ELECTRON HYDRO

Via Electronic Mail

June 1, 2020

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RE Electron Hydroelectric Project – Preliminary Draft HCP

Electron Hydro, LLC (Electron Hydro) is pleased to provide you with the enclosed Preliminary Draft Habitat Conservation Plan for the Electron Hydroelectric Project.

We are pleased to have reached this milestone, and we look forward to improving this draft through your review and comment. That said, if you are not the appropriate point of contact for review of the Preliminary Draft HCP, please forward to the appropriate person in your organization.

We would appreciate receiving your input during the next 60 days, so that we may continue to advance through the HCP/ITP process in a timely fashion. Please direct your comments and any questions you may have to me at (360) 746-3435, or cspens@electronhydro.com.

Sincerely

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Enclosure

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Preliminary Draft
Habitat Conservation Plan
for the
Electron Hydroelectric Project

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Dear Reviewer, June 1, 2020

The following document is a preliminary draft of a Habitat Conservation Plan for the Electron Hydropower Project. This preliminary draft plan is a voluntary effort put forth by Electron Hydro, LLC.

This document should be referred to as a preliminary draft HCP. No material information, figures, tables, pictures, graphics or representations of any kind contained herein have been determined to be final, accurate, appropriate, complete or represent a final statement, position, promise or agreement by Electron Hydro, LLC in any way. This preliminary draft document includes data and descriptions from pre-existing documents and scientific reports combined with new descriptions and statements provided by Electron Hydro, LLC. This draft document has not been fully annotated yet. This draft document may not be cited as any type of definitive information source or binding statement of any kind. This document will be periodically updated as new input from reviewers is received and considered, therefore, all reviewers must consider future changes to this draft as imminent.

Abbreviations and Defined Terms

Acronym, Abbreviation, Symbol, Term:	Refers to:
cfs	Cubic Feet per Second
cm	Centimeter
DPS	Distinct Population Segment
EH	Electron Hydro LLC
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
fps	Feet per Second
ft	Feet
HCP	Habitat Conservation Plan
IA	Implementation Agreement
in	Inch
ITP	Incidental Take Permit
LWD	Large Woody Debris
MIF	Minimum in Stream Flow
NMFS	National Marine Fisheries Service
PLC	Program Logic Controller
PSE	Puget Sound Energy
PTI	Puyallup Tribe of Indians
REA	Resource Enhancement Agreement
RM	River Mile
USFWS	U.S. Fish and Wildlife Service
7-DADMax	7-day average of the daily maximum temperatures

Contents

Definitions:

A

Action Area - All areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action.

Adfluvial - Life history of fish spawning in tributary streams and migrating to a larger body of water to grow to maturity.

B

Bladder - The Inflatable Bladder Component of the New Bladder Spillway

Bladder Spillway - The Entire Inflatable Bladder Spillway System

Bypass Reach - That section of the Puyallup River between the Diversion and the Powerhouse, also referred to as the Middle Reach.

C

D

E

Electron - Electron Hydroelectric Project, and all its facilities and operations.

F

Flume - The water delivery Flume from the Intake to the Forebay

Forebay - The 10-acre reservoir that supplies water to the Penstocks

G

H

Headworks facility - Intake, rock chutes, diversion dam, and all associated work structures and facilities at the Electron Headworks site.

I

Incidental Take - take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.

Intake - The project intake where water is diverted to the flume

Intake Window - A 52 ft wide by 5 ft deep opening within the concrete riverbank wall located immediately upstream of the spillway on the left bank where water enters the water gallery and flume delivery system

J

K

L

Ladder – The Fish Ladder located on the right bank at the Diversion.

M

Middle Reach – That section of the Puyallup River between the Diversion and the Powerhouse, also referred to as the Bypass Reach.

N

O

P

Powerhouse - structure housing the four hydroelectric generating units consisting of eight Pelton turbines and the Electron control center.

Project – The Electron hydropower project

Q

R

Research - biological monitoring activities performed by Tollhouse Energy at Electron that advance the current environmental knowledge base and test various devices, facilities, and operations that affect fish passage survival at Electron. Research activities are in addition to compliance or effectiveness monitoring activities specified in the Electron HCP. The results may directly or indirectly pertain to the Electron HCP.

S

Services - USFWS and NMFS

Sluice - controllable gate or opening for water passage

Sluice Radial Gate - a structure where a small portion of a cylindrical surface serves as a gate and is supported by radial constructions through the cylinder’s radius. Used mainly in dam structures.

Spillway - The old wooden three-gate Obermeyer Diversion outlet

T

Tainter Gate **-** The main radial gate flow controller, located at the head of the Flume at the downstream end of the Water Gallery

Take - harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct.

U

Upstream Fish Passage Facility - upstream fish passageway and associated facilities, including but not limited to the existing fish ladder operated and maintained by PTI.

V

W

Water Gallery - The confined concrete water delivery channel from the intake wall to the Tainter Gate.

X

Y

Z

LIST OF FIGURES

LIST OF TABLES

APPENDICES

1.0 INTRODUCTION

Electron Hydro, LLC (EH) owns, operates, and maintains the Electron Hydro Project (Project) on the Puyallup River, in Pierce County, Washington. The Project has been in operation since 1904. EH, which acquired the Project in 2014, operates the Project to supply a renewable source of energy to its market in Pierce County.

As described in more detail below, the Puyallup River provides habitat for populations of Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*), Puget Sound Steelhead trout (*O. mykiss*), and Bull trout (*Salvelinus confluentus*). These three fish species (or distinct population segments (DPS), also referred to as an evolutionarily significant units (ESU), of a fish species) have been listed as "threatened" under the Endangered Species Act of 1973 (ESA).

EH developed this Habitat Conservation Plan (HCP) to support an application for an Endangered Species Act (ESA) section 10(a)(1)(B) Incidental Take Permit (ITP). The HCP includes all of the elements required under ESA section 10(a)(2)(A) and the associated permitting regulations at 50 CFR 17.22(b)(1), 17.32(b)(1), and 222.22. These elements include:

- impacts likely to result from the proposed taking of the species for which permit coverage is requested;
- measures that will be implemented to monitor, minimize, and mitigate impacts; funding that will be made available to undertake such measures; and procedures to deal with unforeseen circumstances;
- the alternative actions to incidental taking the applicant has considered and the reasons the applicant rejected those alternatives; and
- additional measures the Service may require as necessary or appropriate for purposes of the plan.

Specifically, the HCP includes the project description, covered activities, covered species, environmental setting and biological resources in the covered area, the potential biological impacts, and an assessment of the incidental take caused by those activities. This information sets the context for the HCP Conservation Program (including the biological goals, objectives, and strategies (measures, actions and other commitments) for minimizing and mitigating the effects of incidental take. In addition, the HCP includes monitoring and reporting on HCP compliance and effectiveness, Information from effectiveness monitoring will be used to inform some adaptive management during the proposed permit term. Finally, the HCP describes how EH will address and respond to Changed and Unforeseen Circumstances and fund the HCP.

1.1 Overview and Background

Electron began operations in April 1904 under the ownership of Puget Sound Energy (PSE). The project was "grandfathered" 16 years later after passage of the Federal Water Power Act (June 10, 1920). Because of this "grandfathered" status, the Project has never undergone review or licensing by the Federal Energy Regulatory Commission (FERC) and its continued operation has not required any other federal agency permit or review.

In 1997, PSE and the Puyallup Tribe of Indians (PTI) entered into a fisheries Resource Enhancement Agreement (REA) to address some of the adverse effects of project maintenance and operations on fish and other aquatic resources. In 1998, under the terms of the REA, PSE constructed a Transfer system to improve downstream fish passage and survival of juvenile salmonids that become entrained in the Project Diversion and transit the Flume to the Project Forebay. The Transfer Facility enabled operators to transport fish from the Project Forebay to downstream of the Powerhouse to avoid exposure to the penstocks and powerhouse turbines which would otherwise kill them.

Implementation of the REA and the Transfer system reduced but did not eliminate the Project's potential impact on native fish populations. In addition, certain Project operations and maintenance activities still have the potential to cause incidental take of listed species.

Shortly after the Transfer Facility was completed, Puget Sound Chinook salmon were listed as "threatened" under the ESA on August 2, 1999, followed by Bull trout on November 1, 1999. In 2000, PSE built a fish ladder under the REA, enabling upstream fish passage at the Project Diversion for the first time since the Project began operating. The ladder provides access to approximately 26 miles of additional river and tributary habitat above the Diversion. Subsequently, Puget Sound Steelhead trout were listed as "threatened" under the ESA in 2007.

The Project continued to operate under the terms of the REA for the remainder of PSE Project ownership, while PSE considered various options for the Project including upgrades, sale to a new owner, or retiring the Project.

EH, the current owner of the Project, purchased the property and facilities from previous owner PSE on November 14, 2014. The ownership change provided an opportunity for renewed efforts to address conservation of listed species. EH developed a plan to improve the Project's Diversion structure to produce more natural sediment transport and to install a fish screen to exclude fish from the Project's water intake.

The Project experienced a large storm event (over 10,000 cfs) just a few weeks after EH purchased the Project in November 2014. Large flow volume during this event also highlighted the need to repair, revise, and protect the Diversion structure and nearby shoreline. Two more 10-year events hit the Project in December 2015 and January 2016. During the December event the right riverbank overtopped upstream of the Diversion and started an end run around the northeast end of the Diversion. EH analyzed the effects of those events and identified the need to replace the small wooden spillway with a larger capacity inflatable Bladder spillway and reinforce the left and right bank shoreline protection. Completing a Bladder spillway would enable EH to pass large sediment loads as they naturally occur, minimize debris entering the intake opening and control flows in the flume as they enter the sediment and Fish Exclusion Facilities.

The U.S. Army Corps of Engineers issued a permit, following ESA consultation with the Services, authorizing the first phase of work on the Project (Phase I), entailing in-water work to reconstruct and repair the diversion structure and spillway. The Corps' ESA consultation resulted in biological opinions issued by the Services in July of 2018 (NMFS 2018; USFWS 2018).

Phase I does not include any modification to the Flume. All the work is on the river side of the Intake window wall. Phase I was originally intended to be constructed in a single season but was subsequently divided into three summer seasons to reduce risks inherent with in-water construction. Left-bank shoreline protection consisting of deep foundation large diameter rock rip-rap from the Diversion Intake upstream approximately 300' was completed summer 2018. Similarly, left-bank shoreline rock rip-rap protection downstream of the Diversion for approximately 400' was completed summer 2019. Spillway replacement with an inflatable rubber Bladder 70' long, 12' in diameter with a built in Sluice Gate and all foundation, bank protection walls, operational elements and other related Diversion repair will occur during summer 2020. All in-water work, i.e. between the ordinary high-water mark of the riverbanks, will thereafter be substantially completed.

The remainder of the construction work (Phase II) to implement fish screens is off-channel and, like the ongoing operation and maintenance of the Project, does not require a federal permit. Accordingly, to address the reasonable potential for Phase II construction and ongoing Project operation to result in the incidental take of ESA-listed fish species, EH elected to develop this HCP with the technical assistance of the Services and to seek an ITP. The process has included extensive review of applicable scientific reports, habitat restoration and species recovery plans and other references that include contributions from local, state and federal resource agencies. EH and the Services also regularly sought input on scoping, basin ecology and species details, operational details, and monitoring from PTI. In addition, EH sought contributions from local, state and federal resource agencies.

1.1.1 Description of the Electron Hydro Project Facilities and Operations

The Project is located on the upper mainstem Puyallup River in Pierce County near the town of Kapowsin, Washington. The Project diverts up to 400 cfs from the Puyallup River at RM 41.7 and generates up to 26 Megawatts of electricity, enough power for 20,000 homes.

The Puyallup River and its largest tributaries, the Carbon and White rivers, originate at high elevations on the west and north slopes of Mt. Rainier, within Mt. Rainier National Park. As a snowpack and glacier-fed system, the Puyallup River typically experiences two seasonal peaks, a large peak in the early summer in response to snowmelt and a smaller peak in the late fall in response to rainfall. Glacial meltwater maintains baseflows in the mainstem and causes high turbidity levels in the Puyallup River during summer and early fall periods.

Water enters the Project at the headworks located at RM 41.7 (Diversion structure and Spillway, Intake), where it is diverted into a 10-mile Flume, passes through a mid-course Settling Basin, and flows into a Forebay. Four Penstocks exit the Forebay and deliver water to the Powerhouse 873 ft in elevation below. The water exits the Tailrace (return flow) to the Puyallup River at RM 31.2.

The Project has no significant water storage above the Diversion and is operated as a run-of-river project. Electron operates continuously throughout the year except for planned maintenance outages and during emergency outages. Operating the Diversion affects instream flow in the approximately 10.5 miles of the Puyallup River (the "Middle Reach") that bypasses the Intake and Flume, and remains in the river.

At times high river flows will overwhelm the Diversion structure topping over the entire crestline, sweeping sediment and woody debris downstream. Major planned improvements will address the need to pass increasingly higher sediment volumes as well as establish and maintain fish exclusion, i.e. keep fish from entering the water delivery Flume and return them to the river immediately below the Diversion instead.

Figure 1.1. Electron Hydroelectric Project, upper Puyallup River, Pierce County, Washington

1.2 Purpose and Need

The purpose of the Project is to generate renewable electricity to meet energy demand in the Pacific Northwest. Electric power from the Project currently is sold to PSE, helping that utility meet energy policy objectives to obtain a share of total electricity supplies from renewable energy sources and reduce greenhouse gas emissions associated with energy production.

The purpose of this HCP is to support EH's application to each of the Services for an ITP. The ITP will cover three threatened fish species and their habitat within the designated areas of the Puyallup River, along with the facilities, operations, and conservation activities EH will conduct for the lifetime of the permit.

1.3 Plan Area/Permit Area

The plan area for this HCP and the permit area for the ITP includes the approximately 2,200 acres owned by EH, shown in Figure 1.1, and the portion of the Puyallup River from USGS Gage 12093500 located at river mile 26.4 to a location 1000 feet below the Project's Powerhouse.

1.4 Permit Duration

EH is seeking an ITP for an initial period of 30 years, with the possibility of a permit extension under terms and conditions as specified by the Services. This HCP will be implemented for 30 years and any renewable periods to run concurrent with the term of the ITP.

1.5 Alternatives to the Taking

The Fish Exclusion Facility that EH will install at the Project's Intake (Phase II) is the primary proposed method for avoiding and minimizing take of listed fish species.

1.5.1 Transfer Facility

EH evaluated an alternative of continued operation of the existing Transfer Facility in the Forebay as the primary mechanism for minimizing take of listed fish species. The Transfer system was installed by PSE under the terms of the 1997 REA, which predated ESA listings for the listed fish species. PSE developed a draft HCP that would have relied upon continued operation of the Transfer Facility. While the Transfer Facility minimizes the take of listed fish species by returning captured fish to the river, the impacts on listed fish species resulting from their transit through the Flume and Sediment Basin, capture and handling in the Transfer Facility, and the escape of some fish to the Forebay all can be avoided by installing a fish screen at the intake, preventing fish from entering the Flume.

1.5.2 Transfer Facility plus Penstock Screens

One of the concerns that the Services have expressed regarding the existing Transfer Facility is the potential for fish to get past the barrier nets at the entrance to the Forebay. If that occurs, the fish cannot escape the Forebay, and will either remain there or enter the Penstocks. Any fish entering the Penstocks cannot survive the trip through the Penstocks and turbines. Placing screens on the Penstocks would reduce the potential for entrainment of fish that escape the nets, but the incremental reduction in take of listed fish species compared to Transfer alone would be insignificant and would present significant maintenance issues and costs and could impact power production.

1.5.3 No Action

EH evaluated an alternative in which it installed the Fish Exclusion Facility but did not seek an ITP. Once the Fish Exclusion Facility is installed and operational, the Project's primary impact on listed fish species – entrainment in the Flume – will be eliminated and take in the form of mortality to listed fish species will be unlikely to occur.

1.6 Coordination with the Services and Tribe

Before EH purchased Electron on November 14, 2014, EH principals evaluated the Project operations and maintenance in view of the ESA listings. EH personnel have met with NMFS, USFWS, and the PTI Department of Fisheries personnel since 2013 and identified the need to exclude fish from entering the Flume as a top priority. EH, the Services, and the PTI identified other, desirable operational modifications to minimize potential adverse Project effects on listed species. In addition, EH principals also contacted the PTI Tribal Council regarding development of a new REA.

Subsequently, during Spring 2015, the Services and EH discussed the process for review of the proposed improvements under the ESA. EH, the Services, and PTI staff met on July 28, 2015 to discuss potential fast track actions that could be implemented to exclude fish from the Project intake. The improvements to the Diversion structure required a permit from the U.S. Army Corps of Engineers, and so would be reviewed by the Services through an ESA section 7 consultation. The Fish Exclusion Facility and ongoing Project operations do not require a federal permit. The Services encouraged the development of an HCP as the best way to address necessary repairs, improvements, installation and future facility operations.

During the Fall of 2015 EH began developing design feasibility and project scope for fish exclusion from the intake. EH and the Services separated planning for the improvements and the HCP into two "phases." Information from operating the Phase I components is needed to complete the design of the Phase II Fish Exclusion Facility. In addition, separating the Diversion and shoreline protection improvements "Phase I" and the HCP "Phase II" enabled EH to apply for needed permitting for Phase I immediately, and to complete that work while developing the HCP for the non-federal portion of the work on a separate track.

EH submitted Phase I design and permit application materials to the U.S. Army Corps of Engineers (COE) requesting issuance of a Nationwide Permit #3 for the Diversion repair, Bladder spillway replacement, and shoreline protection in April 2016. The application for a Federal permit triggers an ESA section 7 interagency consultation, completion of which included biological opinions issued by each of the Services. During the application period, EH continued to informally consult with stakeholders, including PTI and state and local agencies. The COE issued permits for Phase I on August 9, 2018.

1.7 Summary of Relevant Laws

1.7.1 Endangered Species Act

Section 9 of the ESA prohibits take of federally listed species. The ESA defines take as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (16 United States Code [USC] 1532(19)). Harm is defined by regulation as "an act which actually kills or injures wildlife and may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns including breeding, feeding or sheltering" (50 CFR 17.3). Harass is defined by regulation as "an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering" (50 CFR 17.3). Section 10(a)(1)(B) of the ESA authorizes the Services to issue permits allowing take that is "incidental to, and not the purpose of, the carrying out of an otherwise lawful activity."

Section 10(a)(2)(A) of the ESA provides that the Services shall not issue an ITP unless the applicant provides a conservation plan that specifies:

(1) the impact that will likely result from the taking;

(2) the steps the applicant will take to minimize and mitigate the impacts and the funding available to implement those steps;

(3) the alternative actions to the taking that were considered and the reasons the alternatives were not chosen; and

(4) other measures that the Services may require as necessary or appropriate for purposes of the conservation plan.

The Services will evaluate an HCP to ensure it meets the issuance criteria for an ITP. The issuance criteria are [16 USC §1539(a)(2)(B)]:

(i) the taking will be incidental;

(ii) the applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such taking;

(iii) the applicant will ensure that adequate funding for the plan will be provided;

(iv) the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and

(v) the measures, if any, required 'as determined by [the Services] to be necessary or appropriate' will be met.

The Habitat Conservation Planning and Incidental Take Permit Processing Handbook (HCP Handbook) also provides guidance on the elements of a habitat conservation plan (USFWS and NMFS 2016).

1.7.2 National Environmental Policy Act

The National Environmental Policy Act (NEPA) is the basic national charter for protection of the environment; it establishes policy, sets goals, and provides means for carrying out the policy, and contains "action-forcing" provisions to make sure that federal agencies act according to the letter and spirit of NEPA. The purpose of NEPA is to ensure that federal agencies consider the environmental impacts of their actions and decisions. NEPA requires that the federal government use all practicable means and measures to protect environmental values and make environmental protection a part of the mandate of every federal agency and department. To accomplish this goal, NEPA establishes a process and approach to determine the environmental impacts associated with proposed federal actions that significantly affect the quality of the human environment.

1.7.3 Magnuson-Stevens Fishery Conservation and Management Act

Section 305(b) of the Magnuson Stevens Fishery Conservation and Management Act (MSA) directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect Essential Fish Habitat (EFH). The MSA (section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."

Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

1.7.4 National Historic Preservation Act

The National Historic Preservation Act (NHPA) of 1966 was created to preserve historical and archaeological sites as well as form the National Register of Historic Places (NRHP), the list of National Historic Landmarks, and the State Historic Preservation Offices (SHPO). Section 106 of the NHPA establishes a review process that federal agencies must undergo for all federally funded and federally permitted projects that will impact historical sites, particularly those listed on or eligible for listing on the National Register of Historic Places (16 USC 470).

2.0 PROJECT DESCRIPTION AND COVERED ACTIVITIES

2.1 Project Description

This section describes Project construction activities and the scope of ongoing and planned operations and maintenance activities. The HCP includes measures to minimize and mitigate the effects of incidental take from these activities. The HCP biological goals, objectives, and strategies relative to the covered activities and conservation program are discussed in Section 6.0. The strategies in section 6.0 represent the prescriptive and other measures the HCP incorporates to minimize and mitigate the effects of incidental take to the maximum extent practicable as required under ESA section 10(a)(2)(B)(ii).

2.1.1 Upstream Fish Passage

In 2000, PSE constructed the fish Ladder providing upstream fish passage on the right bank of the Diversion, opposite the Intake. Adult fish migrating upstream use the Ladder to access about 26 miles of river and tributary habitat for spawning and rearing. Naturally returning Chinook and Steelhead have been observed above the Diversion. Bull trout are also within the upper reaches of the river, as they have been observed in the Transfer Facility, located in the Forebay.

For optimal performance, the Ladder must be kept clear of obstructions including sediment and woody debris and provide adequate through-flow ranging between 10 and 52 cfs. Sediment accumulates in the pools within the Ladder, and may be removed from time to time, but the Ladder is designed to function as both a pool/weir system and roughened channel. Entrances to the Ladder must remain connected to the main river channel above and below the Diversion.

2.1.2 Downstream Fish Passage

Fish may pass the Diversion and continue downstream via four different routes: 1) through the Ladder 2) through the Spillway 3) over the Diversion at high flows or 4) entering the Intake and the Flume.

2.1.2.1 Prior to Completing Phase II (Fish Exclusion Facility)

Fish that enter the Flume prior to completion of Fish Exclusion Facility could exit one or both rock chutes and be immediately returned to the river, or they would continue to travel down the Flume. Fish remaining in the Flume would continue travel approximately four miles down the Flume and enter the 1600-foot long Settling Basin, where the speed of the water slows. Fish re-enter the Flume at the basin outlet and then travel another 6 miles to the Forebay, a 10-acre storage and settling pond.

Fish entering the Forebay are guided toward the Transfer Facility by a set of flow deflectors (a line of 8- by 4-ft steel plates attached to a linked series of buoys near the flume entrance). A barrier net of fine mesh (6 mm hole, knotless polyester) forms a fence from the water surface to the bottom of the forebay guiding fish to the Transfer Facility. The barrier net is periodically cleaned and re-set. As the barrier net is withdrawn on spools for cleaning, a temporary net replacement is simultaneously drawn into place. A log boom is positioned up-current of the barrier net to prevent debris from entering the Transfer Facility or displacing the net.

The Transfer Facility consists of the barrier net as well as a trap transition structure, fish trap, fish hopper and electric hoist, fish sample tank, and fixed pumping system. The fish trap uses pumped water at up to 28 cfs to draw fish into the trap. Water is drawn into a fish holding area within the trap over an adjustable weir gate. The weir gate adjusts to maintain a preset water level in the holding area.

At the Transfer Facility fish are trapped, sorted, enumerated, processed for sampling, and transported by tank trucks for release back into the river downstream of the Powerhouse.

2.1.2.2 Phase II (Fish Exclusion) Operational

Phase II will modify the water supply flow line beginning immediately downstream of the Intake window wall for approximately 1,100 feet. This section includes the present Intake water gallery, the Tainter Gate and the entire concrete section of the flume. New facilities will be constructed adjacent to the concrete Flume section. The existing concrete flume section will be retained as a facilities bypass for maintenance and de-watering purposes.

EH plans to operate the project for one season to determine if further sediment removal is required. If sediment removal is required to successfully operate the Fish Exclusion Screens, then the new facilities will include multiple sediment settling and return-to-river chambers, lying parallel to one another with individual entry and exit gate controls. The entire sediment exclusion facility may be up to 600 feet long. As water approaches the sediment chambers the new channel will shallow up and widen to slow and distribute flow into the individual sediment chambers (up to six chambers) such that suspended sediment will have time to settle and become trapped in each chamber as flow passes over sediment containment sills. The sediment chambers may be closed, drained, and flushed individually, draining to one or both of the existing rock/sediment outfalls. The approach velocity and water depth will be safe and sufficient for all life stages of all fish species to pass through the sedimentation facilities downline to the Fish Exclusion Facility.

After water flow passes through the sedimentation facilities the channel will again be shaped to provide the optimal approach velocity and depth for the Fish Exclusion Screens. This section will be constructed in a proven configuration as either a single vertical or double-V vertical screen system whereby fish are concentrated to an outlet flow and returned to river. All specifications established by the USFWS and NMFS for Fish Exclusion Facilities will be met including approach flow velocity, screen hole/slot size, material type, through-flow and sweeping flow velocity and measures to periodically clean screens of debris.

The final design details of the sediment and Fish Exclusion Facilities are pending an observational period of the new Bladder Spillway and Sluice Gate. This will be necessary to estimate and design for the anticipated sediment load after optimization of the new spillway and Sluice Gate. The Phase II facilities are anticipated to be completed approximately two years after completion of Phase I, to allow a satisfactory operational observation period, design revisions and construction.

2.1.3 Spillway Operation

2.1.3.1 Description of the Diversion and Spillway

The Project's Headworks includes a wooden Diversion structure, which currently is 200 ft wide and 12 ft tall with a shallow 30 ft wide by 3 ft deep spillway. The already-permitted Phase I work on the Project involves reconstructing the Diversion and replacing the existing spillway with a 70-foot inflatable rubber Bladder Spillway and Sluice Gate.

Operation of the Intake flow controls, including the present and future Spillway configuration, requires maintaining adequate flow release to the river for instream flow requirements. In addition, adequate pool elevation must be maintained behind the Diversion to provide for adequate flow through and access to the fish ladder.

Occasionally during very high flows water will sweep over the Diversion along its entire crest.

[Add Figure showing Diversion at typical river elevation]

Figure _. Approximately 8000 Cfs Overwhelming the Diversion in 2015

As noted above, the Corps has issued the permits necessary to replace the existing 30-foot Obermeyer spillway within the 200-foot wooden diversion structure with a 70-foot inflatable rubber Bladder Spillway and Sluice Gate (Phase I), and the Services have completed ESA consultation on that construction work. The spillway replacement is essential for the exclusion of sediment and fish from the water delivery flume. The spillway replacement (Phase I) and construction of subsequent sediment and Fish Exclusion Facility (Phase II) are proposed to prevent the entrainment and potential harm to ESA-listed fish species.

Following completion of Phase I construction, EH proposes to operate the spillway system for approximately one year sufficient to observe performance and make any necessary adjustments prior to final design and construction of the sediment and Fish Exclusions Facility (Phase II). Construction of Phase II is expected to take 7 months following issuance of any required State and local permits.

2.1.3.2 Spillway Revision

The primary purpose of the spillway replacement is to ensure bedload remains below the intake sill, maintain a clear intake pool behind the diversion structure, and minimize or prevent bedload entrainment at the intake opening. When deflated, the Bladder Spillway will allow for the natural transport of bedload downriver from behind the diversion structure, thereby providing for the maintenance of clear-pool storage capacity.

Similarly, the Sluice Gate will allow accumulated sand deposition that occurs during glacial meltwater periods to be either continually or periodically sluiced without deflating the Bladder Spillway during periods of lower summer flows. The Sluice Gate would keep the intake window clear but release much less water than lowering the Bladder Spillway.

The combined operation of the Bladder Spillway and Sluice Gate will minimize the entry of bedload and fine sediment into the intake and thus into the sediment removal and Fish Exclusion Facility. It is essential that the majority of sediment be removed from the flume water prior to reaching the Fish Exclusion Facility for the exclusion screens to perform effectively. It is not possible to safely exclude ESA listed fish without first removing the majority of the sediment.

Flow diverted into the Intake would be controlled by the combined operation of the Bladder Spillway, Sluice Gate, and the existing radial gate in the flume. Effective operation of these controls will facilitate steady diversion of up to 400 net cfs for power generation.

The Bladder Spillway will also be operated to flush sediment that accumulates in front of the intake bulkhead and maintain the riverbed elevation at least a foot lower than the intake sill elevation at the intake entrance. The objective of sediment flushing will be to transport this material past the Diversion and continue downriver similar to the natural transport process, while minimizing the entrainment of sediment into the intake.

2.1.3.3 Spillway Commissioning and Startup

Commissioning and startup will occur within the first two weeks after the Bladder Spillway construction is finished and the temporary cofferdams are removed. This testing period is anticipated towards the end of September when the river flows are still low. During this period, it is essential to establish and affirm the operations of the Bladder Spillway, Sluice Gate and rock chutes. The Program Logic Controller (PLC) which automatically controls and adjusts the Bladder and the other outlets will be programmed and thoroughly tested during this time. The PLC monitors the pool elevation behind the Bladder to maintain a constant level.

Cycling of the Bladder deflation and re-inflation times will be measured and quantified. Specific questions to be addressed include determining the range of deflation and re-inflation rates that will ensure changes to the river flow comply with the prescribed ramping rates of 2 to 4 inches per hour. River stage measurements will be made approximately 2500 feet downstream from the diversion structure, known as the “rock gage”. The station is located downstream of the outfall for the floodgates, in a location where the river is stable and not braided. Measurements will be made using a continuous stage recorder and corresponding staff gauge. River flow (Q) will also be measured at this station to verify the operational parameters to ensure that the minimum in stream (MIF) flows are met.

Monitoring of the upstream and downstream discharge and stage also will be done during the startup. Data will be collected from USGS Electron Gage, the fish ladder, rock gage, Neisson Creek and above the powerhouse tailrace. Plant operation would also resume during the startup and be included with the monitoring. Results of the startup monitoring and measurements will be combined with the monitoring data as discussed in the Monitoring Plan.

2.1.3.4 Day to Day Diversion Operation

Total river flow entering the project will be measured by the USGS Electron Gage 12092000 located 1,700 feet upstream of the intake diversion.

Instream flow below the diversion at the head of the bypass reach, below the rock chute returns and fish ladder, will be measured at the rock gage. A recording gage is installed in the fish ladder facility to enable monitoring of river flow through the ladder. The upstream entrance of the ladder may need to be adjusted to control the flow between 10 to 55 cfs.

To maintain a consistent pool elevation (1620 MSL) at the intake, with the Fish Ladder operational, gradual adjustments would occur using the Flume radial gate, Sluice Gate, rock chute 1, rock chute 2, and Bladder Spillway. Conceptually, operation would begin when minimum instream flows of between 60 and 80 cfs are met via flow through the Fish Ladder and Sluice Gate. At this stage there would be a full intake pool with fish ladder flow and minimum instream flow provided.

As the river flow increases upstream and operation begins, the Flume radial gate will open enough to deliver increasing flows up to the maximum net of 400 cfs into the Flume, after all rock chute returns, for power generation, while maintaining the required minimum instream flow via discharge from the Fish Ladder and Sluice Gate. Water always will be provided through the fish ladder during operation, as a function of maintaining pool elevation.

Once the maximum net 400 cfs flume delivery is achieved, the Sluice Gate will open until it reaches maximum capacity of 100 cfs. To maintain a static pool level at elevation 1620’, total inflow exceeding the combined capacities of the Fish Ladder, Flume, Sluice Gate and rock chutes will require lowering the pressure to partially deflate the Bladder and spill the excess water. The adjustments of the Sluice Gate, Flume radial gate, rock chutes and Bladder will be automatic to maintain a constant pool elevation of 1620’ at the intake. At some point, for example flows greater than 1,500 cfs, the Bladder could be fully deflated.

The Bladder crest elevation is adjusted by changing the internal pressure and partially deflating the Bladder to spill water. Water may also pass through the 3 ft Sluice Gate, located at the base of the intake and runs through the left abutment of the spillway, then outlets on the dissipation slab. These two controls may be used to regulate pool elevation.

When the Bladder is fully deflated it will lay flat and allow water and sediment to flow through a 62 feet wide and 12 feet deep opening at the diversion structure. The Bladder also can be partially deflated to adjust the size of the opening and maintain the water surface elevation in the diversion pool.

River flow varies continuously, and the Bladder Spillway, Sluice Gate, and Flume radial gate will be adjusted in response to variable river flow to maintain a consistent pool elevation and steady diversion flow. The Bladder elevation will provide infrequent coarse adjustments, and the Sluice Gate, existing Flume radial gate and rock chutes will provide more frequent fine adjustments. Coarse adjustment is anticipated when the river flows are in excess of 700 to 2,500 cfs.

The Bladder will be fully deflated to flush accumulated sediments when deposition at the intake approaches the sill elevation at the intake. Complete deflation of the Bladder offers the most rapid sediment flushing performance. Sediment flushing could also occur using the Sluice Gate in front of the intake while the Bladder is fully inflated or partially deflated. The Sluice Gate provides a range of flow from 5 to 100 cfs. The timing and duration of flushing will change with seasonal differences in flow and sediment transport. Sediment flushing scenarios for the range of anticipated conditions are described in more detail below.

