SNOHOMISH COUNTY
PUD
PUBLIC UTILITY DISTRICT NO. 1
Your Northwest renewables utility

December 20, 2016

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. 2157-221
License Article 405 – Ramping Rate Evaluation Plan Supplement Final Report

Dear Secretary Bose:

With this letter, Public Utility District No. 1 of Snohomish County (the District) is filing its Sultan River Side Channel Enhancements Ramping Rate Evaluation Updated Supplement Final Report for the Jackson Hydroelectric Project (Project), per License Article 405. This report is the culmination of a multi-year effort to describe how streamflow adjustments, made under the current Project ramping rates, influence habitat conditions within recently created side channel environments under License Article 404. The report was provided to the Aquatic Resources Committee for a 30-day review and comment period; consultation documentation is included in the appendices.

In addition, attached is a Technical Memo describing specific maintenance actions undertaken in 2016 to address flow distribution and routing issues observed under low flow conditions within one of the recently created side channels, per License Article 404.

These two documents highlight the District's ongoing commitment to operate the Project in a manner demonstrating stewardship of aquatic resources in the Sultan River. If you have any questions regarding the report or technical memo, please do not hesitate to contact Keith Binkley, Natural Resources Manager, at (425) 783-1769.

Sincerely,

/s/ Tom DeBoer

Tom DeBoer
Assistant General Manager of Generation, Power, Rates and Transmission Management
TADeBoer@snopud.com
(425) 783-1825

Enclosures: RREP Report; Technical Memo

cc: Joy Kurtz, FERC DHAC
Keith Binkley, District
Aquatic Resource Committee

Henry M. Jackson Hydroelectric Project
FERC Project No. 2157

Sultan River Side Channel Enhancements Ramping Rate Evaluation Updated Supplement Final Report

Prepared for:
Public Utility District No. 1 of Snohomish County
2320 California Street
Everett, WA 98201

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&

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November 2016

Final – This document has been prepared for the District. It has been peer-reviewed by the District for accuracy and formatting based on information known at the time of its preparation and with that understanding is considered complete by the District. The document may be cited as:

District. 2016. Sultan River Side Channel Enhancements Ramping Rate Evaluation Updated Supplement Final Report, for the Henry M. Jackson Hydroelectric Project, FERC No. 2157. Prepared by Meridian Environmental, Inc. and River Design Group, Inc. November 2016.

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1.0 INTRODUCTION

This report describes the methods and results of the Side Channel Enhancement Ramping Rate Evaluation Plan Supplement (Supplement) conducted in Side Channel 4 (SC4) and Side Channel 1 (SC1) along the lower Sultan River in Snohomish County, Washington (Figure 1). The Supplement was developed by Public Utility District No. 1 of Snohomish County (the District) in consultation with the Aquatic Resource Committee[1] (ARC) to address the license requirement for a ramping rate evaluation at the Henry M. Jackson Hydroelectric Project (Project) under License Article 405. The Federal Energy Regulatory Commission (FERC) requested this evaluation in its letter dated February 2, 2015, to address the need for a scientifically sound and cost-effective ramping rate evaluation in the lower Sultan River. FERC approved the Supplement in its order dated July 11, 2015. Field data collection commenced in September 2015. Due to drought conditions during the summer and fall 2015, and unusually wet conditions during the winter and spring, field data collection was completed in July 2016. A time extension was issued by FERC on May 21, 2016, which granted an extension until December 31, 2016, to file the Ramping Rate Evaluation Plan Supplement final report for the Project.

[1] The ARC is composed of representatives from the National Marine Fisheries Service, U.S. Fish and Wildlife Service, U.S. Forest Service, Tulalip Tribes, Washington State Department of Fish and Wildlife, Washington State Department of Ecology, Snohomish County, City of Everett, City of Sultan, and American Whitewater.

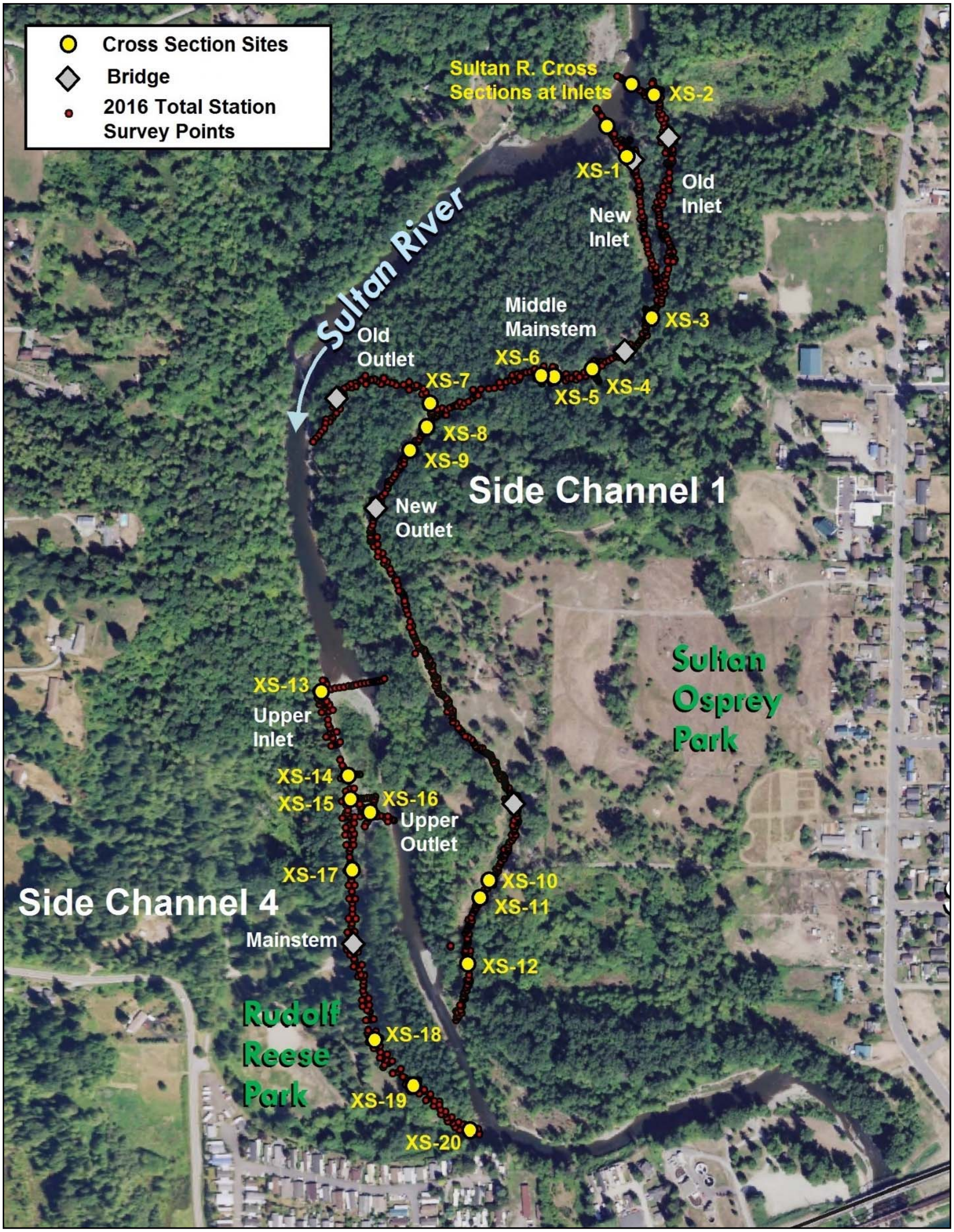

Figure 1. **Sultan River side channel ramping rate study location.**

1.1 BACKGROUND

In compliance with License Article 405 of the Project's license, the District has completed a series of detailed flow and aquatic habitat surveys in the newly constructed side channels in the lower Sultan River. These side channels (SC) – SC1, SC2, SC3, and SC4 – had each undergone varying degrees of construction during summer 2012 to restore and/or enhance salmonid habitat. The objective of the District's 2013 surveys was to assess flow behavior and distribution and to determine whether additional downramping rate restrictions were necessary to prevent juvenile fish stranding in these side channels.

The results of the surveys indicated that connectivity between the mainstem and side channel habitat is maintained over the range of normal operational flow conditions. The surveys also documented sufficient flow volume under normal operational conditions and the presence of suitable and diverse physical habitat conditions in terms of depth and flow exchange. While the District concluded that stranding potential was extremely limited under the existing range of flows, the side channel surveys were conducted prior to the occurrence of habitat shaping river flows greater than 2,300 cfs. The District also noted that several side channels, most notably SC1 and SC4, were still undergoing adjustments to the Sultan River flow regime.

Consistent with License Article 405, the District's 2013 study report was prepared in consultation with the members of the ARC, and the ARC was provided a copy of the draft report for a 30- day review and comment period prior to it being filed with the FERC. During their review, Washington Department of Fish and Wildlife (WDFW), the Tulalip Tribes, and Snohomish County Surface Water Management identified several data gaps and requested additional information to better understand the behavior of hydraulic controls during downramping.

On October 21, 2013, the District filed its report with the FERC. Upon review, FERC staff agreed that additional monitoring and evaluation of the suitability of the downramping rates were warranted (FERC 2014) and requested the District develop a supplemental plan to address some of the aforementioned data gaps and concerns. The District developed a supplemental plan and filed it with the FERC on August 28 and December 15, 2014. However, the FERC requested that the District re-consult with the ARC at its spring 2015 meeting (FERC 2015). The updated Supplement study plan expanded the District's original side channel evaluation (District 2013), and replaced the supplement filed with the FERC on August 28, 2014, and again supplemented on December 15, 2014, with survey efforts focused on SC1 and SC4.

1.2 STUDY OBJECTIVES

The objectives of this supplemental study include the following:

1. Conduct supplemental habitat and thalweg profile surveys of SC1 and SC4 and use preliminary information to select cross section sites in each side channel;
2. Establish, monument, and measure a series of channel cross sections at fixed stations located throughout SC1 and SC4, and review and replace inlet cross sections from the original habitat survey;

3. Plot the channel profile and determine width-to-depth ratios;

4. Conduct a ramping rate evaluation from 600 cfs to 300 cfs (Sultan River below Powerhouse flows) in SC1 and SC4 to assess the adequacy of existing downramping criteria; and

5. Prepare draft and final reports.

2.0 METHODS

The thalweg and water surface profiles were surveyed in SC1 and SC4 from September 1 to 3, 2015 (Figure 2). The flow in the Sultan River during this period was about 215 cfs, below the 300 cfs minimum flow requirement due to emergency drought conditions; however, the ARC agreed to move forward with the survey. During this initial survey effort, the thalweg profile, habitat unit types, and breaks between habitat units were surveyed; large wood was counted in each habitat unit; the downstream end of each habitat unit was photographed; and 22 cross sections were established and measured.

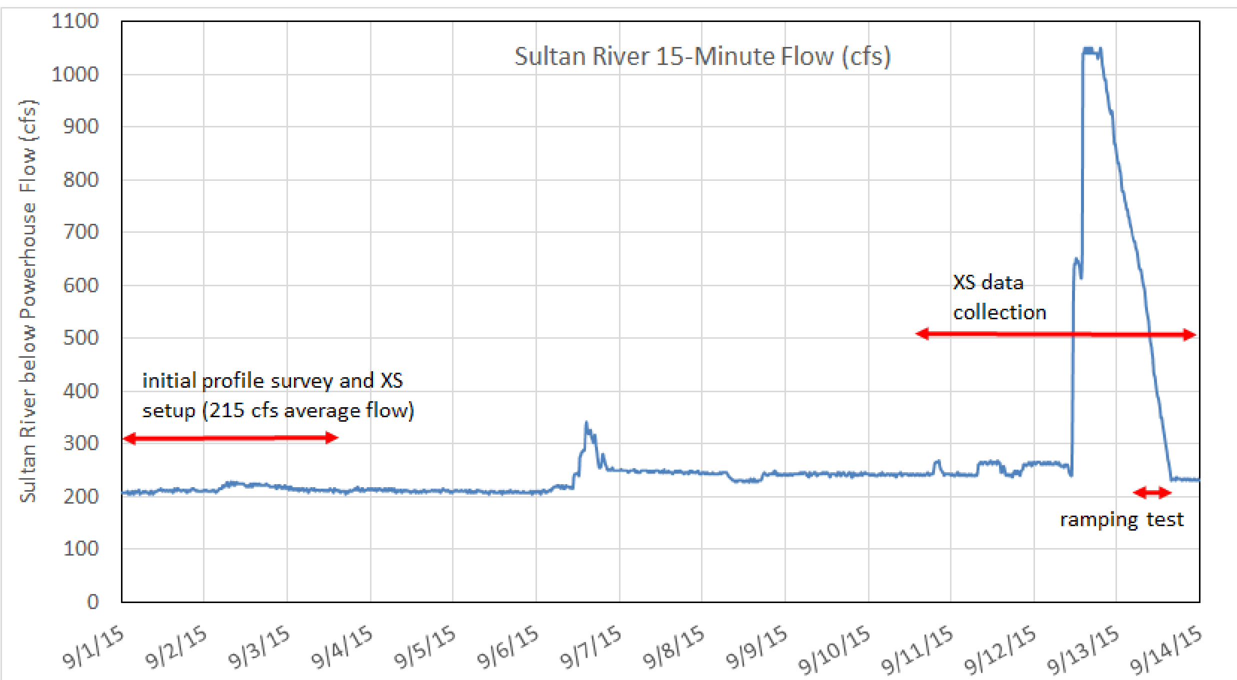

Figure 2. 2015 field data collection timing and flow.

Because flows in the Sultan River were only about 215 cfs, a large portion of SC1 was dry. As a result, the plan was to collect the remaining habitat unit data (wetted width, bankfull width, etc.) when flows were raised to the normal minimum of 300 cfs, which was anticipated to occur in late September or October once the fall rains began. The downramping test and fish stranding survey were conducted on September 13, 2015 (Figure 2) after flows began increasing on September 12, 2015, and then were lowered over a one-day period to facilitate the downramping test. Immediately after the downramping test, continuing drought conditions caused flows to drop below 250 cfs for an extended period through October (Figure 3). At the end of October, intense storms and extended heavy rains caused flows to quickly rise from below 300 cfs to well above 1,000 cfs, where they remained through December 2015. An instantaneous peak flow occurred in November of slightly over 7,000 cfs. Between 1984 and 2015 (a 27-year period), annual peak flow exceeded 7,000 cfs in only 5 years. Annual peak flows have generally been below 5,000 cfs over the last 20 years (maximum 5,600 cfs) and have not exceeded 7,000 cfs since 1996.

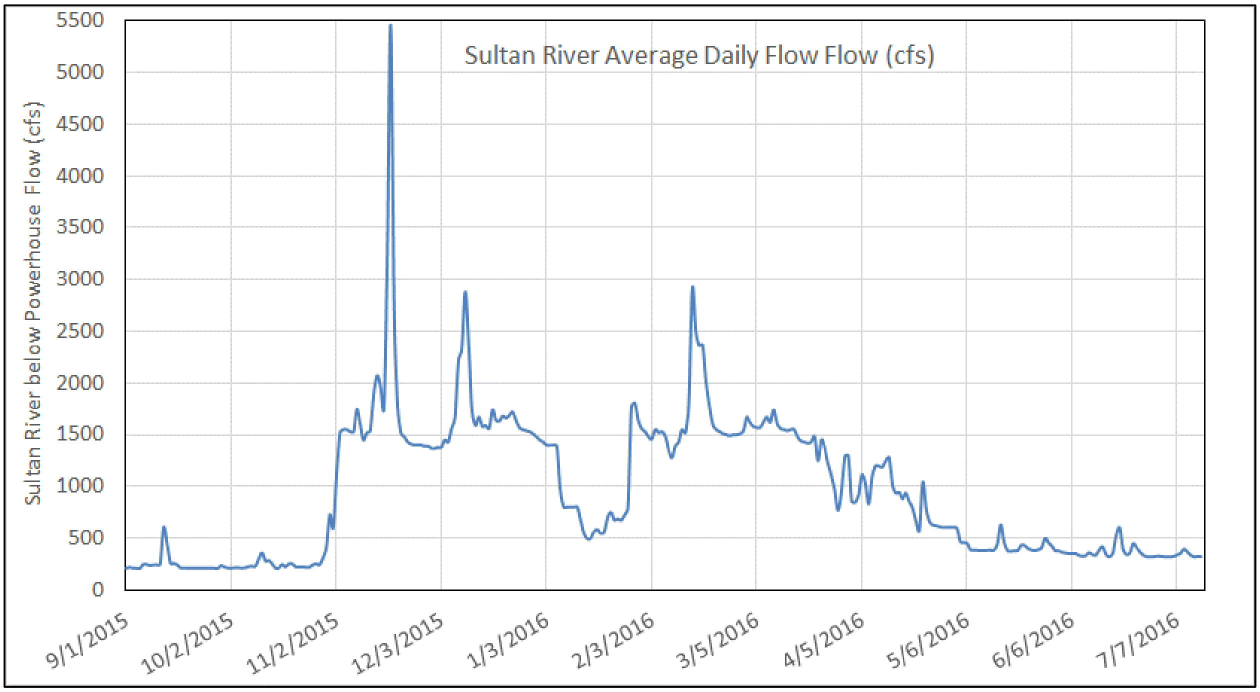

Figure 3. Sultan River average daily flow (September 1, 2015 to July 15, 2016).

Individual habitat unit conditions may have changed substantially after the high flow event. Due to the anticipated habitat unit changes, linking individual habitat unit measurements from pre- to post-high flow event was not prudent. The purpose of the habitat survey was to collect data to evaluate the future response of the channel to high flow events. In this case, the high flow event occurred before data collection could be completed at 300 cfs. The ARC was consulted on April 19, 2016, and agreement was reached to resurvey the channel thalweg and water surface elevation, habitat types and attributes, and cross sections to establish new baseline conditions within SC1 and SC4 after the November 2015 high flow event. The resurvey was conducted when the Sultan River flow was about 322 cfs from July 12-14, 2016 (Figure 4). Specific survey methods are described below.

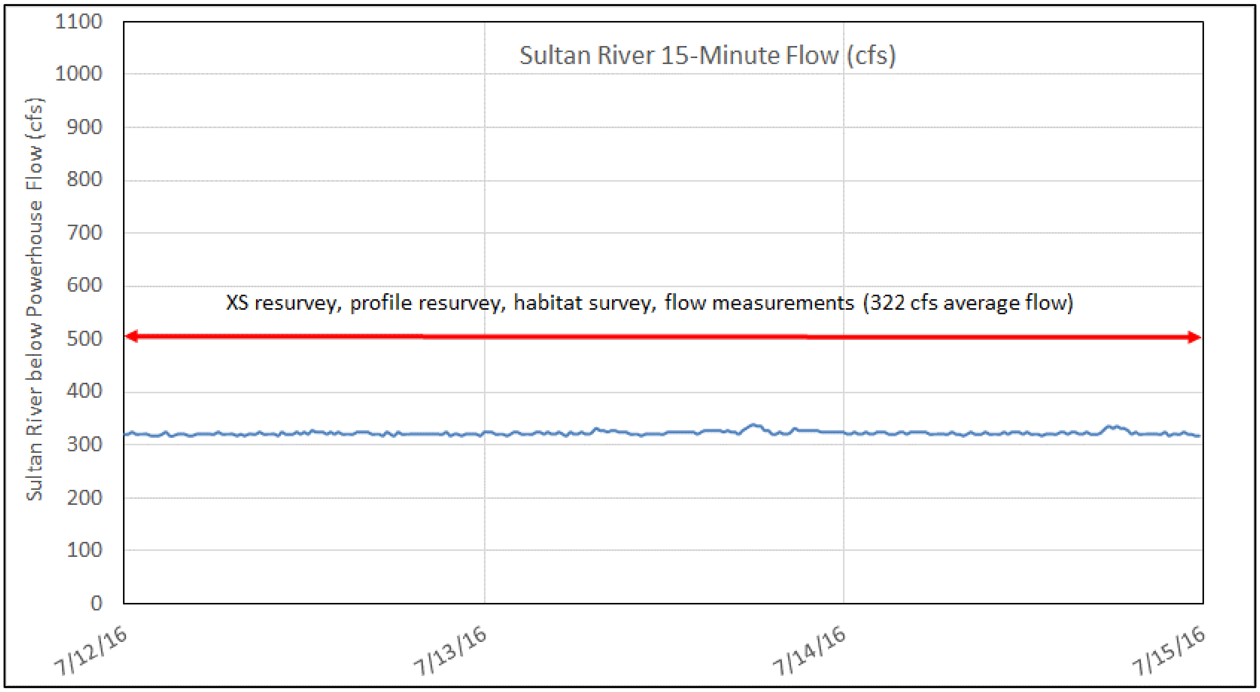

Figure 4. **2016 field data collection timing and flow.**

2.1 Channel Cross Section Measurement

The FERC-approved Supplement stipulates that District staff or contracted consultants will establish, monument, and measure a series of channel cross sections at fixed stations located throughout SC1 and SC4 (maximum of 10 cross sections in each side channel). A total of 20 cross sections were established within SC1 and SC4 (Figure 1). In addition, the Sultan River cross sections at the upstream inlet of SC4 and at the two inlets to SC1 were also measured. Per the Supplement, cross sections were placed at hydraulic controls and/or habitat units of interest that may affect stranding or available habitat area during downramping events (e.g., where the bed is wide and gently sloping from bank to thalweg). Channel cross section locations were chosen based on review of the initial habitat and thalweg profile survey preliminary findings conducted in early September 2015, and tied to points within the thalweg profile survey. Each side channel cross section was tied to benchmarks, which were clearly documented using field notes, GPS, total station location, survey flagging and photographs. One end of each cross section was marked with a metal rebar survey cap and the other with a metal spike. Cross section bed and water surface elevations were measured with a total station in 2015 and 2016. At least 20 stations were measured at each cross section or at every foot where cross sections were less than 20 feet wide. Additional water surface elevations were measured using a rotary laser level during the downramping test and calibrated to the benchmark cap, which was surveyed with the total station. All cross sections were measured in September 2015 and re-measured in July 2016. Water surface elevations were measured at nearly all cross sections at a range of flows from 215 to 1,000 cfs.

