COUNTYLINE LEVEE SETBACK PROJECT

BASELINE MONITORING REPORT

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Executive Summary

This report documents baseline conditions at the Countyline Levee Setback Project to establish pre-construction conditions. Results of the monitoring described here will be used as a point of comparison to establish whether the project has met or is moving towards its established ecological objectives and habitat performance standards under U.S. Army Corps of Engineers Permit No. NWS-2011-211. The focus of this report is habitat monitoring. Flood risk reduction parameters will be monitored by King County, and monitoring protocols will be described in the *Public Safety Management Plan: Countyline Levee Setback Project* (King County 2015a).

Project actions to reconnect floodplain habitat are expected to increase riverine habitat complexity, increase aquatic habitat area and low velocity edge habitats for juvenile salmonid rearing, establish a robust riparian buffer, and increase wood loading throughout the reach. Baseline monitoring focused on measuring pre-project channel dynamics, mapping low velocity edge habitat area and inundated areas, quantifying wood loading, and establishing habitat use by fish and amphibians.

Baseline monitoring was conducted from 2011-2016, prior to project construction in 2017. Results show that the active channel was confined to the mainstem White River throughout the project reach, with little river inundation into the floodplain, particularly at low flows. There were a number of key pieces of large wood in the mainstem, with additional pieces in the floodplain wetland that may contribute to habitat complexity once the floodplain has been reconnected. Little low velocity edge habitat existed for salmonid rearing in the reach, however juvenile Chinook, coho, chum, and bull trout were all documented using these edge habitats, and so additional habitat created by project implementation is expected to benefit these species. Amphibian surveys revealed use of wetland areas by Northwestern Salamanders, Pacific treefrogs, and long-toed salamanders. Given that project actions will largely convert wetland habitat to riverine habitat, amphibian abundances and communities are expected to change post-project.

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I. Project Summary

Project Location

The Countyline Reach of the Lower White River is bounded by the A Street SE and Burlington Northern Santa Fe (BNSF) Railway Bridges at the upstream end (River Mile 6.3) and the 8th Street East Bridge at the downstream end (RM 5.0), and is so named because it spans the King-Pierce County boundary (Figure 1). Portions of this reach fall within the City of Auburn, City of Pacific, City of Sumner, and unincorporated Pierce County. The Countyline Levee Setback Project (Project) will reconnect approximately 120 acres of floodplain to the White River channel, thereby reducing flood risk, restoring natural river processes, and improving fish habitat. The Pacific Right Bank Levee Setback Project will reconnect approximately 20-34 additional acres of floodplain.

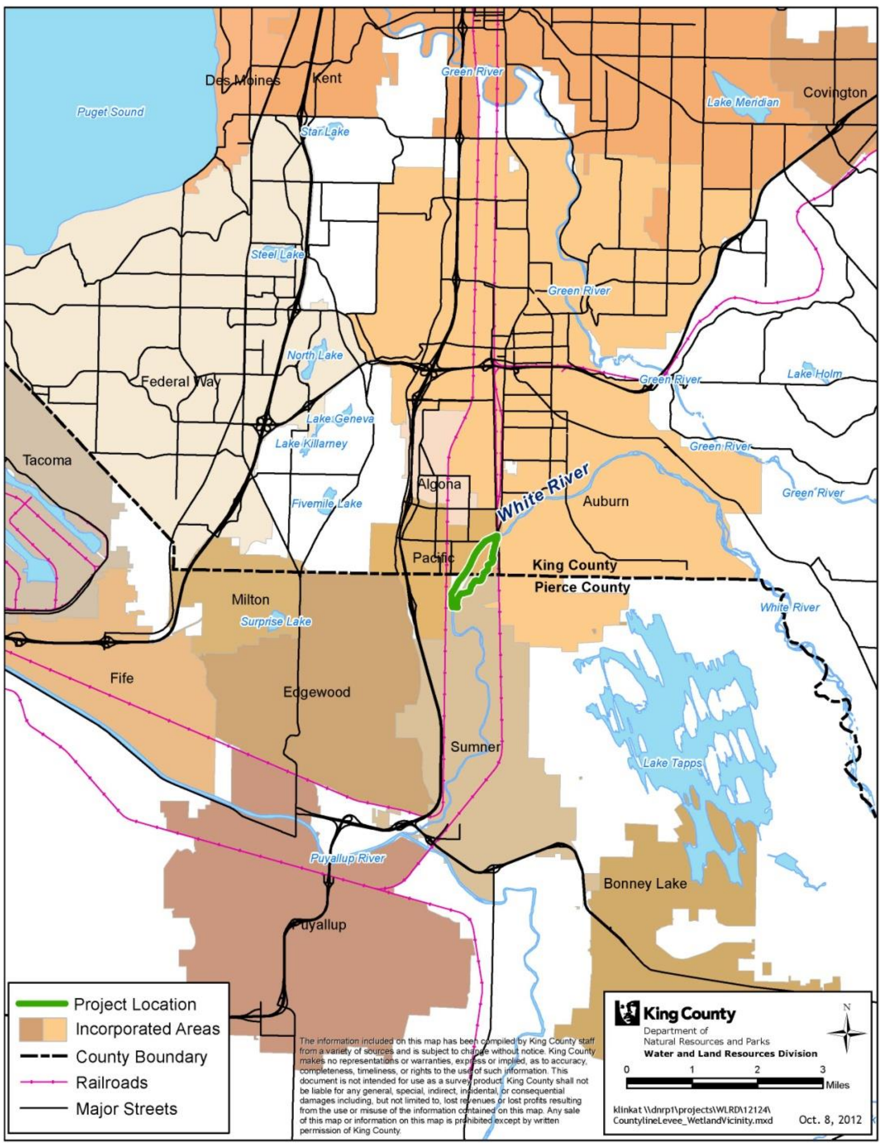

FIGURE 1. COUNTYLINE REACH VICINITY MAP

Project Setting

The lower White River is a highly modified system. The White River historically flowed into the Green River in the City of Auburn. In 1906, the river avulsed to the south into the Stuck River channel, a substantially smaller distributary channel that flowed to the Puyallup River, and in 1915, the Auburn Wall was built to permanently divert the White River. The new channel was enlarged by dredging to accommodate White River flows.

The White River carries a high sediment load because it originates on the Emmons and Winthrop glaciers on Mount Rainier and flows through a high gradient channel through most of its length, eroding through relatively new glacial and volcanic deposits. A marked decrease in channel gradient and valley confinement downstream of the White River canyon near the City of Auburn causes the river to deposit sediment, where a broad alluvial fan has formed. The 1906 channel avulsion was directly caused by the buildup of sediment and a significant wood jam on the alluvial fan and the need for the river to access a steeper path to its outlet and a new area to deposit its high sediment load. Channelization and construction of a confining levee system in the early 1900s in this broad and naturally depositional alluvial fan environment probably increased the vertical rates of sediment accumulation within the highly constricted channel. The historical human response to this was a consistent river management program of sediment removal to maintain river channel capacity (Herrera 2010). Cessation of gravel removal in the late 1980s probably contributed to channel aggradation within the confines of the levees in the lower reaches of the White River.

Project Justification

Flood Risk Reduction

Problems associated with channel aggradation became increasingly clear during the January 2009 flood, when the U.S. Army Corps of Engineers released up to 11,700 cubic feet per second (cfs) of water from behind Mud Mountain Dam, as had been done in past floods. However, flood damage in 2009 along the Countyline Reach of the Lower White River was much greater than damage during previous floods, with flood damage to over 100 homes in the White River Estates neighborhood, along with several commercial businesses on Butte Avenue and the Megan’s Court Apartments near the Pacific City Park. On the left bank, floodwaters inundated agricultural lands in the City of Sumner and overtopped 8th Street E (also known as Stewart Road SE); a major arterial.

Subsequent investigations by King County and Herrera Environmental Consultants revealed that the channel flood capacity in the Countyline Reach of the White River decreased from 25,000 cfs in the 1980s (when channel capacity was maintained by dredging) to 8,000 cfs. The channel was projected to completely fill with sediment at the King-Pierce county line in about 15 years, significantly increasing the flood risk for commercial, industrial, and residential parcels adjacent to and downstream of the project area. Analyses indicated that gravel removal would have a relatively minor and short-lived effect on reducing flood water levels in the Countyline Reach, especially when compared with reduced flood levels achieved with a setback levee. Gravel removal would also have significant environmental impacts, would be time-consuming to permit, and would likely require significant mitigation. The 8th Street E Bridge in Sumner, which has two in-channel piers and little remaining clearance from its lowest point,

significantly constricts flows and will be at increased risk of overtopping or failing during high flows. The left bank levee overtopped near the county line at 3,500 cfs (as of 2015), and flows escaped the wetland at 7,500 cfs, flowing down 142nd Street and over 8th Street East. Pre-project hydraulic modeling of the 100-year flood event showed one third of the flow (5,000 cfs) moving through this area (Herrera 2012).

Habitat Restoration

The levees and their riprapped banks have reduced access to side channels and floodplain wetlands, reduced the quality of channel edge and riparian habitat for fish, aquatic species, and other riparian wildlife, reduced the supply of large wood to the active river channel, and changed the way the river transports and deposits sediment. Channelization associated with the levees has shortened the White River's length.

The lower White River today is geomorphologically simple relative to historic conditions. River habitat is mostly fast-water riffles or runs, with very few pools or off-channel habitats. The lack of slow water areas with good cover results in poor habitat for juvenile salmon, making the lower river less productive for many species at critical life stages.

The need for rearing and off channel salmonid habitat in this reach of the White River is documented in the Puyallup Watershed (WRIA 10) and Chambers/Clover Creek Watershed (WRIA 12) Salmon Habitat Protection and Restoration Strategy (Pierce County 2008). This report notes:

> *"The loss of floodplain habitat that is limiting the performance of Puyallup and White River Chinook is due to the channelization and confinement of the river within an extensive system of revetments and levees (flood works) in the mainstems of the Puyallup, White, and Lower Carbon Rivers. Preferred projects in the mainstem areas would protect and restore floodplain habitat such as side channels and backwaters." (Page 17)*

The Strategy identifies the lack of this type of habitat as a bottleneck in meeting basin-wide recovery goals for Chinook salmon and concludes:

> *"Levee setbacks and estuarine habitat creation are the most beneficial types of actions needed for recovery of Chinook in WRIA 10." (Page 21)*

WRIA 10/12 conducted a levee setback feasibility study in 2008, and the Countyline Levee Setback Project was a highly ranked project for its potential to recover lost flood storage and provide aquatic habitat for juvenile salmon rearing habitat (GeoEngineers 2008). The project was also added to the WRIA 10/12 3-Year Implementation List and ranked as having a high benefit to salmon.

Habitat Goals and Objectives

The restoration goal of the Countyline Levee Setback Project was written to complement goals in both the WRIA 10/12 Salmon Habitat Protection and Restoration Strategy (Pierce County 2012) and the King County Flood Hazard Management Plan (King County 2006). Protection and reconnection of floodplain habitat and fluvial processes is expected to support the productivity of freshwater life stages of salmonids, and floodplain reconnection projects have been identified by the Puyallup/White Watershed (WRIA 10) as the highest priority for lower White River Chinook habitat protection and restoration

(Pierce County 2012). Floodplain reconnection and levee setbacks are key strategies in the FHMP for reducing flood risks while working with natural riverine processes. These techniques are also thought to be less costly over time than traditional structural approaches to flood hazard management (King County 2006).

The habitat restoration goal and related objectives of the Countyline Levee Setback Project are:

> **Goal:** Restore riverine processes and functions to the lower White River and its floodplain within the project area in order to enhance salmonid rearing habitat, in particular for spring and fall Chinook, coho, and steelhead.
>
> **Objectives:**
> 1. Allow natural channel movement within the project area by removing and setting back the existing levee along the left bank.
> 2. Encourage the formation of off-channel rearing habitat (pool complexes and side-channels), such as through installation and future natural recruitment of large wood, that will promote the return of the complexity, diversity, and morphology found in an unconstrained floodplain.
> 3. Provide off-channel flood refuge for salmonids by allowing a more natural frequency of inundation of the floodplain complex during flood events within the project boundaries.
> 4. Protect existing mature riparian buffer areas and restore a corridor of mature riparian vegetation within the project boundaries to provide shoreline and stream channel shading, invertebrate prey supply, and large wood recruitment.

Project Actions

Because the lower White River is highly modified and constricted, the approach to resolving existing flood risks focuses on increasing flood flow and sediment load capacity. The strategy is two-fold: (1) acquire land rights (fee or easements), and (2) implement capital improvements to modify levees and retrofit revetments so that the river is reconnected to its floodplain. This will increase flood conveyance and storage as well as accommodate sediment deposition. Returning the lower White River to a more naturally functioning floodplain will improve aquatic and wildlife habitat. Levees will be reconstructed along an alignment set back from the current active channel, large wood structures will be installed to disperse adversely erosive flows and provide complex habitat, and native vegetation will be planted to eventually provide a healthy riparian buffer (Figure 2).