Re-inflation of the Bladder will be controlled to maintain a stable pool at a desired elevation threshold. Automatic adjustments of the Flume radial gate and Sluice Gate will also be made as river flow recedes. This may result in reduced flow from the rock chutes to maintain a steady pool and the net generation flow of 400 cfs.

2.1.3.5 Sediment Flushing

The Bladder Spillway may be deflated within a 70 feet wide section of the diversion structure by as much as 12 feet. The effect of lowering the Bladder will be to accelerate flow velocity immediately upstream, which will mobilize and flush accumulated sediment from the diversion pool.

Sediment deposition within the pool varies throughout the year with seasonal changes in river flow and sediment supply. Fine sediment (e.g. sand and silt) accumulates most rapidly during glacial melt conditions that prevail from June through September. Based on typical flow and sediment concentrations during that period, fine sediment would likely fill the pool in approximately 30 days. Bedload (e.g. cobbles, gravel, and sand) will deposit in the pool during periods of high flow. The riverbed may be partially mobilized at flows as low as 700 cfs. The volume of bedload transported increases sharply in proportion to flow such that infrequent high flow events between 4,000 and 15,000 cfs can quickly deliver high volumes of bedload sediment. Under such high flow conditions, bedload sediment delivery rate is fast enough to fill the diversion pool within a few hours (e.g. 13 hours for 2-year flow, 2 hours for 100-year flow). If the pool is already partially filled at the start of the event, it will take less time to be filled.

2.1.3.6 Sediment Flushing During Glacial Melt Period (Late June through September)

Both fine sediment and bedload will gradually fill the diversion pool during glacial meltwater periods since fine sediment load is high and flows often exceed 700 cfs. After spring snowmelt is finished (typically May and June), flow rarely exceeds 1,500 cfs during the glacial melt period, so bedload transport is much smaller compared to transport rates during rare peak flow events. Flushing frequency during glacial meltwater will be at least once per month. Sediment delivery is variable, and the pool may fill up with sediment faster (e.g. 1 - 2 weeks) in response to a series of clear sunny warm days that increase both flow and sediment concentration.

Any time flow exceeds 1,000 cfs there is an opportunity to flush accumulated sediment. Opportunistic flushing more often than once per month may be a good strategy for maintaining sediment capacity within the diversion pool. Both flow and sediment concentration decrease progressively from June to October. Flows rarely exceed 1,000 cfs after July until storms that generate peak flow events begin typically in November. Between August and the end of October, there could be few opportunities to quickly flush accumulated sediment. Sediment may be flushed at any river flow, but it will take more time and interrupt power generation at lower river flows. The sediment accumulation rate between August and October will be slower compared to June and July, but flushing may be required at least once or twice during that period.

Sand may also accumulate at the lower flows in front of the intake during the summer months which could require continuous flushing using the Sluice Gate located at the base of the intake. The Sluice Gate consists of a slotted pipe that is located behind the vertical coarse trash rake at the intake. The slot size is less than 6 inches to prevent cobbles and boulders from entering the sluice bypass pipe. The 3-foot Sluice Gate is planned within the left abutment which can be opened to sluice sand that accumulates without having to deflate the Bladder. A computer system will monitor the upstream water pool level and adjust the Sluice Gate, Flume radial gate, and rock chutes until they reach a maximum or a preset value. Once this level is reached the Bladder would be inflated or deflated to maintain the upstream water level.

The Sluice Gate would act as an ejector to vacuum material accumulated in front of the intake. It would operate from 5 to 100 cfs and with sediment-laden water being discharged beyond the Bladder in the bypass trough.

2.1.3.7 Flushing During Winter Months

Sediment delivery to the pool and intake during winter months is almost exclusively tied to discrete peak flow events. In between peak flow events, suspended sediment concentration is low, and flows are typically less than 700 cfs resulting in minimal gravel transport. Snow cover and cold temperatures reduce or eliminate fine sediment delivery to the river from the landscape and flows under 700 cfs transport little bedload. With this prevailing condition, flushing during winter months will likely only be needed to pass sediment that would be deposited during peak flow events. Any time flow exceeds 1,000 cfs presents an opportunity to quickly flush accumulated sediment from the diversion pool. Sediment delivery at a steady flow of 1,000 cfs would fill up the diversion pool in approximately 8 days. At 2,000 cfs, sediment delivery would take only 2 days to fill up the pool. During winter months, accumulated sediment will need to be flushed every time flow exceeds 2,000 cfs. For flow events that last less than 3 days and are less than 1,500 cfs the operation will have the option to flush sediment or continue operating and accept some accumulation that could be flushed during the next high flow event.

2.1.4 Down-Ramping Rate

Diversion discharges to the Middle Reach and Tailrace discharges will follow the down-ramping rate of 2 – 4 inches per hour. The ramping rate is best measured by the change in stage at a given location and refers to the stage decline at this location. Decline of the stage can result in stranding if it occurs too fast (Hunter 1992). The downstream stage will be monitored at the Rock Gage 2500 feet downstream of the Diversion.

Following a high flow event when the Bladder has been deflated, it will be re-inflated as needed and adjustments will be made to the other outlet points to maintain a consistent pool elevation of 1620'.

2.1.5 Fish Ladder Operations

Design flows through Fish Ladder range from 10 cfs to 55 cfs and vary depending on the flow of the Puyallup River to the degree that variable river flow alters the pool elevation for short times. Stop logs and slots are present in the last weir to adjust the flow depths in the Ladder. The elevation and setting of the stop logs will be verified and tied to the project datum prior to completion of the Phase I construction. Along with visual observation, a flow meter and a web-based camera will be used to ensure that the Fish Ladder trash rack is not plugged. Debris has blocked the trash racks in the past.

As previously discussed, the Bladder operation will monitor and maintain a constant pool elevation at 1620 MSL, which will result in a generally consistent flow rate through the Fish Ladder. At this level, the Fish Ladder will have water depth of 1.5 feet and a flowrate of approximately 60cfs. Vertical stops logs in the last pool at weir 17 may need to be adjusted to maintain the flow depth and a maximum velocity less than 6 fps. Presently, these logs are set at the same elevation as the crest of the Diversion and thus, may require adjustment during the commission and startup phase.

Flow and stage data will be collected from instrumentation at the Fish Ladder with the other operational parameters. Bladder sediment flushing will reduce the amount of sediment and debris that enters the Fish Ladder resulting in less frequent maintenance needed to remove accumulated sediment from the drop pools. Periodic inspections, particularly after a high storm event, will be done to document the conditions of the pools and determine when maintenance is needed.

Attraction flows to the entrance to the fish ladder will also be maintained. A channel will initially be constructed connecting the spill on the left bank to the entrance of the Fish Ladder. This channel will convey the Fish Ladder flows at a depth of 6 to 12 inches. Sediment accumulation in that channel that occurs in association with flows below the 10-year recurrence interval may require gravel manipulation to maintain the channel. As an alternative to gravel manipulation, the Bladder could be left inflated for a short time during high flow events smaller than the 10-year flow to force water over the wooden apron and effectively maintain a channel at the toe of the apron.

During summer low flow periods when the spillway is occasionally deflated to pass fine sediment, the flow through the fish passage facility will be maintained. To ensure that adequate flow is maintained in the Fish Ladder, a channel will be maintained in the river boundary to deliver flow into the Ladder. EH is currently authorized by Washington State Department of Fish and Wildlife Hydraulic Project Approval (HPA Number 2016-6-374+01) to manipulate gravel in the river channel. Prior to and during each planned flushing event, a qualified technician will inspect the river channel and if flow into the fish ladder is not adequate, the technician will manipulate sediment in the river channel to improve flow through the Ladder.

Adjustments of the vertical slots and flow controls in the last weir of the Fish Ladder may also be necessary to maintain the depth of flow between 0.5 and 1.5 feet in the Fish Ladder, flow between 10 to 55cfs, and velocity less than 6 fps.

2.1.6 Operation During Peak Flow Events

Rare peak flow events present occasional short-term risk to the facility posed by high flow volume, high sediment delivery rates, and mobilization of large debris (e.g. trees and ice). Risk to the headworks facilities may be mitigated by fully deflating the Bladder to maximize conveyance capacity in the river and closing off the intake to prevent entrainment of coarse sediment into the intake channel. When the river flows reach 8,000 cfs the Bladder will be fully deflated, and it will remain deflated until the river flow drops below 8,000 cfs. For such high flows, sediment accumulates so rapidly that it is more effective to completely deflate the Bladder for the duration of the event. The 10-year flow event is 8,584 cfs, so this is a rare condition.

Whenever river flows exceed 2,000 cfs, bedload rapidly deposits in the pool and more frequent flushing will be required by a combination of the Sluice Gate and deflation of the Bladder.

2.1.7 Water Conveyance and Storage

The concrete Intake window wall (approximately 62 ft wide by 5 ft tall) and water gallery lies on the left bank at the Project Headworks, adjacent to the Diversion. Water is diverted through a Tainter gate just downstream of the concrete Intake window wall, then to the Flume. Immediately downstream of the Tainter gate are two rock chutes, i.e. transverse box channels in the bottom of the flume that discharge large rock, cobble & sediment back into the river. The chutes have an outlet control gate to regulate their discharge. Combined operation of the Tainter gate and rock chutes determines how much flow is delivered to the Flume.

The diverted water is conveyed down a 10-mile long Flume. After about four miles, the Flume enters the Settling Basin, which is approximately 60 feet wide, 8 feet deep and 1600 feet long. The water slows and settles suspended sediment before re-entering the Flume at the basin outlet. It then continues another 6 miles to the Forebay reservoir.

The Flume box is built on a uniform grade of 7 feet per mile (0.13 percent) and consists of a wooden lined steel-framed box (8 feet, 3 inches wide by 8 feet high) built on top a steel trestle supported with vertical pile bents spaced 8 feet apart.

Rail cars (called speeders) travel along standard gauge train track laid along the top of the Flume to provide maintenance access the full length of the Flume. The Flume bridges several deep ravines. Natural conditions (i.e., steep slopes, thin soils, and areas along the Flume subject to erosion), as well as impacts associated with third-party timber harvest and other land disturbing activities in the vicinity of the Project may result in damage to the flume and the uncontrolled evacuation of water upon Covered Lands. In addition to these events, Flume repair occurs on a regular and situational basis, although these activities do not typically result in disruption of water conveyance or they occur during scheduled outages when the flume is dry.

Water is temporarily stored in the Forebay, a reservoir located approximately 10 miles downstream and approximately 873 feet above the Powerhouse on the Puyallup River. There is sufficient quantity of water stored in the Forebay to provide approximately 3.6 hours of normal power generation. The Forebay reservoir was designed and built to store 124 acre-feet of water. The Forebay slowly fills with fine sediment entrained in the water diverted from the glacial Puyallup River that requires routine maintenance and sediment management.

The 10-acre Forebay reservoir includes a downstream fish passage Transfer Facility. A barrier net dividing the Forebay aids in preventing fish from entering the Penstocks. Steel penstocks deliver water from the Forebay to the Powerhouse. Normal sediment management (dredging) operations occur periodically in the Forebay during scheduled power outages.

Sediment releases may also occur on the flume under emergency circumstances (high flow conditions) by means of operating floodgates 1,500 feet downstream of the Diversion and a valve at the Settling Basin.

2.1.8 Power Generation & Ramping

This includes generation of electricity from a clean and reliable renewable resource with no greenhouse gas emissions. Total generating capacity at Electron is approximately 26.4 MW. Steel penstocks deliver water from the Forebay to the Powerhouse and through the horizontal-type Pelton impulse turbines. The steel penstocks follow a 2,200-foot long, 30-degree descent to the powerhouse (approximately 873 ft of head). Impulse turbines have flow deflectors that can function as flow continuation devices. The Powerhouse contains four main generating units, and one smaller unit, each consisting of horizontal-type Pelton turbines. Electricity generated at Electron is transmitted via transmission lines to the Electron Heights substation about 1/3 mi away. The Powerhouse discharges water directly to the Puyallup River.

Figure _. Electron Powerhouse at RM 31.2

The act of generating electricity, especially during project startup and shutdown can influence surface water elevations in the river. Presently, river stage fluctuations are minimized to protect fishery resources with the use of ramping rate restrictions.

2.1.9 Facilities and Equipment Operation and Maintenance

This includes all operation and maintenance activities associated with Electron that are necessary to keep the project in normal and reliable commercial operations. Presently, this activity includes but is not limited to:

- Daily and annual operation and maintenance
- Scheduled maintenance outages
- Maintenance of coarse sediment deposits upstream and downstream of Diversion
- Maintenance of fine sediment deposits in the Basin and Forebay
- Normal flume maintenance and bent replacement
- Flume inspection by use of speeder cars

Maintenance of related facilities including the Diversion, Rock Chutes, settling basin, Forebay, fish ladder, Powerhouse, fish transfer operations, including support building at the Headworks, along the Flume, Forebay, Lower Electron, and human use at each of these locations.

2.1.10 Shutdowns & Emergency Operations

Shut-downs may occur as planned events or as sudden emergency actions. Planned events will typically include regular scheduled maintenance and inspections, periodic repairs, upgrades and infrastructure replacement. Planned events will occur with an orderly and efficient water delivery and Powerhouse shutdown that meets ramping and fish exclusion/recovery protocols.

Emergency actions are inherently unpredictable. They may include necessary responses to storm damage, equipment failure, accident or other unforeseen events. Flume and Powerhouse shutdown may need to occur rapidly if the threat of greater potential harm to human safety, Project facilities or environment is imminent. Rapid shutdown of water delivery may require sudden actions that cannot meet the criteria for a planned shut down and therefore may not meet ramping or recovery requirements. These types of emergency actions are infrequent.

2.1.11 Resource Conservation and Enhancement Activities

This covered activity includes resource conservation and enhancement actions that are ongoing as well as those prescribed within the HCP and planned for the future. Some of these actions include maintenance of the Fish Ladder, Trap & Haul facilities, stream gaging, water quality monitoring, construction and maintenance of fish rearing facilities, habitat enhancement projects and scientific studies and monitoring required by or otherwise necessary to continue the operation of Electron. Prospectively, these activities will include fish enhancement projects required to implement the Electron HCP, the ITP and any other applicable requirements, including projects identified in the Implementation Agreement.

2.2 Covered Activities and Facilities

The Electron HCP covers all Project facilities and activities that have the potential to affect listed fish species, including construction, operation, maintenance, repair (including emergency repairs), and replacement of all facilities and equipment. The major components of the Project and their operations are described in Sections 1.1.1 and 2.1. Once Phase II (Fish Exclusion Facility) is operational, the Project's Flume, Settling Basin, Forebay, Penstock, and Powerhouse and their operations will no longer have the potential to affect listed fish species and so these structures and their operations will no longer be covered activities and facilities under this HCP.

3.0 COVERED SPECIES

The Puyallup River hosts numerous species of anadromous salmonids. These include Chinook salmon (*Oncorhynchus tshawytscha*), Chum salmon (*O. keta*), Coho salmon (*O. kisutch*), Pink salmon (*O. gorbuscha*), Steelhead trout (*O. mykiss*), Cutthroat trout (*O. clarki*) and Mountain Whitefish (*Prosopium williamsoni*). Two anadromous char species, Bull trout (*Salvelinus confluentus*) and Dolly Varden (*S. malma*) are also known to use these waters. Bull trout and Dolly Varden are similar in appearance and are often mistaken for one another.

This HCP addresses and the requested ITP would cover Puget Sound Chinook salmon, Puget Sound steelhead trout, and bull trout. Each of these species meets the following criteria for inclusion in the Electron HCP:

1. The species is known to be present or has the potential to be present within the Plan Area during the term of the Electron HCP.

2. The species is currently listed or has the potential to be listed under the federal ESA as threatened or endangered during the term of the Electron HCP.

3. The species has the potential to be adversely affected by one or more of the Covered Activities.

3.1 Puget Sound Chinook Salmon

3.1.1 Status and Distribution

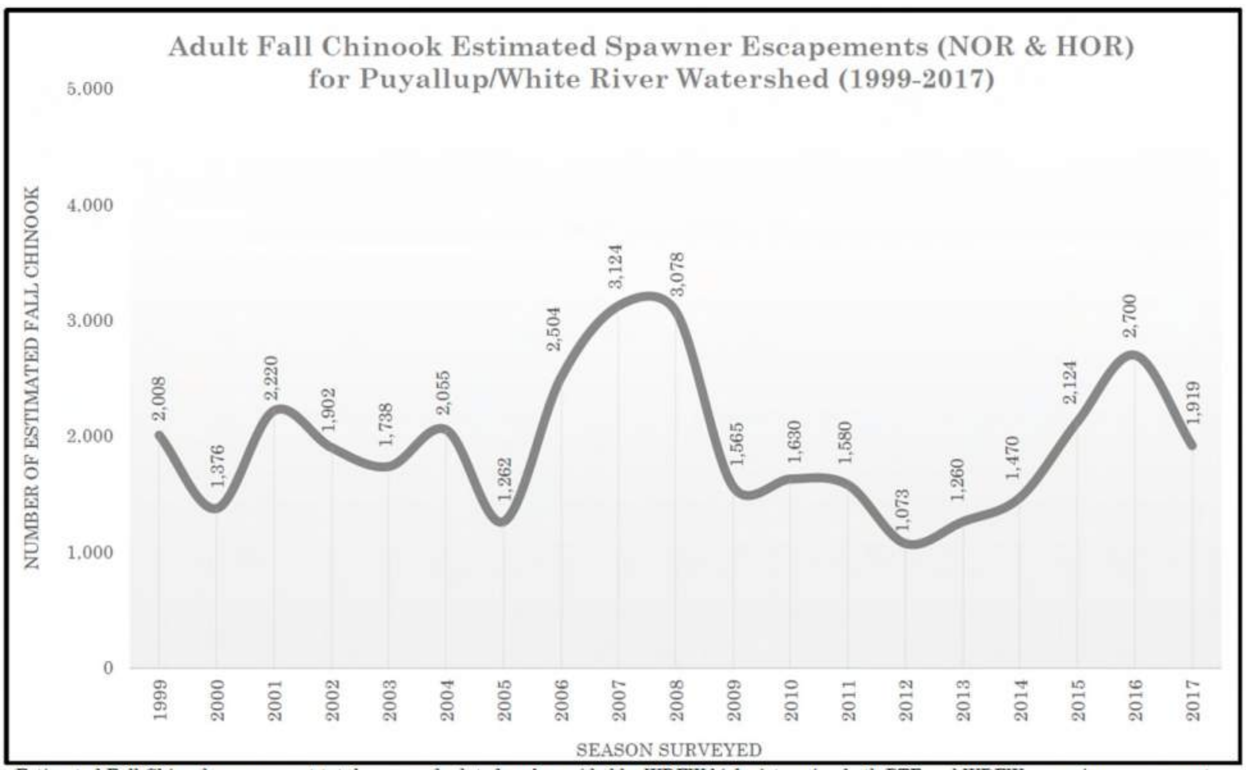
Puget Sound Chinook salmon were listed as threatened 6/2005 (70 FR 37160) with the most recent status review in 2015 (NWFSC). This ESU consists of 22 Chinook salmon populations, including the Puyallup River population.

The Puyallup River population of Chinook salmon is a significant contributor to the Puget Sound ESU. Five populations of Chinook salmon in the Puget Sound ESU, including the Puyallup, have experienced critically low returns within the last 20 years. The Puyallup is within the group of rivers with population abundance and productivity at critical levels (NMFS 2007). The Puyallup population must be recovered from the current "high risk" status to "low risk" in order for the Puget Sound ESU to reach viability (NMFS 2006).

Fall-run Chinook salmon migrate upstream in the Puyallup River and through the fish ladder at the Diversion. Spawning has been documented in tributaries upstream of the Diversion. Factors that have led to the decline of Chinook salmon populations in Puget Sound include:

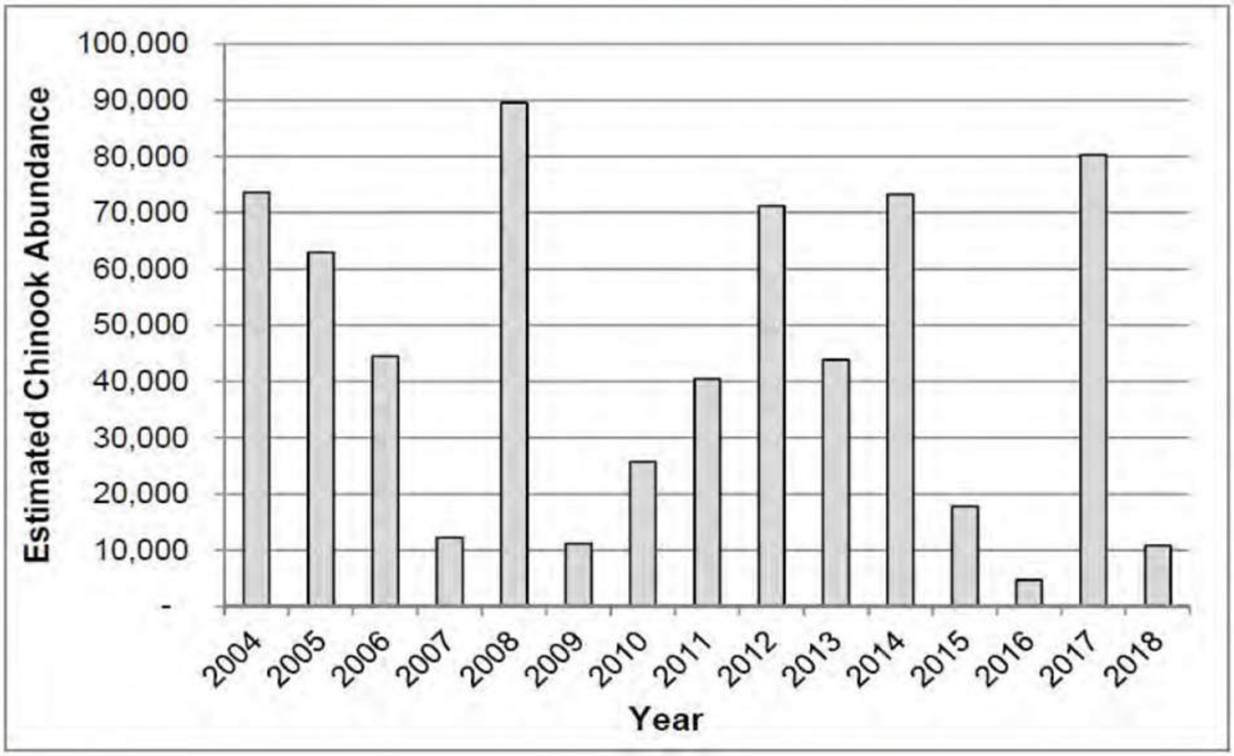
- Degradation of spawning and rearing habitat due to human activities

- Limited access to historic spawning habitat due to development activities
- Altered stream flow regimes and water temperatures
- Loss of riparian vegetation and soils that alter hydrologic and erosion rates
- Increased sedimentation
- Decreased large woody debris (LWD) in rivers and loss of potential recruitment of LWD
- Filled estuarine rearing areas
- Channelizing and diking of rivers leading to loss of rearing and spawning habitat
- Dams blocking access to historic spawning and rearing channels and altering hydrologic regimes, water temperature and sediment transport
- Over exploitation of Chinook stocks by commercial and recreation fisheries have contributed to lower numbers of returning adult salmon
- Introduction of non-native species have increased populations of predator and competitive species
- Some hatchery programs have led to competition between artificially produced fish with naturally reproduced fish
- Warming temperatures trends in the Pacific Ocean



Estimated Fall Chinook escapement totals were calculated and provided by WDFW biologists using both PTF and WDFW spawning escapement data. As additional DNA results become available, the reassignment of Spring and Fall Chinook may result in adjustments to the escapement estimates. The AUC method is used to determine escapement during pink runs (odd years). Addition biological expansion factors are applied to estimate escapement for suitable habitat areas that are often unsurveyable (i.e. mainstem rivers).

2018-2019 ANNUAL SALMON, STEELHEAD AND BULL TROUT REPORT



Annual production estimates of unmarked age 0+ Chinook smolts (2004–2018).
Source: (Berger and Conrad 2018) Puyallup River Juvenile Salmon Production Assessment Project 2018

3.1.2 Habitat Characteristics and Use

The final designation of critical habitat for Puget Sound Chinook salmon was published on September 2, 2005 (70 FR 52630). The Plan Area is within the Puyallup River sub-basin critical habitat area. Within this critical habitat area, the primary elements essential for the conservation of Chinook salmon are those sites and habitat components that support one or more life stages, including:

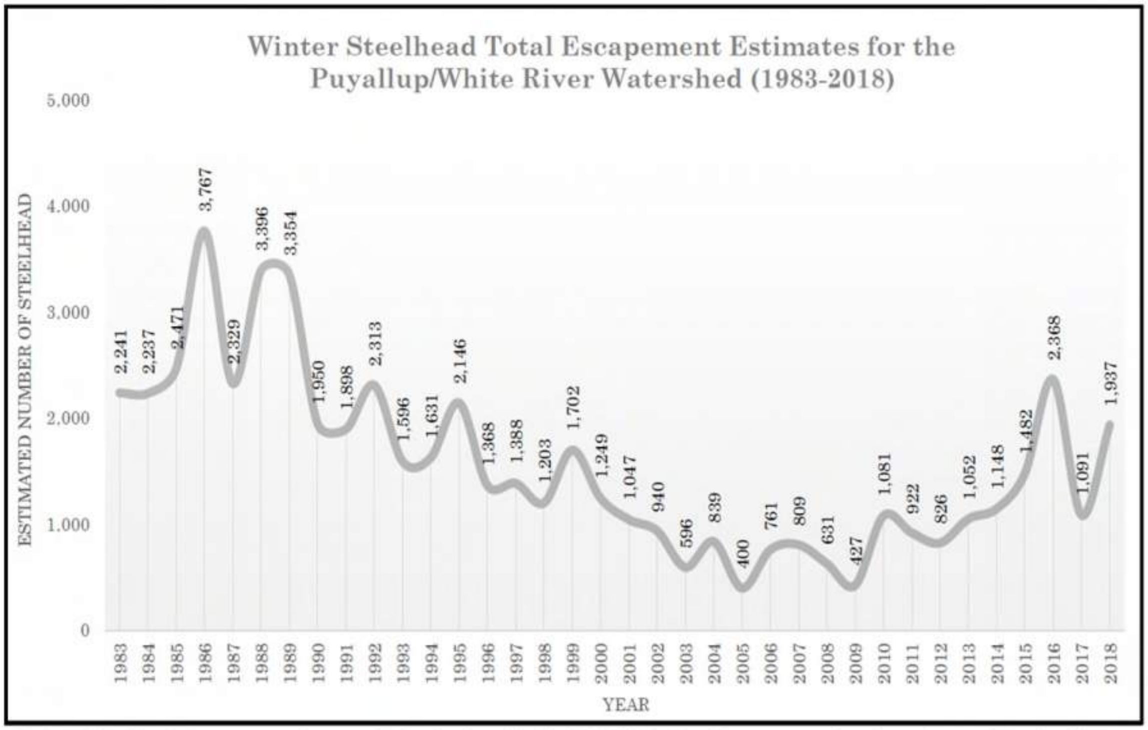
- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development;
- Freshwater rearing sites with: (i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) Water quality and forage supporting juvenile development; and (iii) Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks;
- Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.

3.2 Puget Sound Steelhead Trout

3.2.1 Status and Distribution

The Puget Sound population of steelhead trout was listed as threatened under the ESA on 5/2007 (72 FR 26722). Along with Puget Sound Chinook salmon, a recent review of Steelhead trout conducted in 2016 concluded this species should remain listed as threatened. The biological review team determined that naturally spawning winter and summer run steelhead populations and two hatchery steelhead stocks within Puget Sound constitute a Distinct Population Segment (DPS) that is reproductively isolated from other groupings of West Coast steelhead. Historically, steelhead trout were distributed along the marine waters and inland rivers of West Coast North America and northern Asia from northern Mexico to the Kamchatka peninsula. Human development has negatively impacted spawning and rearing habitat and has created barriers to upstream migration in much of the historic range (Wydoski and Whitney 2003, 71 FR 15666). Steelhead is a sea-run form of *O. mykiss* and rainbow trout is the freshwater resident form. Offspring from either form may either reside in its natal freshwater system or migrate out to marine waters after rearing in freshwater from one to seven years (Wydoski and Whitney 2003). Factors leading to the decline of Puget Sound steelhead include:

- Destruction and modification of spawning and rearing habitat in freshwater and estuarine systems
- Over-fishing for commercial, recreational, scientific or educational purposes
- Disease and predation especially by non-native species
- Inadequacy of existing regulatory mechanisms e.g. fisheries management and land use regulations
- Other natural and manmade factors such as Pacific Decadal Oscillation and climate change



Estimated steelhead escapement totals were calculated and provided by WDFW biologists. Escapement and total run size was determined by utilizing both PTF and WDFW spawning escapement data; Buckley trap capture/sampling data, and biological expansion factors. Addition biological expansion factors are applied to estimate escapement for suitable habitat areas that are often unsurveyable (i.e. mainstem rivers and tributary headwaters). See following graph for the breakout of the White, Puyallup and Carbon river basins steelhead escapements.

3.2.2 Habitat Characteristics and Use

The Plan Area is within critical habitat designated as Puyallup River sub-basin critical habitat area, however, the upper Puyallup River and tributaries are excluded in the final designation of Steelhead trout critical habitat published February 2016 because this reach is protected by a Western Forest Practices Habitat Conservation Plan. Primary elements of Steelhead trout critical habitat include:

- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development. These features are essential to conservation because without them the species cannot successfully spawn and produce offspring.

- Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. These features are essential to conservation because without them juveniles cannot access and use the areas needed to forage, grow, and develop behaviors (e.g., predator avoidance, competition) that help ensure their survival.
- Freshwater migration corridors free of obstruction with water quantity and quality

conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. These features are essential to conservation because without them juveniles cannot use the variety of habitats that allow them to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner. Similarly, these features are essential for adults because they allow fish in a non-feeding condition to successfully swim upstream, avoid predators, and reach spawning areas on limited energy stores.

3.3 Coastal/Puget Sound Bull Trout and Dolly Varden

3.3.1 Status and Distribution

Coastal/Puget Sound Bull trout were officially listed as threatened under the ESA on November 01, 1999. Due to similarity in appearance to bull trout, Washington State Dolly Varden was projected for listing as threatened on January 09, 2001. The U.S. Fish and Wildlife Service proposed Dolly Varden would only be treated as a listed species where its range overlaps with that of the Puget Sound Bull trout in Washington State. The current range as of this year is wherever found in Washington State. These two anadromous char species are managed jointly because they co-exist and have similar habitat requirements and life histories.

Bull trout have a variety of life-history strategies. They may reside in a river system, as adfluvial, or anadromous that spawn in cold clear headwaters before they migrate to large bodies of water including the Puget Sound for rearing. Bull trout may spawn more than once in their lifetime. Factors leading to prevention of large numbers of reproduction include:

- Habitat degradation
- Barriers to migration
- Over harvest
- Fragmentation and genetic isolation
- Introduction of non-native species

3.3.2 Habitat Characteristics and Use

According to the USFWS Electron Diversion Project Biological Opinion (2018), Bull trout may be present in the Electron Project Action Area and utilize this river reach for migration. Spawning has been documented in the upper reaches of the tributaries to the Puyallup River upstream of the Diversion. Primary fundamental elements of bull trout critical habitat include:

- Water temperature that support Bull trout use;
- Complex stream channels with woody debris, side channels, pool, and undercut banks with a variety of velocities and instream structures;
- Substrates of satisfactory amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-year, and juvenile survival;
- A natural hydrograph, including peak, high, low, and base flows within historic ranges;

- Springs, seeps, groundwater sources, and subsurface water to contribute to water quality and quantity;
- Migratory corridors with minimal physical, biological, or water quality obstacles between spawning, rearing, overwintering, and foraging habitats;
- An abundant food base including terrestrial organisms of riparian origin, aquatic macroinvertebrates and forage fish;
- Sufficient water quantity and quality such that normal reproduction, growth and survival are not inhibited.

3.4 Species in the Plan Area that Do Not Need Coverage

The following additional bird, animal and plant species were considered for inclusion in the HCP based on a remote potential for occurrence within the project area. They have subsequently been excluded for the reasons described herein.

Species	Status[1]	Jurisdiction
Marbled murrelet (*Brachyramphus marmoratus*)	T	USFWS
Marbled murrelet critical habitat		USFWS
Yellow-billed cuckoo (*Coccyzus americanus*)	T	USFWS
Canada lynx (*Lynx Canadensis*)	T	USFWS
Canada lynx critical habitat		USFWS
Gray wolf (*Canis lupus*)	E	USFWS
Golden paintbrush (*Castilleja levisecta*)	T	USFWS
Marsh sandwort (*Arenaria paludicola*)	E	USFWS

[1] Status: **T**hreatened or **E**ndangered.

3.4.1 Marbled Murrelet

Marbled murrelet (*Brachyramphus marmoratus*) was listed as threatened by the USFWS in 1992. Marbled murrelets breed from April 1 to September 15 and nest in mature and old growth forests within 60 miles of marine waters. Potential threats to marbled murrelet populations include loss of old-growth forest, disturbance during nesting, nest predation, oil spills, entanglement in gill nets, and disturbance during foraging (Ralph et al. 1995). Marbled murrelets forage and winter in marine habitats in relatively low densities with the highest numbers generally observed in fall (Speich and Wahl 1995). There are no known marbled murrelet nest sites in the Plan Area (WDFW PHS web maps) and wooded areas in the Plan Area are 2nd or 3rd growth forests which have low potential for murrelet-nesting habitat.