2.2 Ramping Rate Evaluation

The FERC-approved Supplement stipulates that a series of temporary staff gages will be installed for recording water level (stage) at the inlet and outlet of each side channel and at cross sections with high stranding potential. The downramping evaluation will occur at flows ranging from 600 cfs down to 300 cfs following standard Project downramping protocols. Permanent photo stations will document important hydraulic controls and other areas of interest during downramping, and will be marked for future monitoring. Flow releases for the study will be based on readings obtained from U.S. Geological Survey (USGS) Gage No. 12138160 (Sultan River below Powerhouse).

Per the Supplement, temporary staff gages were installed at a series of sites (cross sections 5, 6, 7, 9, 10, 11, 13, and 16) (Figure 1). To augment manual data collection at temporary staff gage sites, automatic water level loggers were installed at cross sections 1, 2, 3, 12, 14, and 20 (Figure 1). Staff gages and level loggers were installed on September 11 and 12, 2015, prior to the downramping test, which was conducted on September 13, 2015. Per the Supplement, the downramping test began when the Sultan River flow was about 600 cfs and ending at approximately 300 cfs. At cross sections with staff gages, surveyors manually observed the water stage decline and recorded stage approximately every 5 minutes. Level loggers were set to record stage decline at 15-minute intervals.

Following the downramping event, the surface area of potential stranding habitat below the initial high-water line in each side channel was estimated. This dewatered stranding habitat was photographed and visually examined for stranded fish. Observations were made by two teams of two biologists slowly walking back and forth in the dewatered zone. Special attention was given to areas containing previously submerged vegetation (aquatic and terrestrial) and any depressions or isolated water pockets. The number, species, and condition of any observed stranded fish were documented.

Per the Supplement, the change in stage over time data collected from the temporary staff gages and level loggers in the side channels was used to calculate the ramping rate associated with the downramping event at each side channel site in terms of a rolling calculation of inches/hour. These data were also used to determine the time it takes for the flow to reach the study sites from the Powerhouse, and to determine the degree of the stage-change attenuation, if any, between the USGS gage below the Powerhouse and the study sites.

2.3 Thalweg Profile and Habitat Survey

The FERC-approved Supplement stipulates that biologists will conduct a habitat survey in SC1 and SC4 to supplement data gathered during 2014 (Stillwater 2015). The habitat survey will cover all of SC1 and SC4. The Supplement stipulates the longitudinal thalweg profile (bed depth and water surface) will be measured every 6 meters (approximately 20 feet) and at hydraulic controls for each habitat unit. The survey will be tied to existing control and monumentation and referenced to a known datum. The thalweg profile survey will be carefully tied to each habitat unit. Metrics will include, but not be limited to, habitat unit type, habitat unit depth, wood counts, and bank erosion.

The thalweg and water surface profile was measured in September 2015 and July 2016 following the methods stipulated in the Supplement (stated above) using a rod and total station. Survey control was established at the site using RTK GNSS GPS and survey points were georeferenced to real-word coordinates and elevations by RDG’s licensed professional land surveyor. All coordinates are provided in the NAD83 Washington State Plane North projection, horizontal and vertical units are US survey feet, and the vertical datum is NAVD88.

The habitat survey was conducted in July 2016 at the same time the thalweg profile resurvey was conducted. Discrete habitat units were delineated (i.e., individual pools, riffles, glides, etc.). Total station data were used to calculate individual habitat unit length, average wetted width, average wetted depth, and active channel width and depth (analogous to bankfull width/depth). Visual estimates of the type of dominant and subdominant substrate were made for each habitat unit, as well as percent undercut banks, percent active bank erosion, and percent potential spawning habitat. Wood counts were also made for each habitat unit.

3.0 RESULTS

Results are presented below following general study and chronological order. Cross section data are presented first; 2015 and 2016 cross section measurements are presented to illustrate channel change before and after the November 2015 high flow event. The downramping test results are then presented, followed by the post-November 2015 high flow event thalweg and habitat base-line survey completed in 2016.

For the purposes of this report, the SC1 side channel complex is divided into five discrete reaches: the New Inlet (constructed in 2012); the Old Inlet (historic channel); Middle Mainstem (historic channel from the confluence of the Old/New Inlets to the Old/New Outlet split); the New Outlet (constructed in 2012), and the Old Outlet (historic channel). SC4 is divided into three discrete reaches: the Upper Inlet (from the upstream end to the short Upper Outlet); the Upper Outlet (a short channel connecting SC4 to the Sultan River); and the SC4 Mainstem (from where the Upper Outlet connects to the Sultan River downstream). Figure 1 shows specific reach locations.

3.1 Channel Cross Section Measurement (2015 & 2016)

Cross section plots and photos are presented below for each side channel. Figure 1 shows specific cross section locations. Where water surface elevation lines fall below the bed elevation, the side channel cross section was dry for that specific associated Sultan River flow. Cross section plots are oriented looking in the downstream direction except where noted.

3.1.1 Side Channel 1

A cross section was established that continues the upstream end of the SC1 Old Inlet thalweg across the Sultan River. Some adjustment of the Sultan River cross section and upstream end of the Old Inlet thalweg is apparent between September 2015 and July 2016 measurements (Figure 5, Photo Collection 1). Note that the Sultan River cross section plot (Figure 5) is oriented looking upstream.

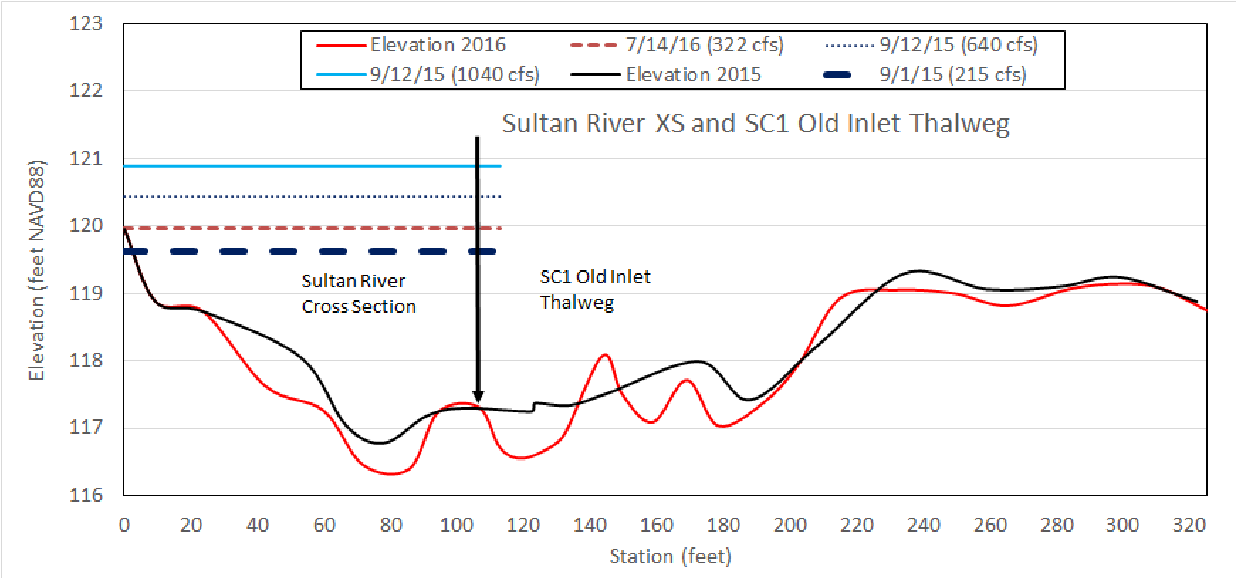

Figure 5. **Sultan River Cross Section at SC1 Old Inlet (oriented looking upstream).**

Photo Collection 1. **Sultan River Cross Section at SC1 Old Inlet[2].**

A cross section was established that continues the upstream end of the SC1 New Inlet thalweg across the Sultan River. Relatively little adjustment of the Sultan River cross section and upstream end of the New Inlet thalweg is apparent between September 2015 and July 2016 measurements (Figure 6, Photo Collection 2). Note that the Sultan River cross section plot (Figure 6) is oriented looking upstream.

[2] September 2015 photo file for this cross section was corrupted.

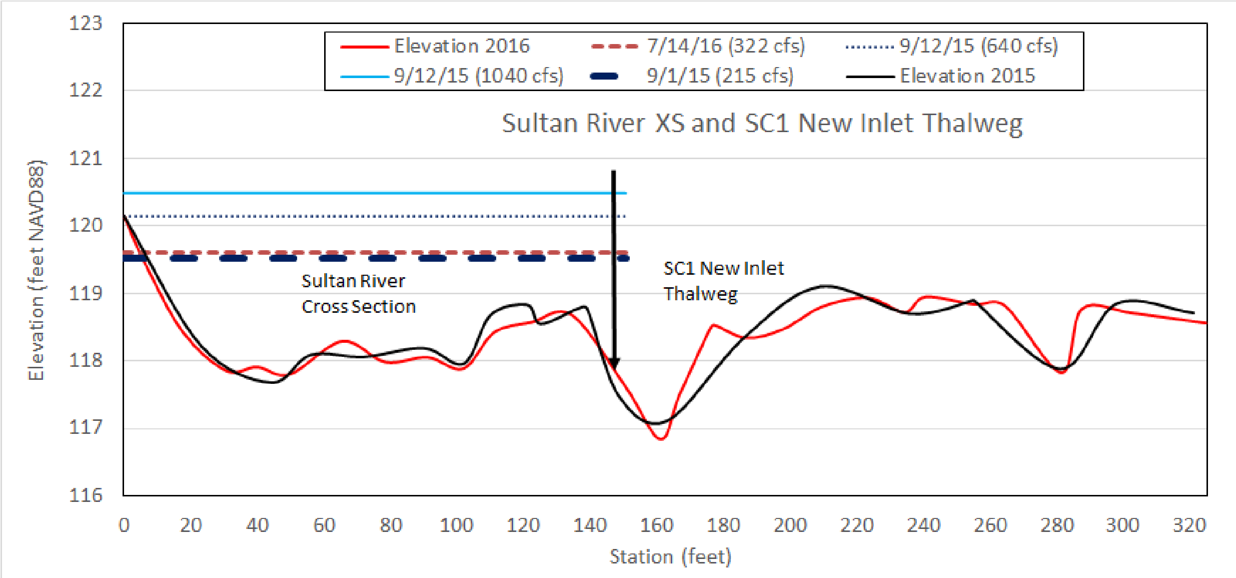

Figure 6. Sultan River Cross Section at SC1 New Inlet (oriented looking upstream).

Photo Collection 2. Sultan River Cross Section at SC1 New Inlet.

Cross Section 1 is located at the upstream entrance to the New Inlet; relatively little adjustment of the cross section is apparent between the September 2015 and July 2016 measurements (Figure 7, Photo Collection 3).

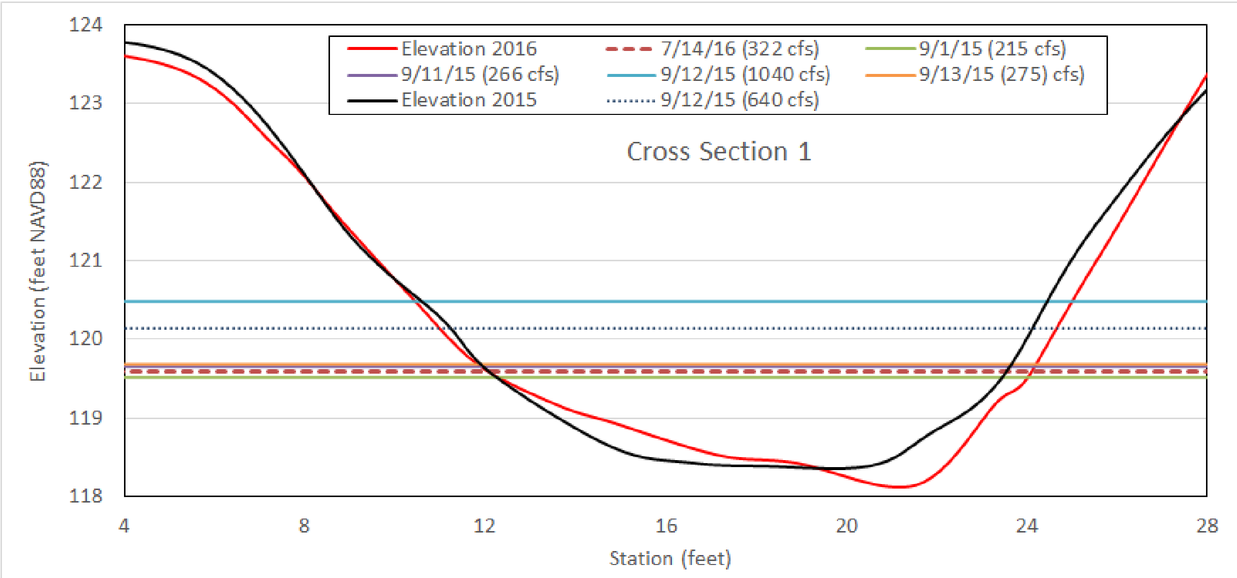

Figure 7. SC1 Cross Section 1 at upstream end of New Inlet.

Photo Collection 3. SC1 Cross Section 1 at upstream end of New Inlet.

Cross Section 2 is located at the upstream entrance to the Old Inlet; relatively little adjustment of the cross section is apparent between the September 2015 and July 2016 measurements (Figure 8, Photo Collection 4).

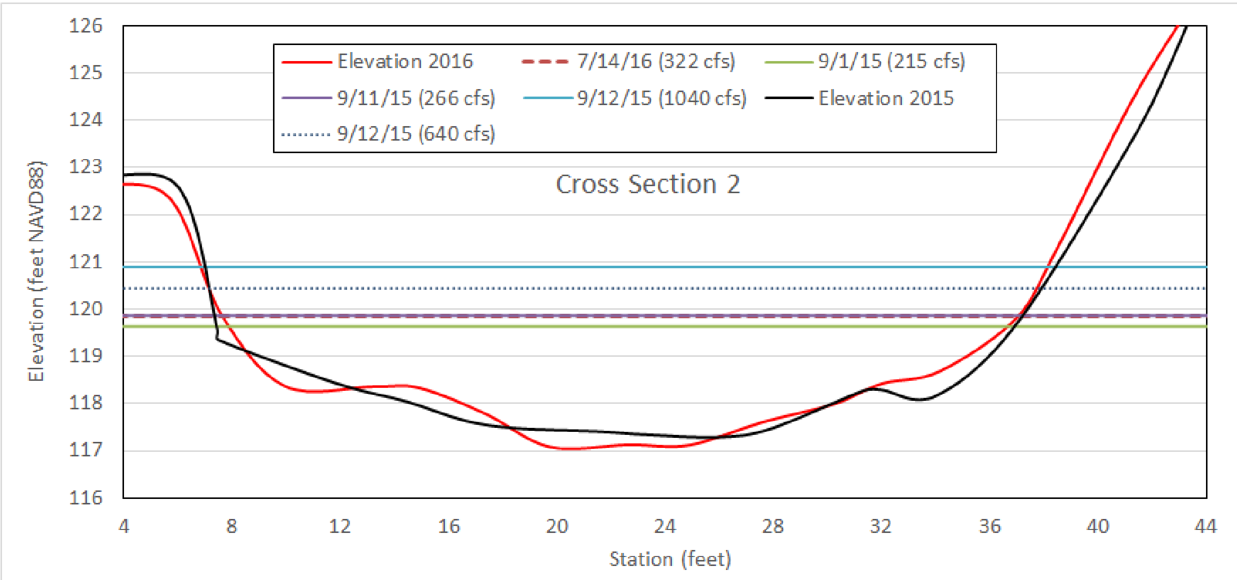

Figure 8. SC1 Cross Section 2 at upstream end of Old Inlet.

Photo Collection 4. SC1 Cross Section 2 at upstream end of Old Inlet.

Cross Section 3 is located at the Middle Mainstem a short distance downstream of the Old and New Inlet confluence; some adjustment of the cross section is apparent between the September 2015 and July 2016 measurements (Figure 9, Photo Collection 5).

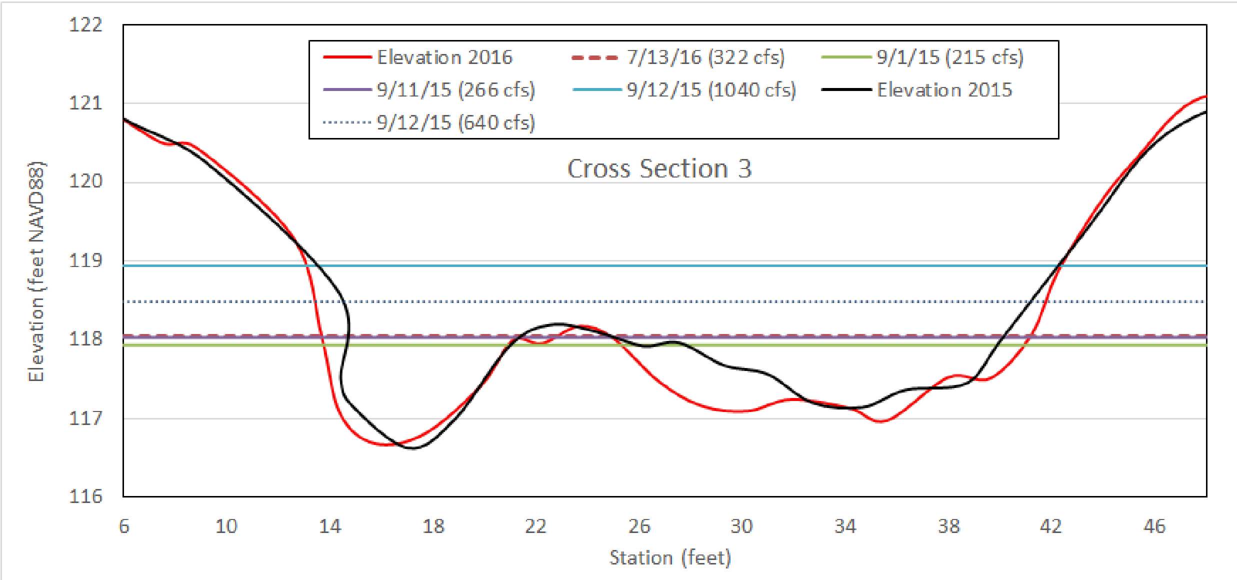

Figure 9. SC1 Cross Section 3 downstream of SC1 Old and New Inlets within the SC1 Middle Mainstem.

Photo Collection 5. SC1 Cross Section 3 downstream of SC1 Old and New Inlets within the SC1 Middle Mainstem.

Cross Section 4 is located within the Middle Mainstem in an area with a relatively wide potential floodplain with what appears to be a legacy channel system to the east that has been blocked by a large boulder/log structure. The cross section contains a portion of a small side channel. Some adjustment of the cross section is apparent between the September 2015 and July 2016 measurements (Figure 10, Photo Collection 6).

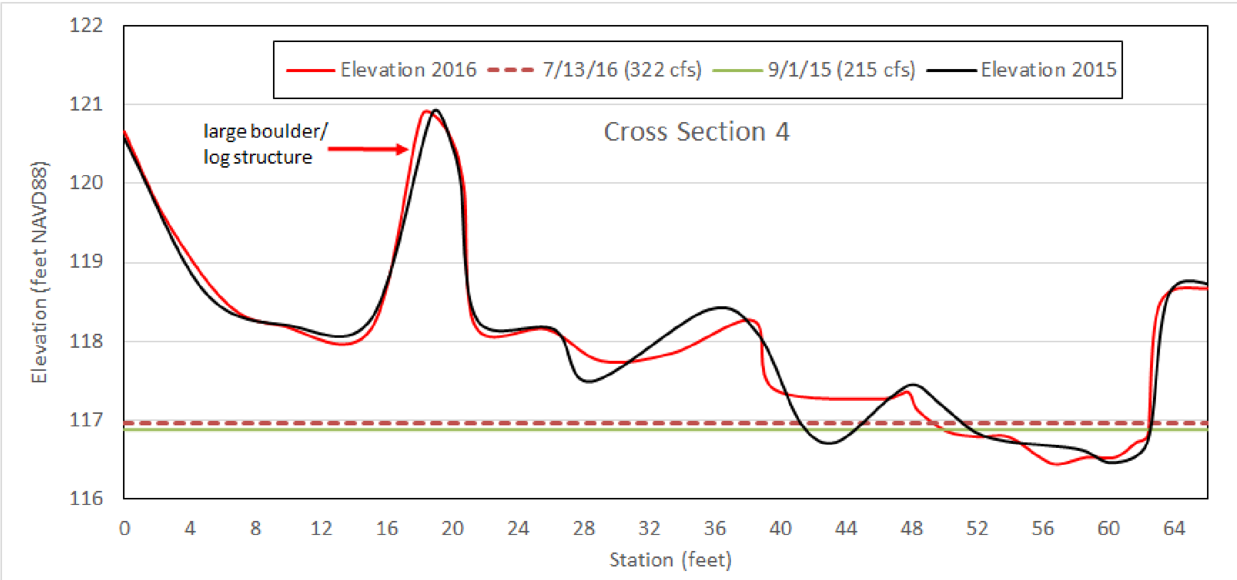

Figure 10. SC1 Cross Section 4 within SC1 Middle Mainstem.

Photo Collection 6. SC1 Cross Section 4 within SC1 Middle Mainstem.

Cross Section 5 is located within the Middle Mainstem in an area with a relatively wide potential floodplain. The cross section contains the inlet to a side channel. Some adjustment of the cross section is apparent between the September 2015 and July 2016 measurements (Figure 11, Photo Collection 7).