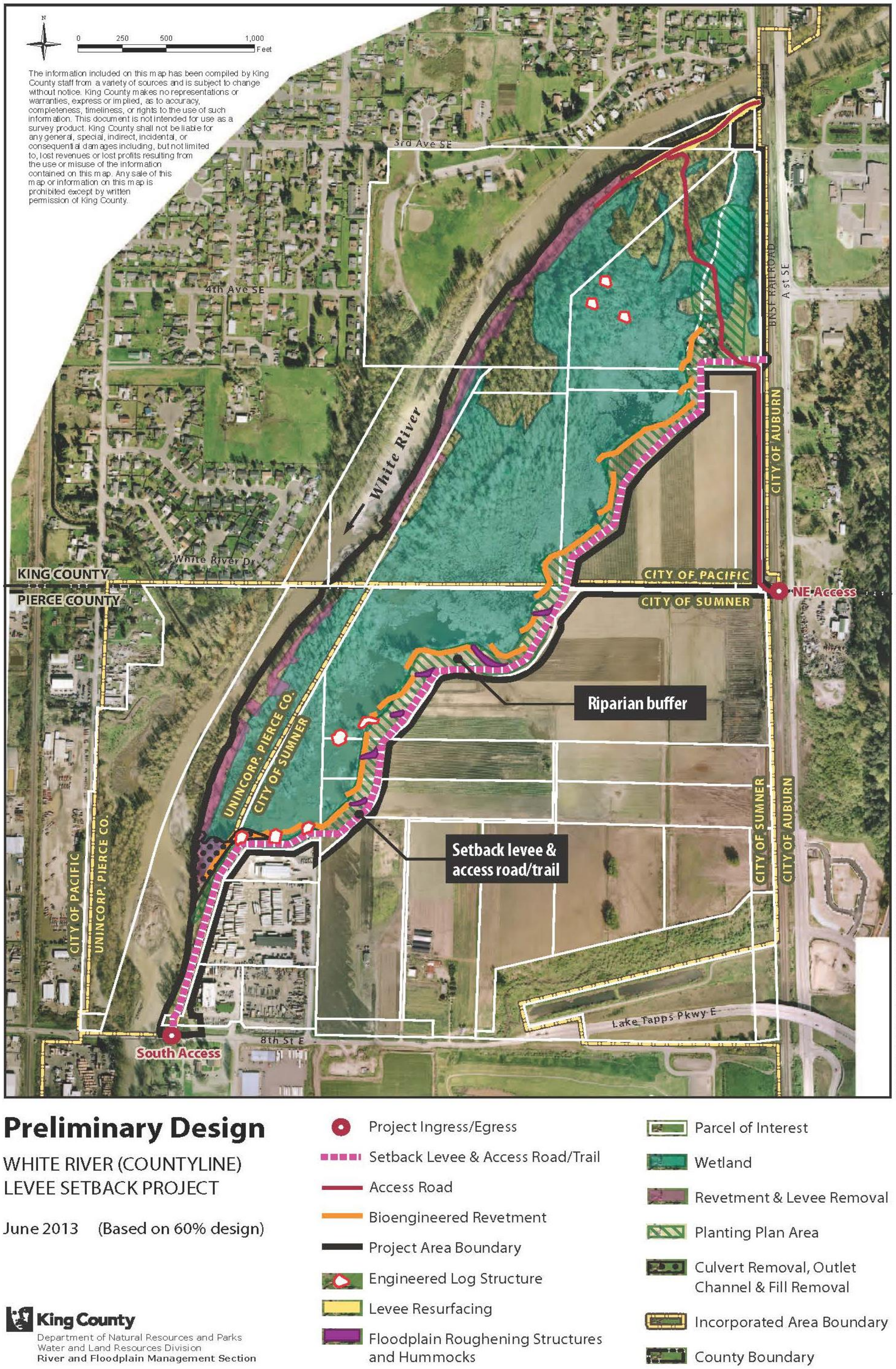

FIGURE 2. COUNTYLINE LEVEE SETBACK PROJECT ELEMENTS

Performance Standards

Monitoring objectives and performance standards are designed to determine project effectiveness, and adaptive management recommendations have been identified as potential actions or lessons learned in the event that performance standards are not met (Table 1).

TABLE 1. PERFORMANCE STANDARDS ESTABLISHED BY THE DESIGN TEAM AND AGENCY PERMITS.

Category	**Indicator**	**Objective**	**Performance Standards**[1]	**Adaptive Management**
Project Implementation	As-built condition	Project is constructed according to design specifications and regulatory conditions.	As-built condition satisfies design objectives.	Adjustments to meet design specifications made during construction.
Channel Dynamics	Movement	Channel complexity (e.g., sinuosity, formation of multiple channels) will increase.	New channel(s) form outside of the present (pre-project) active channel.	Consider measures to initiate a flow path through appropriate means.
Habitat Benefit	Aquatic habitat	The area of slow-water edge habitat will increase.	Sum of slow-water (<1.5 ft/sec) bar, bank, backwater and side channel area increases by >50%, relative to baseline condition.	Project objective not met.
		The area of floodplain inundation will increase.	Floodplain inundation within the project area will increase after project construction, as measured between February 1 and March 31 utilizing aerial photography.	Consider measures to promote floodplain inundation.
	Wood	Wood loading will increase over baseline condition.	Wood loading (natural and placed) on site meets or exceeds NMFS recommendation for properly functioning condition (>80 pieces/mile; NMFS 1996).	Project objective not met.
	Riparian cover	Installed plants survive.	80% survival[2] at end of Year 1 growing season for all installed trees and shrubs (excluding stakes)[3].	Additional planting or maintenance needed.
		Installed plants, as well as volunteers of desirable native woody species, form a dense canopy cover.	Cover by installed trees and shrubs, including cover by volunteers of desirable native woody species: Year 2 at least 15%, Year 3 at least 20%, Year 5 at least 40%, Year 7 at least 60%, and Year 10 at least 75%.	Additional planting or maintenance needed.
		Biorevetment allows a vegetated riparian buffer to establish between river and setback levee.	Average vegetated riparian buffer width of 75 feet.	Reconsider design approach in similar settings.
	Invasive cover	Invasive plant cover is minimized due to native revegetation and weed control.	Less than 10% invasive cover (non-regulated noxious weeds and weeds of concern) in planted areas (5% for KC Class A noxious weeds, bindweed, and knotweed). Less than 25% reed canary grass on site as a whole.	Additional maintenance needed. If reed canarygrass performance standard exceeded, plant areas with willow (cultural control).
	Wetlands	Wetland area temporarily impacted by construction is restored.	1.08 acres temporary impacts in Wetlands A and B restored to aquatic habitat condition.	To be determined depending on conditions.
Fish use	Habitat preference	Juvenile salmonids preferentially use low velocity edge habitat (specifically backwaters and side channels).	Juvenile salmonid density (or frequency of occurrence) is highest in backwaters and side channels, compared to other edge types.	Revise habitat priorities in future design considerations in Lower White River.
	Habitat capacity	Habitat capacity is increased by increasing low velocity edge habitat.	Habitat capacity at project site – estimated as the product of the average density of juvenile salmonids in edge habitats and the area of edge habitat (by type) at median rearing flows increased by >50% compared to baseline.	Project objective not met

[1]Performance assessed over 10-year monitoring period, unless otherwise noted.
[2]Only installed plants count towards achieving the Survival Performance Standard; volunteers do not count.
[3]Plant survival and cover on top of the apex logjams will be assessed when access is feasible.

II. Monitoring Strategy

The focus of this baseline report is habitat monitoring. Flood risk reduction parameters will also be monitored by King County, and monitoring protocols will be described in the *Countyline Levee Setback Public Safety Site Management Plan* (King County 2015a). This monitoring report will help establish baseline conditions in order to later evaluate the effectiveness of project elements intended to improve natural processes that create and sustain productive aquatic habitat.

Monitoring Purpose

An understanding of natural floodplain processes and baseline conditions is essential for planning river and floodplain restoration projects and for evaluating effectiveness (Ward et al. 2001, Pess et al. 2005). Because the science of floodplain restoration is still evolving, actions should be viewed as experimental manipulations linked to explicit hypotheses (Pess et al. 2005). The purpose of this monitoring effort is to evaluate whether a large-scale floodplain reconnection project on the Lower White River effectively meets the stated habitat goal and objectives and is able to meet the performance standards. This document states baseline monitoring that was done and summarizes the data.

The purpose of this monitoring effort is to:

1. Ensure the projects match design specifications (Implementation Monitoring),

2. Determine whether levee setback project actions are producing the intended effects on habitat conditions, watershed processes, and threatened fishes (Effectiveness Monitoring), and

3. Improve design, construction, and maintenance practices using monitoring results (Adaptive Management).

Audience

The primary audiences for implementation and effectiveness monitoring results include:

1. King County staff – Results will be shared to inform future project design, construction, and monitoring protocols, as well as project maintenance needs. The reporting format includes presentations, monitoring reports, and access to real-time data.

2. Regulatory agencies – Monitoring results will allow regulatory agencies to determine whether performance standards are being met, as well as inform review of future projects with similar elements. Monitoring reports will be submitted to the US Army Corps of Engineers in Years 1, 2, 3, 5, 7, and 10.

3. Funding agencies and project stakeholders – Monitoring results will provide funding agencies and project stakeholders with the information necessary to determine whether funding agreements are being followed, as well as to evaluate the effectiveness of the project at meeting funding priorities. The reporting format includes presentations and monitoring reports.

4. Scientific community – This study will add to a growing body of research into the effects of large-scale floodplain reconnection projects on channel processes and habitat conditions, as well as the efficacy of levee setbacks for flood risk reduction in depositional rivers.

Monitoring Design

The project reach will be monitored before and after project implementation to measure changes in physical and biological processes as well as to assess the ability of the project to meet its stated performance standards. This report documents baseline monitoring.

Monitoring Tasks and Objectives

This section explains the specific steps that are being followed to measure performance indicators (Table 2).

TABLE 2. MONITORING OBJECTIVES, METHODS, AND OUTPUTS

Category	Indicator	Performance Standard	Task	Monitoring Method	Timing (Years)	Output
Project Implementation	As-built condition	As-built condition satisfies design objectives.	1	Manage construction to ensure project satisfies design objectives; Produce record drawings.	Immediately post-construction	Record drawings
Channel Dynamics	Movement	New channel(s) form outside of the present (pre-project) active channel.	2	LiDAR, aerial photography, and field survey	1, 3, 5, 10 (timing may be adjusted based on high flow events)	Mapped channel forms
Habitat Benefit	Aquatic habitat	Sum of slow-water (<1.5 ft/sec) bar, bank, backwater and side channel area increases by >50%, relative to baseline condition.	3	Map slow water areas on channel margins at flows representing 50th, 75, and 90th percentile flows during Jan-Jun	1, 3, 5, 10	Change in edge habitat area relative to baseline
		Floodplain inundation within the project area will increase after project construction, as measured between February 1 and March 31 utilizing aerial photography.	4	Georeferenced aerial photography and field ground-truthing	1, 3, 5, 7, 10; additional photography may be collected during and following high flow events	Georeferenced photograph of inundated area
	Wood	Wood loading (natural and placed) on site meets or exceeds NMFS recommendation for properly functioning condition (>80 pieces/mile; NMFS 1996).	5	Object-based image analysis (based on LiDAR and orthophotos) and field survey	1, 5, 10	Estimates of wood loading
	Riparian cover	80% survival[2] at end of Year 1 growing season for all installed trees and shrubs (excluding stakes)[3].	6	Fixed plots	1, 2, 3, 5, 7, 10	Percent survival of installed plants
		Cover by installed trees and shrubs, including cover by volunteers of desirable native woody species: Year 2 at least 15%, Year 3 at least 20%, Year 5 at least 40%, Year 7 at least 60%, and Year 10 at least 75%.	7	Fixed plots	1, 2, 3, 5, 7, 10	Percent cover of native installed and volunteer woody vegetation (trees and shrubs)
		Average vegetated riparian buffer width of 75 feet.		See task 4	1, 5, 10	Minimum, average, and maximum buffer width
	Invasive cover	Less than 10% invasive cover (non-regulated noxious weeds and weeds of concern) in planted areas (5% for KC Class A noxious weeds, bindweed, and knotweed). Less than 25% reed canary grass on site as a whole.		See task 7	1, 2, 3, 5, 7, 10	Percent cover of invasive plants
	Wetlands	1.08 acres temporary impacts in Wetlands A and B restored to aquatic habitat condition.		See task 4	1	Wetted area
Fish use	Habitat preference	Juvenile salmonid density (or frequency of occurrence) is highest in backwaters and side channels, compared to other edge types.	8	Sample juvenile salmonids in edge habitat during rearing period	1, 3, 5, 10	Relative abundance of juvenile salmonids in discrete habitat types
	Habitat capacity	Habitat capacity at project site – estimated as the product of the average density of juvenile salmonids in edge habitats and the area of edge habitat (by type) at median rearing flows increased by >50% compared to baseline.		See tasks 3 and 10	1, 3, 5, 10	Change in habitat capacity

III. Monitoring Methods

Only monitoring that was done as part of the baseline effort are described here. All of the monitoring methods are described in the Countyline Monitoring Plan (King County 2014).

General Site Conditions

In addition to monitoring of specific parameters and site attributes, surveyors noted general site and habitat conditions including observed fish and wildlife use (direct observation of live or dead animals or indirect observation of prints, scat, etc.), general patterns of vegetation condition, invasive vegetation presence, illegal use or dumping, deformation or damage (movement of installed wood, bank erosion, etc.), and anything else considered worth noting. These include conditions not otherwise captured in monitoring associated with site performance standards.

Channel Dynamics

Channel location and planform were mapped using GIS measurements taken from high-resolution orthoimagery captured before project construction (April 2016, 1800 cfs). The sinuosity metric proposed in the project monitoring plan does little to capture fluvial geomorphic complexity or demonstrate side channel development and so alternate metrics are presented in this report. Channel complexity was characterized by several metrics that reflect emerging science to improve assessment of channel dynamics:

- Number of side channel nodes and ratio of side channel to main channel length (Stefankiv et al. 2019). Side channel nodes mark the start and end of a side channel that is connected to the mainstem (or another side channel) at one end.
- Total active channel area (sum of area of water, banks, unvegetated gravel bars, and bars without perennial vegetation) (Collins and Montgomery 2011; Konrad 2015)
- Floodplain connectivity and continuity (Konrad 2015). Area of floodplain inundated at a design flow.
- Number of braid channel nodes (Stefankiv et al. 2019). Braid channel nodes mark the start and end of a smaller channel within the active channel across or between gravel bars.

The orthoimagery collected to monitor channel location and planform was also used for these new metrics. The flow rate at the time of imagery collection are noted as water surface elevation may affect side channel and braid channel engagement.

Habitat

Aquatic Habitat

Floodplain Inundation

Inundated area was estimated using georeferenced aerial imagery during March 2016 (1800 cfs). Wetted areas were visually delineated from this imagery by drawing a digital line around wetted areas and calculating the acreage in ArcGIS. Floodplain wetlands were known to be primarily ground-water driven, with a hydraulic outfall connection near the downstream end of the floodplain at RM 5.2 (Figure

9). At flows below 3,000 cfs, the White River was largely disconnected from the 120-acre floodplain, and so the only inundated area at these flows was through the backwater connection at this connection near RM 5.2. When the mainstem White River seasonally exceeded 3,000 cfs, additional portions of the floodplain were known to be inundated but these areas were not quantified as part of the baseline monitoring effort.

Low Velocity Edge Habitat

Juvenile salmonids rely heavily on shallow relatively slow moving waters for rearing (Bjornn and Reiser 1991, Beechie et al. 2005), therefore we surveyed the availability of this critical habitat in the project reach. The margin of the wetted channel was mapped on foot by GPS. The midstream (waterward) margin of the low velocity edge habitat was located by visually determining the shear line (water velocity was approximately <0.45m/sec). Visual determination was verified at several points with a Swoffer flow meter and the slow-water boundary was mapped at multiple points using a Trimble GeoXH GPS. Edge habitat was categorized into backwater, bar, bank and side channel habitat types as outlined in Beechie et al. (2005). Points and water margins were transferred to a GIS and the area, number, and distribution of low-velocity edges was quantified for each habitat type. While low flow habitat may be present along the entire bank of the river, it was only mapped if the habitat unit area was greater than the stated accuracy of the GPS as reported in real time. Anything smaller than this could not be accurately mapped and likely provided very little habitat value.