Marbled Murrelet Critical Habitat

Critical Habitat for the marbled murrelet has been designated in 1996 to protect nesting areas with the primary constituent elements (PCEs) described as (1) trees with potential nesting platforms and, (2) forested areas within 1/2 mile of potential nest trees with a canopy height of at least 1/2 of the site potential tree height. Marine forage areas are not specifically designated as critical habitat however, forage habitat is implied as important through general PCEs including but not limited to, the following:

- Space for individual and population growth, and for normal behavior;
- Food, water, air, light, minerals or other nutritional or physiological requirements;
- Cover or shelter;
- Sites for breeding, reproduction, rearing of offspring; and
- Habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species.

The Plan Area associated with the proposed Electron diversion project is privately owned and is managed for forest harvesting. The forested uplands in the project area are second and third growth forests that are unsuitable or have low potential for nesting.

3.4.2 Yellow-billed Cuckoo

The Yellow-billed cuckoo (*Coccyzys americanus*) was listed as threatened by USFWS in 2014. Historically, western yellow-billed cuckoos occurred west of the Continental Divide, from British Columbia south into northern Mexico. They no longer occur in much of their historic range and are now a rare visitor in Washington State. Between 1950 and 2000, only 12 sightings have been recorded, four in western Washington and eight in eastern Washington). These birds breed rarely and locally along rivers in Arizona, California, and New Mexico. They migrate to wintering grounds in South America. Habitat loss, specifically near-water habitat and pesticide use have been the primary causes for the decline of the yellow-billed cuckoo. Critical habitat designation is currently in review and would include protecting of 80 separate units in western States. No critical habitat areas are proposed in Washington State.

3.4.3 Canada Lynx

The lynx (*Lynx Canadensis*) is a medium-sized cat with long legs, large, well-furred paws, long tufts on the ears, and a short, black-tipped tail. Adult males average 22 pounds in weight and 33.5 inches in length, head to tail, and females average 19 pounds and 32 inches. The lynx's long legs and large feet make it highly adapted for hunting in deep snow. The distribution of lynx in North America is closely associated with the distribution of North American boreal forest. In Canada and Alaska, lynx inhabit the classic boreal forest ecosystem known as the taiga. The range of lynx populations extends south from the classic boreal forest zone into the subalpine forest of the western United States, and the boreal/hardwood forest ecotone in the eastern United States. Forests with boreal features extend south into the contiguous United States along the North Cascade and Rocky Mountain Ranges in the west, the western Great Lakes Region, and northern Maine. Within these general forest types, lynx are most likely to persist in areas that receive deep snow and have high-density populations of snowshoe hares, the principal prey of lynx. Lynx are secretive and very rare; there has been a recorded capture of a lynx in Pierce County in the 1960s (Stinson 2000).

Critical habitat was designated in November 2014 and includes areas in north central Washington State from the US Canada boundary south to Lake Chelan. The Action Area is not within the critical habitat designated for Canada lynx. Primary Constituent Elements of Canada lynx critical habitats are boreal forest landscapes supporting a mosaic of differing successional forest stages and containing:

1. Presence of snowshoe hares and their preferred habitat conditions, which include dense understories of young trees, shrubs or overhanging boughs that protrude above the snow, and mature multistoried stands with conifer boughs touching the snow surface
2. Winter conditions that provide and maintain deep fluffy snow for extended periods of time
3. Sites for denning that have abundant coarse woody debris, such as downed trees and root wads
4. Matrix habitat of hardwood forest, dry forest, non-forest, or other habitat types that do not support snowshoe hares which occurs between patches of boreal forest in close juxtaposition (at the scale of a lynx home range) such that lynx are likely to travel through such habitat while accessing patches of boreal forest within a home range.

3.4.4 Gray Wolf

Gray wolves (*Canis lupus*) were formerly common throughout most of Washington but declined rapidly between 1850 and 1900. The primary cause of this decline was the killing of wolves by settlers as ranching and farming activities expanded. Wolves were essentially eliminated as a breeding species from the state by the 1930s. Wolves are returning into Washington from populations in adjacent states and provinces (Idaho, Montana, Oregon, and British Columbia) and some are forming resident breeding packs. The first documented breeding pack was confirmed in 2008. As of July 2011, there were five confirmed packs in the state: two in Pend Oreille County; one in Pend Oreille/Stevens counties; one in Kittitas County; and one in Okanogan/Chelan counties. There have been no recent sightings of wolfs in Pierce County or in the Mt. Rainer National Park. Gray wolf Critical Habitat has not been designated.

3.4.5 Golden Paintbrush (Castilleja levisecta)

Golden paintbrush is a short perennial herb that grows in open grasslands in the Puget Trough lowlands generally in glacial outwash or depositional material, at elevation less than 300 feet. This plant is often associated with grasses, Roemer's fescue, red fescue, and the invasive shrub, Scot's broom. Historically, fire played a key role in the maintenance of open prairie habitat and may enhance plant vigor and seedling recruitment. No critical habitat has been designated for this rare plant. The Plan Area is at elevations of greater than 1,500 feet MSL in a managed forest. Suitable habitat for golden paintbrush is not present in the Plan Area.

3.4.6 Swamp Sandwort (Arenaria paludicola)

Swamp sandwort is a very thin trailing perennial that grows in swamps, wetlands and freshwater marshes along the coast to the elevation of 1,500 feet. There has been one verified collection from swamps near Tacoma. The Plan Area is at elevations of greater than 1,500 feet MSL in a managed forest although forested wetland habitat may be present these areas are not likely suitable habitat for swamp sandwort is not present in the Plan Area. No Critical habitat has been designated for this species.

4.0 ENVIRONMENTAL SETTING

4.1 Environmental Setting

4.1.1 Climate

WESTERN WASHINGTON – West of the Cascade Mountains, summers are cool and comparatively dry and winters are mild, wet and cloudy. The average number of clear or only partly cloudy days each month varies from four to eight in winter, eight to 15 in spring and fall, and 15 to 20 in summer. The percent of possible sunshine received each month ranges from approximately 25 percent in winter to 60 percent in summer. In the interior valleys, measurable rainfall is recorded on 150 days each year and on 190 days in the mountains and along the coast. Thunderstorms over the lower elevations occur on four to eight days each year and over the mountains on seven to 15 days. Damaging hailstorms rarely, if ever, occur in most localities of western Washington. During July and August, the driest months, it is not unusual for two to four weeks to pass with only a few showers; however, in December and January, the wettest months, precipitation is frequently recorded on 20 to 25 days or more each month. The range in annual precipitation is from approximately 20 inches in an area northeast of the Olympic Mountains to 150 inches along the southwestern slopes of these mountains. Snowfall is light in the lower elevations and heavy in the mountains.

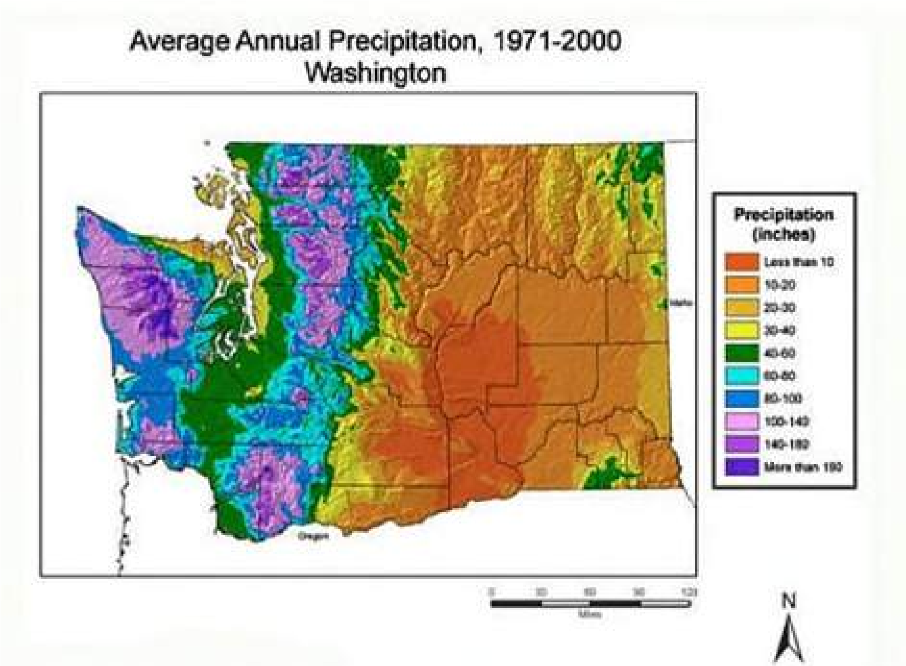
During the wet season, rainfall is usually a light to moderate intensity and continuous over a period of time, rather than heavy downpours for brief periods. Maximum rainfall intensities to expect in one out of ten years are: .6 to 1.0 inch in one hour; 1.0 to 2.5 inches in three hours; 1.5 to 5.0 inches in six hours; and 2.0 to 7.0 inches in 12 hours. The heavier intensities occur along the windward slopes of the mountains.

During the latter half of the summer and early fall, the lower valleys are sometimes filled with fog or low clouds until noon, while at the same time, the higher elevations are sunny. The strongest winds are generally from the south or southwest and occur during the late fall and winter. In the interior valleys, wind velocities can be expected to reach 40 to 50 m.p.h. each winter and 75 to 90 m.p.h. once in 50 years. The daily variation in relative humidity in January is from approximately 87 percent at 4 a.m. to 78 percent at 4 p.m., and in July from 85 percent at 4 a.m. to 47 percent at 4 p.m. During periods of easterly winds, the relative humidity occasionally drops to 25 percent or lower. The highest summer and lowest winter temperatures are usually recorded during periods of easterly winds. The total evaporation for the warm season, May through September, as measured by a National Weather Service evaporation pan at Seattle, is 25 Inches with an average of seven inches in July.

CASCADE MOUNTAINS-WEST[1] **–** This area includes the western slope of the Cascade Range from an elevation of approximately 1,000 feet to the summit and extending from the Columbia River to the Canadian Border. Daily temperatures and precipitation reporting stations have been limited to elevations below 5,500 feet. Snow course measurements consisting of snow depth and water content of the snowpack are available for some of the higher elevations. Orographic lifting of the moisture-laden southwesterly and westerly winds results in heavy precipitation in this area. The annual precipitation ranges from 60 to 100 inches or more. Indications are that the heaviest precipitation probably occurs along the slopes of east-west mountain valleys which become narrower as the elevation increases along the windward slopes of the Cascades. Annual precipitation in some of the wetter areas has reached 140 inches in one out of ten years.

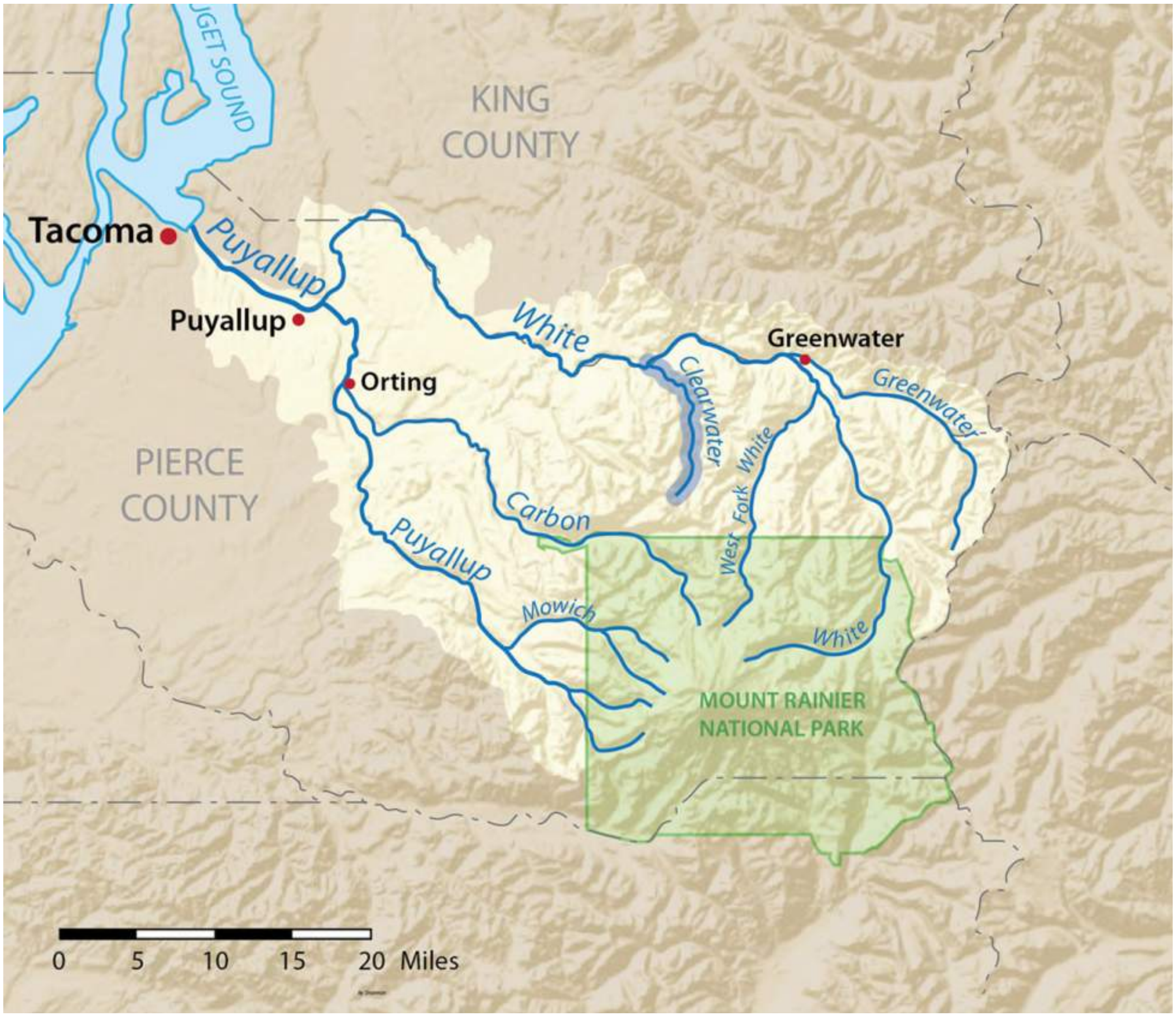
The average winter season snowfall ranges from 50 to 75 inches in the lower elevations, gradually increasing with elevation to between 400 and 600 inches at 4,000 to 5,500 feet. Some of the greatest seasonal snowfalls and snow depths in the United States have been recorded on the slopes of Mt. Rainer (14,410') and Mt. Baker (10,778'). The greatest seasonal snowfall recorded at Mt. Rainer-Paradise Ranger Station (elevation 5,500 ft) was 1,000 inches in 1955-56. These and other high peaks above 7,000 or 8,000 feet remain snowcapped throughout the summer. Snowfall usually begins in the higher elevations in September, gradually working down to 3,000 feet by the last of October. The snowline in midwinter varies from 1,500 to 2,000 feet above sea level. Although snowfall continues until late spring, the maximum depth is usually reached during the first half of march. At this season of the year, snow depths above 3,000 feet range from 10 to 25 feet. The density of the snowpack increases from approximately 30 percent water the first of December to 45 percent water in March. In elevation above 5,000 feet, snow remains on the ground until the last of June or first of July.

The average January maximum temperature ranges from 40° F in the lower elevations to 30° F at the 5,500-foot elevation. Minimum temperatures range from 30° F in the lower elevations to 20° F in the higher elevations. Minimum temperatures from 0° to -17° F have been recorded in the higher elevations to the lower 60's in the higher elevations. The minimum temperature is in the 40's. Above 4,000 feet minimum temperatures occasionally drop below freezing in midsummer. In general, the temperature decreases approximately 3° F with each 1,000 feet of elevation.



[1] Western Regional Climate Center

4.1.2 Topography/Geology



4.1.2.1 Puyallup River, Upper Reach

The Puyallup River originates from glaciers on the west and north slopes of Mt. Rainier within Mt. Rainier National Park. Upstream of the Electron Diversion, located at RM 41.7, river channels begin to form at about 6000-7000' in elevation as steep cutting ravines between mountainous rock ridgelines following historic glacial paths down valley to more moderate river grade profiles. Rainier's glaciers are leaving extensive unconsolidated glacial sediment exposed as lateral and terminal moraines along the upper valley floors as they slowly recede back up the mountain. These vast exposed areas of unconsolidated sediment are gradually being transported downstream to the gentler sloped valley floors, causing a significant rise in riverbeds and amplifying meandering river channels downstream.


Headwaters, N. Fork Puyallup River on Western Slopes of Mt Rainier

Outside of the Park, land within the watershed is primarily used for timber production and as a result has a high road density and is frequently disturbed by logging operations. This type of land use also contributes significantly to sediment runoff and transport downriver.


Typical Commercial Timber Landscape at Confluence of N. and S. Forks Puyallup River

Bedload and suspended sediment loads are highest in the river typically in late spring through early fall when snow and glacier melt combined with precipitation are at their highest (Embrey 1991).

The Mowich River is the largest tributary to the Upper Reach, entering the Puyallup at RM 42.4, about 2/3rds of a mile upstream of the Diversion. Other notable tributaries discharging into the Upper Reach consist of:

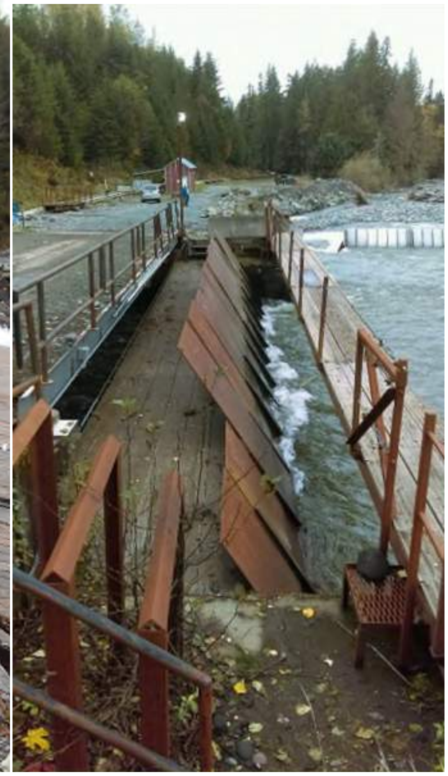
- Deer Creek (west bank tributary at RM 45.7)
- North Fork Puyallup River (east bank tributary at RM 47.0)
- South Fork Puyallup River (west bank tributary at RM 47.0)

A total of approximately 93 square miles of watershed land area lie above the Diversion.

Watershed Discharge Measured at USGS Electron Gage 12092000, Located 1/3 Mile Upstream of the Diversion

4.1.2.2 Puyallup River Middle Reach

The Diversion represents the upper end of the approximately 10-mile long middle reach. For over 115 years sediment has collected and remained behind the Diversion structure, flattening the natural river profile immediately upstream, causing increased channel width, meandering and bank cutting. These effects appear to extend up to 1,200ft. upstream of the Diversion.



Bedload stacked upstream of Diversion structure | Existing Intake Wall & Flow Plates

Downstream of the Diversion begins an approximately 2.5-mile reach that is a wide, low gradient (less than 2%), braided and meandering channel section. This segment includes some intermittent gravel bar islands, some with established tree and shrub vegetation, that move and shift periodically with increasing high flows.

2.5 Mile Section of the Middle Reach Immediately Downstream of the Diversion

For the next 3.5 miles downstream the river channel steepens somewhat and essentially maintains a single channel. There are a few prominent gravel bars in this section, as well as the occasional deep pool. The first in-river rock outcrops begin to show about 6 miles downstream of the Diversion, indicating the beginning of the canyon for the lowest 4 miles of the middle river reach before reaching the Powerhouse.

The canyon refers to the lowest 4 miles of the middle reach. The river flows faster in a single narrow channel within a ravine-turned-gorge with very steep side walls, some of which are all rock. There are periodic narrows as slight as 20 ft wide with corresponding deep channel, deep pool structure. There is evidence of periodic landslides on both sides of the channel in this section of river.

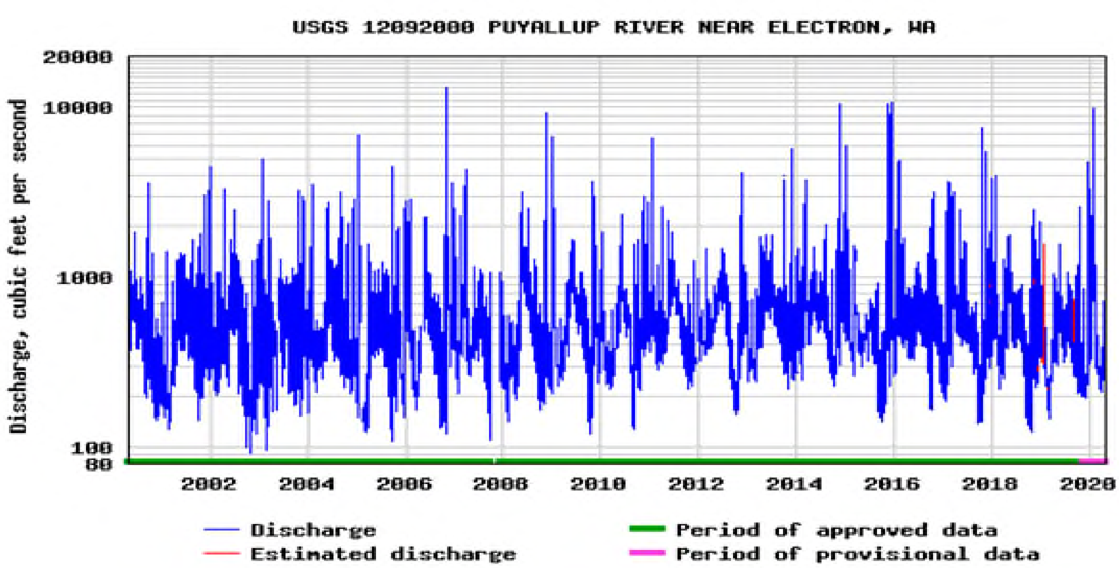
4.1.2.3 Lower Reach

The Puyallup River downstream of the Powerhouse (RM 31.2) maintains a moderately shallow gradient to the confluence with the Carbon River (RM 17.9). The stream channel has increasing pool-riffle habitat sequences that provide improved fisheries habitat compared to the cascading headwater streams (Pierce County 1999). The valley side slopes maintain relatively dense, mixed deciduous and coniferous forest (Williams et al. 1975). Agricultural and rural land uses are more prevalent in the Lower Reach compared to the upstream reaches. The heavy sediment load present in the Middle and Upper reaches persists through the Lower Reach. Setback levees are present between RM 16 and 18, where diking and channelization have occurred (Williams et al. 1975). Major tributaries entering the Lower Reach include: 1) Fox Creek (east bank tributary at RM 29.3), Kapowsin Creek (west bank tributary at RM 27.5), Fiske Creek (east bank tributary at RM 26.7), and Unnamed Tributary #10-0589 (west bank tributary at RM 20.2).

Electron's influence on the Lower Reach is associated with river stage fluctuations during project start up and shut down, however is attenuated by time and distance downstream.

4.1.3 Hydrology

Hydrology of the river is bi-modal with two peak flow periods each year. The larger peak flows occur in the late fall primarily from rain and a smaller peak period in the late spring from rainfall and snow/glacier melt. There is heavy natural summer silt flow in this reach due to the glacial melt, unconsolidated slopes, wide shallow channel, occasional glacial bursts and historic mudflows. Bedload and suspended sediment loads are high in the river, particularly in late spring through early fall when snow and glacier melt are at their highest (Czuba et.al. 2010).



Glacial meltwater maintains a baseflow in the mainstem and causes high turbidity levels in the river during summer and early fall.

Over recent years the river appears more "flashy", i.e. rapid runoff in shorter time frames. This is witnessed recently as four storm events within the last six years resulting in river discharges of at least 10,000 cfs (at the Electron USGS Gage), a threshold previously calculated to re-occur approximately every 18 years.

The Project may draw a maximum of 400 cfs for power generating purposes and is required to maintain instream flows of 60-80 cfs immediately below the Diversion. The hydrology of the river generally supports this regime for nearly the entire year, but sometimes flow falls below 500 cfs either during a hard, extended freeze or late summer/early fall. A full treatise of the river hydrology upstream of the Powerhouse is provide in Appendix A, "Hydrology Tech Memo".

4.1.4 Water Quality

The Puyallup River and its tributaries lying upstream of the Powerhouse encompass a watershed that is a combination of public and private property used predominantly for timber production, with the exception being Mt. Rainier National Park. Essentially devoid of development and any appreciable human occupancy, there are few unnatural pollutants introduced to the river system as a result. The primary water quality considerations are temperature and turbidity, both being heavily influenced by the quantity of river flow discharge and timber harvest operations.

4.1.4.1 Temperature

During the late summer/early fall period when there may be some temperature vulnerability from a fish habitat perspective, the snow and glacial meltwater runoff from Mt Rainier keeps water temperature cool within the Project reach and upstream thereof. Even during seasonal low flow periods temperatures stay within the range of "Core Summer Habitat"[1] WDOE water quality standards for temperature.

[1]WAC 173-201A-602 Table 602:

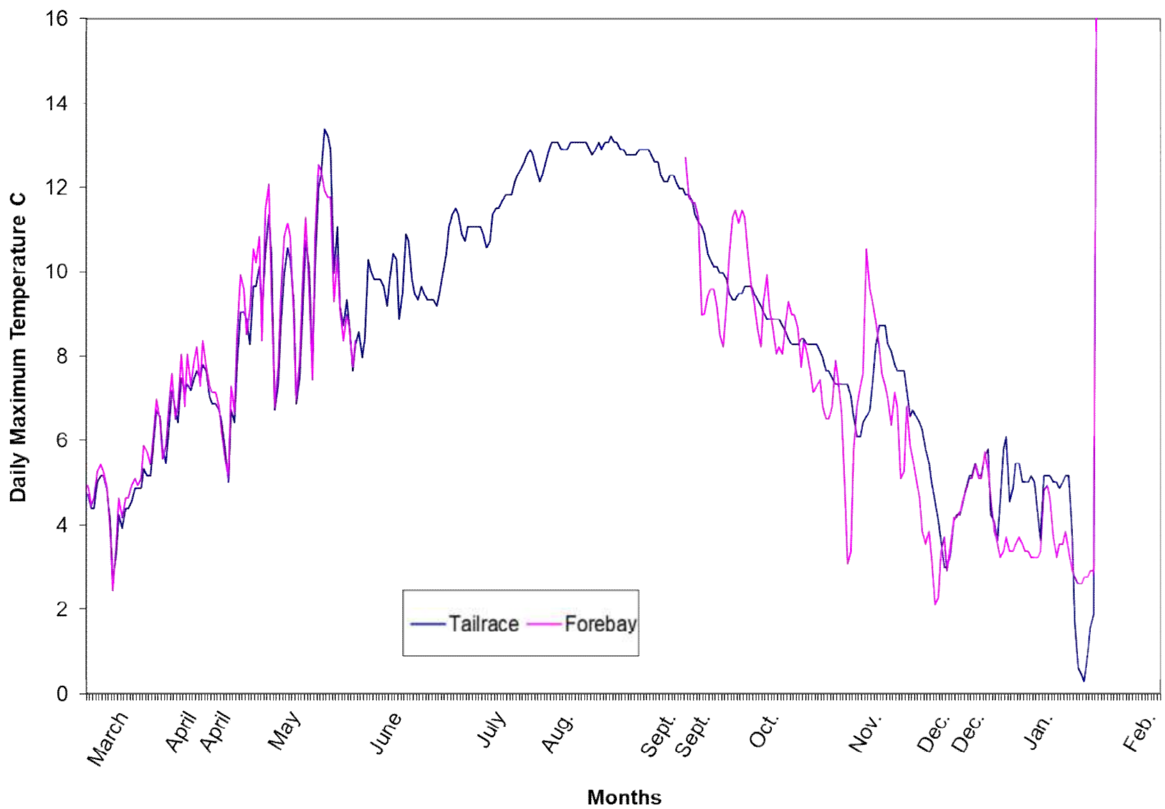
Puyallup River: Upstream from the confluence with White River (latitude 47.1999, longitude -122.2591) to Mowich River (latitude 46.9005, longitude -122.031), including tributaries (except where designated char).

WAC 173-201A-200 (1)(c) Core Summer Salmonid Habitat

Table 200 (1)(c)

Category	Highest 7-DADMax
Char Spawning and Rearing*	12°C (53.6°F)
Core Summer Salmonid Habitat*	16°C (60.8°F)
Salmonid Spawning, Rearing, and Migration*	17.5°C (63.5°F)
Salmonid Rearing and Migration **Only**	17.5°C (63.5°F)

Typical annual water temperature profile for Forebay and Tailrace shown below.



Maximun daily water temperature measured at the Electron forebay and tailrace for January 2006 to January 2007.

4.1.4.2 Turbidity

Outside the Park boundaries, the river courses through industrial forestlands including national forest but primarily private timber company ownership. Much of these forestlands have been harvested at least once, and in many cases twice. Lands in timber production have dense road networks with some sections approaching six lineal miles per square mile. Roads have contributed to many of their trademark problems such as landslides, slope failures, altered hydrology, culvert and bridge projects that can affect upstream migration and result in high levels of sedimentation. This is the primary ongoing unnatural adverse impact on water quality.

Construction and operation of the Project has the potential to impact naturally occurring turbidity, sedimentation and bedload quantities.

Prior to completion of Phase I, sediment is/was inducted at the Diversion intake, entering the flume and transported 4 miles downline to the Settling Basin, and then another 6 miles to the Forebay. The Settling Basin is routinely bailed/dredged by excavator, sometimes daily, to remove sand from the settling channel and then spread it on adjacent uplands for disposal. Finer suspended materials continue onward to the Forebay. The Forebay has been periodically drained and dredged of fine sediment every few years, with disposal occurring on nearby uplands. Under this pre-Phase I completion scenario there is a net removal of fine sediment, sand and therefore turbidity from the 10 mile bypass reach.

Construction of Phase I will avoid turbidity impacts by isolating the work area from the open river channel with cofferdams, geo-membranes and fixed walls. The de-watering plan will provide for settling and clarifying before water returns to the river.

Completion of Phase I, successful operation of the Bladder Spillway and the sand sluice will prevent the vast majority of sediment from entering the Flume and instead will pass the sediment and bedload through the spillway naturally resulting in no net diversion of sediment.

Generally speaking, the river exhibits three main turbidity/sediment/bedload phases: 1) low flow, cold weather, clear water 2) low flow, warm melting weather, glacial flour, gray/brown colloids 3) any flow over 700 cfs starts to move bedload resulting in brown opaque water.

As noted in numerous reports and discussion of river changes, there is a trend toward more flashy flows, higher peaks and shorter duration discharge, more sediment and fewer clear water days. Also as glaciers melt, bedload becomes exposed increasing bedload in the lower drainage.

4.1.5 Existing Land Use

Land use within the Project watershed is predominantly commercial timber land, the exception being the headwaters that lie within Mt Rainier National Park.

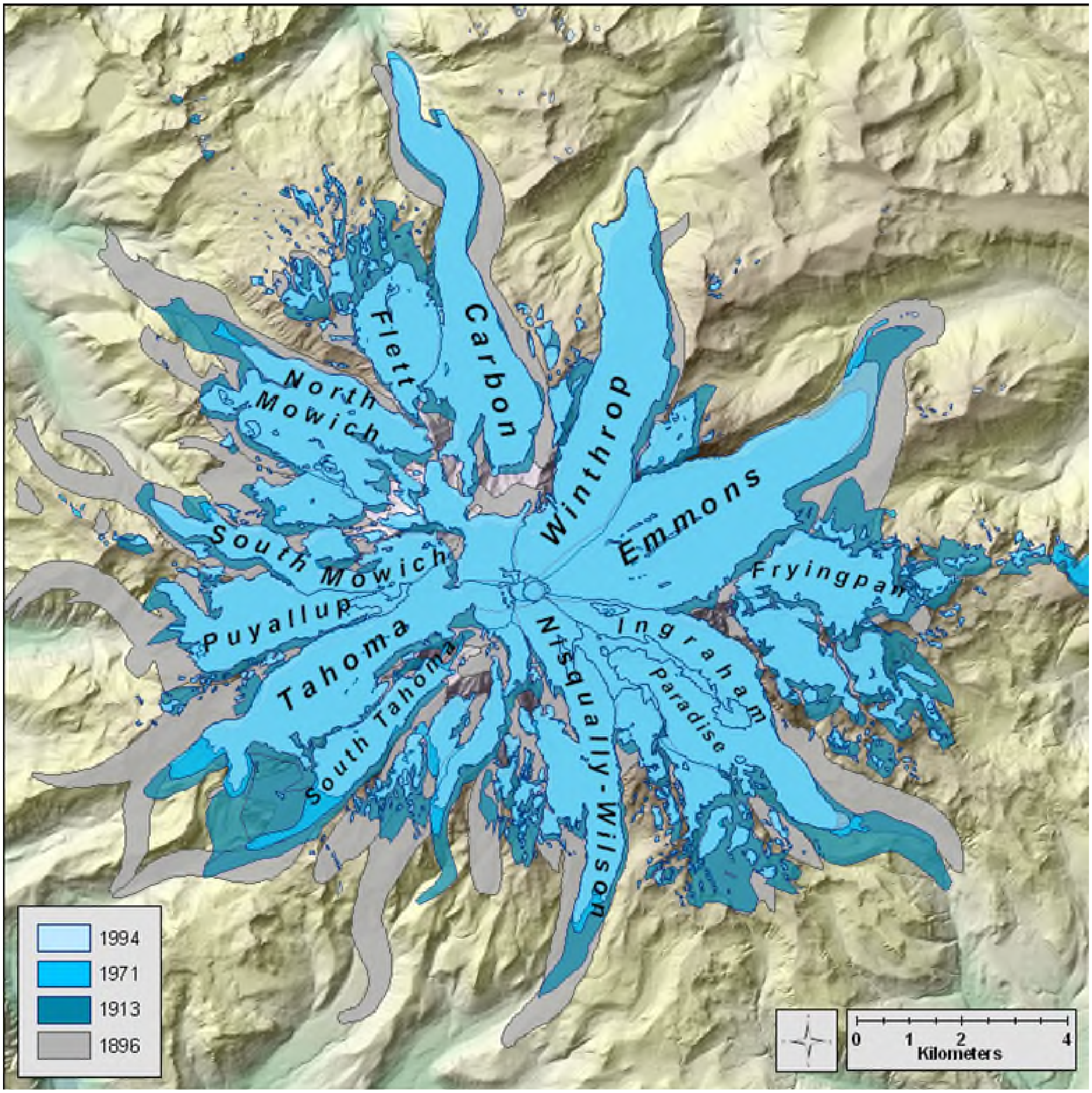
Outside the Park there is some outdoor recreational use of the private timberland by fee permit system administered by the private timberland owners. This use is relatively light due to the numerous public access option alternatives such as National Forest and State-owned lands nearby. These uses have little impact or consequences on the environment.

