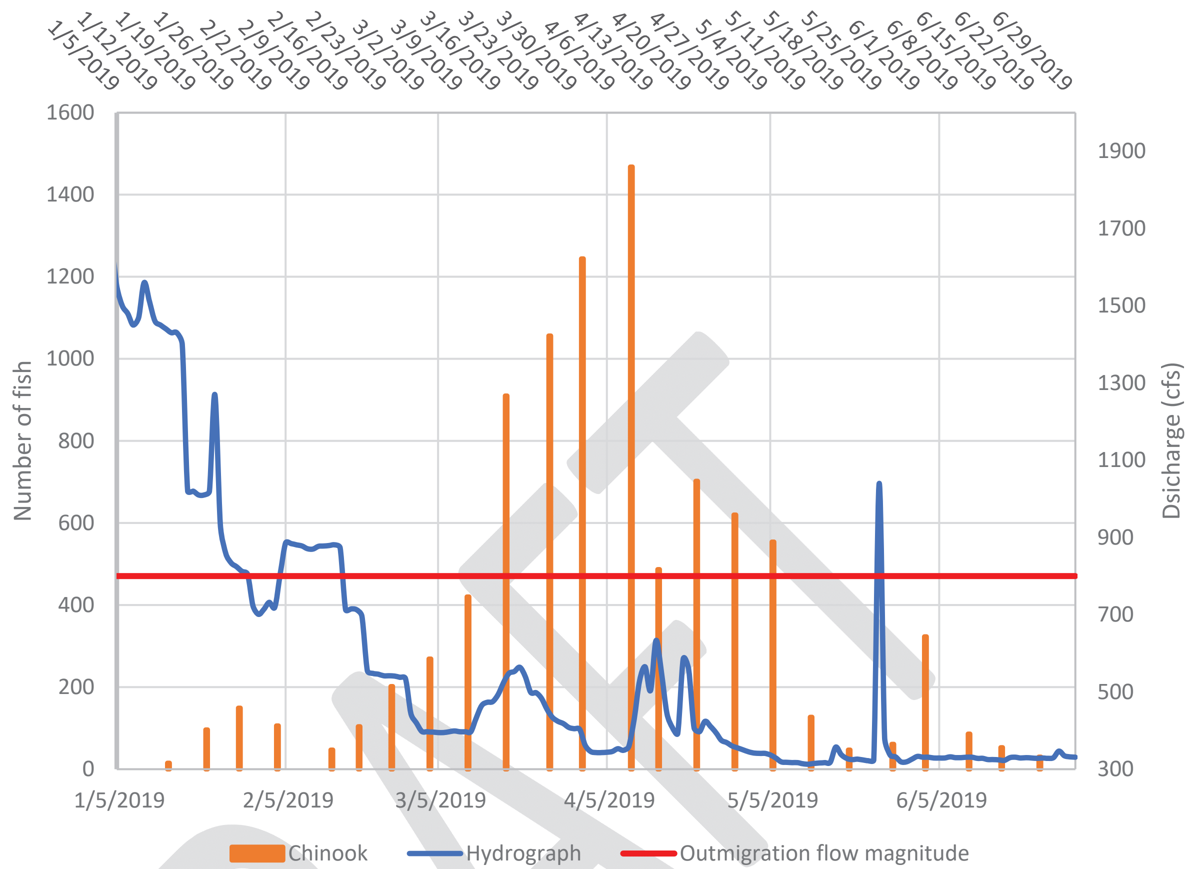
Figure 12. Weekly Chinook outmigration and hydrograph of mean daily flow in the lower Sultan River, 2017.

Number: 1 Author: Anne Savery Date: 9/19/2022 10:38:04 PM

AS: seems to be a lot of outmigration over the time period and during the magnitude of the outmigration flow

Number: 2 Author: Anne Savery Date: 10/10/2022 6:32:47 PM

AS: 2014 escapement was 365, impressive catch at such consistently high flows
- what was reason for frequency of high flows?



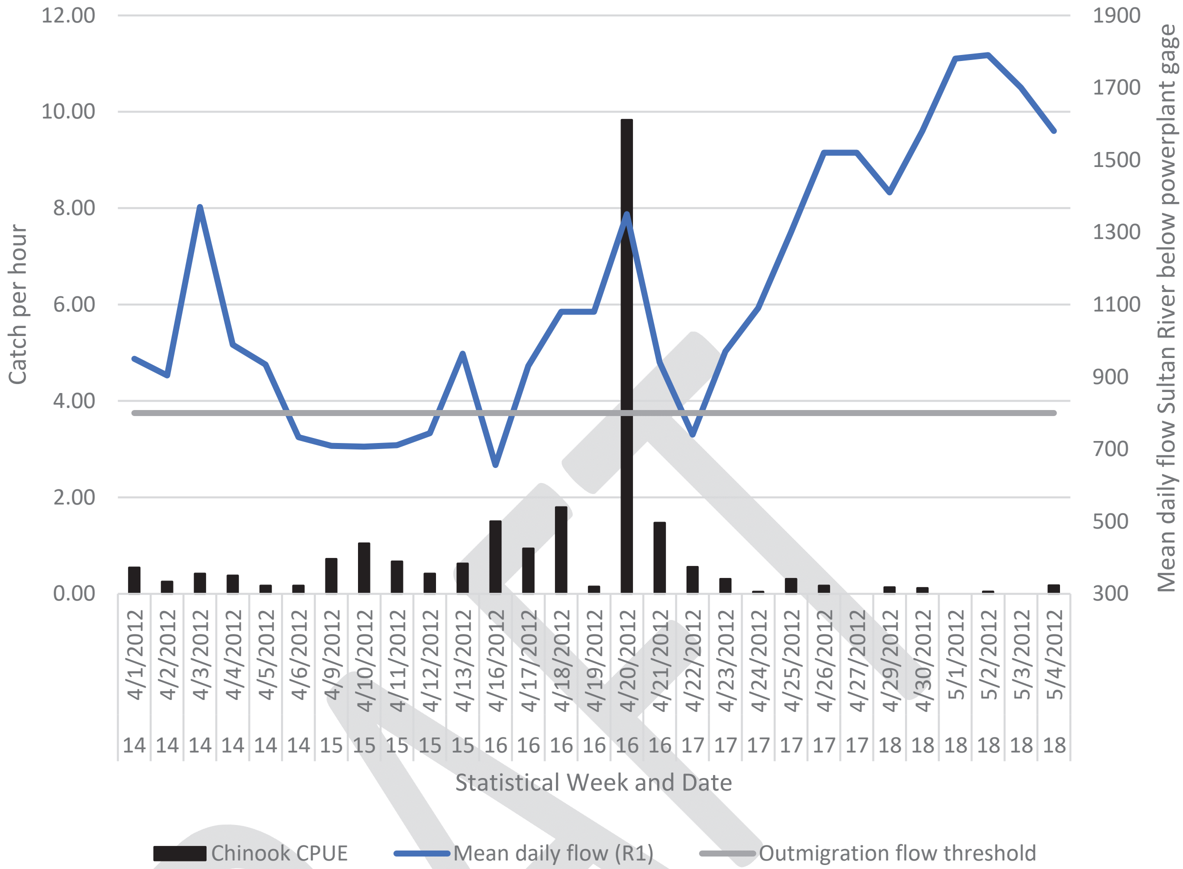
lots of fish, low flow, high catch escapement in 2016 was 687 (4 yr running avg is 450) [1]

Figure 13. Weekly Chinook outmigration and hydrograph of mean daily flow in the lower Sultan River, 2019.

The examples provided above are intended to show outmigration run-timing patterns in high and low-water years. In the absence of scour effects or other biological or physical perturbations, the outmigration timing of juvenile salmonids migrating from the Sultan River generally displays in a bell-shape, normalized distribution (Figures 7-10, 12, and 13). To further investigate the relationship between hydrology and catch and to potentially identify any preference for flow within the peak of the outmigration period, Figures 14–19 below zoom in on the two-week period before and after the peak of the sub-yearling Chinook outmigration in years 2012–2015, 2017, and 2019.

Number: 1 Author: Anne Savery Date: 9/20/2022 7:00:29 AM

lots of fish, low flow, high catch escapement in 2016 was 687 (4 yr running avg is 450)



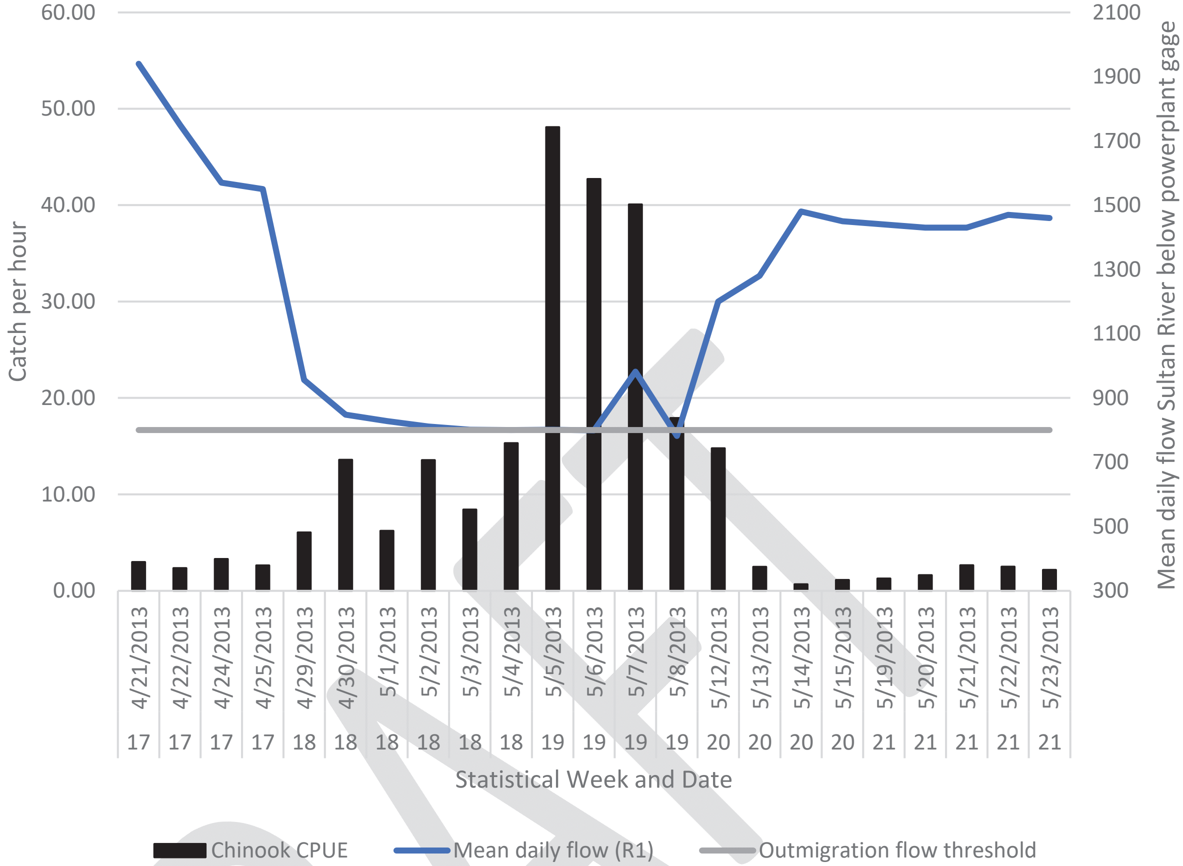
1

escapement in 2009 was 133 fish

Figure 14. Chinook catch per hour and mean daily flow during peak outmigration, 2012.

Number: 1 Author: Anne Savery Date: 9/20/2022 7:08:06 AM

escapement in 2009 was 133 fish



escapement in 2009 133,

Figure 15. Chinook catch per hour and mean daily flow during peak outmigration, 2013.

Number: 1 Author: Anne Savery Date: 9/20/2022 7:23:54 AM

escapement in 2009 133,

Number: 2 Author: Anne Savery Date: 10/10/2022 6:34:05 PM

KN: Right during coho migration? Very high rate of catch.

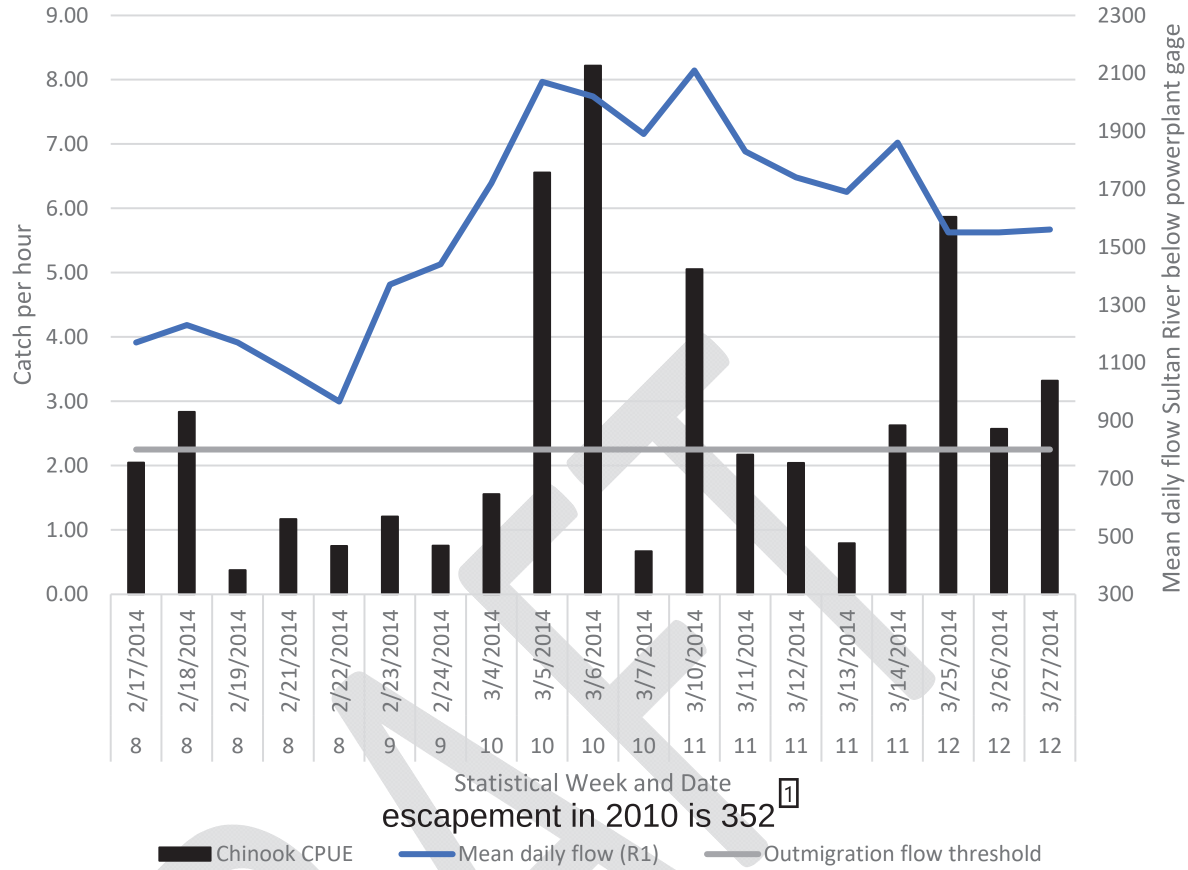
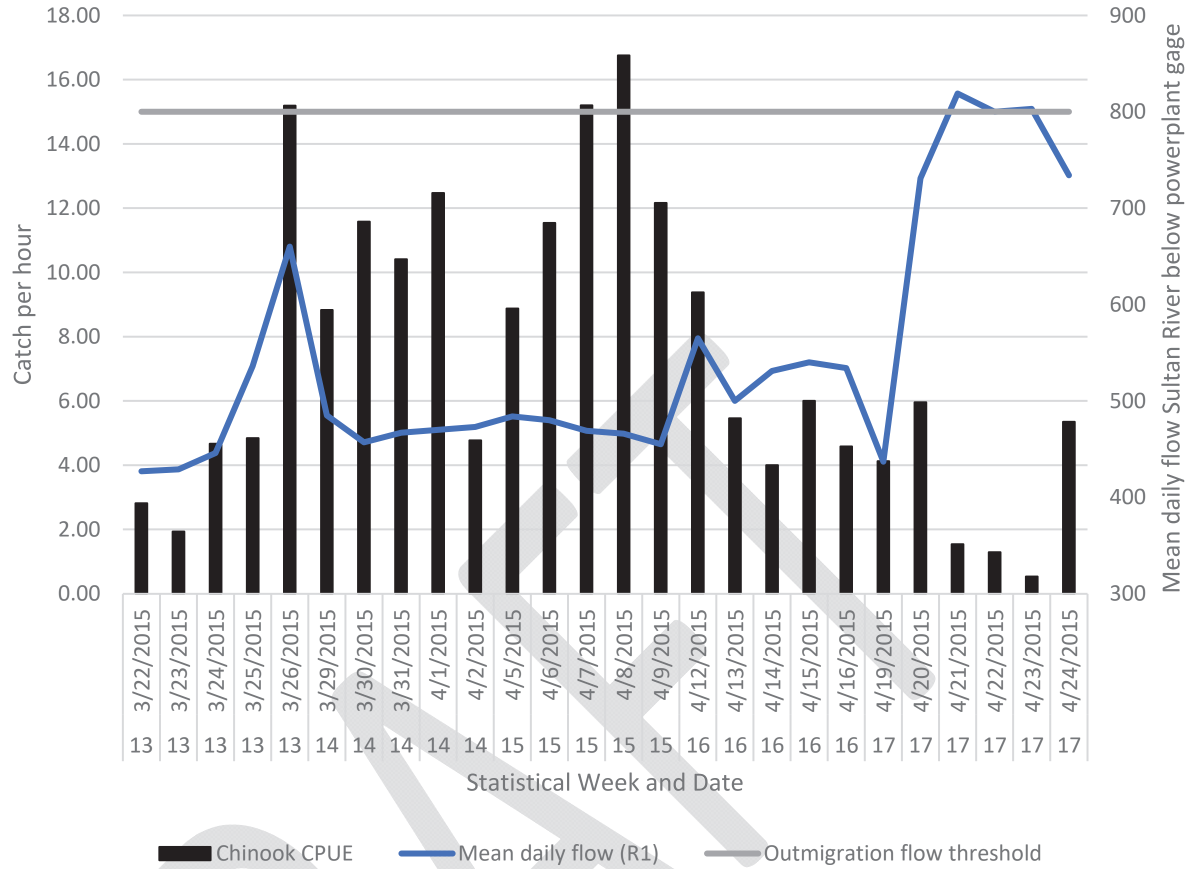


Figure 16. Chinook catch per hour and mean daily flow during peak outmigration, 2014.

Number: 1 Author: Anne Savery Date: 9/20/2022 7:24:11 AM

escapement in 2010 is 352



escapement 2012 is 975[1]

Figure 17. Chinook catch per hour and mean daily flow during peak outmigration, 2015.

Number: 1 Author: Anne Savery Date: 9/20/2022 7:25:31 AM

escapement 2012 is 975

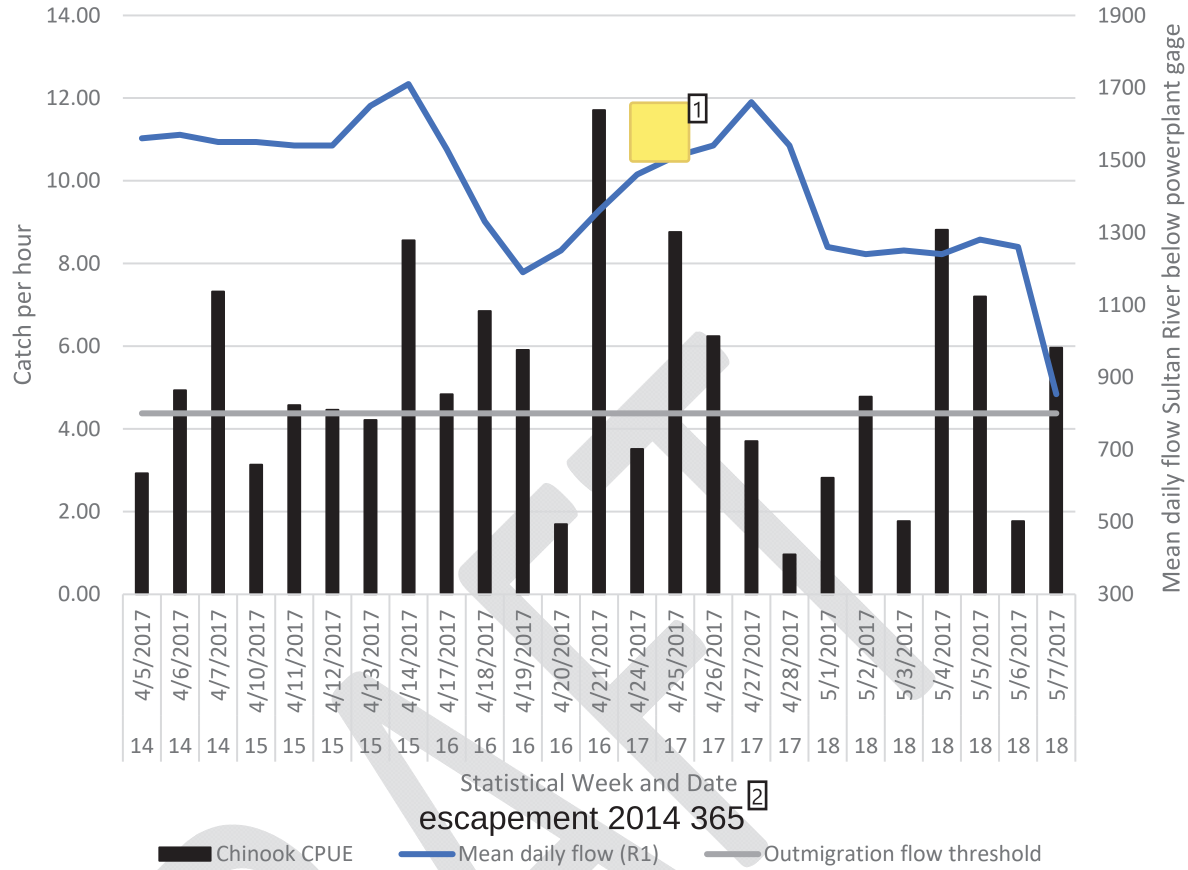


Figure 18. Chinook catch per hour and mean daily flow during peak outmigration, 2017.

Page: 35

Number: 1 Author: Anne Savery Date: 9/20/2022 6:52:54 AM

AS: interesting there is no real peak, but a long and late outmigration period Was this a cold year?

Number: 2 Author: Anne Savery Date: 9/20/2022 7:26:05 AM

escapement 2014 365

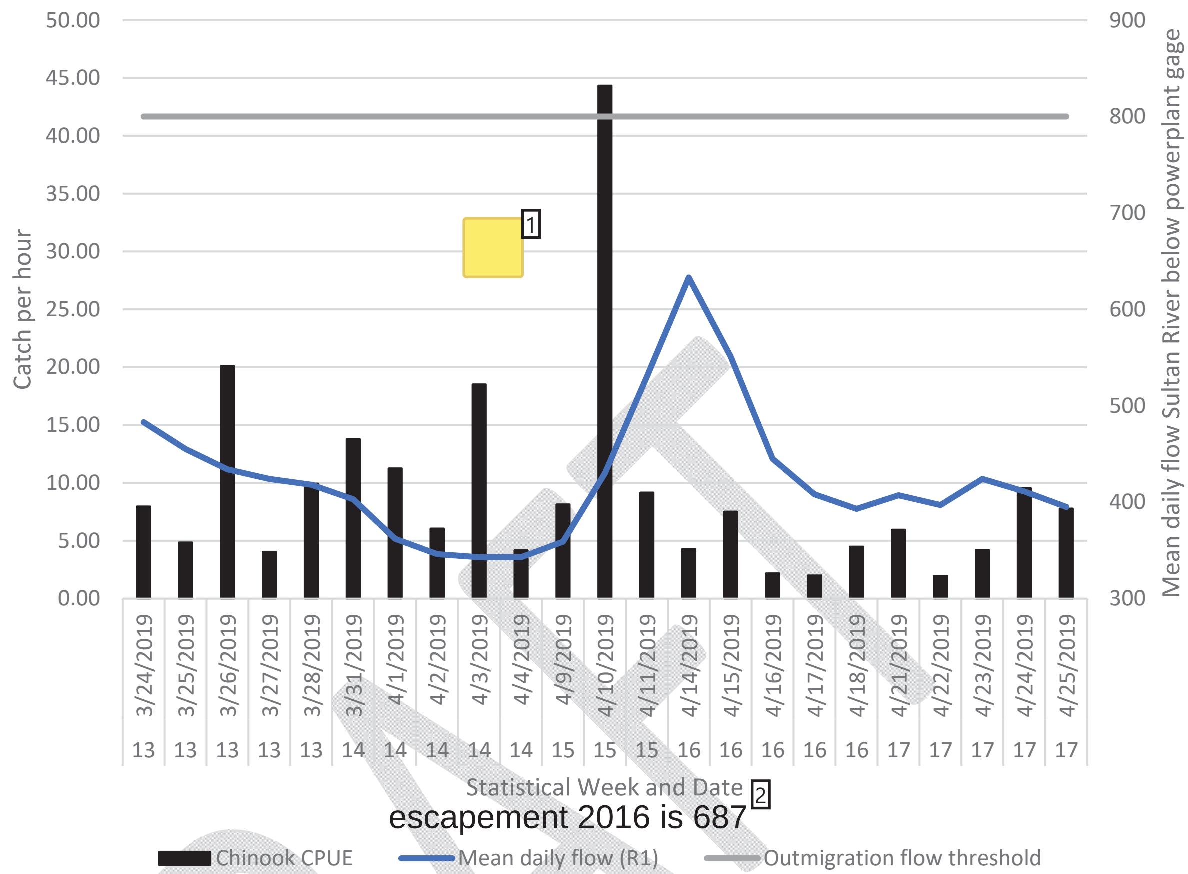


Figure 19. Chinook catch per hour and mean daily flow during peak outmigration, 2019.

These figures provide additional evidence that highlights the insignificance of flow on trap catch. In the data, there are however discrete instances where flow and catch correlate. These data points likely represent a coincidence where an increase in flow occurs during peak migration rather than from the peak flow stimulating juvenile salmonid outmigration. These examples suggest hydrologic conditions in the Sultan River during the entire outmigration period provide sub-yearling Chinook, and other juvenile salmonids sufficient flow to stimulate their downstream migration without concern over delay or freshwater residualization. This conjecture is further supported by data which indicates juvenile salmonid outmigration timing is similar in low and high-water years.

Effect of Outmigration Flows on Catch

Smolt trap catch data from the April 2012 outmigration process flow is provided in [illegible]e 11. This data highlights catch immediately before, during, and after an outmigration process flow. Noteworthy during this event was the number and overall percent of unbuttoned and dead pink salmon. While trap catch was not correlated to discharge (Figures 5 and 6), data presented in Table 11 suggests that higher flows during outmigration releases can forcefully push fish out and result in an increased incidence of vulnerable yolk-sac fry compared to the level of incidence at lower flows.

Number: 1 Author: Anne Savery Date: 9/20/2022 6:42:14 AM

AS:Here it seems that chinook are cueing to the rising hydrograph and outmigratingon 4/10?

Number: 2 Author: Anne Savery Date: 9/20/2022 7:26:39 AM

escapement 2016 is 687

Number: 3 Author: Anne Savery Date: 10/10/2022 6:35:55 PM

KN: I would not make this claim. The deaths could be due to debris in the smolt trap, not due to process flow. AS: You present one incident of this occuring.

Are there other years this happened?

Table 11. Catch Data from Smolt Trap Operation, Lower Sultan River, April 2012.

Set #	Cone Down (Date/ Time)	Cone Up (Date/ Time)	Hours Fished	Total pink Live	Live pink w/yolk	Pink dead	# live pink w/yolk + dead	% pink live w/yolk + dead	Comments /Mean discharge during set (RM 4.5 / RM 9.6)
50	4/1/12 8:00 AM	4/2/12 8:00 AM	24.0	208	11	3	14	7%	958 / 272 cfs
51	4/2/12 8:00 AM	4/3/12 8:00 AM	24.0	31	2	1	3	10%	913 / 156 cfs
52	4/3/12 8:00 AM	4/3/12 8:45 AM	0.8	28	4	0	4	14%	moderate debris (alder casings); beginning of process flow (1,535 / 171 cfs)
53	4/3/12 8:45 AM	4/3/12 10:25 AM	1.7	139	20	0	20	14%	moderate debris (alder casings); process flow (1,544 / 335 cfs)
54	4/3/12 10:25 AM	4/3/12 11:55 AM	1.5	79	12	1	13	16%	moderate debris (alder casings); proc[illegible]06 / 557 cfs)
55	4/3/12 11:55 AM	4/3/12 4:45 PM	4.8	1451	167	22	189	13%	heav[illegible](alder casings); process flow (1,976 / 557 cfs)
56	4/3/12 4:45 PM	4/3/12 7:30 PM	2.8	428	14	2	16	4%	[illegible]s, river dropping (1,613 / 452 cfs)
57	4/3/12 7:30 PM	4/4/12 8:00 AM	12.5	89	4	1	5	6%	1,018 / 199 cfs
58	4/4/12 8:00 AM	4/5/12 8:00 AM	24.0	63	7	0	7	11%	968 / 143 cfs
59	4/5/12 8:00 AM	4/6/12 8:00 AM	24.0	136	5	0	5	4%	879 / 123 cfs
60	4/6/12 8:00 AM	4/7/12 8:00 AM	24.0	49	0	0	0	0%	734 / 121 cfs
61	4/9/12 3:20 PM	4/10/12 8:00 AM	16.7	31	0	1	1	3%	704 / 121 cfs
62	4/10/12 8:00 AM	4/11/12 8:00 AM	24.0	158	0	0	0	0%	708 / 121 cfs
63	4/11/12 8:00 AM	4/12/12 8:00 AM	24.0	101	0	1	1	1%	720 / 121 cfs
64	4/12/12 8:00 AM	4/13/12 8:00 AM	24.0	74	0	0	0	0%	784 / 123 cfs
65	4/13/12 8:00 AM	4/14/12 8:00 AM	24.0	222	0	0	0	0%	902 / 122 cfs

The comments column in Table 11, identifies mean daily discharge at the top of Reach 1 (USGS Streamflow Gage No. 12138160, RM 4.5) and Reach 2 (USGS Streamflow Gage No. 12137800, RM 9.6) during each trap set. While it is impossible to determine the river reach from which the unbuttoned pink salmon originated, the flow data provides a potential peak flow avoidance volume with a prospective goal aimed at reduc[illegible]or eliminating, when possible, the unintended forcing out effect from outmigration process flows.

In broader examples, data from the Sultan River smolt trap allow the insight into catch of downstream juvenile salmonids before, during, an[illegible]er outmigration process flows. This section contains Figures 20–26 which illustrate catch per week as background and visually compare to catch per hour during outmigration process flows in years 2012–2014, 2017, and 2019.

Number: 1 Author: Anne Savery Date: 9/20/2022 7:27:59 AM

Are there other years this happened?

Number: 2 Author: Anne Savery Date: 10/10/2022 6:37:14 PM

KN: deaths due to debris in trap are common in smolt trapping; rather than attributing to PF

Number: 3 Author: Anne Savery Date: 9/28/2022 1:14:46 PM

AS: do you have other years this happened? what about other species?

were there other years the flows occured and you didn't have the mortality

did a lot of pinks return in 2012?   I think this flow is higher than required?

Number: 4 Author: Anne Savery Date: 9/28/2022 1:17:14 PM

AS: it might be possible that the flow magnitudes you are fishing may miss the majority of the outmigration eg the threshold flows are higher than what you are fishing

Number: 5 Author: Anne Savery Date: 9/20/2022 7:28:55 AM

AS: it seems there may be a more complex story here. Temperature has not been considered as a factor for determination of smolt outmigration
Previous year escapement not taken inot account

it seems based on most years that outmigration is later in the season than the process flow is initiated.

Also the PUD may be discounting other years that flows were high naturally, not a process flow when looking at pink mortality

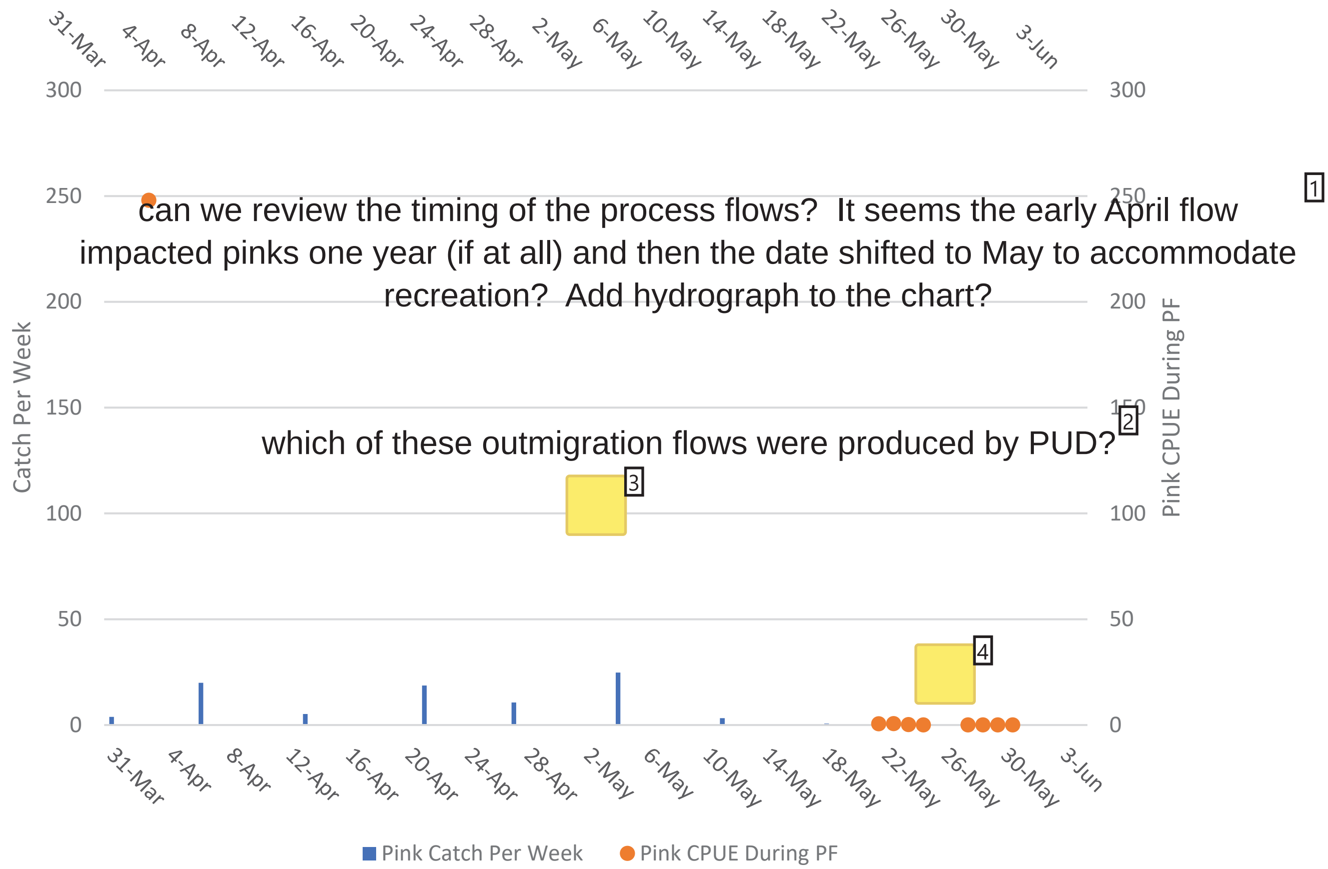


Figure 20. Pink catch per hour by week and catch per hour during outmigration flows, 2012.