Edge habitat was surveyed multiple times per year to quantify the relationship between flow and edge habitat availability. Prior to project construction, twelve surveys were conducted across 2011, 2012, 2013, and 2015. Due to safety and logistical challenges associated with mapping the entire project reach, three edge habitat sampling areas along the mainstem were selected to survey during the pre-project period (Figure 3). These areas were considered representative of available habitat conditions and channel morphology present pre-project throughout the entire reach. Several pre-project surveys limited habitat collection to along the left bank in 2011 and 2012 due to logistical constraints (Table 3).

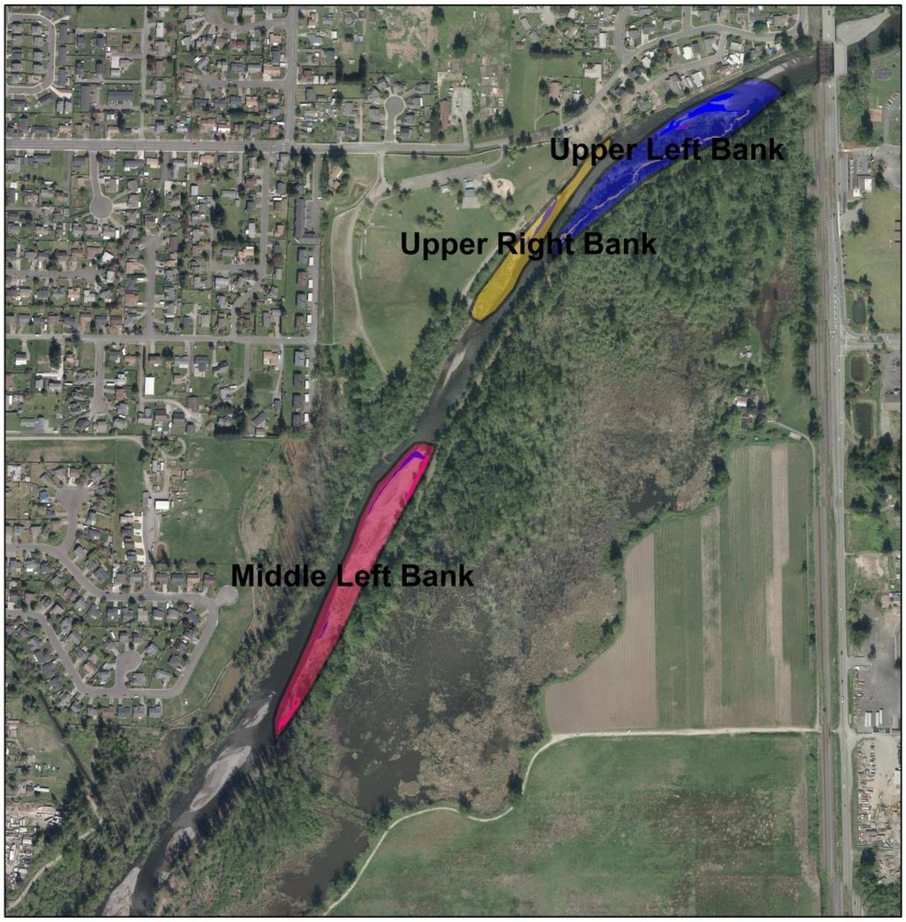

FIGURE 3. LOW VELOCITY EDGE HABITAT SAMPLING AREAS

TABLE 3. LOW FLOW HABITAT SAMPLING EVENTS

Date	Flow (cfs)	Areas Sampled
4/13/11	1530	Upper Left Bank, Middle Left Bank
7/12/11*	3000	--
10/3/11	657	Upper Left Bank, Middle Left Bank
1/31/12	2830	All sampling areas
5/8/12	2920	Upper Left Bank, Middle Left Bank
7/25/12*	3210	--
11/6/12	1350	Middle Left Bank
2/19/13	1100	Upper Left Bank, Middle Left Bank
3/19/15	1510	All sampling areas
5/20/15	1080	All sampling areas
7/22/15	836	All sampling areas
9/3/15	603	All sampling areas

*Indicates dates where GPS data was corrupt or otherwise unusable

Wood

Wood loading (natural and placed) in the project reach has the potential to drive multiple physical and ecological functions (Gurnell et al., 2002, Collins et al. 2012). Large wood in rivers can drive the physical processes of channel formation, channel complexity, and sediment deposition, provide areas for the rearing and refuge of juvenile salmonids, and contribute to terrestrial and aquatic food webs. The presence and dynamics of wood within the project reach will be monitored and compared to pre-project baseline conditions.

Baseline wood loading was characterized using field surveys in the mainstem White River (August and September 2017), and aerial photo interpretation in the floodplain. Field surveys for wood in the main stem followed methods specified by Montgomery (2008), mapping individual pieces within the ordinary high water mark into alphanumeric bins for sizes >/= 2 m long and 10 cm in diameter (Montgomery size-class C2 and larger). Individual pieces within the floodplain were not accessible to field survey, and so were counted and size-classed using GIS measurements taken from high-resolution 2017 orthoimagery (image date: April 21, 2017).

Log jam heights and perimeters were field surveyed and mapped using a handheld GPS unit. To quantify individual pieces within mapped log jams (collection of ≥3 pieces of wood), aerial counts were combined with lidar-derived jam heights, and a piece-size distribution was calculated using volumetric and porosity metrics (assumed 75% porosity). As a result, baseline wood totals include all naturally occurring wood size classed above C2 from the Stewart Street Bridge to north of A-Street at RM 6.2 including downed wood in the floodplain.

Fish Use

Habitat Use

The study area has the potential to provide valuable rearing habitat for salmonids which is limited in the Lower White River (Pierce County 2012). Pre-project fish monitoring focused on establishing baseline levels of fish use, while post-project fish monitoring will focus on quantifying changes in distribution and catch per unit effort of juvenile Chinook, steelhead, and coho. Monitoring will also document use of the site by other species such as bull trout.

Fish were captured by one pass of a beach seine (1/8” mesh size) in mapped low velocity edge habitat units (backwater, bank, side channel, and bar) to determine the relative use of each habitat type for each species and life stage. Seines are effective at trapping juvenile fish but are generally less effective at trapping larger individuals and so our sampling efforts primarily focused on juvenile salmonids. Sampling targeted the early morning crepuscular period to coincide with periods of increased fish activity, however sampling extended beyond dawn as well, occurring from 5:10 am to 9:00 am (ranging from 37 minutes before sunrise to 4.1 hours after sunrise; median 1.1 hours after sunrise). The order of sampling edge habitat units often (but not always) followed a pattern, with sampling of backwater units generally preceding sampling of bar or bank units. As such, results comparing habitat use between

habitat types should not be interpreted without consideration of time sampled since detection may decline after sunrise, and so these analyses controlled for time after sunrise. Although we sought to sample fish from each habitat type during each sampling event, on some sampling dates, some habitat types (side channel and/or backwater) were absent due to variation in flow, and so habitats were selected for sampling proportional to the availability of habitat types in the study reach.

Year-round (seasonal) surveys were conducted between April 2011 and February 2013 to document salmonid use of different habitat types (Table 4). In the final year of baseline monitoring (2015), fish surveys targeted the spring and summer months when juvenile salmonid use was determined to be highest (Table 4). At each sampling unit, the seine was deployed a single time to sample fish. Since seines were walked through habitat units to capture fish, the area sampled was not consistent across seine sets. Therefore, we represented our data as catch per unit effort (CPUE), where effort is measured in the seconds fished.

TABLE 4. FISH SAMPLING DATES 2011-2015 AND FLOW AT R STREET

Date	Flow (cfs)	Season
4/20/11	1530	Spring
7/12/11	3000	Summer
10/4/11	657	Autumn
2/1/12	2830	Winter
5/8/12	2920	Spring
7/25/12	3210	Summer
11/6/12	1350	Autumn
2/20/13	1000	Winter
3/19/15	1270	Spring
5/20/15	1120	Spring
7/22/15	836	Summer
9/3/15	584	Summer

Beach seines were deployed on foot, given the shallow habitat sampled, and captured fish were kept in buckets containing fresh river water and anaesthetized with a small amount (<50mg/L) of MS-222 (Tricaine Methanesulfonate). All fish were identified to species and measured to the nearest millimeter (fork length). A small number (~10) of salmonids were weighed to the nearest gram and stomach contents were collected via gastric lavage for another study (Black et al. 2016). After processing, the fish were placed in a recovery bucket of fresh water until completely revived, then released back to the ambient water near their point of capture.

CPUE of Chinook and coho salmon was analyzed using generalized linear models (GLMs) with a quasi-Poisson error distribution to account for overdispersion. We included the seconds fished as an offset to account for variable effort between sets. To evaluate habitat use and preference, models analyzed all

years of data combined and included edge habitat type (e.g., backwater, side channel, bar, bank) and season as covariates of interest, as well as spawner abundance in the fall prior to sampling to control for interannual differences in productivity. Spawner abundances were derived from counts at the Buckley fish trap, which is 18 river miles upstream from the site and therefore may not perfectly reflect spawner abundances in the lower White River, however lower White River spawning surveys were not conducted during the study period and so could not be used. The maximum flow in the spring rearing period following emergence (from USGS gage 12100490) was also included in these models to account for higher flows in some years that may flush fry downstream. Peak flow during the incubation period was also considered, but was highly correlated with peak rearing period flows (r=0.99), and so was excluded from analyses. To control for the effect of hatchery-released Chinook on observed Chinook abundances, models also included the number of hatchery releases from the Muckleshoot Indian Tribe's White River Hatchery and WDFW's Minter Creek Hatchery. Additionally, the time since sunrise was included in models to control for potential effects of light/timing on fish abundance, particularly since habitat unit types were not randomly sampled with regard to time as discussed above. To evaluate differences in Chinook and coho size between habitat types and seasons, a GLM with a Gaussian error structure was used, with fork length as the response variable and habitat type and season as covariates. All analyses were conducted in R version 3.6.1 using the "lme4" package.

We note that although the initial performance standard listed fish habitat preference as the metric of interest, the sampling conducted is more reflective of patterns of juvenile salmonid occupancy/use between edge habitat types. A true assessment of habitat preference would present a range of habitats available to a fish, and observe which habitat is selected from the range (e.g., in a lab setting). In the field, we cannot assume that habitat types with high fish abundance implies fish preference, as observed fish densities in a particular location may be influenced by a variety of factors beyond preference, including limitations on physical ability to inhabit fast/slow water and/or territorial behavior (especially in coho) that may exclude less fit individuals from choice habitats (Chapman 1962).

Habitat Capacity

Our habitat capacity index weights each habitat type by average CPUE, (multiplying average spring/summer CPUE in each edge habitat type by the area of that edge habitat), and then sums the weighted value across habitat types for an index measure of total habitat capacity across the project area. Importantly, this index is not equal to the potential number of fish that the project area can support, as was initially proposed in performance standards, given that our CPUE data does not directly reflect fish densities. Thus, the index units are not directly interpretable, but rather will provide a method of quantitatively evaluating relative changes in habitat capacity between pre-construction and post-construction time periods. Since only a small portion of the project reach was mapped for edge habitat during baseline conditions, this index will be standardized by river mile to allow for site-wide comparisons with post-construction monitoring.

In the future, a more direct approach to evaluating the capacity of a reach to produce fish might be to tag individual salmonids and compare abundances of outmigrants rearing within the project reach

versus a control reach. Additionally, the habitat quality of a reach may influence the ability of a reach to produce smolts, and so evaluation of bioenergetically favorable habitat availability (as in Black et al. 2016) may also help evaluate habitat lift for salmonids.

Amphibian Use

There is no amphibian performance standard, but open water wetlands are anticipated to decrease in area following project construction. Therefore, lentic amphibian breeding surveys were conducted in 2011 at 12 wetlands and 2012 at 7 wetlands[1] to document which species of amphibians were using these wetlands (Figure 6).

Amphibian breeding surveys generally followed methods outlined by (Thoms et al. 1997), modified by Richter and Ostergaard (1999), and summarized briefly here. Two annual egg mass surveys were conducted by a team of two biologists generally in late February to mid-March and the middle two weeks of April. Rain, high winds, and overcast conditions were avoided whenever possible to maximize visibility through the water column. Surveys were conducted in the wetlands by wading in shallow water or floating in a small float tube in water deeper than 3.3 ft (1 m) (Figure 4).

Egg masses were identified by species and Northwestern salamander (*Ambystoma gracile*) egg masses counted during the first survey were marked with small pieces of brightly colored yarn (less than 4 inches in length) tied to adjacent vegetation (Figure 5). During the second survey the biologists noted whether egg masses had been previously marked. As a result, it was possible to estimate the total annual abundance of northwestern salamander egg masses without double counting. Other species of amphibian egg masses including Pacific treefrogs (*Pseudacris regilla*) and long-toed salamanders (*Ambystoma macrodactylum*) were not marked in this way. The egg masses of these two species often do not persist long enough to be present for both survey periods and the egg masses are frequently attached to smaller, less robust vegetation which makes marking the masses extremely challenging and ineffective. For marked Northwestern salamander egg masses, percent mortality per clutch was estimated within eight categories (0, 1-5, 6-25, 26-50, 51-75, 76-95, 96-100, or partially hatched) when revisited. Mean egg mass mortalities were calculated for northwestern salamanders for each wetland survey period by averaging the midpoint of each percent mortality category.

Larva, paedomorph[2] , juvenile, and adult amphibians were identified to species if observed during field surveys, and frogs were noted and identified by call when heard.

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[1] 5 wetlands were dropped from the amphibian monitoring surveys between 2011 and 2012 because no sign of amphibian use was observed in 2011 and the habitat seemed unsuitable for amphibian breeding (e.g., water level too shallow, too turbid, or lack of emergent vegetation for egg mass attachment).

[2] Paedomorphs retain larval characteristics (such as the retention of gills) into adult life (Jones et al. 2005).

FIGURE 4. AMPHIBIAN SURVEYS WERE CONDUTED VIA FLOAT TUBE (LEFT) OR WADING (RIGHT)

FIGURE 5. NORTHWESTERN SALAMANDER EGGMASSES WERE MARKED WITH BRIGHTLY COLORED PIECES OF YARN ON ADJACENT VEGEATION DURING THE FIRST SURVEY PERIOD AS PICTURED. THE EGG MASS CAN BE SEEN FAINTLY BELOW THE WATER SURFACE

FIGURE 6. LOCATION OF AMPHIBIAN MONITORING WETLANDS

IV. Results

General Site Conditions

A bald eagle nest was identified and located using GPS in Summer 2014 (Figure 7). Following documentation of the bald eagle nest, we wrote a Bald Eagle Management Plan which was reviewed and approved by the US Fish and Wildlife Service. The Plan is intended to guide protective actions during construction (King County 2015b).