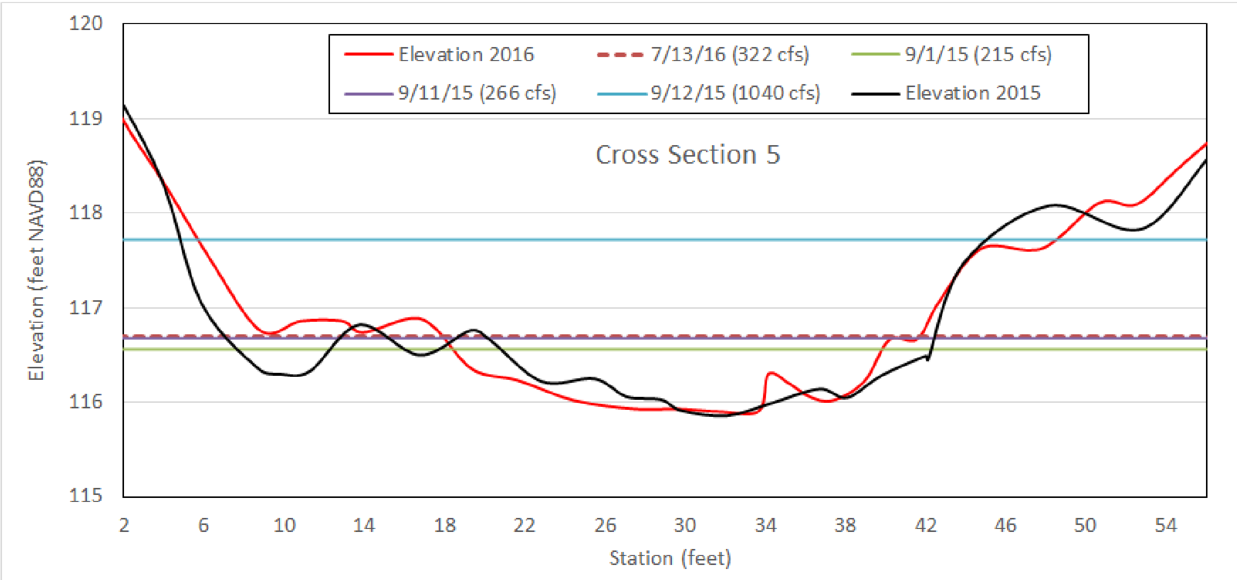

Figure 11. SC1 Cross Section 5 within SC1 Middle Mainstem.

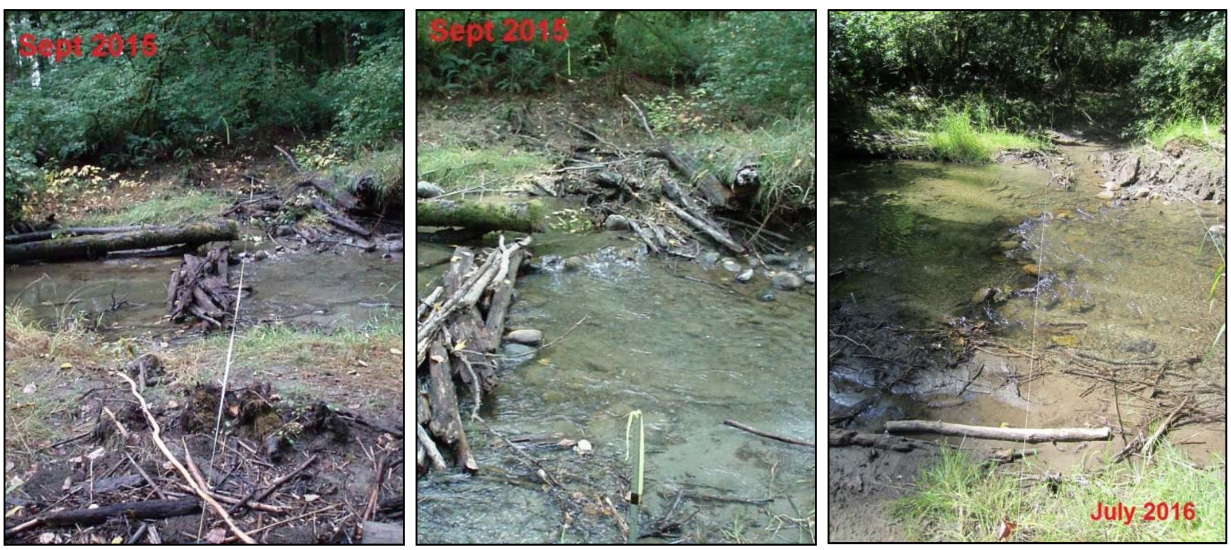

Photo Collection 7. SC1 Cross Section 5 within SC1 Middle Mainstem.

Cross Section 6 is located within the Middle Mainstem in an area with a relatively wide potential floodplain. The cross section contains a side channel (same side channel that is part of Cross Section 5). Little adjustment of the cross section is apparent between the September 2015 and July 2016 measurements (Figure 12, Photo Collection 8).

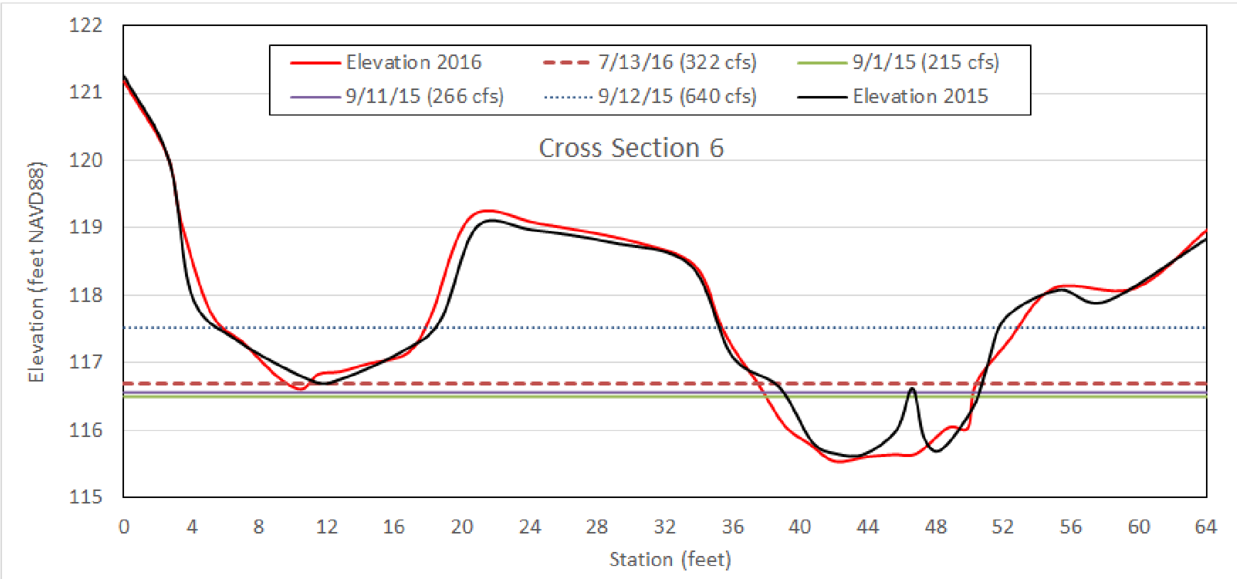

Figure 12. **SC1 Cross Section 6 within SC1 Middle Mainstem.**

Photo Collection 8. SC1 Cross Section 6 within SC1 Middle Mainstem.

Cross Section 7 is located at the upstream end of the Old Outlet; little adjustment of the cross section is apparent between the September 2015 and July 2016 measurements (Figure 13, Photo Collection 9).

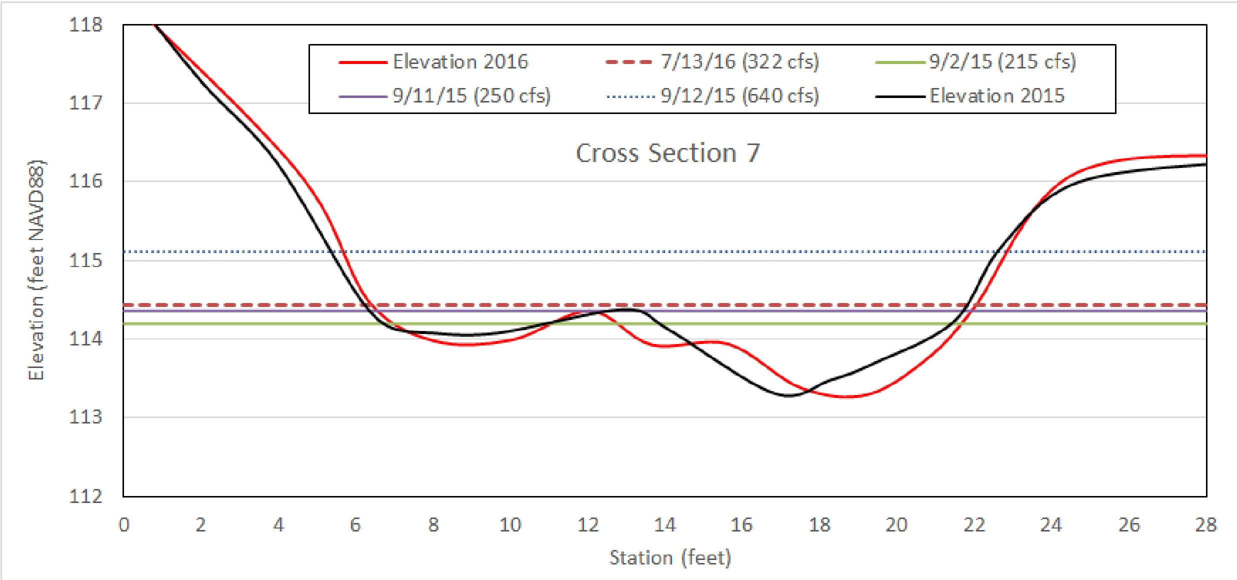

Figure 13. SC1 Cross Section 7 at the upstream end of the Old Outlet.

Photo Collection 9. SC1 Cross Section 7 at the upstream end of the Old Outlet.[3]

[3] July 2016 photo file for Cross Section 9 was corrupted.

Cross Section 8 is located within the New Outlet a short distance downstream of the Old/New outlet split, near where surface flow ceased during the 2015 survey at 215 cfs. Little adjustment of the cross section is apparent between the September 2015 and July 2016 measurements (Figure 14, Photo Collection 10).

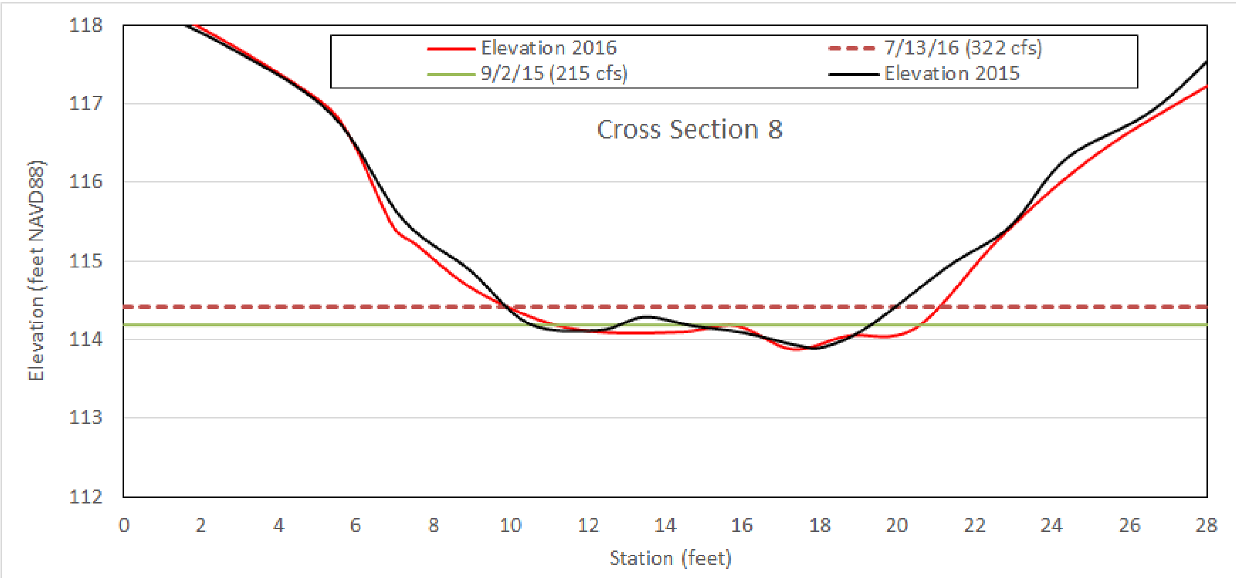

Figure 14. **SC1 Cross Section 8 near the upstream end of the New Outlet.**

Photo Collection 10. **SC1 Cross Section 8 near the upstream end of the New Outlet.**

Cross Section 9 is located within the New Outlet a short distance downstream of the Old/New outlet split, where the channel was dry during the 2015 survey at 215 cfs. Little adjustment of the cross section is apparent between the September 2015 and July 2016 measurements (Figure 15, Photo Collection 11).

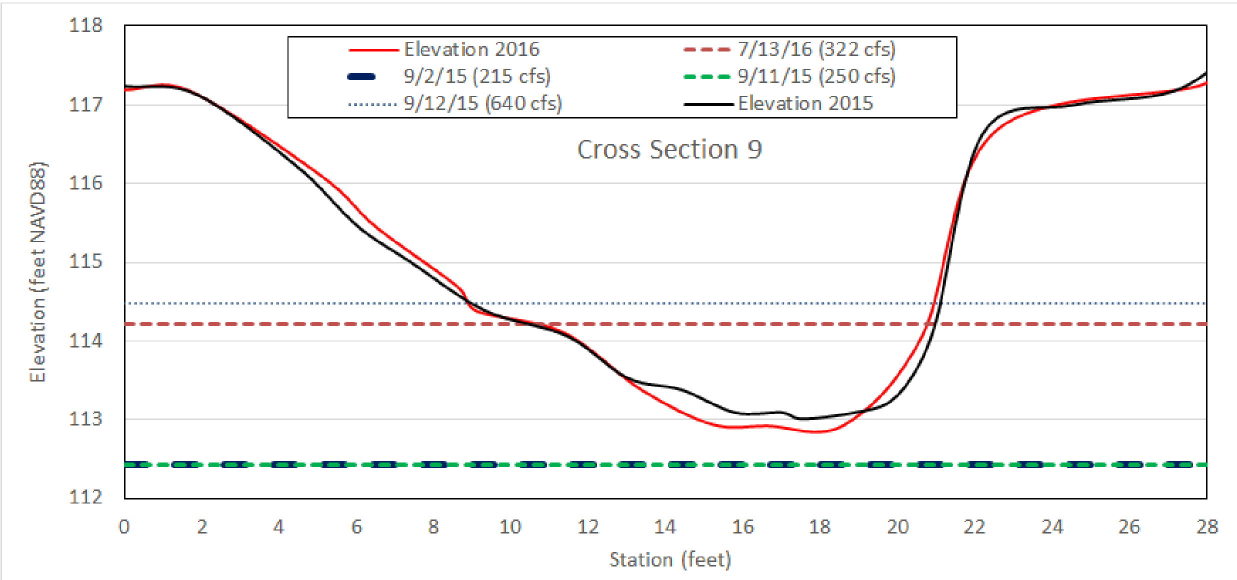

Figure 15. SC1 Cross Section 9 near the upstream end of the New Outlet.

Photo Collection 11. SC1 Cross Section 9 near the upstream end of the New Outlet.

Cross Section 10 is located within the New Outlet where surface flow was intermittent during the 2015 survey at 215 cfs. Little adjustment of the cross section is apparent between the September 2015 and July 2016 measurements (Figure 16, Photo Collection 12).

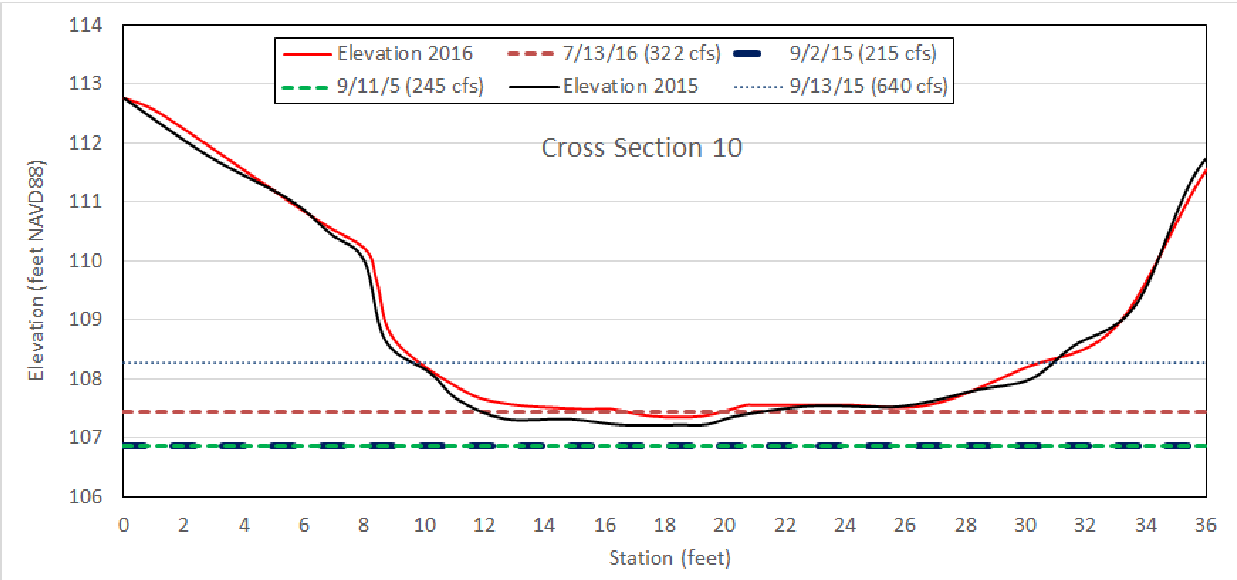

Figure 16. SC1 Cross Section 10 within the New Outlet.

Photo Collection 12. SC1 Cross Section 10 within the New Outlet.

Cross Section 11 is located within the New Outlet where surface flow was intermittent during the 2015 survey at 215 cfs. Little adjustment of the cross section is apparent between the September 2015 and July 2016 measurements (Figure 17, Photo Collection 13).

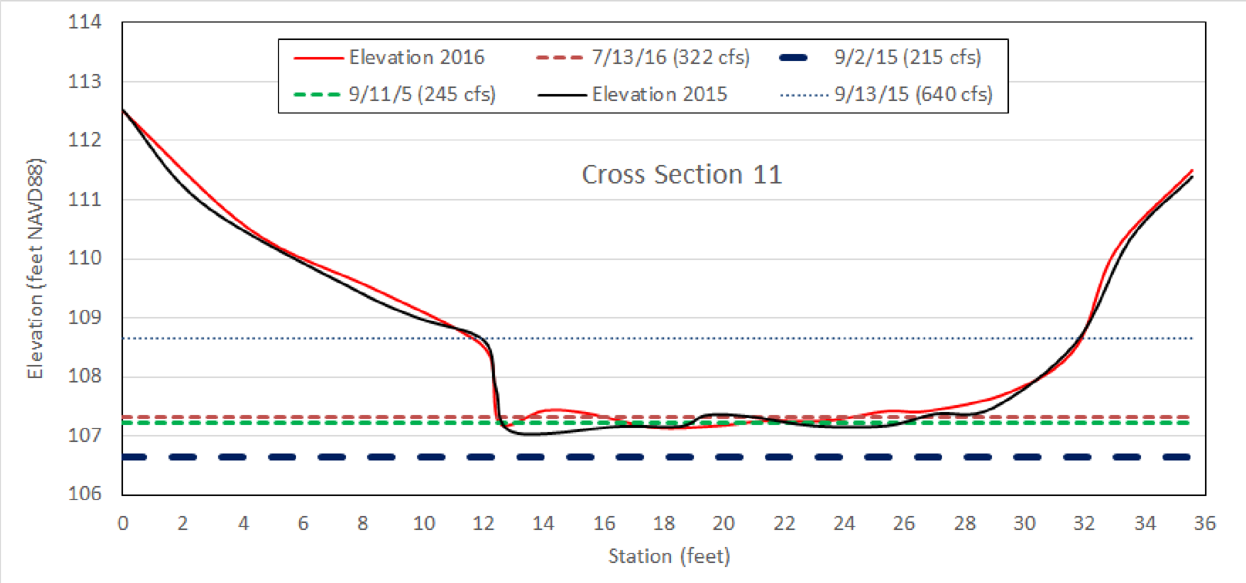

Figure 17. SC1 Cross Section 11 within the New Outlet.

Photo Collection 13. SC1 Cross Section 11 within the New Outlet.

Cross Section 12 is located within the New Outlet where surface flow was continuous to the Sultan River confluence during the 2015 survey at 215 cfs, and is also located at the District's previously established staff gage monitoring site. Little adjustment of the cross section is apparent between the September 2015 and July 2016 measurements (Figure 18, Photo Collection 14).

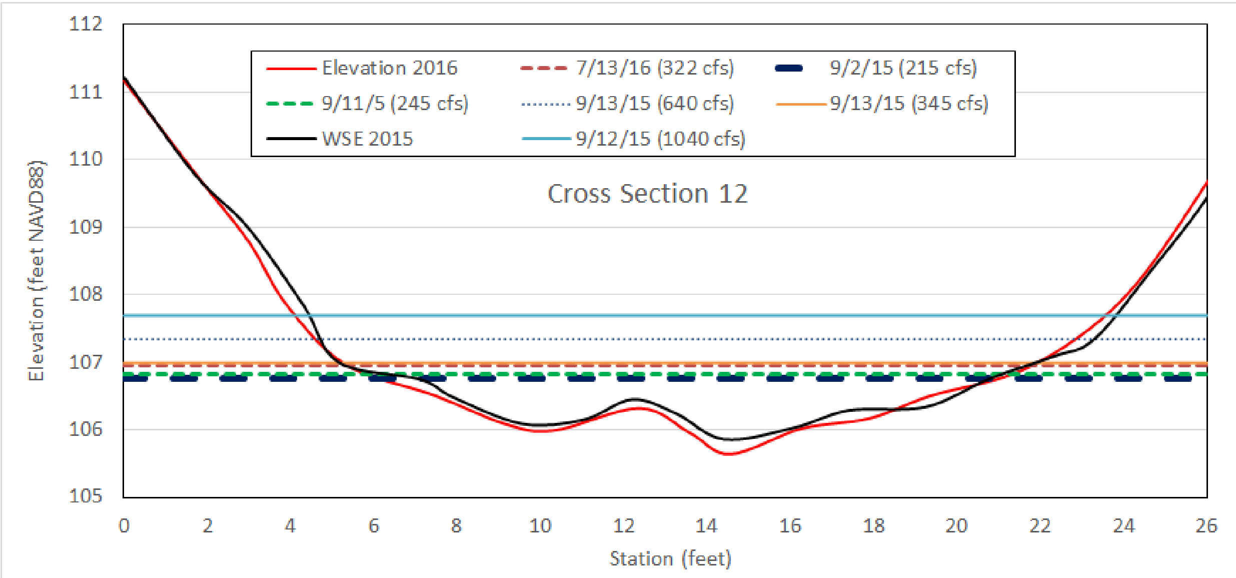

Figure 18. SC1 Cross Section 12 near the downstream end of the New Outlet.