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Number: 1 Author: Anne Savery Date: 10/10/2022 6:41:00 PM

can we review the timing of the process flows? It seems the early April flow impacted pinks one year (if at all) and then the date shifted to May to accommodate recreation? Add hydrograph to the chart?

Number: 2 Author: Anne Savery Date: 10/10/2022 6:41:13 PM

which of these outmigration flows were produced by PUD?

Number: 3 Author: Anne Savery Date: 9/28/2022 1:18:43 PM

AS: it seems you missed the peak pink outmigration. or very few fish returned. Plus, didn't you say there was a process flow on april 3-4 with pink mortalities? where is that reflected in this chart?

Number: 4 Author: Anne Savery Date: 9/28/2022 1:20:12 PM

AS: I don't think all these process flows (orange dots, what is the magnitude and origin project operations vs. rain) were required by the license? They are naturally occurring? And they have no biological tie in to outmigration of the species (timing is wrong)

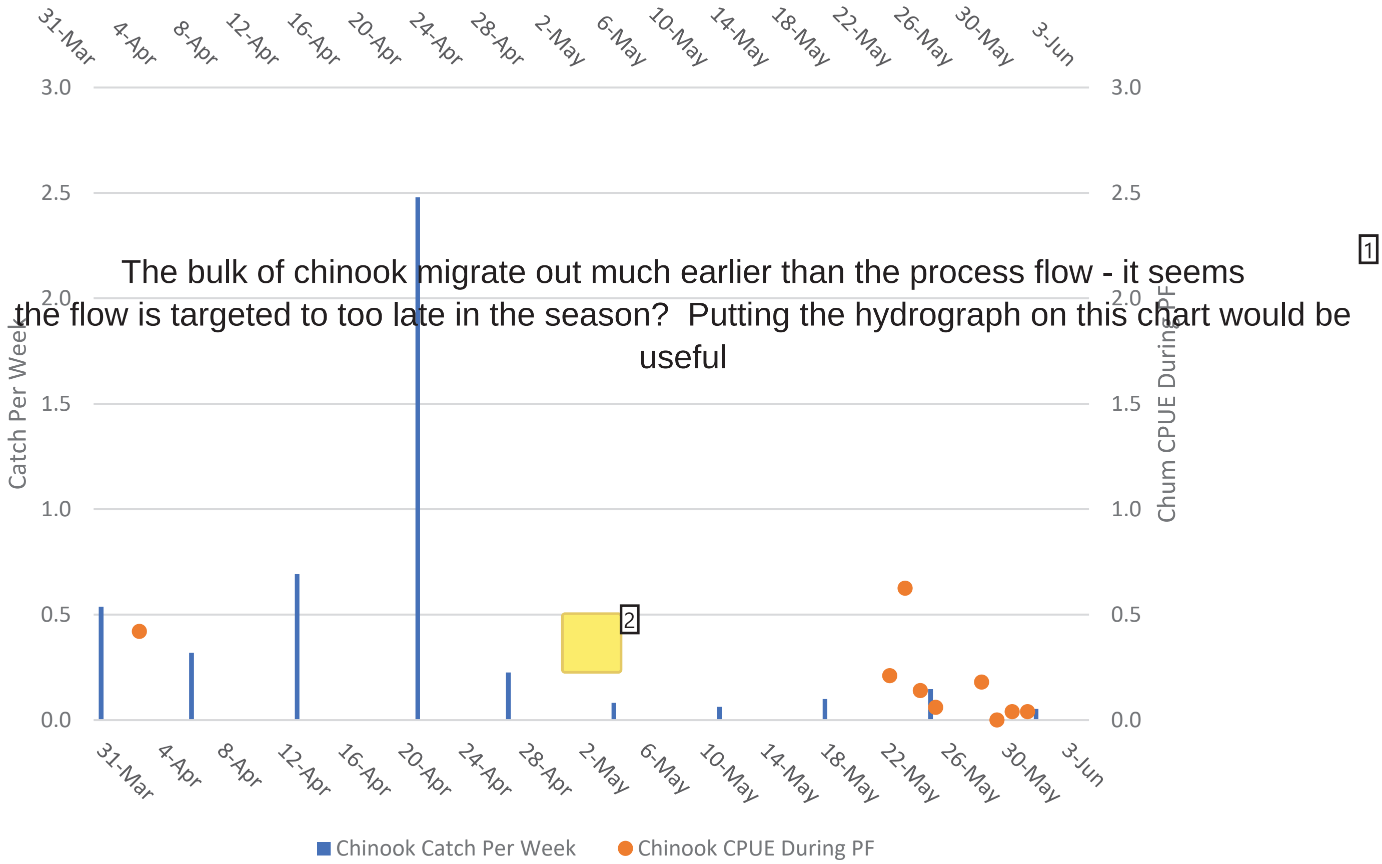


Figure 21. Chinook catch per hour by week and catch per hour during outmigration flows, 2012.

Number: 1 Author: Anne Savery Date: 9/28/2022 1:21:18 PM

The bulk of chinook migrate out much earlier than the process flow - it seems
the flow is targeted to too late in the season? Putting the hydrograph on this chart would be
useful

Number: 2 Author: Anne Savery Date: 9/28/2022 1:21:25 PM

which of these flows were released by Snohomish PUD? April 3? . any others? what is the origin of the other process flows? Project Operations?
Many of these flows are too late

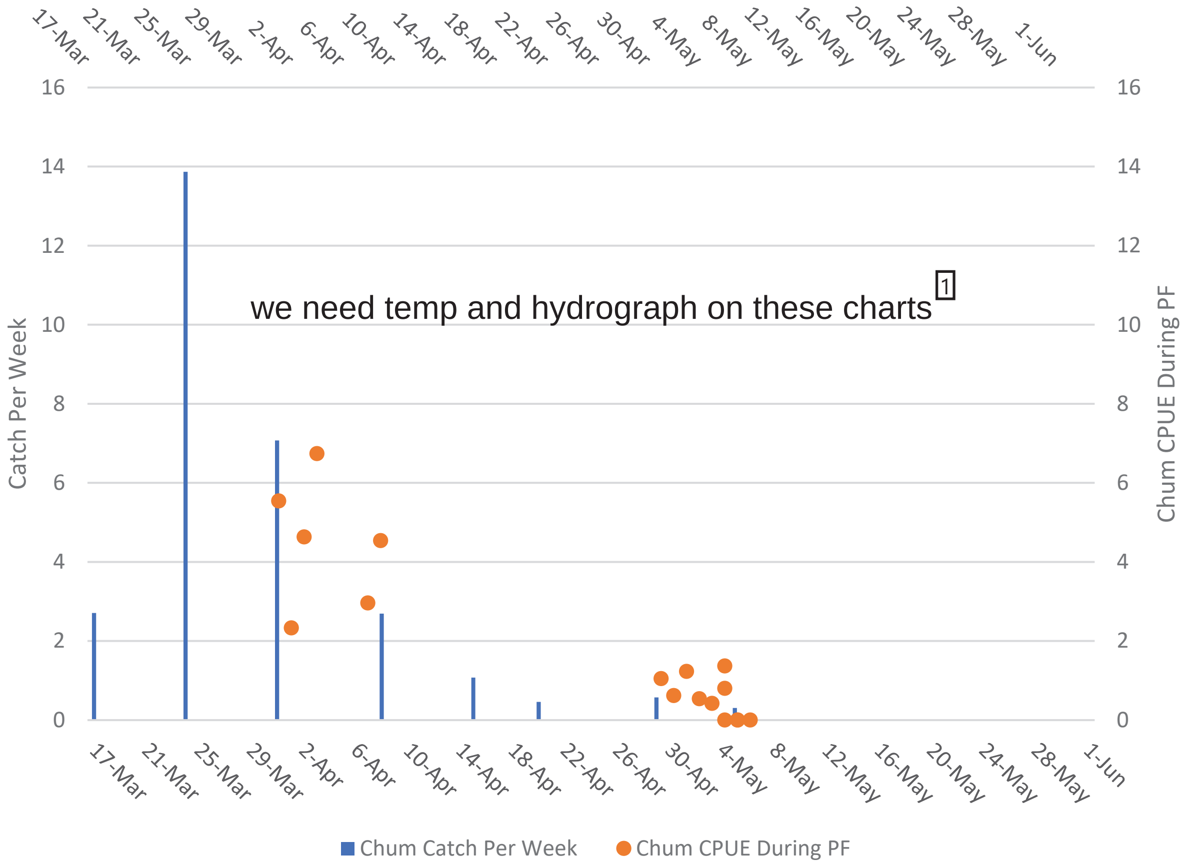


Figure 22. Chum catch per hour by week and catch per hour during outmigration flows, 2012.

Number: 1 Author: Anne Savery Date: 9/28/2022 1:23:13 PM

we need temp and hydrograph on these charts

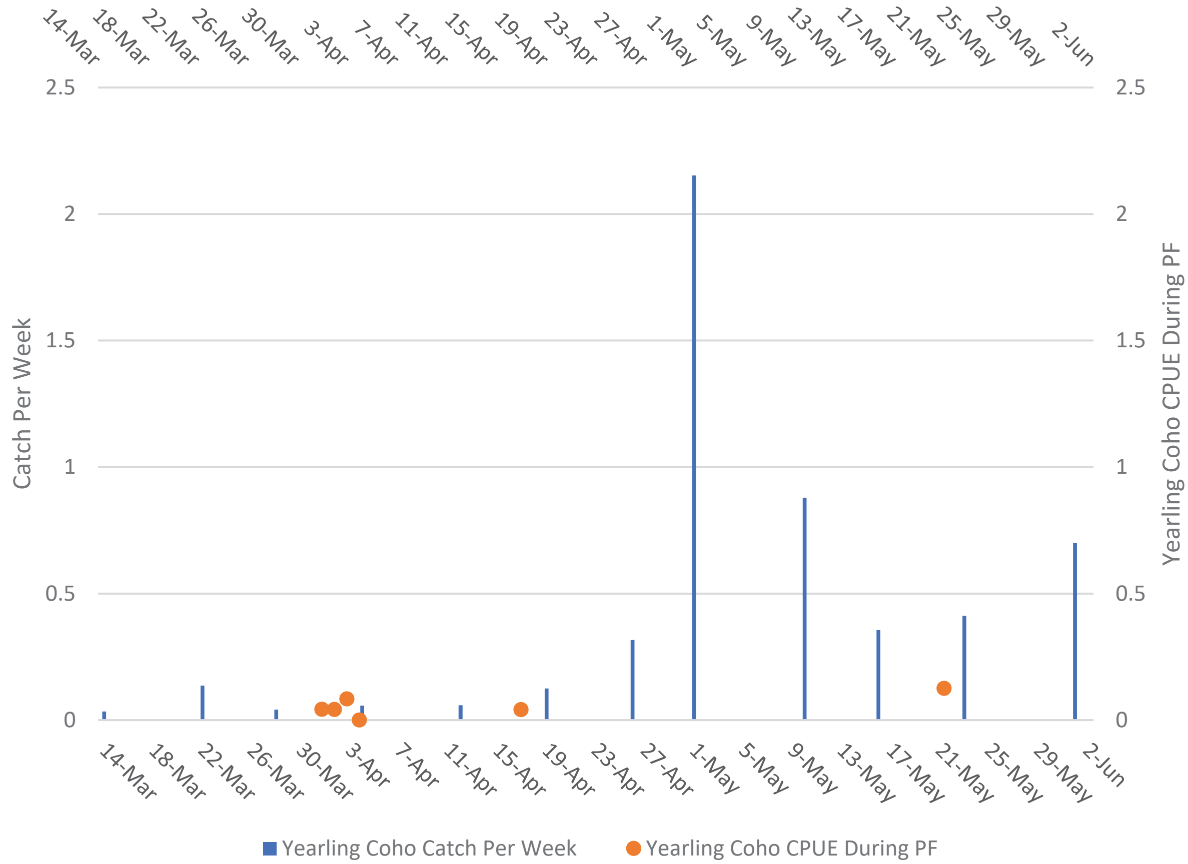


Figure 23. Yearling coho catch per hour by week and catch per hour during outmigration flows, 2014.

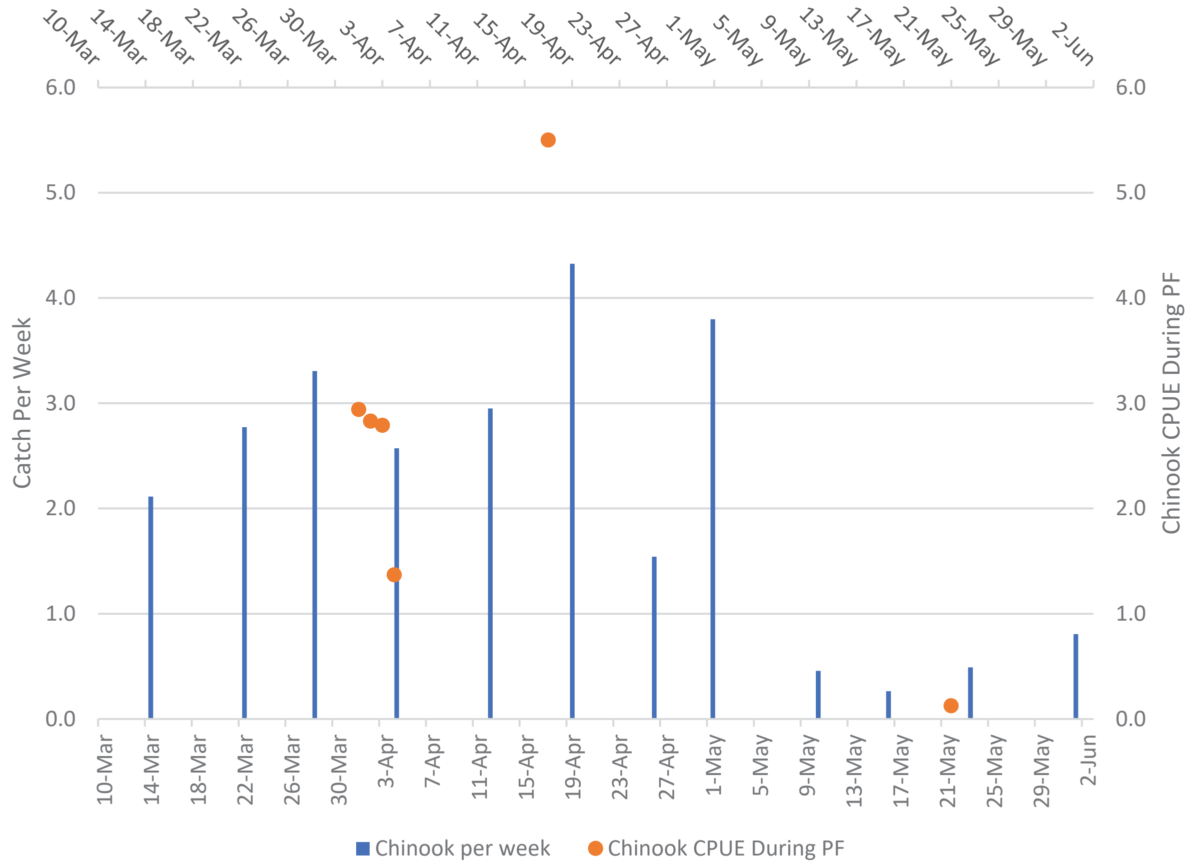


Figure 24. Chinook catch per hour by week and catch per hour during outmigration flows, 2014.

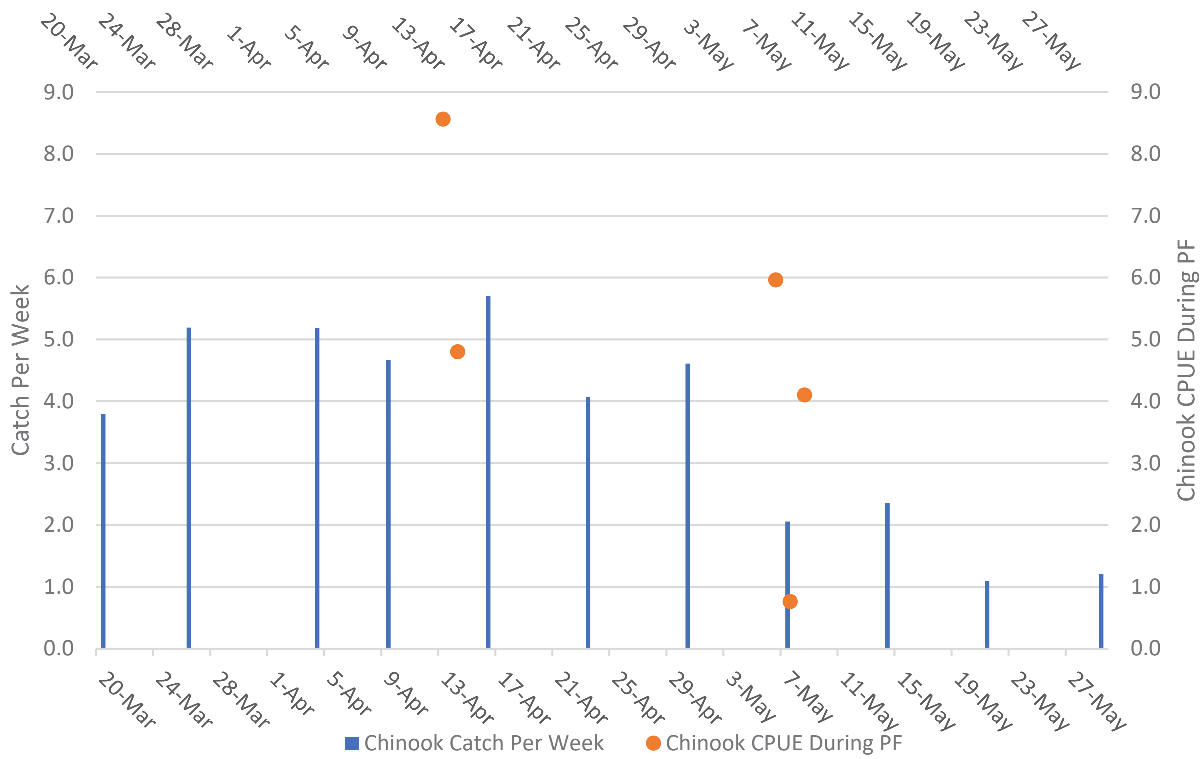


Figure 25. Chinook catch per hour by week and catch per hour during outmigration flows, 2017.

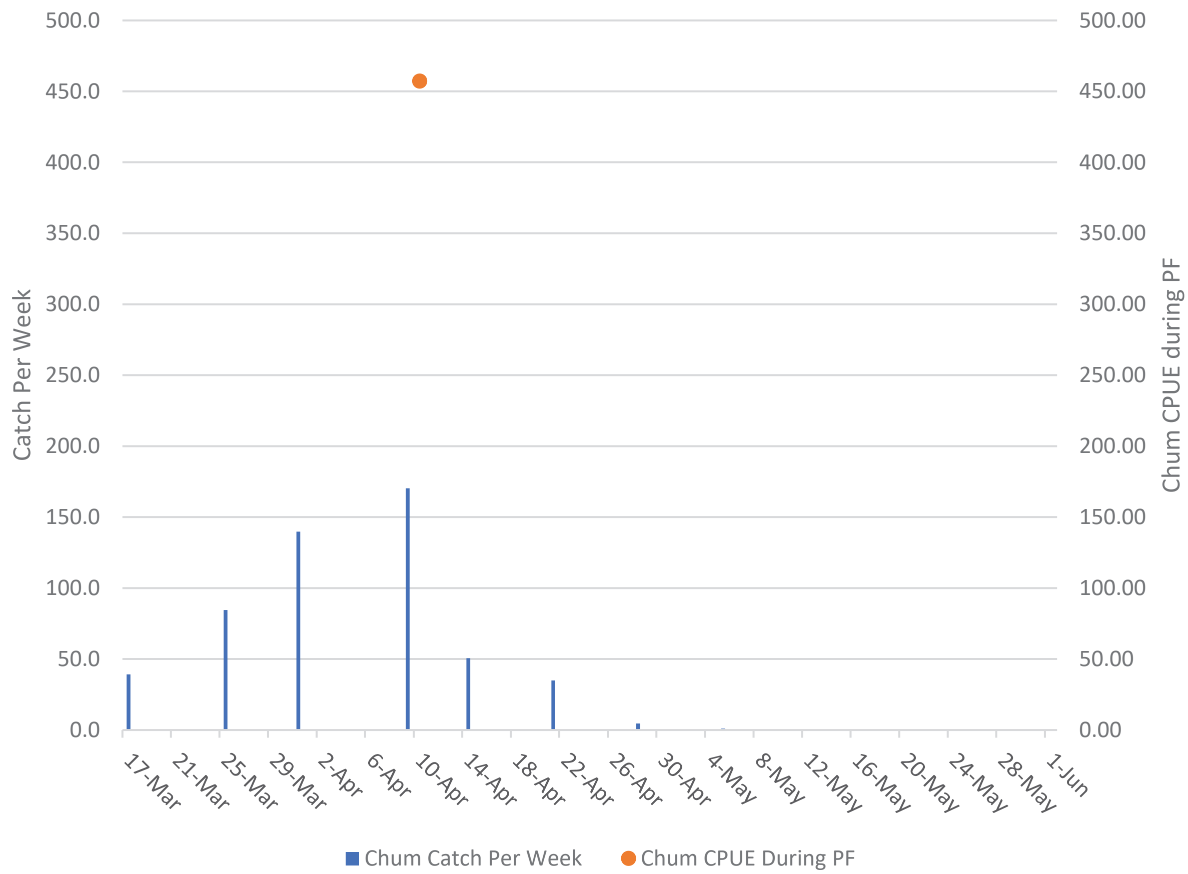


Figure 26. Chum catch per hour by week and catch per hour during outmigration flows, 2012.

Catch per hour during process flows generally resembles the weekly catch values, however, catch can also vary considerably based on species and on timing of the outmigration release. For catch during outmigration releases to be similar to the relative catch of the same week, the release has to occur when the species are actively present in the river and are either in active migration mode, or fish are not actively migrating and instead are forced out prematurely. The bulk of yearling coho, for example migrate in May, therefore, catch during an outmigration process flow in April results in very few yearling coho (Figure 23). Similarly, catch of chum and pink salmon does not occur in outmigration process flows conducted in mid to late May as these species have already migrated out of the system (Figure 20).

2.2.5. Unforeseen Consequences

The outmigration flow program aimed to increase juvenile salmonid survival and provide elements of a more normative hydrograph in the Sultan River compared to existing conditions. While much of the data analyzed is not concerning, unforeseen consequences such as forcing out unbuttoned yolk-sac fry is a primary concern. Additional unforeseen consequences relate to spawning disruption of ESA-listed steelhead. Pulse flows intended to stimulate juvenile outmigration occur during the prime steelhead spawning window (March – June), and likely disrupt active spawning of an ESA-listed species (T. Cox, WDFW, personal communication, 2022; JHP Whitewater Recreation Plan, 2019). Considering the predominantly confined, high gradient channel morphology in the upper river, the disruption associated with an all reaches release is likely most pronounced in the upper reaches where increases in stream power are greatest. While the timing of these scheduled releases does occur during the outmigration season, the volume of water in the Sultan River during this time of year is already normative based on hydrology comparisons with the Skykomish and Pilchuck rivers (Appendices A and B) and provides stimulation without the need of having to conduct outmigration pulse flows (Figures 5 and 6).

2.2.6. Adaptive Actions Undertaken

No adaptive management was implemented as part of this program.

2.2.7. Recommended Modifications

Data gathered and observations made during the first ten years of License implementation provide three conclusions related to assessing the value of the outmigration process flow program.

- Even in low water years spring hydrology in the Sultan River is conducive to stimulate juvenile salmonid outmigration without the need for outmigration pulse flows;
- the compliance target for duration only accounts for 0.8% of the outmigration season (April and May; 12 hours / 1,464 hours); and
- some outmigration process flows can have the unintended consequence of forcing juvenile salmonids out prior to their own volition, and likely disrupts steelhead spawning.

Overall, the implementation of the outmigration process flow program has provided limited biological and hydrologic benefit as it was originally assumed to provide. The PFP identified three benefits the outmigration program would provide: to stimulate juvenile salmonid outmigration, result in increased survival of juvenile outmigrants, and provide elements of a more normative hydrograph compared to existing conditions. After ten years of data collection, we conclude that these assumptions fell well short of their expected beneficial impact, and we propose the following recommendations.

Moving forward, and in the spirit of continued data collection and learning, recommendations for the next ten-year cycle include:

- Suspend outmigration process flows for the next ten-year cycle and compare data to the first ten-year period to identify any differences in outmigration patterns.
- Continue to document occurrences of flows that through accretion or power generation meet the outmigration flow criteria.
- Use data collected through smolt trapping operations to further define outmigration periodicity as related to environmental / hydrologic conditions.
- Collect the same biometrics for replication of future and past analysis.
- Add the documentation of all incidences of unbuttoned fry to the Standard Operating Procedures associated with operation of the rotary screw / smolt trap.

Number: 1 Author: Anne Savery Date: 10/10/2022 6:45:58 PM

This does not seem throroughly vetted.

Number: 2 Author: Anne Savery Date: 9/20/2022 7:50:34 AM

AS: Tulalip and WDFW requested multiple spring pulses to help cue salmon to outmigrate due to the hydrograph produced by the JHP. After the raising of the dam and operational tweaks, the PUD has effectively shaved off peaks througout the system.

The SA wound up with one pulse flow for fish and then it got combined with the recreational flow later in the season - which is what is now impacting steelhead??.

We were presented with one year of pinks affected by scour (? or debris in smolt trap), is this something that happens every year? What about during other process flows?

Temperature is a consideration that has not been taken into account, this is another major part of outmigration cuing.

Adding temperature and hydrograph to the outmigration numbers may help tease out what is happening and also indicating the date of the PF release

Number: 3 Author: Anne Savery Date: 10/10/2022 6:49:29 PM

KN: Not much evidence has been given to support this.

Number: 4 Author: Anne Savery Date: 10/10/2022 6:49:04 PM

KN: What data do you have regarding steelhead?

Number: 5 Author: Anne Savery Date: 9/29/2022 2:30:45 PM

Rather than suspend flows, we should work on adaptive management over the next few years to address data gaps, questions and concerns and perhaps to better analyze the information that has been gathered - there seems to be no connection to the basin at large - smolt traps in the area, stream temperatures

Number: 6 Author: Anne Savery Date: 9/28/2022 1:39:05 PM

AS: Here is where adapative managment comes in, lets come up with another style of analysis, rather then means and averages and lack of temperature or comparison to other smolt traps.

show the max cfs fished in every year,

- Compare information collected on the Sultan with that collected by other agencies and/or tribes operating traps in the Snohomish Basin.
- Work with the ARC and co-managers to secure funding for more frequent operation of the smolt trap in the lower Sultan River beyond the 2 of 6-year commitment in the FHMP.
- Identify opportunities to gather reach specific production information including the operation of an upper and lower trap during the same season.

3. Habitat-Based Process Flow Releases

3.1. Flushing

The intent of the Channel Flushing element of the PFP is to provide benefits to the spawning habitat within each of three reaches of the Sultan River downstream of Culmback.

3.1.1. Program

aren't these combined with other flows? [1]

Frequency and Timing: This element of the channel flushing program involves two releases annually, one in the spring and one in the fall. The spring release is scheduled to occur between April 1 and May 31. The fall release is scheduled to occur during the month of September. The timing was selected to theoretically occur in advance of the respective steelhead and Chinook spawning seasons although it can and has occurred coincident with active spawning.

Duration: The duration of this specific element of the channel flushing program varies between either 3 hours or 6 hours, depending on the magnitude of the release. For Reach 1, the duration of the release is not contingent on magnitude.

Magnitude: As previously stated, the magnitude of the flow release for channel flushing in Reach 3 and Reach 2 is intertwined with the duration of the release. Furthermore, the magnitude of the release is reach specific with the magnitude increasing further downstream. For Reach 3, the release magnitude is 600 cfs for a 3-hour release duration or 400 cfs for a longer duration of 6 hours (Table 12). Similarly, for Reach 2, the release magnitude is 700 cfs for a 3-hour release duration or 500 cfs for a longer duration of 6 hours (Table 12). For Reach 1, the magnitude is 1,500 cfs unless the elevation of Spada Reservoir is below 1,420 feet msl in which case, the release magnitude is 1,200 cfs.

Table 12. Reach-specific discharge for flushing flow compliance.

	Discharge value for Compliance (by reach)	
	3-hour duration	6-hour duration
Reach 3	600 cfs	400 cfs
Reach 2	700 cfs	500 cfs
Reach 1	1,500 cfs	

Number: 1 Author: Anne Savery Date: 9/20/2022 8:22:19 AM

aren’t these combined with other flows?

3.1.1. Objectives and Assumptions

The primary objective of this element of the PFP is to flush the streambed of fines and organic matter under the presumption that this objective is not being met absent these releases. Restated, this element of the PFP was crafted with the specific language “if necessary”, largely because of differences in opinions on the need. The supposition and ultimate impetus for implementation of the program was that it was deemed necessary despite the results of five separate investigations conducted between 1982 and 2005 (R2 Resource Consultants 2006, Shapiro and Associates 1995, Shapiro and Associates 1988, Wert 1984, Wert 1982). Information from R2’s 2005 investigation and review of past work in combination with the gravel quality analysis, resulted in the formulation of the following conclusions:

- *The spawning gravel samples collected in 1982 and 1984, prior to initiation of power generation, were of good quality.*

- *Since 1984, the magnitude and frequency of floods in the Sultan River below Culmback Dam have been reduced, consistent with intended flood protection provided by the Project.*

- *Although the magnitude and frequency of floods in the Sultan River have been reduced, the river still has sufficient capacity to transport the sediment supplied to the river from sources downstream from Culmback Dam.*

- *Under the flow regime in the Sultan River since 1984, the armor layer of gravel deposits in the Sultan River is mobilized about once every 3 to 4 years on average based on sediment transport analyses. Scour depth measurements suggest that the armor layer may be mobilized even more frequently than once every 3 to 4 years.*

- *Except for occasional disturbances associated with gold prospecting activities and potential backwater effects caused by the Skykomish River near the mouth of the Sultan River, the quality of spawning gravels collected in 1987, 1994, and 2005 has remained “good” and on par with pre-Project conditions. Historical operations of the Project do not appear to have caused the quality of the spawning gravels to decline.*

- *The persistent trend of good quality spawning gravels is consistent with reported success of Chinook salmon spawning and escapement in the Sultan River downstream from the diversion dam.*

Another assumption implied through the twice annual frequency was the inference that fine sediment conditions were either so poor or that contributions were so chronic as to warrant flushing releases twice per year, 4 to 5 months apart. Another assumption was that timing of the release had to occur within weeks of active spawning to “prep the gravels” as to imply that sediment inputs were constant and that conditions were so dire that infilling would occur if scheduled further in advance. A final assumption was that the magnitude of the prescribed releases would be sufficient to mobilize the streambed and achieve the desired objectives and address the perceived need.

Number: 1 Author: Anne Savery Date: 10/10/2022 6:51:34 PM

AS: This doesn't seem fully supported by the cross sections and wolman pebble counts presented below.

Number: 2 Author: Anne Savery Date: 9/30/2022 2:35:58 PM

AS: The IHA RVA report has information that shows the drastic changes in the flood frequency duration and magnitude in all reaches of the Sultan River

Number: 3 Author: Anne Savery Date: 9/28/2022 3:54:47 PM

AS: I don't recall this and I don't think this was recorded in the License Article, the studies or the Settlement Agreement, I find this statement to unnecessary

Reach 3 was packed with scum in the summer and early fall. We were concerned by the lack of flushing of algae mats and stagnant water before resident fish would spawn. We also wanted gravels flushed at a time that a natural flow would occur. It used to be there was no fall pulse.

Number: 4 Author: Anne Savery Date: 9/20/2022 8:26:50 AM

These requests were based on photos of Reach 3 and reveiw of the hydrograph in which the PUD had basically stopped the variabliity of flow in the river, except for accretion flows.

3.1.2. Results

Snohomish PUD staff analyzed the hydrologic record between 2018 and 2021 and tallied the number of events, by reach, that met or exceeded the magnitude and duration established as the threshold for the channel flushing element of the PFP (Appendix B). The analysis clearly indicates that during the wet months of late fall and early winter, hydrologic events frequently exceed the established reach-specific criteria of a channel flushing event with the average number of events per month over the 4-year period presented in Table 13.

Table 13. Average Number of Channel Flushing Events October through February, 2018-2021

Reach	October	November	December	January	February
3	2.5	13.5	7	5.25	15
2	6	20	14.5	30.75	32.25
1	12.25	36.5	49	85.5	66

This analysis indicates that channel flushing element of the PFP is achieved regularly and that the magnitude and duration of the twice annual releases provide no added value beyond what is typically provided during late fall and early winter under normal operations.

Turbidity data were collected early on after License issuance but it was soon determined that use of the valves at the base of Culmback Dam for these releases introduced sediment from the bottom of the reservoir and confused the analysis for flushing effectiveness. Despite the absence of this data, Snohomish PUD brings forward the following egg-to-migrant survival information and believes that it is consistent with prior investigations as to the quality of spawning habitat relative to substrate conditions and the presence of fine sediment.

One indirect overall measure of fine sediment conditions in the Sultan River during fall is the Chinook percent egg-to-migrant survival data collected during operation of the smolt trap. Absent the influence of high flow scouring events, this egg-to-migrant survival index reflects the relative success of freshwater production which for sub-yearling migrants would largely be attributed to spawning habitat conditions and interstitial conditions within the redds. The mean and median percent egg-to-migrant survival for the years that the smolt trap has been operated was 25.7 and 25.2 %, respectively (Table 14). For Chinook that spawned in the fall of 2016, when no flushing flow occurred because of fish passage construction at the Diversion Dam, the egg-to-migrant survival was 34.3 percent (Table 14).

Number: 1 Author: Anne Savery Date: 9/20/2022 8:30:37 AM

AS: missing september!!! these flows are intended for early in the season. So Sept Oct are the relevant dates. Plus the spring dates.

why didn't you look at all 10 years? More informative

Number: 2 Author: Anne Savery Date: 10/11/2022 3:06:44 PM

later events in the table have nothing to do with the intent of the flushing flow. The flushing flows are not large enough to create scour

Number: 3 Author: Anne Savery Date: 9/30/2022 2:55:49 PM

AS: 2017 peak flow was 2,900 while chinook were in gravel, that far exceeds what the process flow is.

Table 14. Chinook egg-to-migrant survival, Sultan River, 2012-2021.

Year of Trap Operation	Chinook Redds (Year)	Number of Eggs Deposited	Total Out-Migration	Percent Egg-to-Migrant Survival	Peak Flow During Incubation (cfs)
2021	277 (2020)	1,249,270	[illegible]90	55.3	3,140
2020	34 (2019)	153,340	5,830	3.8	13,900
2019	234 (2018)	1,055,340	380,428	36.0	2,600
2017	275 (2016)	1,240,250	424,858	34.3	2,970
2016	156 (2015)	703,560	52,294	7.4	7,320
2015	146 (2014)	658,460	231,397	35.1	4,700
2014	184 (2013)	829,840	124,770	15.0	4,940
2013	390 (2012)	1,758,900	443,789	25.2	2,290
2012	53 (2011)	239,030	45,986	19.2	3,360

3.1.3. Unforeseen Consequences

Any release of this magnitude that occurs at the timing prescribed in the License article and PF Plan can be disruptive to staged or actively spawning fish.