Notably, the Project does own 10 miles of shorelands adjacent to the river that help preserve a mature landscape, hillslope stability and provide undisturbed habitat for potentially sensitive wildlife species.

4.2 Climate Change

Climate change is an alteration in regional and global climate patterns, which largely attributes to increased levels of carbon dioxide and other "greenhouse" gases that trap heat within the earth's atmosphere. Over the millennia climate change has occurred due to natural processes, but more recently since the mid 1900's scientists claim the rate of climate change has been attributed to industrialization and anthropogenic activities, mostly due to the combustion of fuels.

Changes may occur in seasonal precipitation, temperature, wind patterns and the frequency and intensity of specific weather events. The operation of the Project itself does not affect these variables, but the Project may need to adjust to any critical changes in these parameters to continue to operate effectively without increasing any potential harm to the listed species. Some observations of climate change locally include monitoring the retreat (and occasional advance) of glaciers on Mt Rainier. With a few exceptions, most of the glaciers on Mt Rainier have retreated notably in the past 100+ years. Several glaciers on the north and west sides contribute to the Puyallup River.



Mt Rainier Glacial Change

The *Climate Change Impact Assessment and Adaptation Options*[2] describe the many possibilities of climate change impacts on the Puget Sound region. A few examples include:

- Increasing average annual temperatures
- More rainfall in the winter months, contributing to higher rates of run-off
- Dryer summer months, meaning lower river flows and higher possibilities of wildfire

[2] Puyallup Tribe of Indians 2016, Puyallup Tribe and Cascadia Consulting Group

Throughout the lifespan of the Project power generation has continued during periods of extreme weather and therefore hydrology. There have been river flows too low to operate as well as extreme flood events, landslides, snow and ice storms, windstorms, falling timber and forest fires that have periodically interrupted generation. Weather is a short term naturally occurring event but over the past 115+ years has represented the full range of potential conditions that may affect the Project operational constraints year after year throughout decades of prior climate change. During the most extreme natural events the Project simply does not operate.

The potential Project influences on the listed species specifically due to potential climate change over the 30-year Incidental Take Permit period are likely to consider specific provisions for adequate instream flow to provide for all instream life stage habitat and migration as well as sediment release and transport in a benign manner. Instream flow, water temperature, ramping and sediment transport are essential considerations for all phases of instream life support and are not likely to change in priority. Specific responses to potential climate change Project management and operations are addressed in Chapter 7.0.

5.0 POTENTIAL BIOLOGIICAL IMPACTS AND TAKE ASSESSMENT

5.1 Direct and Indirect Impacts

The potential direct impacts of the Project on the listed species result from:

(a) Under current Project conditions and until completion of Phase II:

(1) Fish leaving the river at the water intake and being entrained in the Flume (including Settling Basin and Forebay);

(2) Capture of fish in the Forebay and return of the fish to the river;

(b) Following completion of Phase I, Bladder and Sluice Gate operations;

(c) At any point during the term of the HCP:

(1) Stranding of fish in the Middle Reach due to rapid ramp-down of instream flow;

(2) Obstruction of the fish ladder; and

(3) Project construction, routine or emergency repairs and replacement of Project components, and maintenance activities.

The potential indirect impacts of the Project on the listed species are: (a) impairment of upstream fish passage, affecting access to habitat above the diversion structure; (b) impairment of downstream fish passage within the Middle Reach; (c) potential “false attraction” of listed species to flow from the Rock Chutes; and (d) interference with the natural movement of bedload rock and sediment down the river channel, affecting habitat conditions immediately upstream and downstream of the diversion structure.

The potential direct impacts of the Project on designated critical habitat are changes in habitat conditions immediately above the Diversion and below the Diversion within the Middle Reach resulting from existence or operation of the Project, including instream flows, ramping rates, sediment movement, water temperature and water quality.

5.2 Anticipated Take

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect," or to attempt to engage in any such conduct. 50 C.F.R. §§10.12, 222.102.

"Harm" is further defined by the Services as an act which actually kills or injures wildlife, including significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns. 50 C.F.R. §§17.3, 222.102. USFWS regulations provide examples of "harm" as "including breeding, feeding, or sheltering. 50 CFR §17.3. NMFS provides examples of "harm" as "including breeding, spawning, rearing, migrating, feeding, or sheltering." 50 CFR §222.102. "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant. 50 CFR §402.02.

5.2.1 Entrainment Prior to Phase II.

Until EH completes installation of fish exclusion screens at the Intake, the Project will continue to entrain fish, requiring continuing operation of the Trap and Haul system at the Forebay. A limited number of entrained fish leave the Flume and re-enter the river (below the Diversion) at the rock chutes built into the Flume. The rest are shunted down the Flume to the Settling Basin and Forebay where they are removed by the Trap and Haul system, which returns between 85 and 95 percent of entrained fish to the river.

Any entrained fish that are not removed by the Trap and Haul system may remain in the Forebay, become prey for predators, or be entrained in the Penstocks and killed in the turbines.

Once the fish screen is operational, the fish exclusion facility will eliminate entrainment of fish in the Flume.

5.2.2 Impingement Following Completion of Phase II.

The fish exclusion facility will prevent fish from being diverted into the Flume. However, fish still could be injured by impingement against the fish screen and concentrated predation. The potential for this to occur is influenced by the design of the fish exclusion facilities and its adaptation to river conditions.

EH is developing the exclusion facility design with input from the Services regarding best practices and design features to minimize impingement or other impacts to listed fish species. In addition, the Phase II design will not be finalized until after completion of Phase I to allow the Phase II design to be optimized for the behavior of the river with the Bladder Spillway installed and in operation. By incorporating site-specific conditions and the Services' guidance, the fish exclusion structures should be able to operate with minimal impingement and little or no potential for injury to listed species.

There also will be the potential for periodic partial or complete sediment, debris or ice obstruction of the fish exclusion facility, inadequate flow-through volumes, and concentration of adult predator species in the flow gallery and at the return outfall. If these events were to occur fish may be stranded, isolated, preyed upon or otherwise unable to migrate downstream. These potential sources of fish mortality may be avoided or minimized by monitoring and maintenance of the facilities to ensure proper functionality, maintain design velocities for sweeping flows and passage flows, provide regular screen cleaning and return outfall inspection. Fencing and overhead predator control netting may become necessary if there appears to be fish concentration and concentrated predation.

5.2.3 Stranding due to Downward Ramping/Bladder Operation/Pool Drawdown

During high flow events, the Bladder is likely to be deflated quickly to facilitate bedload transport that mimics natural conditions. This could result in a rapid decrease in the volume of water in the pool above the Diversion, which could have the potential to strand fish at the margins of the Diversion pool, resulting in direct mortality or increased exposure to predation.

Similarly, if the Bladder is inflated quickly, that could result in a rapid decrease in the rate of discharge over the Spillway to the Middle Reach, which could have the potential to strand fish as water levels rapidly drop within the Middle Reach. A rapid reduction in tailrace discharge rates from the Powerhouse could have a similar impact in the river segment immediately below the Powerhouse.

A study of the impact of ramping rates (Hunter 1992) found that fish stranding is likely to be avoided by maintaining ramping rates of 2 to 4 inches per hour. When deflating the Bladder, it will not be feasible to maintain those ramping rates in the pool above the Diversion in many operating scenarios. However, when inflating the Bladder and reducing discharge to the Middle Reach, EH will operate the Project consistent with ramping rates of 2 to 4 inches per hour to avoid fish strandings.

For the Powerhouse tailrace discharges, EH will follow the Hunter 1992 ramping rates to the maximum extent practicable. During emergencies and upsets, it may not be feasible to do so. Such emergencies are unlikely to occur more than one to two times a year.

5.2.4 Fish Ladder

The Project's Diversion structure was constructed in 1904. The Diversion structure blocked all upstream fish passage until 2000 when a concrete pool and weir-type fish ladder was constructed. The Ladder requires at least 10 cfs to function properly, and it provides passage over the design flow range from 10 to 55 cfs. This range of flows through the ladder corresponds to river flows ranging from 160 to 1,100 cfs.

If the Ladder's design flows are not maintained, or if the entrances to the Ladder are blocked by debris, fish may be unable to migrate upstream past the Diversion to fully utilize upstream habitat. Fish might also become stranded or isolated, or become more vulnerable to predator species. When design flows are occurring but sediment accumulates within the Ladder, it may take more energy for fish to make their way upstream through the Ladder but the Ladder continues to function as a roughened channel and to facilitate fish passage around the Diversion. These direct and indirect impacts can be substantially avoided through proper maintenance of the Ladder.

The Ladder is located on the opposite side of the Diversion from the Intake. The thalweg, at times, flows within the Puyallup River along the left bank of the river. With the Project's current configuration, water re-entering the river through the rock chutes can be more of an attraction flow for bull trout migrating up-river than the attraction flows out of the Ladder. USFWS has expressed concern that this may result in bull trout entering the rock chutes and getting entrained in the Flume instead of migrating above the Diversion via the Ladder. (USFWS 2018). Installation of the Bladder spillway will reduce this potential impact by maintaining a steady pool height behind the Diversion, maintaining flows to the Ladder. The potential for false attraction to result in entrainment in the Flume will be eliminated by installation of the fish exclusion facility during Phase II construction and reduced flow in the rock chutes.

5.2.5 Project Construction, Maintenance, Repairs and Replacement

The construction of Phase II and ongoing Project maintenance, repairs and routine replacement, such as debris removal, Ladder maintenance, and repairs to Intake and Sluice gates, could temporarily affect water quality in the river by dislodging sediments and briefly increasing turbidity. Phase II construction will be off channel and is not expected to materially impact water quality. While none of these activities are likely to result in take of listed fish species, EH will implement best practices to avoid and minimize impacts to water quality during ongoing construction, maintenance, repair, and routine replacement activities.

EH operates gas-powered and diesel-powered equipment and machinery that uses lubricating and hydraulic oils at the Headworks and along the Flume, including the Speeders that run on the tracks on top of the Flume. There is a potential for releases of gas or oils from these operations, which could affect water quality in the River. To minimize any potential impact on listed fish species, EH has developed and implements practices and procedures designed to eliminate any discharge of waste or pollutants to any water body, or to the ground, to the maximum extent practicable.

5.3 Anticipated Impact on Critical Habitat

5.3.1 Above the Diversion

EH conducted a Geomorphology and Sediment Transport Study (Cherry 2016) to assess the extent to which Bladder operations would affect channel sediments above the diversion. Continuous operation of the Bladder to maintain a steady pool elevation will minimize the effects of the Diversion on bedload sediment transport. Bedload will pass the Diversion in proportion to the amount of flow in the river. The effect of the Bladder on temporary sediment storage upstream will be highest when fully inflated and lowest when fully deflated. Generally, EH will vary Bladder inflation with flow to closely mimic the natural transport of bedload with river flow.

Deflating the Bladder at high flow and lowering the controlling bed elevation from the existing 3 feet to the proposed 12 feet would result in an immediate and rapid response as bed scour or "headcut" in the immediate vicinity of the Diversion. Over time, the scour would progress upstream and the effective bed slope (and related water surface slope) would get progressively flatter. The rate of bed scour slows down as it progresses upstream. According to Cherry 2016, this scour could progress as far as 800 feet upstream of the diversion structure.

USFWS conducted a rough analysis based on topography maps and calculated the headcut may migrate as far as 0.5 mile upstream (approximately 2,700 feet) to the confluence with the Mowich River (USFWS 2018).

The headcut results from the difference in river elevation above and below the Diversion. The 12-foot difference in elevation would migrate upstream until either the headcut hits a hard surface, like a bedrock outcrop, or a gradient change in the river results in the headcutting stopping its upstream migration. Following Cherry 2016, EH estimates the headcut will migrate upstream approximately 800 feet. As noted, USFWS has estimated that headcutting may extend up to 2,700 feet. The headcut would occur, most often, in the fall and winter during the highest flows of the year.

5.3.2 Middle Reach

The Project's diversion of water may have adverse impacts on listed fish species during low flow periods, although the diversion may enhance habitat conditions somewhat during high and very high instream flow events. Reduced instream flow reduces wetted area habitat for fish and their food sources (such as macroinvertebrates), reduces channel depth where needed for upstream and downstream migration, may concentrate adult and juvenile fish in available pools altering predator/prey relationships and could result in raised temperatures and lower dissolved oxygen within isolated pools within the Middle Reach. Very low flows would also likely result in greater exposure of all life stages of fish to avian and terrestrial predators. Low flow impacts would most likely be significant within the first 3800 ft. downstream of the Diversion before Neisson Creek, the first tributary below the Diversion, joins the main river. The approximately 2.5 mi reach downstream of the Diversion could experience some adverse effects due to the wide, shallow and often braided channel. The absence of flow concentration in this river segment could create upstream fish passage challenges; due to the shallow and often braided channel this reach of the river is not considered spawning habitat. Flows within the Middle Reach typically increase downstream of the Diversion as each tributary provides additional flow, except occasionally during periods when tributary base flow is exhausted.

Sediments will be flushed into the Middle Reach by Spillway Sluice and Bladder operations. PTI and the Services have expressed concerns that this could damage spawning habitat and redds and rearing habitat downstream of the Diversion. As just noted, the reach immediately below the Diversion is not considered spawning habitat, as it is relatively wide, shallow, and likely to have braided channels. The release of sediments from above the Diversion during Bladder operations should be similar to natural sediment transport. The Bladder will be deflated at relatively high river stages, during conditions when significant amounts of sediment and bedload are being mobilized by high instream flow rates.

Sediment also will be transported through the Spillway Sluice Gate. The volume of sediment that moves through the Spillway Sluice Gate will be fairly small in relation to the high flow discharges through the Bladder Spillway. However, it is possible that sediment released by the Sluice could have an impact on spawning/rearing habitat downstream of the Diversion. Turbidity monitoring in the Middle Reach will be used to determine whether Sluice operations have a significant impact on water quality more than 1,500 feet below the Diversion.

5.3.3 Puget Sound Chinook Salmon and Steelhead Critical Habitat

The Puyallup River includes critical habitat for Puget Sound Chinook salmon and steelhead above and below the Diversion. Within these areas, the primary biological features (PBFs) essential for the conservation of these ESUs are those sites and habitat components that support one or more life stages. The PBFs of critical habitat include 1) Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development; 2) Freshwater rearing sites with: i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; ii) Water quality and forage supporting juvenile development; and iii) Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks; and 3) Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.

The Fish habitat in the Middle Reach and immediately above the Diversion lacks many PBFs, with most of the river consisting of riffles with short segments of boulder cascades. Sediment bedload and suspended sediment loads are naturally high in the river, particularly in late spring through early fall when snow and glacier melt are at their highest (Czuba et.al. 2010) affecting substrate which is an essential feature of both the freshwater spawning and freshwater rearing PBFs. The Middle Reach immediately downstream from the Diversion also lacks woody material to form cover and other physical habitat features at moderate to low flow conditions. Instead, wood in the system is mobilized by high flows and deposited on gravel bars and perch along the riverbank.

As noted above, Bladder operations may result in headcutting upstream above the Diversion during the highest flows of the year, in the fall and winter. This time of year could coincide with incubating upstream redds between the Diversion and the confluence with the Mowich River. PTI regularly surveys for steelhead redds up- and downstream of the Diversion. Although the river upstream of the Diversion has some structure and gravels that would support spawning, PTI surveys reveal little spawning activity in the mainstem Puyallup River upstream of the Diversion until reaching tributaries of the Mowich River. However, PTI surveys note extensive steelhead spawning in Ledout, Kellogg, and Neisson Creeks, tributaries to the Puyallup downriver of the Diversion, that would be unaffected by the headcut.

5.3.4 Bull Trout Critical Habitat

Minimum instream flows in the Middle Reach immediately below the Diversion, are 80 cfs from July 15 to November 15, and 60 cfs the rest of the year. USFWS has expressed a concern that these minimum flow rates may result in a decline in bull trout prey abundance both for spawning habitat for salmon and steelhead, and in macroinvertebrate abundance. At other times of the year, minimum flows may reduce available rearing habitat for juvenile and sub-adult bull trout, increasing the risk of predation.

Headcutting that occurs above the Diversion during high flows could, as discussed in the prior section, result in the loss of Chinook salmon, steelhead, and Coho salmon redds. This would adversely affect bull trout through a decline in the abundance of prey. In addition, the headcut will result in macroinvertebrates being flushed downstream of the action area and unavailable as forage for juvenile bull trout.

5.4 Anticipated Impact of the Taking

Until Phase II is completed, fish entrainment in the Flume will continue to be the most notable impact of the Project on listed fish species. Operation of the Trap and Haul system minimizes this impact, but Flume entrainment nevertheless could result in mortality of listed fish species. Construction of Phase II is anticipated to be completed approximately two years after completion of Phase I. While the Project is expected to take some listed fish species during the period from issuance of the ITP to completion of Phase II and the fish exclusion facility becoming operational, the take that occurs during that period is unlikely to have a significant impact on the survival and recovery of Puget Sound Chinook salmon, Puget Sound steelhead, and bull trout.

Once Phase II is completed and when the avoidance and minimization measures described in this HCP are implemented, the Project is not likely to directly cause mortality to more than very limited numbers of listed fish species, which is unlikely to have a significant impact on the survival and recovery of Puget Sound Chinook salmon, Puget Sound steelhead, and bull trout.

During implementation of this HCP, the Project will continue to take listed fish species in the form of harm to critical habitat. Those impacts will mainly result from the diversion of water from the Middle Reach and headcutting above the Diversion during high flows. The impacts on critical habitat are likely to be fully offset by the mitigation projects described in this HCP.

5.5 The Amount or Extent of Take

5.5.1 Prior to Completion of Phase II

From issuance of the ITP until the completion of Phase II, the Project is expected to take (capture or kill) the following number of listed fish species each year through entrainment in the Flume (numbers to be determined in consultation with the Services):

PS Chinook salmon	_____
PS Steelhead	_____
Bull Trout	_____

Of this number, ________ percent are expected to be returned to the river via the Transfer system.

5.5.2 After Completion of Phase II

Following completion of Phase II, take of listed fish species will occur in the form of harm from habitat modification above and Diversion and in the Middle Reach. The number of individual fish injured or killed as a result of this take is impossible to determine using the best available information. In situations where the number of animals taken cannot be estimated, it is appropriate to rely on a surrogate measure of incidental take in the form of the extent of spatial measures of habitat modified.

[Surrogate for take (mortality and harm to habitat) to be determined in consultation with the Service]

6.0 HCP CONSERVATION PROGRAM

The primary goal of implementing this HCP is to minimize any potential harm to the listed species and their habitat resulting from operating and maintaining the hydropower Project. The ideal goal would be to "do no harm" and to assist in the recovery of the listed species. To the extent possible, this may be achieved by setting specific performance goals and objectives and implementing conservation measures associated with the covered species, the facilities and operational activities. In addition, carrying out certain enhancement measures intended to increase the native populations of the listed species may contribute toward their ultimate recovery.

6.1 Biological Goals and Objectives

The biological goals of an HCP are the guiding principles for the proposed conservation program and the rationale for the minimization and mitigation measures. Goals are descriptive, open-ended, and a broad statement of desired future conditions that conveys a purpose (USFWS 2016b). The biological objectives of an HCP are the specific measurable and attainable targets intended to meet or achieve the biological goals. The biological goals and objectives of this HCP were designed to be SMART: specific, measurable, achievable, results-oriented, and time-fixed (USFWS 2016b).

Goal 1: Maintain Upstream Fish Passage That Allows Movement of Listed Fish Species Past the Diversion

> **Objective 1.1**: Maintain the fish ladder structure, maintain access and channel connectivity, maintain design flows, prevent debris obstruction.

> **Objective 1.2**: Reinforce high wear areas of fish ladder,

Goal 2: Provide Downstream Fish Passage That Allows Movement of Listed Fish Species Past the Diversion

Objective 2.1: Install Fish Exclusion Facility (Phase II) at the Diversion that are suitable for all life stages.

Objective 2.2: Until completion of Fish Exclusion Facility (Phase II), continue operation of "trap and haul" system at the Forebay.

Goal 3: Provide Year-round Instream Flow That is Fully Supportive of Listed Fish Species Movement and of Spawning and Rearing Habitat in the Middle Reach

Objective 3.1: Establish instream flow thresholds consistent with the REA.

Objective 3.2: Establish accurate instream discharge measurement system.

Objective 3.3: Monitor Chinook upstream migration channel limitations.

Goal 4: Maintain Instream Water Quality

Objective 4.1: No Project-induced water temperature increases that exceed Washington State Water Quality Standards for spawning and rearing anadromous and resident fish in the Middle Reach.

Objective 4.2: Restore areas disturbed by construction to a pre-construction habitat state.

Goal 5: Avoid stranding Listed Fish Species in the Middle Reach due to Project operations

Objective 5.1: Follow Hunter (1992) Downramping parameters for Diversion Spillway and Powerhouse discharges.

Goal 6: Provide Sediment and Debris Management that is Supportive of Middle Reach Habitat

Objective 6.1: Develop and follow sediment sluicing and bladder bedload release best management practices for removal and discharge of sediment.

Objective 6.2: Prior to the completion of Phase II, implement best management practices for removal and discharge of sediment from Settling Basin and Forebay.

Goal 7: Establish Zero Discharge Operations & Maintenance Practices

Objective 7.1: Develop materials handling, storage, equipment operation and maintenance practices and procedures that will avoid and minimize any discharge of waste or pollutants to any water body in the Project area or the ground.

Goal 8: Identify and Implement Associated Resource Mitigation and Restoration

Objective 8.1: Identify habitat enhancement projects or actions that have been identified by resource agencies, PTI, managers or community plans that may improve habitat quantity or quality for listed species. Implement those most closely associated with the Project.

6.2 Measures to Avoid and Minimize Take

Consistent with ESA §10(a)(2)(B), the following sets forth how EH will, to the maximum extent practicable, minimize and mitigate the impacts of the taking for which EH is seeking authorization.

6.2.1 Upstream Fish Passage

Upstream fish passage is provided by the concrete fish Ladder that was constructed in 2000, with inlets above and below the Diversion. So long as EH properly maintains the Ladder, it effectively minimizes the Project's impact on upstream fish passage past the Diversion.

The Ladder is designed to function adequately during 91% of the average annual river flow range, essentially between 160 cfs and 1,100 cfs. Ladder flows will range from 10 to 52 cfs with a maximum velocity of 6 fps. The ladder requires periodic cleaning of sediment and woody debris from the upper and lower entrances as well as the individual cells. High river discharges tend to pile up debris. Although the ladder will still function and be passable as a "roughened channel", the best fish access is provided when sediment is removed from the individual ladder cells thereby providing a series of small pools.

Access to the ladder for light maintenance is available downstream via a ¼ mile walk-in from the terminus of the "62" road on the right bank. The end of that road is washed out and there is no vehicle access from the ladder side at this time.

When maintenance requires equipment, i.e. a tracked excavator, access is accomplished by crossing the river from the Intake side during low flows. This requires notification and approval from resource agencies and PTI.

EH will regularly monitor the condition of the Ladder and conduct maintenance as needed to ensure Ladder structural integrity, performance functionality and main channel connectivity. Sediment and woody debris will be periodically removed with both machine and hand tools as the situation may call for. Maintenance, repair and replacement will be scheduled as forecast, and as needed.

EH will maintain the Diversion pool elevation to provide access to the upstream Ladder inlet and supply adequate through-flow for all species to transit upstream through the Ladder.

To further ensure structural integrity and extend the life of the Ladder, EH will install metal plating at locations that exhibit significant wear and material loss, such as cell wall chevrons and wall corners.

[For discussion with the Services: USFWS has requested installation of a Passive Integrated Transponder (PIT) tag reader on the Ladder to monitor bull trout use of the ladder. What is the likely efficacy of a tag reader in this location, and how will collected data be used? Could the same benefits be achieved with a one-time or multi-year study?].

6.2.2 Downstream Fish Passage

6.2.2.1 Prior to Completion of Phase II (Fish Exclusion Facility Not in Place)

As discussed in Section 2.1.2, fish currently may pass the Diversion and continue downstream via any of four different routes: 1) through the Ladder; 2) through the Spillway; 3) being swept over the Diversion; or 4) entering the Intake and the Flume line. When Phase II is completed and the fish diversion structure is operational, fish will no longer have access to the Flume. The Project will no longer entrain fish or expose them to the Flume, Settling Basin, Forebay, Transfer Facility, Penstocks and Powerhouse. However, Phase II construction is expected to be completed about two years after the completion of Phase I, allowing for a period of observation, design revisions, obtaining necessary state permits, and completing construction.

Fish entrained within the Flume are unable to return to the river through their own efforts. To minimize this impact, the Project has operated a Trap and Haul facility at the Forebay since 2000. EH has continued the Trap and Haul operation since it acquired the Project and has made several improvements to the barrier nets.

To reduce mortality among listed fish that are entrained in the Flume, EH will continue operating the Trap and Haul facility until Phase II is operational, with the objective of removing fish from the Forebay as quickly as possible while preventing them from escaping past the barrier net and entering the Penstocks.

EH will conduct regular maintenance of the barrier net including debris cleaning, net maintenance to repair damage, and maintaining the top cork float line and bottom lead line to prevent gaps for escapement. The fine mesh of the net, approximately 6mm, requires frequent cleaning to prevent flow distortion and excessive current loading. A back-up net is pulled into place simultaneously with the retrieval of the primary net for cleaning. The associated wear and tear may require biennial net replacement.

6.2.2.2 Following Completion of Phase II (Fish Exclusion Operational)

After EH installs sediment and Fish Exclusion Facility at the Project Intake and those facilities are operational, listed fish species may still pass downriver through the Ladder or the Spillway, or by being swept over the Diversion, but will be excluded from the Flume. Any fish entering the Intake will be returned to the river below the Diversion by the Fish Exclusion Facilities.

Completion of the sediment and Fish Exclusion Facilities will effectively avoid and minimize take related to the Project’s Intake. EH will monitor and maintain the sediment and Fish Exclusion Facilities to ensure proper functionality, maintain design velocities for sweeping flows and passage flows, and provide regular screen cleaning and return outfall inspection. Fencing and overhead predator control netting may become necessary if there appears to be fish concentration and concentrated predation.

6.2.3 Instream Flow

Operating the Diversion affects instream flow in the approximately 10.5 miles of the Puyallup River (the “Middle Reach”) between the Diversion and the Powerhouse Tailrace. The diverted water returns to the river after being used to generate electric power, from the Powerhouse Tailrace.

EH will minimize impacts on listed species by maintaining minimum instream flow (MIF) past the Diversion structure and into the Middle Reach. Project instream flow releases are comprised of the sum of all flows that may originate from the Ladder, Spillway, rock chutes, fish and sediment return and flow over and leakage through the Diversion. Additional instream flow begins accreting below the Diversion, particularly below Neisson Creek.

Historically the Project was operated without maintaining MIF. However, MIF was set for the Project through negotiation of the 1997 REA entered into between PSE and PTI. In accordance with the REA, the Project is being operated to maintain a MIF of 60 cfs for 8 months of the year, raised to 80 cfs from July 15th to November 15th. The REA is contractually binding on EH, but expires at the end of 2026.

As a conservation measure to minimize take of listed species and their critical habitat, EH will maintain the MIF established in the REA for the life of the HCP (subject to a potential increase in response to climate change, as discussed under Changed Circumstances in Section 7.1.2).

Implementation of this conservation measure require ongoing accurate release measurement below the Diversion that is inclusive of all discharges and flow returns to ensure that the cumulative discharge remains equal to or greater than the MIF. Instream flow is measured by stream gaging immediately downstream of the last outfall return below the Diversion.

To improve upstream fish passage through the Middle Reach, each year that the river experiences a high flow event exceeding 4,000 cfs (as determined at the USGS Electron gage), EH will survey the 2.5 mi braided channel reach immediately below the Diversion during low flow conditions prior to Chinook salmon upstream migration to identify potential physical obstacles to upstream fish passage, such as shallow channels or excessive velocity. The morphology of the stream channels in that area changes regularly in response to high water and other events common to braided river channels. EH will document any observed barriers to fish passage. If feasible, EH will correct the conditions, such as placement of woody debris or gravel manipulation to increase depth in a shallow channel.

6.2.4 Instream Water Quality

6.2.4.1 Temperature

Past temperature records have indicated that water temperatures upstream from the Project and in the Middle Reach are below existing Washington water quality standards. To determine whether the Project has an impact on water temperature in the future, EH will establish temperature monitors at representative locations above the Diversion, in the Middle Reach below the Diversion, immediately upstream from the Powerhouse, and below the Powerhouse.

Adaptive management measures shall be triggered if monitoring during low flow periods show water temperature in the Middle Reach exceeding 16°C/61°F as a seven-day average, or a 1-day maximum temperature of 23°C/73.4°F.

6.2.4.2 Turbidity

During any construction activities within the channel of the Puyallup River, turbidity will be monitored in accordance with conditions of the construction permits.

6.2.5 Down-Ramping Rates

Following a high flow event when the bladder has been deflated, it will be re-inflated as needed and adjustments will be made to the other outlet points to maintain a consistent pool elevation of 1620 ft.

When the Bladder is being inflated and Spillway discharge to the Middle Reach is being reduced, EH will follow the ramping rate (change in downstream water depth) of 2 – 4 inches per hour. The ramping rate is best measured by the change in stage at a given location and refers to the stage decline at this location. The best location for determining ramping rate is at the Rock gage located 2500 feet downstream of the Diversion.

6.2.6 Sediment and Debris Management

The Diversion's existing spillway configuration has resulted in the accumulation of bedload behind the Diversion and material amounts of sediment entering the Intake and Flume, as well as a shallower pool above the Diversion. It also has resulted in upstream bedload accumulation.

The Bladder Spillway is configured to reduce the sediment entering the Intake. Following the completion of Phase I construction, the Bladder Spillway will be operated to flush sediment that accumulates in front of the Intake bulkhead and maintain the riverbed elevation at least a foot lower than the Intake sill elevation at the Intake entrance. This is expected to result in limited unraveling above the Diversion, as the riverbed returns to a more natural gradient. It also could result in the release of pulses of sediment to the Middle Reach.

During the first year of operation of the Bladder Spillway and Spillway Sluice Gate, EH will establish operating protocols that allow sediment and bedload transport through the spillway to mimic natural conditions to the maximum extent practicable, while minimizing impacts on spawning habitat below the Diversion. The operating protocols will include strategies for operating the Spillway Sluice Gate to minimize pulsing of sediment discharges.

During the first year of implementation of this HCP, EH will develop a debris cleaning and disposal plan for clearing Intake and fish ladder. The objective of this plan also will be for the movement of large woody debris and sediment through the river system to mimic natural conditions.

EH also will maintain the shoreline riparian area at the Project's headworks to maximize shoreline slope stability and minimize landslide and debris potential.

6.2.7 O&M Practices

EH will develop written practices and procedures for equipment operation and maintenance and materials handling and storage for each component of the Project and shall have the practices and procedures in place by the end of the second year following issuance of the ITP. The objective of the practices and procedures will be to eliminate any discharge of waste or pollutants to any water body, or to the ground, to the maximum extent practicable.

EH also will develop and update a spill prevention, control, and containment plan for its equipment and operations that have the potential to result in releases and will use vegetable-based hydraulic oil in its equipment that could come in contact with waters of the State.

6.3 Measures to Mitigate the Unavoidable Take

6.3.1 Electron Pond & Outlet Channel Spawning Habitat

EH has made changes to an existing (constructed) stormwater retention pond to allow its use by PTI for hatchery smolt acclimation. The pond has been designed to mimic river conditions, including maintaining flow with water drawn from the flume. The pond is located approximately 1000 feet below the Diversion. Outfall from the pond is in the floodgate channel located 1400 feet downstream of the Diversion.

EH will continue to make the pond available to PTI for acclimation of hatchery salmon and provide flow from the flume to support pond operations. And, as a further mitigation measure, EH proposes operating the pond to provide additional off-channel spawning habitat for natural origin salmon during the portion of the year it is not being used to support hatchery operations.