In wetland B (see King County 2013 for boundaries of wetland B), the following bird species were noted while amphibian breeding surveys were taking place in 2011: red wing blackbird, bald eagle, great blue heron, pileated woodpecker, Canada geese, swallows, and cormorant.

FIGURE 7. BALD EAGLE NEST LOCATION. BUFFERS RELEVANT TO US FISH AND WILDLIFE'S NATIONAL BALD EAGLE MANAGEMENT GUIDELINES ARE SHOWN

Channel Dynamics

Active channel location and planform pattern is shown in Figure 8. At 1,800 cfs, the main channel and the project area were connected via backwater at the south end of the project, however this area was not part of the active channel. The total active channel area calculated in 2016 was 33.9 acres, and the mainstem was 7,041 feet in length (Table 5). The mainstem channel was slightly greater in length than the total length of side channel in the reach (total length of side channel = 5,745 ft), while the length of braided channels exceeded that of the mainstem channel (total length of braided channel = 7,437 ft).

TABLE 5. GEOMORPHIC METRICS AND MEASURES OF CHANNEL DYNAMICS.

Geomorphic Metric	Value
Active channel area (acres)	33.9
Side Channel total length (ft)	5,745
Number of side channel nodes	20
Side channel:Mainstem channel ratio	1.056
Number of braided channel nodes	30
Braided Channel total length (ft)	7,437
Braided channel:Mainstem channel ratio	0.816

FIGURE 8. CHANNEL FORM DERIVED FROM ORTHOIMAGERY ON APRIL 21, 2016 (1800 CFS)

Habitat

Aquatic Habitat

Floodplain Inundation

The area of inundated floodplain was 7.8 acres at 1,800cfs (March 2016; Figure 9). Inundation was primarily through a backwater connection at the southern end of the disconnected wetland. A large area of the remaining wetland was also wetted but was determined to be uninfluenced by river conditions via field observations.

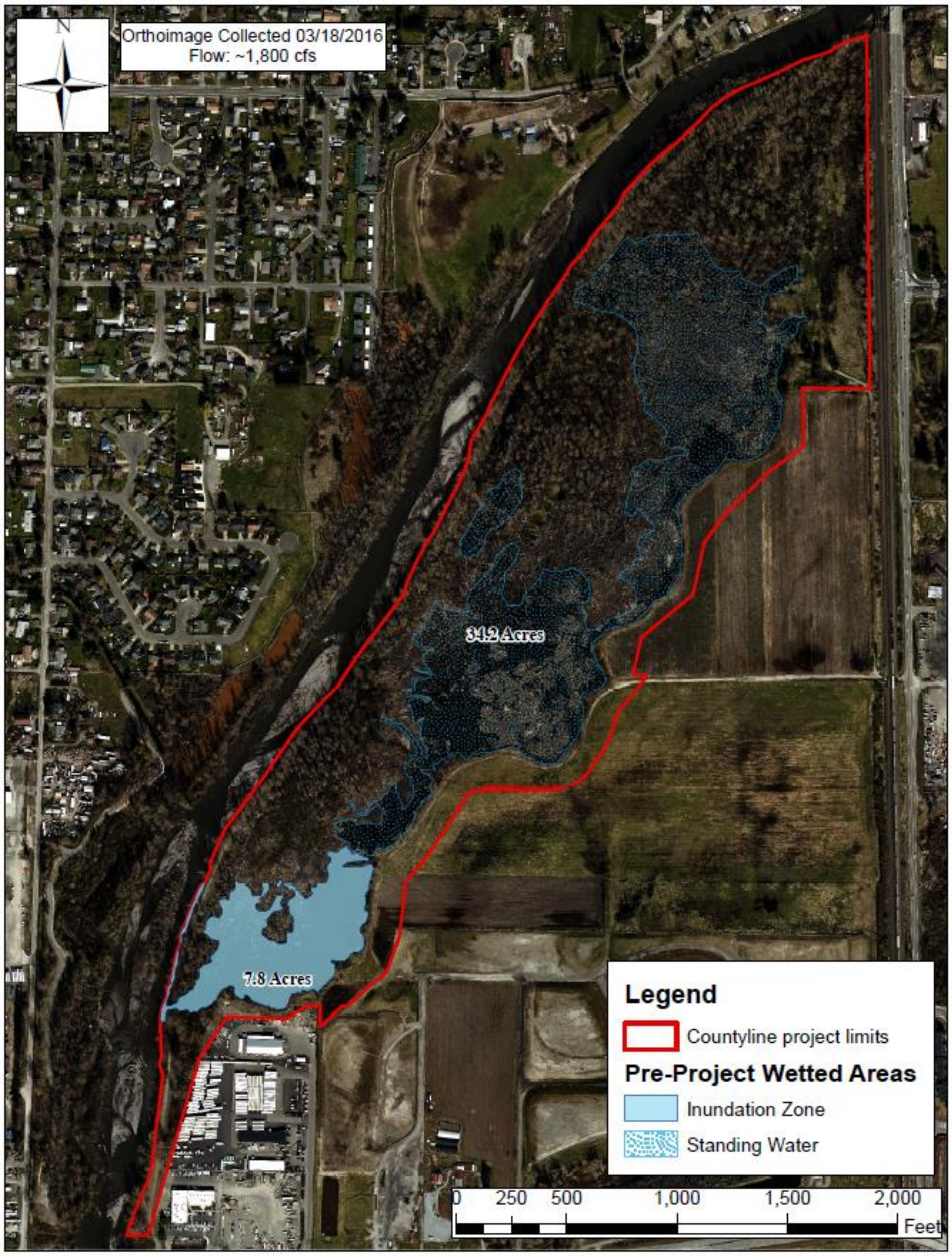

FIGURE 9. PRE-PROJECT INUNDATED AREA AND STANDING WATER AREA AT 1,800 CFS (MARCH 2016).

Low Velocity Edge Habitat

Ten successful sampling events resulted in low velocity edge habitat data within the three sampling areas between 2011 and 2015. Two sampling events did not yield useable data (Table 3). The specific areas sampled and their associated habitats changed between years due to changes in channel morphology, as well as variation in flow. Due to this dynamic nature, low velocity edge habitat is reported in square meters of edge habitat per meter of river (m^2/m) to allow for unbiased comparison between different years.

Total edge habitat of all combined sampling areas resulted in a range of 1.34 m^2/m to 8.63 m^2/m of edge habitat for all years. Total low velocity habitat generally increased with increasing stream flow ($R^2 = 0.8$), which was consistent for all data as well as for years with multiple sampling events (Figure 10).

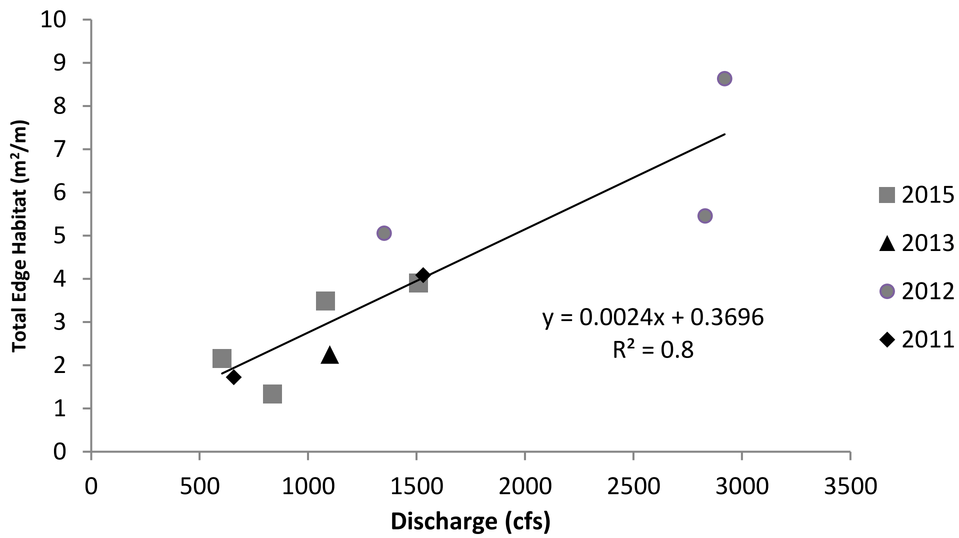

FIGURE 10. TOTAL LOW VELOCITY EDGE HABITAT BY DISCHARGE FOR ALL SAMPLING EVENTS. TRENDLINE CORRESPONDS TO ALL YEARS OF DATA COMBINED

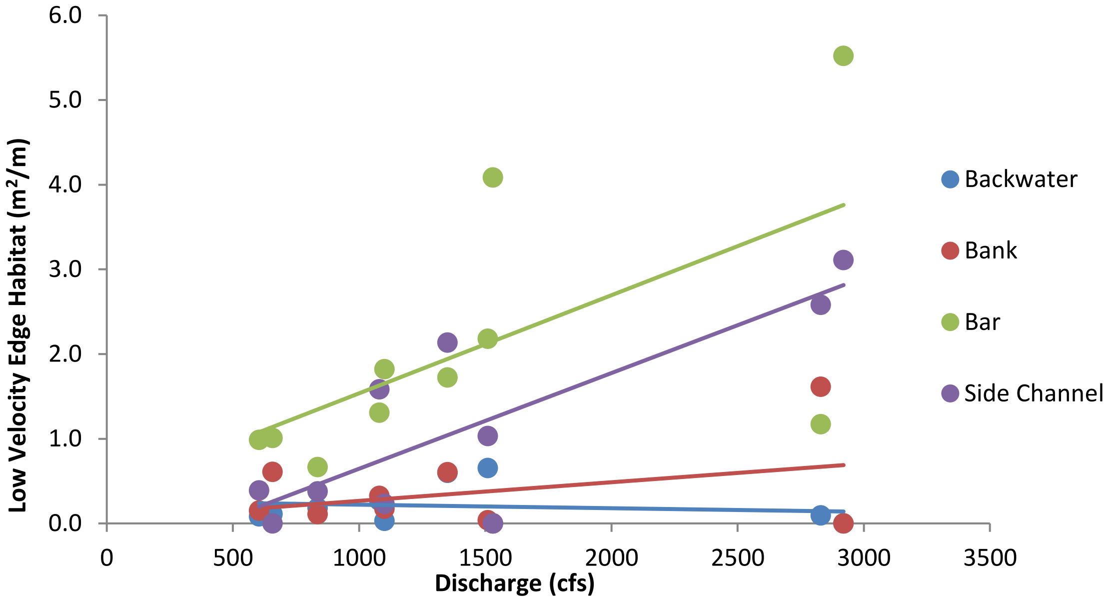

FIGURE 11. LOW VELOCITY HABITAT BY TYPE AND DISCHARGE FOR ALL SAMPLING EVENTS.

While total low velocity habitat generally increased with discharge, the relationship between low velocity habitat and discharge varied between edge habitat types (Figure 11). Area of bar and side channel edge habitats increased with flow, but little to no trend was identified between bank or backwater habitat area and flow (Figure 11). Backwater habitat was generally the least available throughout all years, while bar and side channel were generally the most prevalent.

The availability of low velocity habitat changed not only with discharge, but by sampling location as well. Sampling areas differed in morphology, and represented the different channel characteristics from the site. Breaking down low velocity habitat by sampling area allows us to see not only fine scale trends of habitat availability between flows, but also changes from year to year as high winter flows change channel and floodplain morphology. The Middle Left Bank (MLB) is characterized by a large gravel bar in a relative straight leveed portion of the river (Figure 3). The MLB area features primarily bar habitat, with increasing side channel and bar habitat at higher flows and a small amount of bank and backwater habitat at lower flows (Figure 12A). This area showed the strongest relationships between edge habitat and discharge compared to the two other locations sampled.

The Upper Left Bank (ULB) is characterized by an inside bend and features a vegetated bar and a small side channel that is often occupied at higher flows (Figure 3). Low velocity edge habitat in the ULB area is generally dominated by side channel habitat, which is characteristic of natural inside bend areas. Bar habitat is the next most prevalent habitat in the area, with small amounts of backwater and bank habitat often found (Figure 12B).

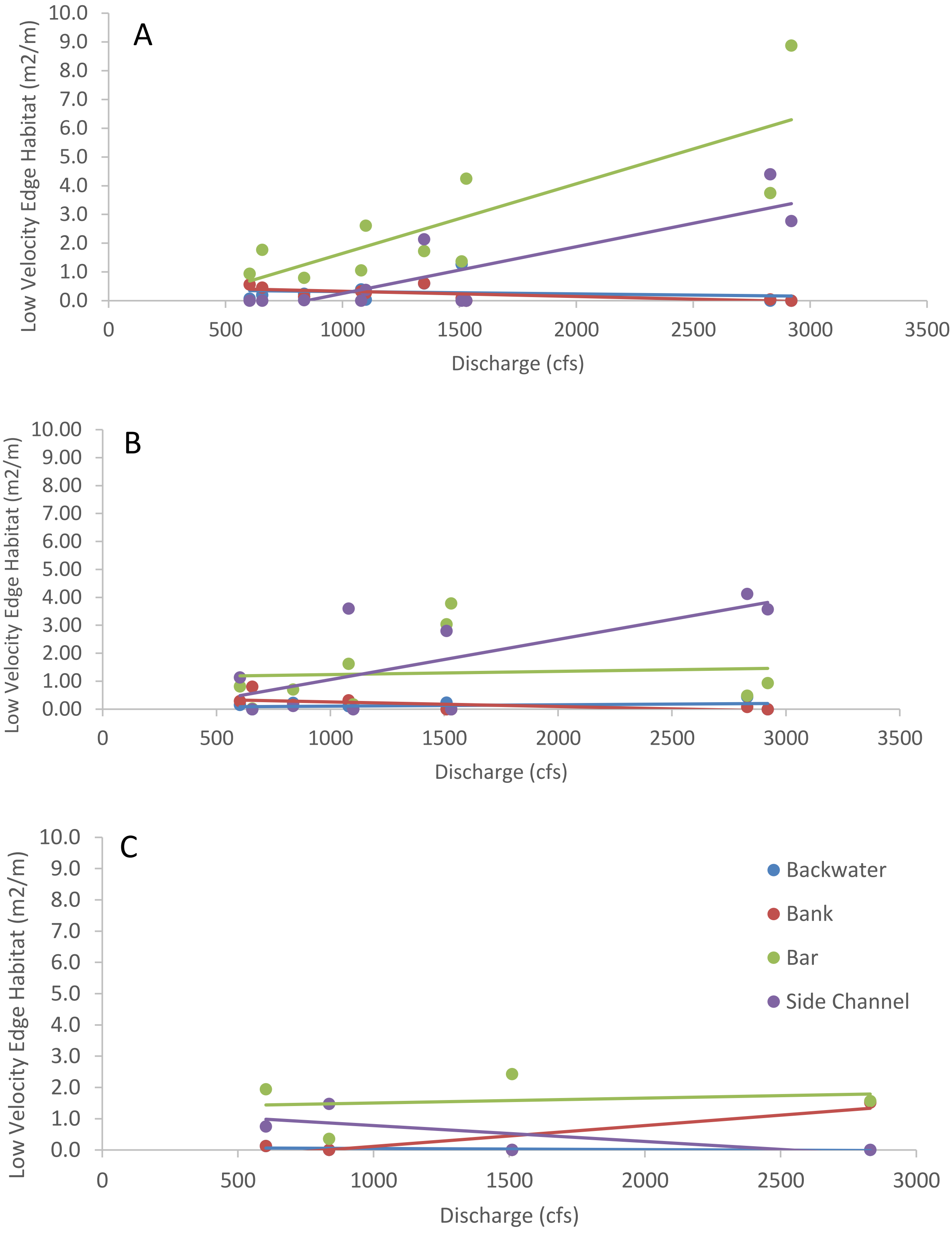

FIGURE 12. LOW VELOCITY HABITAT BY TYPE FOR THE MIDDLE LEFT (A), UPPER LEFT (B), AND UPPER RIGHT (C) BANK SAMPLING AREAS

The Upper Right Bank (URB) is characterized by an outside bend following a concrete revetment with a small depositional bar with a small side channel behind it (Figure 3). The URB area tended to have the lowest amount of available edge habitat (Figure 12C), and no relationship between discharge and edge habitat area was observed, which was likely a result of the adjacent revetment.