3.1.4. Adaptive Actions Undertaken

No adaptive management was implemented as part of this program.

3.1.5. Recommended Modifications

The following recommendations for modifications to the channel flushing element of the PF Program are presented for consideration:

- Suspend releases specifically for channel flushing for the next 10-year period,
- Conduct study to further define the threshold for bed mobilization within Reach 3 and Reach 2:
  - Use study results and literature review to identify the magnitude and duration of flows that achieve flushing and maintenance objectives in the upper reaches.
  - Use study results to identify the magnitude of flow that results in scour,
  - Identify periods where incubating eggs are particularly vulnerable to scour.
- Monitor hydrologic variability during Water Year and prepare annual technical memorandum, and
- As part of the next 10-Year Process Flow Plan Effectiveness Report, incorporate collected information and evaluate whether flushing related needs are being met either through: a) normal operational hydrology or b) bi-annual channel maintenance program as brought forth under the following Channel Maintenance discussion.

3.2. Channel Maintenance

3.2.1. Program

The primary intent of the Channel Maintenance element of the PFP is to provide benefits to Reach 1 of the Sultan River. As such, all compliance related parameters are focused on Reach 1.

Number: 1 Author: Anne Savery Date: 9/20/2022 8:35:01 AM
All of the peak flows are well above the prescribed flushing flows and don't seem to correlate with the final number of egg to migrant survival

This is likely a more complicated story of escapment, flow, temperature.

cherry picking 2016 doesn't really make a case

Number: 2 Author: Anne Savery Date: 10/10/2022 6:57:33 PM
KN: how was this calcuated?

Number: 3 Author: Anne Savery Date: 9/30/2022 2:57:48 PM
AS: more likely a flushing flow is actually helping fish in river with temperatuers.

I'd say the flushing flow being released is not having a scour effect, since the magnitude is quite low. Are the releases in table 14 on days when a process flow occured?

Number: 4 Author: Anne Savery Date: 10/10/2022 6:58:36 PM
You'll need to be specific about which studies you are referencing.

Number: 5 Author: Anne Savery Date: 9/30/2022 2:59:27 PM
AS: what kind of benefits? This section needs fleshing out - the point of channel maintenance flows was to get the river hydrology up to a point where it could do work on the channel such as moving lwd, scouring gravels AND interacting with LWD installations that were required by the license. The LWD installations were required to have zero rise by fema and were subsequently placed in areas that were not originally intended by the negotiators. Tulalip has frequently pushed for additional LWD / boulder structures to be added into the channel so that channel maintenance flows could interact and create some scour - rack wood and improve habitat in the lower reach. It is anticipated the new structures that are due in the next phase should intereact more with channel maitenance flows.

3.2.1.3. Frequency and Timing

The compliance magnitude for a Channel Maintenance event hinges heavily upon accretion (rainfall) which ultimately drives both the frequency and timing. While these events are controlled, the events are considered “opportunistic” as operations must be tailored and sequenced to co-occur with rainfall to achieve compliance.

In terms of frequency, Channel Maintenance is to occur four times per a Ten-Year Accounting Cycle, with not less than 4 years between events. Timing is predicated on the presence of somewhat predictable rainfall event within the lower Sultan River Basin that delivers adequate flow volumes over a duration of a least 24 hours.

3.2.1.2. Duration and Magnitude

Compliance with the Channel Maintenance requirements is achieved when (a) a target flow of at least 4,100 cfs instantaneous minimum flow in maintained for twenty-four (24) consecutive hours at USGS Gaging Station No. 12138160 (below the Powerhouse) or (b) a target flow of a least 4,100 cfs is achieved but not sustained for a 24-hour duration and the Licensee demonstrates a good faith effort by providing a maximum release flow from the Powerhouse[2], the outlet pipe located adjacent to the City of Everett’s Diversion Dam, and Culmback Dam (via the Howell-Bunger and 42-inch slide valves) at the time when flow drops below 4,100 cfs for a total duration (including the target flow and maximum release) of twenty-four consecutive hours as measured at USGS Gaging Station No. 12138160.

3.2.2. Objectives and Assumptions

The objectives of the Channel Maintenance element of the PFP include:

- Formation and re-distribution of physical habitat features (riffles, pools, runs, point bars)
- Effective transport, sorting, and distribution of large woody debris (LWD) and sediment
- Alteration of channel features (increase lateral channel movement, improved connectivity between mainstem and side channel habitat)
- Creation of undercut banks

Primary assumption is that the magnitude, duration, and frequency of these events are meeting the intent and objectives of this element of the program for Reach 1. Of note is that several of these objectives are also achieved in reaches 2 and 3, despite the predominantly confined nature of the channel in these reaches. The existing infrastructure and specifically, the location of the high-capacity valves at the upper end of Reach 3, results in the introduction of significant streampower in the upper reaches which may be disproportionate when considering benefits and objectives for the entire river.

3.2.3. Results

The following executive summary excerpt from the Stillwater Sciences (2016) report highlights some of the overall general changes documented during their habitat surveys conducted after

[2] Under conditions of high flow (>2,200 cfs) / elevated water surface, the plants “air depression” system is triggered to maintain plant output. At flows greater that 3,500 cfs, the backwater effect requires plant output to be reduced by X megawatts to prevent equipment damage.

Number: 1 Author: Anne Savery Date: 9/30/2022 3:09:01 PM

AS: what percentage of the channel maintenance flow is achieved from which source?

Number: 2 Author: Anne Savery Date: 9/30/2022 3:09:58 PM

AS: we chose the target flows off the hydrograph of before and after raising the dam for the Project and chose which flows were missing flows in the range of roughly 4,500 to 6,000 cfs. Individuals interested in delving into the Stillwater Sciences reports and data files are encouraged to do so. Upon request, Snohomish PUD will provide links to these reports.

Stillwater Sciences conducted a field habitat survey of the lower 2.7 miles of the Sultan River in July 2016, including four side channels (all of which had been previously surveyed). The study was undertaken to determine if any habitat changes have occurred due to a significant high-flow event that occurred in November 2015. The 2016 survey was the second such resurvey conducted since issuance of the new license for the Henry M. Jackson Hydroelectric Project (Project) in 2011. The project is operated by the Public Utility District No. 1 of Snohomish County (the District) and these habitat surveys are required by the Fisheries and Habitat Monitoring Plan under Article 410 of the license.

Surveys conducted in 2007 and 2010, as part of the relicensing of the Project, provided the baseline data that have allowed post-2011 resurveys to determine the effects of subsequent high-flow events, of which the first occurred in March 2014 (Stillwater Sciences 2015). Table 15 lists each reach and the year they were each surveyed.

Riverine habitat attributes recorded for this study included instream unit subtype (e.g., pools, riffles, glides, islands), measurements of wetted unit surface area dimensions (length and width), unit margin features (lengths of undercut banks and bar edges), and the distribution and characterization of large woody debris (LWD). Subsequent to the 2007 and 2010 surveys, engineered LWD structures were installed in 2012 along the margins of the mainstem and side channels, along with other channel enhancements in all four side channels.

Table 15. Reaches surveyed and the year the survey was conducted.

Reach	Surveyed in 2007	Surveyed in 2010	Resurveyed in 2014	Resurveyed in 2016
Mainstem	Yes	No	Yes	Yes
Side Channel 1	No	Yes (partially)	Yes	Yes
Side Channel 2	No	Yes	Yes	Yes
Side Channel 3	Yes	No	Yes	Yes
Side Channel 4	No	No	Yes	Yes

LWD INSTALLATIONS ↑ 2012 — ↑ HIGH FLOW MARCH 2014 — ↑ HIGH FLOW NOVEMBER 2015

As in 2014, the results of the 2016 study indicate that natural processes of wood recruitment and channel evolution have thus far resulted in modest changes to habitat attributes in the mainstem of the Sultan River since the baseline surveys were conducted. Although the mainstem is largely unchanged, the side channels have been transformed into more variable reaches with frequent pools and pool-riffle-glide complexes. This represents a marked improvement over their previous composition of primarily glide habitat dotted with some low-gradient riffles and a few small pools. Since 2012, high flows have reworked and modified the channels. This has led to a system

Number: 1 Author: Anne Savery Date: 10/10/2022 7:02:37 PM

KN: TTT suggest adding a channel profile to the post channel maintenance assessement and residual pool depth

Number: 2 Author: Anne Savery Date: 9/30/2022 3:19:04 PM

AS: channel maintenance flows are having effects in the side channels. making more variable habitats and doing work when interacting with instream structures, moving sediment. this is very important work

What hasn't happened is effective maintanence or change in the mainstem - due to lack of roughness *that overall expresses a somewhat more dynamic, "natural" trajectory. For this survey, the largest positive changes observed since the 2014 survey occurred in Side Channels 2 and 4 (SC2 and SC4).*

While the presence of engineered LWD structures and LWD in the mainstem river and along the side channels has successfully stabilized the inlet to side channels, one small area in the mainstem and a longer section of Side Channel 1 (SC1) that had flowing water in 2014 at the 320 cubic feet per second (cfs) mainstem discharge were dry at a similar discharge in 2016. This change was most evident in SC1 and comprised 594 feet (ft) of dry channel with marsh and isolated interspersed pools.

In summary, little measurable change can be documented in the mainstem as a result of this survey. However, the study results indicate that installations have initiated changes in habitat features and improved channel complexity, in terms of variability of depths and flow, in the side channels following high flows. Pool habitat has significantly increased, both in terms of the amount of surface area pools encompass and the overall number of pools observed in the study area. Based on relatively consistent results to date, future high flows are expected to interact with the installations and result in even greater side-channel habitat complexity in the future.

Per the monitoring requirements listed in the License article, Snohomish PUD has collected additional post-high flow data that complements the data collected by Stillwater Sciences during their collective habitat surveys (Stillwater Sciences 2007, 2010, 2015, 2016, 2021). This information, collected at eight locations spanning all 3 reaches, includes channel cross-sectional profiles, Wolman (1954) Pebble Counts, and photographs. This information is presented below by site with a brief commentary on the most relevant takeaways.

<u>Reach 1 – Site 1</u>

Site 1 is located at RM 0.5 and is the most downstream location surveyed. This location is frequently backwatered under flood conditions in the Skykomish River. As such, the level geomorphic activity varies at the location. Cross-sectional measurements over time at this location indicate some aggradation reflected in the progressive development of a gravel bar between stations 150' and 230' (Figure 27). The Wolman Pebble Counts collected over time at this location suggest a relatively consistent grain size distribution (Figure 26).

Number: 1 Author: Anne Savery Date: 10/8/2022 12:16:17 PM

AS: Stilwater report stated the gravel size distributions were not readily comparable from year to year.

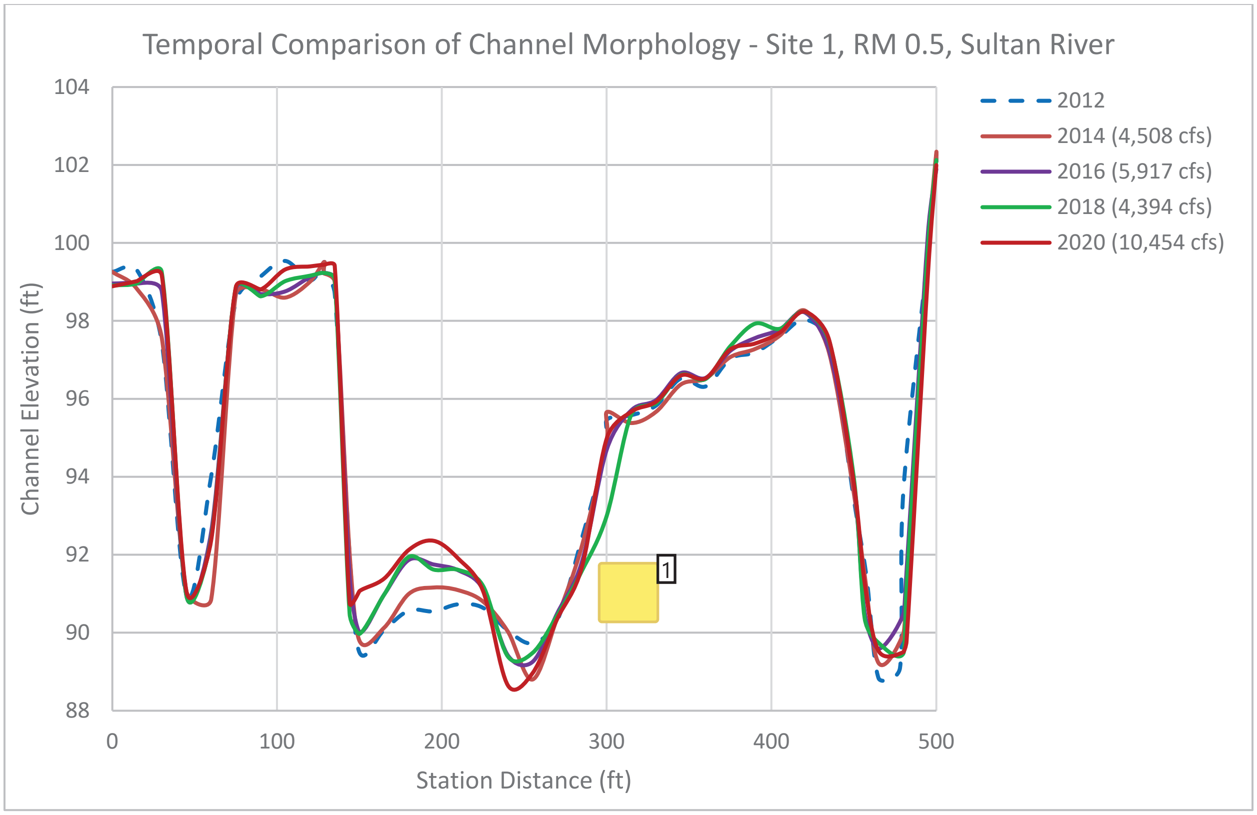


Figure 27. Temporal comparison of channel morphology, Site 1

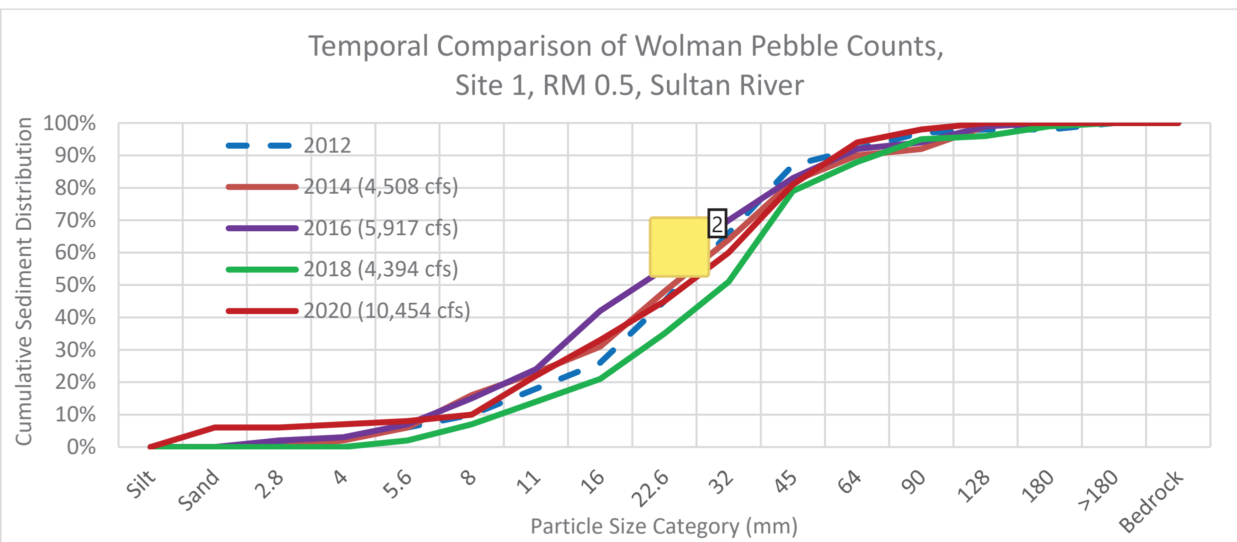


Figure 28. Temporal comparison of Wolman pebble counts, Site 1

Number: 1 Author: Anne Savery Date: 10/7/2022 6:51:49 PM

AS, KN: need WSE on all of the x-s graphs

Here we have aggradation and degradation in the bed, as you would expect at high flows. However it is mainly in the thalweg, if fish have limited ability to spawn out of the thalweg, then scour events will impact fish disproportionately. If fish are able to spawn in a greater distribution of habitats, then scour events in thalweg may not be an extreme issue.

Number: 2 Author: Anne Savery Date: 10/10/2022 7:17:33 PM

AS: percentages of spawning size gravels are fluctating , but are these in a pool? run? do fish spawn here?

Reach 1 – Site 2

Site 2 is located at RM 1.5 which is upstream of the inlet to Side Channel 1 and downstream of the inlet to Side Channel 2. Two islands are present along this cross-section with distinct smaller channels along the left and right banks and the main channel in the middle, between stations 200' and 300' (Figure 29). Over time, there has generally been little change detected with the notable exception being the degradation observed with channel forming flow (Figure 29). The Wolman Pebble Count collected after the 2020 flow event indicated an increase in the 22 to 45 mm size fraction undoubtedly indicative of the mobilization and deposition of those size classes (Figure 30).

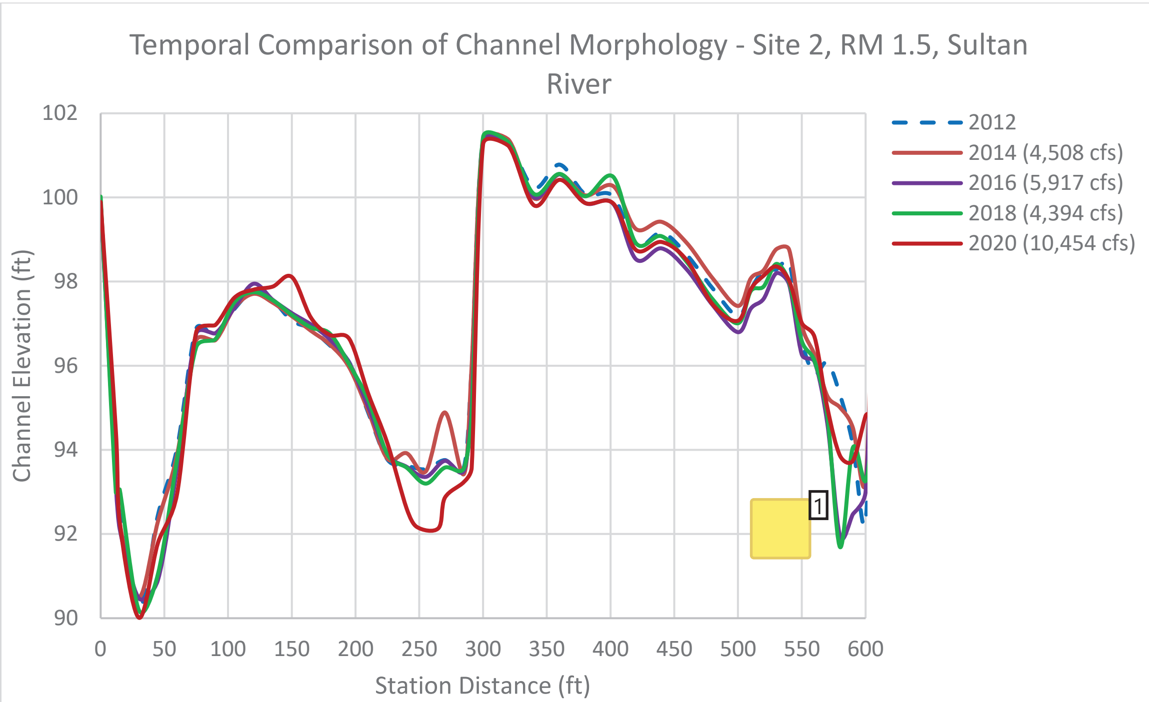


Figure 29. Temporal comparison of channel morphology, Site 2

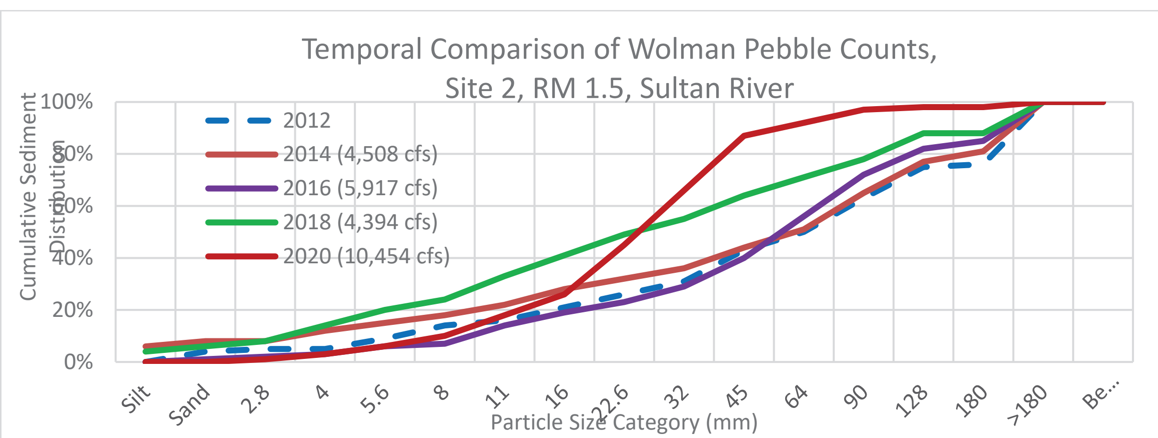


Figure 30. Temporal comparison of Wolman pebble counts, Site 2

Number: 1 Author: Anne Savery Date: 10/10/2022 7:21:05 PM

AS: Scour and deposition in thalweg: allowing for fish to distribute away from spawning in the thalweg gives more opportunites to avoid scour.

Reach 1 – Site 3

Site 3 is located at RM 2.5, just downstream of the Trout Farm Road Recreation Site. Very little change in channel morphology was documented since implementation of the program indicative of a stable channel (Figure 31). Similarly, the Wolman Pebble Counts indicated no significant change in substrate composition over time (Figure 32).

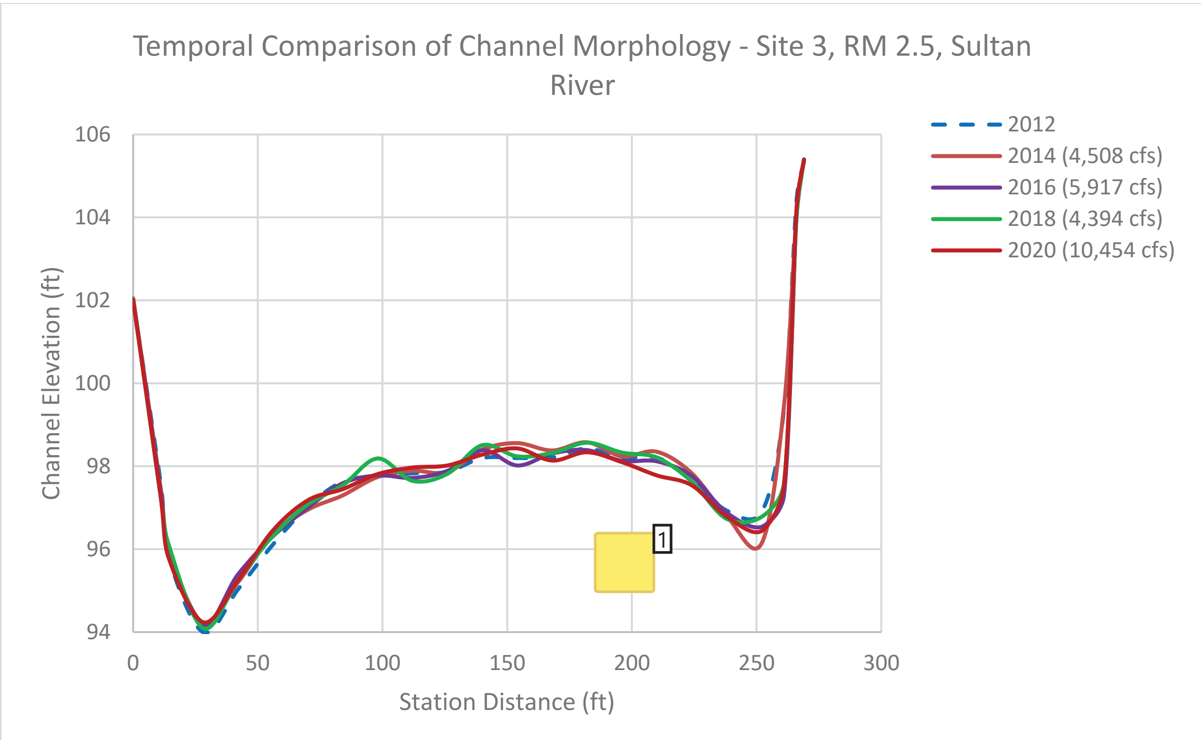


Figure 31. Temporal comparison of channel morphology, Site 3

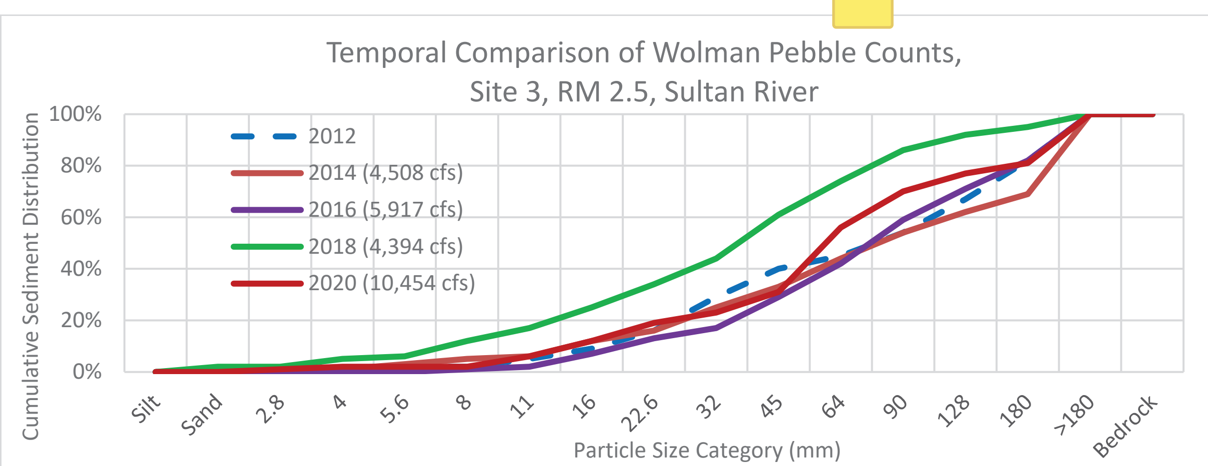


Figure 32. Temporal comparison of Wolman pebble counts, Site 3

Page: 55

Number: 1 Author: Anne Savery Date: 9/30/2022 3:38:29 PM

this is the problem we are trying to address, changing the channel structure in the lower reach - so channel maintenance is ineffective absent hard structures.

channel is very wide and likely lacks roughness features.

Number: 2 Author: Anne Savery Date: 10/10/2022 7:22:53 PM

AS: Majority of Substrate is quite large

Reach 1 – Site 4

Site 4 is located at RM 4.5, just downstream of the Powerhouse. The channel at this location has remained largely unchanged over time (Figure 33). The Wolman Pebble Counts indicate a shift in substrate composition after the channel forming flow, especially in the 5.6 to 11 mm size range (Figure 34).

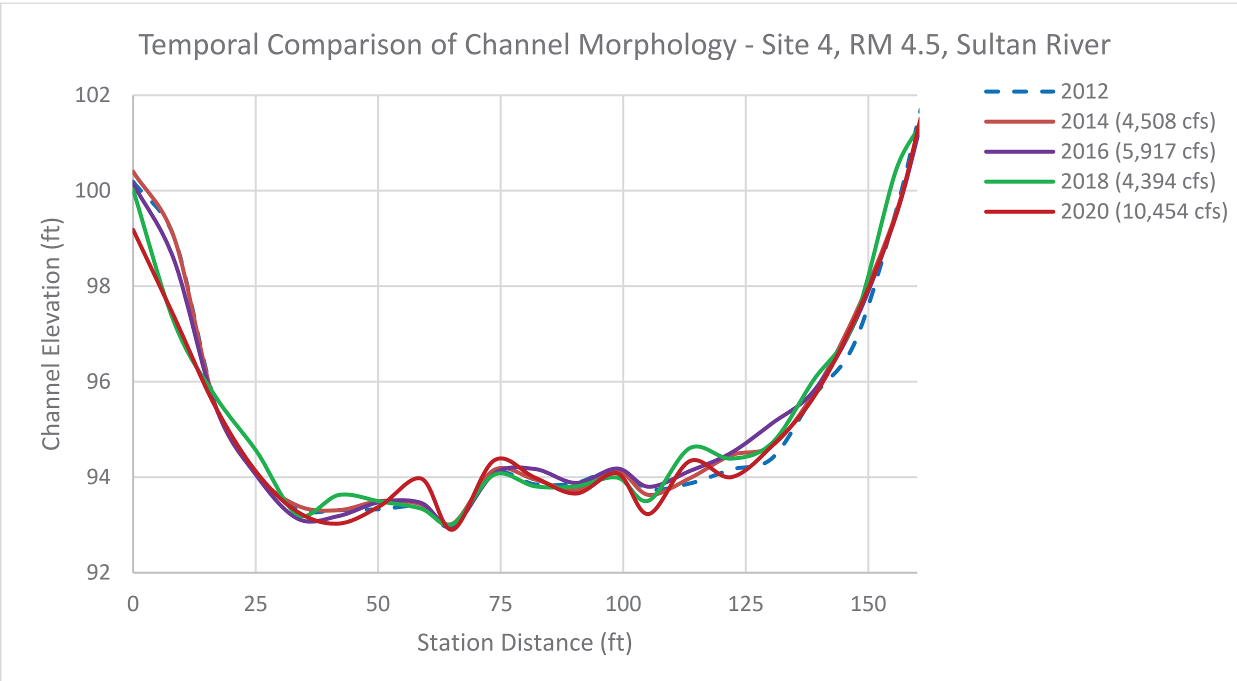
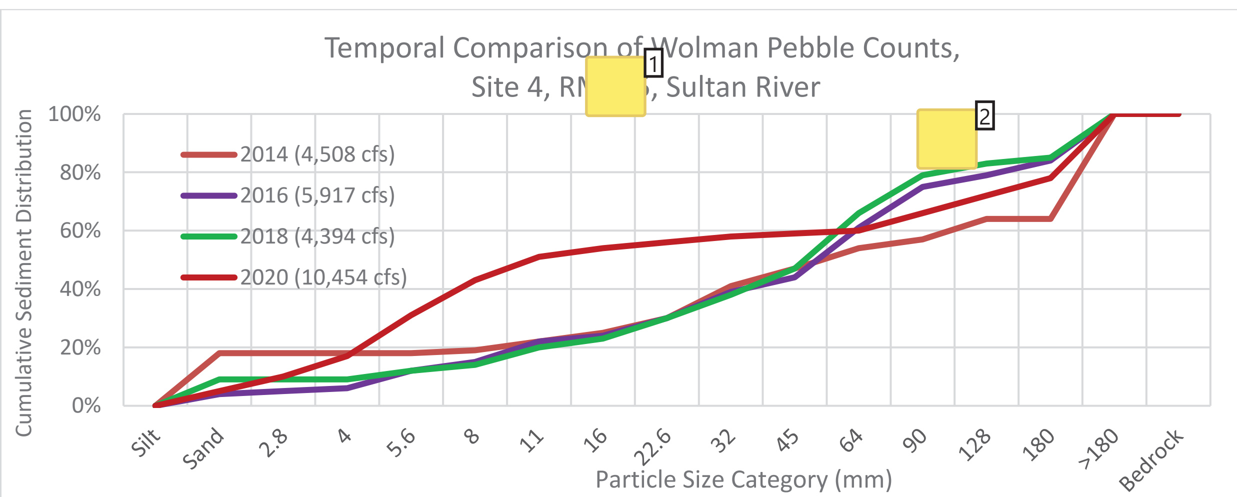


Figure 33. Temporal comparison of channel morphology, Site 4



*no 2012 Site 4 data

Figure 34. Temporal comparison of Wolman pebble counts, Site 4

Number: 1 Author: Anne Savery Date: 10/7/2022 6:56:18 PM

AS: could it be that the long duration pulses and the low rise and fall rate could be affecting the deposition, scour of the bed.

These are tiny clasts that are mvoing around.

Number: 2 Author: Anne Savery Date: 9/30/2022 3:40:15 PM

AS: the larger clast size increased after 2016 and 2018 flows, so smaller stuff was blown out, yet no change in channel form. that speaks to an armored bed

There is some sort of activity in the larger clasts at this site, what is different/

<u>Reach 2 – Site 5</u>

Site 5 is located at RM 4.9, just upstream from the Powerhouse. Minor changes in channel morphology were observed over during the first 10 years since License issuance (Figure 35). Similarly, modest changes in substrate composition were noted until the Channel Forming Event of 2020 (Figure 36). The observed changes in substrate were likely attributed to the active sediment transport underway during that event. In 2021, Snohomish PUD continued with a pilot project it initiated to refine our understanding of the thresholds for activation of the bed and attendant sediment transport and mobilization. While most of the instrumentation was lost (buried or dislodged), the accelerometer deployment within lower Reach 2 did remain providing a single data source. The data from this particular accelerometer suggests that transport may be initiated at a discharge of around 1,240 cfs (Figure 37).