The pond and outlet channel may be capable of providing seasonal spawning habitat from mid-September to Early March, by providing continuous flow from the flume. This would allow natural origin salmon to spawn within the pond's off channel habitat, providing eggs/alevins/fingerlings that would rear in the pond and migrate downstream, leaving the pond before the end of March, when the pond would be closed off and filled for hatchery fish acclimation. This dual operating scenario would facilitate the production of both natural and hatchery origin salmon.

6.3.2 Large Woody Debris Supplementation

Habitat surveys have determined that the Middle Reach has a deficiency of large wooden debris. EH will develop a plan, in consultation with the Services and PTI, for the addition of large woody debris to the Middle Reach. Under this plan, when EH has large woody debris such as root wads that are available at the Headworks area or can feasibly be transported to the Headworks area, EH will place them on the river bed below the Diversion, where natural processes can transport the large woody debris down the river, into the Middle Reach.

6.3.3 Other EH Support for PTI's Fisheries Programs

EH is committed to support PTI's fisheries program and will collaborate with PTI on enhancement efforts that benefit the listed fish species.

6.3.4 Habitat Enhancement

Electron owns land that may be suitable for additional enhancement or development of rearing facilities. Additional measures to increase low-flow habitat could be developed both within the Middle Reach as well as other locations above and below the Project. There are numerous beneficial habitat enhancement projects identified in the Salmon Habitat Protection and Restoration Strategy for Puyallup and Chambers Watersheds, June 2018. Project and actions also may include specific projects as described in the Pierce Co. WRIA 10 Salmon Habitat Enhancement Plan. EH will implement actions most closely associated with the Project.

6.4 Monitoring

6.4.1 Fish Ladder

EH will install a web-based camera to observe the entrance to the fish ladder, so that any debris blockage or flow problems can be quickly identified and remedied. Project personnel will monitor the camera after a high-flow event. In the event that a debris blockage is observed, a maintenance crew will be dispatched as soon as practicable, taking into account prevailing conditions such as very high flow events.

6.4.2 Downstream Fish Passage

Prior to completion of the Fish Exclusion Facility (Phase II), the number of each of the listed fish species that becomes entrained in the flume will be determined by observing and recording the fish collected in the Transfer Facility. Data will be recorded regarding all fish collected in the Trap and Haul facility, including number by species, size, and condition.

Following completion of Phase II, water flow rate within the Fish Exclusion Facility will be monitored to determine consistency with design velocities. EH initially will observe the Fish Exclusion Facility weekly. The condition of the fish screens will be observed, including description and estimated volume of any accumulation of sediment or debris on the screens and the effectiveness of any screen cleaning procedures. Any injured or dead fish observed in the return flow will be recorded, as well as any indications of predation on fish within the Fish Exclusion Facility. The condition of any predator controls that have installed will be recorded. The Trap and Haul facility will remain in place and will be monitored for three months after the completion of Phase II to determine whether fish are getting past the fish screen and into the Flume.

Three months after Phase II begins operation, EH will no longer be obligated to operate the Transfer Facility (assuming no listed fish species have been observed in the Transfer Facility for 4 weeks) and physical observations of the Fish Exclusion Facility may be reduced to monthly. Observations of the Fish Exclusion Facility will revert to weekly for one month following any material modifications to the Fish Exclusion Facility. Water flow rate within the Fish Exclusion Facility will continue to be monitored for the life of the HCP.

6.4.3 Instream Flow

River stage measurements will be made approximately 2,500 feet downstream from the diversion structure, known as the “rock gage”. The station is located downstream of all discharges from the Headworks structures, as well as return flow from the Fish Exclusion Facility, where the river is stable and not braided. Measurements will be made using a continuous stage recorder and corresponding staff gauge. River flow (Q) will also be measured at these stations to verify the operational parameters to ensure that the minimum in stream (MIF) flows are met.

6.4.4 Water Temperature

Water temperature will be monitored at representative locations above the Diversion, within the Middle Reach below the Diversion, and above and below the Powerhouse Tailrace. Temperature data will be collected from well-mixed portions of the river. Temperature monitors will not be placed in shallow stagnant backwater areas, within isolated thermal refuges, at the surface, or at the water's edge.

6.4.5 Sediment

During the first year of operation of the Bladder Spillway, a sediment monitoring study will be conducted upstream (for background concentrations) and downstream of the Diversion during sediment flushing operations during summer glacial melt (Late June-September) and during the winter months. Downstream monitoring locations will be selected to provide information regarding potential sediment release impacts on spawning and rearing habitat within the Middle Reach. This study will be designed to evaluate the effect of Bladder Spillway and Sluice Gate operations on sediment downstream of the diversion and will be used to inform the operating protocols for the bladder and the sluice gate.

In order to evaluate the impact of Bladder Spillway operations on headcutting of sediment above the spillway, EH will identify observation locations at approximately 200-foot intervals upstream from the Diversion, as determined by access points and the ability to observe the river, continuing upriver to the point where no headcutting is observed. For five years after the Bladder Spillway begins operation, EH will observe the condition of the riverbed at each location, making a written description of the observations, and taking photographs to document the observed conditions. Observations will be made in the fall before sediment flushing occurs and in the late winter or spring after Sediment flushing operations have occurred.

Following development of best operating practices for sediment flushing, EH will document that BMPs are being followed during operation of the Bladder Spillway and Sluice Gate.

6.4.6 Ramping Rates

A ramping study will be conducted following the Phase I construction period to locate the best river station(s) to monitor the downstream stage in the Middle Reach.

EH will monitor changes in river stage at the selected location within the Middle Reach during down-ramping operations to assure that down-ramping occurs no more quickly than 2 to 4 inches an hour.

6.4.7 Take Surrogates

Following the completion of the Fish Exclusion Facility (Phase II), the Project's take of listed fish species will be determined by surrogates for the harm to fish that results from the impacts of Project operations on the river upstream and downstream of the Diversion (headcutting, instream flow). EH will select an appropriate surrogate in consultation with the Services. Monitoring will be tailored to the selected surrogate or surrogates.

6.4.8 Mitigation Measures

EH will observe and record the use of the existing Electron Pond and Outlet Channel by returning salmonids. EH will determine that no naturally spawning fingerlings are present before closing off the Pond for use in acclimation of hatchery fish.

6.5 Adaptive Management Strategy

6.5.1 Fish Exclusion Facility

If listed fish species appear in the Transfer Facility more than two weeks after the Fish Exclusion Facility begins operation, EH will work with the Services to determine whether fish are passing through the Fish Exclusion Facility, and will modify the Fish Exclusion Facility as necessary to assure that listed fish species are excluded from the flume.

If operation of the fish screens in the Fish Exclusion Facility becomes impaired by sediment accumulation on the screens, EH will evaluate the cause of the accumulation. EH will modify screen cleaning practices or pre-screen sediment removal as necessary to correct sediment accumulation and allow adequate water passage through the screens while maintaining design sweeping flows and passage flows so as to avoid and minimize impacts on the downstream movement of listed fish species.

If predator activity (birds, otters) is around the Fish Exclusion Facility, EH will install and maintain bird netting or other appropriate measures to deter predation on fish within the Fish Exclusion Facility.

6.5.2 Climate Change/Instream Flow

Should water temperature monitoring conducted within the Middle Reach show that temperatures exceed the Washington water quality standard for core summer salmonid habitat (16 degrees centigrade) during the term of the HCP, Electron will analyze the temperature data to determine the time period during which such elevated temperatures occurred and the climatological conditions giving rise to the increased temperatures. Based on that information, EH will develop a plan that identifies one or more triggers for temporarily increasing instream flow or taking other measures likely to decrease water temperatures in the Middle Reach. Such plan will be subject to approval from the Services, following consultation with PTI.

6.5.3 Sediment Management

EH will use sediment monitoring and physical observation of upstream headcutting (documented by photos) to modify operating protocols for the Bladder Spillway and Sluice Gate so that sediment and bedload movement through the Diversion blends into natural sediment movement to the greatest extent practicable.

6.6 Reporting

6.6.1 Project Status

EH will provide regular progress reports to the Services, at least every quarter, from ITP issuance until the Fish Exclusion Facility (Phase II) begins normal operation. The progress reports will include a description of activities that have occurred since the most recent report and identify the projected schedule through completion of Phase II construction and implementation the beginning of routine operation of the Fish Exclusion Facility. EH will notify the Services within two weeks of the Fish Exclusion Facility beginning operation.

6.6.2 Monitoring Report

EH will submit an report to the Services within 60 days after the end of each year, regarding events during the preceding calendar year. In lieu of a report, if there have been no changes from the prior year, EH may submit a letter to the Services stating as much.

6.6.2.1 Tracking Take

EH will annually report all listed fish species collected in the Transfer Facility, including their size and condition and whether they were returned to the river, from issuance of the ITP through completion of Phase II and the Fish Exclusion Facility.

After EH notifies the Services that the Fish Exclusion Facilities have begun operating, EH will report regarding the status of the surrogate or surrogates for take.

6.6.2.2 Avoidance and Minimization Measures

EH's report will include a summary of instream flows, temperature monitoring data, and describe any deviation from established best operating practices during sediment flushing operations.

6.6.2.3 Performance of Mitigation Measures

EH's report will include a summary of the observed use of the Electron Pond by native spawning salmonids.

6.6.3 Changed Circumstances

EH will notify the Services within 30 days of learning that a Changed Circumstance, as described in Chapter 7.0, has occurred.

6.6.4 Funding

EH will be responsible for the full cost of obtaining an ITP under Section 10(a)(1)(B) of the ESA and adhering to all conditions imposed by the Services to do so. Funding and disbursements reports will be made available to the Services upon request at the end of each fiscal year.

7.0 CHANGED AND UNFORESEEN CIRCUMSTANCES

The No Surprises Rule defines "changed circumstances" as "circumstances affecting a species or geographic area covered by a conservation plan that can reasonably be anticipated by plan developers and the Services and that can be planned for (e.g., the listing of new species or a fire or other natural catastrophic event in areas prone to such events)" (50 CFR §§ 17.3).

The HCP must identify provisions to compensate for negative impacts to covered species from changed circumstances in order to qualify for No Surprises Rule assurances. If circumstances change, the permittee must implement any provisions included in the HCP and/or ITP that address such circumstances.

The following sections describe the changed circumstances that EH and the Services can reasonably anticipate and for which responses can be planned. The responses provided for each changed circumstance represent an opportunity for EH and the Services to reevaluate the effectiveness of the conservation program and adjust priorities, reallocate resources, or otherwise modify how the HCP is implemented.

7.1 Changed Circumstances

7.1.1 Damage to Rearing Ponds/Fishery Enhancement Projects

Changes to the Project's existing acclimation pond and future habitat improvements located on EH lands adjacent to the river constitute a significant portion of the mitigation measures proposed in this HCP. Because of the location of these features adjacent to the river channel, it is possible that future high-flow events will damage one or more of these habitat enhancement projects. If this occurs, EH will repair the damaged habitat enhancement project, or develop a replacement project if repairs are not feasible. Funding for these repairs will be provided from the Project's operating budget.

7.1.2 Climate Change

Global climate change is the observed increase in mean global temperature, and scientific research indicates this is due to an increase in greenhouse gas emissions, primarily carbon dioxide, as a result of human industrialization (IPCC 2007). According to IPCC (2007), the earth's climate has warmed between 0.61 and 0.89 °C (1.1 and 1.6 °F) over the past century. Over the past 30 years, temperatures have risen more rapidly in winter than in any other season.

Some of the changes have been faster than previous assessments had suggested (Melillo et al. 2014).

Global climate change also is predicted to include secondary global effects, such as sea-level rise and changing weather patterns; rainfall patterns, storm severity, snow and ice cover, and sea level appear to be changing already (USEPA 2016b). As the Puyallup River is a glacier-fed river, with seasonal peak flows from snowmelt, over time climate change may induce changes in the volume and timing of peak water flows and more frequent surge flows, with resulting changes in sediment load and bedload movement. Both of these factors also could result in increased water temperature.

As these changes unfold, modifications to the Project's sediment and debris management practices may prove necessary to minimize the Project's impact on the natural movement of sediment and bedload through the river system.

Some potential shallow channel upstream obstacles may periodically exist in the 2.5 mi braided channel reach immediately below the Diversion. Upstream Chinook migration monitoring, and river discharge monitoring may result in more effective flow management to aid in successful upstream migration. Similarly, the ability to make channel modifications (flow concentration) might also assist in improved upstream fish passage.

Any resulting changes in Project operation will be considered if approved by the Services, and if they will not require an increase in the take authorization for the Project.

7.2 Unforeseen Circumstances

"Unforeseen circumstances" are changes in circumstances affecting a species or geographic area covered by an HCP that could not reasonably have been anticipated by EH and the Services at the time of the conservation plan's negotiation and development and that result in a substantial and adverse change in the status of any covered species. The Services will have the burden of demonstrating that unforeseen circumstances exist and must base the determination on the best scientific and commercial data available. The Services shall notify the Applicant in writing of any unforeseen circumstances the Services believes to exist.

The No Surprises Rule states that the Services may require additional conservation measures of an incidental take permittee as a result of unforeseen circumstances "only if such measures are limited to modifications within conserved habitat areas, if any, or to the conservation plan's operating conservation program for the affected species, and maintain the original terms of the conservation plan to the maximum extent possible." The Services shall not require the commitment of additional land, water, or financial resources by the permittee without the consent of the permittee or impose additional restrictions on the use of land, water, or other natural resource otherwise available for use by the permittee under the original terms of the ITP. No Surprises assurances apply only to the species adequately covered by the HCP and only to those permittees who are in full compliance with the terms of their plan, permit, and other supporting documents, as applicable.

8.0 FUNDING ASSURANCES

EH estimated the costs and guarantees the funding for the implementation of the HCP, which includes operation and maintenance costs, mitigation and monitoring costs, inflation, adaptive management, and contingency costs. EH will provide all funds necessary for the mitigation and continued monitoring for 30 years at a level consistent with the budget shown in **Table ___**.

The primary minimization methods are maintenance of the Ladder and the Fish Exclusion Facility, which are funded from the Project's operating budget, and maintenance of minimum instream flows, which will result in lost power generation revenues but does not require funding costs. Minimization of sediment and debris impacts are operating practices with no future funding requirements. Mitigation measures [will be funded at or before the time of ITP issuance] or [are estimated to cost _____ over _____ years, as reflected in the budget].

EH intends that any costs incurred due to Changed Circumstances (**Section 7.1**) or the adaptive management responses (**Section 6.5**) will be paid out of the Project O&M budget.

Table __: Funding Assurances

HCP Action	Estimated Cost	Cost Basis and Assumptions	Financial Assurance
Minimization			
a. Upstream Fish Passage		**Sec. 6.2.1** – Fish Ladder is an existing structure. Estimated cost of maintaining Fish Ladder is based on _____	O&M Budget
b. Downstream Fish Passage – Transfer Facility		**Sec. 6.2.2.1** – Estimated cost of operating Transfer Facility is based on _____. Once fish exclusion facility is in place no longer needed.	O&M Budget
c. Downstream Fish Passage – Fish Exclusion Facility	TBD	**Sec. 6.2.2.2 –** Estimated cost of installing fish exclusion facility is based on _____.	
d. Instream Flow		**Sec. 6.2.3 –** Measures to maintain minimum instream flow will result in lost revenue from power generation, but do not involve any additional costs	N/A
d. Instream Water Quality		**Sec. 6.2.4** – Estimated cost of temperature and turbidity monitors is based on ____	Monitors will be purchased and installed prior to issuance of ITP
e. Ramping Rates		**Sec. 6.2.5** – Operating the Project within specified ramping rates may have an impact on revenue from power generation, but does not involve any additional costs	N/A

HCP Action	Estimated Cost	Cost Basis and Assumptions	Financial Assurance
f. Sediment and Debris Management	No additional cost	**Sec. 6.2.6** – Implementation of sediment and debris management plans are a part of normal operating costs and will not result in any additional costs.	N/A
g. O&M Practices	No additional costs	**Sec. 6.2.7** – Implementation of practices to eliminate spills and waste discharges are a part of normal operating costs and will not result in any additional costs.	N/A
Mitigation			
a. Electron Pond & Outlet Channel		**Section 6.3.1** – Existing pond; no material costs to make it available to native spawning fish	N/A
Monitoring			
a. Evaluation monitoring		**Section 6.4.1** – TPZ Camera, Tower, Fiber Optic Connections, Programming	
b. Monitoring Mitigation Projects		**Section 6.4.4** – Temperature monitoring devices	
Changed Circumstances Fund (Total = $__________)			
a. Repairs to mitigation projects	$_______	**Section 6.5. __** - If triggered by damage to a habitat enhancement project on the Project's property, the estimated cost of repairs will be included in the following year's O&M budget.	
Total HCP Costs do not include revenues lost to minimum instream flows and ramping rates			

9.0 AMENDMENTS

It may be necessary at some time over the duration of the proposed permit for the Services and EH to clarify provisions of the HCP or the requested ITP with respect to program implementation or the meaning and intent of language contained in these documents. Such clarifications should not change the substantive provisions of any of the documents in any way but merely clarify and make more precise the existing provisions.

In addition, it may be necessary to make administrative changes or minor modifications to the documents at some time over the duration of the proposed permit. Such changes should not result in substantive changes to any provisions of the documents but may be necessary or convenient to represent the overall intent of EH and the Services. Examples of such administrative changes or minor modifications include correction of typographic errors in the documents, changes in the legal business name or mailing address of a permittee, or clarification of reporting procedures. Requests for administrative changes and minor modifications must be received in writing and may be reviewed and approved by [for the Services] in accordance with applicable regulations and policies.

Except as provided for above, the HCP and the ITP may not be amended or modified in any way without the written approval of EH and the Services. The Services will not need to publish an HCP or ITP amendment when levels of incidental take do not increase, and the activity does not expand in ways not analyzed in the original NEPA or Section 7 documents. In limited instances, amendments to the HCP or the ITP may require publication in the Federal Register. These instances would include changes in Permit Area, Proposed Action, Covered Activity, type or amount of take, additions to Covered Species, significant changes to the minimization, or mitigation measures under the HCP, including funding, that may affect the type or amount of take, the effects of the Covered Activities, or the nature or scope of the minimization or mitigation measures in a manner or to an extent not previously considered (through adaptive management of changed circumstances) in the HCP. Such amendments will be processed by the Services in accordance with the provisions of the ESA and the applicable regulations and will be subject to the appropriate level of environmental review under the provisions of NEPA.

LITERATURE CITED

Memorandum

To: Thom Fischer

CC: Tom Szymoniak, Shane Cherry, Chris Spens, Danielle Zitomer

From: Miranda Eckert

Date: February 15, 2016

Re: Hydrologic Summary for the Electron Project on the Puyallup River, WA

This technical memorandum discusses the hydrology and basin characteristics of the Puyallup River contributing to the Electron Project in Orting, WA. This work was conducted to determine design criteria for the diversion dam repair, Obermeyer sluice replacement, and fish screen installation. The results of the analysis are the recurrence interval event magnitudes and flow duration curves. The flow duration curves are used to determine the design flow for the temporary sluice way during the In-Water Work window.

BASIN CHARACTERISTICS

The Project is located in the upper reaches of the Puyallup River drainage basin. The area of the drainage basin that contributes to flows at the facility intake is approximately 93 square miles (See **Figure 1)**. The yellow diamond is the Project intake, RM 41.8, and the red dot is the USGS 12092000 gage, RM 42.0. The USGS 12092000 gauge has been in operation since 1909 with peak streamflow statistics available for the 1912-2014 water years. A summary of the gages attributes and history are included in **Attachment A**.

Streamflow in the Puyallup River is fed primarily from snowmelt on the glaciated volcano of Mt. Rainier. The topographic relief between the headwaters and the point of diversion for the Project is 12,800 feet with the majority having a slope of greater than 30 percent. It is estimated that 980,000 tons of sediment flows from the headwaters to the mouth of the river each year (USGS, 2011). Mean annual precipitation is approximately 103 inches.

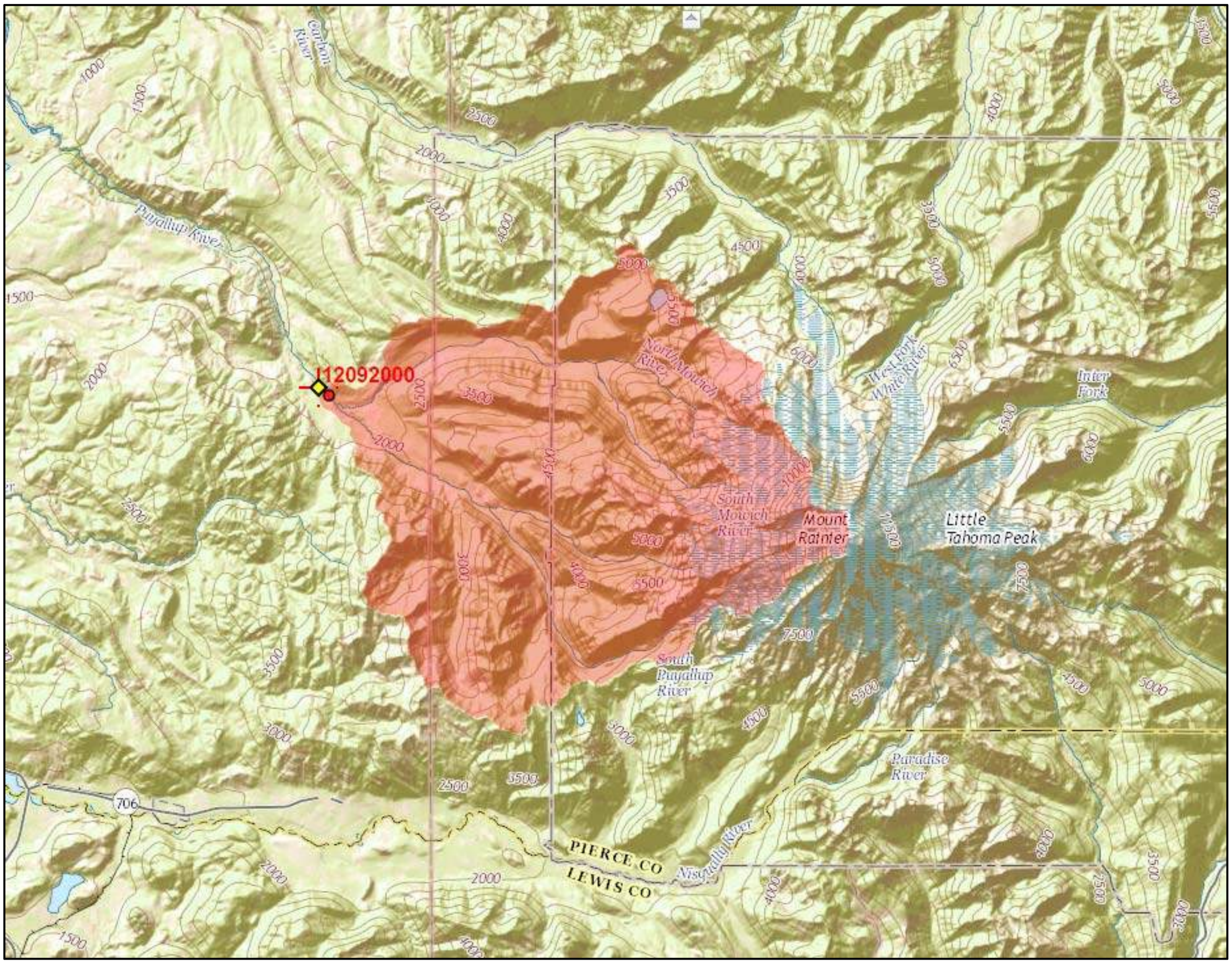


Figure 1 – Electron intake drainage basin as delineated by USGS Stream Stats.

HYDROLOGY

Hydrologic analysis of the Project intake location was conducted using the USGS 12092000 gage data. No scaling or other adjustment to flow is needed due to gage proximity to the Project intake, 0.2 miles upstream. Annual and monthly flow duration curves were developed using 1986-2012 data and are presented in **Attachment B**.

Discharge recorded at the USGS 12092000 gage is plotted in **Figure 2** for 1985 – 2015 civil years. Peak events typically occur over the winter with summer baseflow supported by snowmelt. The lower flow times of the year are in early spring and fall when conditions are dryer. The Projects hydraulic capacity of 400 cfs is supported nearly year round with a plant capacity factor of 82 percent. The daily average flow 1985-2015 is shown as a solid black line. The charts abscissa only goes to 4,500 cfs which is the approximate magnitude of the 2 year recurrence event.

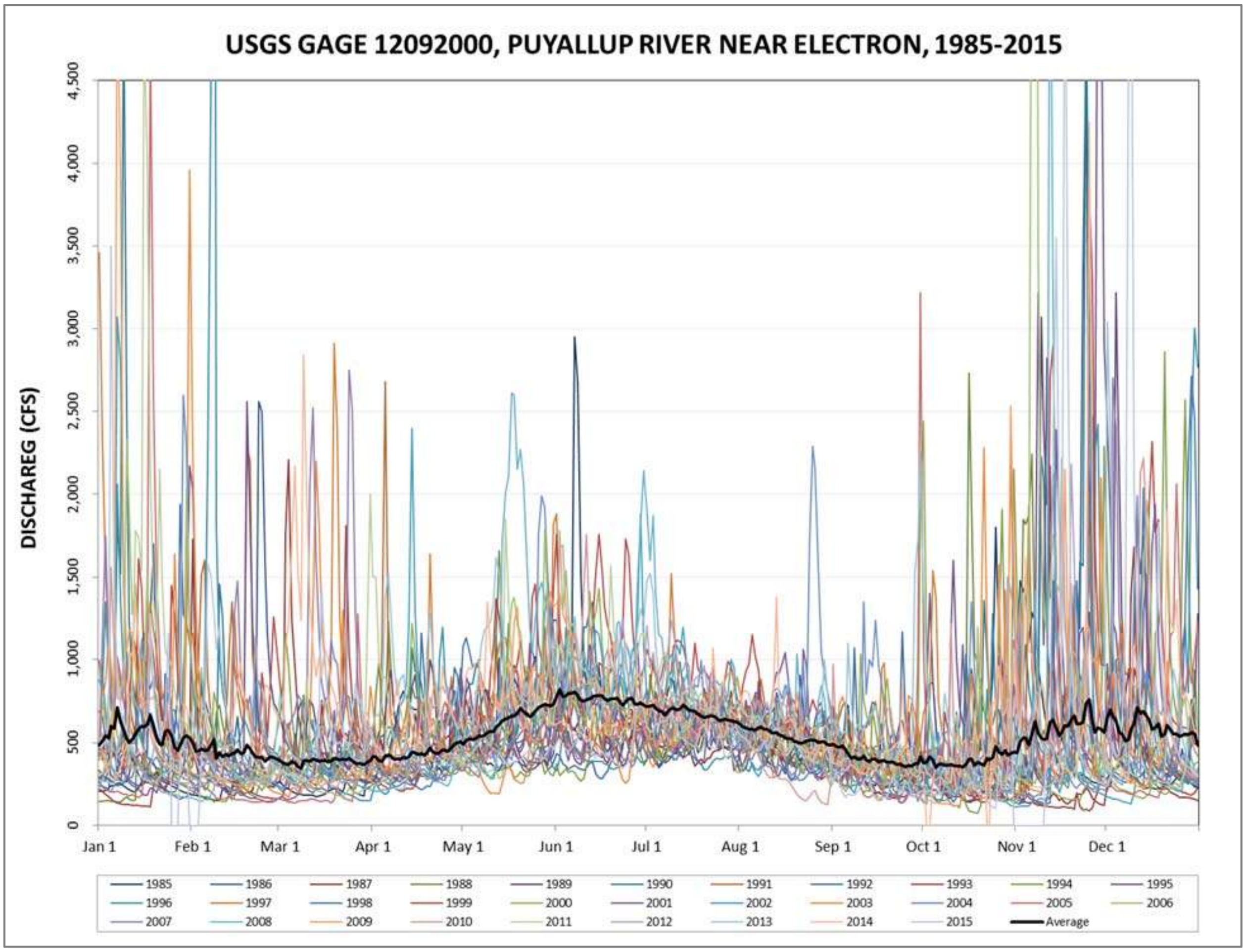


Figure 2 - Hydrographs for the USGS 12092000 Gage, 1985-2015.

FREQUENCY ANALYSIS

A peak recurrence interval analysis was conducted following the methodology presented in USGS Bulletin 17B (USGS, 1982). The analysis was conducted using the USGS PeakFQ model and the peak flow events 1909 - 2015 at the USGS 12092000 gage. PeakFQ output is presented in **Attachment C**. A summary of the recurrence intervals for peak events is shown in **Figure 3.** The analysis was verified by comparison to the 1998 *Magnitude and Frequency of Floods in Washington* study conducted by Sumioka and the values are in close agreement.

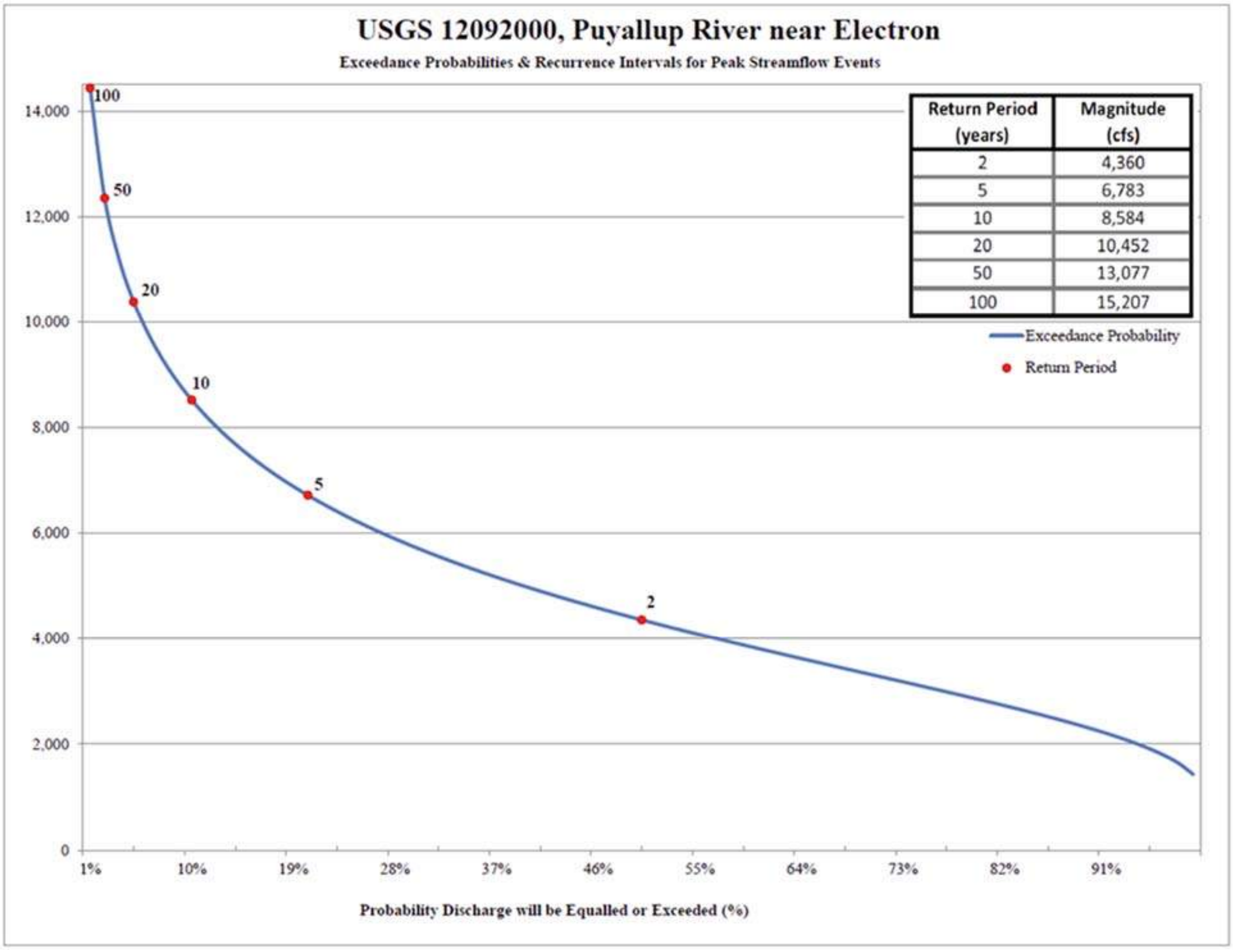


Figure 3 - Recurrence intervals for peak events at the Project intake.

WORKS CITED

Sumioka, S. S. (1998). *Magnitude and Frequency of Floods in Washington.* Tacoma: US. Geological Survey Water-Resources Investigations Report. Retrieved from https://pubs.er.usgs.gov/publication/wri974277

USGS. (1982). *Guidelines For Determining Flood Flow Frequency.* Reston, Virginia: USGS.

USGS. (2011). *Sediment Load from Major Rivers into Puget Sound and its Adjacent Waters.* Tacoma: US Department of Interior, US Geological Survey.

Watershed Sciences, I. (2011). *LiDAR Remote Sensing, Pierce County, Delivery 21 - 12/31/2011.* Corvalis, OR: Watershed Sciences.

PSLC (2015) Pierce County 2010 LiDAR data set
http://pugetsoundlidar.ess.washington.edu/lidardata/ accessed 7-16-2016

USGS 12092000 PUYALLUP RIVER NEAR ELECTRON, WA

LOCATION - Lat 46°54'14", long 122°02'02" referenced to North American Datum of 1927, in SE 1/4 NW 1/4 sec.03, T.16 N., R.6 E., Pierce County, WA, Hydrologic Unit 17110014, on right bank 1,000 ft upstream from Electron Hydro, LLC's flume headworks, 0.3 mi downstream from Mowich River, 9.8 mi southeast of Electron, and at mile 42.0.