Wood

In total, 1,852 large wood pieces were found in the project reach. The majority of large wood pieces were 4-16 m long and 0.1-0.4 m in diameter (Table 6). The total volume of wood in the project area was 5297.96 m^3, and the log jam volume within the project area was 1161.71 m^3. There were 18 key logs measured within the project area in the field.

TABLE 6. LARGE WOOD PIECES IN 2017 BY SIZE CLASS (DOES NOT INCLUDE LOGJAMS)

	Length Class (m)			
Diameter Class (m)	C (2-4)	D (4-8)	E (8-16)	F (16-32)
2 (0.1 – 0.2)	181	268	138	13
3 (0.2 – 0.4)	176	361	298	121
4 (0.4 – 0.8)	15	66	108	96
5 (0.8 – 1.6)	0	3	3	5

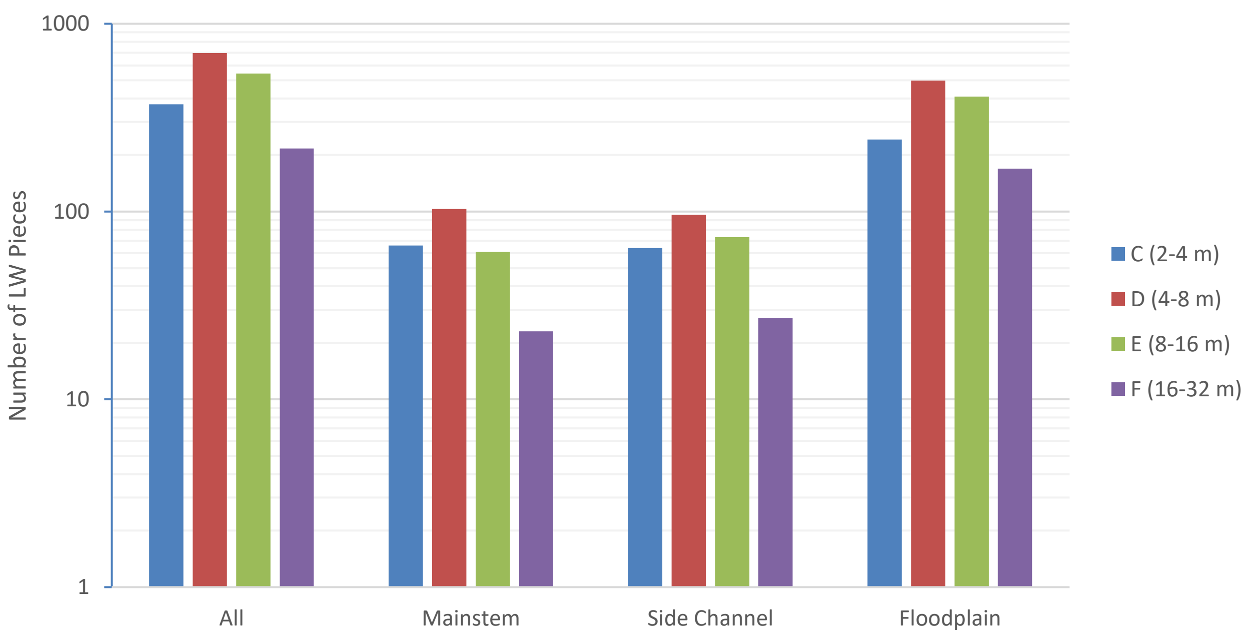

FIGURE 13. NUMBER OF LARGE WOOD PIECES BY HABITAT TYPE WITHIN THE PROJECT AREA (LOG SCALE)

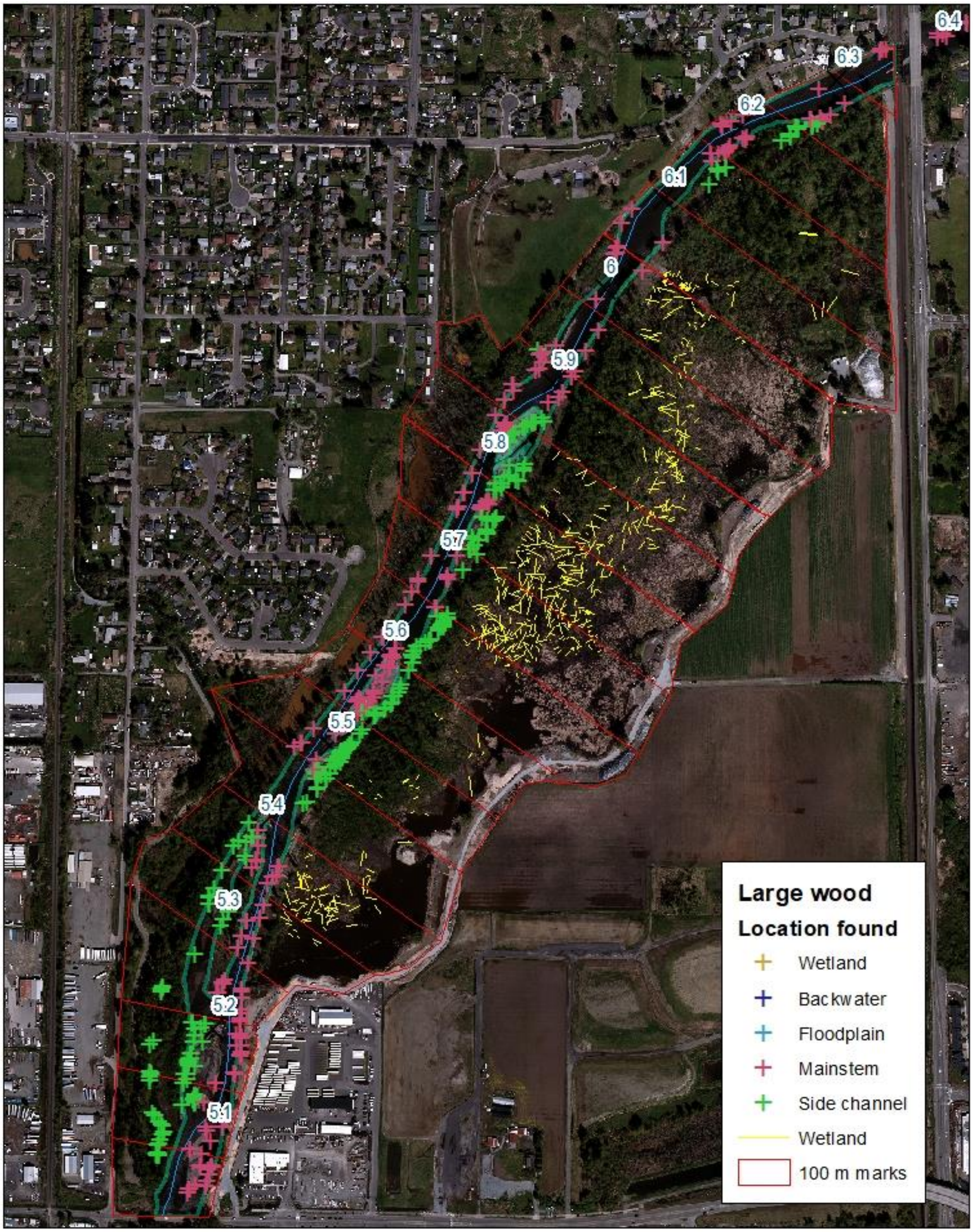

FIGURE 14. MAP OF INDIVIDUAL LARGE WOOD PIECES THROUGHOUT THE PROJECT AREA IN 2017

Most individual large wood pieces were located in the floodplain, and similar amounts of large wood were found in mainstem and side channel habitats (Figure 13, Figure 14). The largest wood pieces (size class ≥E4) were primarily found at river mile 5.36 and between river mile 5.7-5.83 (Figure 15), which corresponds with areas of high wood density overall (Figure 14). Log jams were patchily distributed, with a few very large jams contributing the majority of log jam volume observed at river mile 5.15, 5.36, and 6.38 (Figure 16).

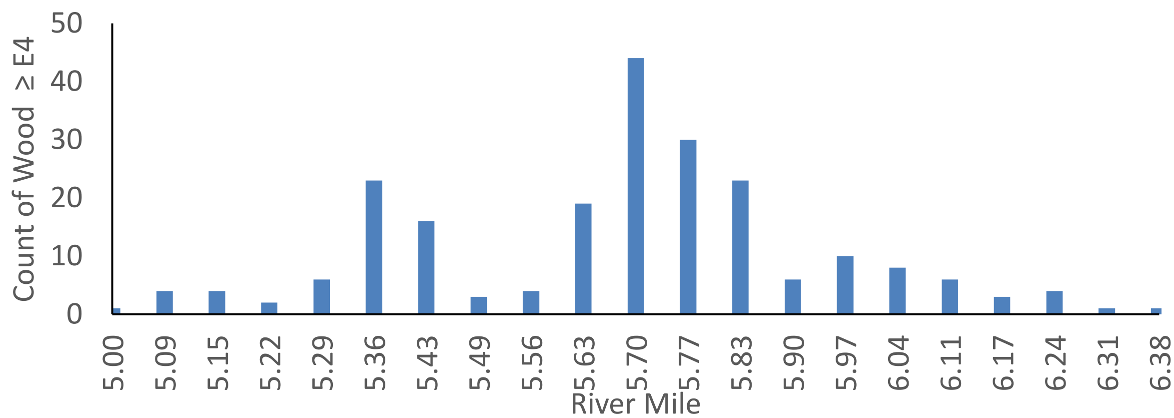

FIGURE 15. WOOD COUNT (≥ E4) BY RIVER MILE

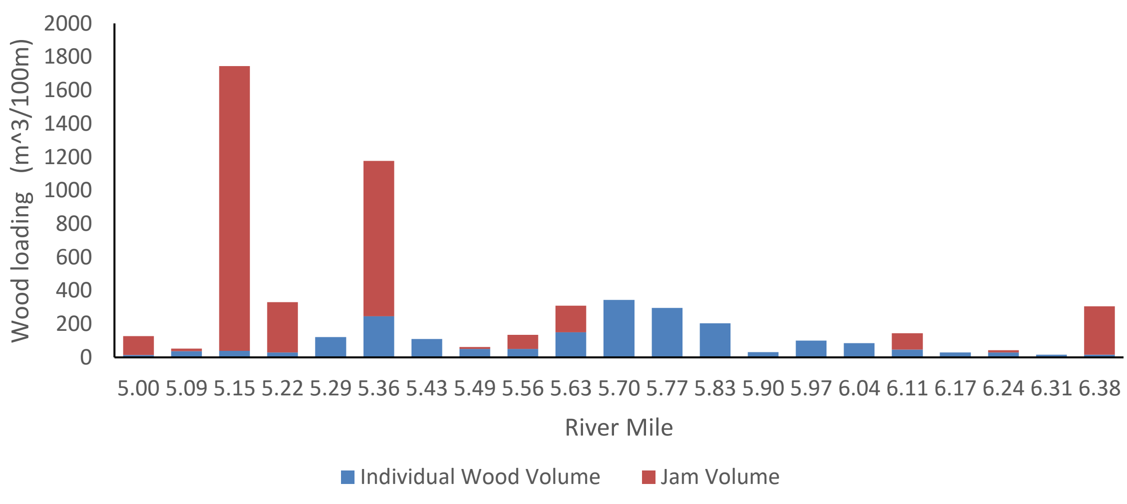

FIGURE 16. VOLUME OF INDIVIDUAL WOOD PIECES (ALL SIZE CLASS ≥C2) AND WOOD JAMS BY RIVER MILE

The project area did not meet standards set by the National Marine Fisheries Service (NMFS) or Fox and Bolton (2007) for pieces of wood per mile or meter. Wood loading in the project reach achieved 17.30% of the targeted 80 pieces/mile set by NMFS. Baseline wood loading achieved a greater percentage of the target loading set by Fox and Bolton (2007), which incorporate smaller size classes of wood, but the number of key pieces per 100 m was also much lower than the target (Table 7). We include comparison to both Fox and Bolton (2007) standards and NMFS standards, since Fox and Bolton standards apply specifically to streams with a bankfull width of 30-100 m, and therefore may apply more specifically to the study reach than NMFS standards.