Photo Collection 14. SC1 Cross Section 12 near the downstream end of the New Outlet.

3.1.2 Side Channel 4

Cross Section 13 is located at the upstream end of SC4 and extends across the SC4 Upper Inlet as well as the mainstem Sultan River channel. Some adjustment of the Sultan River cross section and upstream end of the SC4 inlet is apparent between September 2015 and July 2016 measurements (Figure 19). Adjustments observed included some scouring of the gravel bar along the SC4 Inlet and deposition of a log/rootwad (Photo Collection 15).

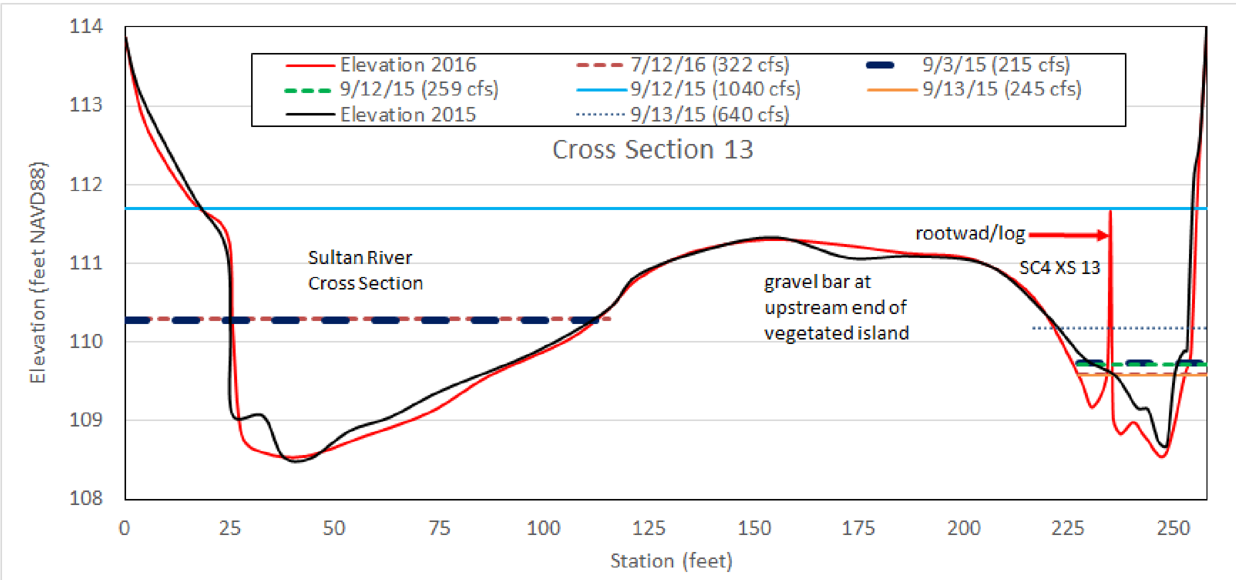

Figure 19. **SC4 Cross Section 13 at the upstream end of the Upper Inlet and the Sultan River.**

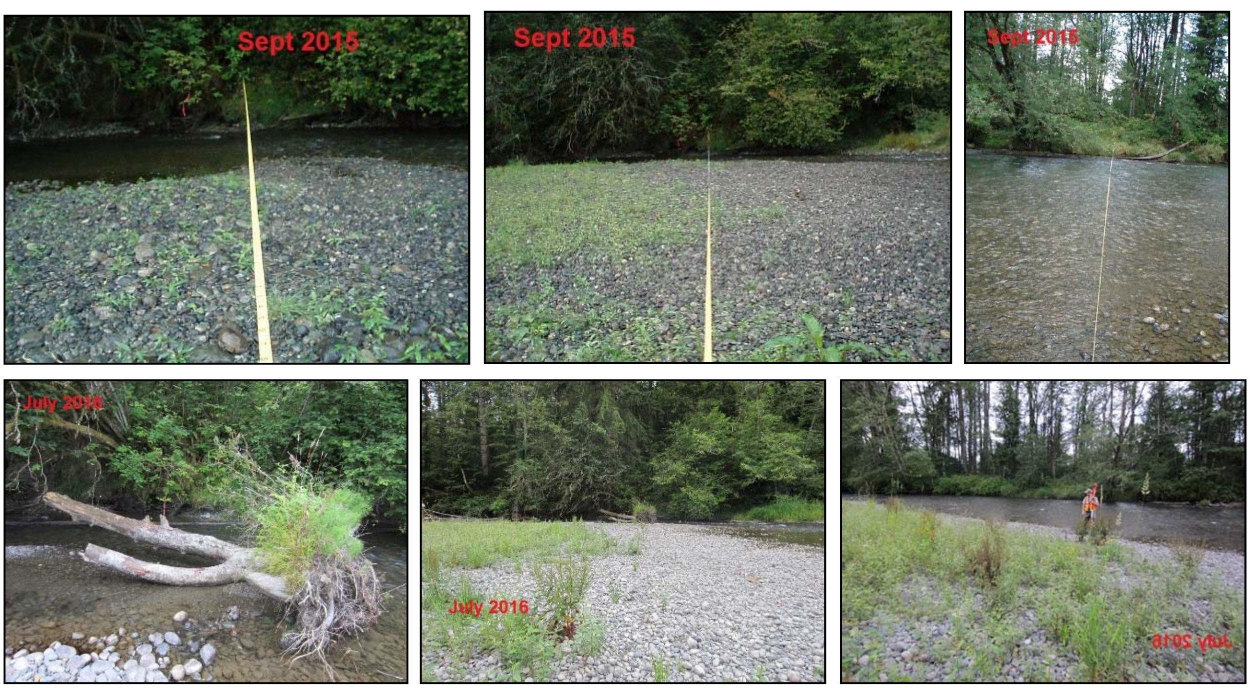

Photo Collection 15. **SC4 Cross Section 13 at the upstream end of the Upper Inlet and the Sultan River.**

Cross Section 14 is located within the Upper Inlet of SC4; some adjustment of this cross section is apparent between September 2015 and July 2016 measurements (Figure 20, Photo Collection 16).

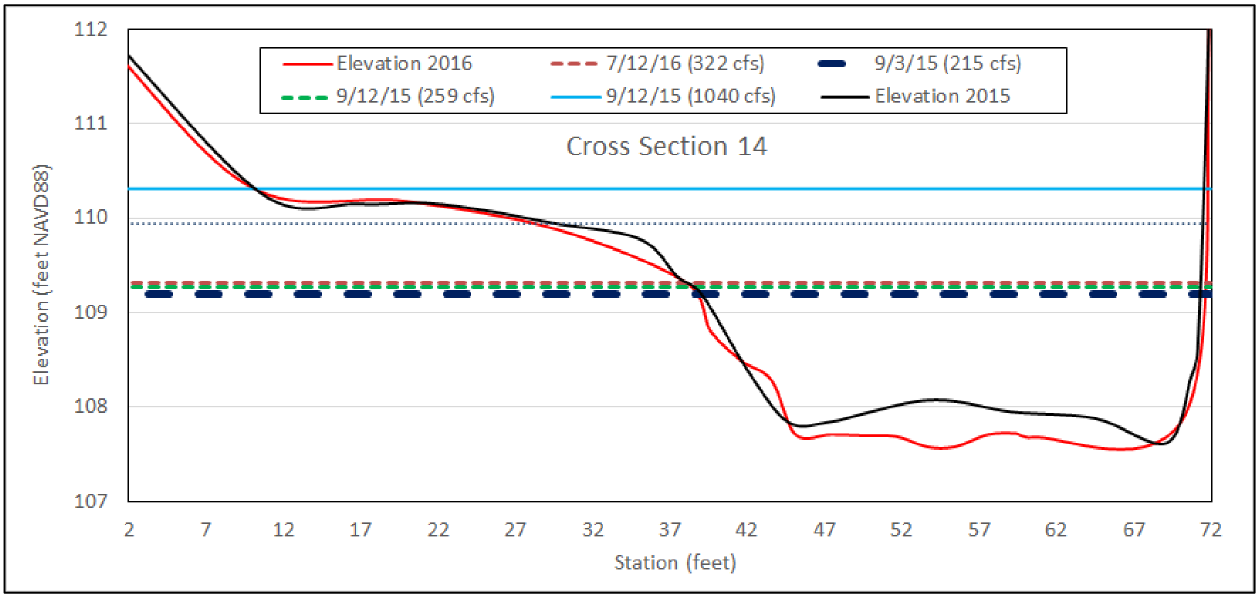

Figure 20. SC4 Cross Section 14 within the Upper Inlet.

Photo Collection 16. SC4 Cross Section 14 within the Upper Inlet.

Cross Section 15 is located within the Upper Inlet of SC4 just upstream of where the Upper Outlet channel connects to the Sultan River. Some adjustment of this cross section is apparent between September 2015 and July 2016 measurements (Figure 21, Photo Collection 17).

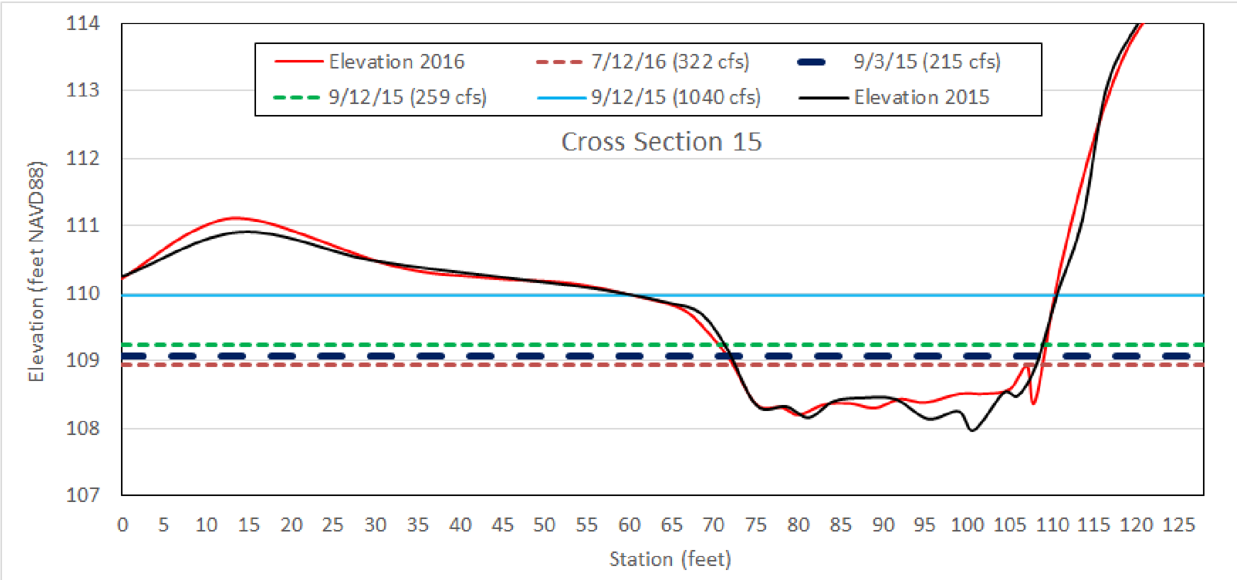

Figure 21. SC4 Cross Section 15 at the downstream end of the Upper Inlet.

Photo Collection 17. SC4 Cross Section 15 at the downstream end of the Upper Inlet.

Cross Section 16 is located within the short Upper Outlet channel of SC4. This channel was dry during the 2015 measurement and barely flowing during the 2016 measurement. Some adjustment of this cross section is apparent between September 2015 and July 2016 measurements (Figure 22, Photo Collection 18).

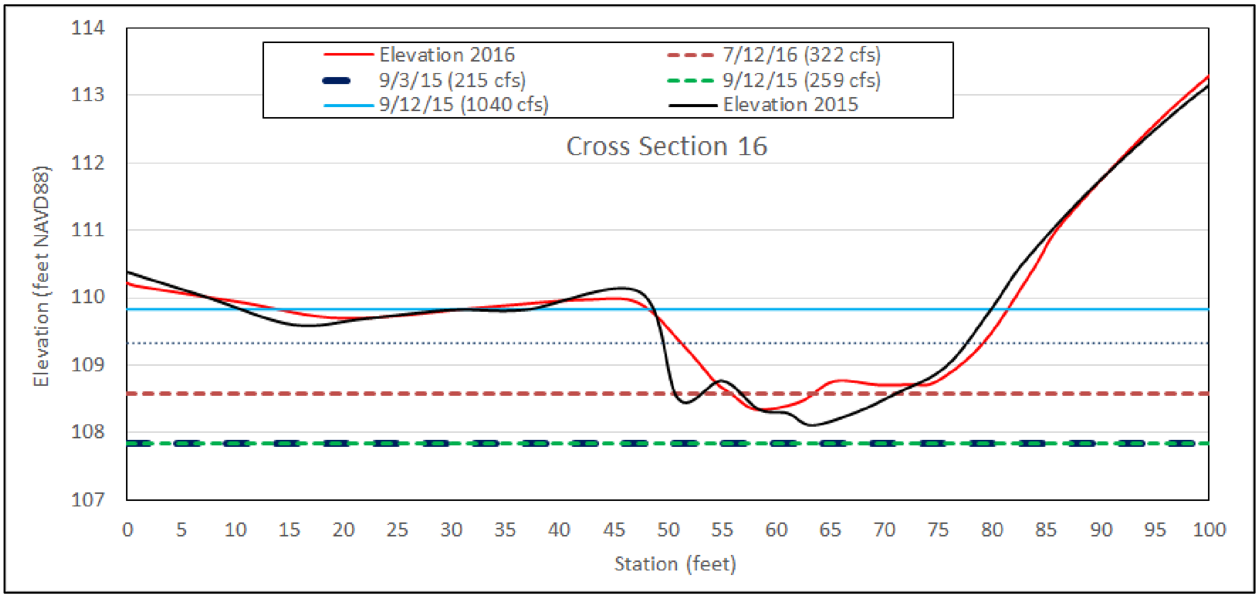

Figure 22. SC4 Cross Section 16 within the Upper Outlet.

Photo Collection 18. SC4 Cross Section 16 within the Upper Outlet.

Cross Section 17 is located within the SC4 mainstem downstream of the Upper Outlet. Little adjustment of this cross section is apparent between September 2015 and July 2016 measurements (Figure 23, Photo Collection 19).

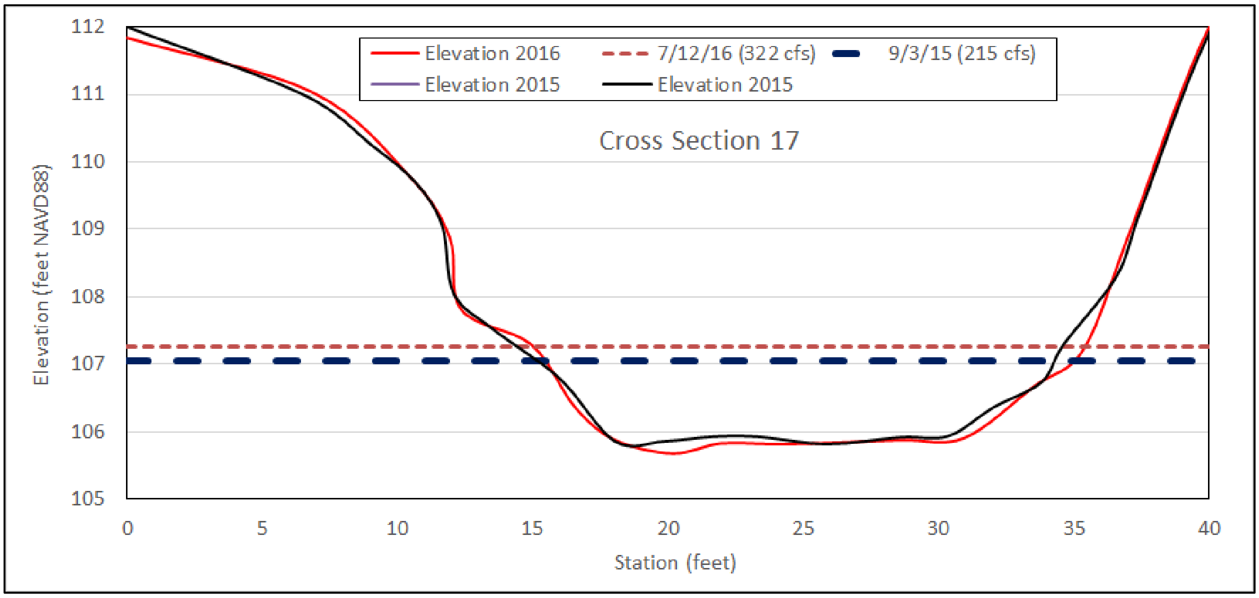

Figure 23. **SC4 Cross Section 17 within the Mainstem.**

Photo Collection 19. **SC4 Cross Section 17 within the Mainstem.**

Cross Section 18 is located within the SC4 mainstem. Some adjustment of this cross section is apparent between September 2015 and July 2016 measurements (Figure 24, Photo Collection 20).

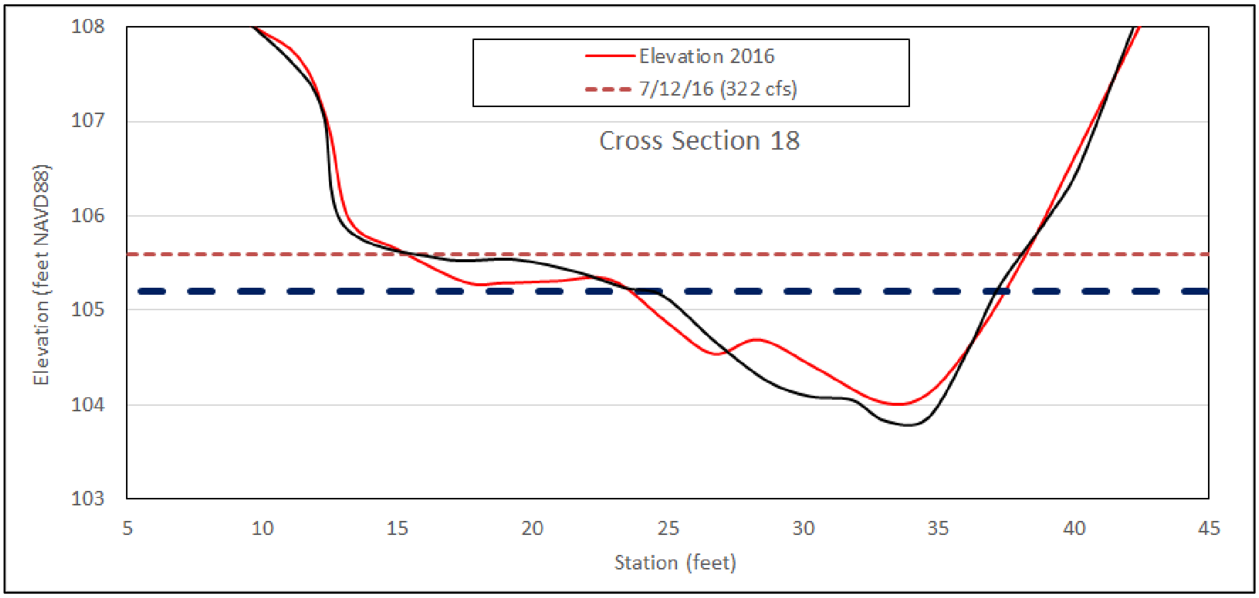

Figure 24. SC4 Cross Section 18 within the Mainstem.

Photo Collection 20. SC4 Cross Section 18 within the Mainstem.

Cross Section 19 is located within the SC4 mainstem. Some adjustment of this cross section is apparent between September 2015 and July 2016 measurements (Figure 25 Photo Collection 21).

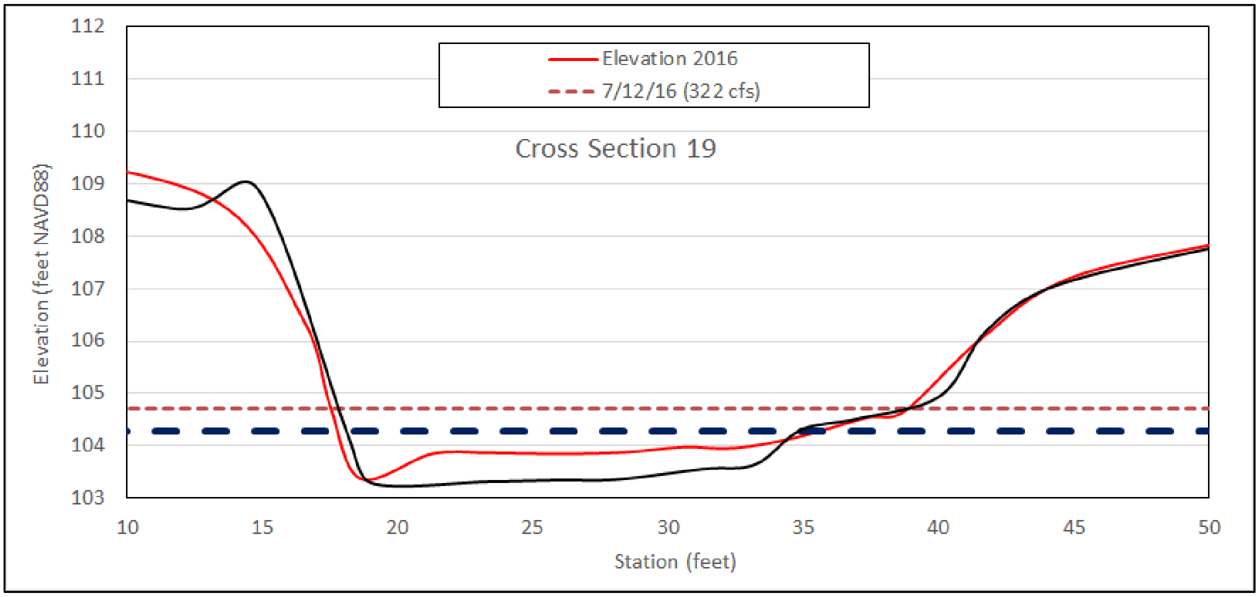

Figure 25. SC4 Cross Section 19 within the Mainstem.