DRAINAGE AREA - 92.8 mi^2.

SURFACE-WATER RECORDS

PERIOD OF RECORD - October 1908 to December 1933, October 1944 to September 1949, October 1957 to current year.

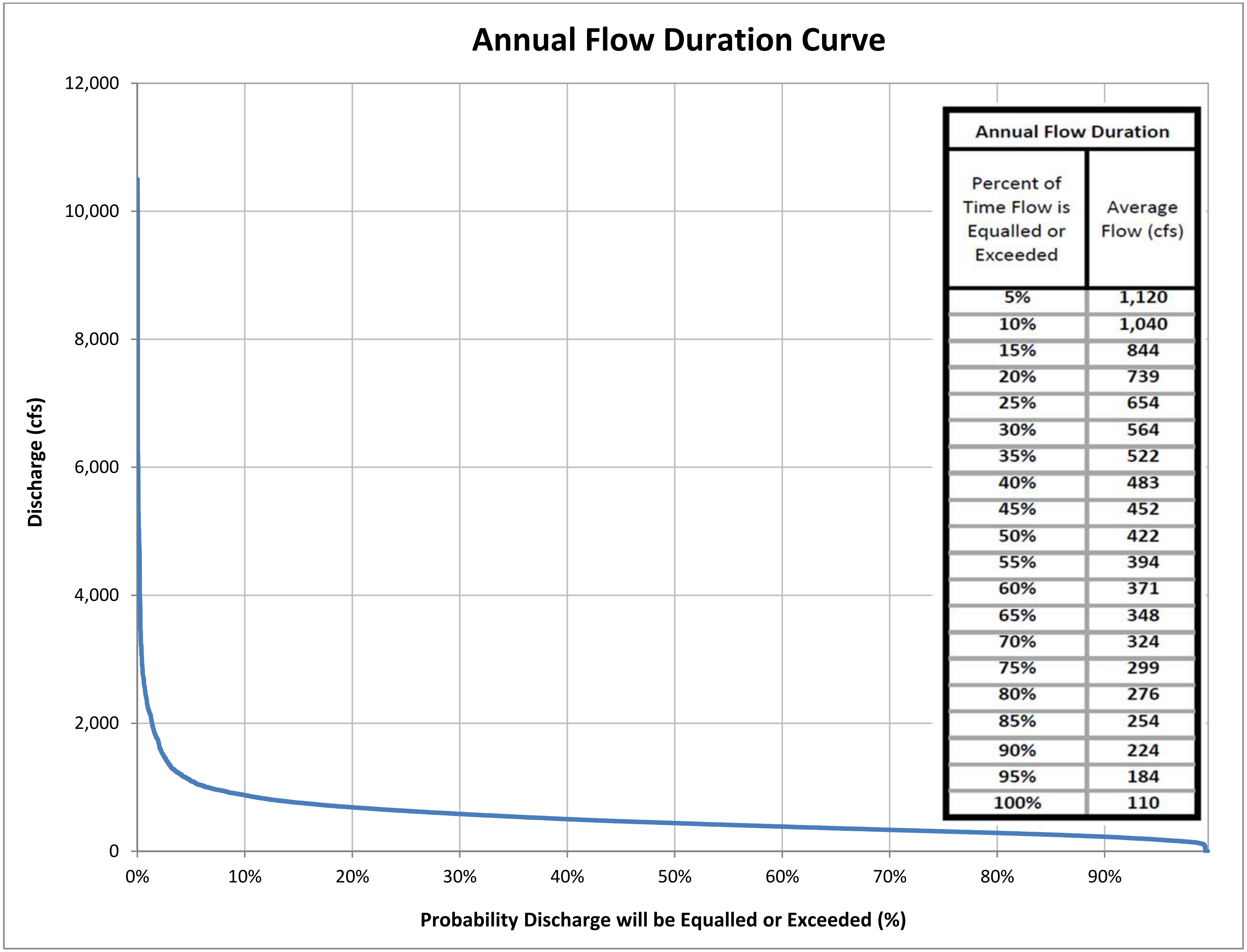
REVISED RECORDS - WSP 1092: 1946(M). WSP 1346: 1913, 1916-17(M), 1918-23, drainage area. WSP 1566: 1945(M), 1947(P).

GAGE - Water-stage recorder and crest-stage gage. Datum of gage is 1,632.7 ft above NGVD of 1929. Prior to Jan. 1, 1913, non-recording gage, and Jan. 1, 1913, to Sept. 30, 1926, Oct. 1, 1944, to Sept. 30, 1949, and Oct. 1, 1957, to Nov. 22, 1959 (gage destroyed by flood), water-stage recorder, at sites near present gage at different datums. Aug. 19, 1960, to Dec. 23, 1980, at site 160 ft downstream at different datum. Dec. 24, 1980, to Dec. 24, 1987, at site 60 ft downstream at different datum. Dec. 24, 1987, to Feb. 8, 1996 (gage destroyed by flood), at site on left bank near present gage at same datum. Feb. 8 to June 5, 1996, no gage at site.

REMARKS - No regulation or diversion upstream from station. U.S. Geological Survey satellite telemeter at station.

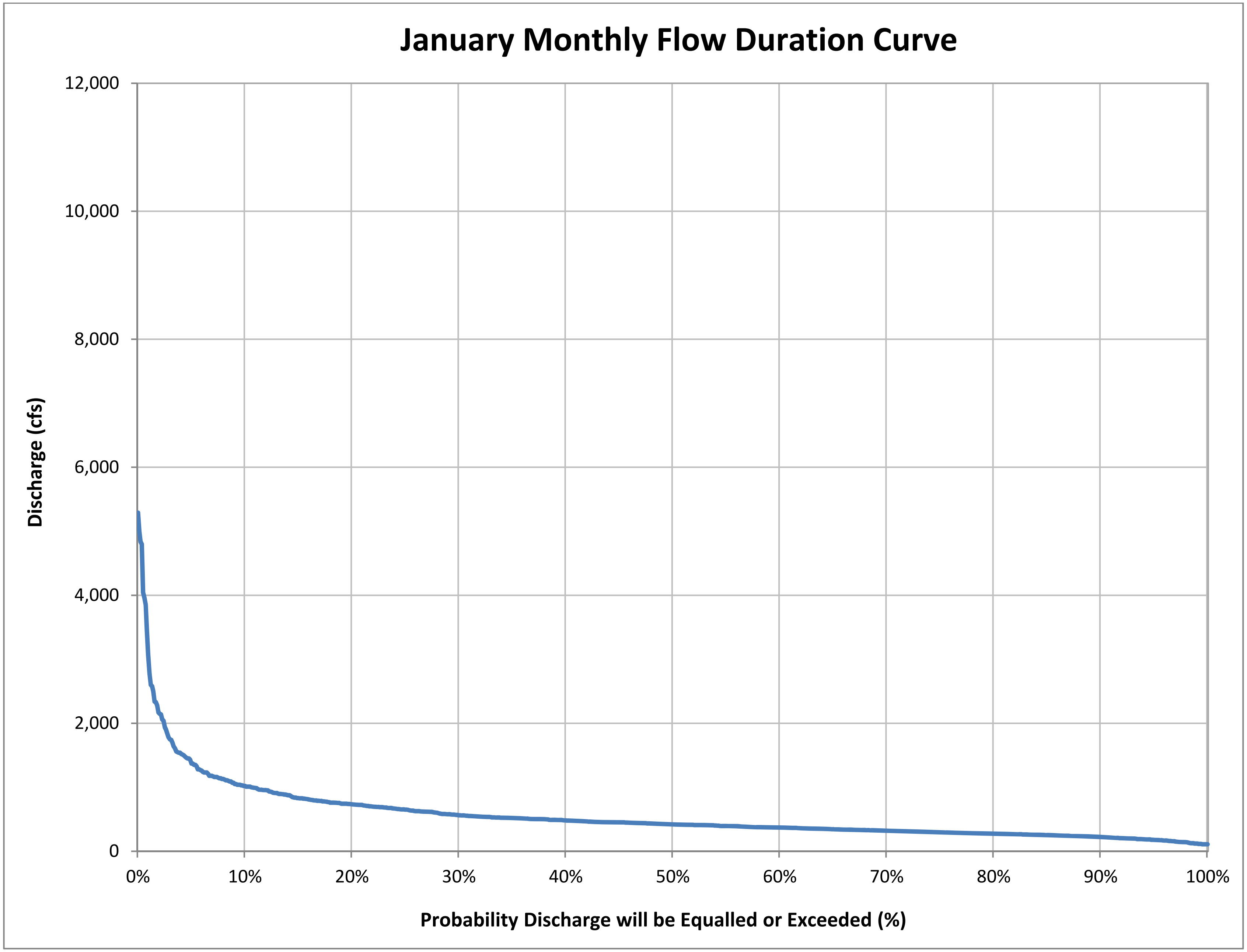
EXTREMES FOR PERIOD OF RECORD - Maximum discharge, 16,000 ft^3/s, Feb. 8, 1996, gage height, 10.94 ft, from floodmarks, result of slope-area measurement; maximum gage height, 11.30 ft, Nov. 7, 2006; minimum daily discharge, 75 ft^3/s, Oct. 19, 1994.

Attachment B



Annual Flow Duration	
Percent of Time Flow is Equalled or Exceeded	Average Flow (cfs)
5%	1,120
10%	1,040
15%	844
20%	739
25%	654
30%	564
35%	522
40%	483
45%	452
50%	422
55%	394
60%	371
65%	348
70%	324
75%	299
80%	276
85%	254
90%	224
95%	184
100%	110

Attachment B



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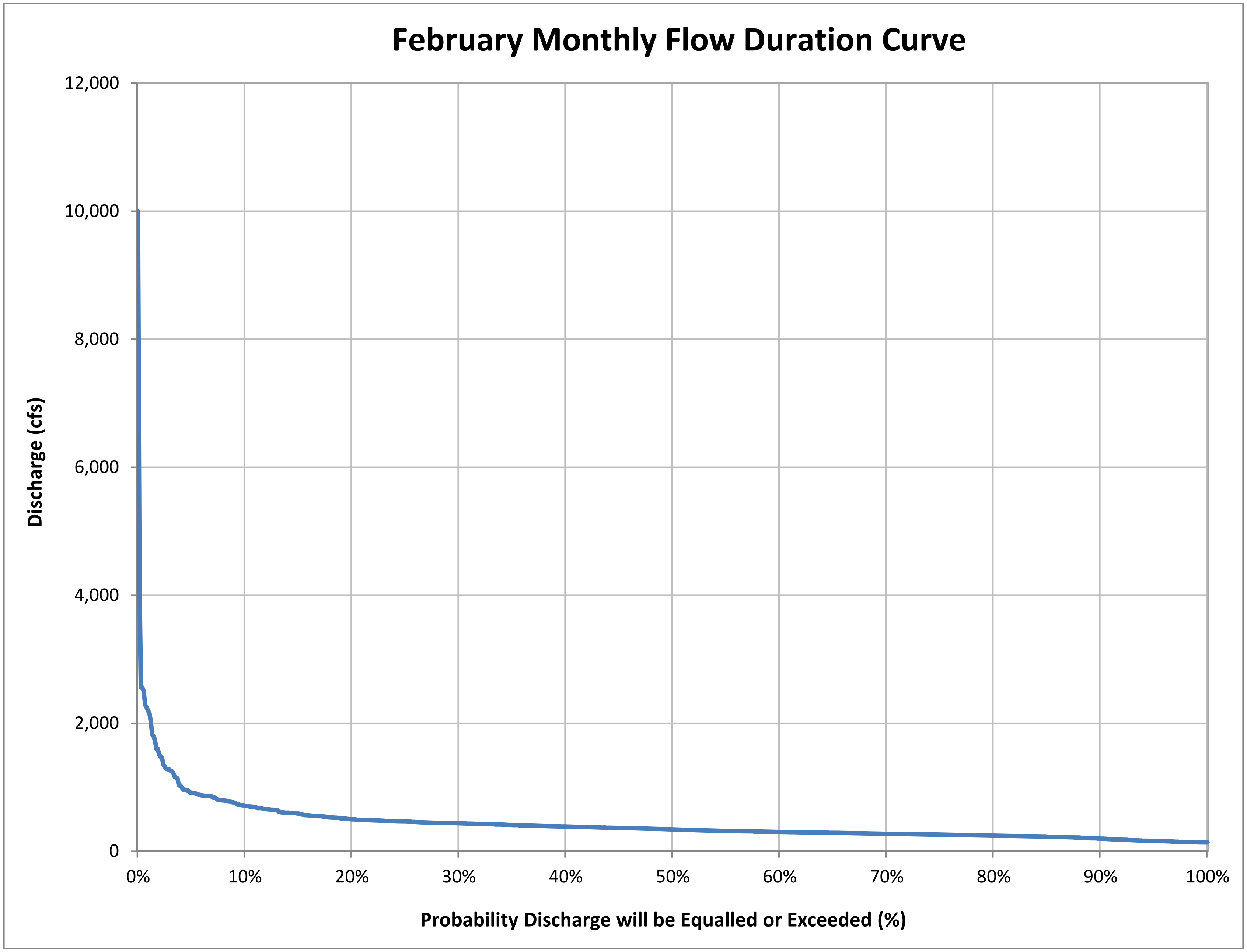

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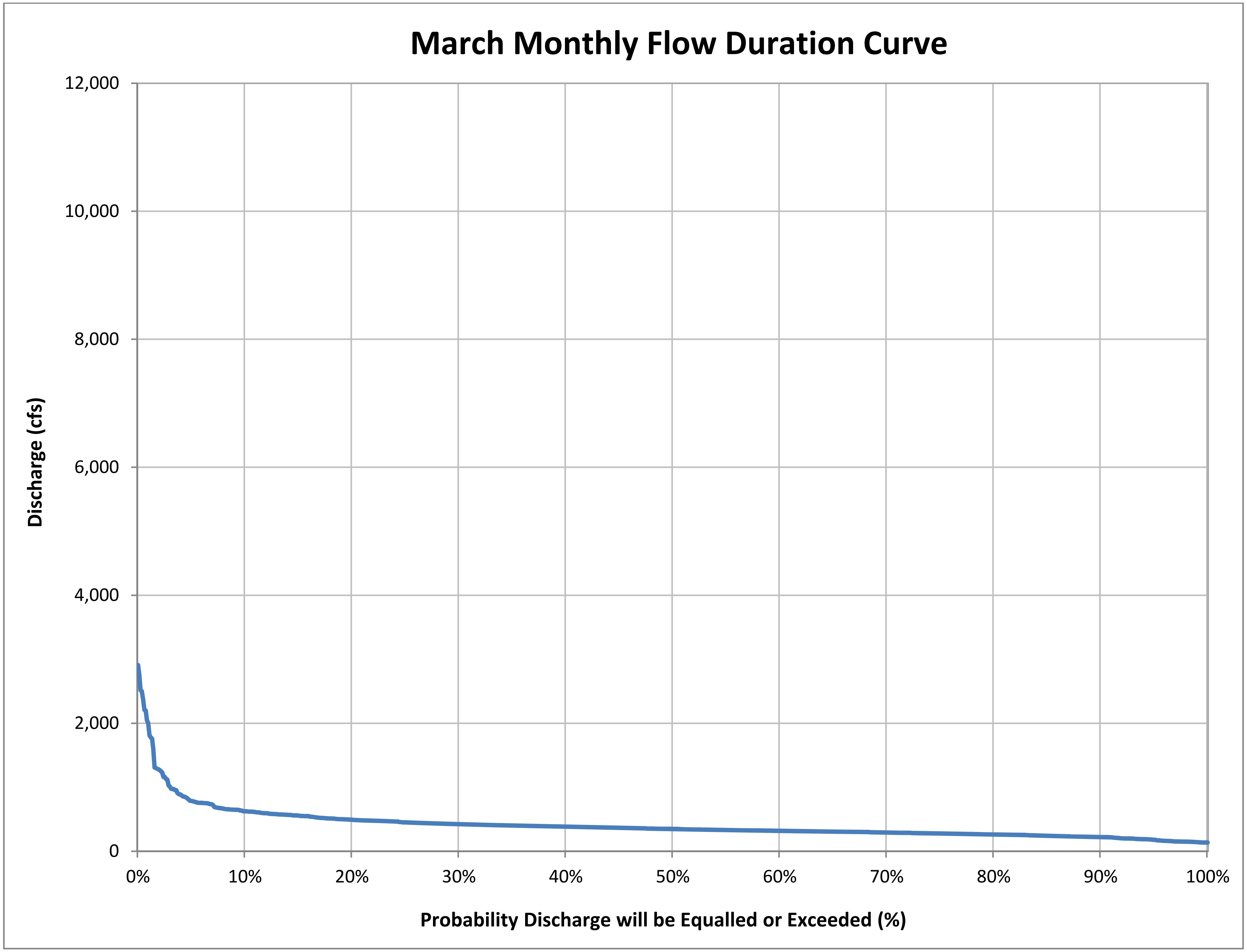

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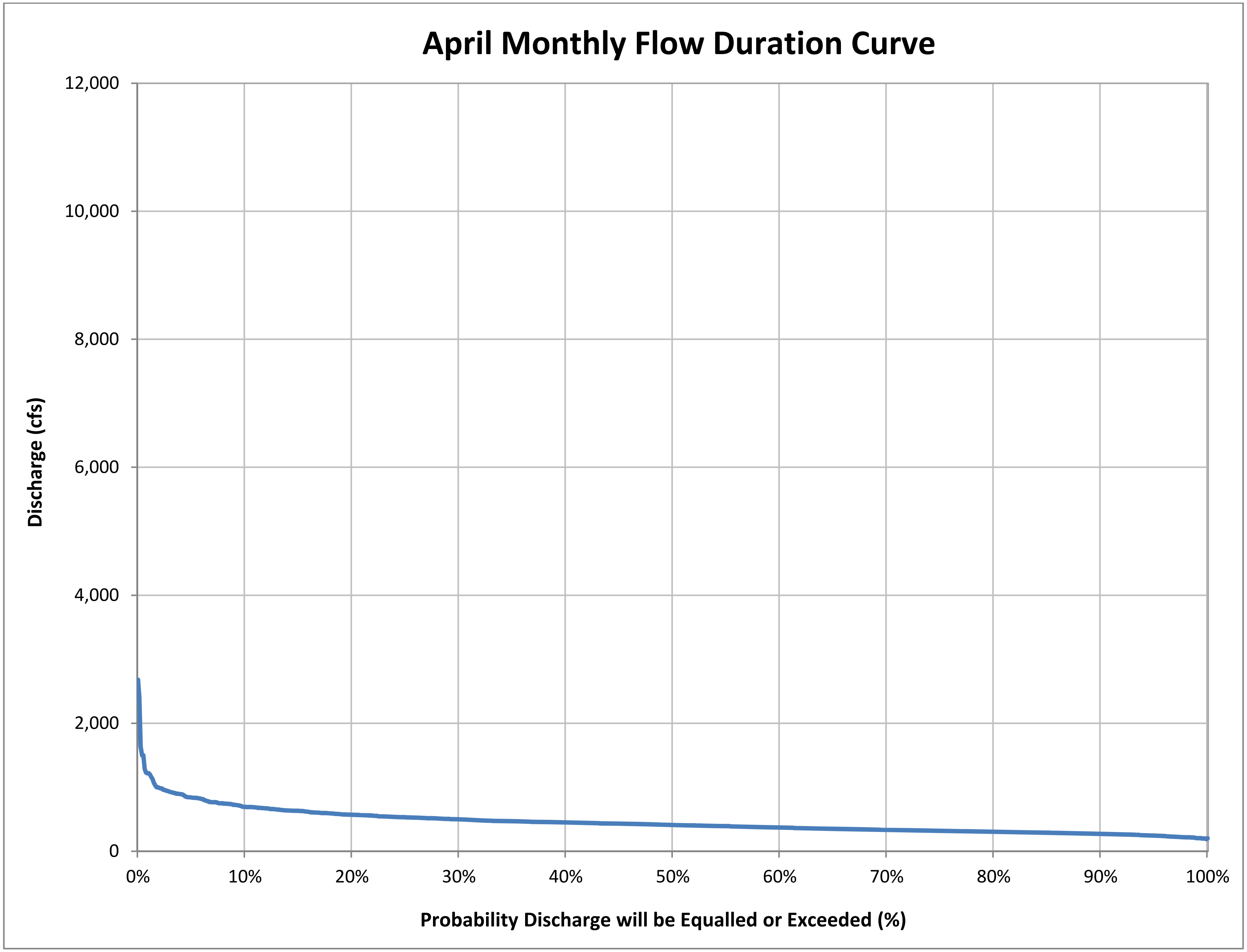
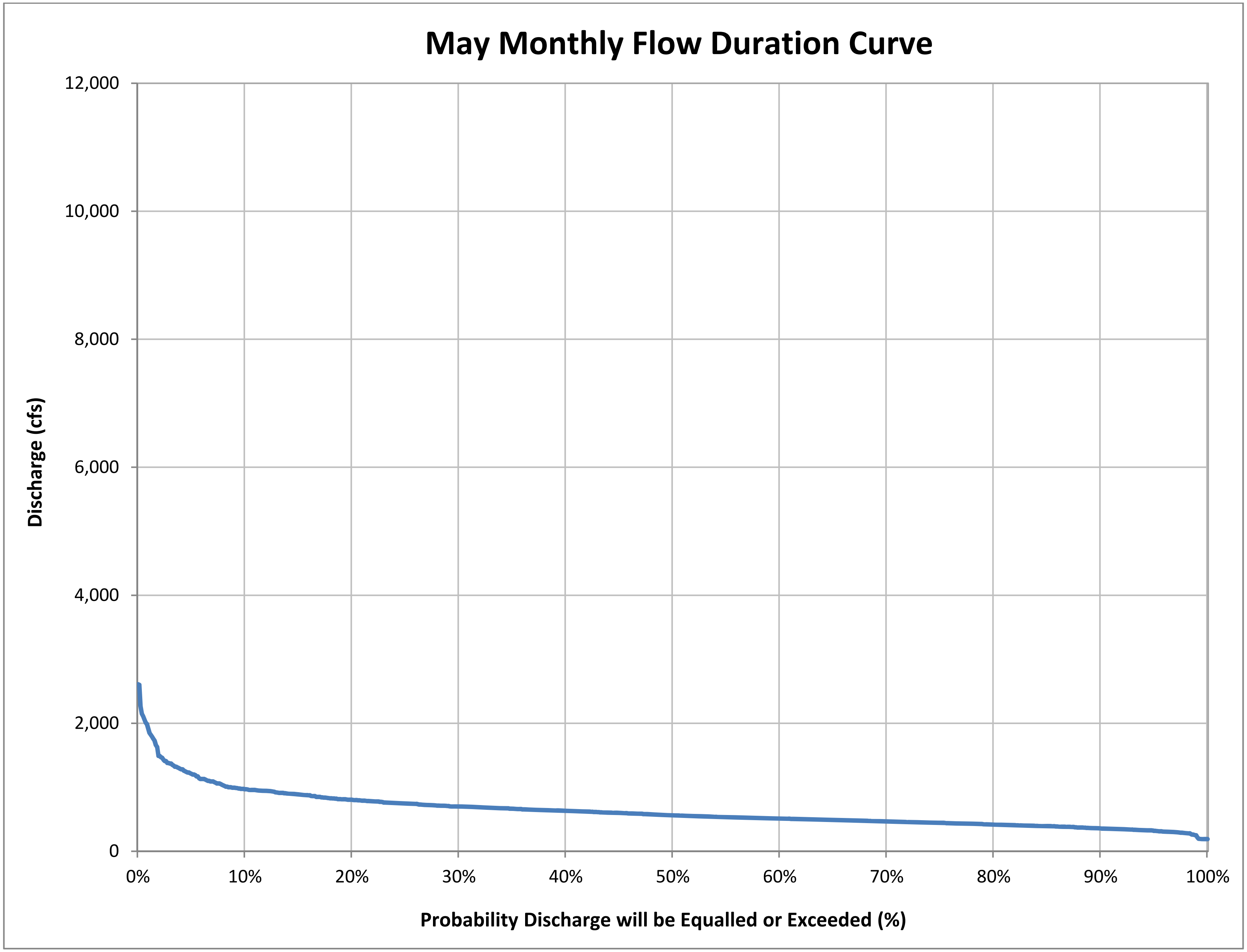
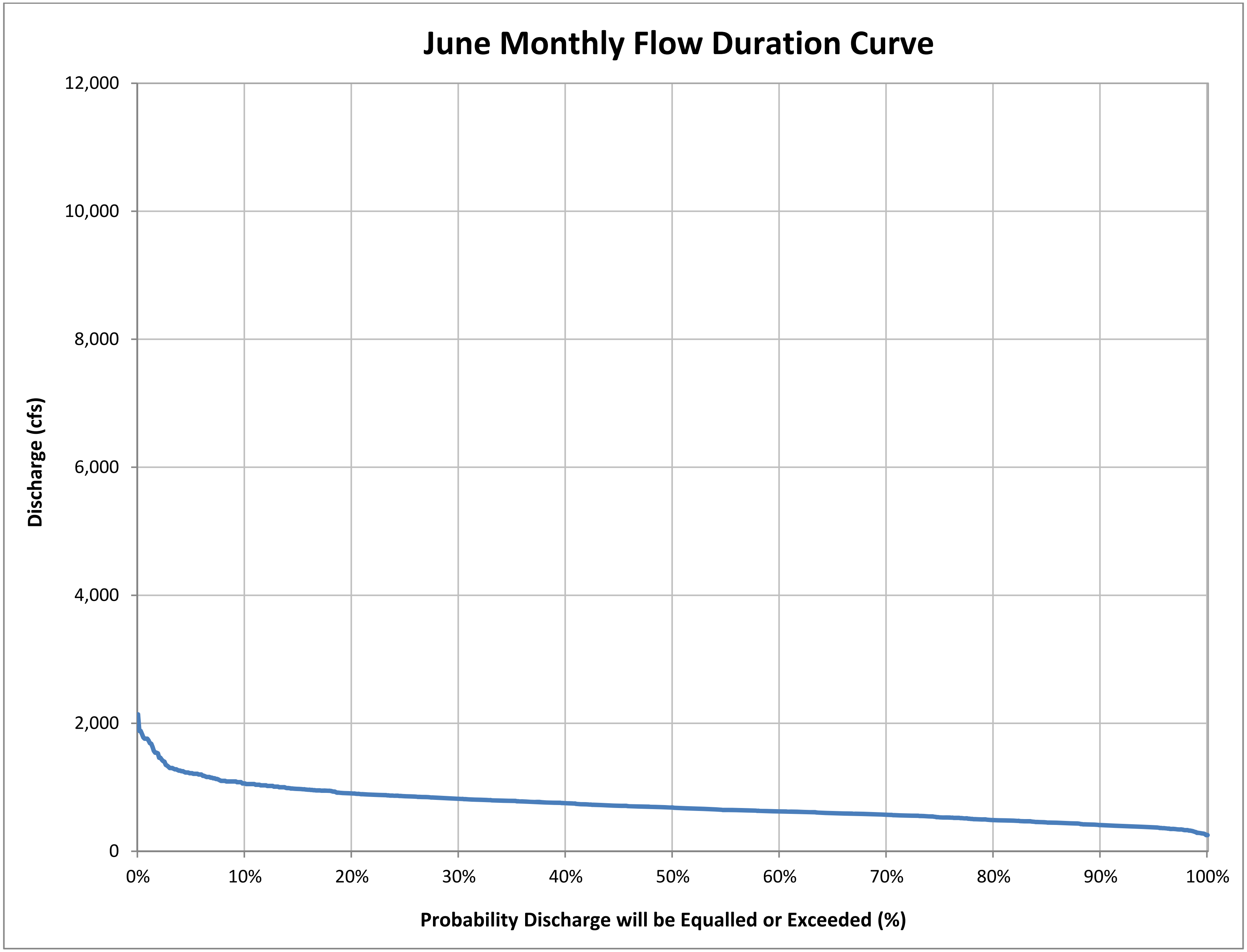



May Monthly Flow Duration Curve
12,000
10,000
8,000
6,000
4,000
2,000
0
Discharge (cfs)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability Discharge will be Equalled or Exceeded (%)

Attachment B



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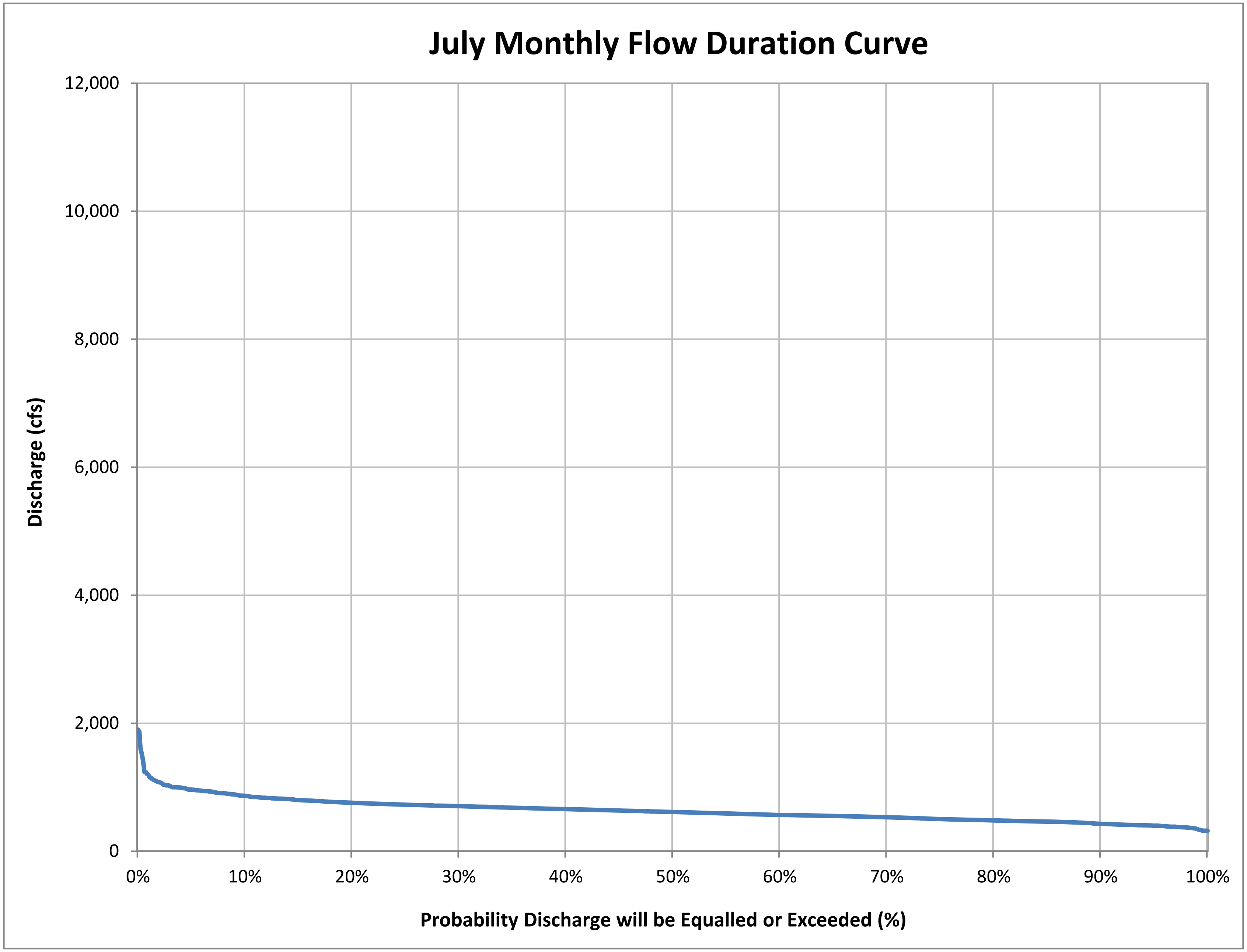