TABLE 7. COMPARISON OF OBSERVED LARGE WOOD QUANTITIES WITH EXISTING GUIDELINES

Source	LW Minimum Size Criteria	Quantified Size classes in project area	Observed Value in 2017 (Approx.)	Guidelines or target	Percent achieved
National Marine Fisheries Service	15.2 m long and 0.6 in diameter (50ft x 24 in)	E4-6; F4-6	18 in Project area (1.3 mi) 13.84 per mile	>80 per mile	17.30%
Fox and Bolton (2007)	2 m long and 10 cm in diameter (6.6 ft x 4 in)	All except B class	Averaged 88.19 pieces per 100 m (328 ft)	>208 per 100 m (75th percentile)	42.40%
	Key Piece (50 ft x 24 in) volume is 10.75 m^3 or more	E5-G5; D6-G6	Average 0.86 pieces per 100 m (328 ft)	>4 (75th percentile)	21.50%

Fish Use

Habitat Use

Fish sampling was conducted over 12 discrete sampling dates (Table A1). One hundred and six total samples (i.e., net hauls) were collected; 24 hauls resulted in no fish caught. Of these, six occurred in the autumn, two in the spring, five in the summer, and 11 in the winter; 14 were in bank habitat, seven were in bar habitat, and three were in side channel habitat.

In total, 2,388 fish were sampled between April 2011 and September 2015 (Table A2). Because very few fish were caught in the fall and winter months, we focused the final year of baseline data collection on the spring, summer, and early fall. Therefore, in 2015, fish and aquatic habitat sampling occurred in March, May, July, and September, and analyses for baseline reporting focus on spring and summer sampling.

Across all sampling events, 972 salmonids were sampled and measured (Table A2). The majority (90% of the juvenile Chinook, coho, and steelhead) were captured in the spring and summer months. Habitat use by Chinook, coho, and steelhead in each edge habitat type across seasons, years, and age classes are shown in Figure 17 as proportions captured in each habitat type, revealing substantial use of backwater habitat by juvenile Chinook and coho salmon, and bar habitat by juvenile steelhead. Additional species captured included sculpin species, longnose dace, mountain whitefish, lamprey, largescale sucker, and red-sided shiner (Table A1).

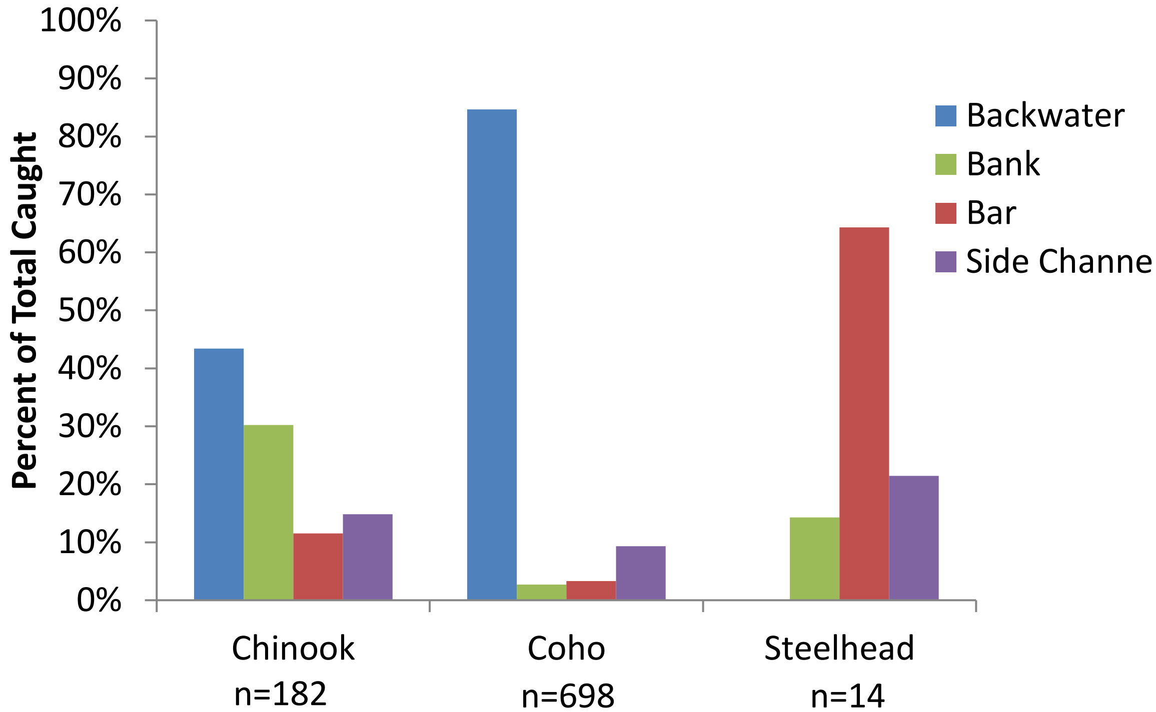

FIGURE 17. SALMONID HABITAT USE IN ALL YEARS (2011-2015), SPRING AND SUMMER. NOTE THAT THE MAJORITY OF CHINOOK AND COHO CAPTURED WERE AGE 0, WHILE THE MAJORITY OF STEELHEAD CAPTURED WERE AGE 1+.

Juvenile Chinook

In total, 194 Chinook were captured across all four years of baseline sampling. Average catch per unit effort (CPUE) of age-0 Chinook was highest in backwater and bank habitats in spring, and side channel habitat in summer. CPUE was significantly higher in spring and summer compared to fall (p=0.005 and p=0.01), but differences between edge types were not statistically significant after controlling for hatchery releases, escapement, and sampling timing (Figure 18; Table 8).

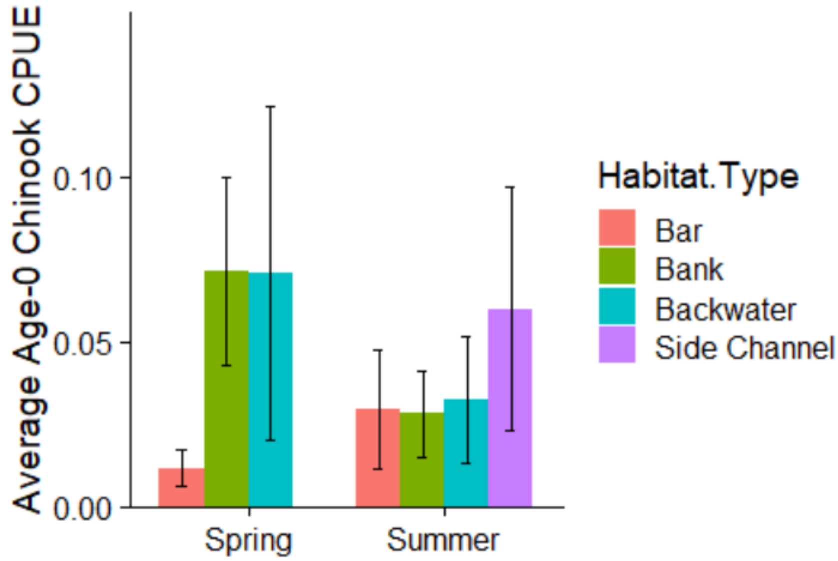

FIGURE 18. AVERAGE CATCH PER UNIT EFFORT OF YOUNG-OF-YEAR CHINOOK CAPTURED IN FOUR HABITAT TYPES DURING SPRING AND SUMMER 2011, 2012, AND 2015. ERROR BARS DEPICT STANDARD ERRORS.

TABLE 8. CHINOOK CPUE (CATCH/SECOND) ± SE BY SEASON AND EDGE HABITAT TYPE.

	Bar	Bank	Backwater	Side Channel	**TOTAL**
Winter	0.02 ± 0.01	0.0 ± 0.0	--	0.01 ± 0.01	**0.01 ± 0.003**
Spring	0.01 ± 0.01	0.07 ± 0.03	0.07 ± 0.05	0.0 ± 0.0	**0.05 ± 0.02**
Summer	0.03 ± 0.02	0.03 ± 0.01	0.03 ± 0.02	0.06 ± 0.04	**0.03 ± 0.01**
Fall	0.002 ± 0.002	0.003 ± 0.003	0.0*	0.0 ± 0.0	**0.002 ± 0.001**
TOTAL	**0.02 ± 0.01**	**0.03 ± 0.01**	**0.05 ± 0.03**	**0.02 ± 0.01**	

*Only one habitat unit sampled.

Captured Chinook ranged in size from 32mm to 110mm FL. The size distribution of juvenile Chinook was bimodal in spring when both newly emerged fry were present as well as parr (Figure 19A). Fry were an average of 46.1 mm FL (SD = 13.1), while parr were 82.2 mm on average (SD = 10.5). Primarily larger parr (average = 94.6 mm, SD = 9.8) were found in summer months (Figure 19B), likely reflecting growth (Table 9).

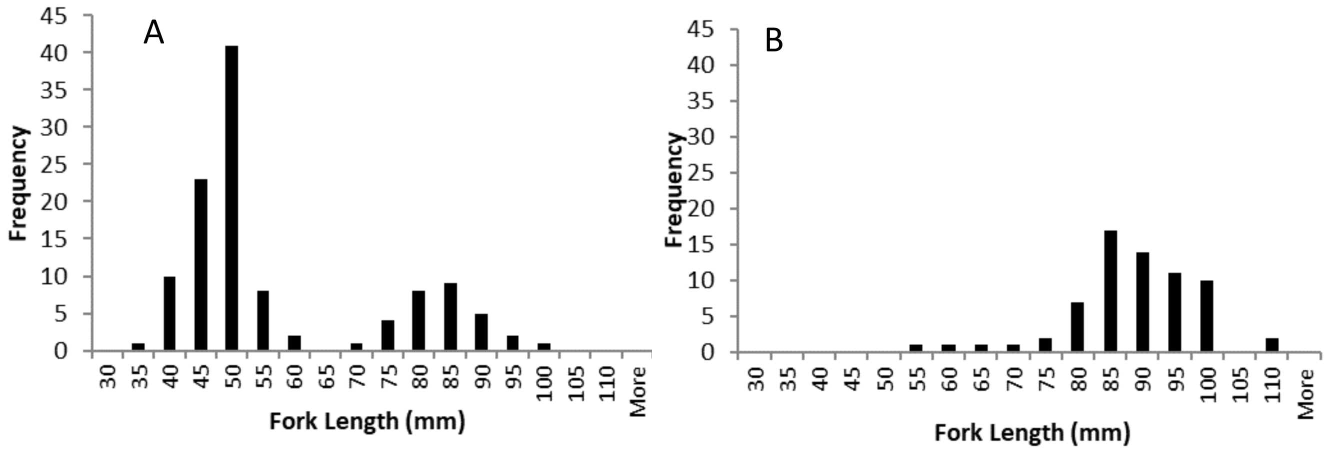

FIGURE 19. LENGTH FREQUENCIES OF JUVENILE CHINOOK CAPTURED IN SPRING (A) AND SUMMER (B)

Chinook size was significantly different between seasons (Figure 20; Table 9), with significantly smaller fish found in winter and spring compared to summer and fall (p<0.001). Chinook size also differed with edge habitat type, with larger fish found in bank habitat compared to backwater or side channel habitat (p<0.001).

TABLE 9. AVERAGE CHINOOK FORK LENGTH ± SE BY SEASON AND EDGE HABITAT TYPE.

	Backwater	Side Channel	Bank	Bar	**TOTAL**
Winter	--	39.0 ± 0.5	--	53.0 ± 14.3	**46.0 ± 7.1**
Spring	45.7 ± 0.5	--	70.5 ± 2.7	62.4 ± 8.1	**55.5 ± 1.5**
Summer	86.1 ± 3.0	83.3 ± 1.8	90.2 ± 3.5	90.4 ± 1.5	**86.8 ± 2.5**
Fall	--	--	99.0*	104.0*	**101.5 ± 1.2**
TOTAL	**51.3 ± 1.7**	**76.3 ± 3.3**	**75.5 ± 2.5**	**78.8 ± 4.4**	

*Only one fish measured.

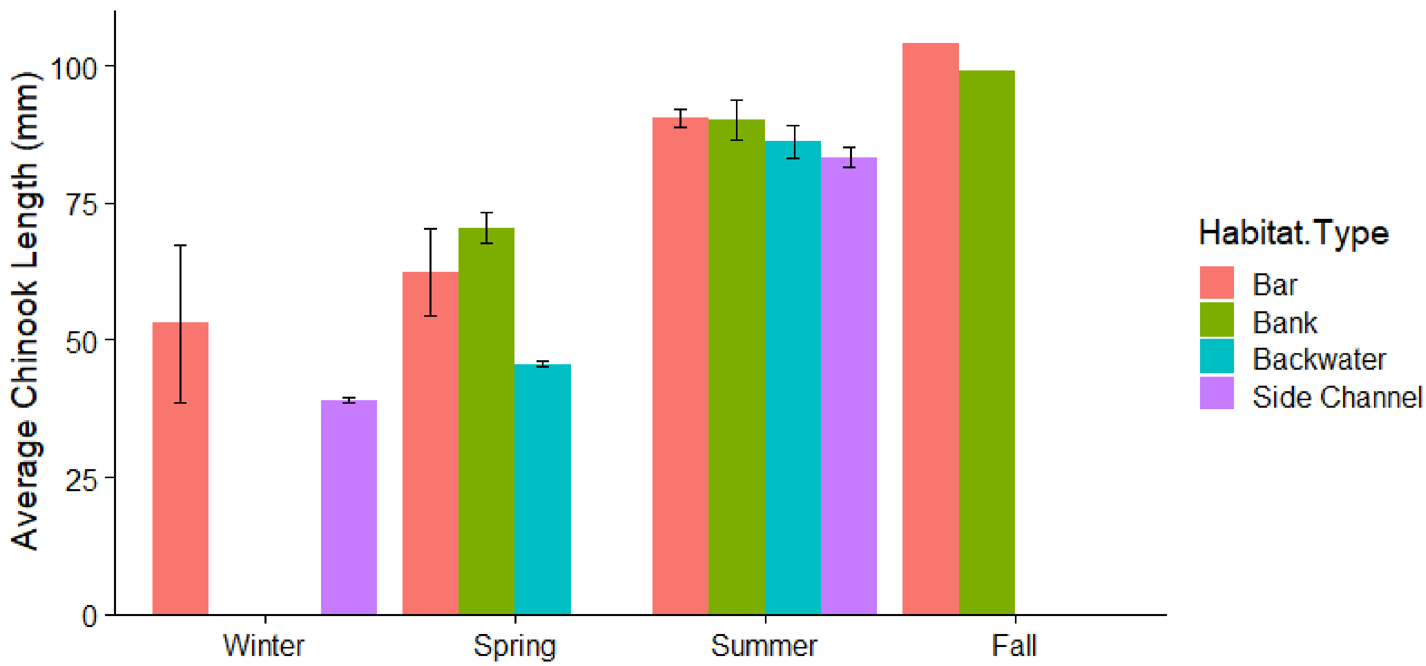

FIGURE 20. AVERAGE CHINOOK FORK LENGTH (MM) BY SEASON AND HABITAT TYPE. ERROR BARS DEPICT STANDARD ERRORS.