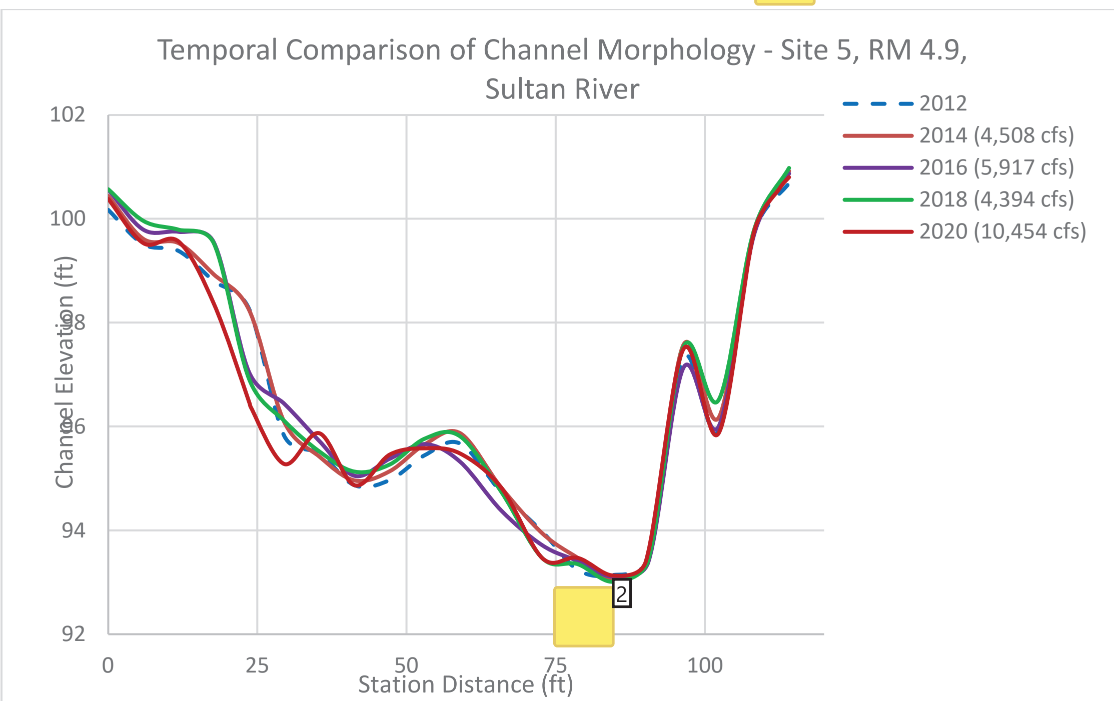


Figure 35. Temporal comparison of channel morphology, Site 5

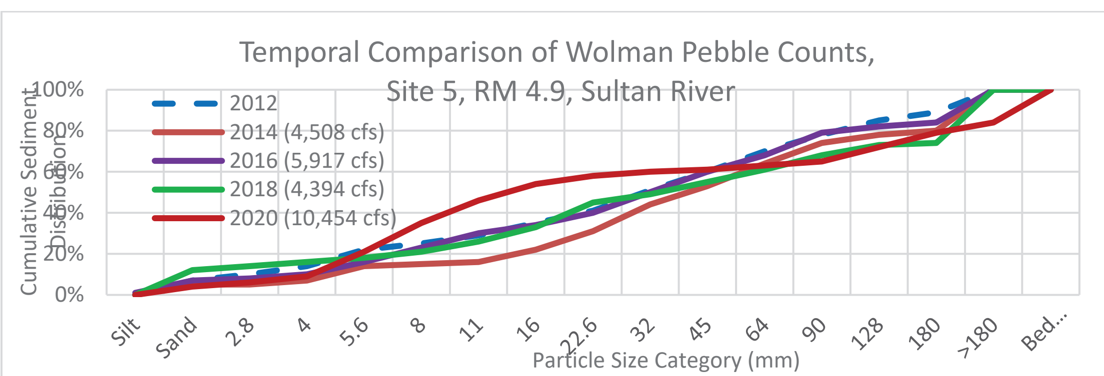


Figure 36. Temporal comparison of Wolman pebble counts, Site 5

Number: 1 Author: Anne Savery Date: 9/30/2022 3:42:25 PM

AS: transport of what clast size? I don't think this is a valid point to make, since there is no information about the clast size and the entire bed mobilized. This does not define bed mobilization

Number: 2 Author: Anne Savery Date: 10/8/2022 11:56:24 AM

In 2020 the percentage of spawning sized materials increased; what is the mechanism for small sediments to drop in one place? the shape of the tail end of the flood?

also a decrease in larger sized material,

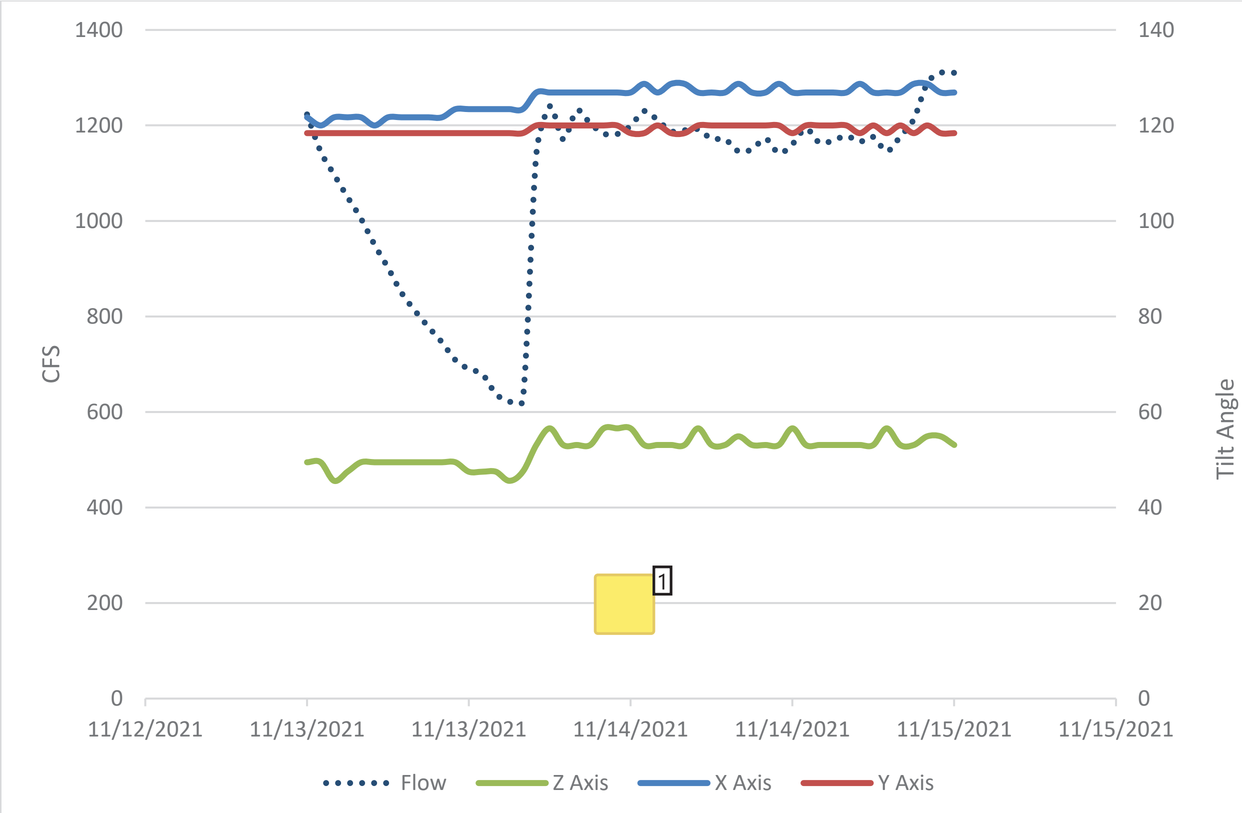


Figure 37. Substrate movement in response to flow, as detected by accelerometer deployed near RM 4.7

Number: 1 Author: Anne Savery Date: 9/30/2022 3:37:30 PM

AS: i need this explained to me

One data point is not a trend or threshold determination...

Reach 2 – Site 6

Moving further upstream, Site 6 is located at RM 9.5, just downstream of the Diversion Dam. The channel morphology has shifted over time in response the transport of sediment from sources further upstream in Reach 3 including much from immediately upstream of the Diversion Dam in association with fish passage related changes to the infrastructure at the Diversion Dam. The passage project was completed late in 2016 and subjected to the first major flow event in early 2018. Significant deposition was noted at Site 6 after that event and then remobilized after the major event in 2020 (Figure 38). The Wolman Pebble Counts for Site 6 are also indicative of a very active channel with shifting substrate composition (Figure 39). Accelerometers deployed at this site are buried under a large deposit of fine gravel and have not yet been recovered.

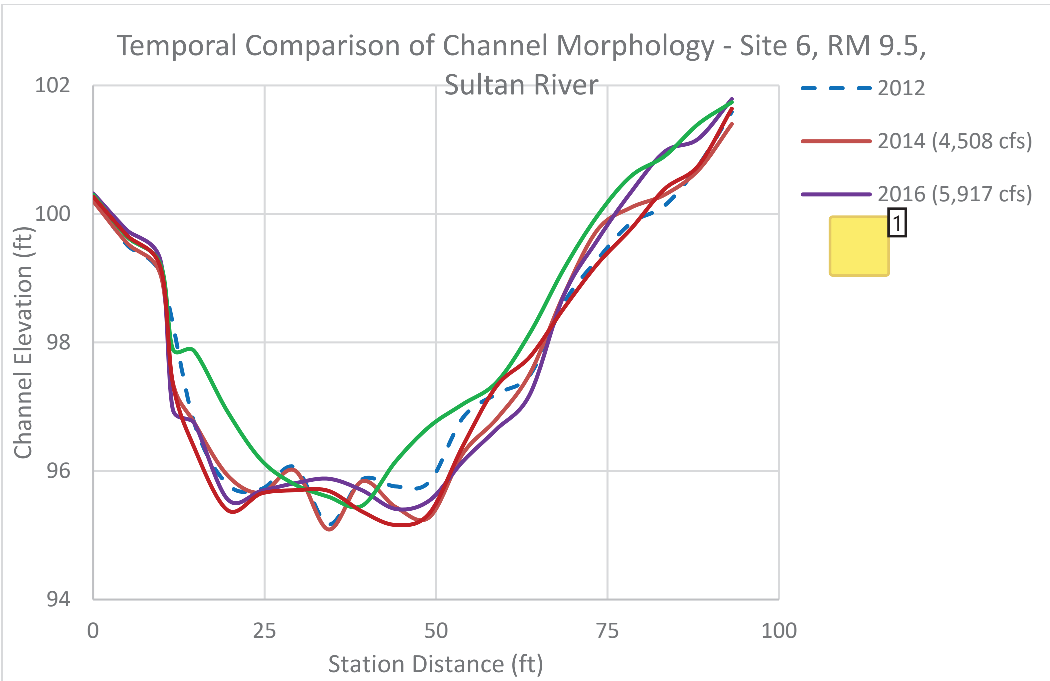


Figure 38. Temporal comparison of channel morphology, Site 6

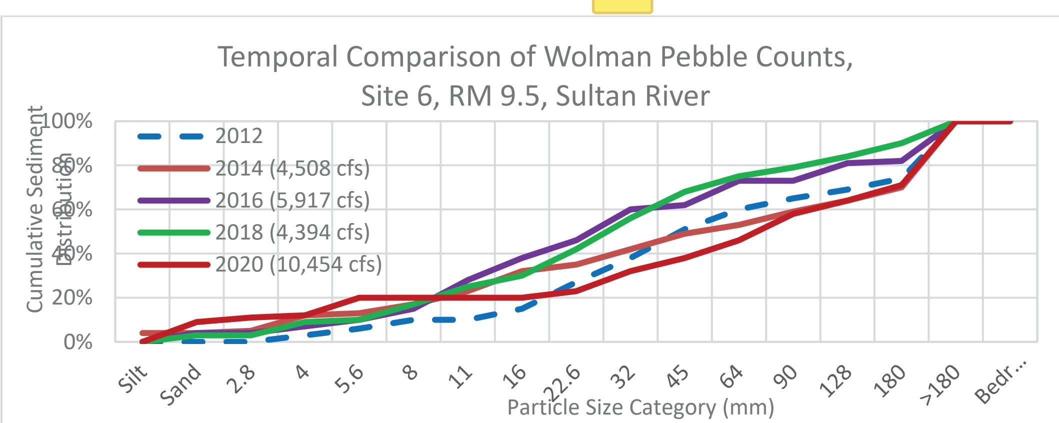


Figure 39. Temporal comparison of Wolman pebble counts, Site 6

Number: 1 Author: Anne Savery Date: 9/30/2022 4:59:31 PM

add 2020 to legend
add 2018 to legend

AS: very active x-section

Number: 2 Author: Anne Savery Date: 10/7/2022 7:01:52 PM

This channel is more confined

There seems to be scour and deposition, as expected.

Reach 3 – Site 7

Site 7 is located a RM 9.8, just upstream of the Diversion Dam. The site has seen the most dramatic changes in channel morphology over time and since implementation of fish passage at the Diversion Dam and the elimination of the forebay impoundment (Figure 40). Modifications of the sluiceway at the Diversion Dam to provide volitional fish passage involved excavating to the historic channel elevation. As intended, this changed initiated significant head cutting upstream as the channel grade adjusted and material was transported. These changes are captured in pictures taken before and after the site was subjected to the high flows of 2018 and then 2020 (Figures 41, 42, 43, and 44). The Wolman Pebble Counts also imply a progressive coarsening and shifting of the landscape in terms of substrate composition (Figure 45). The accelerometers at this site are buried under approximately 4 feet of gravel in an expansive deposit.

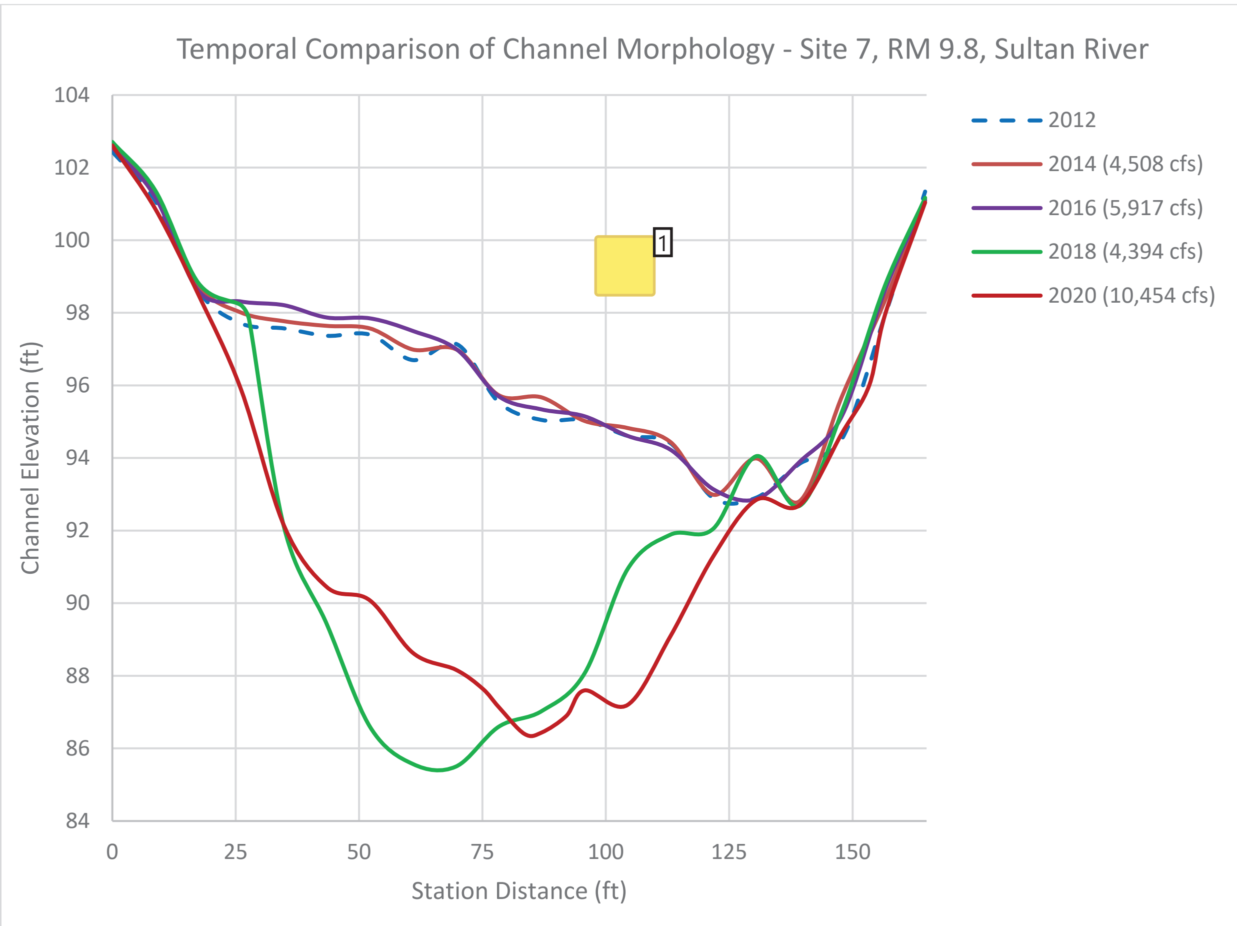


Figure 40. Temporal comparison of channel morphology, Site 7

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Number: 1 Author: Anne Savery Date: 9/30/2022 5:00:51 PM

AS: The bed is reaching a new equilibrium now that the diversion dam has been breached, it makes sense that the cross section has changed.

2014 appears to have the largest negative shift in spawning size gravel.

Figure 41. Habitat Transect (left to right bank), Site 7, 2012.

Figure 42. Habitat Transect (left to right bank), Site 7, 2020.

Figure 43. Habitat Transect (right to left bank), Site 7, 2012.

Figure 44. Habitat Transect (right to left bank), Site 7, 2020.

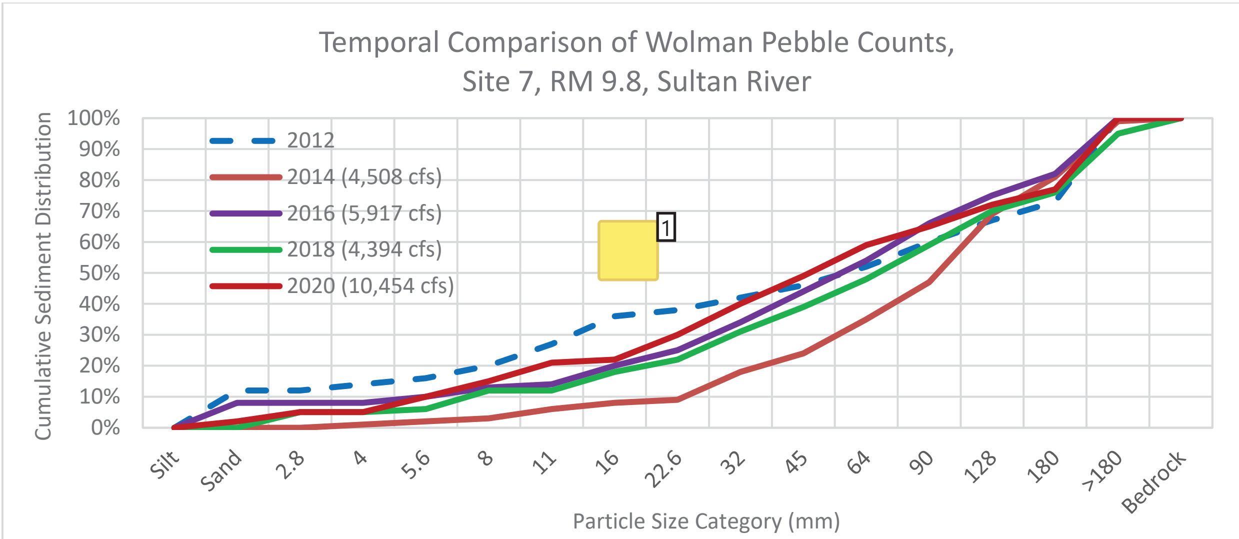

Figure 45. Temporal comparison of Wolman pebble counts, Site 7

Number: 1 Author: Anne Savery Date: 10/7/2022 8:16:09 PM

AS: the bed is aggrading here, that’s a change

It is back to the 2012 level. The percentage of larger cobble is back to where it originally was

spawning gravels are back to 2012 levels

Reach 3 – Site 8

Site 8 is located at RM 14.3, immediately upstream of the famed Stringer Bridge. This site is also immediately downstream of a historic massive landslide that continues to be a significant source of gravel supplied to the river. While this site is boulder dominated, the channel morphology at this site reflects a very active channel with degradation evident after the 2020 flow event (Figure 46). The Wolman Pebble Counts suggest a shift in substrate composition with a removal of some of the smaller size fractions (Figure 47).

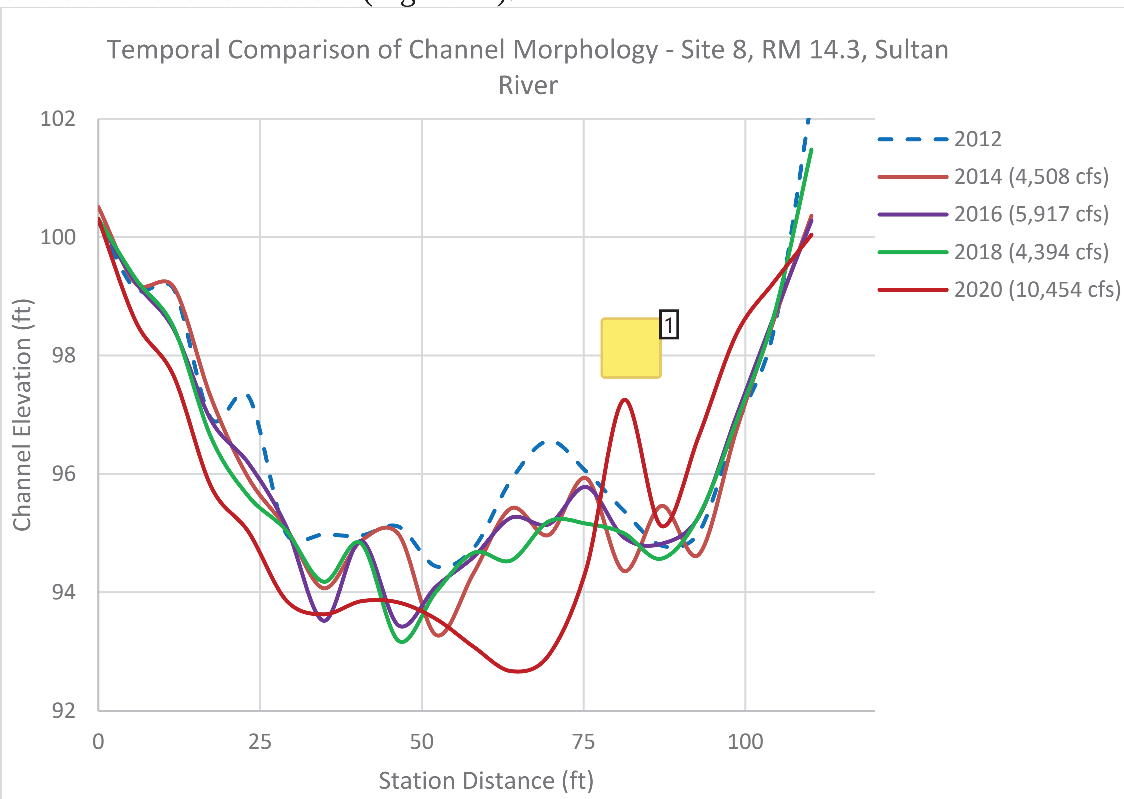

Figure 46. Temporal comparison of channel morphology, Site 8

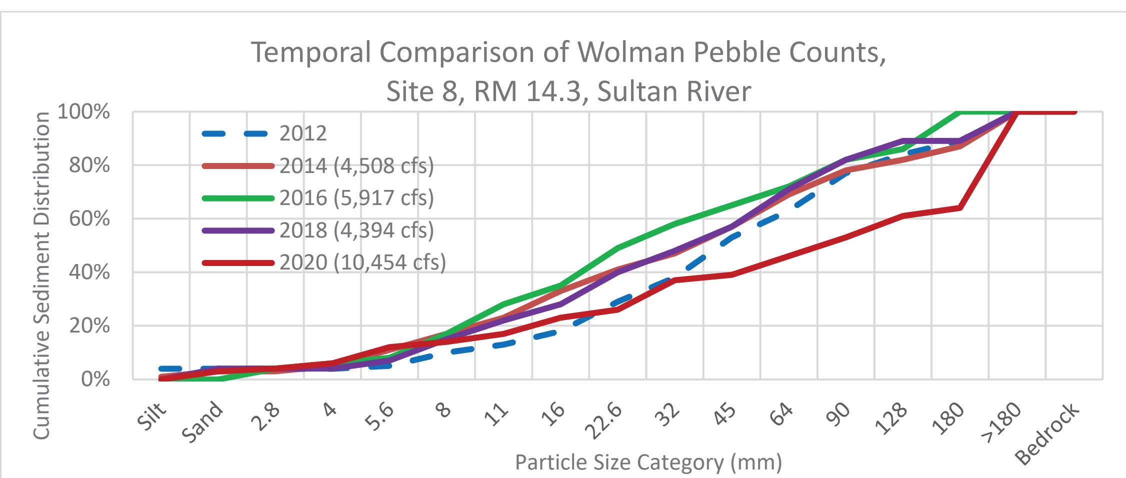

Figure 47. Temporal comparison of Wolman pebble counts, Site 8

Number: 1 Author: Anne Savery Date: 10/7/2022 8:18:44 PM

big supply of sediment and a lot of movement in the channel

The change in the 2020 cross section isn't necessarily degredation, the relative percentage of cobble went down.

3.2.4. Unforeseen Consequences

Use of both the Howell-Bunger (variable capacity up to 946 cfs, at full pool) and Slide (fixed capacity of 1,165 cfs, at full pool) valves simultaneously to achieve the flow magnitude desired for channel maintenance in Reach 1 has consequences that were not fully identified during the development and crafting of the License article. The release location at the base of Culmback Dam (RM 16.1) for these high-volume flows for the benefit of aquatic habitat in lower Reach 1, 13 miles downstream, has a disproportionate impact on the relatively confined, high gradient reaches of the Sultan River located upstream of the Powerhouse (Reach 2 and Reach 3). Depending on timing, these releases can induce scour and be destructive to eggs incubating in the gravel in these reaches. While past studies have defined the approximate threshold for incipient motion, Snohomish PUD has conducted studies to refine the level of understanding and is committing to furthering those investigations. Limited information from the installation of accelerometers indicates that sediment transport in lower Reach 2 is initiated at flows of approximately 1,200 cfs (Figure 37). This value is consistent with the past transport related investigations (GeoEngineers 1984) and is cause for concern when implementation high flow releases, especially those that rely on the use of the Slide valve.

Again, the data from the operation of the smolt trap can provide valuable insight into the relationship between high flow and freshwater production. The magnitude of flow required to induce scour varies by reach with the required flow being greatest for Reach 1 and least for Reach 3 owing to the prevalent channel morphology within each reach. High flows, that potentially induce scour, have a far greater probability of occurring further upstream in the river. This probability is increased and exacerbated by the location of the release point for channel maintenance flows. Furthermore, the effects of scour can vary from year to year depending of spawning distribution. This effect is evident when comparing 2013 and 2014, two consecutive years with similar peak flows but variable Chinook spawning distribution owing to the presence of pink salmon. In pink years, Chinook more frequently elect to use the reaches above the Powerhouse in an attempt to avoid the high densities of pink salmon. In 2013 (a pink year), 55 percent of the returning Chinook spawned upstream of the Powerhouse. In contrast, in 2014, 43 percent of the Chinook spawned upstream of the Powerhouse. When subjected to similar peak flow events during incubation, the net result during the non-pink year of 2014 was higher percent egg-to-migrant survival and greater overall production, despite lower escapement (

Number: 1 Author: Anne Savery Date: 9/30/2022 3:30:09 PM

AS: I don’t think 1200 cfs is definitive, nor would it apply to the entire river.

Number: 2 Author: Anne Savery Date: 9/30/2022 3:33:24 PM

AS: this is definitely an important issue, however, you weren’t finding dead chinook in the smolt trap - although that’s a long way to travel.

What is a way to get scour data in reach 3?

Table 16). These data highlight high flow impacts and how the scheduling of high flow releases should be considered reach specific impacts and the spawning distribution of ESA listed stocks.

Table 16. Percent Egg-to-Migrant Survival versus Peak Flow During Incubation.

Year of Trap Operation	Chinook Redds (Year)	Number of Eggs Deposited	Total Out-Migration	Percent Egg-to-Migrant Survival	Peak Flow During Incubation (cfs)
2021	277 (2020)	1,249,270	691,190	55.3	3,140
2020	34 (2019)	153,340	5,830	3.8	13,900
2019	234 (2018)	1,055,340	380,428	36.0	2,600
2017	275 (2016)	1,240,250	424,858	34.3	2,970
2016	156 (2015)	703,560	52,294	7.4	7,320
2015	146 (2014)	658,460	231,397	35.1	4,700
2014	184 (2013)	829,840	124,770	15.0	4,940
2013	390 (2012)	1,758,900	443,789	25.2	2,290
2012	53 (2011)	239,030	45,986	19.2	3,360

3.2.5. Adaptive Actions Undertaken

No adaptive management was identified for this program.

3.2.6. Recommended Modifications

The first 10 years of implementation of the PFP clearly indicate that controlled releases for channel maintenance purposes tend to underperform in terms of meeting the full range of desired objectives within Reach 1. This general realization has been recognized and acknowledged by the ARC and has led to discussions around the implementation of more pronounced physical interventions in Reach 1. The thinking is that the desired objectives have the best chance of being met through these interventions, coupled with the occurrence of both controlled releases and uncontrolled spill events.

An adaptive approach to implementation of the PFP over the next 10 years could include an enhanced focus on potential impacts to fish during this period of recovery period for ESA listed stocks. Actions could be undertaken to fine tune our understanding of the threshold for bed mobilizing events with the intent to balance the stimulation of habitat related processes across the landscape with actions that reduce the potential for scour events in newly colonized and/or vulnerable habitats. Implementation of this approach could support greater life history resiliency and boost freshwater production during recovery.

- Reduce the magnitude and increase the frequency of individual Channel Maintenance events,
- Move towards adaptive / scheduled events that are resource protective and consider either every other year events or events occurring no more three (3) years apart,
- Integrate within season information on Chinook run timing, spawning distribution, site specific water temperature, and developmental stage when scheduling events to limit scour related impacts,
- Continue to explore more aggressive physical interventions as part of the Fish Habitat Enhancement fund and Side Channel and Large Woody Debris Plan in the lower river that promote the attainment of habitat related objectives.

Number: 1 Author: Anne Savery Date: 10/10/2022 7:32:01 PM

KN: It is not necessarily the threshold for mobilization, we are concerned with depth of scour.

AS: And ensuring that Chinook and other salmon can spawn outside of the thalweg, where the majority of scour occurs.

Number: 2 Author: Anne Savery Date: 10/10/2022 7:36:04 PM

KN: Does this help Reach 1. I am confused where chinook spawning. I thought Reach 1 was the principle chinook spawning area? Where is steelhead spawning occurring.

Number: 3 Author: Anne Savery Date: 10/10/2022 7:33:30 PM

AS: add roughness features to Reach 1 and where feasible in Reach 2.

Number: 4 Author: Anne Savery Date: 10/10/2022 7:34:31 PM

AS: ensure sufficient habitat exists to keep fish from having to spawn in thalweg where majority of scour occurs.

Implementation of a channel maintenance program with greater frequency but of a reduced magnitude, including complete reliance on the use of solely the Howell-Bunger valve, could lead to development of a predictable program tailored to balance and meet the comprehensive needs of the fish and habitat resources along the entire river.

Given what we have learned over the first 10 years since implementation, it is prudent to revisit the basis for determining the appropriate discharge magnitude to achieve the desired fish and habitat objectives along the entire river downstream of Culmback Dam. While 4,140 cfs is the bankfull discharge value (Qbf) in Reach 1 based on the instream flow study (R2 Resource Consultants 2009), a value less than that may have the same level of general effectiveness (Qeff) and simultaneously be less destructive to fish and aquatic resources in reaches 2 and 3 and especially so, if timed carefully. Schmidt and Potyondy (2004) state that the initiation of coarse sediment transport can occur at 60-80 percent of Qbf.

With the reduced magnitude of 70 percent Qbf (2,898 cfs) and same duration of 24 hours, a greater level of control and predictability would be possible. The increased frequency could be implemented in a way where these events are scheduled / timed to occur during even years when Chinook are move heavily distributed in the lower river and therefore less likely to be impacted by the relatively high flow releases from Culmback Dam. This action would also support stock rebuilding and recovery. These releases could be predictably scheduled to occur in late November if not provided naturally during the preceding 6 weeks, prior to November 15. In terms of frequency, 5 scheduled channel maintenance events would be required during the 10-year accounting cycle as compared 4 in the current program. The program could be structured and implemented so that no more than 3 years occurs between channel maintenance events and that such events do not occur in years when a channel forming event has occurred. This frequency and magnitude would ensure that the bed in the upper river is regularly mobilized addressing any flushing related concerns and that sediment and large woody debris transport processes remain intact.

3.3. Channel Formation

3.3.1. Program

The primary intent of the Channel Forming element of the PFP is to provide benefits to Reach 1 of the Sultan River. As such, all compliance related parameters are focused on Reach 1.

3.3.1.3. Frequency and Timing

The frequency and timing of Channel Forming Flow events is difficult to predict because the compliance magnitude for these event hinges heavily upon either perfect sequencing with significant and sustained accretion (rainfall) and/or spill. In terms of probability, conditions for a Channel Forming Event are mostly likely to manifest between the months of November and March and may occur during periods of intense rain, rain on snow, or rapid snowmelt. While, theoretically, a Channel Forming Event could occur in a controlled manner, the events are subject to precise forecasting and are very difficult to manage for in terms of operations and logistics. Operationally, the execution of these events is considered highly “opportunistic” as valve operations and the controlled release of roughly 2,200 cfs need to be perfectly sequenced to co-occur with a sustained rainfall event delivering a cumulative accretion at the Powerhouse gage of roughly 4,300 cfs to achieve compliance. These challenges were apparent during November 2015 as Snohomish PUD made its initial attempt at executing a Channel Forming Event during an intense, but short-lived rainfall event. In reality, compliance with the magnitude target is most likely to be achieved under an uncontrolled spill condition. Furthermore, the Morning Glory Spillway Rating Curve (Figure 48) indicates that the compliance flow is most likely to occur when the reservoir elevation is over 1,453 feet msl for a sufficient duration. Hydrologic modeling indicates that the probability of a spill of this magnitude occurring in any given year is about 10 to 12%.

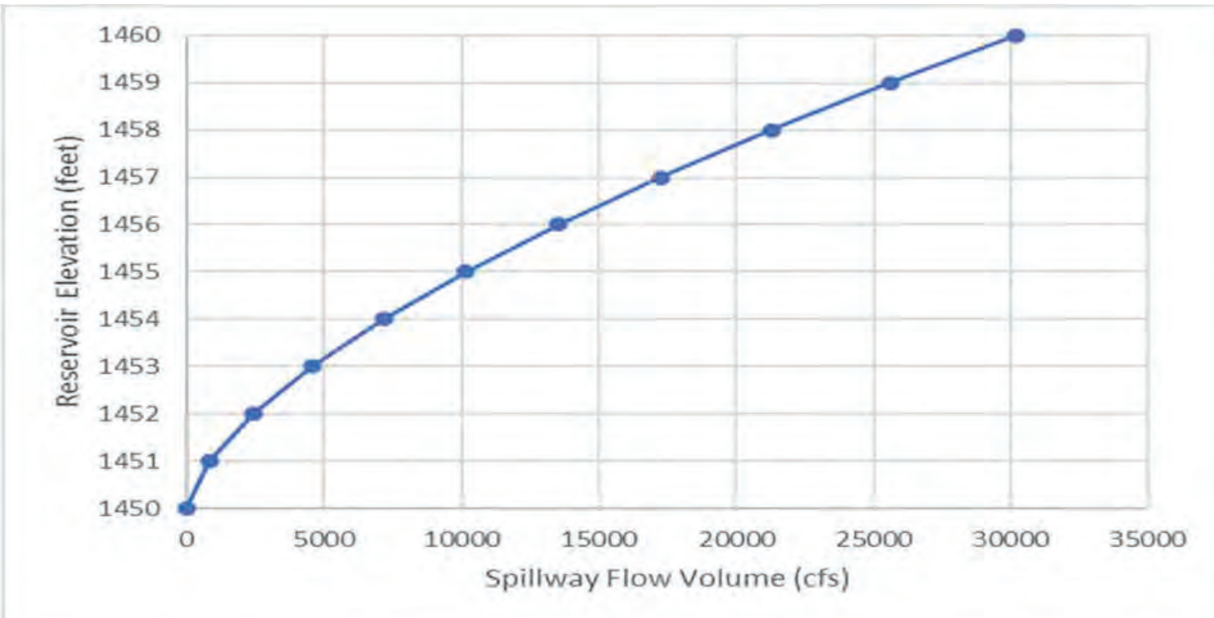

Figure 48. Morning Glory Spillway Rating Curve, Culmback Dam

In terms of compliance frequency, Channel Forming Flow events are to occur once per Ten Year Accounting Cycle.