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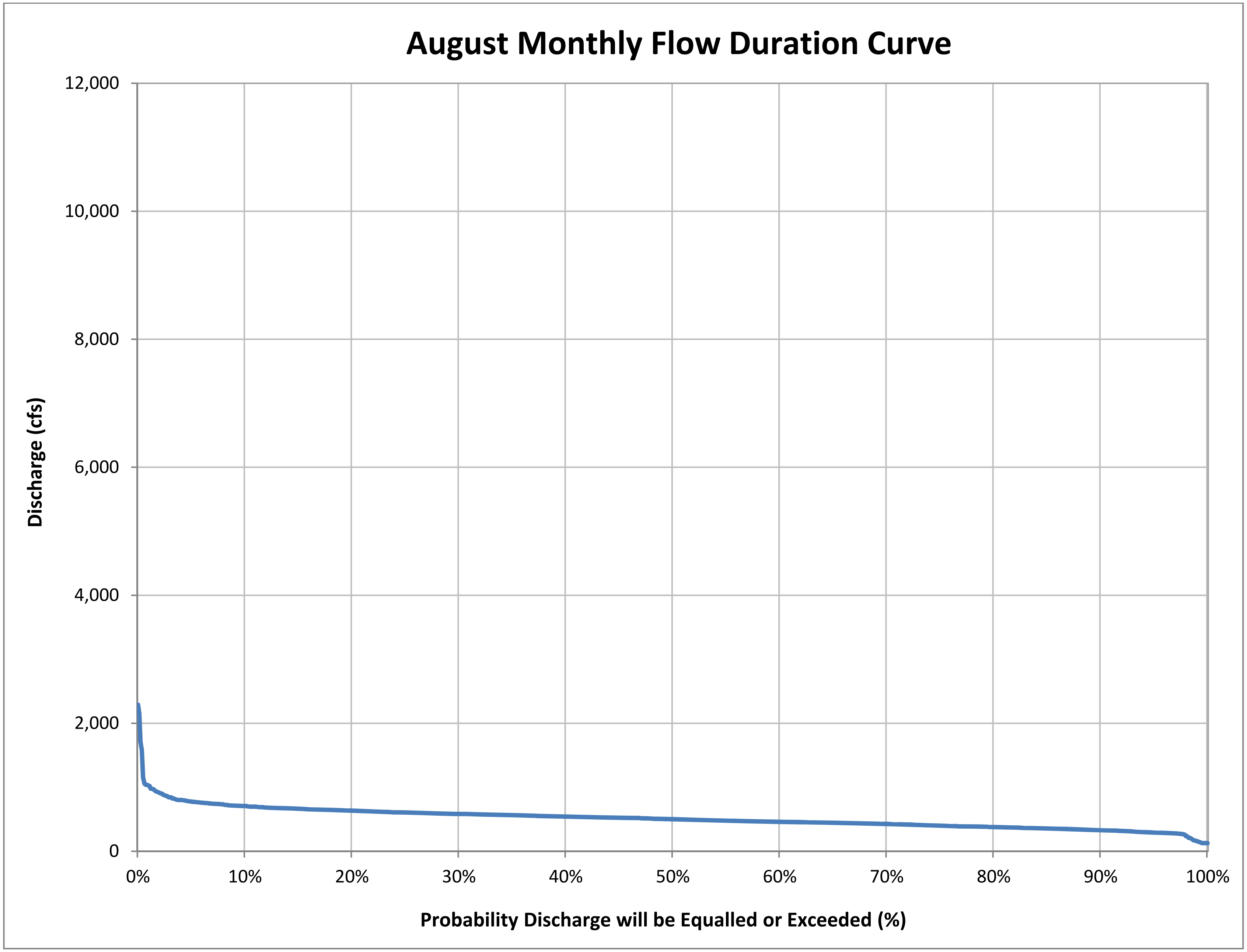

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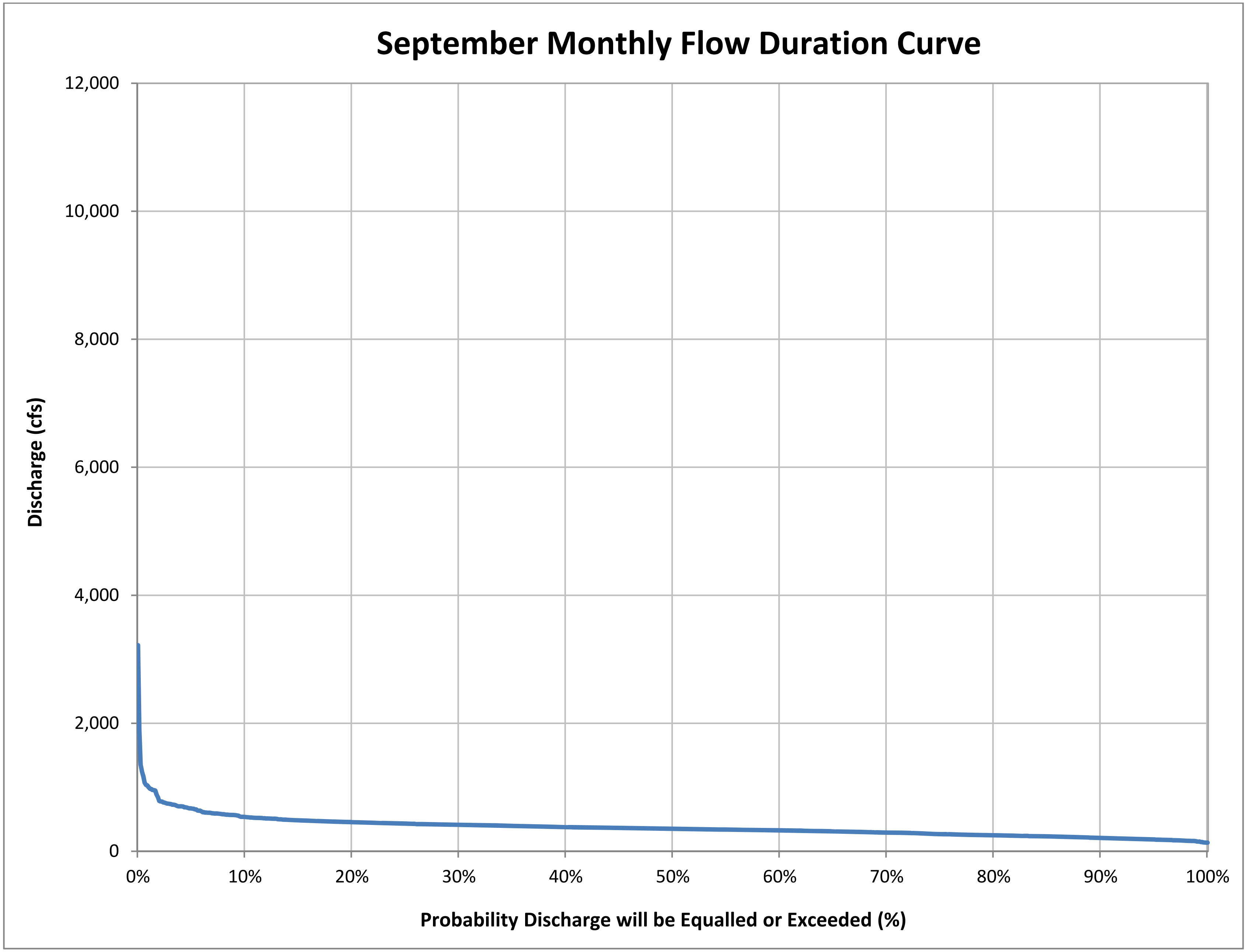

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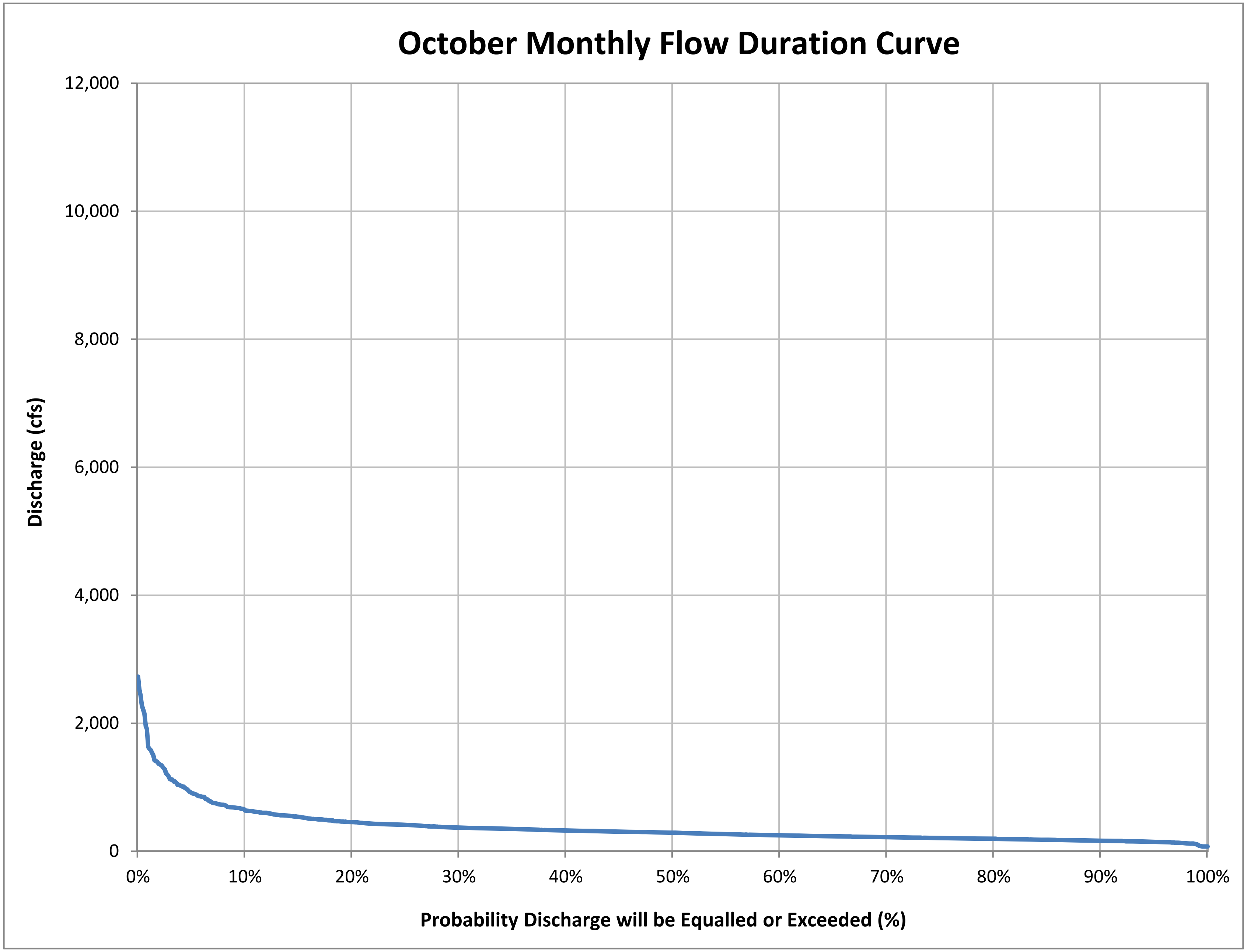

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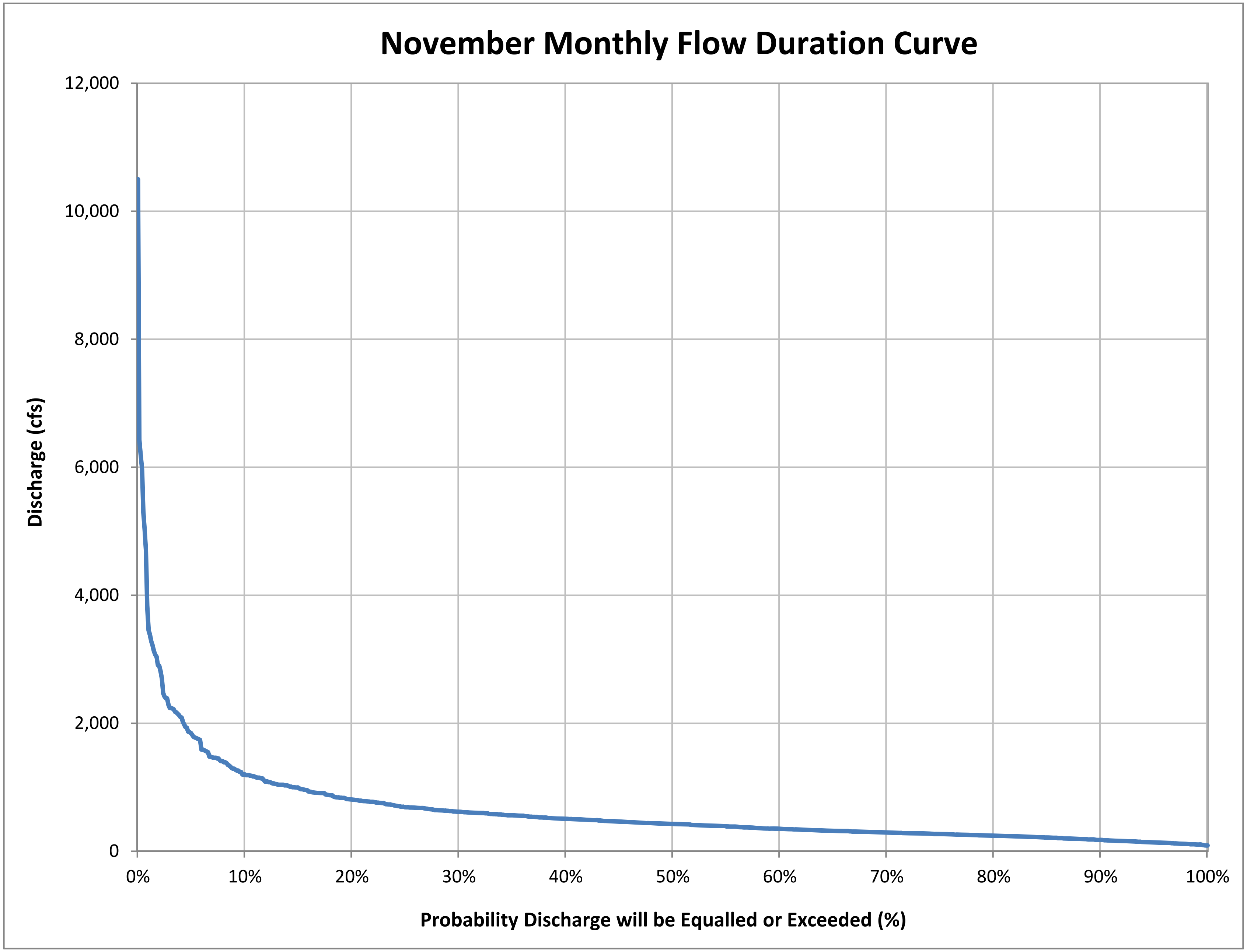

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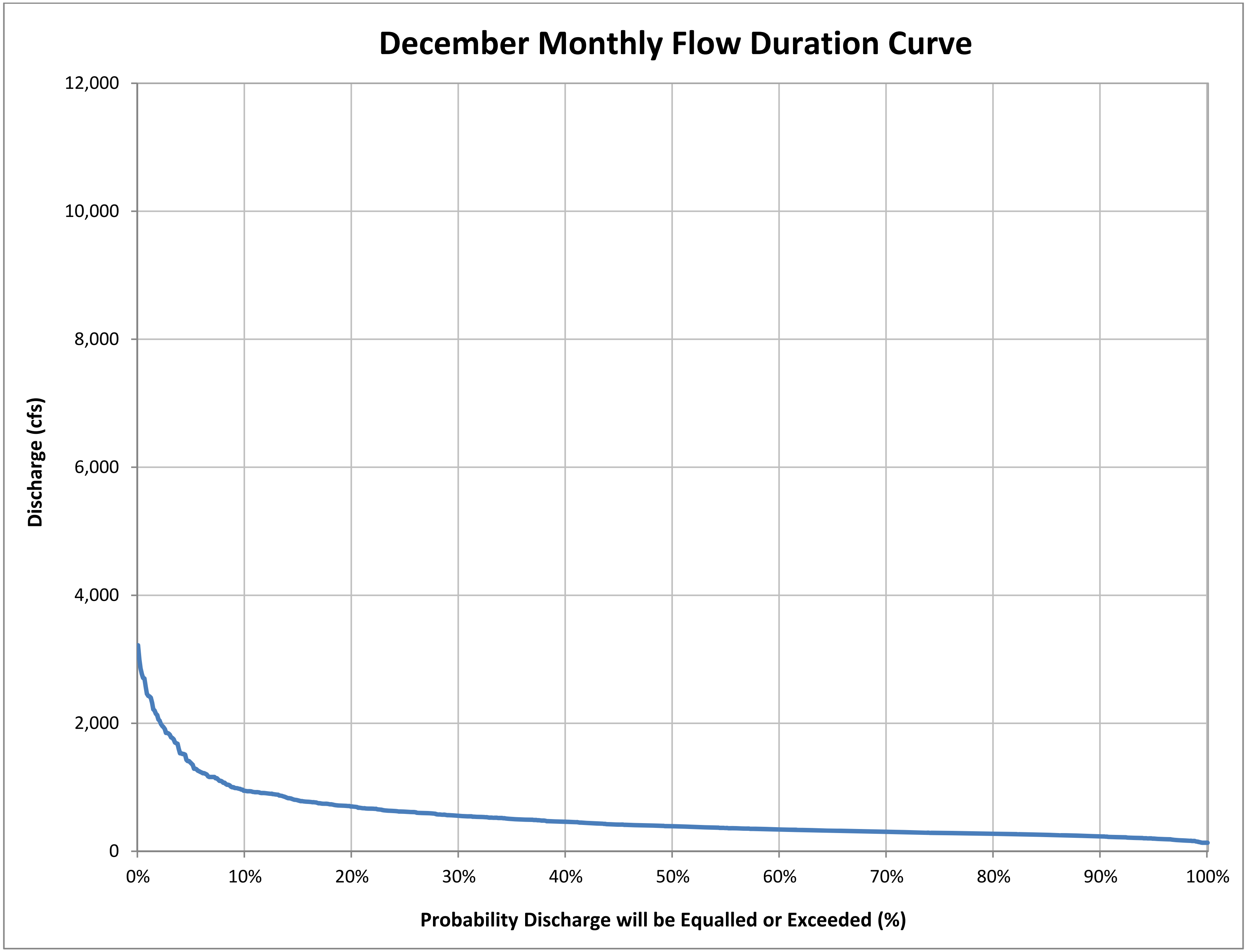
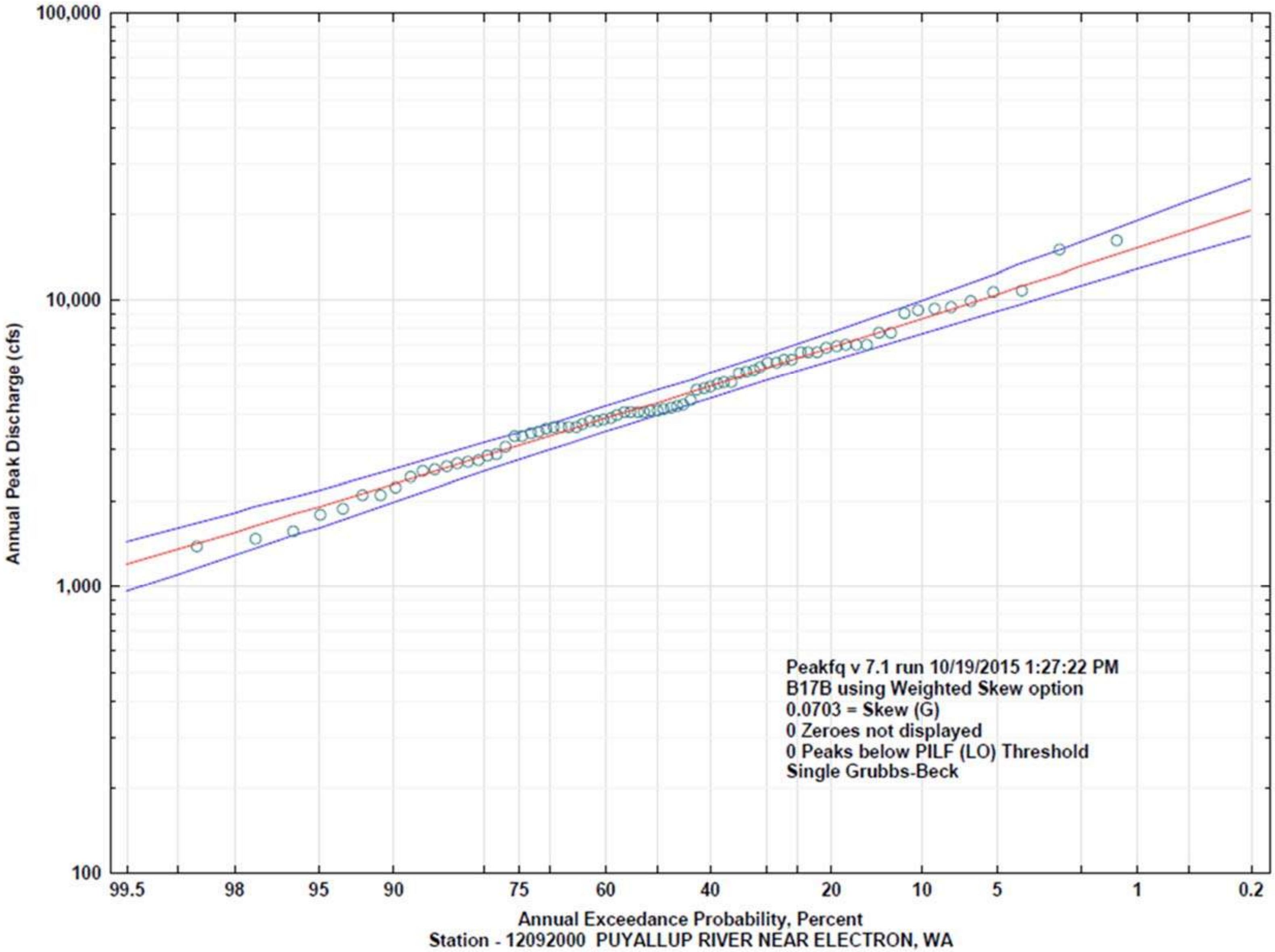


Attachment C



ELECTRON HYDRO LLC

Geomorphology and Sediment Transport Study DRAFT

Electron Hydro LLC

19318 Electron Road
Orting, WA 98360

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2/28/2016

ABSTRACT: *This study provides essential insights into the physical behavior of the Puyallup River in the vicinity of the Electron Hydro water diversion and head works. Proposed rehabilitation of the diversion and intake require an assessment of the relation between physical river processes and the facility. This assessment informs the design and operation plan for modifications so that impacts to the river are minimized and river process effects on the operation are effectively managed.*

Contents

Figures

Tables

1.0 Introduction

Electron Hydro, LLC operates a power generation facility on the Puyallup River in Pierce County, Washington. A low-head wooden diversion structure diverts water from the Puyallup River into a flume that conveys the water approximately 10 miles downstream to the forebay, then through penstocks to the powerhouse. The existing diversion structure entrains a large amount of sediment that is constantly flowing down from the glaciers on Mt. Rainier. Fish passing downstream pass through the fish ladder on the right bank, pass over the diversion in the middle of the river, or go into the Electron intake on the left bank. Both fish and sediment are transported through the flume before being removed. Rocks and gravel are removed by two rock chutes that intercept such material at the bottom of the flume and send it back to the river within a few hundred feet of the diversion. Sand and silt are removed by tracked excavator from a large settling pond near the midpoint of the flume. Fish are collected and removed from a forebay at the downstream end of the flume and transported by truck back to the river at a point just below the powerhouse. Electron Hydro presently seeks to perform maintenance on the diversion spillway, and modernize the facility by rehabilitating the diversion structure and intake to better manage both fish and sediment at the point of diversion.

This geomorphology study provides essential insights into the physical behavior of the Puyallup River in the vicinity of the water diversion and intake. Sediment delivery and channel instability in the vicinity of the diversion affect the operation of the project intake and fish ladder. This requires episodic gravel manipulation within the river channel to maintain reliable operation of the fish ladder and generating facility. This assessment informs the design and operational plan for modifications so that fish and bedload transport are more natural, and project operations are effectively managed.

Specific components of the geomorphology study target certain design and operational needs. The following key issues are addressed by this study:

- Bedload sediment dynamics in the vicinity of the diversion
- Channel stability for existing and proposed conditions

Suspended sediment transport is evaluated and addressed in a separate technical document.

2.0 Background

2.1 Project Description

Electron Hydro proposes a two-step process to modernize the facility. The first step would be to perform all in-water work. In-water work includes replacement of the existing Obermeyer spillway (steel plates over rubber bladders) with a single rubber bladder spillway, and reinforcing the left bank of the Puyallup River just upstream and downstream of the diversion. The second step would be installation of a fish screen facility and sediment management facility. The new bladder spillway would provide a lower and wider spillway than the existing spillway. The fish screen facility would exclude fish from the flume and downstream facilities, and return the fish safely to the river. The sediment management facility would deposit sediment back to the river that would mimic natural timing and volume of bedload sediment transport.

2.1.1 Bladder Spillway

An inflatable bladder spillway would be 12 feet high, 70 feet wide, and would be installed within the existing footprint of the spillway and diversion. The bladder spillway would maintain a pool level above the diversion at elevation 1620.70. During high flood events, the bladder spillway could be lowered all the way to allow episodic flushing of the bedload material sediment that accumulates upstream of the diversion without putting construction equipment in the river bed. Episodic sediment flushing would also help maintain the pool above the diversion with a reduced volume of sediment, which would reduce the sediment diverted into the project intake on the left bank, and fish ladder on the right bank. The bladder spillway also provides the essential function of preventing coarse bedload from impacting the proposed fish screen facility.

The existing fish ladder would remain in operation to ensure upstream fish passage around the diversion. The proposed bladder spillway would occupy only 70 feet of the existing diversion width. The remainder of the channel width at the diversion would remain in place in its existing configuration. Hydraulic conditions upstream and downstream of the diversion would be altered by the proposed construction and operation of the bladder spillway. Existing hard bank stabilization in the vicinity of the diversion, intake and fish ladder would be upgraded.

2.1.2 Fish Screen Facility

A fish screen facility would be installed upland, downstream of the diversion to exclude salmonids from being entrained into the flume. Screened fish would be returned to the river via return channel that discharges downstream of the diversion. Reduction of sediment entrainment at the intake is important to ensure reliable operation of the fish screen facility. The operation of the bladder spillway to flush bedload sediment and maintain a pool in front of the diversion is essential for preventing entrainment of large bedload sediment that could damage the existing fish ladder and proposed fish screen facility.

2.2 Puyallup River Basin Characteristics

The Puyallup River and its major tributaries originate from glaciers on the northern and western flanks of Mount Rainier, and flows approximately 50-90 miles (depending on river course) to Puget Sound in Tacoma (**Figure 1**). The contributing watershed area is approximately 990 square miles. About 75% of the basin sits within the Cascade Range and its foothills with the remaining 25% occupying Puget Sound Lowland. Major tributary rivers to the Puyallup River include the White River, Mowich River, and the Carbon River each originating on Mount Rainier. Elevation ranges from 14,410 feet at the top of Mount Rainier to sea level at the confluence with Puget Sound in Commencement Bay in Tacoma. High sediment transport rates have been driven by the combined effects of high rainfall, steep channel gradient, and steep topography including glacial erosion of volcanic rock at the headwaters (Czuba et al. 2010). As the glaciers on Mt. Rainier recede, the outwash plains and steep side slopes previously covered by glaciers have become exposed to erosion causing a substantial increase in bedload transport. Glacial retreat on Mt. Rainier has been occurring since the Little Ice Age ended in the mid-1800s, but within the past decade the rate of glacial retreat has accelerated to over 6 times the historical rate (Grove 1988; Czuba et al. 2010; Carson et al. 2014).

2.3 Channel Morphology and Hydrology at Electron Hydro Diversion

The diversion for Electron Hydro is located on the Puyallup River approximately 13 miles downstream of the Tahoma Glacier and Puyallup Glacier on Mount Rainier. The Mowich River confluence with the Puyallup River is located approximately 3,000 feet upstream of the Electron Hydro diversion. Puyallup River valley slope was calculated in the vicinity of the diversion using publically available topographic information (**Table 1**)[1]. Average river gradient within approximately 1 mile of the diversion is 2.27% with reach-scale variations between 1.3% and 2.9%. Bank full channel width varies from approximately 150 - 300 feet in this same reach. The river bed composition includes a wide range of material from silt to boulders larger than 5 feet in diameter. Bed composition varies widely along the river and across the channel. The combination of high gradient and high sediment load determine the predominantly braided channel pattern. The main river divides into as many as 3 or 4 parallel channels where the valley bottom is wider. The river coalesces into a single channel in locations where terraces or shallow bedrock slopes confine the valley bottom. The channel form changes notably from year to year in response to large flow events through rapid deposition and bed scour, bank erosion, avulsion, and channel migration.

Long-term trends in sediment supply and delivery processes are important considerations for any facility located within the river valley. Glacial retreat within the past 150 years has exposed unstable slopes along the edges of the glacial valleys on Mount Rainier (Grove 1988 cited in Czuba et al. 2010). Debris flows and landslides on these lateral slopes add to the overall volume of sediment delivered to the river's headwaters by glacial processes. These smaller localized slope processes are likely to produce a net increase in the long-term average sediment supply at the headwaters. The most pronounced effect will be significant aggradation of the riverbed in close proximity to the sediment sources. The amount aggradation will diminish downstream. For the Electron Hydro facility, any pulse or increase in the sediment supply at the headwaters is

[1] Reach scale slope was calculated using topography and distances measured on Google Earth™. Distance along the river channel was measured between each 40 feet contour interval, and overall gradient was calculated along with local gradient measured for each contour interval. This approach provides a useable result for average valley slope and reach scale channel slope, but does not capture local variations associated with riverbed features including pools, riffles, and cascades.

somewhat attenuated by transport and deposition within 13 miles of upstream river valley. At the point when sediment delivery is limited by transport capacity (instead of supply), the river bed would aggrade to increase channel slope, stream power, and transport capacity to match supply. Any such aggradation would be thickest close to the source and diminish downstream. The zone of aggradation will gradually progress downstream getting slower with distance from the source. The river valley upstream of the Electron Hydro diversion has enormous sediment storage capacity within the valley sufficient to absorb and attenuate long-term gradual increases in sediment delivery. In the absence of a catastrophic event, such as a volcanic eruption or massive debris flow, any channel bed aggradation for the next several decades at the diversion intake site should be limited to small localized responses to reach-scale sediment dynamics. The projected long-term trends in sediment supply from upstream sources indicate there would be a steady and abundant supply of bedload, and the river would persist in a predominantly "transport limited" condition with respect to bedload sediment transport.

The Puyallup River and its tributaries are subject to rare catastrophic events related to the volcanic geology of Mount Rainier. The Electron mudflow occurred approximately 600 years ago depositing sediment approximately 100 feet thick near Electron and tapering off to 2 feet thickness near Orting (Czuba et al 2010). Some of the alluvial terraces present along the Puyallup River valley were formed by this event. Geologic analysis of floodplain deposits in the Cascade Range foothills and Puget Lowland indicates that at least 60 lahars (large volcanic debris flows) have occurred in the Puyallup River Basin during the Holocene (Hoblitt et al. 1998 cited in Czuba et al. 2010).

Flow monitoring data collected by U.S. Geological Survey (USGS) are available at a stream gage station near the Electron Hydro diversion located approximately 1,000 feet upstream (USGS Gage Station 12092000). Detailed analysis of local river hydrology based on USGS data is reported separately (Eckert 2016). Drainage basin area upstream of this gage is approximately 93 square miles. Estimated annual peak flows at the diversion are summarized in **Table 2** for a range of recurrence intervals. Generally, seasonal average flows are approximately 500 cubic feet per second (cfs) with episodic flows up to 2,000 cfs occurring commonly. Peak flows range from the 2-year flow of 4,360 cfs up to the 100-year flow of 15,207 cfs. Maximum flow of record (16,000 cfs) occurred on Feb. 8, 1996. Minimum daily discharge (75 cfs) occurred on October 19, 1994.

Both flow and sediment load are seasonally affected by the combination of glacial meltwater and seasonal precipitation varying between rain and snow at higher elevations. The largest peak flow events are most commonly floods resulting from rain on snow, but peak flow events can also result from runoff during regional rainfall events in the absence of snow.

3.0 Bedload Sediment Transport

Bedload sediment delivery to the diversion vicinity causes changes in the riverbed that alter local hydraulics in the vicinity of the diversion, the intake, and the upstream entrance to the fish ladder. A primary purpose of the proposed bladder spillway is to manage bedload sediment transport upstream of the diversion to maintain a pool between the intake and fish ladder entrance. This would minimize entrainment of bedload sediment material into the fish ladder and flume. Bedload sediment transport analysis addresses three study questions:

- What is the relation between river flow and bedload sediment delivery at the diversion?
- How would the riverbed respond to episodic lowering of the proposed bladder spillway?
- How long would it take for sediment to fill up the pool behind the diversion?

3.1 Relation between River Flow and Bedload Transport Rate

The bedload sediment transport analysis estimates the total sediment load as a function of river flow at the Electron Hydro diversion. Bed load sediment transport was evaluated in the vicinity of the diversion using Bedload Assessment for Gravel-bed Streams (BAGS) software (Pitlick et al. 2009). The surface-based relation of Wilcock and Crowe (2003) was selected based on the nature of the study area and the available information about flow, channel dimensions, and bedload material. The Wilcock and Crowe (2003) equation is a surface-based bedload transport equation developed from flume experiments using mixtures of sand and gravel. This description matches observed sediment bed conditions in the upper Puyallup River. The "hiding function" included in this equation reduces the transport potential of smaller particles as they are effectively sheltered by larger gravel particles and not subjected to the full force of the flow. The hiding function has the effect of increasing gravel-transport potential as the sand content increases (Wilcock and Crowe, 2003). This same bedload transport equation was used by USGS to evaluate channel aggradation in the lower Puyallup River (Czuba et al. 2010). Results of the bedload transport analysis include a sediment rating curve for the main river channel (**Figure 2**) and a table of sediment transport rates for recurrence interval flow events (**Table 3**).

Bedload sediment transport rate is a function of river flow and bed material characteristics (e.g. size, shape, density). The transport rate increases steeply with increased flow as higher flows mobilize more of the bed and the effect of bed armoring is weaker above the threshold of full bed mobilization. Extensive riverbed modifications are likely during rare large flow events.

Bedload is typically a small fraction of the total sediment load because bedload travels more slowly along the channel boundary while suspended load moves at a faster pace with the flow. For the Puyallup River, bedload sediment transport rate can be estimated as approximately 4% of the suspended sediment load by similarity to studies on the White River with data showing that ratio (Nelson 1978; Dunne 1986 cited in Czuba et al. 2010).