Juvenile Coho

Across all sampling events, 709 juvenile coho were captured. Catch of age-0 coho was highest in spring (p = 0.002), when these fish primarily used backwater habitat, then reduced in summer when the majority were caught in side channel habitat (Figure 21; Table 10). These differences were statistically significant; age-0 coho CPUE was significantly higher in side channel habitats compared to banks (p=0.04) or bars (p=0.05). Age-1+ coho were also caught in higher numbers in spring, with greatest CPUE in side channel habitats compared to banks or bars, though these differences were not statistically significant (Figure 22). Use of backwater habitat by age-1+ coho was comparable to use of side channel habitats in spring, and decreased in summer (Table 10).

TABLE 10. COHO CPUE (CATCH/SECOND) ± SE BY SEASON AND EDGE HABITAT TYPE.

Age-0 Coho	Bar	Bank	Backwater	Side Channel	**TOTAL**
Winter	0.0 ± 0.0	0.0 ± 0.0	--	0.0 ± 0.0	**0.0 ± 0.0**
Spring	0.02 ± 0.02	0.004 ± 0.003	0.92 ± 0.34	0.07 ± 0.04	**0.26 ± 0.11**
Summer	0.01 ± 0.004	0.007 ± 0.004	0.01 ± 0.01	0.07 ± 0.04	**0.02 ± 0.01**
Fall	0.0 ± 0.0	0.0 ± 0.0	0.0*	0.0 ± 0.0	**0.0 ± 0.0**
TOTAL	**0.007 ± 0.004**	**0.004 ± 0.002**	**0.60 ± 0.25**	**0.03 ± 0.02**	

Age-1+ Coho	Bar	Bank	Backwater	Side Channel	**TOTAL**
Winter	0.0 ± 0.0	0.0 ± 0.0	--	0.001 ± 0.001	**0.0005 ± 0.0005**
Spring	0.01 ± 0.01	0.004 ± 0.003	0.05 ± 0.03	0.06 ± 0.03	**0.02 ± 0.01**
Summer	0.01 ± 0.004	0.02 ± 0.02	0.004 ± 0.004	0.03 ± 0.01	**0.02 ± 0.01**
Fall	0.02 ± 0.01	0.003 ± 0.003	0.0*	0.0 ± 0.0	**0.01 ± 0.01**
TOTAL	**0.01 ± 0.004**	**0.01 ± 0.01**	**0.03 ± 0.02**	**0.02 ± 0.01**	

*Only one habitat unit sampled

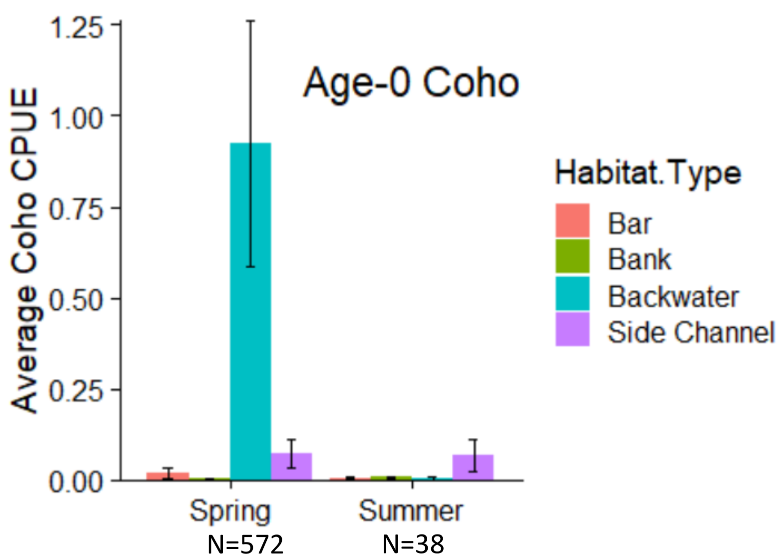

FIGURE 21. AVERAGE CATCH PER UNIT EFFORT (CATCH/SECOND) OF YOUNG-OF-YEAR COHO CAPTURED IN FOUR HABITAT TYPES DURING SPRING AND SUMMER 2011, 2012, AND 2015. ERROR BARS DEPICT STANDARD ERRORS.

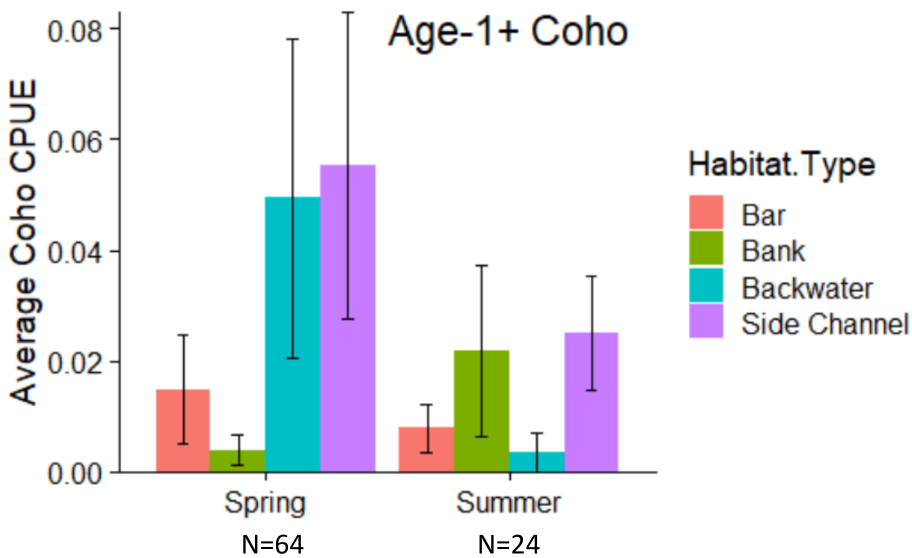

FIGURE 22. AVERAGE CATCH PER UNIT EFFORT (CATCH/SECOND) OF AGE-1+ COHO CAPTURED IN FOUR HABITAT TYPES DURING SPRING AND SUMMER 2011, 2012, AND 2015. ERROR BARS DEPICT STANDARD ERRORS.

Age-0 coho ranged in size from 28mm – 87mm across seasons, while age-1+ coho ranged from 55mm – 133mm. Both age-0 and age-1+ coho were captured in both spring and summer, however bimodality in the size distribution was not as clear as was observed for juvenile Chinook (Figure 23). Average size of juvenile coho (both age classes) was 50.6 mm FL (SD = 18.8) in the spring, and 63.2 mm (SD = 18.2) in the summer.

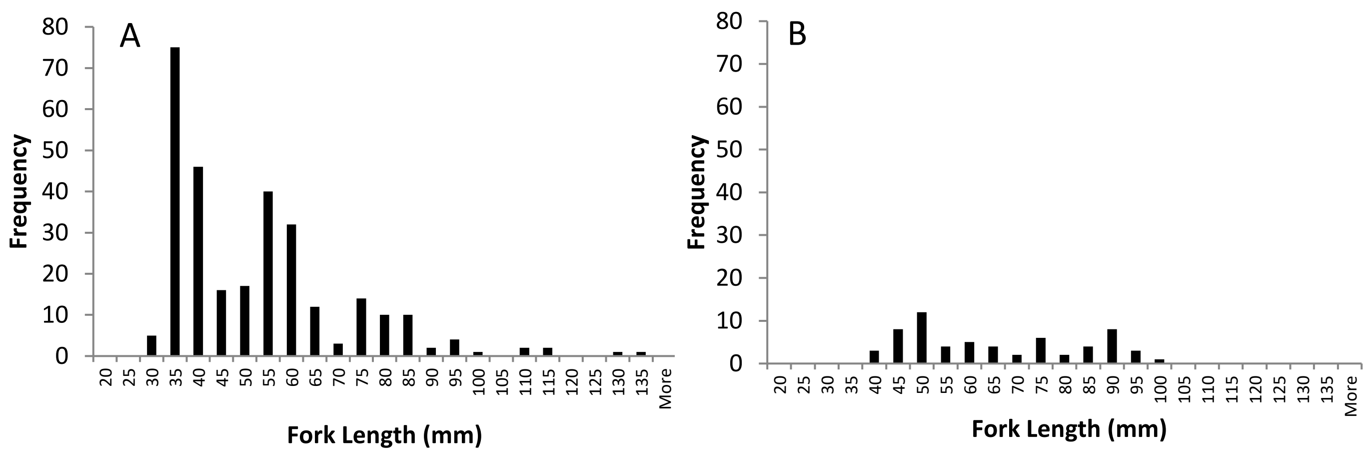

FIGURE 23. LENGTH FREQUENCIES OF JUVENILE COHO CAPTURED IN SPRING (A) AND SUMMER (B)

TABLE 11. COHO FORK LENGTH ± SE BY SEASON AND EDGE HABITAT TYPE.

Age-0 Coho	Backwater	Side Channel	Bank	Bar	**TOTAL**
Spring	42.9 ± 0.7	38.8 ± 0.8	45.5 ± 1.5	43.0 ± 1.1	**42.6 ± 0.6**
Summer	44.0 ± 2.0	48.7 ± 1.3	51.0 ± 4.3	69.0 ± 7.5	**50.8 ± 1.6**
TOTAL	**42.9 ± 0.7**	**44.9 ± 1.1**	**49.2 ± 3.0**	**51.0 ± 4.1**	

Age-1+ Coho	Backwater	Side Channel	Bank	Bar	**TOTAL**
Winter	--	90.0*	--	--	**90.0***
Spring	75.3 ± 1.2	83.8 ± 6.2	92.5 ± 35.5	93.5 ± 10.8	**79.1 ± 2.0**
Summer	89.0*	72.8 ± 0.9	88.3 ± 1.7	85.8 ± 1.5	**82.7 ± 1.7**
Fall	--	--	70.0*	92.3 ± 1.8	**90.1 ± 2.8**
TOTAL	**75.6 ± 1.2**	**79.9 ± 3.7**	**87.6 ± 4.2**	**91.3 ± 3.4**	

*Only one fish measured.

Age-0 coho were significantly larger in summer compared to spring (p<0.001; Figure 24), but age-1+ coho sizes were not significantly different between seasons, likely due to high variability (Table 11). No statistically significant differences in age-0 coho size were observed between habitat types, however those in backwater and side channel habitats tended to be smaller. Age-1+ coho found in bank or bar habitat were significantly larger than those in side channel (p=0.01 and p=0.004 respectively) or backwater habitats (p=0.04 and p=0.01 respectively).

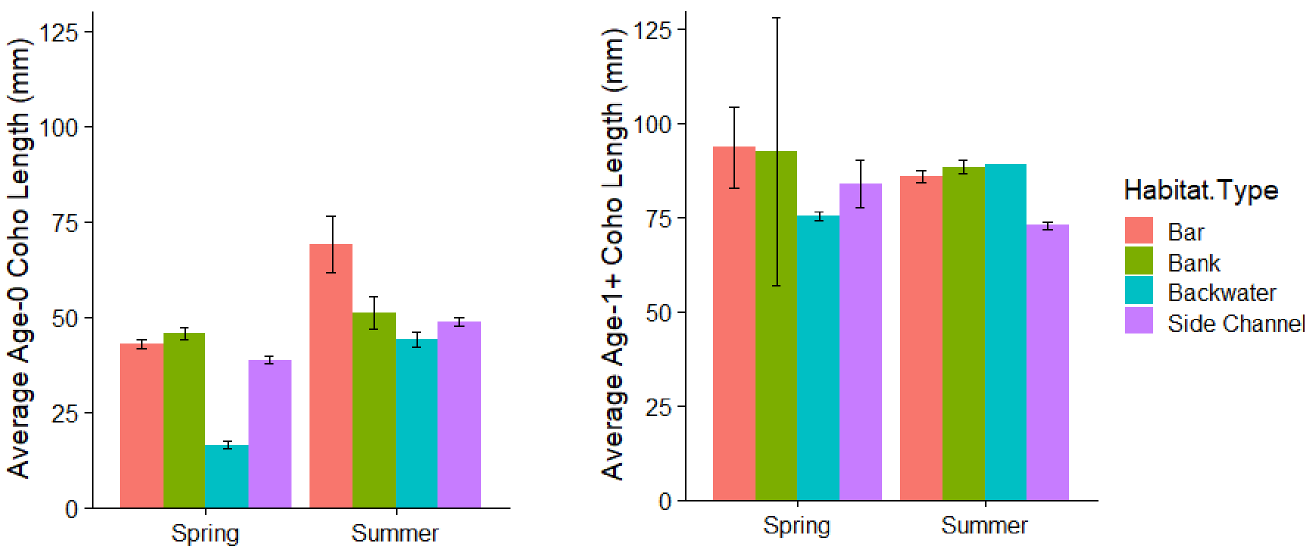

FIGURE 24. AVERAGE AGE-0 AND AGE-1+ COHO FORK LENGTH (MM) BY SEASON AND HABITAT TYPE. FISH CAPTURED IN WINTER AND FALL EXCLUDED DUE TO SMALL SAMPLE SIZE. ERROR BARS DEPICT STANDARD ERRORS.

Habitat Capacity

At close to median rearing flows, (here calculated using data from 3/19/2015, 1500 cfs), the habitat capacity index was highest for age-0 coho (49,500), followed by juvenile Chinook (19,259) and age-1+ coho (9,427). Again, this index does not represent the number of fish supported (CPUE was measured per seconds fished rather than per area); instead this index weights available habitat by fish use to provide a quantitative metric by which to compare pre- and post-project values.

Given that fish catch was typically highest in spring, the habitat capacity metric calculated here weights habitats used in spring more heavily, which does not perfectly represent habitat importance; fish sampling results show habitat types used varies by salmonid life history stage and timing, indicating that a diversity of habitat types is important to support salmonids throughout freshwater rearing.

Amphibian Use

No amphibian egg masses were observed in wetlands C, D, RB_WQ, or RB1 during either visit in 2011. The Pierce County mitigation wetland (PCMW) was only surveyed during the first visit in 2011 and no amphibian egg masses were observed in the very turbid waters. None of these five wetlands were surveyed in 2012.

Seven distinct sections of the "B" complex wetland were surveyed in both 2011 and 2012. Wetland B2 had a unique amphibian species composition with seven Pacific treefrog egg masses counted in 2011 and 17 long-toed salamander egg masses counted in 2012. Egg masses of northwestern salamanders were the only amphibian species observed in the remaining six B-complex wetlands. Abundance varied from a single northwestern salamander egg mass in B3 in 2011 to over 180 egg masses in B4 and B5 in 2012 (Figure 25).