3.3.1.2. Duration and Magnitude

Compliance with the Channel Forming Flow requirements is achieved when (a) a target flow of at least 6,500 cfs instantaneous minimum flow in maintained for twenty-four (24) consecutive hours at USGS Gaging Station No. 12138160 (below the Powerhouse) or (b) a target flow of a least 6,500 cfs is achieved and the Licensee provides a maximum release flow from the Powerhouse, the outlet pipe adjacent to the City of Everett’s Diversion Dam, and Culmback Dam (via the Howell Bunger and 42-inch slide valves) for twenty-four (24) consecutive hours at the time when flow drops below 6,500 cfs for a total duration (including the target flow and maximum release) of twenty-four (24) consecutive hours as measured at USGS Streamflow Gage No, 12138160, or (c) the Licensee provides a maximum release flow from the Powerhouse, the outlet pipe located adjacent to the City of Everett’s Diversion Dam, and Culmback Dam (via the Howell Bunger and 42-inch slide valves) for twenty-four (24) consecutive hours that is timed to achieve, to the extent feasible, a target flow of 6,500 cfs at USG Streamflow Gage No. 12138160.

3.3.2. Objectives and Assumptions

The objectives of the Channel Formation element of the PFP include:

- Formation and re-distribution of physical habitat features (riffles, pools, runs, point bars)
- Effective transport, sorting, and distribution of LWD and sediment
- Alteration of channel features (increase lateral channel movement, improved connectivity between mainstem and side channel habitats)
- Creation of undercut banks

3.3.3. Results

Since issuance of the new License in 2011, there have two flow events, both under conditions of uncontrolled spill, that can be used to inform the effectiveness of these types of events when it comes to channel formation and the achievement of the desired objectives articulated in the PF Plan. During the initial 10-year period, the first event occurred between November 17 and November 18 (Figure 49). The mean discharge over the 24-hour duration for compliance was 6,016 cfs, with a range between 4,620 and 7,320 cfs. While below the 6,500 cfs threshold value, this event was deemed a Channel Forming event under provision C of Aquatic License Article 8 which states that the component flow is achieved when the Licensee provides a maximum release flow for twenty-four (24) consecutive hours that is timed to achieve, to the extent possible, a target flow of 6,500 cfs. At the time, the designation of this event as a Channel Forming event triggered a comprehensive survey of habitat conditions in the lower river which was conducted by Stillwater Sciences and presented in their 2016 report. Roughly 5 years later, a second flow / spill event occurred between February 1 and February 2, 2020, which was substantially greater in volume (Figure 50) and was the largest flow event since 1995. The 2020 event was over the compliance threshold of 6,500 cfs for a period of 26.75 hours with a range in discharge between 6,540 and 13,900 cfs and an average of 10,454 cfs. Owing to the magnitude, this event was subsequently designated as the Channel Forming event for the 10-year reporting period with the PF log and other records changed to reflect that. With that designation, a comprehensive survey of habitat in the lower river was triggered and again commissioned to be conducted by Stillwater Sciences. Given the rarity of spill events of this magnitude, Snohomish PUD opted to voluntarily expand the scope of the 2020 habitat to include the entire river downstream of Culmback Dam. With the baseline established in 2007 during relicensing, the 2020 survey provides a solid basis for comparison of flow induced changes over that 13-year span and most notably those attributed specifically to the 2020 event. In addition, because this was the largest peak flow event since November 29, 1995, it effectively resets the baseline for future surveys and change detection over time because of the state-of-the-art LiDAR and imagery techniques employed.

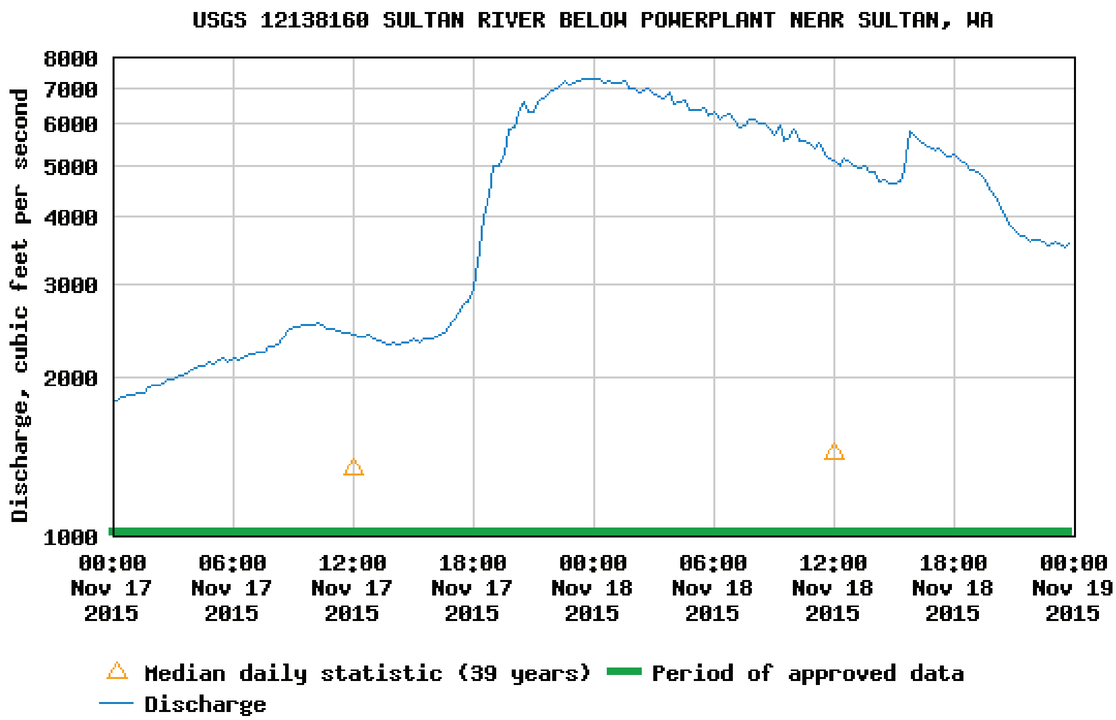

Figure 49. USGS hydrograph for the Sultan River below Powerplant compliance location, November 17-18, 2015.

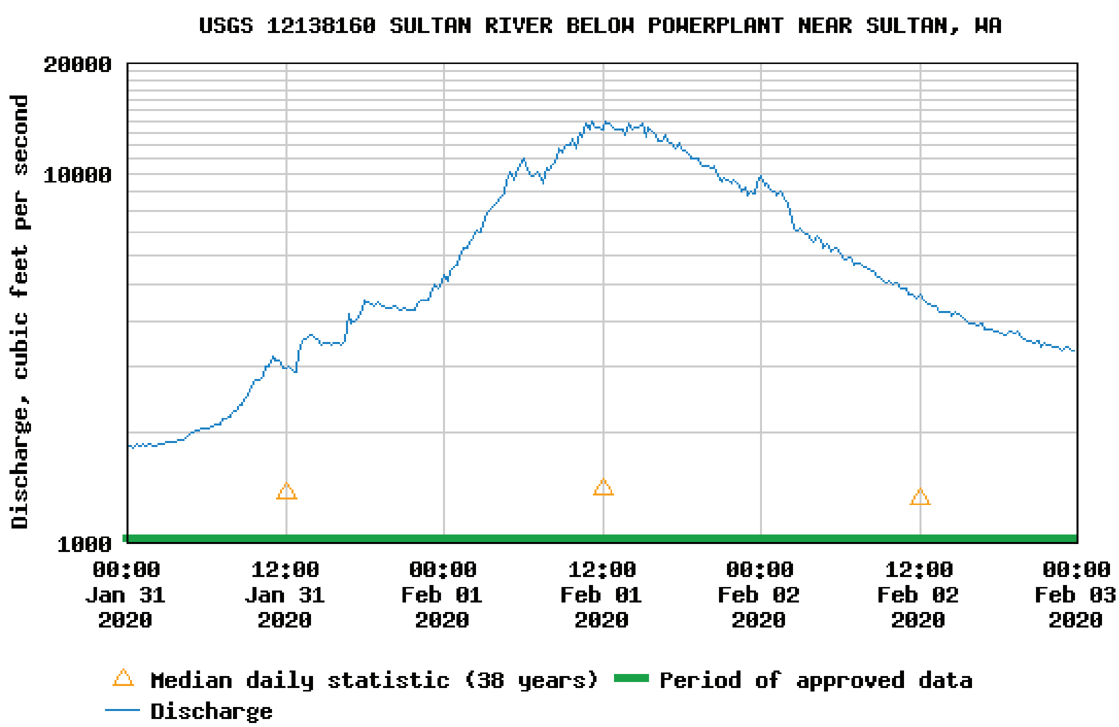

Figure 50. USGS hydrograph for the Sultan River below Powerplant compliance location, February 1-2, 2020.

The following executive summary excerpt from the Stillwater Sciences report highlights some of the overall changes documented during their habitat survey.

Stillwater Sciences conducted a riverine habitat survey that entailed characterization and measurement of aquatic habitat features in the river corridor from Culmback Dam (river mile [RM] 16.5) to its confluence with the Skykomish River (RM 0). The study was separated into two efforts that included a survey of the lower 2.7 miles of the Sultan River and its four side channels ("Lower Reach") and a survey of the uppermost (RM 2.7-16.5) Sultan River (Upper Reach"). The Lower Reach habitat survey is required by the Comprehensive Settlement Agreement for the Henry M. Jackson Hydroelectric Project (Project), which includes Culmback Dam operated by the Snohomish Public Utility District (the District). The requirement for a habitat survey was triggered by a significant high-flow event that occurred in winter 2020. Additional tasks executed as part of this work included data synthesis, mapping, analysis, and reporting of all collected data.

Previous surveys were conducted in 2007 and 2010 to provide baseline data as part of the relicensing of the Project and to determine the effects of prior high-flow events that occurred in March 2014 (as reported in Stillwater 2015) and November 2015 (Stillwater 2016).

Table 17 lists each reach and the year they were surveyed. Riverine habitat attributes recorded for these studies include in-stream unit subtype (e.g., pools, riffles, glides, islands), measurements of wetted unit surface area dimensions (length and width), unit margin features (lengths of undercut banks and bar edges), and the distribution and characterization of large woody debris (LWD). Subsequent to the 2007 and 2010 surveys, habitat enhancements were made to the Lower Reach including the installation of engineered large wood jams along the margins of the mainstem and side channels, and side-channel enhancements including contouring, dredging, reconnection of historic channels as well as establishment of new channels in select locations.

Table 17. Reaches surveyed and the year the survey was conducted.

Reach	Surveyed in 2007?	Surveyed in 2010?	2012	Surveyed in 2014?	Surveyed in 2016?	Surveyed in 2020?
Mainstem (Lower Reach)	Yes	No	LWD installations	Yes	Yes	Yes
Mainstem (Upper Reach)	Yes	No		No	No	Yes
Side channel 1	No	Yes (partial)		Yes	Yes	Yes
Side channel 2	No	Yes		Yes	Yes	Yes
Side channel 3	Yes	No		Yes	Yes	Yes
Side channel 4	No	No		Yes	Yes	Yes
				↑ High flow March 2014	↑ High flow November 2015	↑ High flow January & February 2020

While it may not be possible to directly attribute habitat changes in the Sultan River system to the winter 2020 storm event, the 2020 study shows that habitat diversity continues to increase when comparisons are made between the 2020 study and studies conducted in 2007, 2010, 2014, and 2016.

Habitat diversity, or number of habitat units within the Study Area, has increased between 2007 and 2020 with most of the changes occurring within the side channels in the lowermost Sultan River (Figures 51-53). Locally, changes in aquatic habitat within the side channels are often occurring near the inlets of these channels and in other reaches where large wood and jams are providing complexity and habitat formation. Overall, low-gradient riffles, pools, and glides are the most abundant habitat subtypes and are represented almost equally in terms of surface area across the Study Area.

Large wood continues to accumulate throughout the Study Area. When comparing the amount of LWD throughout the Sultan River system, the number of LWD jams increased by 186% from 2007 to 2020 and the overall density of LWD pieces and jams increased throughout the Study Area. Between 2016 and 2020, the number of LWD jams in the Lower Reach increased threefold. While much of the LWD is situated above the wetted channel during low flow conditions in the Lower Reach, the remainder of the wood lies within the channel and will likely provide habitat complexity and habitat formation during periods of low and high flow (Figure 53).

Figure 51. Erosion of right bank along lower Side Channel 3 after Channel Forming event of 2020.

Figure 52. Deposit of large woody debris in lower Side Channel 3 after Channel Forming event of 2020.

Figure 53. Racking of large woody debris on Engineered Log Jam 1 at the head of Side Channel 4 after Channel Forming event of 2020.

In addition to the documented changes in habitat diversity, side channel engagement, and large wood dynamics captured in the Stillwater survey, Snohomish PUD's established channel cross sections in the lower river reveal some interesting changes in response to the high flow events of November 2015 and February 2020.

For Site 1, near Reese Park, what is noticeable is the aggradation between Station 150' and Station 230', as measured from the left bank (Figure 54). The development of this pronounced gravel bar is likely attributed to several factors including the increased mobilization and transport of smaller sized gravel upstream of the site and a reduction in stream power at the site either as a result of a more active wider channel including Side Channel 4 or the presence of a backwater effect which often occurs when the Skykomish River is above flood stage. The degradation of the channel near Station 250' is also worth noting in that it clearly establishes the channel thalweg. Near Station 470', some modest infilling of Side Channel 4 is evident. This side channel is far more geomorphically active than the extension of Side Channel 1 near Station 50'. This is not surprising given the extreme low gradient of the extension relative to the prevailing gradient within Side Channel 4.

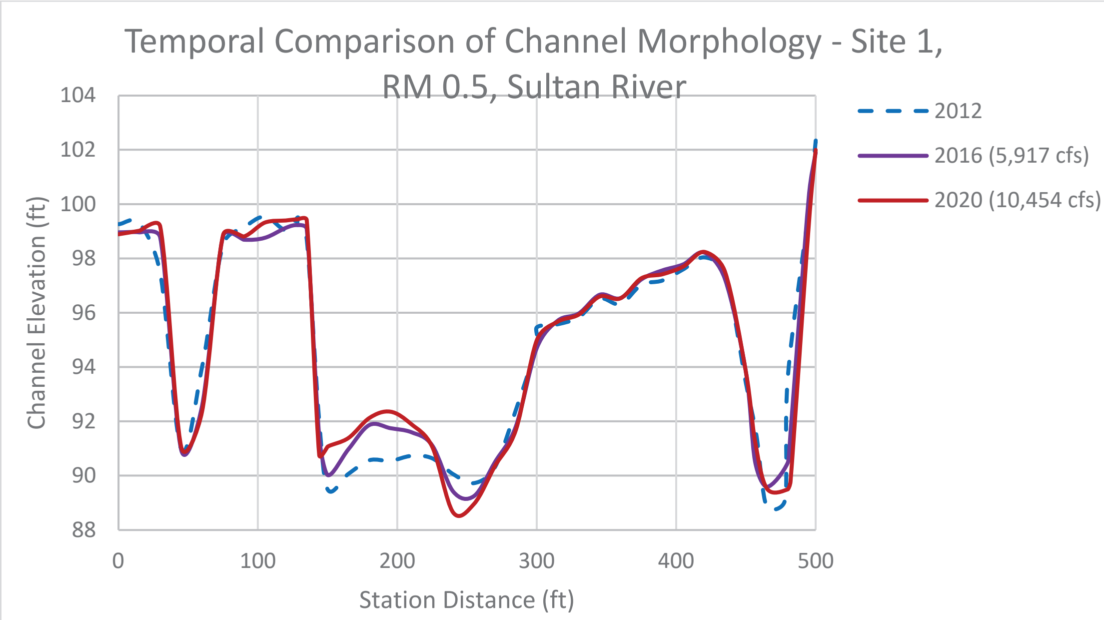

Figure 54. Channel cross section: Site 1, RM 0.5 (2012 baseline, 2016, and 2020)

The temporal changes documented at the channel cross section established at Site 2, RM 1.5 are most evident in the main channel, near Station 250', and along the right bank within Side Channel 2 (Figure 55). These subtle geomorphic changes are believed to reflect altered flow routing as a result of the placement of ELJ 8, upstream along the left bank, coupled with the significant accumulation of wood and fine sediment on the "island" in the proximity of Station 150'.

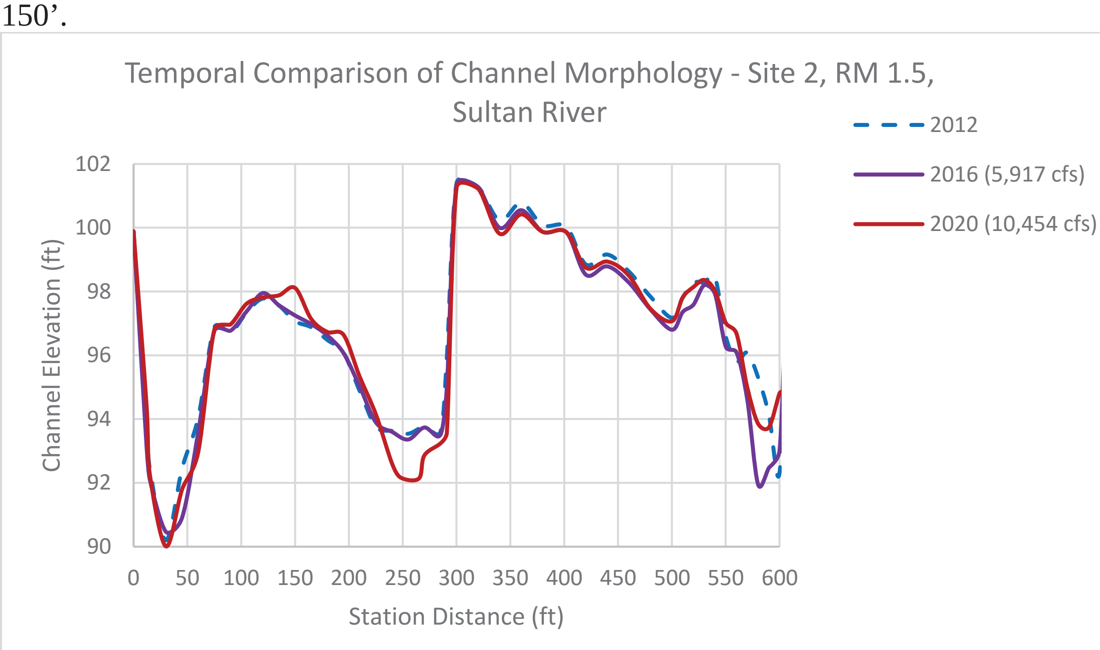

Figure 55. Channel cross section: Site 2, RM 1.5 (2012 baseline, 2016, and 2020)

No pronounced changes over time were evident at Site 3, just downstream of Snohomish PUD's Trout Farm Road Recreation Site (Figure 56). This undoubtedly reflects the presence of a very stable channel feature.

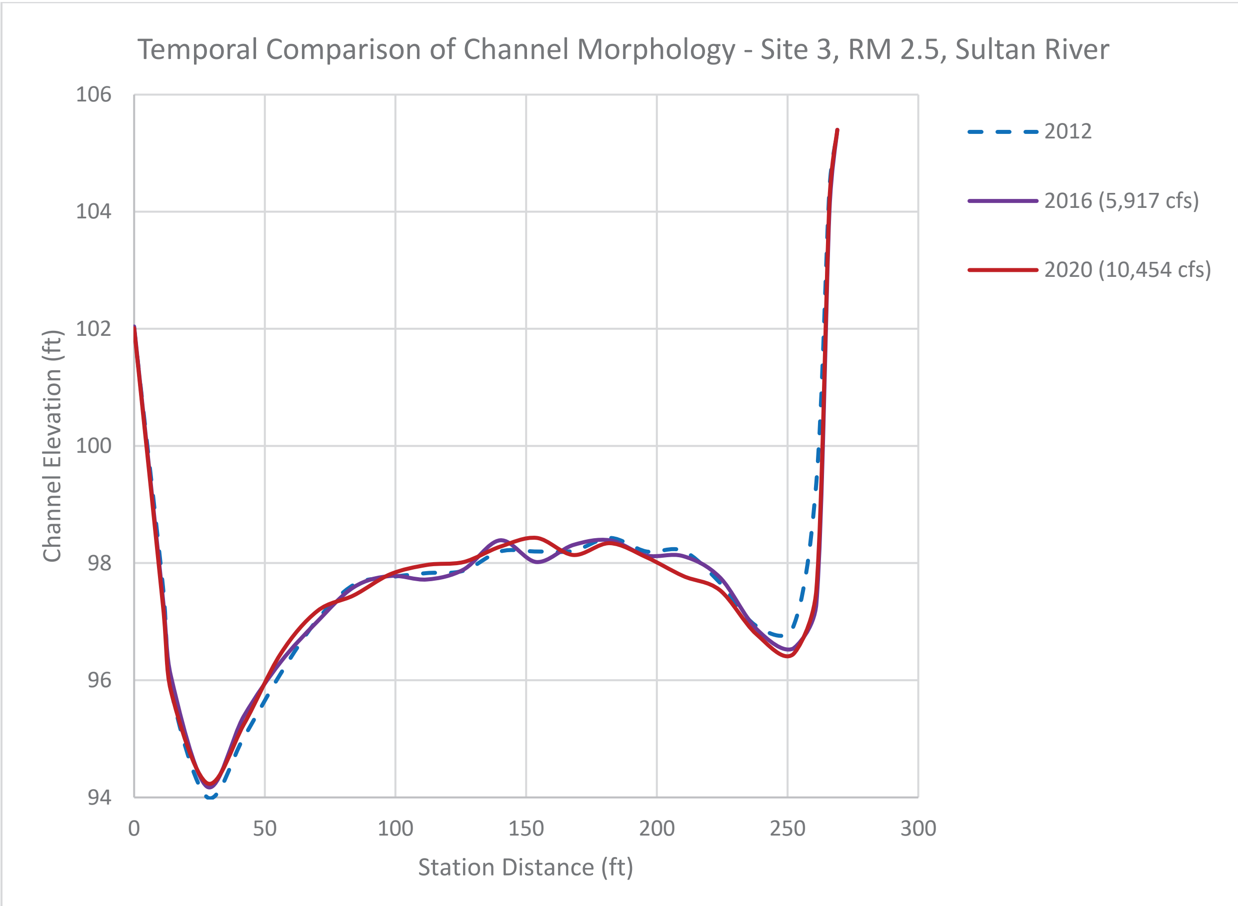

Figure 56. Channel cross section: Site 3, RM 2.5 (2012 baseline, 2016, and 2020)

No pronounced changes over time were evident at Site 4, just downstream of the Jackson Powerhouse (Figure 57). This also undoubtedly reflects the presence of very stable channel features at this location.

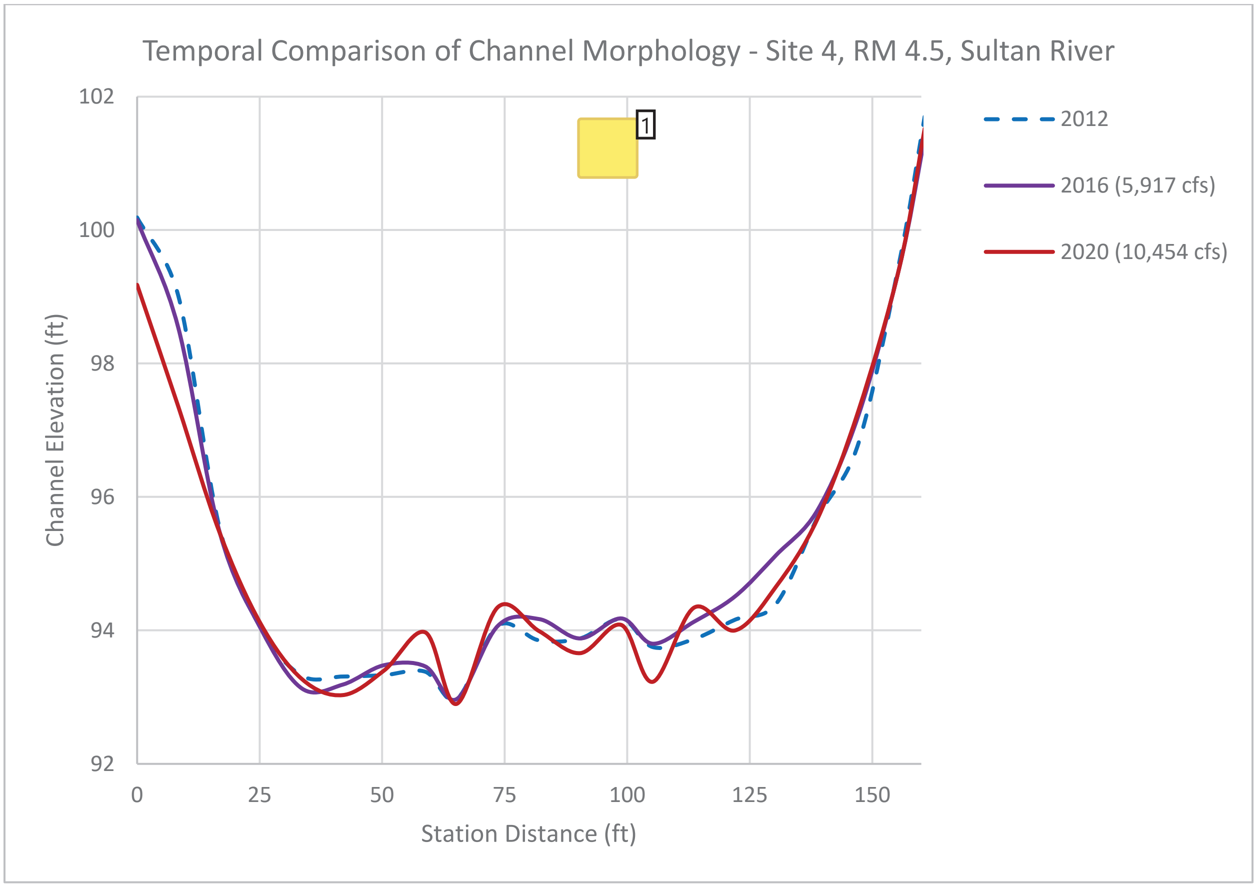

Figure 57. Channel cross section: Site 4, RM 4.5 (2012 baseline, 2016, and 2020)

3.3.4. Unforeseen Consequences

No unforeseen consequences have been identified for this PFP element.

3.3.5. Adaptive Actions Undertaken

No adaptive actions occurred since issuance of the License for this PFP element.

3.3.6. Recommended Modifications

In consideration of the fact that Channel Forming events rely heavily on the occurrence of spill which is largely an event outside the control of Snohomish PUD and beyond the level of control in place with the Project, there are no recommendations for modifications or improvements to this element of the PFP for the next 10-year period. Snohomish PUD will continue to integrate state of the art forecasting in its ongoing hydrologic modeling efforts and track changes that may occur as climate change advances and the probability of intense high inflow conditions increases.

Number: 1 Author: Anne Savery Date: 10/4/2022 3:07:02 PM

this also makes me wonder if this area is really armored.

4. Literature

GeoEngineers, Inc. 1984. Phase 1 Report River Gravel Quantity Study, Henry M. Jackson Hydroelectric Project (Sultan River Project), Snohomish County, Washington for Public Utility District No. 1 of Snohomish County

R2 Resource Consultants, Inc. 2006. Spatial and Temporal Comparison of Spawning Gravel Quality in the Sultan River, Washington. Prepared for Snohomish County Public Utility District No. 1.

R2 Resource Consultants, Inc. 2009. Determination and Evaluation of Habitat – Flow Relationships in the Sultan River, Washington – Sultan River Instream Flow Study – RSP 3. Prepared for Snohomish County Public Utility District No. 1.

Schmidt, L. and J. Potyondy. 2004. Quantifying Channel Maintenance Instream Flows: An Approach for Gravel-Bed Streams in the Western United States. Gen. Tech. Rep. RMRS-GTR-128. Forth Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 33 p.

Shapiro and Associates, Inc. 1988. Evaluation of the textural composition of Sultan River salmonid spawning gravels following hydroelectric project construction, prepared for Snohomish County Public Utility District No. 1.

Shapiro and Associates, Inc. 1995. Evaluation of the textural composition of Sultan River salmonid spawning gravels following hydroelectric project construction, prepared for Snohomish County Public Utility District No. 1.

Stillwater Sciences. 2007. Study Plan 18: riverine, riparian, and wetland habitat assessment technical report. Prepared by Stillwater Sciences for Snohomish County Public Utility District No. 1.

Stillwater Sciences. 2010. Sultan River geomorphic assessment of side channel enhancement opportunities. Prepared by Stillwater Sciences for Snohomish County Public Utility District No.1.

Stillwater Sciences. 2015. Sultan River riverine habitat monitoring. Prepared by Stillwater Sciences, Portland, Oregon for Snohomish County Public Utility District No.1.

Stillwater Sciences. 2016. Sultan River riverine habitat monitoring. Prepared by Stillwater Sciences for Snohomish County Public Utility District No.1.

Stillwater Sciences. 2021. Sultan River riverine habitat monitoring. Prepared by Stillwater Sciences for Snohomish County Public Utility District No.1.

Wert, M.A., C.R. Steward, and F. Winchell. 1982. Baseline evaluation of the textural composition of Sultan River salmonid spawning gravels, prepared for Snohomish County Public Utility District No. 1.

Wert, M.A., C.R. Steward, and F. Winchell. 1984. Evaluation of the textural composition of Sultan River salmonid spawning gravels following hydroelectric project construction, prepared for Snohomish County Public Utility District No. 1.

Wolman, G. M. 1954. A method of sampling coarse river-bed material. Transactions, American Geophysical Union 35, Number 6. Stillwater