Photo Collection 21. SC4 Cross Section 19 within the Mainstem.

Cross Section 20 is located in a scour pool at the downstream end of SC4 mainstem, just upstream of the Sultan River confluence. Some adjustment of this cross section is apparent between September 2015 and July 2016 measurements (Figure 26 Photo Collection 22).

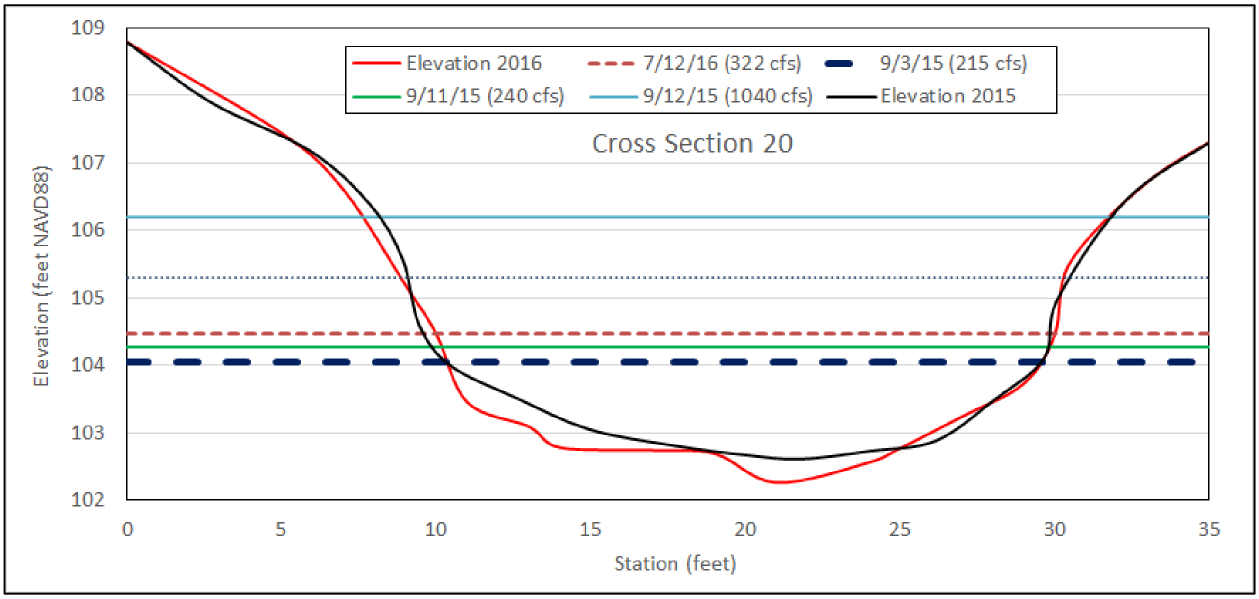

Figure 26. SC4 Cross Section 20 near the Mainstem outlet to the Sultan River.

Photo Collection 22. SC4 Cross Section 20 near the Mainstem outlet to the Sultan River.

3.2 Ramping Rate Evaluation (2015)

The ramping rate test was conducted from about 7:30 am to 3:00 pm on September 13, 2015. In general, the rate of stage decline (slope of the stage decline) was less (i.e., somewhat attenuated) at most cross sections compared to the mainstem Sultan River downstream of the Powerhouse gage (Figures 27 and 28), except at Cross Section 10 in SC1 and Cross Section 13 in SC4 (Figure 28). The downramping test results show that most sites had downramping rates less than 1.5 inches/hour throughout the test (Figures 29 and 30), except Cross Section 10 in SC1 and Cross Section 13 in SC4 which slightly exceeded two inches/hour (Figure 30). The Sultan River below the Powerhouse gage site experienced downramping rates also general below 1.5 inches/hour (Figure 29).

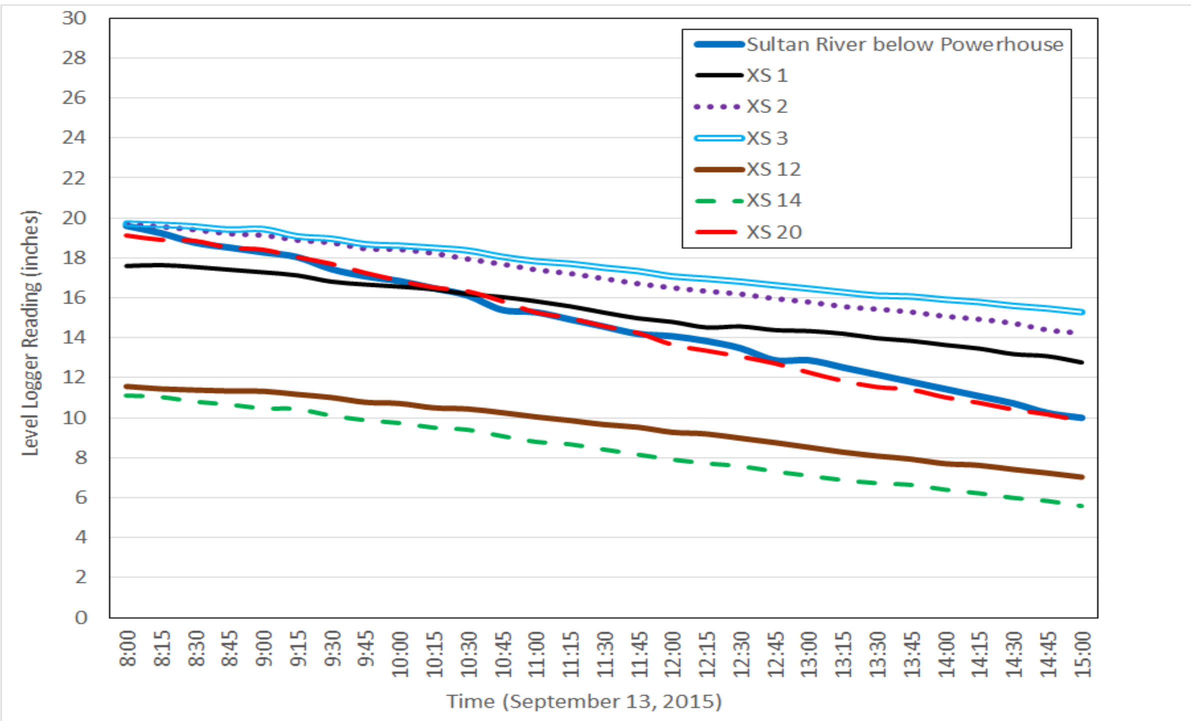

Figure 27. Stage readings at automatic level logger monitoring sites (September 13, 2015).[4]

[4] The Sultan River below Powerhouse (USGS Gage No. 12138160) stage reading was converted to inches and adjusted to a lower value range for comparison to manual staff gage readings.

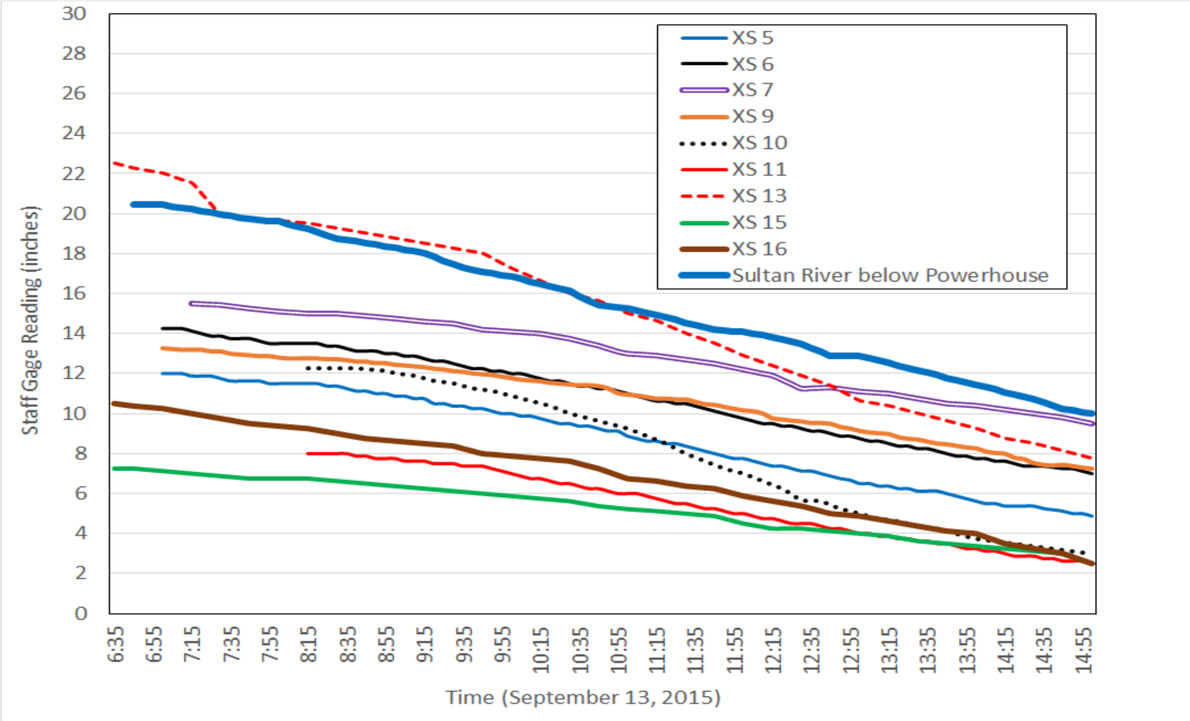

Figure 28. **Stage readings at manual staff gage monitoring sites (September 13, 2015).**[4]

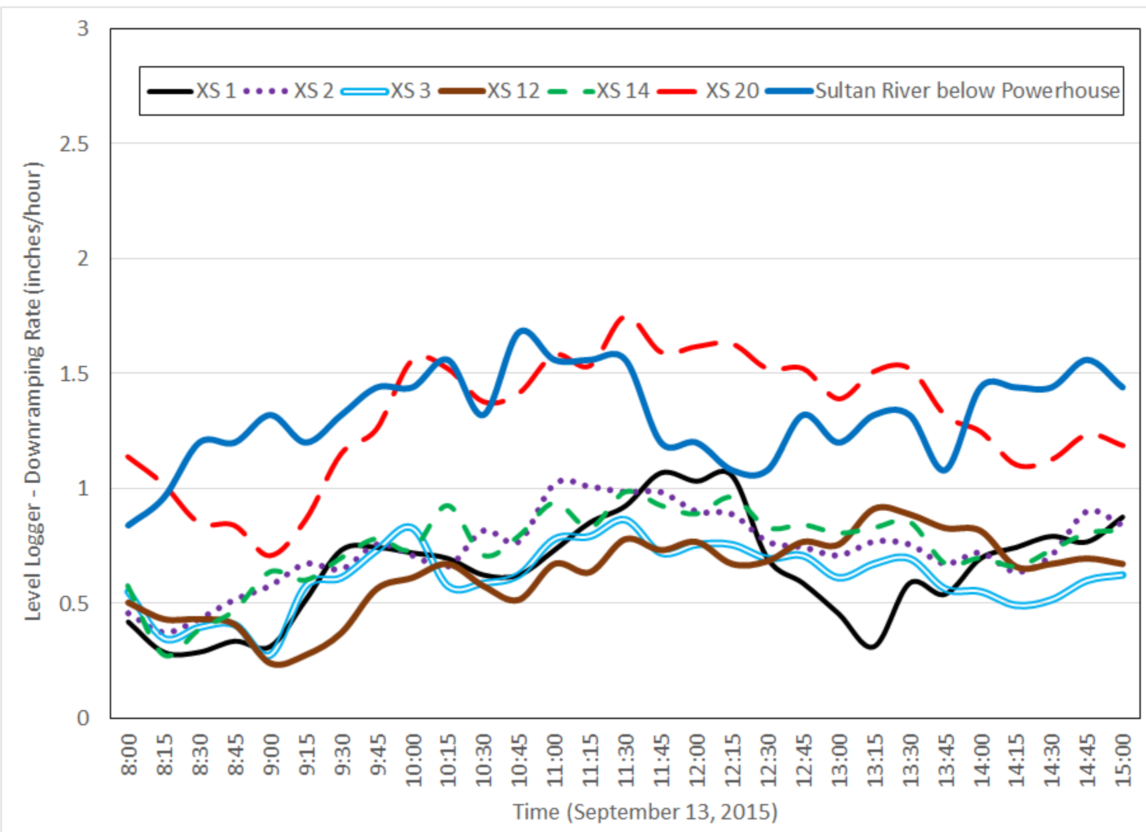

Figure 29. **Downramping rates measured at automatic level logger monitoring sites (September 13, 2015).**

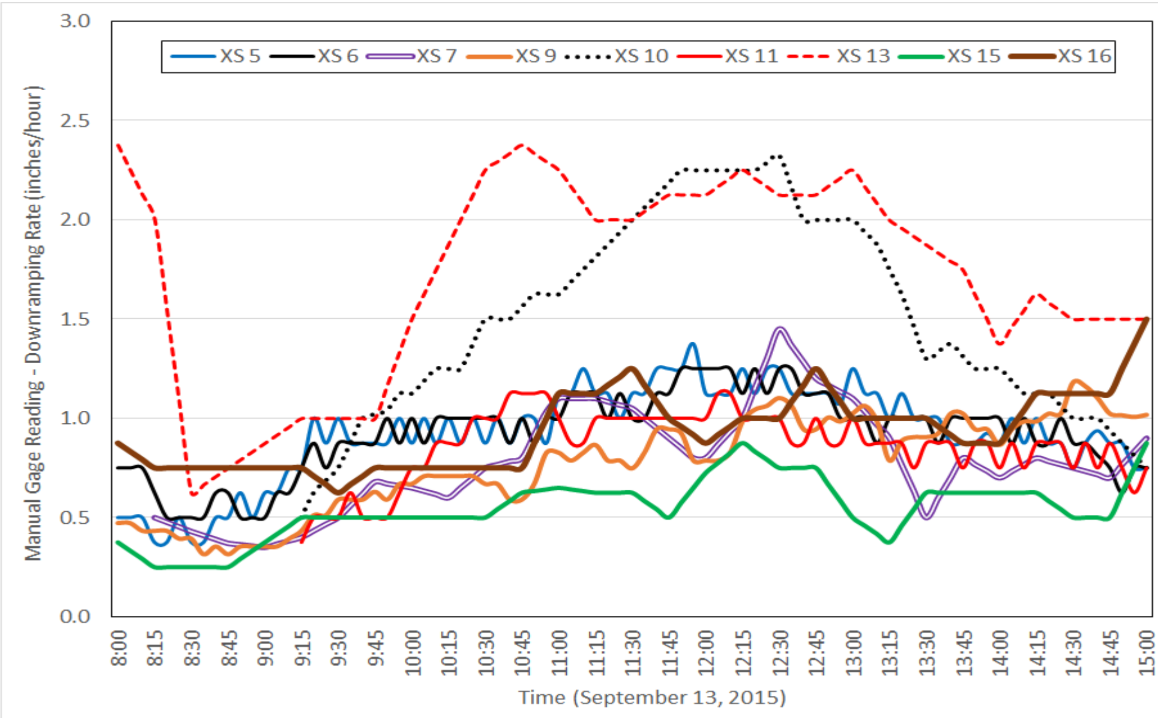

Figure 30. Downramping rates measured at manual staff gage monitoring sites (September 13, 2015).

Flow travel time from the Sultan River below Powerhouse gage site was also assessed using the ramping rate data. Flow travel time from the Sultan River gage site to the upstream end of the SC1 Old and New Inlets is about 1.0 to 1.25 hours and to the downstream end of the New Outlet is about 2.0 to 2.25 hours. Travel time to the SC4 Upper Inlet is about 1.25 to 1.35 hours and about 1.5 to 1.75 hours to the downstream end of the SC4 Mainstem channel. Factoring in about a 2 hour lag time for flow to reach Cross Section 10 (near the downstream end of the SC1 New Outlet) from the Powerhouse, the Sultan River gage was between about 500 and 450 cfs when the downramping rates greater than 2 inches per hour were experienced at Cross Section 10. Factoring in about a 1.5 hour lag time for flow to reach Cross Section 13 (at the upstream end of the SC1 Upper Inlet), the Sultan River gage was between about 540 and 400 cfs when the downramping rates greater than 2 inches per hour were experienced at Cross Section 13.

Following the downramping event, a team of biologists walked the entirety of SC1 and SC4 looking carefully for stranded fish and estimating the area of potential fish stranding habitat. In general, potential stranding habitat is most prevalent in the SC1 New Outlet as a portion of the channel becomes dewatered near 300 cfs (Table 1, Photo Collection 23), whereas the majority of the other portions of SC1 and SC4 remain wetted at 300 cfs. Only one stranded fish was found; a juvenile lamprey which was trapped in a small pocket of water within the portion of the SC1 New Outlet that goes dry below 300 cfs (Table 1, Photo Collection 24). Of note is that as soon as the flow was raised on September 12, many adult pink salmon entered the previously dry segment of the SC1 New Outlet. Adult pink salmon were observed migrating through the SC1 New Outlet during the downramping test, yet none were observed beached or trapped in isolated pools during the fish stranding study on September 13.

Table 1. Stranding survey results (September 13, 2015).

	Potential Beaching Area (ft^2)	Potential Trapping Area (ft^2)	Fish Stranded
Side Channel 1			
New Inlet	0	0	0
Old Inlet	175	0	0
Middle	300	175	0
New Outlet	5,500	1600	1 juvenile lamprey
Old Outlet	0	0	0
Total	5,900	1,725	1
Side Channel 4			
Upper Inlet	100	30	0
Upper Outlet	100	0	0
Mainstem	65	0	0
Total	265	30	0

Photo Collection 23. Typical SC1 New Outlet potential fish stranding habitat.


Photo Collection 24. Stranded juvenile lamprey trapped in isolated puddle within the SC1 New Outlet.

3.3 THALWEG PROFILE SURVEY (2016)

The baseline resurvey data of the thalweg and water surface profile of SC1 and SC4 are presented below (Figures 31 to 36). For each profile figure, station 0 is located at the upstream end of each reach. The water surface represents about 322 cfs as measured at the Sultan River below Powerhouse gage site. The average active channel width and wetted width for each habitat unit (delineated simultaneously during the 2016 profile/habitat survey) are depicted on the secondary y-axis and essentially represents a simplified straight plan view of the stream channel dimensions. Representative reach photos are also included (Photo Collections 25 to 30). The FERC-approved Supplement also stipulated plots of the width to depth ratios, which are depicted in Figure 37. Of note is that a portion of the SC1 New Outlet remained dewatered during the July 2016 survey conducted at 322 cfs, similar to the survey conducted in 2015 at 215 cfs.

Stream flow at key locations within SC1 and SC4 was also measured during the July 2016 profile and habitat survey when the Sultan River below Powerhouse gage was at 322 cfs. Cross Section 1 at the upstream end of the SC1 New Inlet measured 3.0 cfs. A large wetland seep discharges into the upstream end of the SC1 Old Inlet, about 40 feet downstream of Cross Section 2; flow at Cross Section 2 measured 1.5 cfs, and 3.8 cfs about 20 feet downstream of the wetland seep. Therefore, the wetland seep contributed about 2.3 cfs to the SC1 Old Inlet flow (i.e., 3.8-1.5). Combining the SC1 Old and New Inlet flows assumes about 6.8 cfs flowing through the SC1 Middle Mainstem (i.e., 3.0+3.8). Flow at Cross Section 7 at the upstream end of the SC1 Old Outlet measured 6.0 cfs. Flow at Cross Section 8 at the upstream end of the SC1 New Outlet measured <0.1 cfs. Flow at Cross Section 15 within the Upper Inlet to SC4 measured 27.6 cfs, and flow within the SC4 Mainstem measured 29.0 cfs at Cross Section 17.