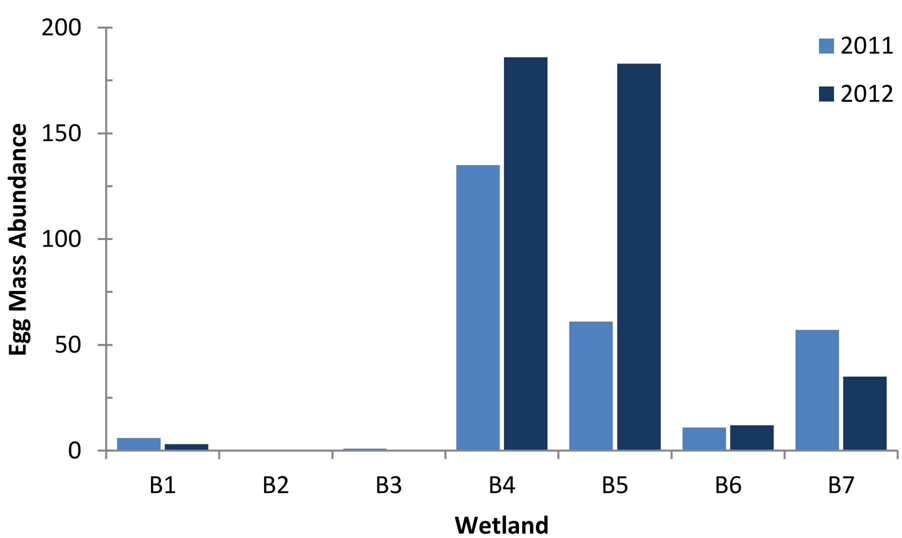

FIGURE 25. NORTHWESTERN SALAMANDER EGG MASS ABUNDANCE IN 2011 AND 2012

Survey results can be used to determine species presence, but failure to see a species does not ensure its absence – especially for long-toed salamanders, which have eggs that are difficult to find and may be active before our survey period. However, previous amphibian breeding surveys of King County wetlands often observed higher amphibian species richness more in the order of two to five species per wetland (Richter and Ostergaard 1999, King County 2010, 2011a). The reason for the low species richness at Countyline wetlands (generally zero or one) is not understood, however wetland water levels fluctuate considerably in response to fluctuating flows in the White River. Beaver dam building activity and these fluctuations may inhibit breeding of some amphibian species in these wetlands.

Northwestern salamander egg mass mortality ranged from less than 1% during surveys at several wetlands to over 60% at wetland B1 during the second survey in 2011 (Table 12). High egg mass mortality of greater than 10% in wetlands B1 and B3 was skewed by a small sample size (fewer than 10 egg masses) that included one or two egg masses with very high mortality. However, the high egg mass mortality in wetland B4 in 2011 (20.8% and 32.0%) was representative of over 90 egg masses in each survey period. At this wetland location, many egg masses appeared to be desiccated and were rough to the touch. We observed signs of large wetland water level fluctuations and this could have contributed to the high mortality as the wetland level dropped and left some egg masses temporarily or permanently out of the water.

The following adult amphibians were observed:

- 1 Northern red-legged frog (*Rana aurora*) at wetland B1 in the first survey in 2011,
- 1 Pacific treefrog at wetland B5 in the first survey in 2011 and a single vocalizing treefrog was also heard,
- 1 non-native American bullfrog (*Rana catesbeiana*) at wetland B6 in the second survey in 2011

TABLE 12. AVERAGE NORTHWESTERN SALAMANDER EGG MASS MORTALITY IN 2011 AND 2012. ITALICIZED PERCENTAGES INDICATE LOW EGG MASS ABUNDANCE (<10).

	Percent Mortality for Survey Period			
Wetland	**2011-1**	**2011-2**	**2012-1**	**2012-2**
B1	*3.9*	*61.2*	no masses	*32.5*
B3	no masses	*15.5*	no masses	no masses
B4	20.8	32.0	0.0	0.9
B5	1.5	2.6	0.4	0.9
B6	*1.0*	*0.3*	*0.0*	*0.0*
B7	0.2	2.7	7.1	0.5

V. Expected Changes Post-Construction

The White River is expected to breach the temporary berm that will remain in the location of the pre-existing levee immediately post-construction, to inundate the project area. As a result, a complex side channel is expected to naturally form in the project area, and the area of active channel and number of side channel/braided channel nodes is expected to increase. Due to creation of this new channel, we expect the area of slow-water edge habitat throughout the project area to increase compared to baseline levels. Juvenile salmonids are expected to use these new edge habitats, especially backwater and side channel habitats.

Wetland area is expected to decrease as a new side channel forms and the habitat is converted from wetland to riverine. This may shift the distribution and/or abundance of amphibians, which are expected to continue using remaining wetland area for breeding.

A wood transport study was conducted to estimate fluvial inputs and outputs of large wood into and out of the project site (King County 2011b). Large wood storage is predicted to increase after the project is constructed. Within the project, wood is expected to recruit laterally in an abrupt pulse from channel avulsion into existing trees in the project site, as well as more gradually from future bank erosion during and after the avulsion. Combined with wood transported from upstream, the project site is expected to accumulate 7,000 m^3 of wood over the first decade. This would exceed target thresholds for large wood set by Fox and Bolton (2007). These anticipated results are dependent on flows comparable to those used in the wood transport study (King County 2011b), as levels sufficient to recruit large wood must be reached.

VI. Future Monitoring

Channel dynamics (active channel area, number of channel nodes, ratio of channel to mainstem length), slow-velocity edge habitat, large wood loading, and fish use will continue to be monitored post-construction. In addition, installed riparian plants will be monitored for several years after project completion (Table 13) to ensure that survival, percent cover, and vegetated buffer width performance standards are being met (Table 1). Dependent on staff availability, amphibian surveys may also be conducted in year 3 and year 5.

TABLE 13. MONITORING SCHEDULE

Task	Objectives	Pre-Construction Baseline	Post-Construction Baseline	Year 1 2018	Year 2 2019	Year 3 2020	Year 4 2021	Year 5 2022	Year 6 2023	Year 7 2024	Year 8 2025	Year 9 2026	Year 10 2027
1	Record Drawings		X										
2	LiDAR/air photos*	X		X		X		X					X
3	Edge habitat	X		X		X		X					X
4	Aerial photography*			X		X		X		X			X
5	Wood loading	X		X				X					X
6	Plant survival			X									
7	Percent vegetative cover			X	X	X		X		X			X
8	Fish sampling	X		X		X		X					X

*Additional sampling may be conducted during and following high flow events

VII. References

Beechie, T. J., M. Liermann, E. M. Beamer, and R. Henderson. 2005. A classification of habitat types in a large river and their use by juvenile salmonids. Transactions of the American Fisheries Society 134:717-729.

Bjornn, T., and D. Reiser. 1991. Habitat requirements of salmonids in streams. American Fisheries Society Special Publication 19:83-138.

Black, R. W., C. Czuba, C. Magirl, S. G. McCarthy, H. Berge, and K. Comanor. 2016. Effect of a levee setback on aquatic resources using two-dimensional flow and bioenergetics models. U.S. Geological Survey Scientific Investigations Report 2016-5025, 26 p., http://dx.doi.org/10.3133/sir20165025.

Collins, B. D., D. R. Montgomery, K. L. Fetherston, and T. B. Abbe. 2012. The floodplain large-wood cycle hypothesis: A mechanism for the physical and biotic structuring of temperate forested alluvial valleys in the North Pacific coastal ecoregion. Geomorphology 139-140: 460-470.

Collins, B. D., and D. R. Montgomery. 2011. The legacy of Pleistocene glaciation and the organization of lowland alluvial process domains in the Puget Sound region. Geomorphology **126**:174-185.

Daubenmire, R.F. 1959. Canopy Coverage Method of Vegetation Analysis. Northwest Science 33: 43-64.

Fox, M., and S. Bolton. 2007. A regional and geomorphic reference for quantities and volumes of instream wood in unmanaged forested basins of Washington state. North American Journal of Fisheries Management 27:342-359.

GeoEngineers. 2008. Levee Setback Feasibility Analysis, Puyallup River Watershed, Pierce County, Washington. Prepared for Pierce County Public Works and Utilities, Tacoma, WA.

Gurnell, A. M., H. Piégay, F. J. Swanson, and S. V. Gregory. 2002. Large wood and fluvial processes. Freshwater Biology 47:601-619.

Herrera. 2010. Summary of Sediment Trends: Lower White River RM 4.44 to RM 10.60. Prepared for King County Department of Natural Resources and Parks, Water and Land Resources Division, River and Floodplain Management Section, Seattle, WA.

Herrera. 2012. Final Hydraulic Modeling Results Technical Memorandum, Countyline Levee Setback, White River. Prepared for King County Department of Natural Resources and Parks, Water and Land Resources Division, River and Floodplain Management Section, Seattle, WA.

Jones, L.L.C. W.P. Leonard, and D.H. Olson, eds. 2005. Amphibians of the Pacific Northwest. Seattle Audubon Society, Seattle, Washington. 227 p.

King County. 2006. Flood Hazard Management Plan: King County, Washington. King County Department of Natural Resources and Parks, Water and Land Resources Division, Seattle, Washington.

King County. 2010. Trilogy and Redmond Ridge Urban Planned Development (UPD) Annual Monitoring Report: Water year 2007. Prepared by Jo Wilhelm, Scott Stolnack, David Funke, and Ray Timm., Water and Land Resources Division. Seattle, Washington.

King County. 2011a. Trilogy and Redmond Ridge Urban Planned Development (UPD) Monitoring Report: Biological, Physical, and Chemical Monitoring for Water Years 2008-2010. Prepared by Jo Wilhelm and Sally Abella., Water and Land Resources Division. Seattle, Washington.

King County, 2011b. Wood budget for Countyline to A Street levee modification project, White River, WA. Prepared by Josh Latterell. King County Department of Naural Resources and Parks, Water and Land Resources Division, Seattle, Washington.

King County. 2013. Countyline Levee Setback Project: Stream and Wetland Delineation Report and Habitat Assessment. Prepared by Sarah McCarthy and Mason Bowles. King County Water and Land Resource Division, Seattle, WA.

King County. 2014. Countyline Levee Setback Habitat Monitoring Plan. Prepared by Sarah McCarthy, Josh Latterell, Terry Butler, Jo Wilhelm, Hans Berge, and Kate Akyuz. King County Water and Land Resources Division, Seattle, WA.

King County. 2015a. Countyline Levee Setback Public Safety Site Management Plan. King County Department of Natural Resources and Parks, Water and Land Resources Division, Seattle, Washington.

King County. 2015b. Bald Eagle Management Plan, Countyline Levee Setback, White River, WA. Prepared by Sarah McCarthy. King County Department of Natural Resources and Parks.

Konrad, C. P. 2015. Geospatial assessment of ecological functions and flood-related risks on floodplains along major rivers in the Puget Sound basin, Washington: U.S. Geological Survey Scientific Investigations Report 2015-5033, 28 p.

Montgomery, D. R. 2008. A simple alphanumeric classification of wood debris size and shape. Stream Notes: Quarterly publication of Stream Systems Technology Center, USFS Rocky Mountain Research Station October:1-3.

National Marine Fisheries Service (NFMS). 1996. Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast. U.S. Department of Commerce, National Oceanic and Atmospheric Administration.

Pess, G., S. Morley, J. L. Hall, and R. K. Timm. 2005. Monitoring floodplain restoration. Pages 127-166 in P. Roni, editor. Monitoring stream and watershed restoration. American Fisheries Society, Bethesda, MD.

Pierce County. 2012. Salmon Habitat Protection and Restoration Strategy - Puyallup (WRIA 10) and Chambers/Clover Creek (WRIA 12) Watersheds. Pierce County, Lead Entity.

Richter, K. O., and E. C. Ostergaard. 1999. King County wetland-breeding amphibian monitoring program: 1993-1997 summary report. King County, Department of Natural Resources, Water and Land Resources Division. Seattle, WA.

Stefankiv, O., T.J. Beechie, J.E. Hall, G.R. Pess, B. Timpane-Padgham. 2019. Influences of valley form and land use on large river and floodplain habitats in Puget Sound. River Research Applications. 35: 133-145.

Thoms, C., C. C. Corkran, and D. H. Olson. 1997. Basic amphibian survey for inventory and monitoring in lentic habitats. Pages 35-46 in D. H. Olson, W. P. Leonard, and R. B. Bury, editors. Sampling amphibians in lentic habitats, volume Northwest Fauna Number 4. Society for Northwestern Vertebrate Biology, Olympia, WA.

Ward, J. V., K. Tockner, U. Uehlinger, and F. Malard. 2001. Understanding natural patterns and processes in river corridors as the basis for effective river restoration. Regulated Rivers: Research & Management 17:311-323.

Appendix A. Fish Sampling Summary

TABLE A1. NUMBER OF DISCRETE HABITAT TYPES SAMPLED DURING EACH FISH SAMPLING EVENT

Sample Date	Flow (cfs)	Backwater	Bank	Bar	Side Channel	TOTAL
04/20/11	1530	2	4	2	0	**8**
07/12/11	3000	2	4	3	2	**11**
10/04/11	657	1	3	4	0	**8**
02/01/12	2830	0	3	3	3	**9**
05/08/12	2920	2	3	3	3	**11**
07/25/12	3210	0	3	3	3	**9**
11/06/12	1350	0	3	3	3	**9**
02/20/13	1000	0	3	3	3	**9**
03/19/15	1270	3	3	3	0	**9**
05/20/15	1120	2	3	3	0	**8**
07/22/15	836	3	3	3	0	**9**
09/03/15	584	0	3	3	0	**6**
TOTAL		**15**	**38**	**36**	**17**	**106**

TABLE A2. FISH CAPTURED IN THE COUNTYLINE REACH IN ALL SEASONS BETWEEN 2011 AND 2015. SALMONID SPECIES WERE SEPARATED BY SIZE CLASS (AGE-0, AGE-1+, AND SPAWNERS)

Species	TOTAL #	Age 0	Age 1+	Spawners
Chinook	194	180	14	0
Coho	709	610	99	0
Pink	37	1	0	36
Rainbow/Steelhead	24	5	19	
Chum	1	1	0	0
Cutthroat	1	0	1	
Bull trout	6	0	6	
Sculpin spp	151			
Dace	809			
Mountain whitefish	34			
Largescale sucker	355			
Red-sided shiner	9			
Lamprey	2			
UNK minnow	54			
UNK salmonid	2			
TOTAL	**2388**	**797**	**139**	**36**