Sediment mobility varies by sediment size with flow. Higher flows have the power to mobilize larger sediments. For the range of conditions evaluated, model results showed that sand and gravel are mobile at all flows except extreme low flow conditions. At modest flows exceeding 1000 cfs, most of the riverbed becomes mobile (including cobbles and small boulders, but transport rate of the largest sizes is very slow. As flows increase to over 4000 cfs, the entire bed is mobilized and cobbles and boulders 3 - 4 feet diameter move along the riverbed. Over all flows, the bulk of the bedload material is half-inch gravel. Although the bed surface composition appears dominated by much larger material, the bed surface shows the results of armoring and hydraulic sorting. Transport rates vary by grain size, and for all flows, the largest cobbles and boulders are transported at slower rates than gravel and sand.

3.2 Riverbed Response to Adjustment of the Proposed Bladder Spillway

The proposed bladder spillway would maintain a pool elevation at 1620.70 by adjusting the degree of inflation in response to changes in flow. As flows increase, the bladder is slightly deflated until it forms a dimple near the left abutment to pass the excess water. As flow further increases, the bladder is further deflated until the dimple increases to the maximum height of 12 feet. As flows further increase, the 12 foot high dimple then becomes wider, until such flows as the bladder is fully deflated 12 feet and the full 60 feet wide. Continuous operation of the bladder to maintain a steady pool elevation would minimize the effects of the diversion on bedload sediment transport. Bedload would pass over the dam in proportion to the amount of flow in the river. The effect of the bladder on temporary sediment storage upstream is highest when the dam is fully inflated and lowest when the dam is fully deflated. The proposed variation of bladder inflation with flow would closely mimic the natural transport of bedload, which varies proportionally with river flow.

During high flood events, the bladder spillway could be lowered to flush accumulated sediment from behind the diversion to maintain the pool at the intake. Given a long enough time (during a very high flood event), the riverbed upstream of the diversion would scour down to establish an equilibrium profile based on the new local base level set by the lowered bladder spillway. **Figure 3** illustrates the likely maximum extent of scour that would result from long-term response to lowering the spillway. Complete deflation of the bladder spillway would likely occur during high flow periods.

Lowering the controlling bed elevation from the existing 3 feet to the proposed12 feet would result in an immediate and rapid response as bed scour in the immediate vicinity of the diversion. Over time, the scour would progress upstream and the effective bed slope (and related water surface slope) would get progressively flatter. The rate of bed scour slows down as it progresses upstream.

River flow determines the rate of pool scour when the bladder spillway is lowered. **Table 4** shows the extent of the temporary scour zone as a function of flow. Highlighted cells in the table correspond to flow and scour length scenarios that are 2 hours or less time.

In summary, the riverbed would scour a pool upstream of the diversion when the bladder spillway is lowered for any flow value, but the extent of the scour pool is small for low flows and larger for high flows. For a 2 hour period, the extent of scour would be limited to a few hundred feet (100 -800 feet) for flows greater than 500 cfs with greater scour extent corresponding to higher flows.

3.3 Rate of Sediment Filling Upstream of Diversion

During periods when the bladder spillway is inflated and there is a pool upstream of the diversion, the bedload delivered from upstream of the pool would be deposited within the pool until the river bed rises up to meet the elevation of the spillway. As flows increase, so also does the bedload. The bladder is designed such that at higher flows, the dam would be partially deflated lowering the elevation of the dimple and allowing bedload to pass over the spillway. This operational strategy would most closely mimic natural bedload transport and limit bedload that would enter into the fish ladder and project intake.

Bedload sediment transport rate varies with river flow – high flows deliver sediment faster – so the time required to fill up the pool behind the diversion varies depending on actual flows. **Table 5** applies the rate of sediment accumulation as a function of flow to estimate the time required to fill up the pool for different flow conditions.

For a steady flow of 500 cfs, the river transports bedload at 0.5 tons/min and would fill up the pool within approximately 42 days. At the extreme high flow condition of the 100-year flow (15,207 cfs), the pool would fill up in approximately 2 hours. For all flows over 2000 cfs, the pool fills up in less than 2 days. These estimates are based on a pool that extends 1200 feet upstream with 75 feet width (approximately half the bank full channel). In situations where the pool is smaller than this, it would take less time to fill up.

This analysis shows that should the flow in the river exceed 1000 cfs for long periods of time, the pool would need to be flushed approximately once per week (during hot glacial melting). The pool should also be flushed after flows that exceed 2000 cfs. Flushing would last approximately 2 hours.

4.0 Channel Stability Evaluation

Channel instability in the vicinity of the diversion must be effectively managed to ensure reliable operation of the diversion, fish ladder, fish screen, and associated components. Dynamic changes to the riverbed, riverbanks, and pathways of multi-thread channels are typical within this reach of the Puyallup River. The existing diversion was first constructed over 100 years ago. A century of operation has demonstrated that the facility was located optimally where the river has a relatively stable single-thread channel. The channel is confined by a steep slope on the right bank and by a slightly higher elevation terrace on the left bank. This confinement has maintained a relatively narrow (i.e. 150 feet bankfull width) single thread channel for approximately 1000 feet upstream of the diversion. The bankfull channel width expands to over 250 feet both upstream and downstream of the diversion and the channel form transitions to multi-thread braided river where valley width allows. The result is long-term channel stability in the vicinity of the diversion compared to the more dynamic reaches upstream and downstream of that location.

4.1 Recent Channel Instability near the Diversion

Even with a relative degree of local stability, recent channel changes have occurred within the vicinity of the diversion affecting road and bridge infrastructure and causing bank erosion. The infrastructure impacts have interfered with normal maintenance of the fish ladder, and ongoing bank erosion has the potential in the long-term to escalate into new channel formation that could bypass the fish ladder and diversion. Specific instances of recent channel instability are shown on **Figure 4** and described below:

- **Bridge washout –** the logging road bridge located approximately 1200 ft upstream of the diversion experienced a washout of the bridge approach fill on the left bank (south bank) during a flood event in 1999. The bridge structure remains in place, but the high flow channel that washed out the bridge approach continues to convey flood flows and the bridge is no longer passable. Hancock has elected not to repair the bridge approach.

- **Road washout –** the logging road located along the right bank (northern bank) in the vicinity of the diversion has served as primary access road for maintenance of the fish ladder. River migration and bank erosion washed out a 200 feet long section of this road downstream of the diversion in November 2015. This location had been the target of previous aggressive bank stabilization measures to protect the road. Those measures failed during the washout. The bank remains exposed and the road has not been repaired or rerouted.

- **Overbank flow upstream of fish ladder –** approximately 600 feet of the right bank upstream of the fish ladder has a low elevation and is only a few feet higher than the adjacent riverbed. The combination of a relatively narrow and shallow single thread river channel causes this location to experience more frequent overbank flooding. The overbank area is mostly forested and somewhat resistant to erosion of the bank and floodplain surface. Long-term accumulation of sediment within the channel upstream of the existing diversion has reduced channel conveyance capacity and increased the frequency of overbank flows in this location compared to a pre-diversion condition. Recently exposed roots and bare soil at the channel margin demonstrate ongoing bank erosion, and flow paths including scour and sand ripples document floodplain pathways for overbank flow. The roadway and cleared access areas along this bank are subject to flooding and have the long-term potential for side channel formation and avulsion. Such a bypass channel would impair the operation of the fish ladder and flow diversion.

4.2 Potential Effects of the Proposed Action on Channel Stability

The installation and operation of the proposed bladder spillway would affect local channel dynamics with some beneficial results and some potential negative results that will need to be minimized and avoided. Potential effects on channel stability are described below with a qualitative description of channel and sediment dynamics, comparison of sediment pulses to peak flow event sediment transport rates, and recommendations for locations and types of bank stabilization.

4.2.1 Local Riverbed Changes and Sediment Dynamics

The proposed bladder spillway is intended to modify the river bed upstream of the diversion by flushing out accumulated gravel. This change would have an immediate and ongoing influence on local riverbed dynamics in the vicinity of the diversion. Previously discussed bedload analysis determined that the typical upstream extent of episodic sediment flushing would be limited to a few hundred feet with a maximum extent of approximately 1200 feet occurring during rare peak flow events. For over 100 years, the existing diversion has forced a localized gradient drop that caused sediment deposition upstream and riverbed scour downstream. These effects are localized and diminish quickly with distance both upstream and downstream. Episodically lowering the proposed bladder spillway would allow the riverbed to move toward a pre-diversion condition with a more continuous transition in the river bed from above the diversion to below it. In terms of the riverbed gradient, the present-day dynamic equilibrium and the pre-diversion riverbed profile serve as bounding conditions for the short-term changes in riverbed profile configuration that could result from lowering the bladder spillway.

The original installation of the diversion interrupts bedload transport downstream until the bed has filled in and adjusted to a new stable longitudinal profile that allows bedload to pass. Episodic gravel manipulation upstream of the diversion has been needed to maintain a small pool at the diversion intake. Replacing the existing 3 foot deep bladder spillway with an adjustable 12 foot bladder spillway would reduce or eliminate the need for gravel manipulation in the channel using heavy equipment. Bedload would be continuously transported and episodically flushed from behind the diversion resulting in bedload transport that closely mimics the natural variation in bedload transport with changes in river flow. Previously described analysis indicates that flushing would be continuous at lower flows, and episodically during periods of sustained moderate flows and in response to peak flow events. Bedload sediment moves naturally in pulses in sync with peak flow events. The proposed sediment flushing would occur during periods of higher flow mimicking the natural pulses of bedload sediment transport. The maximum volume of sediment temporarily stored behind the proposed bladder spillway is a small fraction of the total bedload volume transported during peak flow events. Estimated maximum volume stored behind the diversion is 30,000 tons calculated using the estimated maximum extent of upstream scour. Some fraction of this would actually be flushed for most flow conditions. The 2-year flow event transports bedload at a rate of approximately 40 tons/minute, and the 100-year flow event transports bedload at approximately 250 tons/minute.

Gage records show that peak flow events typically maintain elevated flows for 3-6 days. A sediment pulse resulting from lowering the spillway for a few hours would be completely absorbed into the overall sediment load spanning multiple days around a brief flushing event.

Downstream of the diversion, the channel widens to approximately 270 feet and divides into multiple flow paths. The active channel has ample capacity to absorb short term pulses of sediment that can be stored as mid-channel bars before being transported downstream during subsequent high flows. A wing wall structure may be used immediately downstream of the bladder spillway to direct flow and sediment toward the center of the channel downstream. Based on current channel configuration, the wing wall would be installed at an angle approximately 14 degrees to the bank. This would reduce scour and other potential impacts on the left bank caused by concentrating flow along the channel margin. Installation of rock groins downstream of the wing wall along the left bank would provide additional protection.

4.2.2 Bank Stability

Bank stabilization would be needed as part of the proposed action to address both existing bank instability and potential effects of the proposed bladder spillway. Hard bank stabilization is needed both upstream and downstream of the diversion. On the left bank downstream of the diversion, bank hardening will be limited to the approximate location and extent of existing hard banks that extend approximately 400 feet downstream of the diversion. Upstream of the diversion on the left bank, new hard bank protection would be needed to protect the intake. Wherever feasible and effective, new proposed bank stabilization would utilize natural materials and incorporate logjam structures that would provide habitat benefits as well as contribution to channel stabilization.

The left bank downstream of the diversion may be at risk as a result of concentrating the majority of flow on the left side of the river as it passes through the bladder spillway. Erosion of the left bank would have large consequences to the flume, fish screen, sediment management facility, and supporting infrastructure. This risk should be addressed by ensuring stability of this channel margin. The existing bank is protected by large angular rock for approximately 400 feet downstream of the existing spillway. That existing bank protection should be evaluated based on hydraulic analysis of proposed conditions and maintained or bolstered accordingly. The present extent (approximately 400 feet) should be sufficient to protect the proposed facilities. The use of a wing wall flow deflection structure as noted above is recommended to direct flow and sediment away from the left bank and toward the middle of the channel.

Upstream of the diversion, sediment flushing would result in a deeper channel with respect to the floodplain. Channel deepening would adjust the channel back toward the pre-diversion condition and reduce overbank flooding on the right bank. This would improve channel stability within the affected zone, but that zone may not extend far enough upstream to completely address the risk on the right bank. Stabilization of the right bank and floodplain upstream of the fish ladder using logs, rootwads, and riverbed material should be implemented to prevent long-term formation of a side channel that would bypass the fish ladder and diversion structure.

The left bank within the first 200 feet upstream of the diversion intake may become destabilized by lowering of the bed by 10-12 feet during episodic flushing events. This bank may be effectively stabilized by installation of a hard wall, and then a logjam structure upstream that is well-anchored into the bank. This structure would serve a dual purpose in hydraulically maintaining a scour pool in front of the diversion intake even when the pool is otherwise filled with sediment. Such a structure would also serve as a blocker for debris and boulders that could otherwise directly impact the diversion intake.

The site of the road washout on the right bank downstream of the diversion has continued to erode during high flow events. That location would continue to experience further erosion as long as the majority of flow is concentrated along the right side of the active channel. With the new proposed bladder spillway, the main portion of the flow would be directed more to the center and left bank, which would cause the river to migrate back toward the center of the valley. This would take pressure off the current erosion on the lower right bank. There are no plans to rebuild the road in this location, so bank stabilization is not needed. Erosion may continue at this location until changes in the riverbed.

5.0 Conclusions and Recommendations

- The proposed bladder spillway would be effective for maintaining a constant pool elevation at the intake. As the river flows increase, the inflation of the bladder would be adjusted so the spill dimple in the bladder spillway conveys more flow and maintains a constant pool elevation. This adjustment would continually pass bedload over the spillway. The spillway would flush sediment during episodic high flow events when the bladder is deflated. The combination of continuous sediment passage and episodic flushing would help maintain the pool in front of the project intake and the upstream connection to the fish ladder.

- Bedload sediment transport is sufficient to quickly fill up the pool upstream of the diversion. The time required to fill the pool with bedload sediment varies from about 42 days for continuous river flow of 500 cfs to a few hours for flows larger than the 2-year flow event (4,360 cfs). Flushing during high flow events would maintain a more natural transport of bedload downstream.

- The bulk composition of bedload sediment is finer than the riverbed surface, which is dominated by an armor layer of cobbles and boulders. The median sediment diameter (D50) by mass of the bedload is about ½ inch diameter gravel with maximum mobile sediment size ranging from 6 inches at flows between 500 – 1000 cfs up to larger than 4 feet diameter boulders during peak flood events.

- The projected long-term trends in sediment supply from upstream sources indicate there would be a steady and abundant supply of bedload, and the river would persist in a predominantly “transport limited” condition with respect to bedload sediment transport.

- River response to episodic flushing of sediments behind the bladder spillway during high flow conditions is expected to be small, short-lived, and localized within a few hundred feet upstream and downstream of the diversion. The pulses of bedload sediment that would be generated by flushing would be a small fraction of the total bedload that is being mobilized by the river. Bedload sediment transport occurs naturally in pulses in association with peak flow events. The effect would be similar in scale to the short term variations in sediment storage that naturally occur in a dynamic mid-channel gravel bar.

- Bank stabilization is recommended to address bank erosion and overbank flooding along approximately 600 feet of right bank upstream of fish ladder. Recommended method for stabilization would use engineered log jam structures that integrate anchored logs, root wads, and riverbed material. The log structures would provide bank stability, prevent long-term channel avulsion in this location, and provide in-stream habitat enhancement for salmonids along the right bank.

- Hard engineered bank stabilization is recommended on left bank for 100-200 feet upstream of the diversion intake to stabilize this bank. Upstream of the hard structure, an engineered log jam structure could serve multiple functions by extending bank stability, maintaining a scour pool in front of the intake, and blocking debris and boulders from directly impacting the intake.

- Hard engineered bank stabilization is recommended on the left bank upstream and downstream of the proposed bladder spillway. The bank protection would need to extend far enough downstream to protect the proposed fish screen facility. Existing hardened bank extends about 400 ft – this should be sufficient to protect the proposed infrastructure. Existing bank stabilization should be evaluated under post-action hydraulic conditions and upgraded if necessary.

- Installation of a wing wall flow deflector is recommended for the left bank immediately downstream of the proposed bladder spillway. The proposed spillway would concentration the majority of flow on the left side of the river, and a deflection structure is recommended to route the flow and sediment toward the middle of the channel downstream of the diversion. This would reduce risk of erosion and scour along the left bank. Recommended orientation of the structure is approximately a 14 degree angle to the bank to form a continuous gradual transition from the spillway to the center of the channel. The flow deflector should extend at least 80 feet downstream of the spillway.

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Figures and Tables

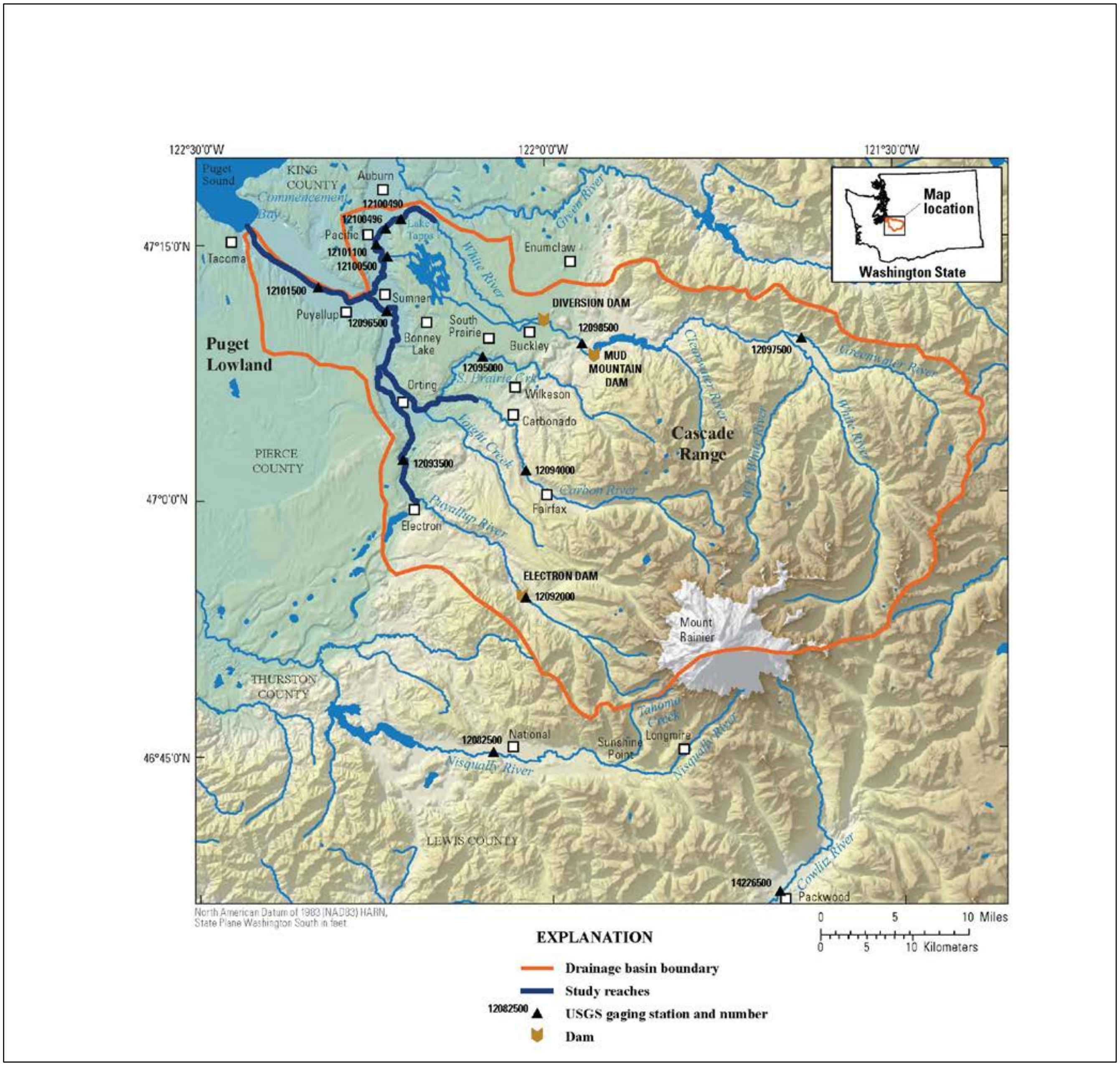


Figure 1 – Puyallup River Basin (Czuba et al. 2010)

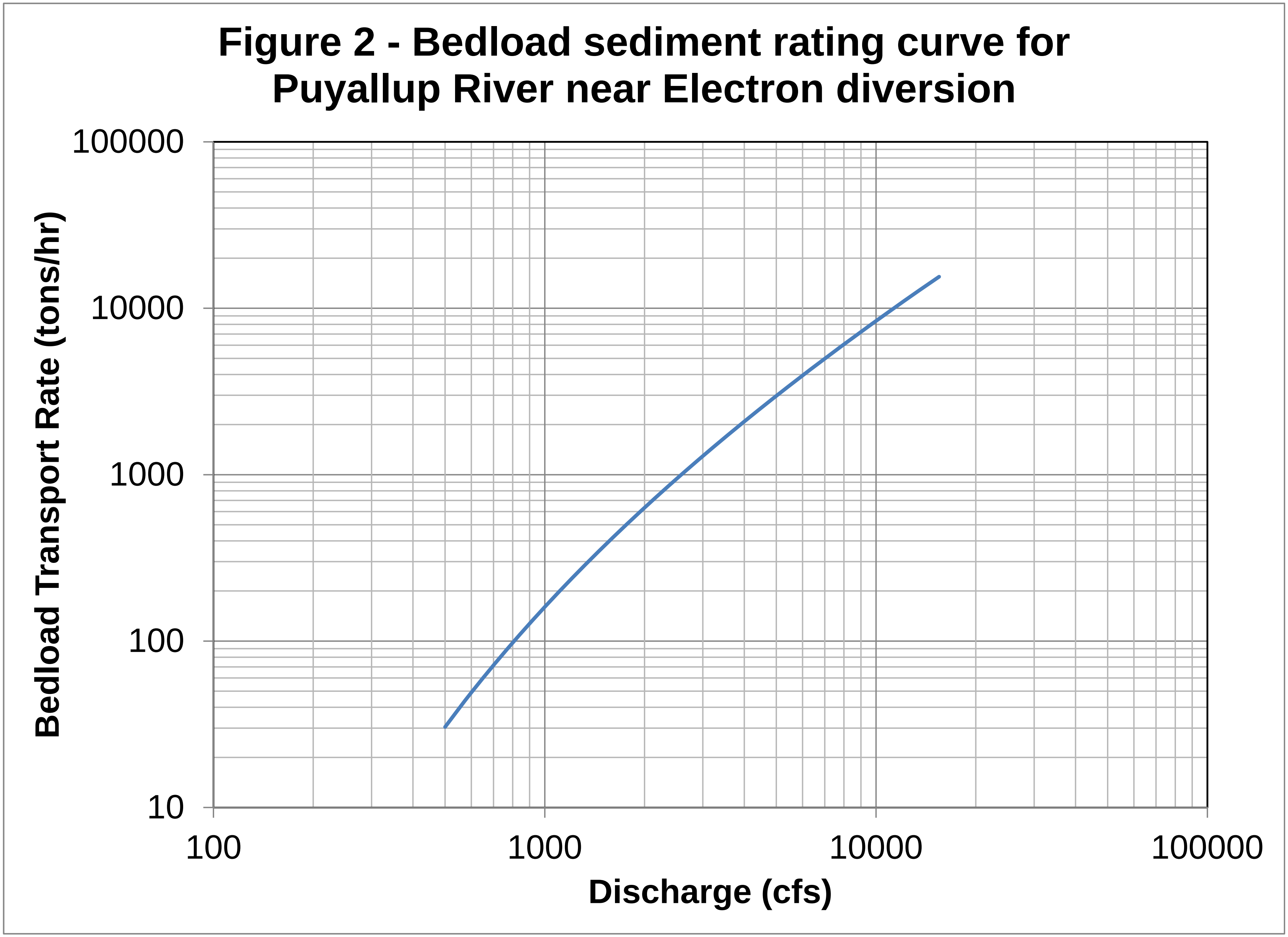
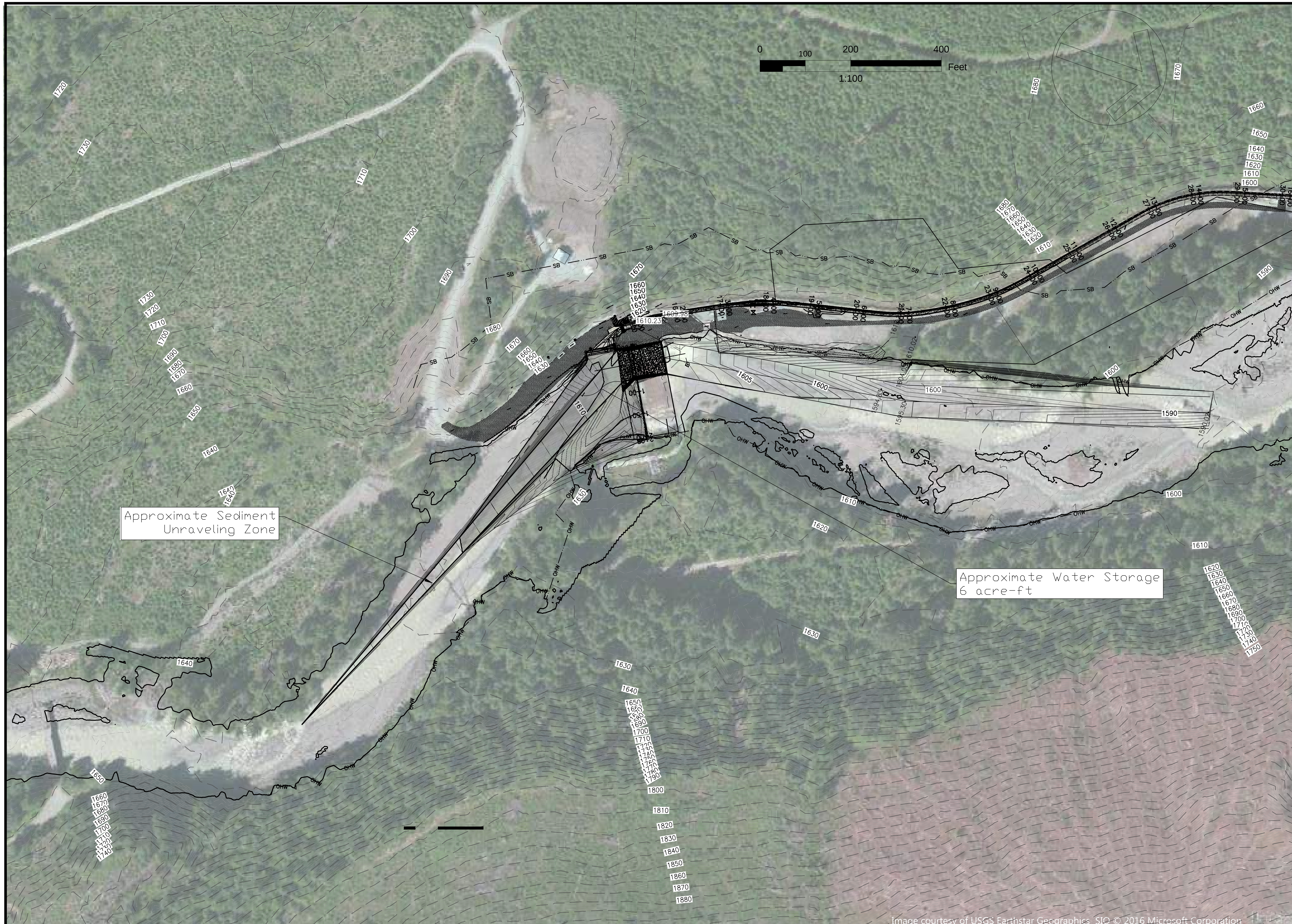


Figure 2 - Bedload sediment rating curve for
Puyallup River near Electron diversion
100000
10000
1000
100
10
Bedload Transport Rate (tons/hr)
100
1000
10000
100000
Discharge (cfs)



NO.	DATE	REVISION	BY	CK

ELECTRON HYDROELECTRIC PROJECT

Upstream Sediment Unravel Zone

PIERCE COUNTY WASHINGTON

SCALE 1" = 100'

DESIGN: TAF
DRAWN: SpG
CHECKED: TAF
DATE: 02/23/2016
JOB#: 11011900

SHEET 1 OF 1

DRAWING CS6

DATE & TIME: February 27, 2016 17:39
PLOTTED BY: ADMIN

Figure 4 – Channel instability in the vicinity of the diversion

Electron Hydro LLC - Diversion Structure Upgrades, Geomorphic Evaluation

Preliminary Summary Tables for Bedload Sediment Transport

Prepared by Shane Cherry

2/28/2016

Table 1 - Estimated Puyallup River valley slope in vicinity of diversion dam

Distance [ft]	Elevation [ft]	Slope	Note
8502	1800		Upstream of diversion
7094	1760	2.84%	
5487	1720	2.49%	
3432	1680	1.95%	Mowich confluence
1267	1640	1.85%	
0	1610	2.37%	Diversion location
-370	1600	2.71%	
-3855	1560	1.15%	
-5228	1520	2.91%	
-8133	1480	1.38%	Downstream of diversin

Notes:

1. Elevations and distances measured on Google Maps using terrain setting (40 ft contours).

2. Overall valley slope over the reach is 2.27%.

3. Flattest local upstream reach near Mowich confluence is 1.85%

4. Reach immediately downstream of diversion is relatively flat at 1.15%.

5. Diversion structure elevation value of 1610 ft is estimated from map context.

Table 2 - Estimated peak flow values for Puyallup River at Electron Hydro diversion

Recurrence Interval [yr]	Q [cfs]
2	4,360
5	6,783
10	8,584
20	10,452
50	13,077
100	15,207

Notes:

1. Hydraulic analysis completed by Eckert (2016).

2. Peak flow recurrence intervals determined using data for USGS Streamgage Station 12092000 Puyallup River near Electron, WA.

Table 3-Bedload sediment transport rates for selected flow events

Recurrence Interval [yr]	Q [cfs]	Bedload [Tons/min]	Bedload [Tons/hour]
< 1yr	500	0.5	30
< 1yr	1,000	3	162
< 1yr	1,500	6	366
< 1yr	2,000	11	630
2	4,360	40	2,394
5	6,783	79	4,746
10	8,584	112	6,732
20	10,452	149	8,940
50	13,077	204	12,246
100	15,207	251	15,066

Notes:

1. Bedload transport rates estimated using lowest local upstream slope of 1.85%.

2. Hydraulic analysis to determine peak flow values completed by Eckert (2016).

3. Bedload transport rates calculated using Wilcock and Crowe (2003) surface-based bedload transport function.

4. Peak flows last for hours with elevated flow rates lasting 3 - 6 days. Hourly rates are most useful for estimating total loads for individual flow events.

Table 4 - Time needed to flush out accumulated sediment by deflating the bladder spillway									
Distance Upstream (ft):		800	700	600	500	400	300	200	100
Recurrence Interval [yr]	Q [cfs]	Time[hrs]	Time[hrs]	Time[hrs]	Time[hrs]	Time[hrs]	Time[hrs]	Time[hrs]	Time[hrs]
< 1yr	500	124	82	54	34	19	9	3	0.9
< 1yr	1000	34	23	16	10	6	3	1.1	0.3
< 1yr	1500	17	12	8	5	3	1.5	0.6	0.2
< 1yr	2000	11	8	5	3	2.0	1.0	0.4	0.1
2	4360	4	2.5	1.7	1.1	0.7	0.4	0.1	0.04
5	6783	2.0	1.4	1.0	0.6	0.4	0.2	0.1	0.03
10	8584	1	1	0.7	0.5	0.3	0.2	0.1	0.02
20	10452	1	0.8	0.6	0.4	0.2	0.1	0.1	0.02
50	13077	1	0.6	0.4	0.3	0.2	0.1	0.04	0.01
100	15207	0.7	0.5	0.3	0.2	0.1	0.1	0.03	0.01

Notes:

1. Assumes flushed out channel extends upstream at a consistent slope to meet existing grade. Slope varies with distance upstream of diversion.

2.Shaded cells indicate flushing time less than 2. 5 hours (maximum duraction to avoid interuption of generation).

3. Time estimates based on dynamic transport rates estimated for changing bed slope at 100 ft intervals.

4. Base sediment delivery from upstream is estimated for each flow value using lowest local upstream slope of 1.85%.

Table 5 - Time needed for sediment to fill available storage behind the diversion structure				
Recurrence Interval [yr]	Q [cfs]	Bedload [Tons/min]	Fill Time	
< 1yr	500	0.5	42	days
< 1yr	1,000	3	8	days
< 1yr	1,500	6	3	days
< 1yr	2,000	11	2	days
2	4,360	40	13	hours
5	6,783	79	6	hours
10	8,584	112	4	hours
20	10,452	149	3.4	hours
50	13,077	204	2.4	hours
100	15,207	251	2.0	hours

Notes:

1. Bedload transport rates estimated using lowest local upstream slope of 1.85%.

2. Fill volume assumes wedge shaped gap 1200 ft upstream of dam with constant width of 75 ft.

3. Fill time assumes stead flow at specified flow rate.

4. Fill time assumes 100% of bed load is trapped upstream of the diversion structure.

5. Fill time assumes sand and silt pass through as suspended load.

6. Total estimated storage accommodates 30,000 tons (20,000 CY).