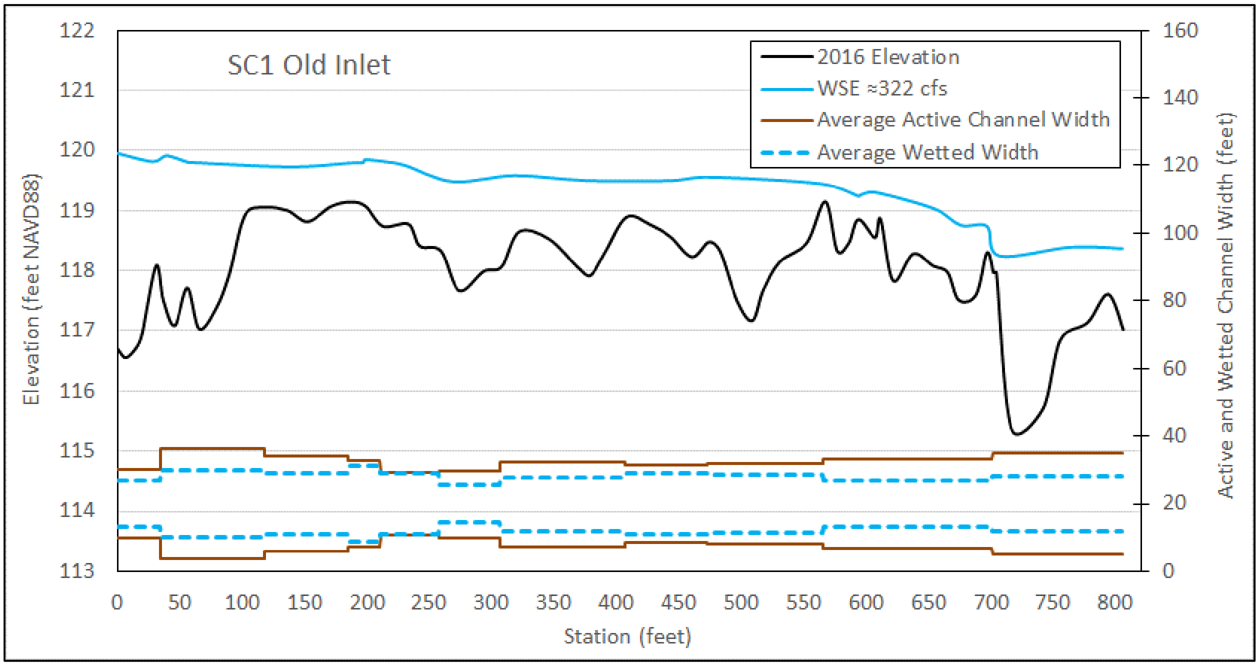

Figure 31. **SC1 Old Inlet profile and active/wetted channel dimension (July 2016).**

Photo Collection 25. **SC1 Old Inlet during profile/habitat survey (July 2016).**

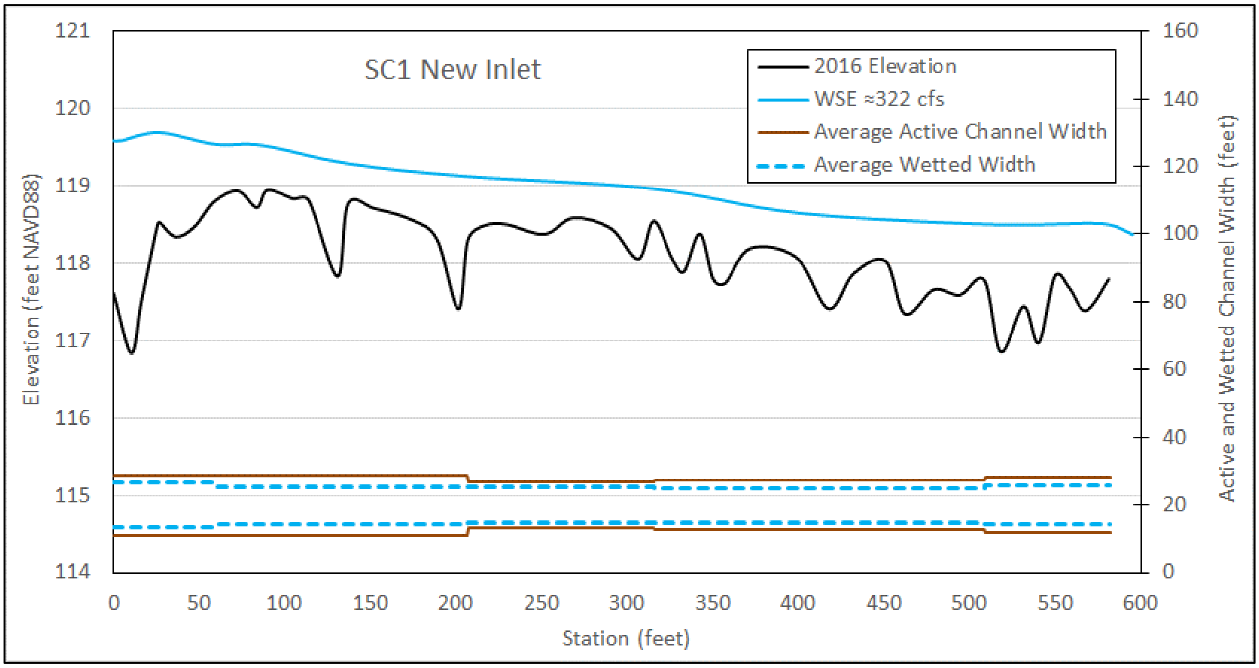

Figure 32. SC1 New Inlet profile and active/wetted channel dimension (July 2016).

Photo Collection 26. SC1 New Inlet during profile/habitat survey (July 2016).

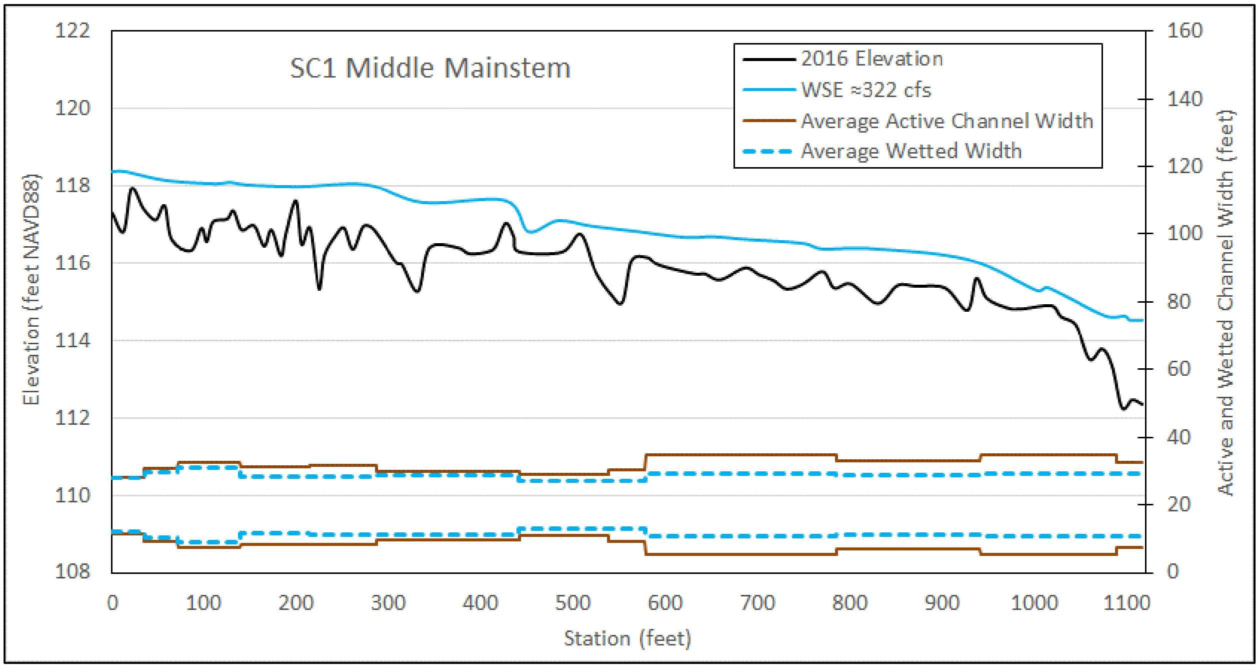

Figure 33. SC1 Middle Mainstem profile and active/wetted channel dimension (July 2016).

Photo Collection 27. SC1 Middle Mainstem during profile/habitat survey (July 2016).

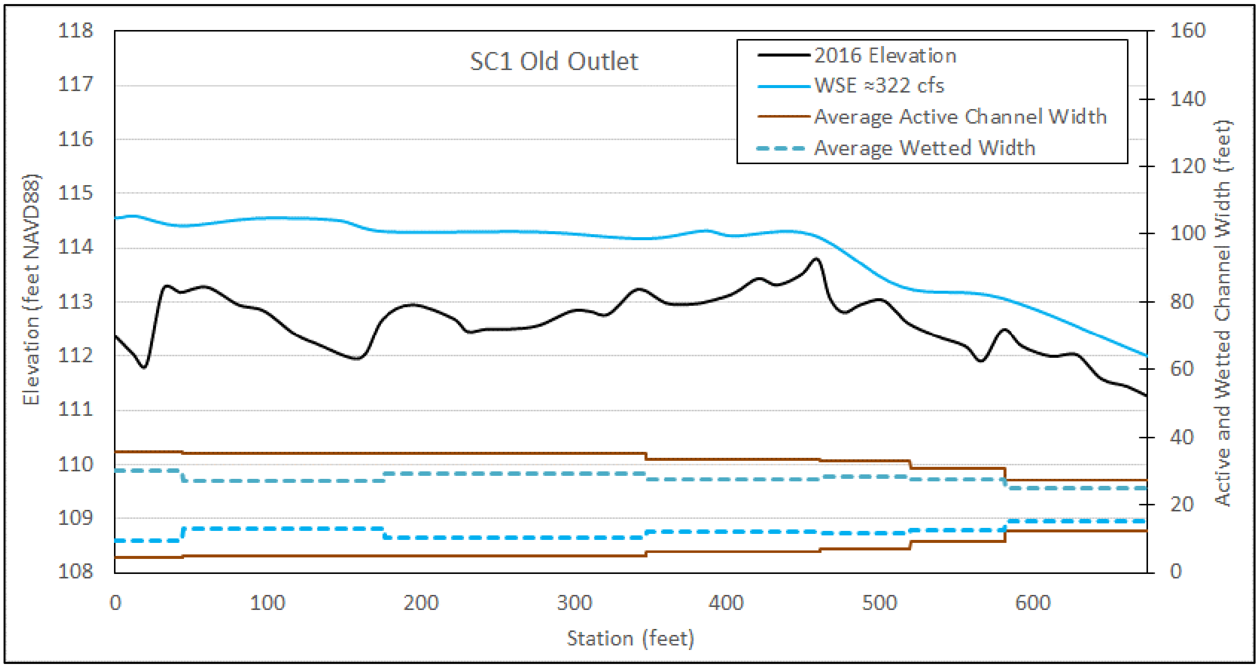

Figure 34. SC1 Old Outlet profile and active/wetted channel dimension (July 2016).

Photo Collection 28. SC1 Old Outlet during profile/habitat survey (July 2016).

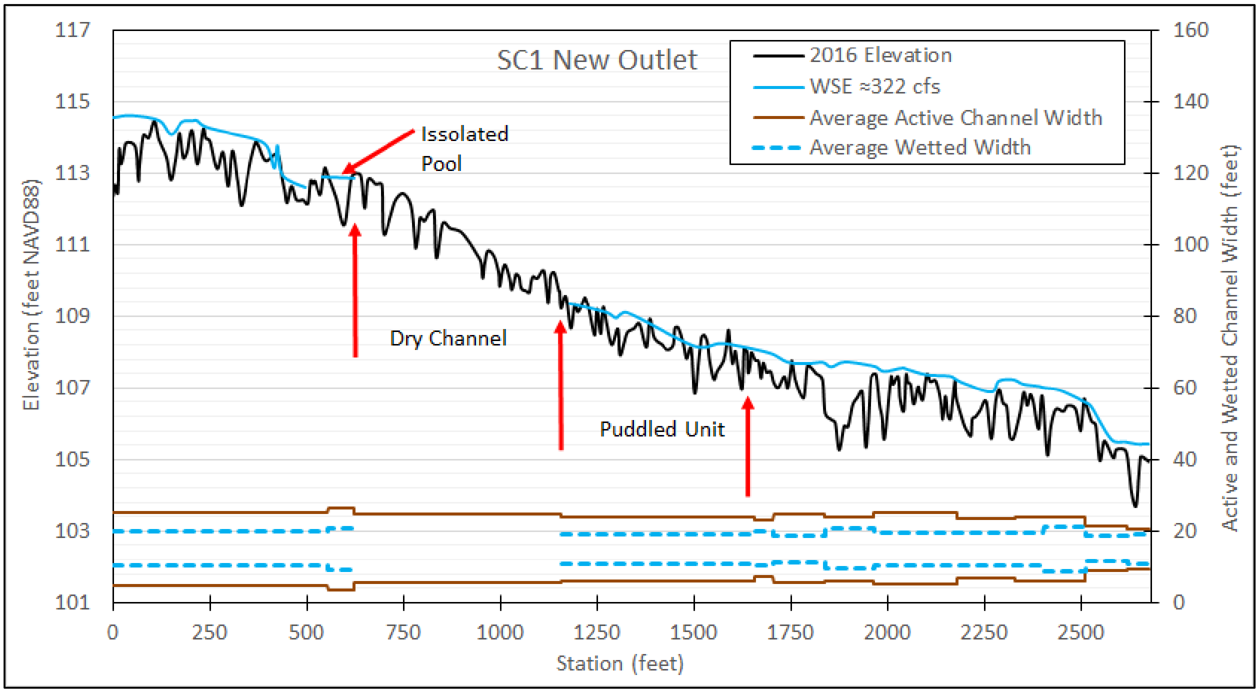

Figure 35. SC1 New Outlet profile and active/wetted channel dimension (July 2016).

Photo Collection 29. SC1 New Outlet during profile/habitat survey (July 2016).

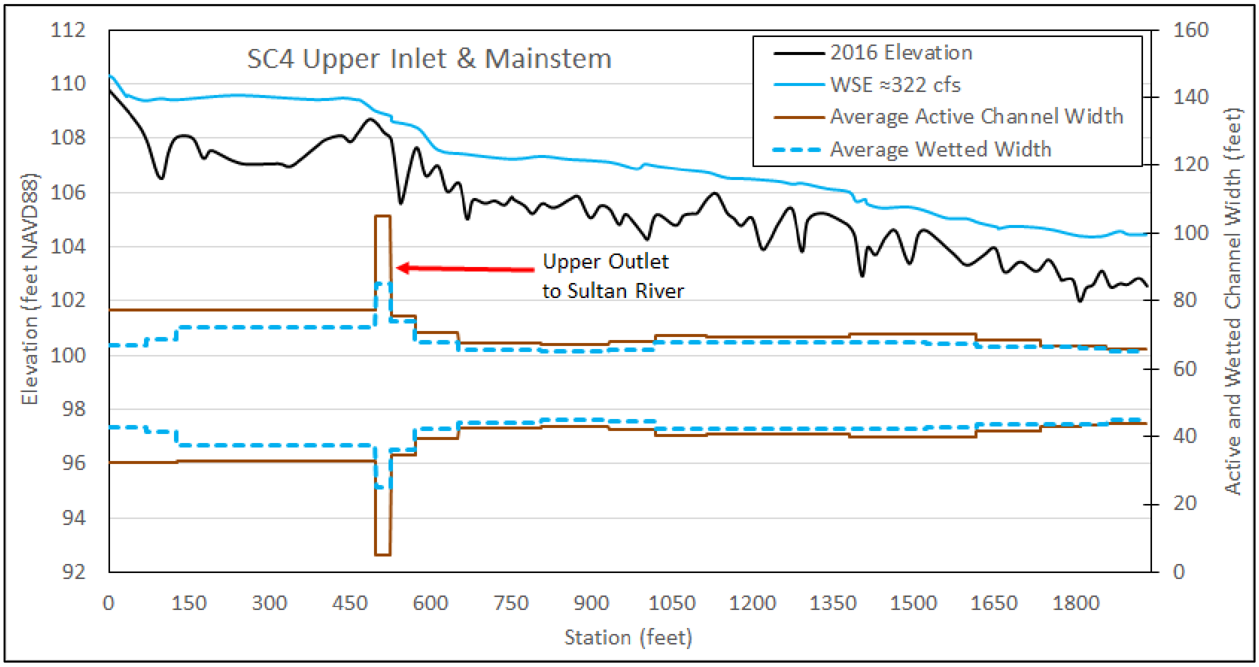

Figure 36. SC4 Upper Inlet and Mainstem profile and active/wetted channel dimension (July 2016).

Photo Collection 30. SC4 Upper Inlet and Mainstem during profile/habitat survey (July 2016).

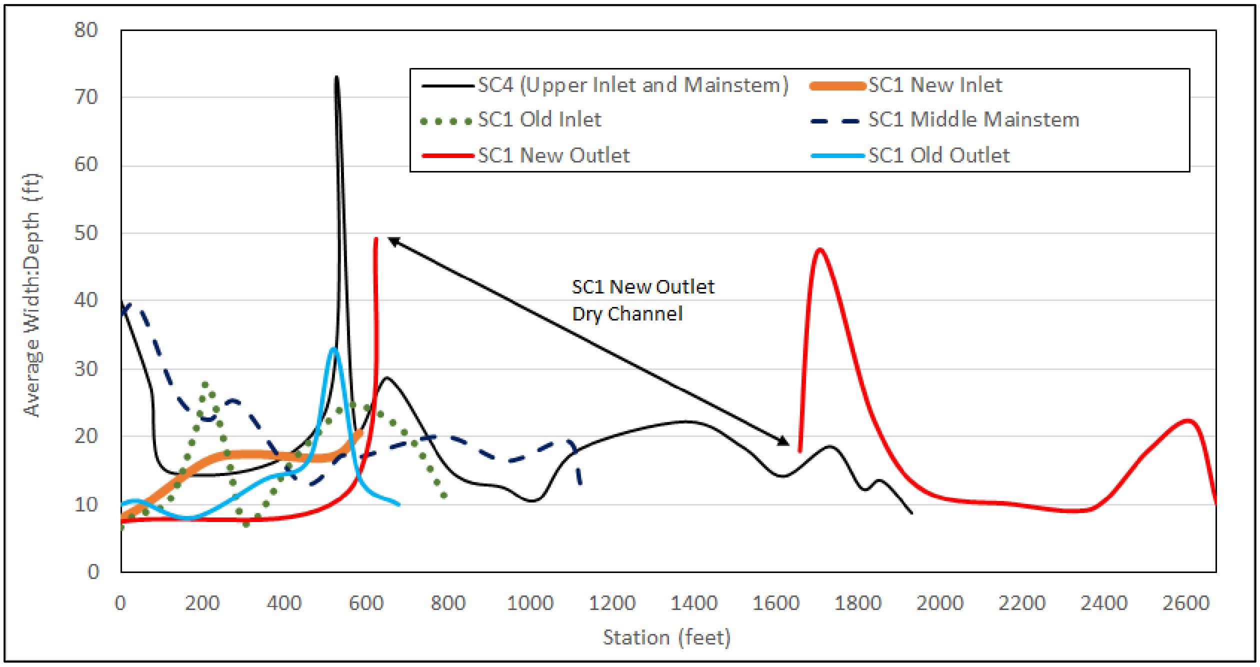

Figure 37. Width to depth ratio based on average wetted width of each habitat unit for SC1 and SC4 study reaches (July 2016).

3.4 HABITAT SURVEY (2016)

July 2016 habitat survey results are summarized by side channel and reach below in Tables 2 through 7.

3.4.1 Side Channel 1

Table 2. SC1 habitat type attributes (July 2016)

Habitat Type	Middle	New Inlet	New Outlet	Old Inlet	Old	Total
Count of Habitat Units						
Scour Pool	5	0	1	2	1	**9**
Glide	3	1	3	6	3	**16**
Isolated Pool	0	0	1	0	0	**1**
Puddled Unit	2	0	1	0	0	**3**
Riffle	4	3	2	3	3	**15**
Riffle with Pockets	0	1	4	1	0	**6**
Dry Channel	1	0	1	0	0	**2**
Total	15	5	13	12	7	**52**
Habitat Length (feet)						
Scour Pool	248	0	57	197	44	**546**
Glide	385	59	383	345	417	**1,589**
Isolated Pool	0	0	68	0	0	**68**
Puddled Unit	125	0	499	0	0	**624**
Riffle	488	450	242	159	216	**1,555**
Riffle with Pockets	0	73	891	135	0	**1,099**
Dry Channel	30	0	535	0	0	**565**
Total	1,276	5,82	2,675	836	677	**6,046**
Wetted Area (ft²) - Sultan River flow ≈ 322 cfs						
Scour Pool	4,448	0	480	3,279	914	**9121**
Glide	6,642	795	4,183	5,694	6,867	**24,180**
Isolated Pool	0	0	780	0	0	**780**
Puddled Unit	125	0	1,600	0	0	**1,725**
Riffle	8,610	4,762	1,756	2,954	2,870	**20,951**
Riffle with Pockets	0	826	8,443	1,810	0	**11,078**
Total	19,824	6,382	17,242	13,736	10,651	**67,836**
% Wetted Area						
Scour Pool	22%	0%	3%	24%	9%	**13%**
Glide	34%	12%	24%	41%	64%	**36%**
Isolated Pool	0%	0%	5%	0%	0%	**1%**
Puddled Unit	1%	0%	9%	0%	0%	**3%**
Riffle	43%	75%	10%	22%	27%	**31%**
Riffle with Pockets	0%	13%	49%	13%	0%	**16%**
Total	100%	100%	100%	100%	100%	**100%**

Table 3. SC1 channel metrics (July 2016).

Channel Metrics	Middle Mainstem	New Inlet	New Outlet	Old Inlet	Old Outlet	Total
Reach Length (ft)	1,276	582	2,675	836	677	**6046**
Average Active Channel Width (ft)	19.7	15.8	17.6	24.6	27.8	**20.9**
Average Active Channel Depth (ft)	2.0	2.1	1.7	2.6	2.6	**2.2**
Average Wetted Width (ft)	14.2	11.3	8.7	16.8	15.9	**13.4**
Average Wetted Depth (ft)	0.7	0.8	0.6	1.3	1.2	**0.9**
Average W:D	20.0	16.3	18.5	16.0	15.2	**17.6**
Wetted Area (ft^2)	19,824	6,382	17,242	13,736	10,651	**67,836**
Active Channel Area (ft^2)	28,485	9,073	49,511	21,372	17,959	**126,400**
% of Active Channel Wetted at 322 cfs	70%	70%	35%	64%	59%	**54%**
% Under Cut Banks	0.1%	1.5%	0.1%	0.2%	2.3%	**0.5%**
% Bank Erosion	17.9%	1.0%	0.6%	9.8%	8.6%	**6.4%**
% Potential Spawning Habitat	12.3%	7.6%	4.0%	1.4%	9.8%	**7.2%**
Dominant substrate	gravel	gravel	gravel	silt	silt	**gravel**
Subdominant substrate	sand	sand	sand	sand	cobble	**sand**

Table 4. SC1 large wood attributes (July 2016).