Appendix A

Mean Daily Discharge for Skykomish, Sultan and Pilchuck Rivers

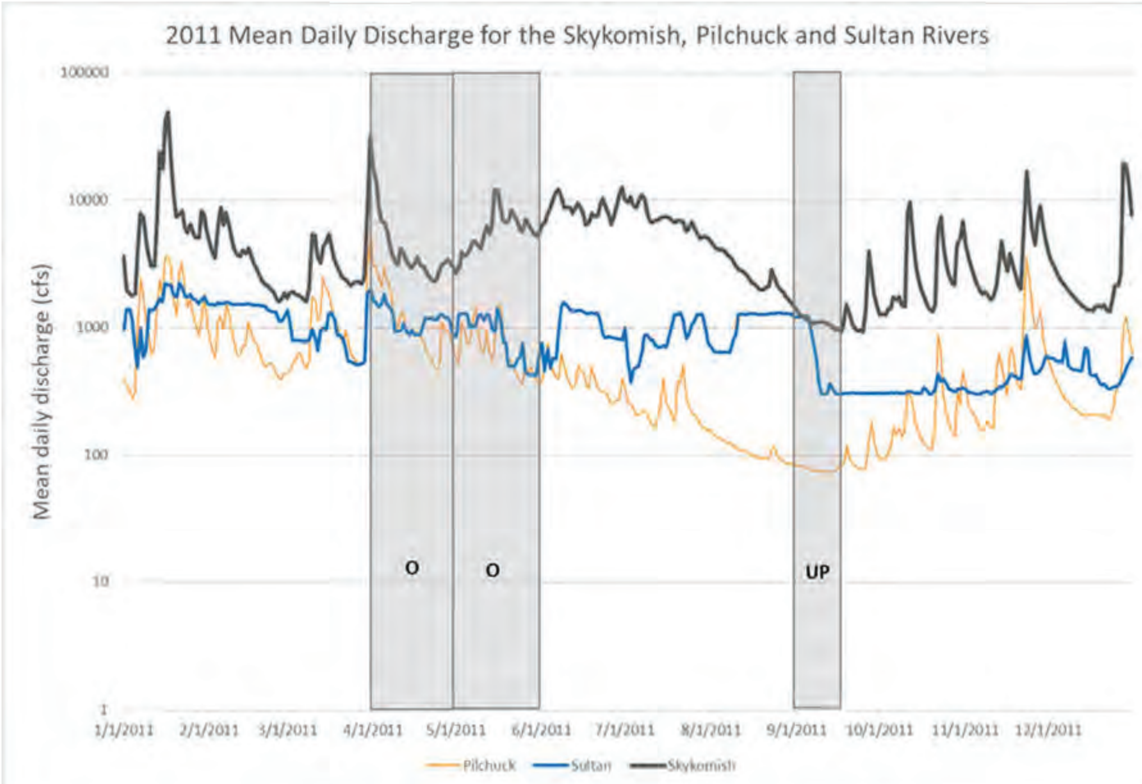

Figure A-1

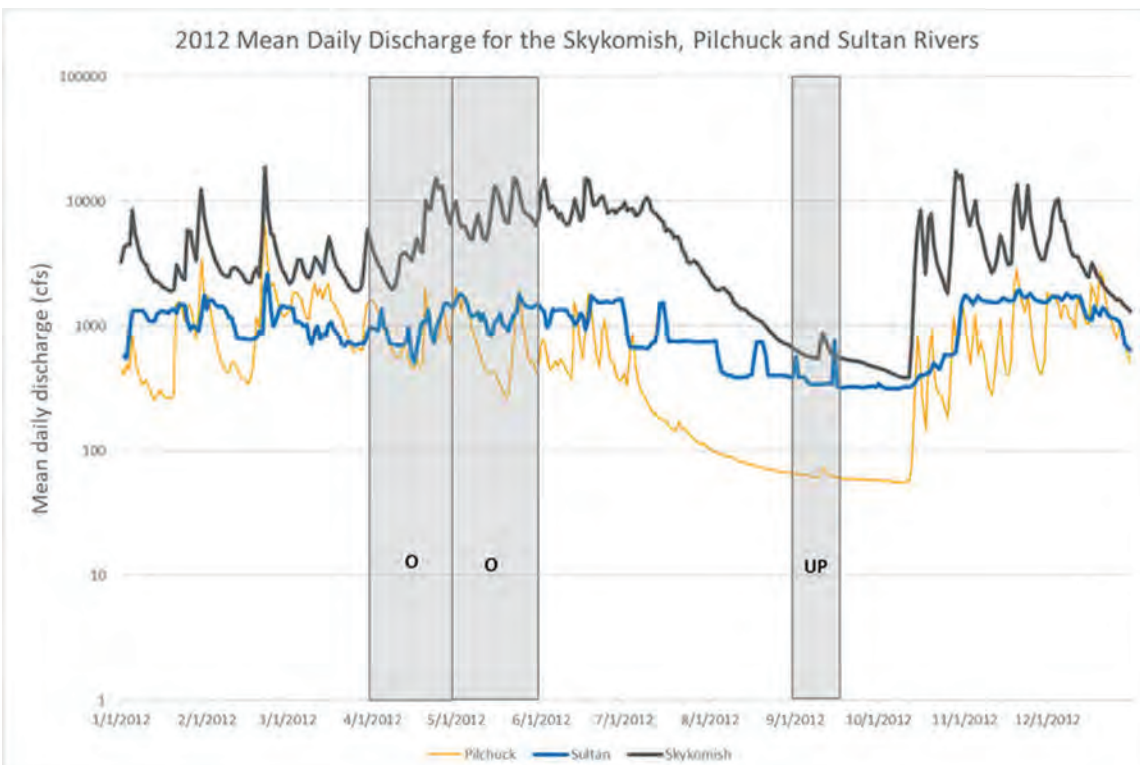

Figure A-2

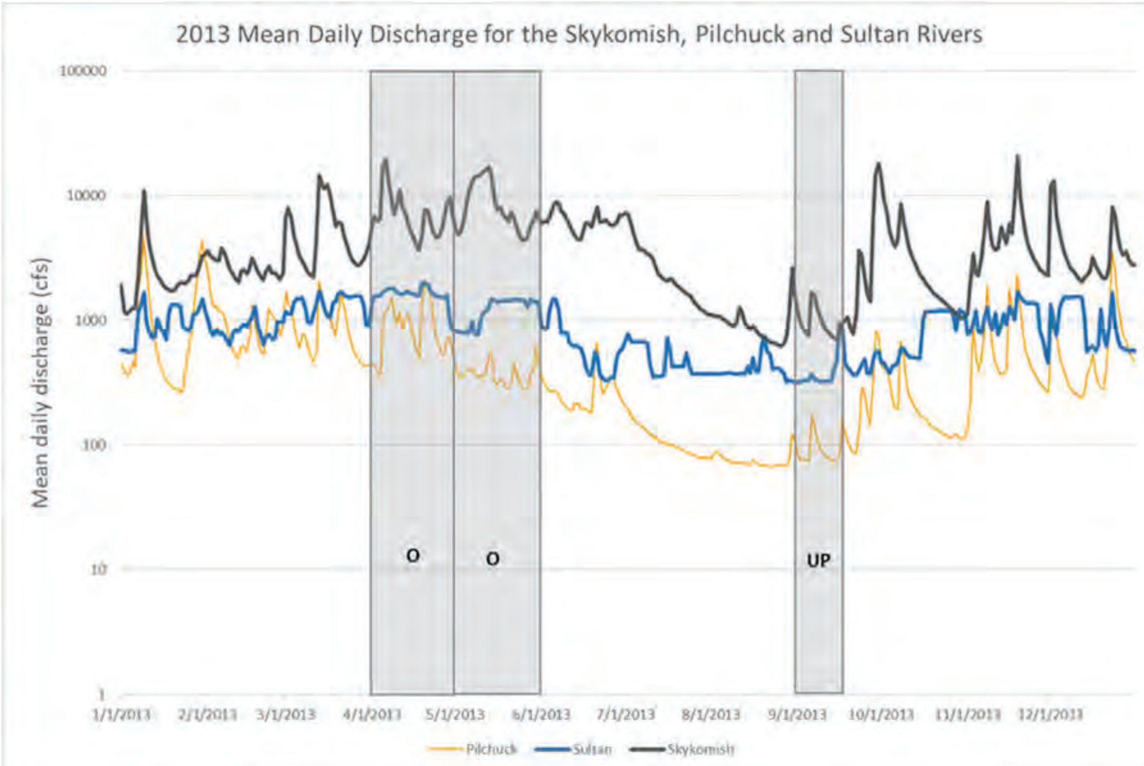

Figure A-3

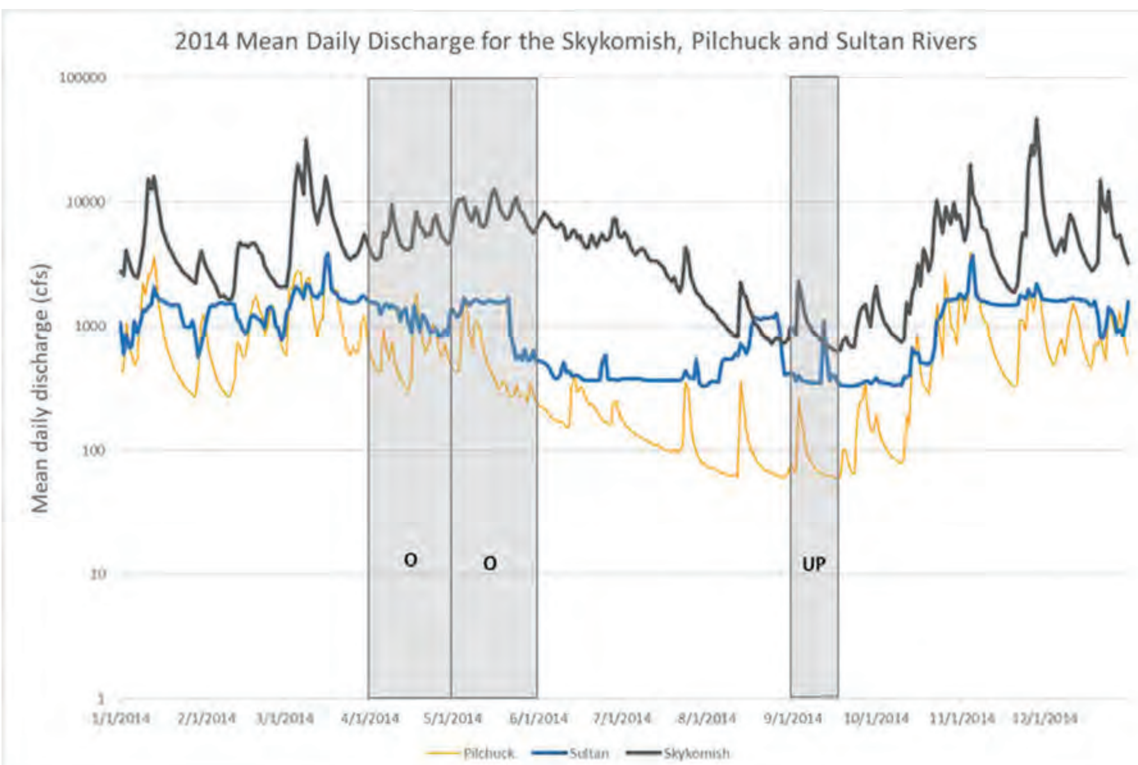

Figure A-4

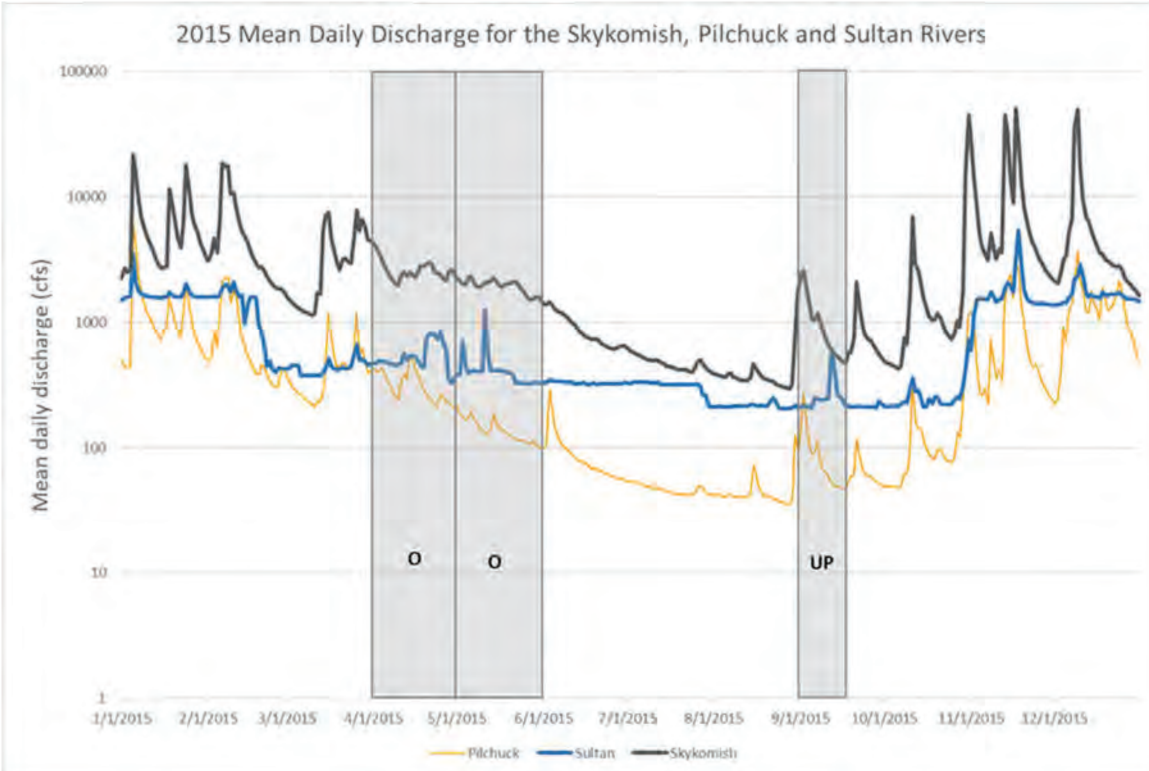

Figure A-5

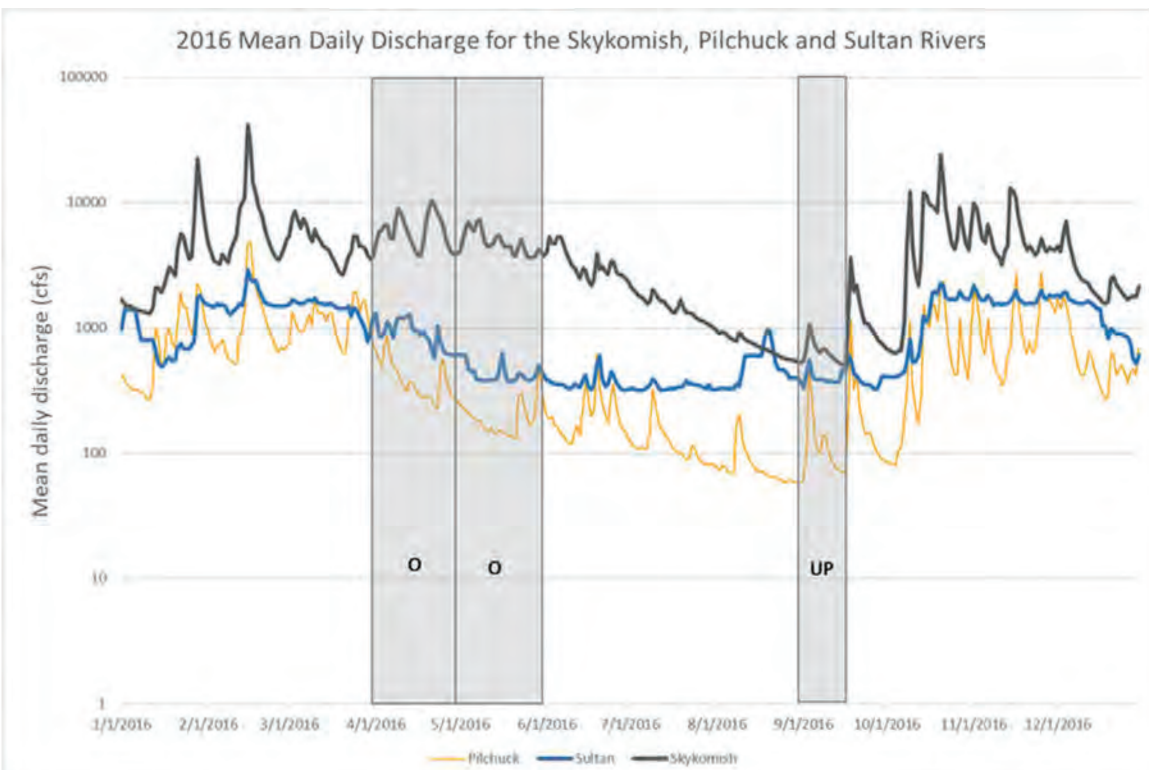

Figure A-6

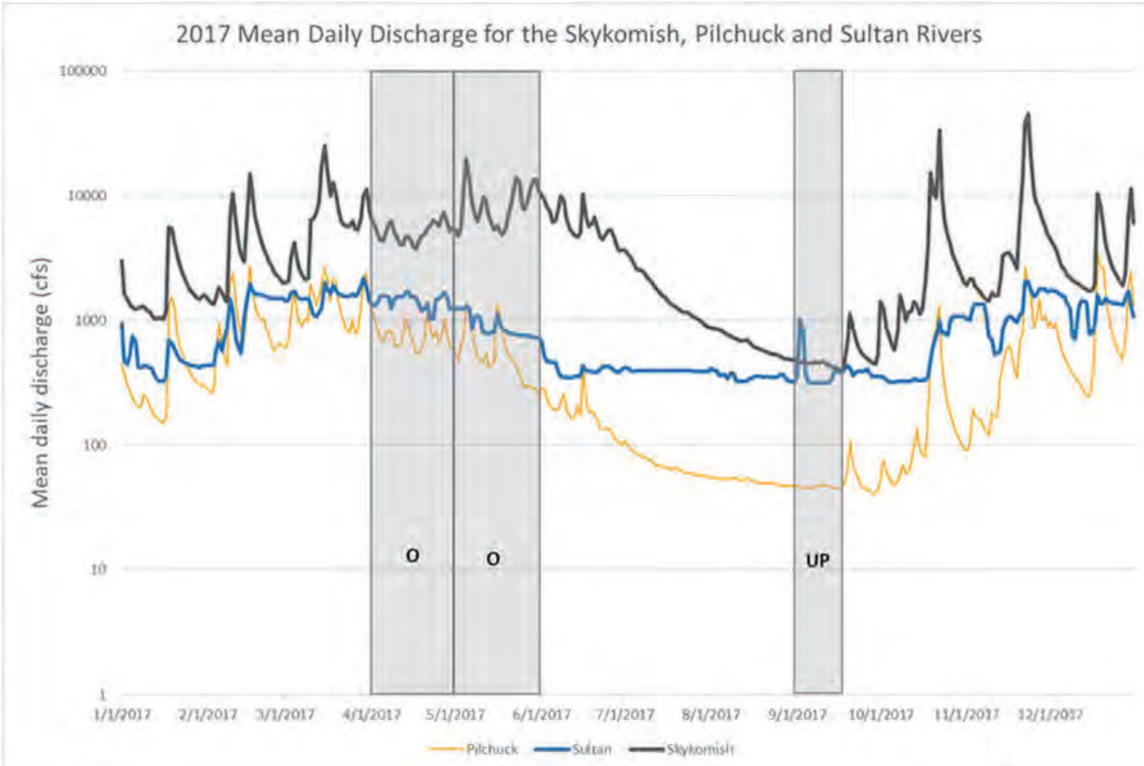

Figure A-7

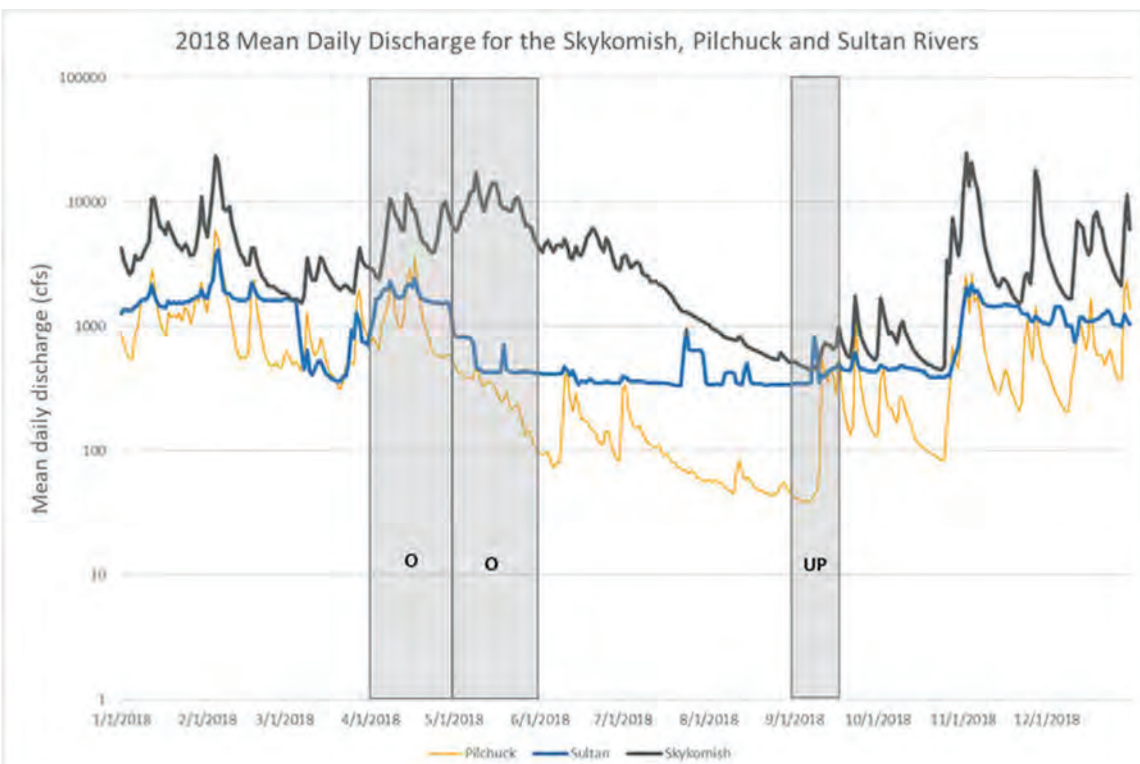

Figure A-8

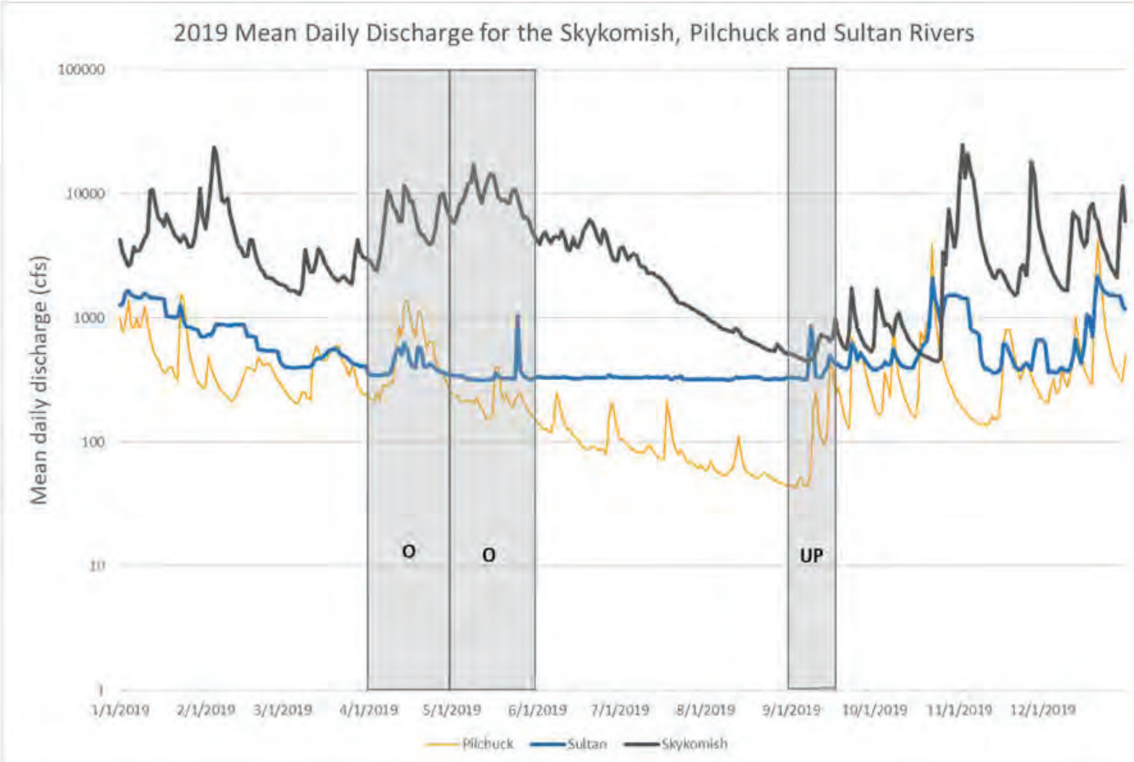

Figure A-9

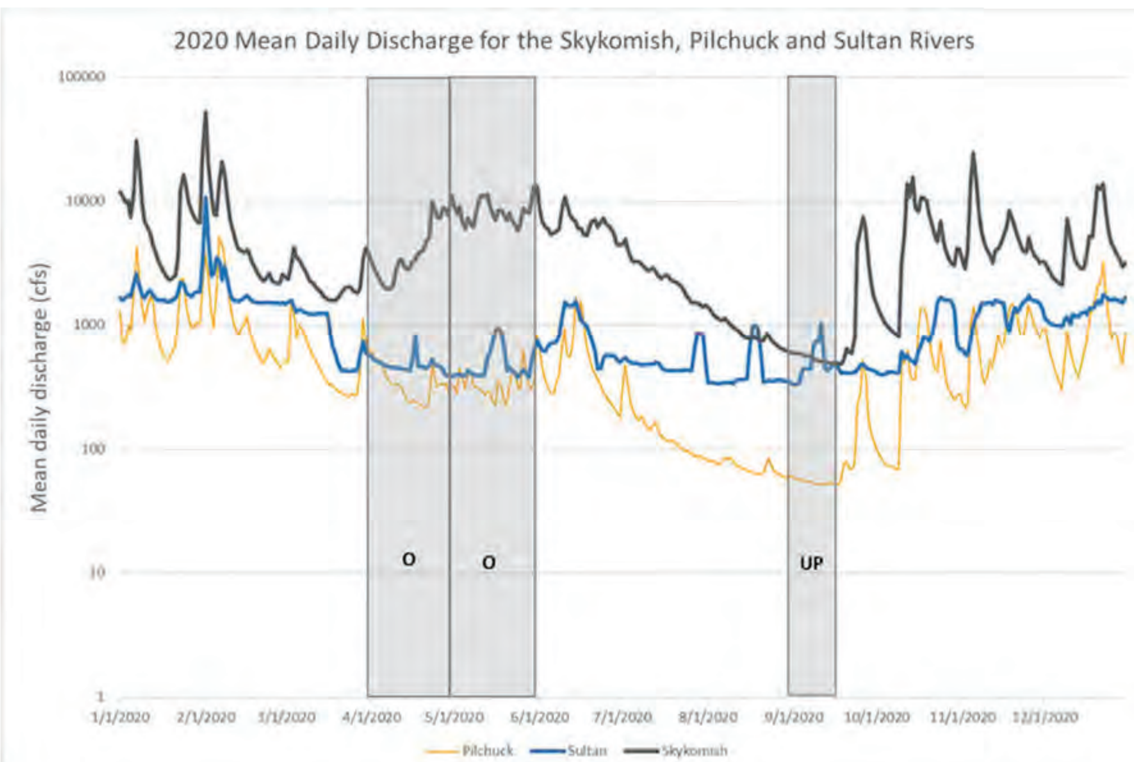

Figure A-10

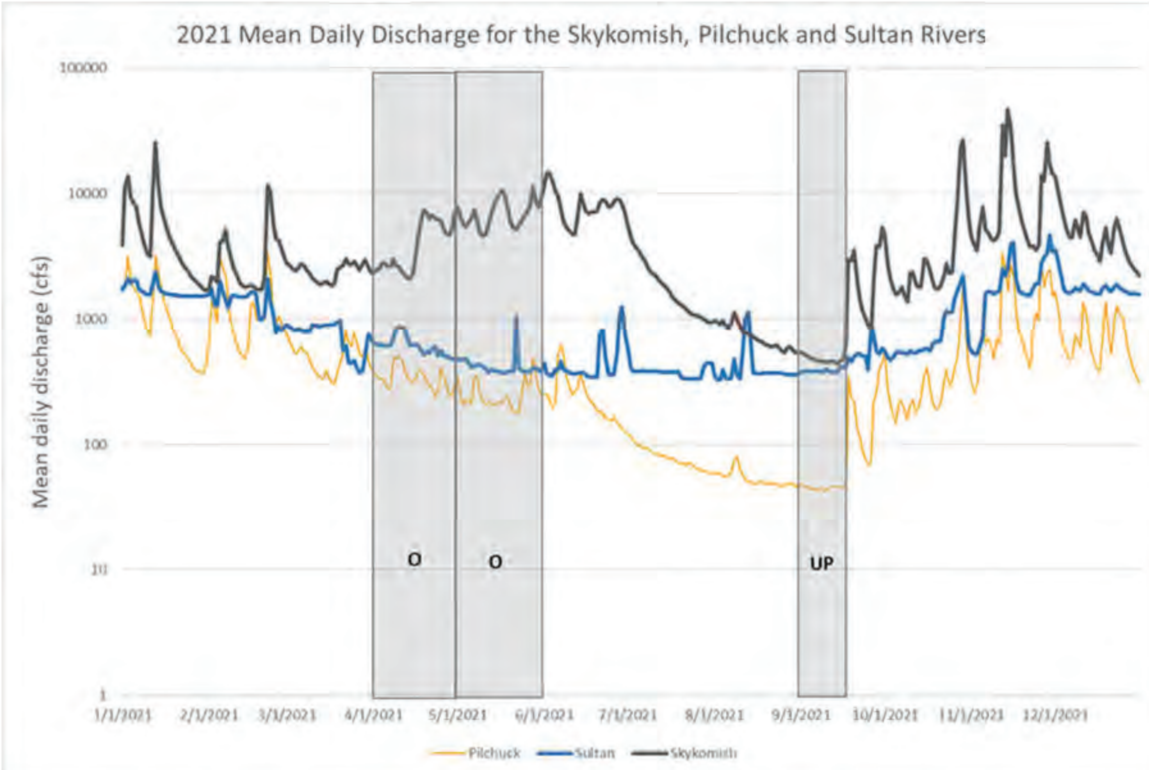

Figure A-11

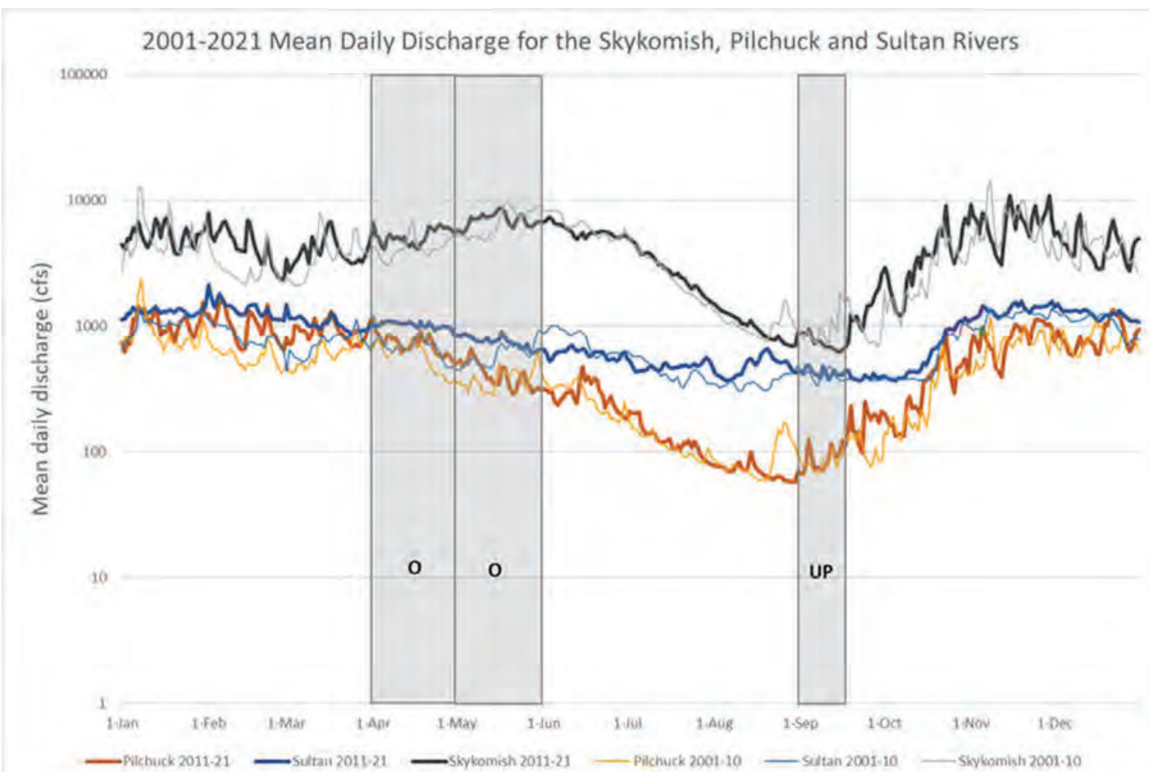

Figure A-12

Appendix B

Number of discrete instances over a 4-year period where mean 6-hour discharge exceeded the threshold for upmigration, outmigration, and channel flushing flow requirements, 2018-2021.

Objective	Reach	January					February					March					April					May				
		2018	2019	2020	2021	Total	2018	2019	2020	2021	Total	2018	2019	2020	2021	Total	2018	2019	2020	2021	Total	2018	2019	2020	2021	Total
Outmigration	**1**	124	116	124	124	**488**	112	0	116	107	**335**	39	0	68	81	**188**	116	1	0	0	**117**	19	0	13	0	**32**
Outmigration	**2**	91	4	61	36	**192**	84	0	43	23	**150**	88	0	11	21	**120**	95	9	0	0	**104**	48	0	0	0	**48**
Outmigration	**3**	16	5	60	34	**115**	35	0	42	23	**100**	77	3	16	33	**129**	62	15	0	3	**80**	0	0	0	0	**0**
Upmigration	**1**	124	116	124	124	**488**	112	4	116	107	**339**	39	0	68	81	**188**	116	0	0	0	**116**	19	0	13	0	**32**
Upmigration	**2**	91	4	61	36	**192**	84	0	43	23	**150**	88	0	11	21	**120**	95	7	0	0	**102**	48	0	0	0	**48**
Upmigration	**3**	5	2	30	20	**57**	20	0	39	14	**73**	53	0	6	32	**91**	38	3	0	0	**41**	0	0	0	0	**0**
Flushing	**1**	81	19	118	124	**342**	112	0	100	52	**264**	23	0	6	2	**31**	108	0	0	0	**108**	0	0	0	0	**0**
Flushing	**2**	59	0	33	31	**123**	74	0	38	17	**129**	36	0	4	6	**46**	92	0	0	0	**92**	45	0	0	0	**45**
Flushing	**3**	2	0	15	4	**21**	16	0	38	6	**60**	13	0	2	2	**17**	24	0	0	0	**24**	0	0	0	0	**0**

*All totals exclude scheduled process flows events.

Objective	Reach	June					September					October					November					December				
		2018	2019	2020	2021	Total	2018	2019	2020	2021	Total	2018	2019	2020	2021	Total	2018	2019	2020	2021	Total	2018	2019	2020	2021	Total
Outmigration	**1**	0	0	45	13	**58**	1	2	0	0	**3**	3	41	41	34	**119**	120	18	104	100	**342**	120	57	121	124	**422**
Outmigration	**2**	0	0	6	0	**6**	3	1	0	3	**7**	0	12	20	10	**42**	26	4	13	66	**109**	14	17	30	30	**91**
Outmigration	**3**	2	0	4	0	**6**	4	11	1	6	**22**	4	13	20	10	**47**	28	4	17	75	**124**	15	16	33	24	**88**
Upmigration	**1**	0	0	45	13	**58**	1	2	0	0	**3**	3	41	41	34	**119**	120	2	104	100	**326**	120	32	121	124	**397**
Upmigration	**2**	2	0	6	0	**8**	3	1	0	3	**7**	0	12	20	10	**42**	26	3	13	66	**108**	14	17	30	30	**91**
Upmigration	**3**	0	0	0	0	**0**	2	2	0	1	**5**	0	5	10	6	**21**	18	2	5	65	**90**	8	11	18	16	**53**
Flushing	**1**	0	0	7	0	**7**	0	0	0	0	**0**	0	24	10	15	**49**	35	2	10	99	**146**	0	32	40	124	**196**
Flushing	**2**	0	0	0	0	**0**	2	0	0	1	**3**	0	6	11	7	**24**	17	3	4	56	**80**	7	12	20	19	**58**
Flushing	**3**	0	0	0	0	**0**	1	0	0	0	**1**	0	4	3	3	**10**	10	2	2	40	**54**	4	6	7	11	**28**

Appendix C

Consultation on Draft Report [placeholder]

Presler, Dawn

From: Applegate, Brock A (DFW) <Brock.Applegate@dfw.wa.gov>
Sent: Thursday, October 6, 2022 12:54 PM
To: Presler, Dawn; Anne Savery; Jeff Garnett; Jennifer Bailey; Mike Rustay; Kannadaguli, Monika (ECY); Nate Morgan; Richard Vacirca; Tom O'Keefe; elizabeth.babcock@noaa.gov
Cc: McDonnell, Andrew; Binkley, Keith; Brown, Chad (ECY)
Subject: RE: JHP (FERC No. 2157) - DRAFT 10-Year Effectiveness Rpt for Process Flow Plan meeting summary from Sept 20
Attachments: 20220920 PF Plan 10YR Rpt ARC meeting summary WDFW edits.docx

CAUTION: THIS EMAIL IS FROM AN EXTERNAL SENDER.
Do not click on links or open attachments if the sender is unknown or the email is suspect.

Hi Dawn, I have made some initial comments in my review of the notes. I may have additional comments, after my review of the slides, settlement agreement and the attached document from WDFW on Process Flows. I will try to get you any additional comment by tomorrow, but I think you will understand my thoughts after reading the comments in the meeting summary. WDFW Process Flows
Document: https://wdfw.wa.gov/sites/default/files/publications/00578/wdfw00578.pdf

Sincerely, Brock

From: Presler, Dawn <DJPresler@SNOPUD.com>
Sent: Monday, September 26, 2022 2:24 PM
To: Anne Savery <asavery@tulaliptribes-nsn.gov>; Applegate, Brock A (DFW) <Brock.Applegate@dfw.wa.gov>; Jeff Garnett <Jeffrey_Garnett@fws.gov>; Jennifer Bailey <JBailey@everettwa.gov>; Mike Rustay <mike.rustay@co.snohomish.wa.us>; Kannadaguli, Monika (ECY) <MKAN461@ECY.WA.GOV>; Nate Morgan <nate.morgan@ci.sultan.wa.us>; Richard Vacirca <richard.vacirca@usda.gov>; Tom O'Keefe <okeefe@americanwhitewater.org>; elizabeth.babcock@noaa.gov
Cc: McDonnell, Andrew <AWMcdonnell@SNOPUD.com>; Binkley, Keith <KMBinkley@SNOPUD.com>; Brown, Chad (ECY) <CHBR461@ECY.WA.GOV>
Subject: JHP (FERC No. 2157) - DRAFT 10-Year Effectiveness Rpt for Process Flow Plan meeting summary from Sept 20

External Email

Hi ARC – attached is the draft meeting summary from the ARC meeting discussing the PF Plan 10-Year Effectiveness Report for your review and comments, if any, by October 3. And also attached is the associated PowerPoint from that meeting as reference. bin

We look forward to reviewing your draft report comments that are due by October 6. I will be sending out the meeting invites for the follow-up meetings shortly.

Cheers,
Dawn

From: Presler, Dawn
Sent: Tuesday, September 6, 2022 10:39 AM
To: Anne Savery <asavery@tulaliptribes-nsn.gov>; Brock Applegate <brock.applegate@dfw.wa.gov>; Jeff Garnett

<Jeffrey_Garnett@fws.gov>; Jennifer Bailey <JBailey@everettwa.gov>; Mike Rustay <mike.rustay@co.snohomish.wa.us>; Monica Kannadaguli <mkan461@ecy.wa.gov>; Nate Morgan <nate.morgan@ci.sultan.wa.us>; Richard Vacirca <richard.vacirca@usda.gov>; Tom O'Keefe <okeefe@americanwhitewater.org>; 'elizabeth.babcock@noaa.gov' <elizabeth.babcock@noaa.gov>
Cc: Andrew McDonnell <AWMcdonnell@SNOPUD.com>; Keith Binkley <KMBinkley@SNOPUD.com>
Subject: JHP (FERC No. 2157) - DRAFT 10-Year Effectiveness Report for Process Flow Plan for your 30-day review and comment period

Dear ARC Members,
Attached is the Jackson Hydro Project's DRAFT 10-Year Effectiveness Report for Process Flow Plan for your 30-day review and comment period. Comments, if any, are **due by October 6**. As always, an email is appreciated too indicating that you have no comments and/or concur with the report. We have a **meeting scheduled for September 20 from 9:00-11:00** to discuss the data and recommendations (let me know if you need me to resend this calendar appointment). Please take some time to review the report and recommendations prior to that meeting.