LWD Attributes	Middle Mainste	New Inlet	New Outlet	Old Inlet	Old Outlet	Total
Total LWD Pieces	30	30	120	43	40	**263**
Total LWD Volume (ft^3)	317	211	1,053	380	376	**2,337**
Total Single LWD Pieces	4	7	27	17	11	**66**
Total LWD Accumulation (2-3	12	5	54	2	8	**81**
Total LWD Jams (4+ pieces)	3	3	3	6	4	**19**
Total LWD Pieces/mile	124	272	237	272	312	**230**
LWD Volume/mile (ft^3)	1,311	1,914	2,078	2,402	2,933	**2,041**
Single LWD Pieces/mile	17	64	53	107	86	**58**
LWD Accumulations (2-3	50	45	107	13	62	**71**
LWD Jams (4+ pieces)/mile	12	27	6	38	31	**17**

3.4.2 Side Channel 4

Table 5. SC4 habitat type attributes (July 2016)

Habitat Type	Mainstem	Upper Inlet	Upper Outlet	Total
Count of Habitat Units				
Scour Pool	5	1	0	**6**
Glide	2	1	0	**3**
Puddled Unit	0	0	1	**1**
Riffle	4	1	0	**5**
Riffle with Pockets	3	0	0	**3**
Total	14	3	1	**18**
Habitat Length (feet)				
Scour Pool	377	56	0	**433**
Glide	174	370	0	**544**
Puddled Unit	0	0	95	**95**
Riffle	322	71	0	**393**
Riffle with Pockets	561	0	0	**561**
Total	1,434	497	95	**2,026**
Wetted Area (ft^2) - Sultan River flow ≈ 322 cfs				
Scour Pool	9,260	1,524	0	**10,784**
Glide	3,647	12,879	0	**16,526**
Puddled Unit	0	0	300	**300**
Riffle	8,878	1,724	0	**10,602**
Riffle with Pockets	13,720	0	0	**13,720**
Total	35,506	16,126	300	**51,932**
% Wetted Area				
Scour Pool	26%	9%	0%	**21%**
Glide	10%	80%	0%	**32%**
Puddled Unit	0%	0%	100%	**1%**
Riffle	25%	11%	0%	**20%**
Riffle with Pockets	39%	0%	0%	**26%**
Total	100%	100%	100%	**100%**

Table 6. SC4 channel metrics (July 2016).

Channel Metrics	Mainstem	Upper Inlet	Upper Outlet	Total
Reach Length (ft)	1434	497	95	2,026
Average Active Channel Width (ft)	27.8	44.7	39.2	30.7
Average Active Channel Depth (ft)	2.7	3.3	1.6	2.7
Average Wetted Width (ft)	26.9	28.8	8.4	26.2
Average Wetted Depth (ft)	1.5	1.4	0.3	1.4
Average W:D	20.5	21.9	26.4	21.1
Wetted Area (ft^2)	35,506	16,126	300	51,932
Active Channel Area (ft^2)	40,012	22,185	3,724	65,921
% of Active Channel Wetted at 322	89%	73%	8%	79%
% Under Cut Banks	1.2%	0.0%	0.0%	0.9%
% Bank Erosion	19.3%	0.0%	0.0%	13.7%
% Potential Spawning Habitat	39.3%	11.4%	0.0%	30.4%
Dominant substrate	gravel	cobble	cobble	gravel
Subdominant substrate	cobble	gravel	gravel	cobble

Table 7. SC4 large wood attributes (July 2016).

LWD Attributes	Mainstem	Upper Inlet	Upper Outlet	Total
Total LWD Pieces	77	12	0	**89**
Total LWD Volume (ft^3)	836	126	0	**962**
Total Single LWD Pieces	13	1	0	**14**
Total LWD Accumulation (2-3 pieces)	16	4	0	**20**
Total LWD Jams (4+ pieces)	15	0	0	**15**
Total LWD Pieces/mile	284	127	0	**232**
LWD Volume/mile (ft^3)	3,077	1,336	0	**2,506**
Single LWD Pieces/mile	48	11	0	**36**
LWD Accumulations (2-3 pieces)/mile	59	42	0	**52**
LWD Jams (4+ pieces)/mile	55	0	0	**39**

4.0 CONCLUSIONS

Implementation of the study addressed all of the objectives outlined in the Study Plan (District 2015). In general, little channel change was observed after the November 2015 high flow event based on cross section survey results. The downramping study showed that most sites had ramping rates less than the rate at the Sultan River below Powerhouse gage site, and less than 1.5 inches per hour, though two cross sections (one in SC1 and one in SC4) had higher downramping rates slightly greater than 2 inches/hour. Only one fish (juvenile lamprey) was observed trapped in an isolated puddle in the SC1 New Outlet immediately after the downramping test.

The SC1 New Outlet was substantially dewatered during the 2015 survey at 215 cfs as well as during the 2016 survey at 322 cfs. Based on the 2016 bed thalweg elevation within the New and Old Outlets and the stage discharge relationship at the upstream end of the Old Outlet at Cross

Section 7 (Figure 38), the SC1 New Outlet would be activated with continuous surface flow at about 385 cfs at the Sultan River below Powerhouse gage. This is because the SC1 Old outlet thalweg is lower than the SC1 New Outlet thalweg. During the July 2016 survey, the highest thalweg bed elevation in the Old Outlet was 113.79 feet (NAVD88), while the highest elevation within the New Outlet was 114.45 feet (NAVD88), about 8 inches higher, located about 106 feet downstream of the New/Old Outlet split. The water surface elevation at about 300 cfs at Cross Section 7 equates to about 114.42 feet (NAVD88) (i.e., lower than the highest thalweg bed elevation in the New Outlet). A flow of about 385 cfs at Cross Section 7 equates to elevation 114.61 feet (NAVD88) (about 2 inches higher than the highest thalweg bed elevation in the New Outlet).

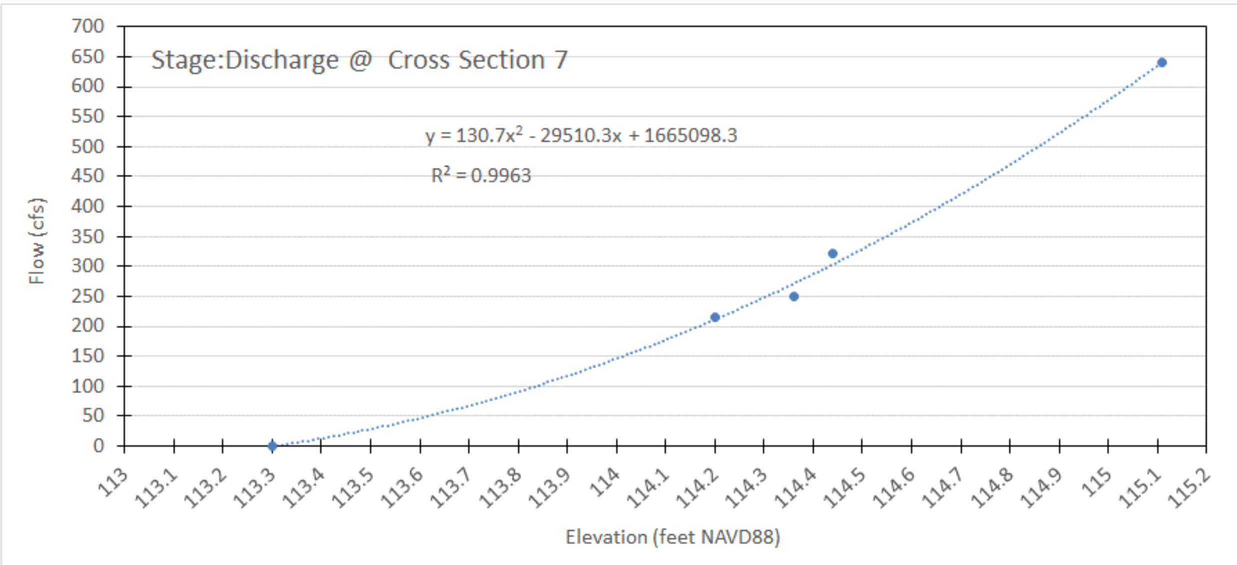

Figure 38. **Cross Section 7 stage:discharge relationship (upstream end of SC1 Old Outlet).**

Coincidently, a study biologist was walking the SC1 New Outlet when the flow increased to over 1,000 cfs in preparation for the downramping test the following day. The biologist was within the dry portion of the SC1 New Outlet just as the wave of surface flow was wetting the previously dry channel on September 12, at 1:20 pm. Flow travel time from the Sultan River below Powerhouse gage is about 2 hours to reach the downstream end of the SC1 New Outlet; the upstream end of the New Outlet should have somewhat less travel time. Flow on the Sultan River gage was 240 cfs at 11:00 am, but 384 cfs at 11:15 am, further suggesting that about 385 cfs results in continuous surface flow in the SC1 New Outlet.

Photo Collection 31. Flow observation wave within the SC1 New Outlet at 1:20 pm on September 12, 2015.

5.0 REFERENCES

District (Snohomish County PUD). 2013. Side Channel Enhancement Ramp Rate Evaluation Report (License Article 405) for the Jackson Hydroelectric Project, FERC No. 2157. October 2013.

District. 2015. Side Channel Enhancements Ramping Rate Evaluation Updated Supplement for the Jackson Hydroelectric Project, FERC No. 2157. May 2015

FERC (Federal Energy Regulatory Commission). 2014. Letter to Mr. Kim Moore Snohomish County Public Utility District No. 1. From: Thomas J. LoVullo, Chief, Aquatic Resources Branch Division of Hydropower Administration and Compliance, FERC. Issuance 20140130-3004. January 30, 2014.

FERC. 2015. Letter to Kim Moore Snohomish County Public Utility District No. 1. From: Joy Kurtz, Aquatic Ecologist, Division of Hydropower Administration and Compliance, FERC. 2157-221. February 2, 2015. .

Stillwater Sciences. 2015. Sultan River Riverine Habitat Monitoring Final Report for the Jackson Hydroelectric Project, FERC No. 2157. February 2015.

Appendix 1

Consultation Documentation Regarding Draft Report

Presler, Dawn

From: Presler, Dawn
Sent: Monday, October 10, 2016 9:32 AM
To: ''Tim_Romanski@fws.gov' (Tim_Romanski@fws.gov)'; 'Anne Savery'; 'Bryden, Andy -FS'; 'Elizabeth Babcock - NOAA Federal'; ''brock.applegate@dfw.wa.gov' (brock.applegate@dfw.wa.gov)'; ''James (ECY) Pacheco' (JPAC461@ECY.WA.GOV)'; 'Rustay, Michael'; 'Jim Miller (JMiller@everettwa.gov)'; 'Mick Matheson'; 'okeefe@americanwhitewater.org'
Cc: Binkley, Keith
Subject: RE: JHP (FERC No. 2157) - SCE Ramping Rate Eval Plan Supplement Draft Report for your 30-day review and comment
Attachments: 201610 SCE Ramping Rate Eval Study Draft Report to ARC for 30day_.pdf

And here is the PDF version of the report since I was getting some bounce-back emails that your systems don't allow 14 MB attachments…

Dawn

From: Presler, Dawn
Sent: Monday, October 10, 2016 9:27 AM
To: 'Tim_Romanski@fws.gov' (Tim_Romanski@fws.gov) <Tim_Romanski@fws.gov>; 'Anne Savery' <asavery@tulaliptribes-nsn.gov>; 'Bryden, Andy -FS' <abryden@fs.fed.us>; 'Elizabeth Babcock - NOAA Federal' <elizabeth.babcock@noaa.gov>; 'brock.applegate@dfw.wa.gov' (brock.applegate@dfw.wa.gov) <brock.applegate@dfw.wa.gov>; 'James (ECY) Pacheco' (JPAC461@ECY.WA.GOV) <JPAC461@ECY.WA.GOV>; 'Rustay, Michael' <mike.rustay@co.snohomish.wa.us>; 'Jim Miller (JMiller@everettwa.gov)' <JMiller@everettwa.gov>; 'Mick Matheson' <mick.matheson@ci.sultan.wa.us>; 'okeefe@americanwhitewater.org' <okeefe@americanwhitewater.org>
Cc: Binkley, Keith <KMBinkley@SNOPUD.com>
Subject: JHP (FERC No. 2157) - SCE Ramping Rate Eval Plan Supplement Draft Report for your 30-day review and comment

Dear ARC,
Attached is the draft report for the Side Channel Ramping Rate Evaluation Plan Supplement for the Jackson Hydro Project. Please take the next 30 days to review the draft report, and provide comments, if any, back to me with a cc: to Keith **by November 9**.

If you should have any questions regarding the study and/or report, please contact Keith directly at 425-783-1769. Thanks.

Sincerely,
Dawn Presler
Sr. Environmental Coordinator
(425) 783-1709

PUD No. 1 of Snohomish County
PO Box 1107
Everett, WA 98206-1107

From:	Anne Savery <asavery@tulaliptribes-nsn.gov>
Sent:	Wednesday, November 09, 2016 2:34 PM
To:	Presler, Dawn; 'Tim_Romanski@fws.gov' (Tim_Romanski@fws.gov); 'Bryden, Andy -FS'; 'Elizabeth Babcock - NOAA Federal'; 'brock.applegate@dfw.wa.gov' (brock.applegate@dfw.wa.gov); 'James (ECY) Pacheco' (JPAC461@ECY.WA.GOV); 'Rustay, Michael'; 'Jim Miller (JMiller@everettwa.gov)'; 'Mick Matheson'; 'okeefe@americanwhitewater.org'
Cc:	Binkley, Keith
Subject:	RE: JHP (FERC No. 2157) - SCE Ramping Rate Eval Plan Supplement Draft Report for your 30-day review and comment
Attachments:	201610 SCE Ramping Rate Eval Study Draft Report to ARC for 30day_TTT comments.docx

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Here are the Tribes' comments. Glad to see this study completed, to have some assurances that the downramping rates are mostly protective in the sidechannels that were studied and to have 'baseline' data for the sidechannel habitats, width to depth rations and hydraulic controls. Very interesting to see that the sidechannels were fairly stable in the 7000 cfs flow.

Anne

Anne Savery
Hydrologist
503-984-0667

From: Presler, Dawn [DJPresler@SNOPUD.com]
Sent: Monday, October 10, 2016 9:27 AM
To: 'Tim_Romanski@fws.gov' (Tim_Romanski@fws.gov); Anne Savery; 'Bryden, Andy -FS'; 'Elizabeth Babcock - NOAA Federal'; 'brock.applegate@dfw.wa.gov' (brock.applegate@dfw.wa.gov); 'James (ECY) Pacheco' (JPAC461@ECY.WA.GOV); 'Rustay, Michael'; 'Jim Miller (JMiller@everettwa.gov)'; 'Mick Matheson'; 'okeefe@americanwhitewater.org'
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Sincerely,
Dawn Presler

sections with high stranding potential. The downramping evaluation will occur at flows ranging from 600 cfs down to 300 cfs following standard Project downramping protocols. Permanent photo stations will document important hydraulic controls and other areas of interest during downramping, and will be marked for future monitoring. Flow releases for the study will be based on readings obtained from U.S. Geological Survey (USGS) Gage No. 12138160 (Sultan River below Powerhouse).

Per the Supplement, temporary staff gages were installed at a series of sites (cross sections 5, 6, 7, 9, 10, 11, 13, and 16) (Figure 1). To augment manual data collection at temporary staff gage sites, automatic water level loggers were installed at cross sections 1, 2, 3, 12, 14, and 20 (Figure 1). Staff gages and level loggers were installed on September 11 and 12, 2015, prior to the downramping test, which was conducted on September 13, 2015. Per the Supplement, the downramping test began when the Sultan River flow was about 600 cfs and ending at approximately 300 cfs. At cross sections with staff gages, surveyors manually observed the water stage decline and recorded stage approximately every 5 minutes. Level loggers were set to record stage decline at 15-minute intervals.

Following the downramping event, the surface area of potential stranding habitat below the initial high-water line in each side channel was estimated. This dewatered stranding habitat was photographed and visually examined for stranded fish. Observations were made by two teams of two biologists slowly walking back and forth in the dewatered zone. Special attention was given to areas containing previously submerged vegetation (aquatic and terrestrial) and any depressions or isolated water pockets. The number, species, and condition of any observed stranded fish were documented.

Per the Supplement, the change in stage over time data collected from the temporary staff gages and level loggers in the side channels was used to calculate the ramping rate associated with the downramping event at each side channel site in terms of a rolling calculation of inches/hour. These data were also used to determine the time it takes for the flow to reach the study sites from the Powerhouse, and to determine the degree of the stage-change attenuation, if any, between the USGS gage below the Powerhouse and the study sites.

Commented [O1]: Was a stage discharge relationship created for side channels? Can it be related to different discharge rates in the mainstem Sultan River?

2.3 THALWEG PROFILE AND HABITAT SURVEY

The FERC-approved Supplement stipulates that biologists would conduct a habitat survey in SC1 and SC4 to supplement data gathered during 2014 (Stillwater 2015). The habitat survey would cover all of SC1 and SC4. The Supplement stipulates the longitudinal thalweg profile (bed depth and water surface) would be measured every 6 meters (approximately 20 feet) and at hydraulic controls for each habitat unit. The survey would be tied to existing control and monumentation and referenced to a known datum. The thalweg profile survey would be carefully tied to each habitat unit. Metrics would include, but not be limited to, habitat unit type, habitat unit depth, wood counts, and bank erosion.

The thalweg and water surface profile was measured in September 2015 and July 2016 following the methods stipulated in the Supplement (stated above) using a rod and total station. Survey control was established at the site using RTK GNSS GPS and survey points were georeferenced to real-word coordinates and elevations by RDG's licensed professional land surveyor. All

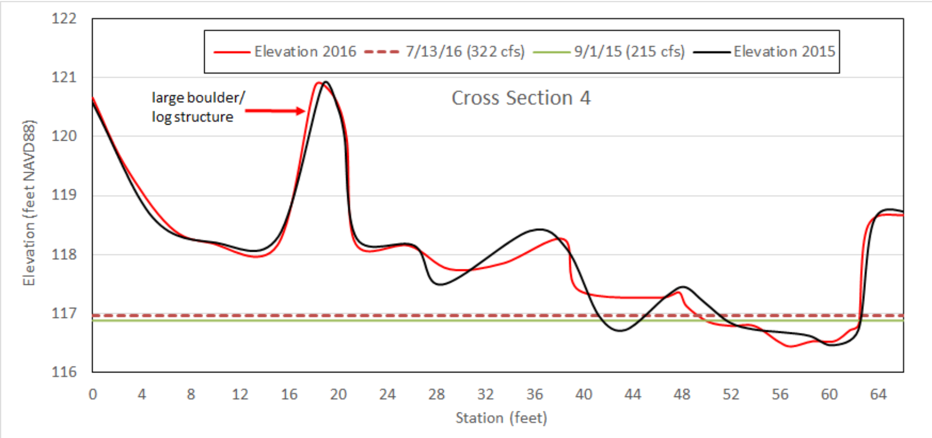

Figure 10. SC1 Cross Section 4 within SC1 Middle Mainstem.

Commented [O2]: This cross section looks problematic for flow continuation within SC1

Photo Collection 6. SC1 Cross Section 4 within SC1 Middle Mainstem.

Cross Section 5 is located within the Middle Mainstem in an area with a relatively wide potential floodplain. The cross section contains the inlet to a side channel. Some adjustment of the cross section is apparent between the September 2015 and July 2016 measurements (Figure 11, Photo Collection 7).

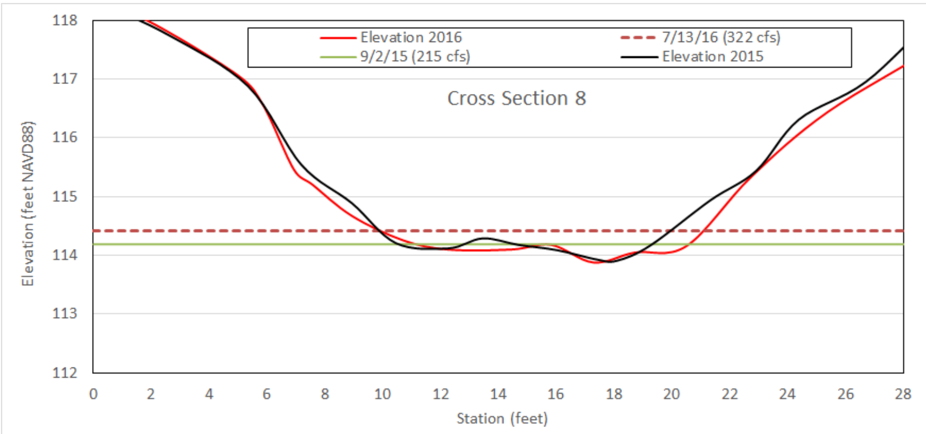

Figure 14. SC1 Cross Section 8 near the upstream end of the New Outlet.

Commented [O3]: Problematic for flow continuation

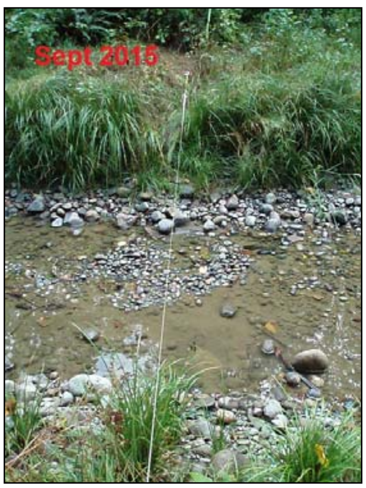

Photo Collection 10. SC1 Cross Section 8 near the upstream end of the New Outlet.

Cross Section 9 is located within the New Outlet a short distance downstream of the Old/New outlet split, where the channel was dry during the 2015 survey at 215 cfs. Little adjustment of the cross section is apparent between the September 2015 and July 2016 measurements (Figure 15, Photo Collection 11).

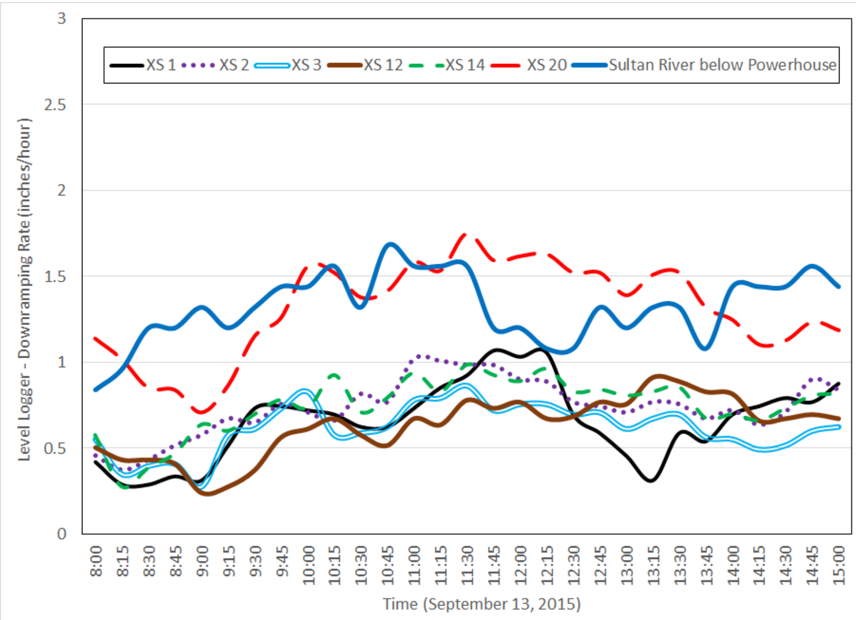

Figure 29. Downramping rates measured at automatic level logger monitoring sites (September 13, 2015).

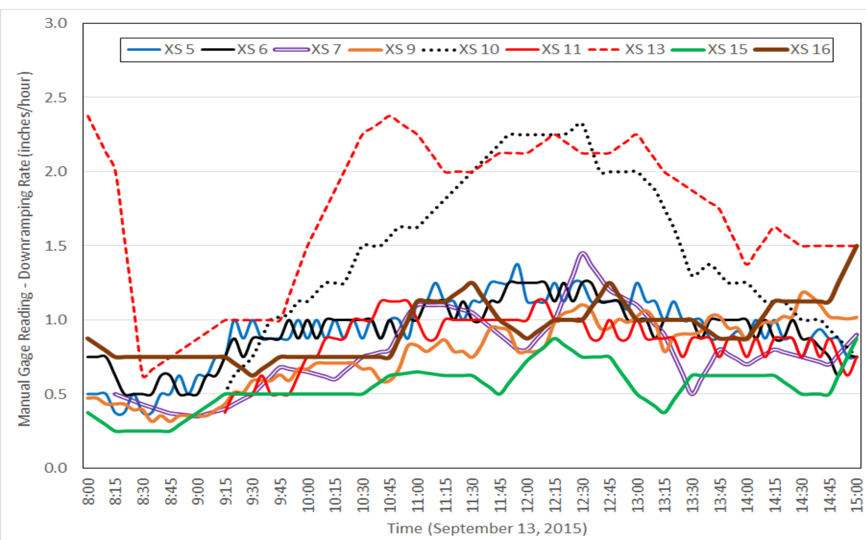

Figure 30. Downramping rates measured at manual staff gage monitoring sites (September 13, 2015).

Commented [O4]: XS 10 and 13 cross sections may need restructuring to reduce ramping rate.

Flow travel time from the Sultan River below Powerhouse gage site was also assessed using the ramping rate data. Flow travel time from the Sultan River gage site to the upstream end of the SC1 Old and New Inlets is about 1.0 to 1.25 hours and to the downstream end of the New Outlet is about 2.0 to 2.25 hours. Travel time to the SC4 Upper Inlet is about 1.25 to 1.35 hours and about 1.5 to 1.75 hours to the downstream end of the SC4 Mainstem channel. Factoring in about a 2 hour lag time for flow to reach Cross Section 10 (near the downstream end of the SC1 New Outlet) from the Powerhouse, the Sultan River gage was between about 500 and 450 cfs when the ramping rates greater than 2 inches per hour were experienced at Cross Section 10. Factoring in about a 1.5 hour lag time for flow to reach Cross Section 13 (at the upstream end of the SC1 Upper Inlet), the Sultan River gage was between about 540 and 400 cfs when the ramping rates greater than 2 inches per hour were experienced at Cross Section 13.

Commented [O5]: Can PUD operate around this flow range to make downramping safer?

Following the downramping event, a team of biologists walked the entirety of SC1 and SC4 looking carefully for stranded fish and estimating the area of potential fish stranding habitat. In general potential stranding habitat is most prevalent in the SC1 New Outlet as a portion of the channel becomes dewatered near 300 cfs (Table 1, Photo Collection 23), whereas the majority of the other portions of SC1 and SC4 remain wetted at 300 cfs. Only one stranded fish was found; a juvenile lamprey which was trapped in a small pocket of water within the portion of the SC1 New Outlet that goes dry below 300 cfs (Table 1, Photo Collection 24). Of note is that as soon as the flow was raised on September 12, many adult pink salmon entered the previously dry segment of the SC1 New Outlet. Adult pink salmon were observed migrating through the SC1 New Outlet during the downramping test, yet none were observed beached or trapped in isolated pools during the fish stranding study.

Commented [O6]: This location is an area of potential stranding. How can downramping rates be altered to reduce stranding during periods of fish use?

Table 1. Stranding survey results (September 13, 2015).

	Potential Beaching Area (ft^2)	Potential Trapping Area (ft^2)	Fish Stranded
Side Channel 1			
New Inlet	0	0	0
Old Inlet	175	0	0
Middle	300	175	0
New Outlet	5,500	1600	1 juvenile lamprey
Old Outlet	0	0	0
Total	5,900	1,725	1
Side Channel 4			
Upper Inlet	100	30	0
Upper Outlet	100	0	0
Mainstem	65	0	0
Total	265	30	0

3.3 THALWEG PROFILE SURVEY (2016)

The baseline resurvey data of the thalweg and water surface profile of SC1 and SC4 are presented below (Figures 31 to 36). For each profile figure, station 0 is located at the upstream end of each reach. The water surface represents about 322 cfs as measured at the Sultan River below Powerhouse gage site. The average active channel width and wetted width for each habitat unit (delineated simultaneously during the 2016 profile/habitat survey) are depicted on the secondary y-axis and essentially represents a simplified straight plan view of the stream channel dimensions. Representative reach photos are also included (Photo Collections 25 to 30). The FERC-approved Supplement also stipulated plots of the width to depth ratios, which are depicted in Figure 37. Of note is that a portion of the SC1 New Outlet remained dewatered during the July 2016 survey conducted at 322 cfs, similar to the survey conducted in 2015 at 215 cfs.

Stream flow at key locations within SC1 and SC4 was also measured during the July 2016 profile and habitat survey when the Sultan River below Powerhouse gage was at 322 cfs. Cross Section 1 at the upstream end of the SC1 New Inlet measured 3.0 cfs. A large wetland seep discharges into the upstream end of the SC1 Old Inlet, about 40 feet downstream of Cross Section 2; flow at Cross Section 2 measured 1.5 cfs, and 3.8 cfs about 20 feet downstream of the wetland seep. Therefore, the wetland seep contributed about 2.3 cfs to the SC1 Old Inlet flow (i.e., 3.8-1.5). Combining the SC1 Old and New Inlet flows assumes about 6.8 cfs flowing through the SC1 Middle Mainstem (i.e., 3.0+3.8). Flow at Cross Section 7 at the upstream end of the SC1 Old Outlet measured 6.0 cfs. Flow at Cross Section 8 at the upstream end of the SC1 New Outlet measured <0.1 cfs. Flow at Cross Section 15 within the Upper Inlet to SC4 measured 27.6 cfs, and flow within the SC4 Mainstem measured 29.0 cfs at Cross Section 17.

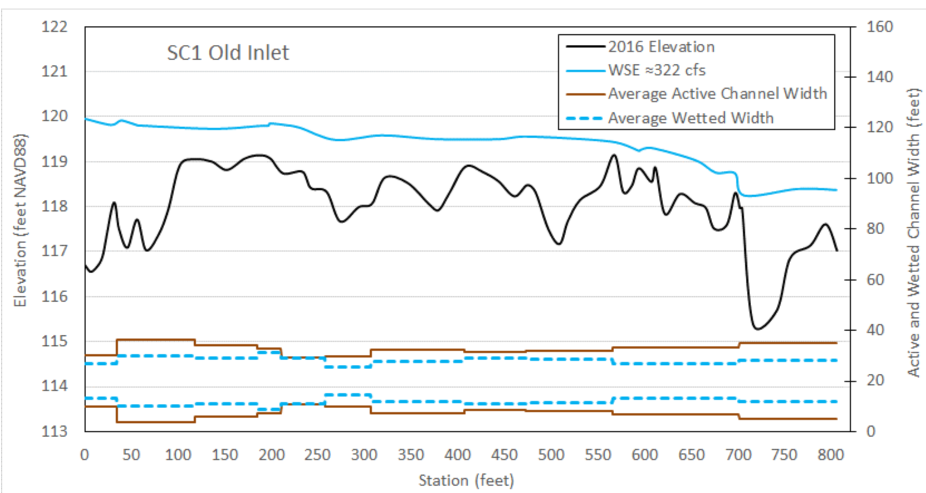

Figure 31. SC1 Old Inlet profile and active/wetted channel dimension (July 2016).

Commented [O7]: Good diagram. Could it be created for entire length of SC 1 on one page and identify the cross sections?

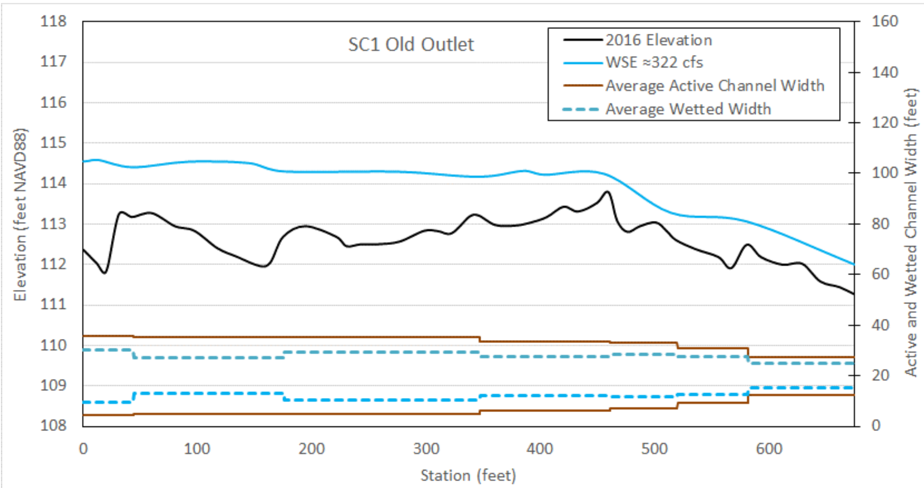

Figure 34. SC1 Old Outlet profile and active/wetted channel dimension (July 2016).

Photo Collection 28. SC1 Old Outlet during profile/habitat survey (July 2016).

Commented [O8]: How much water is exiting the Old Outlet versus the new outlet? Reactivating the old outlet was not in the original plan for recreating side channel habitat. The ARC may consider remedies to the issue of the SC 1 New Outlet dewatering or downramping rates may need to be reduced to prevent stranding

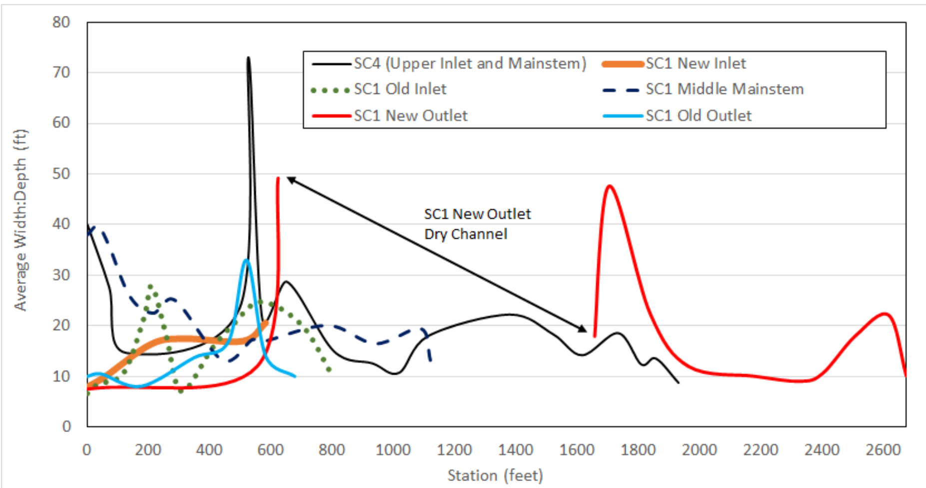

Figure 37. Width to depth ratio based on average wetted width of each habitat unit for SC1 and SC4 study reaches (July 2016).

3.4 Habitat Survey (2016)

Commented [O9]: These habitat data can be used to create performance metrics for the side channels for future work.

July 2016 habitat survey results are summarized by side channel and reach below in Tables 2 through 7.

3.4.1 Side Channel 1

Table 2. SC1 habitat type attributes (July 2016)

Habitat Type	Middle Mainstem	New Inlet	New Outlet	Old Inlet	Old Outlet	Total
Count of Habitat Units						
Scour Pool	5	0	1	2	1	9
Glide	3	1	3	6	3	16
Isolated Pool	0	0	1	0	0	1
Puddled Unit	2	0	1	0	0	3
Riffle	4	3	2	3	3	15
Riffle with Pockets	0	1	4	1	0	6
Dry Channel	1	0	1	0	0	2
Total	15	5	13	12	7	52
Habitat Length (feet)						
Scour Pool	248	0	57	197	44	546
Glide	385	59	383	345	417	1,589
Isolated Pool	0	0	68	0	0	68
Puddled Unit	125	0	499	0	0	624
Riffle	488	450	242	159	216	1,555
Riffle with Pockets	0	73	891	135	0	1,099
Dry Channel	30	0	535	0	0	565

Table 6. SC4 channel metrics (July 2016).

Channel Metrics	Mainstem	Upper Inlet	Upper Outlet	Total
Reach Length (ft)	1434	497	95	2,026
Average Active Channel Width (ft)	27.8	44.7	39.2	30.7
Average Active Channel Depth (ft)	2.7	3.3	1.6	2.7
Average Wetted Width (ft)	26.9	28.8	8.4	26.2
Average Wetted Depth (ft)	1.5	1.4	0.3	1.4
Average W:D	20.5	21.9	26.4	21.1
Wetted Area (ft^2)	35,506	16,126	300	51,932
Active Channel Area (ft^2)	40,012	22,185	3,724	65,921
% of Active Channel Wetted at 322 cfs	89%	73%	8%	79%
% Under Cut Banks	1.2%	0.0%	0.0%	0.9%
% Bank Erosion	19.3%	0.0%	0.0%	13.7%
% Potential Spawning Habitat	39.3%	11.4%	0.0%	30.4%
Dominant substrate	gravel	cobble	cobble	gravel
Subdominant substrate	cobble	gravel	gravel	cobble

Commented [O10]: High width to depth ratios here should be monitored over time. These sites may need additional wood to interact with higher flows to create better habitat and more frequent pools

Table 7. SC4 large wood attributes (July 2016).

LWD Attributes	Mainstem	Upper Inlet	Upper Outlet	Total
Total LWD Pieces	77	12	0	89
Total LWD Volume (ft^3)	836	126	0	962
Total Single LWD Pieces	13	1	0	14
Total LWD Accumulation (2-3 pieces)	16	4	0	20
Total LWD Jams (4+ pieces)	15	0	0	15
Total LWD Pieces/mile	284	127	0	232
LWD Volume/mile (ft^3)	3,077	1,336	0	2,506
Single LWD Pieces/mile	48	11	0	36
LWD Accumulations (2-3 pieces)/mile	59	42	0	52
LWD Jams (4+ pieces)/mile	55	0	0	39

4.0 CONCLUSIONS

Implementation of the study addressed all of the objectives outlined in the Study Plan (District 2015). In general, little channel change was observed after the November 2015 high flow event based on cross section survey results. The downramping study showed that most sites had ramping rates less than the rate at the Sultan River below Powerhouse gage site, and less than 1.5 inches per hour, though two cross sections (one in SC1 and one in SC4) had higher downramping rates greater than 2 inches/hour. Only one fish (juvenile lamprey) was observed trapped in an isolated puddle in the SC1 New Outlet immediately after the downramping test.

The SC1 New Outlet was substantially dewatered during the 2015 survey at 215 cfs as well as during the 2016 survey at 322 cfs. Based on the 2016 bed thalweg elevation within the New and Old Outlets and the stage discharge relationship at the upstream end of the Old Outlet at Cross Section 7 (Figure 38), the SC1 New Outlet would be activated with continuous surface flow at

Commented [O11]: This suggests that the channel at SC1 New Outlet is susceptible to stranding even at rates lower than 2" per hour. While one fish does not necessitate the need for different ramping rates associated with the side channel – this is an area which should be monitored by biologists during downramping events, or checked during sudden dewatering/downramping.

Commented [O12]: SC1 is not meeting the performance objectives set forth by the District. The District offered to create 10,000 lineal feet of new side channel habitat as mitigation. At least 1,000 feet of channel in SC1 is not watered at flows under 385 cfs. The District opened up the Old Outlet in SC1 as an addition to the originally agreed upon channel design, potentially creating a dewatering effect in the side channel. Further, the grading of SC1 at the downstream end has left a hydraulic control with elevation higher than the Old Outlet for SC 1. This issue while not foreseen or intended during construction should be discussed by the ARC.

Appendix 2

Response to Comments Regarding Draft Report

No.	Comment	Response
Tulalip Tribes, emailed dated November 9, 2016		
1	Section 2.2 last paragraph: Was a stage discharge relationship created for side channels? Can it be related to different discharge rates in the mainstem Sultan River?	A stage discharge relationship could be created using the water surface elevations (stage) at cross sections related to the discharge as measured at the Sultan River below powerhouse gage. However, this is not practical given the relatively few water surface elevations measured at most cross sections.
2	Figure 10. This cross section looks problematic for flow continuation within SC1	This area will be flagged for future observation.
3	Figure 14. Problematic for flow continuation	The channel elevation in this area of New Outlet was creating problems with flow delivery at low flows. At the time of original construction in 2012, an intentional “plug” was installed as a preventative measure to control / manage the volume and proportion of flow routed down the New Outlet. Once identified and quantified as a problem under low flow conditions during the 2016 survey, the “plug” was removed and the elevation in this area of the channel was lowered. This area no longer presents a problem for flow continuation.
4	Figure 30. XS 10 and 13 cross sections may need restructuring to reduce ramping rate.	XS 10 will be flagged for future observation and may need restructuring as suggested. XS 13 exists in an actively changing portion of SC 4. XS 13 will also be flagged for observation with future actions informed by evolution of the channel.
5	Section 3.2, second paragraph “500 and 450 cfs when the ramping rates greater than 2 inches per hour were experienced at Cross Section 10. Factoring in about a 1.5 hour lag time for flow to reach Cross Section 13 (at the upstream end of the SC1 Upper Inlet), the Sultan River gage was between about 540 and 400 cfs”: Can PUD operate around this flow range to make downramping safer?	The District recognizes the sensitivity of this particular location to flow changes and will continue to monitor and potentially restructure the channel at this location. The District believes that introducing an additional flow range and rate within the Downramping Rate Schedule is premature given that the issue is localized and that at flows below 750 cfs, the frequency of downramping at rates greater than 1-inch per hour is limited to a total of 48 hours during the January 1 to May 31 outmigration season.
6	Section 3.2, third paragraph “Only one stranded fish”: This location is an area of potential stranding. How can downramping rates be altered to reduce stranding during periods of fish use?	The channel upstream of this location has been modified since this survey was conducted. Dewatering of the channel is no longer expected to occur.
7	Figure 31. Good diagram. Could it be created for entire length of SC 1 on one page and identify the cross sections?	Figure 31 shows the profile of the SC1 old inlet. The profiles for the SC1 new inlet, middle mainstem, new outlet, and old outlet are also individually provided in the report. Figure 31 could be created to cover the entire length of SC1 however, SC1 has two inlets and two outlets, so a single profile of the channel would have to include one or the other (i.e. new vs old inlet or outlet).

		SC1 from the upstream end of the old inlet to the downstream end of the new outlet is nearly 1 mile long. Plotting the profile of this length on one page would lose a lot of resolution and would be about twice as compressed as Figure 35. The location of channel cross sections has been added to the profile figures, as suggested.
8	Figure 34. How much water is exiting the Old Outlet versus the new outlet? Reactivating the old outlet was not in the original plan for recreating side channel habitat. The ARC may consider remedies to the issue of the SC 1 New Outlet dewatering or downramping rates may need to be reduced to prevent stranding	The routing and delivery of flow between the Old Outlet and the New Outlet has been an issue since construction. Since construction, the District has monitored the distribution of flow at the flow split and has observed a trend towards a reduced percentage of flow being routed down the New Outlet. Once the issue of dewatering under low flow was apparent, the District recognized the importance and immediately implemented a plan to resolve the issue. The District will continue to monitor the distribution of flow at this location.
9	Section 3.4 Habitat Survey (2016): These habitat data can be used to create performance metrics for the side channels for future work.	The District agrees on the value of this information.
10	Table 6, Average W:D Total column: High width to depth ratios here should be monitored over time. These sites may need additional wood to interact with higher flows to create better habitat and more frequent pools	The District agrees that SC4 should continue to be monitored to ensure that the intended habitat objectives are being met. Since the time of initial construction, SC4 has received additional habitat treatments utilizing wood from Culmback Dam.
11	4.0 Conclusions, first paragraph last sentence "Only one fish (juvenile lamprey) was observed trapped in an isolated puddle in the SC1 New Outlet immediately after the downramping test.": This suggests that the channel at SC1 New Outlet is susceptible to stranding even at rates lower than 2" per hour. While one fish does not necessitate the need for different ramping rates associated with the side channel – this is an area which should be monitored by biologists during downramping events, or checked during sudden dewatering/downramping.	Agreed. See comments above related to SC1 New Outlet and specifically the issue of dewatering and potential restricting of XS 10.
	4.0 Conclusions, second paragraph "the SC1 New Outlet would": SC1 is not meeting the performance objectives set forth by the District. The District offered to create 10,000 lineal feet of new side channel habitat as mitigation. At least 1,000 feet of channel in SC1 is not watered at flows under 385 cfs. The District opened up the Old Outlet in SC1	As stated above, the District, with WDFW approval, took action to resolve this issue before closure of the in-water work window. Point of clarification: the Old Outlet to SC1 has been functional for decades. The District did not open up the Old Outlet during construction. At the flow split, a portion of the flow that has always travelled towards

	as an addition to the originally agreed upon channel design, potentially creating a dewatering effect in the side channel. Further, the grading of SC1 at the downstream end has left a hydraulic control with elevation higher than the Old Outlet for SC 1. This issue while not foreseen or intended during construction should be discussed by the ARC.	the Old Outlet is now routed down the SC1 New Outlet. The intent was to always have two outlets within the SC1 side channel complex. The gradient of the New Outlet is low and deposition does occur in the lower portion of this channel.