In the meanwhile, if you have questions regarding the attached, please let us know. Wishing you a wonderful week.

Cheers,
Dawn Presler
(she, her, hers)
Sr. Environmental Coordinator
Generation – Natural Resources
Snohomish County PUD No. 1
Everett, WA

(425) 783-1709 (work)

Jackson Hydroelectric Project (P-2157): Aquatic Resource Committee (ARC) Meeting Summary

September 20, 2022

Present:
- District – Keith Binkley, Kyle Legare, Larry Lowe, Andrew McDonnell, Dawn Presler
- City of Everett – Jennifer Bailey
- Snohomish County – Mike Rustay
- Tulalip Tribes – Anne Savery
- U.S. Fish and Wildlife Service – Jeff Garnett
- WA Department of Fish and Wildlife – Brock Applegate

Absent:
- American Whitewater – Tom O'Keefe
- City of Sultan – Nate Morgan
- National Marine Fisheries Service – vacant
- U.S. Forest Service – Richard Vacirca
- WA Department of Ecology – Monika Kannadaguli

TOPICS DISCUSSED

Given new ARC members who were not around during the License obligation and settlement negotiations, the PUD provided an overview and each of the Process Flow (PF) components' obligations, purposes, data, unforeseen circumstances, and recommendations. These components are: upmigration, outmigration, flushing, and channel maintenance. Channel fForming events were not discussed since no changes are recommended. The slides provide a summary of the information in the draft report.

Please see the PowerPoint slides for main points discussed. The following are the questions and answers, extra commentary not on slides, and/or comments provided during the meeting.

Upmigration:
- Barriers and the Marsh Creek Slide – slide occurred in 2004 and partially blocked the river; SnoPUD modified slide and opened access in 2012 for migration past the slide, which then provided limited access to pink salmon but was still accessible to them under the right conditions. In 2020, the largest spill event occurred since 1995 which resulted in significant changes at this former barrier location and pink salmon, the weakest salmonid

species in term of navigating high gradient channels, have been observed above the Marsh Creek slide area and even upstream of the modified Diversion Dam.

- Anne – tagged fish (Chinook salmon?) arrive earlier in the season even before a PF upmigration release. Need to dig in more why this occurs. The background on this upmigration during negotiations was to have the flow supplement a natural rainstorm event rather later in the season. However, because we were avoiding the salmon ceiling in Sept 15-Oct 15, it got moved earlier and made distinct difference(?).
  - PUD – yes, that is correct and relevant information is presented in the report, they do arrive earlier than the upmigration flows; one indication that they are not needed to move fish into the system.
- Brock – based on the graphs, seems that they are more advantageous later in September.
  - PUD – yes, that is why we changed the salmon ceiling to allow for these types of process flows to occur during Sept 15-Oct 15.
- Mike – likes the comparison data with other rivers such as the Pilchuck to show the regulated versus non-regulated system perspective. If you can include more data as an appendix showing this comparison it would be good. Recognizing that we don't necessarily have other system's data (like straying) that we do for the Sultan River.
  - PUD – yes, we can include additional comparison where available.
- Brock – regard~~verify~~ing the suspension of the 10 years of monitoring. Seems that you should pick a target flow and study it to see if it meets the objectives, rather than just getting rid of it.
  - PUD – yes, recommendation is to suspend so you can compare with and without the PUD provided flows, to see if the PUD releases are really necessary to stimulate upmigration. Data shows it occurs naturally and isn't necessary.
- Anne – when is the next opportunity for discussion.
  - PUD – additional discussions are warranted given the meatiness of the topic. The 30-day comment period helps the PUD with questions/concerns the ARC may have and to help guide the discussions necessary.
- Jeff – aren't these coordinated with whitewater events?
  - PUD – yes. However, we are looking at the necessity of these flows independently to see if they are needed from a fish biological standpoint. We can then determine if it is useful to combine other obligations.

Outmigration:

- Brock – are there other species unbuttoned besides pink found in the trap?
  - PUD – yes, however, the majority are pinks. Pinks are extremely vulnerable to flows at this lifestage and location of emergence.
- Anne – Josh Kubo of Tulalips put out a report for correlation of flows and outmigration, has the PUD reviewed it. The report showed no correlation between flows and outmigration. However, increased flows provide more migration paths for fish and traps might not be catching the same percent under higher flows. Chinook are done with

Commented [ABA(1]: Do we have hatchery or natural origin fish arrive earlier?

Commented [ABA(2]: We probably need some sort of word after distinct.

Commented [ABA(3]: Does the upmigration flow not help because of the earlier timing, before September 15th?

Commented [ABA(4]: The Skykomish River has more than one run of Chinook.

Commented [ABA(5]: Does the salmon ceiling represent a maximum flow to have the Chinook spawn at lower channel elevation? Do we need to have the upmigration flow outside of the salmon ceiling?

Commented [ABA(6]: WDFW likes the idea of the preservation of the upstream migration flow target. If you receive it naturally during the right time, we have met the goal. If the Sultan River does not receive the predetermined upmigration flow at the magnitude, frequency, duration etc., the PUD releases it. WDFW currently does not support the removal for the requirement.

outmigration in April. How does temperature effect smoltification and emergence from eggs (more slowly)?

  - PUD – yes, the PUD has reviewed the report. We have lots of temperature data along the river and confluence and it is not that different from other rivers during the Nov – April timeframe. Chinook emergence is typically around 900 accumulated temperature units (ATU's) . If they spawn earlier in the season, they leave the system earlier (given the number of warmer fall days). If they spawn later in the season, they leave the system later.
  - PUD – it is interesting to review the data regarding Chinook. A significant scour event that occurs during incubation, can truncate the outmigration season.
  - PUD - The PUD has lots of data on discharge versus catch efficiencies, under all levels of flows. It is a confined channel which makes for an ideal trap location, a regulated system, operating over a large range of flows. As such, trapping efficiency is very high with efficiency tests conducted at all flow levels. The trap operates ~70% of the time given camera, alarms, and tracking of the drum rotations and fish.
- Brock – do we have target flows for up and out migration?
  - PUD – yes, each reach has target flows and we have presented the data on these in the report.
- Brock – why do we do releases if they occur naturally?
  - PUD – that's exactly what we are studying and addressing; the hydrologic context is highly relevant. If the natural events promote effective outmigration , why bother with implementing short-term episodic releases. The PUD feels that the releases are not needed to meet the objective and have some negative consequences from doing the releases.
- Mike – he does not have a concern for the fish outmigration from the Sultan River. They move out of the system when they need to naturally. The Sultan River is in really good shape and the fish are better to be in the Sultan than to get pushed into the Skykomish.

Flushing:

- Keith – multiple studies have been conducted in the past regarding spawning gravel quality and quantity; there was debate on the necessity of this in the license action during negotiations and so SnoPUD has proposed to ~~it was~~ blend~~ed~~ i~~n~~t~~o~~ the other obligations. This gives us another opportunity to really look at the objective and the necessity of these flows given natural, maintenance, and forming events.
- Brock – why suspend this obligation? Too many variables can impact the results. Suggest setting a target and evaluating it.
  - PUD – there are targets that we met over the last 10 years, data show it is not necessary. Visual data observed by Andrew's weekly visits to the river also indicate high quality gravels and the lack of need for flushing flows.

Commented [ABA(7]: WDFW remains fine with no release of migration flows, if we meet the target naturally at the correct time, for the correct duration. Let's keep the target or goal for migration flows.

Commented [ABA(8]: I have the same comment from above. We have a target flow magnitude, frequency, duration, etc. If we met the target naturally, the river has achieved it. If not, please release it from the reservoir.

Commented [ABA(9]: Why would we assume that we would get the same results if we stopped the flows? Rivers have to many variables. What data has shown that you don't need these flows. I would need a study with numbers, not anecdotal observations.

- Brock – (via chat) Are the 85 natural flushing flow events during the right time of year prior to spawning?
- Anne – in settlement negotiations, Reach 3 photos and info indicated large cobble and algae blooms. The hydrograph pre-new License had all the peaks shaved off and no response to the fall rainfall events. Maybe accretion flows doing it naturally? Figure 14 not relevant to the magnitude of the flows for flushing. What do the flushing flows do? Before/after pictures?
  - PUD – while the figure does include peak flow information the real value of the figure is that it incorporates spawning escapement and trap catch to show general survival to emergence trends which provide an index to the quality of the spawning gravels and doesn't just focus on the gravel component. Within Reach 3, the presence of Didymo observed several years ago has diminished significantly likely as a result of the maintenance and forming events; they have really churned the bed and cleaned the gravel. Tom O'Keefe has mentioned the change in the past and it would be good to hear his perspective.
- Jeff – (via chat) agree with Brock's statement on the variables. Can see suspension of some flow releases but will it be an apples-to-apples comparison?

Maintenance:
Keith presented the info; however, there was no time left for discussion/questions.

Forming:
No changes are proposed so not discussed.

Next Steps:
Meet again to discuss the data and recommendations in more detail. ARC members to submit questions/comments by October 6 so PUD can come prepared. Dawn to send out ppt and doodle poll.

Other:
- Anne – had a couple thoughts to share at this point for the next meeting:
  - 1) does the suspension have to be 10 years?
  - 2) can water be banked for other uses? Horse-trading for more features?
  - 3) features for in-channel for water to interact with still needed?
- Dawn -
  - Ecology is making progress with getting additional staff assigned. Monika is now a section manager and is hiring her replacement (as 401 main point of contact) and Ecology is also hiring a "Jim Pacheco" hydrologist/fish bio role. So hopefully they will be assigned to the ARC in the next few months.
  - Still no word on a NMFS replacement. We have been keeping Elizabeth Babcock informed all the while. Keith will check in with her again.

ACTIONS ITEMS

- **Dawn** –
  - send Doodle Poll for next meetings
  - route PPT slides
- **Keith** –
  - Contact NMFS regarding ARC contact/replacement
- **ARC Members** –
  - Submit comments/questions regarding draft report to the PUD by October 6

END ARC MEETING

Appendix D

Response to Comments Regarding Draft Report

Comment Number	Comment	Response
J. Garnett, U.S. Fish & Wildlife Service, email dated 10/07/2022		
1	USFWS has the following general comments concerning the recommendations from SnoPUD related to upmigration, outmigration, and flushing flows found within the 10-Year Effectiveness Report. Suspending flows for 10 years appears drastic, and USFWS would appreciate that SnoPUD and the ARC consider other, less aggressive measures to modify and test effectiveness of these flows. If there is concurrence among members of the ARC that these flows, as previously implemented, are ineffective, we suggest one or more of the following strategies: • Altering the timing or magnitude of flows; • Reducing the number of annual flow events (in the case of outmigration and flushing flows), or; • Suspending flows for a shorter duration than 10 years. This provides the ARC recourse if undesirable/unintended effects become apparent well before the end of the 10 year period. A shorter suspension would allow the ARC to re-evaluate flow effectiveness and either continue with the suspension or reinstitute flows. A statistically robust comparison could still occur with a smaller data set of suspended flows.	Comment noted. This input was incorporated in the development of revised PFP based on subsequent discussions with the ARC.
2	I also have concerns that other variables may confound a comparison of the previous 10 years to a 10 year suspension of upmigration, outmigration, and flushing flows. For example, the continuation of whitewater flows may effectively serve as a process flow and make a comparison challenging.	Snohomish PUD acknowledges this concern and suspension of flow releases is no longer in consideration for this next 10-year review of the PFP based on subsequent discussions with the ARC.
3	Finally, the 10-Year Effectiveness Report states that outmigration flows as previously implemented “likely disrupts steelhead spawning.” Has this been documented in the Sultan River with empirical data? If not, I would advocate for testing this hypothesis before using it to make long term management decisions; therefore, I would appreciate seeing data that supports this claim. In the event data does exist supporting the hypothesis, I believe identifying ways to modify the timing and/or magnitude of flows, as indicated above, would be a prudent first step before suspending flows for 10 years.	Snohomish PUD acknowledges that the data supporting the assertion of spawning disruption during releases is limited. At this time, suspension of flows is no longer under consideration for this next 10-year cycle based on subsequent discussions with the ARC.
B. Applegate, WA Department of Fish & Wildlife, email dated 10/06/2022 comments from meeting summary		
4	Upmigration: Do we have hatchery or natural origin fish arrive earlier?	Hatchery fish arrive earlier.

5	Upmigration: Does the upmigration flow not help because of the earlier timing, before September 15th? Upmigration: The Skykomish River has more than one run of Chinook.	The concern was that timing of the release could have unintended consequences, such as drawing in hatchery fish destined for Wallace Falls hatchery on the Skykomish River. Comment noted. Snohomish PUD and the Tulalip Tribes are currently conducting genetic analysis to further understand the relationship between run timing and stock definition.
6	Upmigration: Does the salmon ceiling represent a maximum flow to have the Chinook spawn at lower channel elevation? Do we need to have the upmigration flow outside of the salmon ceiling?	The salmon ceiling applies to Reach 1 and represents a maximum flow to ensure that wherever eggs are deposited that they will remain wetted should the Project operate at minimum flows at any time during incubation. The ARC discussed modifications to the Redd Dewatering component of Aquatic License Article 5 to allow for short-term excursions above the ceiling associated with flow releases. These excursions were limited to the month of September corresponding with the first half of the 30-day ceiling period. FERC approved these modifications.
7	Upmigration: WDFW likes the idea of the preservation of the upstream migration flow target. If you receive it naturally during the right time, we have met the goal. If the Sultan River does not receive the predetermined upmigration flow at the magnitude, frequency, duration etc., the PUD releases it. WDFW currently does not support the removal for the requirement.	Snohomish PUD agrees with the logic if continued upmigration flow releases are to be provided. Based on subsequent discussion with the ARC, Snohomish PUD agreed to continue with providing the release, not that the artificial releases are necessary.
8	Outmigration: WDFW remains fine with no release of migration flows, if we meet the target naturally at the correct time, for the correct duration. Let's keep the target or goal for migration flows.	Snohomish PUD agrees with the logic if continued upmigration flow releases are to be provided. Based on subsequent discussion with the ARC, Snohomish PUD agreed to continue with providing the release, not that the artificial releases are necessary.
9	Flushing: I have the same comment from above. We have a target flow magnitude, frequency, duration, etc. If we met the target naturally, the river has achieved it. If not, please release it from the reservoir.	Snohomish PUD agrees with the logic if continued upmigration flow releases are to be provided. Based on subsequent discussion with the ARC, Snohomish PUD agreed to continue with providing the release, not that the artificial releases are necessary.
10	Flushing: Why would we assume that we would get the same results if we stopped the flows? Rivers have to many variables. What data has shown that	Comment noted. Snohomish PUD has repeatedly presented the results of past studies, including hydrologic information on the

	you don't need these flows. I would need a study with numbers, not anecdotal observations.	frequency of flows meeting the flushing criteria. Despite that information, the perception remains that there is a chronic input of sediment that warrants flushing within weeks of spawning in both the spring and fall.
A. Savery, Tulalip Tribes, relines/comments on Draft Report, email dated 10/11/2022		
11	2.1.1.: This is about the initial premises of a single pulse release for "upmigration" purposes that would not occur outside of the normal hydrograph when it is needed the most given we continue to see predictable records and opportunity for a revised approach to account for increasingly prolonged holding under record temps that exceed state standards and record low flows that truncate distribution and force spawning in thalwegs most vulnerable to redd scour and the increasing frequency and intensity of flooding all from climate change	The Sultan River does not typically exceed state standards for temperature, especially not due to Project operations. The Project's ability to release cooler water from the base of Culmback Dam helps cool the Skykomish River to some extent Additionally, minimum flows on the Sultan River are met during the low flow season, which in turn helps maintain access to all available spawning areas.
12	2.1.3.: Fish tend to spawn in the same places, so was this the appropriate test?	The PFP specifically calls (Section 4.3) out annual fall spawning ground surveys as the metric used for determining the need for and effectiveness of upmigration flows. "*The benefit provided by the release will be assessed by looking at the temporal distribution of fish and the presence of redds through the spawning season. This distribution with the release program in place will be compared with the historic distribution without an upmigration release program."*
13	2.1.4: The fall process flow may be achieving an unquantified objective of cooling the Skykomish River and preventing pre spawn mortality	Agreed.
14	2.1.4.: what is normative flow defined as and in what system?	The term "normative flow" is not defined in the PFP. Snohomish PUD uses it to reference and compare hydrologic conditions on the regulated Sultan River with hydrologic conditions on un-regulated rivers in the Snohomish River system (e.g. Skykomish and Pilchuck). From this perspective, Snohomish PUD view "normative flow" as occurring on un-regulated rivers.
15	2.1.4.: we may need to see data in other reaches, since upmigration flow wasn't limited to Reach 1 concerns	Data for Reach 3 is only available after the completion of the Volitional Fish Passage Project in 2016.
16	2.1.4.: before and after implementation is problematic in the annual time series due to lack of sampling before the upmigation flows were initiated and within year, is confounded by the flow manipulations occurring just prior to normal Skykomish Chinook spawn timing ashten "causative" of some increase, or not,	While pre-process flow data is limiting, the PFP specifically calls (Section 4.3) out annual fall spawning ground surveys as the metric used for determining the need for and effectiveness of upmigration flows. "*The benefit provided by the release will be assessed by looking at the temporal distribution of fish and the*

	which can vary from year to year relative to climate effects, which are assumed to be constant	*presence of redds through the spawning season. This distribution with the release program in place will be compared with the historic distribution without an upmigration release program."*
17	2.1.4.: if there was no PFP in 2016, why is it included in the analysis?	It was included for comparative purposes. In both 2012 and 2016, the two largest single day redd counts in Reach 1 occurred under minimum flow conditions. This data point underscores Snohomish PUD's conclusion that upmigration process flows are not needed on the Sultan River because even at low flow, Chinook are successfully migrating into the Sultan River.
18	2.1.4.: KN: Was it agreed that assessment would only take place in Reach 1. Guessing the flows would be more effective in Reach 3 where there are likely more low flow barriers - channels with a higher gradient.	The assessment also included upstream migration data from Reach 3 using the ARIS hydroacoustic device at the Diversion Dam (RM 9.7).
19	2.1.4. upmigration flow dates: Did we bank the water on the upmigration flows that didn't happen; or the ones that did not meet average flow target?	No, this water was not banked.
20	2.1.4. upmigration flow dates: This change may not be something the Tulalip Tribes can agree to long term; in light of need for temperature relief for ESA listed Chinook holding in the Skykomish.	Comment noted.
21	2.1.4. upmigration flow dates: Use 'attraction' rather than 'enticement'. By 2021 Snohomish PUD and Tulalip had had several conversations regarding the PUD concerns about straying into the Sultan River. We will address the issue in depth in our letter.	Comment noted.
22	2.1.4. Table 1: KN: what were the existing flows? Is this a bankfull event?	Table has been updated to show preceding mean weekly flow and range in cfs. Upmigration flows are not bankfull events.
23	2.1.4. run timing: It was not possible to ID the numbers of Hatchery/Wild fish in 1994 or 2002. Those years should not be used. Please provide the sample collection data for 1997, 1999, or 2001 in the Sultan when this was done with otolith analysis.	Table 2 and Figure 2 represent run timing and do not distinguish HOR/NOR fish.
24	2.1.4. Table 2: KN: Initial viewing of this data appears to shift the spawning slightly and narrow the spawning timing.	Snohomish PUD agrees.
25	2.1.4. Table 2: AS: This needs to be looked at by year and compared to brood year. Also, compare run timing by week with Wallace.	This is beyond the scope of the reporting requirements laid out in the process flow plan.
26	2.1.4. Table 2: MC: these are what might be expected as these are redds deposited after the upmigration flows that occurred mainly in weeks 36-38, after which the redd counts increase, but during normal spawn timing	Comment noted.

27	2.1.4. run timing: AS: yes Chinook are returning earlier, but the outmigration flows don't appear to attract the fish	The assertion here is that the upmigration flows themselves don't attract fish, rather that the new license minimum flow and adherence to state water quality (temperature) are bigger drivers in any attraction. This is possible but has not been analyzed.
28	2.1.4. run timing: KN: do you mean low flow barriers and at existing MIF?	Yes, the Sultan River does not have low-flow barriers at and above the prescribed minimum instream flow levels.
29	2.1.4. run timing: MC: This is not supported. While the report does not provide data for an upmigration flow in 2016, for the rest of the years, other than 2021, it occurs in ~ 2nd week of Sept (average is 9/10), like in 2012, the only other year mentioned here where date of the flow release is provided, it was on 9/14/2012, after which all of the redds were deposited and this is presumably the same for 2016 where all of the redds would be deposited after the flow release	No upmigration PF occurred in 2016. This table indicates that migration and spawning occurred during low flow conditions and without an upmigration flow in 2016.
30	2.1.4. run timing: showing the hydrograph would be helpful here in order to see if there are any naturally occurring pulses.	Hydrographs are presented in Appendix A.
31	2.1.4. Table 3: It appears that some sort of pulses may be cueing salmon to move into the system? Also there is probably a temperature component.	Table 3 indicates that fish are moving into the lower river and spawning under lower flow conditions. Peak flows during this time were also low without any distinguished pulse flow. Temperatures from the Skykomish River RM 13.2 below the confluence and the Sultan River at RM 0.2 were all within 1.5 degrees Celsius on and around all dates shown in Table 3. It is likely that a combination of flow, temperature, daylight, and other environmental/genetic factors are cueing movement.
32	2.1.4. run timing: how much of this do you think is related to water temperature? Are these are fall or summer chinook?	Snohomish PUD believes there are multiple variables that coalesce to provide conditions suitable for Chinook salmon to volitionally migrate upstream into Reach 3. Main factors likely include hydrologic and thermal conditions. Snohomish PUD does not conclusively know whether these are summer and/or fall Chinook; however, Snohomish PUD agreed to pay for a backlog of carcass collected DNA samples from the Sultan River to be analyzed.
33	2.1.4. Table 4: MC: 2/3 of fish arriving weeks 35-37	Comment noted.
34	2.1.4. Table 4: AS: interesting that Reach 3 is getting fish earlier than Reach 1 and that Reach 1 peaks in Weeks 40 and 41. How much is this a temperature story? How much is this a run size story? How much of this is a relative flow and temp between Sky and Sultan?	Snohomish PUD agree that the ARIS data provides an interesting ability to detect fish in real-time as they migrate upstream through the Diversion Dam. Remember that the ARIS provides data on migration timing, not to be confused with spawn timing. Redd counts are used to estimate spawn timing, and generally peak

		between weeks 38 and 42. As redd counts increase across the spawning season, the increase is observed in all river reaches, not just in one particular reach. Snohomish PUD currently does not understand the level of effect water temperature, run size, and the relative flow and water temperature contribution from the Sultan River has on fish behavior as adult Chinook enter into and migrate upstream through the Sultan River.
35	2.1.4. Figure 3: do you have weekly data on fish returns in the Pilchuck and Sky?	Snohomish PUD has the SGS data that is uploaded to the State's data portal. All recorded years for these rivers can be found here: WDFW-SGS | Data.WA | State of Washington (https://data.wa.gov/Natural-Resources-Environment/WDFW-SGS/idwx-fext/data)
36	2.1.4 straying: KN: When you report it as a percentage it supports their narrative. What if the number of NOR decreased for some reason – an issue the Mike has mentioned. When the situation is the same number of hatchery fish are entering but there are fewer NOR's	Snohomish PUD does not know how or why the number of NOR would somehow decrease in the Sultan River and the number of HOR would be unaffected. Carcass data provided in the report shows an increase in percent HOR to the Sultan River in the first 10 years of PFP implementation.
37	2.1.4. Table 5: AS: 2015 was the year of the hot blob in the ocean and terrible stream flows and high percentage of HOR in the Skykomish population. The Sultan did have a higher percentage of HOR than the Sky that year However, the Sultan consistently has a lower percentage of HOR than the Skykomish River. We would do well to remember that the Sultan River is a part of a system and not isolated from the whole.	Comment noted.
39	2.1.4. Table 5: MC: some of these years have very poor data and making inferences from a low sample size can be problematic. Further post license sampling was much higher, which can introduce a sampling bias.	Snohomish PUD understands the limitations some data may provide. The intent in presenting this data is consistent with the obligation to adhere to the quantitative measures prescribed in the PFP.
40	2.1.4. Table 5: KN: Do these years of higher numbers correspond to years where flows in the Skykomish were extremely low and maybe hot?	Snohomish PUD did not specifically investigate this question, although it probably warrants further scrutiny. Snohomish PUD asserts that upmigrating Chinook in the Skykomish River will likely enter the Sultan River to seek thermal refuge during periods of low flow when river water temperature exceeds a certain threshold. The Sultan River being regulated, adheres to

		Washington State Water Quality Criteria and provides cool water rarely exceeding 16 degrees C (7DADM). The Skykomish River upstream of the Sultan River often exceeds 18 degrees C (7DADM) and in 2015 exceeded 22 degrees C during the upstream migration time-period. Snohomish PUD hypothesizes that fish in the Skykomish River will migrate to and seek refuge / spawn in the Sultan River under stressful thermal conditions.
41	2.1.4 straying: MC: Not just Wallace, the rest of Sky are summers, and I think the Technical Recovery Team (TRT) said Chinook in the Sultan are considered to be part of the Skykomish summer Chinook population, not a separate fall population. The blue bars mimic the run timing of wild summer Chinook in the basin, not just Wallace, which is indistinguishable and founded from Sunset Falls, which BTW has October-returning fish that still genetically assign to summer Chinook. I have asked a geneticist to look into this who is very interested and willing to take a look at population substructure now that we have many more samples than when this was looked at back in 2006. We should discuss possibilities for greatly improving this as well as increasing scrutiny of current PUD assumptions of Sultan as a unique population (see next para). This can be due to natal fall signature, or it could be a remnant Green River fall signature. NORs return into October at Sunset and return as early as May in the basin. NORs comprise on average 70% of the fish in the Skykomish, which includes the Wallace (79% NOR outside of the Wallace River). But, regarding the possibility of the Sultan fallish signature being due to non-native Green River lineage influence, I think there could be some evidence for this but I need to ask Adrian Spidle, NWIFC geneticist, to re-examine this. He examined Chinook DNA composition of returns to Wallace River Hatchery, Sunset Falls and elsewhere throughout the basin from samples I collected over several years WAY back in ~2006- ?- by origin (hatchery vs wild), return timing (month of return to Wallace River Hatchery week of return to Sunset Falls), AND by location (Sunset Falls, Wallace River Hatchery, and other primary natural spawning aggregations). While Bayesian lineage clustering showed that Chinook returning to Wallace River Hatchery from June through late-September from 2005 and 2006 clustered closely with the native Skykomish River Chinook summer Chinook spawning aggregations including Sunset Falls	Snohomish PUD and the Tulalip Tribes met on this topic and agreed to complete the genetic testing of the backlog samples. The combination of spawn timing, geographical distribution, and genetic differences should provide greater insight to this issue.

	(all Sunset returns through October), a small number of Chinook returning in October to Wallace River Hatchery had a greater affinity to Snoqualmie or Green River fall Chinook than to Skykomish River summer Chinook as sampled in earlier months (A. Spidle, NWIFC, M. Crewson and K. Rawson, Tulalip Tribes, and P. Moran, NOAA NMFS, unpublished data). We need to revisit the old data, analyze the already genotyped data, and run the remaining samples that are still on the shelf, not just for the Sultan, but for the rest of the basin. I seem to remember Sultan looking more fall-ish but that the number of samples analyzed at that time was very limited. Since then, we have collected many more samples, and they all need to be analyzed- this will be part of the conversation with the geneticist	
42	2.1.4. straying: AS, MC, KN: Sultan fish are not fall run, they are summer run. We suggest genetics work in our letter.	Snohomish PUD has agreed to pay for the analysis of current backlogged DNA samples from the Sultan River.
43	2.1.4. Figure 4: AS: It seems there is a case being made to say process flows don't attract Chinook as well as a case that process flows attract hatchery fish. The conversations you have had with Tulalip about the ratio of Hatchery Origin Spawners versus Natural Origin Spawners throughout the Skykomish population are not reflected in the discussion. Also, some years the fish returns are really low and the ratio of hatchery to wild fish returns increases. This is a system wide phenomenon, not a Sultan specific issue.	Based on run timing, existing flow data and field observations the conclusion is that NOR do not require an upmigration flow to initiate migration and successfully spawn in all reaches of the Sultan River. Depending on timing and relative flow volume, the upmigration process flow does have the potential to drawn in HOR fish that would otherwise bypass the Sultan River. While we have had conversations with Tulalip regarding HOR/NOR genetics, those discussions are outside of the scope of – and do not provide any substantive quality to – this 10-year PFP Effectiveness Report. Section 5 of the PFP states, *"Every ten years, the District will develop a Process Flow Effectiveness Report. This report will analyze the results of the monitoring components of the Fisheries and Habitat Monitoring Plan in conjunction with the release data."* Noted, however the total number of marked fish (71) sampled in the ten years after implementation is substantially higher than the number (10) sampled in the ten years prior to implementation.
44	2.1.4. straying: MC: The data I have for 2016 is 10.3% are HOR on the sultan, not 2% HOR on the Sky was 34%. The average annual HOR% on the Sultan	Snohomish PUD contends that upmigration flows do attract Chinook, however, believes the release is not necessary because Chinook have demonstrated the ability to migrate to the Sultan

	is 14%. So again, you are saying the flows don't attract Chinook and then you are saying the flows attract hatchery fish.	River prior to these releases occurring. When they do occur, Snohomish PUD believes they attract all Chinook, natural origin and hatchery origin. In the field Snohomish PUD only has the ability to detect hatchery origin Chinook based on adipose fin clips and/or CWT. That is what the HOR percent is based on in our analysis. Based on the data provided in this comment though, it is likely that our estimates of percent hatchery origin in the Sultan River is less than what Snohomish PUD present in the report. This comment provides further evidence for our assertion that upmigration flows attract hatchery origin Chinook that would otherwise return to the Wallace hatchery. According to the data provided in this comment, the mean HOR on the Sultan River is 14%; in 2016, when an upmigration release did not occur, the percentage was less than the mean at 10%. Data from the ARIS hydroacoustic system at the Diversion Dam (RM 9.7) has documented upmigrating Chinook from June through October (Table 4). In 2021, instream flow through Reach 2 was near minimum from June through the first week of August (Figure 3). During this time of low flow, Chinook were documented arriving at and migrating through the Diversion Dam. Snohomish PUD believes the existing hydrology and water quality conditions are providing the necessary stimulation to cue upstream migration, otherwise, these Chinook would be holding lower in the reach rather than migrating upstream.
45	2.1.5: You have not made an adequate case for this statement. The Sultan River Chinook are not separate from the Skykomish summer Chinook. A fall signature may exist, however it does not mean Sultan fish are different from Sky population – Tulalip suggests genetic work in our comment letter.	Comment noted. See response to comment #41.
46	2.1.6.: Tulalip finds there is a greater need for temperature relief in the Sultan river and confluence with the Skykomish in late August/September than the need for an upmigration flow at this point.	Comment noted; although, temperature relief in the Sultan River is not necessary because of the prescribed minimum flow and water quality requirements in the License.
47	2.1.7.: it would be informative to show the hydrograph for the Sultan for the summer/fall of each year in order to determine if other pulses occurred.	Mean daily discharge charts for the Sultan, Pilchuck and Skykomish rivers are provided in Appendix A.
48	2.1.7.: KN, AS: Here you say again that the PFP does not help Chinook migrate into the Sultan and then that the flows increase hatchery strays which are Chinook.	No, Snohomish PUD asserts that upmigration flows are not necessary because the existing hydrology and water quality is providing the stimulation to cue upstream migration. Data indicate

		that there is a higher proportion of hatchery Chinook spawning in the Sultan River compared with the 10-year time-period prior to process flow implementation. Snohomish PUD believes that the timing of upmigration releases occurs during a time when hatchery origin fish that would otherwise migrate to the Wallace River hatchery, are attracted to the Sultan River by the cool pulse, and increased hydrologic magnitude associated with the upmigration release which is one reason for an increase in HOR in the first 10-year period of process flow implementation.
49	2.1.7.: AS, MC: A better use of the water would be to help reduce high temperatures	Comment noted; however, this is outside the scope of the PFP License article. Note that the volume of water associated with a short duration upmigration release is roughly 300 acre-feet; this volume is minor compared to that associated with the increased minimum flow under the current License. For instance, the previous minimum in Reach 1 varied between 165 and 200 cfs over the course of the year. The current minimum flow is 300 cfs year-round. Over the course of a month, the 100 cfs differential between the old and the new minimum flows schedules equates to approximately 6,000 acre-feet.
50	2.1.7.: AS: More work needs to be done to understand the escapements in the Sultan in context with the Skykomish basin. In some cases the fish counts are occurring a full week after the process flow, which does not create a sound logic for confirming or denying the effectiveness of the process flow. The PUD should also overlay water conditions (flow and temp) in the larger basin and understand that fish are going to move toward cooler water. This is an artifact of the WQ requirements placed by the State. PLUS the higher minimum instream flow requirement for the new license – flows rose from 200 to 300 cfs.	Chinook escapement in the Sultan River tracks closely with the Skykomish River escapement; however, in the last 10 years, a greater proportion of Chinook escapement occurs in the Sultan River compared to the 10-year period prior. Data from WDFW SGS database indicates a mean of 8.4% of Skykomish River escapement was to the Sultan River between 1999-2009, and for the time-period 2010-2020, 10.9% of Skykomish Chinook spawn in the Sultan River. Snohomish PUD agrees that redd surveys occurring a week after an upmigration release does not provide enough information on its own to understand whether the upmigration flow was effective, and that is why language in the PFP states: "*The benefit provided by the release will be assessed by looking at the temporal distribution of fish and the presence of redds through the spawning season.*" In contrast to redd surveys, fish counts detected from the ARIS hydroacoustic system located at the Diversion Dam does allow for direct observations of fish migration prior to and immediately following upstream migration

		releases. That data shows Chinook already being in the system prior to the upmigration release, and yes, fish continue to migrate upstream in the days and weeks following the release as part of natural run-timing during the Chinook migration and spawning timeframe. Snohomish PUD fully understands the relationship between salmonids and cold-water refuge and agrees that salmonids utilize the Sultan River for cold-water refugia when thermal conditions on the Skykomish River become stressful. Also, relative to minimum flows, see response to comment 49.
51	2.1.7.: MC: Co-Managers ESTIMATE the PROPORTION based on otolith analysis, not clipped fish. The only clipped fish used in estimating H:N fractions after all otoliths are read, are the ones clipped but not otolith-marked, which are out-of-basin fish that are not thermally marked (all Snohomish region Chinook are otolith marked, excepting 2021 incubation flow problem that nixed Wallace oto marking that BY)- so only a handful of fish annually estimated this way and both hatcheries have DIT roups comprising hundreds of thousands of fish not clipped. The otoliths tell us what hatchery and broodyear the fish are from. This enables us to know, e.g., that 31% of the hatchery fish in the Sky, on average are from out of basin as are 73% of the hatchery fish in the Snoqualmie, which wasn't figured into anything, and those are all fall Chinook that would introgress more with the Green River fall leftovers in the Sultan	Comment noted.
52	2.1.7.: Assistance paying for analysis would be welcome as well as continued cooperation with sharing survey data.	Snohomish PUD agreed to pay for Sultan Chinook DNA samples to bring the current backlog up to date.
53	2.2.1.1.: KN: do the releases cause increased turbidity?	Turbidity measurements before and after are not taken as part of this program, but observations indicate that they do result in increased turbidity largely as a result of accumulated fine sediment near the outlet works.
54	2.2.1.2.: KN: this is a short duration and likely enough volume or time to initiate a response.	Comment noted.
55	2.2.4. basin hydrology: AS: How much of the increase is due to project management changes versus the required outmigration flows?	Increased flows are from a combination of plant operation discretion, accretion, reservoir rule curves, and process flows. The required outmigration flow duration represents a very small percentage (0.8%) of the total outmigration window identified in the PFP (April and May).

56	2.2.4. Table 8: this likely has more to do with project operations.	Yes, the combination of factors includes but are not limited to, reservoir rule curves, power price signals, energy demand, process flows, whitewater recreation flows, and accretion.
57	2.2.4. Table 8: AS: Aren't you generating more power at this higher flow? What percentage of the mean daily flow does an outmigration flow account for?	Outmigration flows are reach specific. For Reach 3, the base flow does not include generation; therefore, the outmigration flow makes up a significant portion of the mean daily flow in that reach. Similarly, but to a lesser extent, generation is a minor influencing factor in the mean daily flow during an outmigration release in Reach 2. For Reach 1, typically, Snohomish PUD will be generating more at higher flows. The percentage changes as mean daily flow changes. Scheduled process flows account for 0.8% of total flows during the outmigration period but could be as much 50% on the day of the release.
58	2.2.4. Table 8: AS: how does discharge per drainage area ratio compare pre project? I'd assume it is a great deal higher. What proportion of this change has anything to do with the required outmigration flows?	Your assumption is likely accurate, however the intent here is to provide a comparison between the first 10 years of outmigration hydrology tied to process flows with the previous 10-year period without process flows. Since the compliance target for outmigration only accounts for 0.8% of the outmigration season, it is inferred that the increased percent change in mean daily flow is not directly relatable to outmigration process flows. The PFP assumes that an outmigration program will provide elements of a more normative hydrograph compared to conditions observed in the previous license, so the data contained in Table 8 is presented to illustrate the concept of normative flow assuming that normative flow is defined as the hydrology occurring in un-regulated river basins.
59	2.2.4.: AS: the sultan is a flashy basin, put this into context between mean daily and increased pulses, since you are saying the pulses are the issue.	Comparative hydrographs are presented in Appendix A that show pulses in each system.
60	2.2.4.: the graphs show the fish are following a genetic signature to outmigrate. Flows caused scour and death to pink salmon? Evidence shows it isn't the case, Table 11 – attributed the dead pinks to scouring events, but it is more likely the pinks died 12ecause there was debris in the trap, along with the fish, they died in the trap. 2012 must have been cold, in normal years, pink migration is on the downtrend in April.	Snohomish PUD agrees in general that hydrologic conditions in the Sultan River are delivering the necessary stimulation to provide fish the opportunity to volitionally outmigrate based on their biologic and genetic attributes. Table 11 presents trap catch during an outmigration flow and is related to the forcing out of sensitive yolk-sac fry and not necessarily related to scour. During this trap set Snohomish PUD observed a catch containing a higher incidence of encountered yolk-sac fry and dead pink

	Trapping through the release flows, none of the figures are informative, Figure 24, CPUE increased with flow, but they aren't saying there is a relationship, with chinook, there is a relationship. What were the trap efficiencies? That should be included in the report. CPUE should decrease with discharge based on cross sectional area, but CPUE seems to increase with discharge.	salmon than is normal under non-process flow operation. A Snohomish PUD Biologist was actively fishing the trap during this process flow as dead and un-buttoned pink salmon were entering the trap and were not dying in the trap as asserted. This fact indicates to Snohomish PUD that these pinks were forced downstream. Your comment, "*in normal years, pink migration is on the downtrend in April*" does not agree with the data Snohomish PUD have collected to date. When catch is standardized by hour fished, pink salmon outmigration has peaked across the entire month of April ranging from statistical week 14 – 18. Collectively, the figures you reference as not being informative are included to illustrate catch rate on the Sultan River during this 10-year period appears to be more dependent on timing rather than flow. What Snohomish PUD typically observes by species, is a normal distribution (bell-shaped curve) of outmigration across the entire season (January – June) regardless of flow. At specific points within the season, Snohomish PUD certainly expects catch during an outmigration process flow to be higher during the peak of the outmigration compared to catch during an outmigration flow that occurs on the fringes of the season. These figures could be used to refine the timing of outmigration process flows to occur when fish are actively migrating instead of having a scenario where an outmigration process flow is occurring within the current window (April and May), however, at a time when most of the targeted species have already emigrated out of the Sultan River. Snohomish PUD included efficiencies in Table 12 of the updated report.
61	2.2.4. stimulating outmigration: so the peak flow flushed all of the fish out?	The spill event scoured redds (especially in Reach 3) and negatively impacted egg to migrant survival. The 2020 emergence calculator indicates that YOY were either still in the gravel or just recently emerged.
62	2.2.4. stimulating outmigration: i'm not sure we expected to catch more fish during an outmigration flow, since the fish have more flowpaths to follow to outmigrate, also outmigration from reach 3 wouldn't neccessarily result in fish capture out the smolt trap	Comment noted.

63	2.2.4. stimulating outmigration: you are comparing 2 natural systems to a highly regulated system that shaves every peak off	The two natural systems are used for comparison to identify what a normative hydrograph looks like. This includes peak flows during the outmigration period.
64	2.2.4. Table 10: AS: how does this compare to other smolt traps	Kubo et al. (2013), *2000-2012 Skykomish and Snoqualmie Rivers Chinook and Coho Salmon Out-migration Study,* found similar results of insignificance between the CPUE and discharge for both sub-yearling Chinook and yearling coho.
65	2.2.4 Figure 5: KN: Should not be a linear regression. Should have normalized the data and used a nonlinear regression	Regardless of the regression type, previous studies (see comment #64) have found similar results of insignificance between CPUE and discharge.
66	2.2.4. stimulating outmigration: KN: where is discharge point?	The discharge measurement point for Reach 1 is located at RM 4.3 at USGS 12138160 Sultan River below Powerplant near Sultan, WA.
67	2.2.4. Figure 7: AS: indicating the dates of the process flow would be useful	Refer to the Process Flow Log for specific dates of releases.
68	2.2.4. Figure 7: KN: Does occur generally during the ascending limb of the hydrograph	Comment noted.
69	2.2.4. Figure 9: what is the total number of fish estimated to have left the system during the outmigraiton period?	231,397 Chinook.
70	2.2.4. Figure 9: aren't you catching more because the flow is low and you have the smolt trap in the thalweg?	In this figure concerning sub-yearling Chinook, it is true that catch is greater in part due to lower flows; however, catch is also increasing with respect to outmigration run timing.
71	2.2.4 Figure 9: escapement in 2012 was 917 - there is high catch in low flows	Comment noted.
	Figure 10: KN: There doesn't appear to be a sound reasoning for which dates are presented. Perhaps showing all of the years would be better?	Select years were used to show catch under a variety of flows. The common thread is that the peak in run timing is relatively constant under both high and low mean daily flows.
72	2.2.4. Figure 11: AS: how was pink mortality in the trap each year?	Snohomish PUD does not have this data for each year.
73	2.2.4. Figure 12: AS: seems to be a lot of outmigration over the time period and during the magnitude of the outmigration flow	The outmigration trend follows a bell-shaped distribution typically observed during non-flood years.
74	2.2.4. Figure 12: AS: 2014 escapement was 365, impressive catch at such consistently high flows - what was reason for frequency of high flows?	The combination of factors contributing to flows in Reach 1 include, but are not limited to, reservoir rule curves, power price signals, energy demand, process flows, whitewater recreation flows, and accretion. Records show plant load being greater than 75% of plant capacity for much of the 2017 outmigration period, which resulted in additional water discharged to Reach 1.
75	2.2.4. Figure 13: lots of fish, low flow, high catch escapement in 2016 was 687 (4 yr running avg is 450)	Comment noted.

76	2.2.4. Figure 14: escapement in 2009 was 133 fish	Comment noted.
77	2.2.4. Figure 15: escapement in 2009 133,	Comment noted.
78	2.2.4. Figure 15: KN: Right during coho migration? Very high rate of catch.	Comment noted.
79	2.2.4. Figure 16: escapement in 2010 is 352	Comment noted.
80	2.2.4. Figure 17: escapement 2012 is 975	Comment noted.
81	2.2.4. Figure 18: AS: interesting there is no real peak, but a long and late outmigration period Was this a cold year?	Figure 18 provides catch and flow data from the peak outmigration period in 2017. Peak outmigration occurred in statistical week 16. Chinook catch during 2017 was very typical for a non-flood year and extended into late June. Looking at the incubation period in 2016/2017, temperatures did not appear to be out of the normal range.
82	2.2.4. Figure 18: escapement 2014 365	Comment noted.
83	2.2.4. Figure 19: AS:Here it seems that chinook are cueing to the rising hydrograph and outmigratingon 4/10?	Yes, this catch occurred during the peak of the outmigration period, 2019, and during heavy accretion accounting for an outmigration process flow in Reaches 2 and 3. Figure 19 is a prime example illustrating the importance of timing outmigration process flows to occur when fish are actively present and migrating.
84	2.2.4. Figure 19: escapement 2016 is 687	Comment noted.
85	2.2.4. effects of outmigration flows on catch: KN: I would not make this claim. The deaths could be due to debris in the smolt trap, not due to process flow. AS: You present one incident of this occuring.	The important detail observed here is the large number of unbuttoned/yolk-sac fry that were captured in the smolt trap. A Snohomish PUD Biologist was actively fishing the trap during this event. Un-buttoned dead pink salmon were physically observed entering the trap and did not die in the trap, as you suggest. These numbers are not recorded during lower flows that are unlikely to disturb redds.
86	2.2.4. Table 11: Are there other years this happened?	Table 11 contains the best data Snohomish PUD have gathered during the first 10 years of process flow implementation where the trap was fully operational during a process flow. Often, flows in the lower river preclude trapping either as a function of too high velocities when the Skykomish River is low and the Sultan River is high, or conversely when velocities in the Sultan River are too low as a result of the Skykomish River being high and backing up into the lower Sultan River. Moving forward, when Snohomish PUD is trapping, Snohomish PUD is committed to operating as much as is safely practical during outmigration process flows to

		refine our understanding the cause and effect on juvenile salmonids.
87	2.2.4. Table 11: KN: deaths due to debris in trap are common in smolt trapping; rather than attributing to PF	Similar to comment #85, the focus on live pink with yolk sacs is the important detail. This does not typically occur under normal operation and suggests that the higher flows disturb redds and have an unintended impact to YOY fish.
88	2.2.4. Table 11: AS: do you have other years this happened? what about other species? were there other years the flows occured and you didn't have the mortality did a lot of pinks return in 2012? I think this flow is higher than required?	Table 11 contains the best data Snohomish PUD gathered during the first 10 years of process flow implementation where the trap was fully operational during a process flow. Often, flows in the lower river preclude trapping either as a function of too high velocities when the Skykomish River is low and the Sultan River is high, or conversely when velocities in the Sultan River are too low as a result of the Skykomish River being high and backing up into the lower Sultan River. Other species are generally more robust, although Snohomish PUD has observed un-buttoned chum, coho, and Chinook. Understanding how flow may impact un-buttoned fry is important, and Snohomish PUD are committed isPink salmon return in odd years and outmigrate in even years, so no pink salmon returned in 2012. In 2011, pink escapement to the Sultan River was not estimated as visibility was not adequate for surveys to occur. The flow was higher than the required minimum of 800 – 1,200 cfs because a flushing flow was also achieved with this release. The elevation of Spada Reservoir was greater than 1,420 feet msl, and the required magnitude of a flushing flow in Reach 1 under that condition is greater than 1,500 cfs.
89	2.2.4. effects of outmigration flows on catch: AS: it might be possible that the flow magnitudes you are fishing may miss the majority of the outmigration eg the threshold flows are higher than what you are fishing	Unlikely, considering the trap is operating 60-70% of the season across the majority of flows.
90	2.2.4. effects of outmigration flows on catch: AS: it seems there may be a more complex story here. Temperature has not been considered as a factor for determination of smolt outmigration Previous year escapement not taken inot account	In future trapping efforts, Snohomish PUD is committed to studying more thoroughly, the incidence of un-buttoned fry and mortalities as related to flow conditions. Snohomish PUD agree that a refined understanding of water temperature dynamics and conditions is a logical next environmental parameter to examine. The outmigration window relating to process flow releases is

	it seems based on most years that outmigration is later in the season than the process flow is initiated. Also the PUD may be discounting other years that flows were high naturally, not a process flow when looking at pink mortality	defined in the PFP as occurring between April and May. Snohomish PUD selects when to carry out an outmigration process flow based on a variety of factors including existing hydrologic conditions, emergence timing, run-timing, spawn timing of steelhead, staff availability, whitewater recreation opportunities, and hydrologic conditions on the Skykomish River as to not exacerbate flooding in the City of Sultan. Snohomish PUD agrees that the timing of outmigration process flows could be dialed in to better align with peak outmigration rather than occur on the fringes of the season. Snohomish PUD does not discount any data collected, rather Snohomish PUD presents what trends emerge from the data. Snohomish PUD looks forward to continuing to collect high quality data in the future and presenting these data to the ARC to help inform potential modifications to the PFP.
91	2.2.4. Figure 20: can we review the timing of the process flows? It seems the early April flow impacted pinks one year (if at all) and then the date shifted to May to accommodate recreation? Add hydrograph to the chart?	Throughout the new License, two process flows were provided each spring, one in April and one in May. The date was not shifted in response to the impacted pinks. The hydrograph is included in previous figures and in Appendix A.
92	2.2.4. Figure 20: which of these outmigration flows were produced by PUD?	April 3 and May 23 were outmigration process flows that were achieved using the Howell-Bunger valve at the base of Culmback Dam. The other dates shown here are qualified outmigration events that occurred without the use of the valve and were achieved via accretion and/or increased discharge associated with power generation.
93	2.2.4. Figure 20: AS: it seems you missed the peak pink outmigration. or very few fish returned. Plus, didn't you say there was a process flow on april 3-4 with pink mortalities? where is that reflected in this chart?	When catch is standardized by hour fished, pink salmon outmigration has peaked across the entire month of April ranging from statistical week 14 – 18. The high pink catch with un-buttoned and dead fry is represented by an orange dot corresponding to the date of that process flow. It is an outlier of a catch, skewed high compared to the catch during the preceding and succeeding weeks. This high catch rate, in addition to the numbers of un-buttoned and dead pinks observed in-situ, is an indication that this process flow forced some fish out prior to their own volition.

94	2.2.4. Figure 20: AS: I don't think all these process flows (orange dots, what is the magnitude and origin project operations vs. rain) were required by the license? They are naturally occurring? And they have no biological tie in to outmigration of the species (timing is wrong)	The PFP states that a flow between 800-1,200 cfs is intended to stimulate outmigration and satisfies the outmigration requirement if the duration exceeds 6 hours. These orange dots indicate qualified outmigration events based on the criteria established in the PFP. Whereas only two of the qualified events were achieved via the Howell-Bunger valve at the base of Culmback Dam, collectively, these provide a more robust dataset by using additional data points to test assumptions within the PFP. Snohomish PUD agrees that the timing is off for many of these qualified events and believe that a more refined timeframe with respect to the specific months and time of day would an appropriate modification of the plan moving into the next 10-year period.
95	2.2.4. Figure 21: The bulk of chinook migrate out much earlier than the process flow - it seems the flow is targeted to too late in the season? Putting the hydrograph on this chart would be useful	Two outmigration process flows are required per the License, one in April and one in May. Hydrographs are presented in Appendix A. Adding additional data sets to these charts becomes exceedingly difficult.
96	2.2.4. Figure 21: which of these flows were released by Snohomish PUD? April 3? . any others? what is the origin of the other process flows? Project Operations? Many of these flows are too late	April 3 and May 23 were outmigration process flows that were achieved using the Howell-Bunger valve at the base of Culmback Dam. The other dates shown here are qualified outmigration events that occurred without the use of the valve and were achieved via accretion and/or increased discharge associated with power generation.
97	2.2.4. Figure 22: we need temp and hydrograph on these charts	Water temperature and discharge have been added to these figures.
98	2.2.5.: This does not seem throroughly vetted.	Snohomish PUD could not find literature on this subject, so Snohomish PUD inquired with a WDFW fish biologist who has been in the field on the Skykomish River system for the preceding 30 years. Without deploying sophisticated technology and only after capturing and tagging adults would Snohomish PUD understand how pulse flows are affecting actively spawning steelhead. Based on conversations with our source and after observing pulse flows in the field ourselves, our inference remains that steelhead spawning is likely interrupted by pulse flows, especially in upper reaches of the river where increases in stream power are greatest.

99	2.2.5.: Steelhead are evolved to hold during high flows, this seems silly.	The assertion in the report was that potential disruption to spawning steelhead could result from increased flow and/or increased turbidity.
100	2.2.7.: AS: Tulalip and WDFW requested multiple spring pulses to help cue salmon to outmigrate due to the hydrograph produced by the JHP. After the raising of the dam and operational tweaks, the PUD has effectively shaved off peaks througout the system. The SA wound up with one pulse flow for fish and then it got combined with the recreational flow later in the season - which is what is now impacting steelhead??. We were presented with one year of pinks affected by scour (? or debris in smolt trap), is this something that happens every year? What about during other process flows? Temperature is a consideration that has not been taken into account, this is another major part of outmigration cuing. Adding temperature and hydrograph to the outmigration numbers may help tease out what is happening and also indicating the date of the PF release	Comments noted and have been addressed in multiple responses above.
101	2.2.7.: KN: Not much evidence has been given to support this.	See response to comment #102.
102	2.2.7.: KN: What data do you have regarding steelhead?	Snohomish PUD could not find literature on this subject, so Snohomish PUD inquired with a WDFW fish biologist who has been in the field on the Skykomish River system for the preceding 30-years. Without deploying sophisticated technology and only after capturing and tagging adults would Snohomish PUD understand how pulse flows are affecting actively spawning steelhead. Based on conversations with our source and after observing pulse flows in the field ourselves, our inference remains that steelhead spawning is likely interrupted by pulse flows, especially in upper reaches of the river where increases in stream power are greatest.
103	2.2.7.: Rather than suspend flows, we should work on adaptive management over the next few years to address data gaps, questions and concerns and perhaps to better analyze the information that has been gathered - there seems to be no connection to the basin at large - smolt traps in the area, stream temperatures	With this report Snohomish PUD are aiming to objectively use the data collected to date to adaptively manage the program. Our recommendation based on that data is to suspend outmigration pulse flows. This PFP effectiveness section is tied to Sultan River specific data on flow and trap catch to evaluate the current outmigration program rather than how it compares to other traps in the basin. According to the data collected to date, the existing

		hydrograph provides stimulation for juvenile salmonids, thus our rationale for concluding outmigration process flows on the Sultan River are not necessary. Comment noted and feedback incorporated into subsequent ARC workshop discussions.
104	2.2.7.: AS: Here is where adapative managment comes in, lets come up with another style of analysis, rather then means and averages and lack of temperature or comparison to other smolt traps. show the max cfs fished in every year,	Comment noted.
105	3.1.1.: aren't these combined with other flows?	Yes, these typically are combined with outmigration/upmigration and whitewater events.
106	3.1.1.: AS: This doesn't seem fully supported by the cross sections and wolman pebble counts presented below. 3.1.1.: AS: The IHA RVA report has information that shows the drastic changes in the flood frequency duration and magnitude in all reaches of the Sultan River	It is widely accepted that the lower Sultan River downstream of the powerhouse is much more resistant to geomorphic alteration compared to the river upstream of the powerhouse. The locations of the cross-sectional measurements represent a small fraction of the habitat encompassed in the river, so while some of these locations have not experienced much change, other areas have (Stillwater Sciences, 2016). Records of shifts in the USGS rating curves for the streamgages on the Sultan River also provide direct evidence of when the bed mobilizes and fills. There have been numerous rating curve shifts at both USGS streamgaging locations downstream of Culmback Dam since issuance of the new license. Comment noted.
107	3.1.1.: AS: I don't recall this and I don't think this was recorded in the License Article, the studies or the Settlement Agreement, I find this statement to unnecessary Reach 3 was packed with scum in the summer and early fall. We were concerned by the lack of flushing of algae mats and stagnant water before	This comment provides background as to the rationale/goals of the process flows. It helps to put into context the existing conditions before the new license and conditions observed throughout the 10 years of operation since that time. Comment noted. Comparison of hydrographs within the basin (Skykomish and Pilchuck in Appendix A) provide information with respect to natural flow timing.

	resident fish would spawn. We also wanted gravels flushed at a time that a natural flow would occur. It used to be there was no fall pulse.	
108	3.1.1.: These requests were based on photos of Reach 3 and review of the hydrograph in which the PUD had basically stopped the variabliity of flow in the river, except for accretion flows.	Comment noted.
109	3.1.2.: These later events have nothing to do with the intent of the flushing flow. The flushing flows aren't creating scour, they are washing the scum off of the rocks	As stated in Section 1.3 of the PFP, the objective of flushing flows was the removal of interstitial fine sediment from spawning gravels with reach specific criteria in terms of flow frequency, magnitude, and duration. Scheduled releases for flushing were undertaken with the presumption that the frequency, magnitude, and duration of hydrologic events was insufficient to meet the desired habitat objectives. It is also important to acknowledge that during spawning, the very action of creating redds, the pocket and tail spill are cleaned of fine sediments. If the perceived intent is to "wash the scum off the rocks" it is important to have context around the occurrence of scum: Mid-way through the first 10 years of implementation to the PFP and most notably during 2016, a Didymo bloom was observed in the Sultan River and most pronounced within Reach 3. This bloom was documented by Snohomish PUD biologists, whitewater boaters, and the mining community. The term "scum" seems to reference this localized Didymo bloom which has since dissipated. The conditions that lead to establishment of the bloom and its subsequent dissipation are likely climate and hydrologically related with spill events likely being an influential factor.
110	3.1.2.: AS: missing september!!! these flows are intended for early in the season. So Sept Oct are the relevant dates. Plus the spring dates. why didn't you look at all 10 years? More informative	The full monthly record is in the Appendix. Snohomish PUD wanted to present all comparative data here and following fish passage at the Diversion Dam in 2016, the channel morphology changed dramatically and de-watered the stream gage in Reach 3. In 2018, a new stream gage was commissioned, and Snohomish PUD presented that data forward through 2021 along with Reach 1 and 2 for direct comparison by reach.
111	3.1.2.: AS: 2017 peak flow was 2,900 while chinook were in gravel, that far exceeds what the process flow is.	The 2016 year is highlighted here because no flushing flow occurred and there was a higher-than-average egg-to-migrant

		survival. While it is single data point, it does indicate in that given year, fish successfully spawned without the intervention of a prepping flushing flow prior to or during spawning. It is for this reason and based on field observations that Snohomish PUD believes flushing flows are not necessary.
112	3.1.2. Table 14: All of the peak flows are well above the prescribed flushing flows and don't seem to correlate with the final number of egg to migrant survival This is likely a more complicated story of escapement, flow, temperature. cherry picking 2016 doesn't really make a case	Table 14 illustrates egg-to-migrant survival in the Sultan River is generally high which in turn indicates good incubating conditions. It is widely accepted that peak flow during egg incubation correlates with egg-to-migrant survival, and the data provided in Table 14 is no exception. The rationale for highlighting 2016 is because there was no flushing flow that year and provides an opportunity to observe egg-migrant-survival absent flushing. If it is expected that flushing flows result is better gravel quality and better gravel quality results in better incubating conditions, not conducting a flushing flow would result in worse gravel quality and in turn worse incubating conditions. Data presented here show that is not the case, egg-migrant-survival in the one year without flushing was good and what Snohomish PUD would expect especially given low peak flow during egg incubation.
113	3.1.2. Table 14: KN: how was this calculated?	Production estimates were calculated using a modified Peterson mark-recapture approach. See: Volkhardt, G.C., Johnson, S.L., Miller, B.A., Nickelson, T.E., and Seiler, D.E., 2007, Rotary Screw Traps and Inclined Plane Screen Traps, In Salmonid Field Protocols Handbook: Techniques for Assessing Status and Trends in Salmon and Trout Populations, American Fisheries Society, Bethesda, Maryland, p. 235-266.
114	3.1.5.: AS: more likely a flushing flow is actually helping fish in river with temperatures. I'd say the flushing flow being released is not having a scour effect, since the magnitude is quite low. Are the releases in table 14 on days when a process flow occurred?	It is true that the prescribed flushing flow magnitude does not have a scour effect. The peak flow values in Table 14 show the highest peak during the egg incubation period and is not directly tied to any specific process flow element or single day.
115	3.1.5.: You'll need to be specific about which studies you are referencing.	Comment noted.
116	3.2.1.: AS: what kind of benefits? This section needs fleshing out - the point of channel maintenance flows was to get the river hydrology up to a point where it	Section 1.3 of the PFP discusses the assumed benefits of the CM program to include:

	could do work on the channel such as moving lwd, scouring gravels AND interacting with LWD installations that were required by the license. The LWD installations were required to have zero rise by FEMA and were subsequently placed in areas that were not originally intended by the negotiators. Tulalip has frequently pushed for additional LWD / boulder structures to be added into the channel so that channel maintenance flows could interact and create some scour - rack wood and improve habitat in the lower reach. It is anticipated the new structures that are due in the next phase should interact more with channel maintenance flows.	• Formation and redistribution of physical habitat features including riffles, pools, runs, and point bars; • Effective transport, sorting, and distribution of LWD and sediment; • Alteration of channel features including increased lateral channel movement and improved connectivity between mainstem and side channel habitats; • Creation of undercut banks; and Snohomish PUD agrees that more aggressive placement of physical features (ELJ structures, boulders etc.) is needed to achieve greater geomorphic activity in the lower 3 miles of the Sultan River. The largest log jam in the 16-mile extent of the Sultan River is in the lower river at ELJ 1 near Reese Park (RM 0.4).
117	3.2.1.2.: AS: what percentage of the channel maintenance flow is achieved from which source?	Channel maintenance flows are opportunistic and achievement is heavily dependent upon significant accretion. For example, under non-spill conditions the relative components to achieve a channel maintenance process flow of 4,100 cfs include: Howell-Bunger valve (Culmback) 946 cfs (23% of CM flow), Slide valve (Culmback) 1,165 cfs (28% of CM flow), Unit 1 and 2 (powerhouse) 1,300 cfs (32% of CM flow, however variable upon accretion), accretion greater than 689 cfs (17% of CM flow, however variable upon powerhouse discharge). The percentage of these outputs are dependent on accretion and what the total flow of the river is for a given event.
118	3.2.2.: AS: we chose the target flows off the hydrograph of before and after raising the dam for the Project and chose which flows were missing	Comment noted.
119	3.2.3.: KN: TTT suggest adding a channel profile to the post channel maintenance assessement and residual pool depth	Comment noted. Snohomish PUD will explore integrating this information into the data collection efforts tied to monitoring the effectiveness of channel maintenance flows in Reach 1.
120	3.2.3.: AS: channel maintenance flows are having effects in the side channels. making more variable habitats and doing work when interacting with instream structures, moving sediment. this is very important work	Agreed. Remember too, another limitation to the habitat maintenance from flow volume is that the lower Sultan River is subjected to frequent backwatering from the Skykomish River during CM events which reduces stream velocities thereby decreasing shear stress potential.

	What hasn't happened is effective maintanence or change in the mainstem - due to lack of roughness	
121	3.2.3.: AS: Stillwater report stated the gravel size distributions were not readily comparable from year to year.	Snohomish PUD routinely conducts Wolman Pebble Counts to characterize gravel size distributions and has found that information to be comparable between sampling years.
122	3.2.3. Figure 27: AS, KN: need WSE on all of the x-s graphs Here we have aggradation and degradation in the bed, as you would expect at high flows. However it is mainly in the thalweg, if fish have limited ability to spawn out of the thalweg, then scour events will impact fish disproportionately. If fish are able to spawn in a greater distribution of habitats, then scour events in thalweg may not be an extreme issue.	Moving forward Snohomish PUD can commit to collecting WSE at these transects. Site 1 has seen dramatic changes in spawning distribution laterally across the channel. During fall 2022, Chinook were documented spawning near station 150 ft in good numbers (7 redds) compared to previous years (0 redds). This location is out of the thalweg and appears to contain the right blend of depth, velocity, and substrate size that Chinook prefer. This new off-channel spawning habitat extends downstream around the island approximately 250 ft where it discharges back to the thalweg 20 feet upstream of Side Channel 1 extension outlet. As routine practice, Snohomish PUD now records GPS coordinates at all Chinook redd locations. These data indicate broad utilization of the wetted channel.
123	3.2.3. Figure 28: AS: percentages of spawning size gravels are fluctuating , but are these in a pool? run? do fish spawn here?	This site is adjacent to Reese Park and includes the extension outlet of SC1, main stem, and SC4. Spawning occurs in the area immediately upstream of this site and the channel portion at station distance ~150 feet. There are no pools in this transect.
124	3.2.3. Figure 29: AS: Scour and deposition in thalweg: allowing for fish to distribute away from spawning in the thalweg gives more opportunities to avoid scour.	A suite of salmonids spawn adjacent to Site 2, both in the mainstem (upstream and downstream of transect) and both left and right bank side channels. The thalweg at this site is not suitable for spawning due to swift velocities and prevalence of coarse sized substrate conditions.
125	3.2.3. Figure 31: this is the problem we are trying to address, changing the channel structure in the lower reach - so channel maintenance is ineffective absent hard structures. channel is very wide and likely lacks roughness features.	Correct, large boulders, LWD, etc. are absence in the transect. LWD is racking up immediately downstream of transect near the right bank side channel.
126	3.2.3. Figure 32: AS: Majority of Substrate is quite large	Comment noted.

127	3.2.3. Figure 34: AS: could it be that the long duration pulses and the low rise and fall rate could be affecting the deposition, scour of the bed. These are tiny clasts that are mvoing around.	Comment noted.
128	3.2.3. Figure 34: AS: the larger clast size increased after 2016 and 2018 flows, so smaller stuff was blown out, yet no change in channel form. that speaks to an armored bed There is some sort of activity in the larger clasts at this site, what is different/	In addition to the high flow volume achieved in each of these years, remember in 2016 fish passage was provided at the Diversion Dam which resulted in significant volumes of material to be mobilized downstream. The 2020 flow was the highest in 25 years and so between the two actions, sediment is being scoured in some areas and aggradation is occurring in other areas.
129	3.2.3.: AS: transport of what clast size? I don’t think this is a valid point to make, since there is no information about the clast size and the entire bed mobilized. This does not define bed mobilization	Comment noted.
130	3.2.3. Figure 36: In 2020 the percentage of spawning sized materials increased; what is the mechanism for small sediments to drop in one place? the shape of the tail end of the flood? also a decrease in larger sized material,	Comment noted.
131	3.2.3. Figure 37: AS: i need this explained to me One data point is not a trend or threshold determination…	This figure is not meant to represent a trend or threshold determination, but rather it is one piece of data that provides an indication of clast movement associated with specific flows. Additional monitoring is planned to capture substrate response at different flows.
132	3.2.3. Figure 38: add 2020 to legend add 2018 to legend AS: very active x-section	2018 and 2020 have been added to the legend.
133	3.2.3. Figure 39: This channel is more confined There seems to be scour and deposition, as expected.	This is also immediately downstream of the Diversion Dam Volitional Fish Passage Project, which is contributing material as it is responding to the change in site conditions.
134	3.2.3. Figure 40: AS: The bed is reaching a new equilibrium now that the diversion dam has been breached, it makes sense that the cross section has changed. 2014 appears to have the largest negative shift in spawning size gravel.	Comment noted.
135	3.2.4. Figure 45: AS: the bed is aggrading here, that’s a change	Comment noted.

	It is back to the 2012 level. The percentage of larger cobble is back to where it originally was spawning gravels are back to 2012 levels	
136	3.2.3. Figure 46: big supply of sediment and a lot of movement in the channel The change in the 2020 cross section isn't necessarily degredation, the relative percentage of cobble went down.	There is a large landslide adding material directly to the river 0.1 miles upstream of this transect location. Within Reach 3 this slide serves as a primary gravel source downstream of Culmback Dam.
137	3.2.4: AS: I don't think 1200 cfs is definitive, nor would it apply to the entire river	The 1,200 cfs mentioned here is referencing lower Reach 2.
138	3.2.4.: AS: this is definitely an important issue, however, you weren't finding dead chinook in the smolt trap - although that's a long way to travel. What is a way to get scour data in reach 3?	Correct, Snohomish PUD was not finding dead Chinook in the trap and attributing scour to that observation. Channel maintenance flows, in addition to scouring redds, may also prematurely force out juvenile salmonids especially in Reach 3 where the river is contained within a steep, high gradient canyon. As has been the case for the first 10-year period, the smolt trap data provides a robust dataset to understand peak flow and related egg-to-migrant-survival. Of course, to understand peak flow effects on a reach specific bases, a smolt trap would need to be installed in each reach of the river. Currently, Snohomish PUD operates two traps – one per License obligations in Reach 1 and one per Snohomish PUD's desire to learn more about Reach 3 outmigration. The most current scour technology Snohomish PUD is aware of uses accelerometer data loggers to understand the relationship between flow and scour. Snohomish PUD has already launched a novel deployment of accelerometers to better understand reach-specific scour dynamics.
139	3.2.6.: KN: It is not necessarily the threshold for mobilization, we are concerned with depth of scour. AS: And ensuring that Chinook and other salmon can spawn outside of the thalweg, where the majority of scour occurs.	Snohomish PUD is concerned with the unintended consequence of scour, both shallow and deep. Snohomish PUD is committed to understand scour thresholds better and is planning field efforts to help answer those questions. While Snohomish PUD agrees that diversity of spawning habitat outside the thalweg is important in reducing scour, it is also critical to understand that the geological confinement of much of Reach 2 and most of Reach 3 do not contain spawning habitat outside of the thalweg. For this reason, Snohomish PUD recommended in the report, a dampening down

		of the discharge requirement for Channel Maintenance process flows, especially considering declining salmon abundances and to help aid in salmon recovery. Snohomish PUD also recommended in the report additional physical interventions in Reach 1 to help the water do the work to achieve the desired habitat results in the lower river.
140	3.2.6.: KN: Does this help Reach 1. I am confused where chinook spawning. I thought Reach 1 was the principle chinook spawning area? Where is steelhead spawning occurring.	In the first 10-year period, it is well known that the CM program tends to underperform in Reach 1. Realizing this and with a good faith effort in the next 10-year period, Snohomish PUD believes a multi-pronged, synergistic approach utilizing flow and physical interventions to achieve the desired habitat goals makes sense. Further, this strategy would help create new habitat in Reach 1 while reducing the negative effects in scour-prone Reach 3. Chinook salmon and steelhead trout spawn throughout the longitudinal extent of the Sultan River. Chinook spawning distribution is influenced on pink salmon abundance and is inversely related to pink spawning distribution. It is common to have a majority of Chinook spawning in Reach 2 and 3 during a pink year. It is also common for the majority of Chinook choosing to spawn in Reach 1 during a non-pink year.
141	3.2.6.: AS: add roughness features to Reach 1 and where feasible in Reach 2.	Agreed, Snohomish PUD will continue to look for opportunities to provide additional roughness and habitat complexity in Reach 1 that could help engage the channel under a variety of flows.
142	3.2.6.: AS: ensure sufficient habitat exists to keep fish from having to spawn in thalweg where majority of scour occurs.	The current state of the spawning habitat is such that fish can choose their preferred spawning location. Only if escapement trends increase considerably, would spawning habitat become a limiting factor in the Sultan River.
143	3.3.3. Figure 57: this also makes me wonder if this area is really armored.	Additionally, the river is wider in this section than immediately upstream, which may also influence the flows in this area.